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Sustainable Digital Transformation in Automotive Industry

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The textbook is devised for students studying in the fields of electrical engineering, computer engineering, and automotive transport. The book comprehensively overviews key concepts, technologies, and applications related to modern Economic factors, Sustainablity, Digital Transformation in Automotive Industry. It covers theoretical foundations, practical implementation, and recent advances in these fields, offering valuable information for students, researchers, and professionals in the automotive and electrical engineering.

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Preface: Sustainable Digital Transformation in the Automotive Industry

The automotive industry stands at the forefront of a profound transformation, driven by rapid technological advancements and the urgent need for sustainability. This book, "***Sustainable Digital Transformation in the Automotive Industry***", is designed to guide you through this dynamic landscape, equipping you with the knowledge and tools to understand and contribute to the industry's evolution. Whether you are a bachelor's student just beginning your journey or a master's student deepening your expertise, this text will serve as a valuable resource to bridge theory and practice in one of the most innovative sectors today.

The automotive industry is no longer just about manufacturing vehicles. It has expanded into a complex ecosystem involving connected, autonomous, shared, and electrified (CASE) mobility solutions. Digital transformation is the catalyst behind this shift, enabling companies to optimize processes, enhance customer experiences, and meet stringent environmental regulations.

For students, understanding this transformation is critical. The integration of technologies such as artificial intelligence (AI), the Internet of Things (IoT), and big data analytics is redefining how vehicles are designed, produced, and maintained. These innovations are not merely optional—they are essential for staying competitive in a global market that demands efficiency, transparency, and sustainability.

This book is structured to provide a comprehensive overview of the key concepts, technologies, and strategies shaping the automotive industry's digital future. Here's what you can expect:

- *Foundations of digital transformation*: explore the distinctions between "digitization" (converting analogue processes to digital), "digitalization" (using digital tools to improve operations), and "automation" (reducing human intervention in tasks), and learn how these concepts apply to automotive manufacturing, supply chains, and customer interactions.
- *Business planning and information systems*: discover how modern enterprises use Enterprise Resource Planning (ERP) systems and advanced planning software to streamline operations, and analyse case studies of companies leveraging digital tools to enhance productivity and decision-making.
- *Sustainable manufacturing and ecological challenges*: delve into the environmental impact of automotive production and the industry's shift toward circular economy principles, and examine how digital technologies like AI and IoT are reducing waste, optimizing energy use, and supporting greener practices.
- *Human resources and motivation in a digital era*: understand the role of employee motivation and performance management in high-tech automotive environments, and explore digital tools for HR management, from training platforms to performance analytics.

- *Cybersecurity and data integrity:* learn about the critical importance of protecting digital systems in an industry increasingly reliant on connected technologies, and study real-world examples of cybersecurity challenges and solutions.
- *On-line marketplaces platforms*: learn about the critical importance marketplace where sellers (service providers) and buyers (customers) meet and interact with each other providing tools to facilitate transactions between the parties.
- *Emerging trends and future outlook*: investigate cutting-edge developments such as autonomous vehicles, smart factories, and blockchain for supply chain transparency, and reflect on the ethical and societal implications of these advancements.

To reinforce learning, each chapter includes: case studies, discussion questions, and practical exercises:

As future engineers, managers, or policymakers, you will play a pivotal role in shaping the automotive industry's trajectory. The knowledge you gain from this book will prepare you to:

- ***Innovate*** through the development of the solutions that integrate sustainability with cutting-edge technology.
- ***Adapt*** by navigating the rapid changes in industry standards, consumer expectations, and regulatory frameworks.
- ***Lead*** by driving digital transformation initiatives in your future workplaces, ensuring both economic and environmental success.

This book is the result of contributions from experts across Europe, including academics and industry professionals from Riga Technical University, Dunarea de Jos University of Galati, National & Kapodistrian University of Athens, Chernihiv Polytechnic National University, Kharkiv National Automobile and Highway University, Lutsk National Technical University, Cahul State University B.P. Hasdeu, and other esteemed institutions. Their insights provide a balanced perspective, combining theoretical foundations with practical applications.

How to Use This Book:

- For Bachelor's Students: Focus on grasping the core concepts and technologies. Use the case studies and examples to see how theory applies in real-world scenarios.

- For Master's Students: Dive deeper into the strategic and analytical aspects. Engage with the discussion questions and explore further research opportunities.

Final Thoughts

The automotive industry's journey toward sustainability and digital excellence is both a challenge and an opportunity. This book is your roadmap to understanding and contributing to this exciting field. Embrace the learning process, stay curious, and remember—the skills you develop today will help drive the innovations of tomorrow.

We wish you an enlightening and inspiring exploration of "***Sustainable Digital Transformation in the Automotive Industry***".

Chapter 1. Business planning information systems in the automotive industry

In addition to the profound transformations of the automotive industry, imposed by the new Connected, Autonomous, Shared, and Electrified (CASE) mobility, which are driving changes in almost every aspect of the business, there are many other factors (growing demand for battery minerals, challenges in the adoption of electric vehicles, political turbulence and changing consumer expectations) that contribute to the overall uncertainty. All of this is driving a rethinking of traditional strategies for the organization to withstand the changes [1].

1.1. Digitalization, digitization, and automation

By adopting digital technologies (digital tools, platforms, and strategies), processes and operations are streamlined and innovation is increased in the organization [2].

Digitization involves transforming analog processes into digital formats. Technology is used to improve activities in the automotive life cycle, such as design, manufacturing, sales, and after-sales service. Digitization provides data-driven information that is useful in decision-making, simplifying operations, and providing improved customer experiences [2].

By using automation, companies in the automotive industry can reduce labor costs, optimize resource utilization, increase product quality, work safety, and productivity [2].

The three concepts (Digitization, Digitalization, and Automation) constitute Digital Transformation. Digitization is associated with automation in simultaneous actions; digitized processes provide the basis for efficient automation. Automation systems use digitized information to streamline decision-making in autonomous vehicles or supply chain management [2].

Digitizing data flow operations leads to data simplification, protection of stored information, and automation of data extraction, processing, analysis, and use for commercial purposes. These solutions allow automotive companies to make better decisions in a highly competitive market [2].

Of course, this is just one example. We can also talk here about the transformation of paper containing production reports into mega, terabytes of data that are instantly transferred between machines, equipment, and are then presented in a synthetic form to managers in order to make quick decisions. Sometimes changing a production program can be done even from thousands of kilometres away via an internet connection.

Digitalization in the automotive industry has begun to be present at all stages [2]:

- drawing sketches has moved from the drawing board to software programs and ultra-high-performance computer graphics stations;
- component design is done exclusively using computers and software;
- testing/simulating the behaviour of components in use is mostly done digitally;
- production simulation and scheduling of manufacturing flows are largely done digitally.

Management of all aspects related to actual production (material supply, energy consumption, manufacturing cadence, equipment and personnel performance) is done digitally. This has provided more efficiency and less intensive workload for the workforce.

1.2.Planning functions

Business plans involve many uncertainties, the most important of which is the dramatic changes occurring in the automotive market, a very dynamic market.

For companies in the automotive industry, products cannot remain static if they want to maintain sales and gain market share. Therefore, the development of new models/products, or the refreshing of existing models/products, must be at the heart of business planning. A company's comprehensive business plan, which typically covers five years, incorporates the operational business plans of all departments in the company [3].

Modern companies are organized based on business processes. A business process is a collection of activities that have one or more inputs and that create one or more outputs that are valuable to an organization's customers. At the beginning of the 20th century, the organization based on departments or functional areas was born. Due to the disadvantages of this type of organization, starting with the 80s, new trends in the process of organizing companies emerged. An impetus in the search for new types of organization was also the crisis recorded in the American auto industry in the 80s. Not being able to compete with Japanese companies, the problem of their reformation arose. As a result, the process-based organization gained momentum. The main advantage of the process-oriented approach is that it helps managers to look at their organization from the perspective of customers [3].

The key to process-oriented organizations lies in information system that can move the organization and relieve the customer of the unpleasant task of triggering each individual action.

Enterprise Resource Planning (ERP) systems are the current technical solution to make process-based organizations possible. Organizations cannot operate in a process-oriented manner without an ERP system, because the efficient performance of a process requires obtaining, processing and transmitting a very large amount of information quickly and without manual intervention [3]. ERP systems are an information technology infrastructure of an organization on which all transactions generated by the daily business processes that occur in an organization circulate.

Other applications necessary for the modern company are built on this infrastructure, such as Business Planning, Business Intelligence (BI), Customer Relationship Management (CRM) and Supply Chain Management (SCM) [4, 5].

Planning is the creation of a business plan based on which the activities in the organizational process structure are established and coordinated.

Planning refers to the coordination of the company's own production factors or partners (stakeholders). The essence of planning is the attraction, integration and coordination of these general factors from the business world or other fields.

Relaunching economic activity in a business sector, modernizing strategic business units, increasing the volume of supply and, therefore, increasing income can only be achieved through a rigorous and efficient system of resource allocation. Achieving this goal is possible only by creating a coherent system of action planning for better use of opportunities while obtaining important advantages.

Planning involves an overview, which allows the detection of the most important relationships, a better understanding of each activity and a better appreciation of the basic elements that intervene in the following management acts and focusing on major areas.

Planning has the following components:

• strategic planning, in which the major strategic options are presented;

• operational planning, which groups the programming of activities and means necessary for the implementation of decisions;

• budgets that highlight the distribution of resources;

• the continuous process of measurement and control by comparing achievements with the set objectives.

Strategic planning allows for the modification and improvement of the business position within the general activity of the organization. The areas of strategic planning are multiple at the business level, the most important being: commercial, marketing, personnel, production, etc.

Planning calls for prospecting and forecasting, developing possible variants concerning the actions taken. Unlike forecasting methods applied to the near future, prospecting methods target the more distant future and are generally qualitative, including scenarios, multi-criteria qualitative analyses, and the Delphi method, which also has a degree of subjectivity.

The strategy must be decomposed, quantified, and programmed in time and space through activities specific to operational planning carried out over shorter periods and space.

Operational plans are also known as programs or action plans with a continuity of activity over time, ensuring coherence of the objectives with the allocated means and with the actions established by the operations calendar.

The *budget* is the financial expression of the company's action programs and is at the same time a management and control tool. It includes the investment, operating and financial budget. Investment budgets reflect the provisions of the investment programs to expand and modernize capacities. The operating budgets express the forecast of the operating activity for a future period and the financial budgets express the evolution of the payments and the expected results.

Strategic planning is doubled by activities of control of the use of resources and the results obtained, presenting three overlapping levels:

• strategic control for long-term programs;

• management control for annual plans;

• operational control, which is an execution control;

Any desired business at the level of a company cannot be an exception from planning, both strategic in the long term and operational, related to the more efficient management of the activity in the chosen business field.

Functional planning is a management process that involves establishing the actions necessary to achieve short- and long-term strategic objectives, while maintaining the balance between organizational resources and market opportunities. Functional planning is generally carried out at the level of the strategic business unit (activity) - the business plan per activity - but it is preferable to draw up the business plan for each product (product range) separately.

For strategic planning implementation in a company, an appropriate information system is needed. The business information system of an economic organization is a coherent structured set of data, information, procedures, and means of processing data and information, designed to permanently ensure knowledge of its specific activity environment and the correctness of decisions adopted to achieve the established objectives [6].

The information system of an economic organization is that part of the information system automated with the help of information technology means.

A computerized information system uses hardware resources (equipment and storage media), software (programs and procedures), and human resources (specialists and users) to capture input data, process them to generate output data, as well as store and control activities that convert data into information products.

The existence and use of an information system implies its integration into the decision-making system, which leads to the creation of a management information system.

Due to the turbulence in the business environment, especially those caused by globalization, businesses are forced to respond to these uncertainties. Businesses can be supported in their efforts by information systems and strategic planning [7].

The role of information systems in business has changed recently, they are being used for competitive advantage, business effusion, involvement in daily business operations and the growth of interorganizational systems. For companies to achieve their objectives effectively in this complex and dynamic economic environment, strategic planning of the information systems function is necessary [7].

Strategic information systems planning is the ability to shape a business strategy and the tools, techniques, and methodologies used to support organizations in implementing information systems with greater competitiveness. Strategic information systems planning is a process that includes several phases and activities that help companies to define information systems strategy and to develop them [5, 7].

1.3. Planning software

Companies can choose from a wide variety of software designed to help them develop a new business plan. One of these software is the Cognos Enterprise Planning Series software, which contains the following three elements [8]:

- Cognos Planning Analyst - a business planning and forecasting system that allows you to create, compare, and develop business scenarios and hypotheses. It is used to define business processes, display the organizational structure and data flow in the enterprise and its interconnection, and reduce the planning and budgeting cycle. It allows easy adaptation to changes in the environment, such as adding new products, factories, or cost centres;
- Cognos Planning Contributor - allows participation in the planning process of all stakeholders - employees, suppliers, customers;
- Cognos Planning Consolidation - allows the preparation of reports and analyses.

Check-MATE software, which contains the most modern strategic planning techniques, performs planning analysis, generates potential strategies, and promotes communication, understanding, creativity, and progressive thinking of managers and directors [8].

Many software programs are developed to perform analysis and obtain appropriate solutions, based on the information entered into the program, to be used by top managers in strategic analysis for strategic choices.

Strategic management software can be classified as follows [8]:

- Conventional computer software to support strategic decision making, such as: ANSPLAN-A, Strategic Planning Computer model - SPC, BASICS PC and SUCCESS;

- Conventional computer software with general purpose and systems used for strategic planning (database systems, financial analysis and reporting systems, financial planning simulation and modeling, statistical analysis and econometric software, decision matrix software, pairwise comparison, decision trees, linear programming, risk assessment, creativity enhancement, and executive information systems);
- Software for strategic management (experimental intelligent systems and systems for group decision making support).

The ANSPLAN-A is used for developing strategic plans of enterprises in a turbulent environment, in which there is discontinuity, surprises, and unexpected situations.

The BASICS PC is used for preparing forecast scenarios and strategic planning being able to perform the analysis of several factors under extremely uncertain conditions.

The SUCCESS is used to analyse opportunities and threats, to explore strategic changes, and to identify and evaluate possible alternatives for enterprise development.

The Upmetrics is a modern, AI-powered business planning software, especially designed for young entrepreneurs, startup founders, and small business owners. It includes AI business plan generator; 400+ fully customizable templates; Financial forecasting software; Strategic planning tools and AI pitch deck creator for investor-ready pitches [9].

The GoSmallBiz software is used by small businesses and start-ups and includes website hosting and building tools; unlimited business consultation services; industry-specific business plan templates; digital marketing tools and tracking [9].

The Enloop software focuses solely on business plan creation and tools to aid in writing, analyzing, and forecasting business development. It is a simple platform for starting and tracking a business plan [9].

The Bizplan software includes tools for building a business plan and creating the necessary information to gain funding and investors [9].

The PlanGuru is a tool and software for financial planning, financial forecasts, reports and budget creation. It includes cloud-based and localized systems; budgeting and forecasting up to 10 years; the ability to create custom financial formulas and a live customer support team [9].

The IdeaBuddy software is designed to help in the beginning stages of development with the creation and refinement of an initial business idea and plan [9].

The iPlanner is addressed to consultants who create business plans for their clients and offers some tools for startups and new businesses. It helps in the development and modification of a business plan [9].

The Atlas Business Solutions (ABS) is a business planning software that organizes input information into a structured business plan and financial projections. It uses an interview process to gather data and business information and to generate plans and documents [9].

The EquityNet is a business plan software that includes tools for writing a business plan and a network for businesses looking to acquire funding as well [9].

The Stratpad's business plan software offers tools for adjusting, forecasting, and modifying plans. It combines the initial process of creating a business plan and includes tools for project management as it develops [9].

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Chapter 2. Systems for organizing economic activity in the automotive sector

The automotive industry is an important element of global economic growth. However, in today's world, consumer expectations and demands are constantly changing, while market dynamics in the automotive industry are facing a number of pressing challenges, such as disruptions in supply chain or fluctuations in production costs [3].

The most effective response to these challenges is the introduction and release of new car models that meet consumer demands and production efficiency requirements. For each new car model, even before its production begins, the company's sales and marketing departments develop a promotion strategy. Employees of these departments disseminate information about new products long before they enter the market. The company also produces pilot series of new cars, which are used for presentations to customers, dealers and other advertising events [4].

Every new car model has to pass several stages before it is ready for production, including: a) market research, b) modelling, c) prototyping, d) testing, e) evaluation, f) adjustment, g) design and manufacture of production equipment, and h) final assembly [4].

Market Research is used by enterprises to predict consumer preferences for new car model design and features. Typically, car companies survey current owners of their cars, selected by region and demographic group, to determine public opinion about buyers' expectations, likes, and dislikes of their vehicles. Once the survey reveals the market viability of a particular product, model makers create accurate clay models of the proposed car. These clay models are most close to the final product, and allow designers, engineers, and executives to better visualize what the car will look like. Same, clay models also serve as the basis for engineering drawings and blueprints [4].

To ensure that new models meet the company's requirements, cost estimators work with manufacturing and engineering experts to prepare a feasibility study to determine whether the proposed new model can be produced to meet cost and quality standards. Cost estimators provide a detailed analysis and description of the scope of changes and the cost of the new model. They also determine whether the new model can be produced on the factory's existing equipment. Some new vehicle proposals may not justify a costly factory retooling. In this case, the new model is set aside for further consideration or returned to designers and engineers for revision to better fit the existing production equipment [4].

2.1. The automotive manufacturing process.

All actions, from the concept of a new car model to its production and sale, represent a complex manufacturing process, which includes several stages.

- The first stage of production is the *design* stage [12]. This stage (Fig. 2.1) can take months or even years, depending on the complexity of the project. At the same time, during the design stage, manufacturers must follow strict rules and procedures to ensure that new cars are of the highest quality and meet the planned operating parameters [12]. To do this, automakers create *prototypes* of their cars - an experimental batch of new cars that must undergo various *rapid tests*, called rapid prototyping, to evaluate their behaviour under various conditions. *Rapid prototyping*, as the name suggests, creates preliminary models of the design that are quickly tested and either rejected (as quickly showing signs of failure) or improved. The models can be physical or electronic, rough

copies or full-scale working models. The iterative process includes form and function design and manufacturing design [23].

The rapid prototyping or rapid testing process is part of the homologation process.

Homologation in the automotive industry is the process of certifying a vehicle or its component to the regulatory requirements and safety standards set by the relevant authorities. This process ensures that the vehicles are safe, environmentally friendly and meet certain technical requirements. Specific homologation procedures and requirements may vary internationally, in Europe and in individual countries [11].

The vehicle homologation process consists of:

- *Testing and inspection***:** First, a thorough testing and inspection process is carried out on all vehicle components. After the vehicle components are inspected, their correct installation is checked. Then, the vehicle systems are activated and their functionality is checked [28].
- *Certification***:** If the product successfully meets all requirements, it is issued a certificate or homologation mark, certifying its compliance with the applicable standards [11].
- *Market access***:** Once the homologation certificate has been received, the product can be legally sold in the target region or country [11].

In the final stage of the design phase, engineers and designers create a *portfolio of detailed technical documentation and drawings*, including specifications and material specifications for each technical component for the vehicles to be produced [12].

The next crafting step is *tooling and equipment preparation*. At this stage, the tools and equipment necessary for mass production of cars are created and purchased. [12].

Based on the approved model design (body shape) and specific overall dimensions (structural dimensions such as interior panel supports, brackets, joints and flanges, door thickness and other specifications), plant engineers create drawings and tooling for production [4]. Production test areas (or pilot plants) are retooled to handle the new models, while production of current models continues in the main plants. Depending on the extent of the changes, new equipment may be required to meet design and production requirements, or existing equipment may be modified for the same purpose.

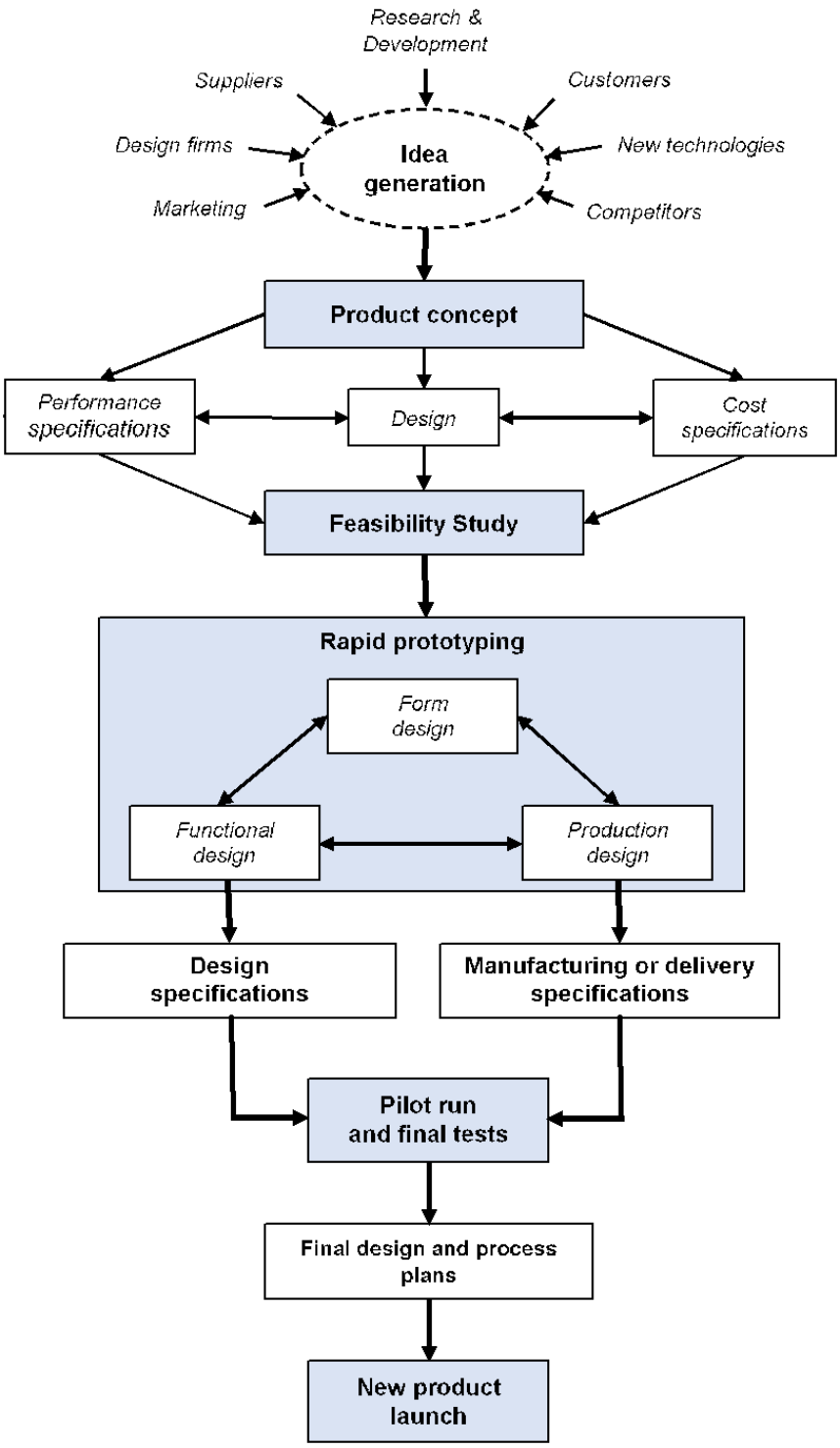


Fig. 2.1. The design phase in automotive production
Source: adapted by author from [23]

Also, before a car enters the final assembly line, many preparatory operations take place. Every part of the car, from the side panels to the gas tank, must be precisely formed using one or more different forming operations, which can be divided into four main groups: [4]

- *Foundry* workers pour molten metal into a mold, where it cools and hardens to form a casting. Castings are made for parts such as an engine block, cylinder head, or camshaft.

Once cooled, the casting is removed from the mold and trimmed to remove excess metal.

- *Machining operators*, one of the largest metalworking groups in the industry, further shape the castings using tools that trim away excess metal.
- *Forging* workers in a forge shop heat metal blanks to shape parts such as crankshafts and connecting rods using forging hammers and presses. Trim panels such as car doors and hoods are formed through the stamping process. Sheet metal is placed between a punch (the top mold of a die) and a die (the bottom mold) and then pressed under high pressure and speed to form the panel.
- *Stamping* workers perform three basic operations: blanking, piercing, and forming. Blanking cuts off excess metal to a specified size, while piercing punches the required holes. The forming process gives the part its final shape. This sometimes requires a series of operations, which may be performed in succession by a series of presses, each bringing the part closer to its final shape.

Once the tools and equipment are set up, the next step is *production planning*. Manufacturers decide and plan how many cars they will produce and when [12]. They also develop schedules for the various stages of the car manufacturing process. This is where assembly lines and industrial robots come into play.

- The second stage of automotive manufacturing involves *the assembly process*, which is used to assemble the various parts of the cars, while robots are used for tasks such as welding and painting [12].

Most auto assembly plants receive many specific parts made by other companies. These supplier companies fall into three main groups: [4]

- *original equipment manufacturers* (OEMs) - work closely with automakers to design and supply frames, bodies, engines, axles, wheels, transmissions, bearings, valves, bumpers, brakes, fuel injectors, seats, seat belts, air bags, and shock absorbers. They often contract with manufacturers to produce a specific part for the life of the vehicle,
- *aftermarket manufacturers* (or aftermarket manufacturers) - produce the parts of a vehicle that will eventually need to be replaced, typically within three to seven years. They supply these parts for both new vehicles and existing vehicles. Most auto parts companies specialize in producing specific parts, such as shock absorbers, brake pads, exhaust systems, windshield wipers, spark plugs, batteries, oil and gas filters, and more,
- *rubber manufacturers* - supply tires, belts, hoses, valves, and other small rubber parts used in automobiles.

However, the basic assembly process itself is largely standardized in the auto industry. Hundreds of workers and many machines perform thousands of important operations to assemble a car [4]. Each auto assembly plant has two main assembly lines - *body* and *chassis* - and several smaller lines that converge onto one main assembly line.

- At the third stage, after assembly, the car undergoes a series of *quality control tests* [12]. After assembly, cars undergo a series of safety tests and quality checks before being sold to consumers and dealers. These tests ensure that the cars meet all safety and performance standards. Only after successfully passing these tests can the cars be sold to customers.
- The final stage of car production is *shipping* the vehicles *to dealers*.

As mentioned above, automotive manufacturing is complex and requires the development and use of an entire system of planning and organizational responsibilities related to the management of production factors and processes that support the value chain - production and processing, human resource efficiency and quality, material supply chain, service equipment, sales and delivery, etc.

Car production involves the manufacture and assembly of various metal, plastic and electrical components into a final product. A wide range of manufacturing processes are used, including metal cutting, pressing, polishing, grinding, welding, electroplating and painting [10].

In addition to components supplied to supplier companies, the automobile industry manufactures many of its own parts. For example, engines are cast from aluminium or cast iron and machined in engine factories - subsidiaries of the main (assembly) plant. Car body parts, on the other hand, are usually manufactured near the assembly shops, from sheet steel or from aluminium or fiberglass-reinforced plastic.

In general, in the automobile industry, the metallurgy industry is closely linked to other sectors, in particular, with foundry, metal surface treatment and metalworking, as well as the production of plastics, glass and textiles. Also, the pressing and electroplating shops are often located on the same site [10]. The automobile manufacturing process is shown in Fig. 2.2.

Most automobile plants can be called assembly plants, because they are limited to the production of body parts, engine machining, final assembly and painting. All other parts, such as castings or forgings, electrical or electronic equipment, wheels, tires, instruments, etc., are usually purchased on a “just-in-time” basis. According to the United States Environmental Protection Agency [27], approximately 8,000 to 10,000 parts are assembled into about 100 major vehicle sub-assemblies [27]. Assembly plants are highly automated, computer-controlled assembly lines.

The unpainted body of the vehicle (also known as the "body-in-white") is assembled from molded body panels joined by welding, gluing, and riveting. The vehicle is then sent on a conveyor to the paint shop for: [10]

- Pre-treatment (degreasing and treating with an anti-corrosion agent);
- Priming;
- Seam sealing and underbody preparation;
- Application of putty and finishing coats of paint;
- Polishing, inspection and defect elimination;
- Anti-corrosion treatment and wax injection.

Then the painted car body goes through the stages of *hard* and *soft finishing*. [10]

- *Hard finishing* includes the installation of such elements as steering columns and body windows, electrical system (wiring and connectors, starters, generator, battery), instrument panels.
- *Soft finishing* includes the installation of seats, door trims and upholstery.

Then the fuel tank, exhaust system and bumpers are installed on the car. At the same time, the engine is assembled. After the engine and tires are installed, the car undergoes a thorough inspection. [10]

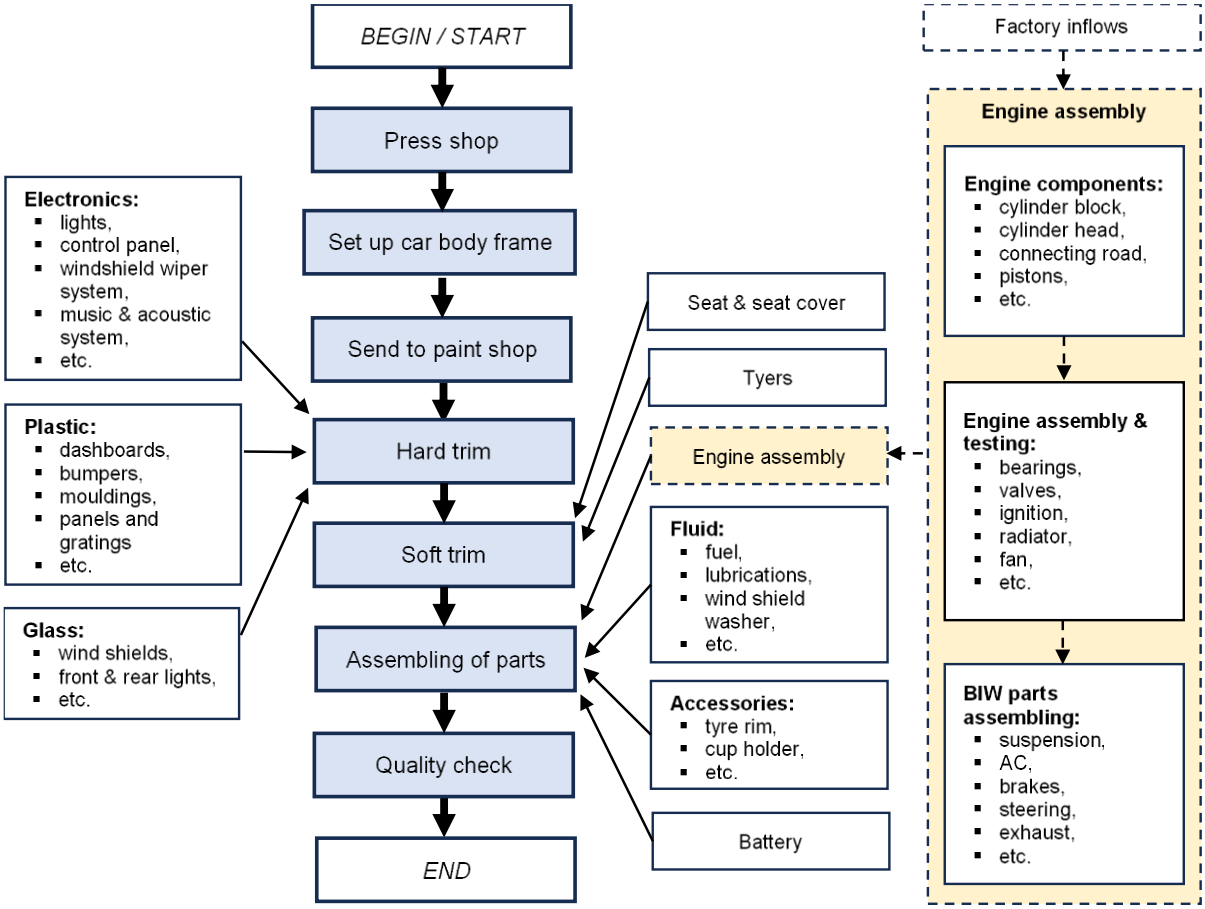


Fig. 2.2. Automotive Company Manufacturing Process Flow Chart[2]

In the automotive industry, the **production line** is a critical stage where most of the workforce is concentrated. An automotive plant typically occupies a large area due to the many operations required to ensure that products meet market demands and regulatory safety standards. Various internal and external specialists ensure that products meet established standards and collaborate to achieve these goals [6].

There are three main types of production lines in automotive manufacturing:

1. Conventional (traditional) production line [12]- the most common type of automotive production line.

In a *traditional (conventional)* or *repetitive* production *process* each vehicle passes through a series of *stations*, each of which is *designed to perform a specific task*. For example, one station may be responsible for installing the wheels, while another station may be responsible for installing the engine. There are many advantages to using a traditional (conventional) production line in the automotive industry.

The advantage of traditional production is its increased efficiency - all stages of the production process are performed in a linear fashion, making it much easier to track the progress of production and ensure that each stage is correct, and can therefore lead to lower costs and better control of quality.

Also, a conventional (repetitive) production line provides more consistent results because it follows *a single, continuous process*. All stages are performed in the same order, making it easier to predict and control the results of the process. This sequence ensures that auto parts meet safety and quality standards. Finally, using a traditional production line can help create a

more comfortable work environment for employees, because specialization in one specific task increases the skills and efficiency of employees.

2. Flexible production line [12] - a *flexible* production line or *discrete manufacturing* is similar to a regular production line, but has greater flexibility. For example, an assembly line may have stations that can be reconfigured *to perform different tasks* depending on the model or configuration of the car being assembled.
A flexible line has a number of advantages over other production systems. Its main advantage is *increased efficiency and productivity*, which allows for greater *customization*, meaning each car can be produced faster and with fewer errors.

In addition, flexible production lines also help reduce production costs. This is because they often require less investment in machinery and equipment and tend to use less energy and water than other types of production systems.

Finally, a flexible production line also helps improve communication and coordination within a company. This allows different departments to work more closely together, resulting in a more efficient production process.

3. Modular Production Line [12] - a *modular production* line, or a line *for small-scale production* (*job shop manufacturing*), consists of producing a number of modules, each representing a specific part of the final product (the vehicle). Once a module is assembled, it moves to the next station on the line.
Modular lines are used to assemble *cars with complex designs*. Having a *separate line for each type of product (module)* helps reduce waste and errors and improves the overall quality of the manufactured product.

Modular production lines can also be easily reconfigured to respond to changes in demand or production volume, making them extremely versatile and adaptable.

In today's competitive environment, modular production lines offer manufacturers the ideal solution to ever-changing market conditions and customer requirements.

2.2. Master Production Schedule (MPS).

During the whole automotive manufacturing process, the primary objective is to deliver products on time, with the required quality parameters and maximum efficiency. For this purpose, the majority (75%) of automotive plants use a *master production schedule (MPS)* to optimize production operations. Companies using MPS can reduce inventory costs by up to 50% [24].

A master production schedule (MPS) is *a production plan that specifies which products will be manufactured, their quantities, and the start dates of production.*

MPS is a vital part of production planning. By implementing Master Production Schedules, a company can ensure the satisfaction of all customers, maximize productivity and profitability, and ensure its success [24]. Thus, MPS is a production planning tool that determines the production volumes of products in different periods. This simple schedule can be used as a basis for further planning and scheduling at all stages of production (Fig. 2.3).

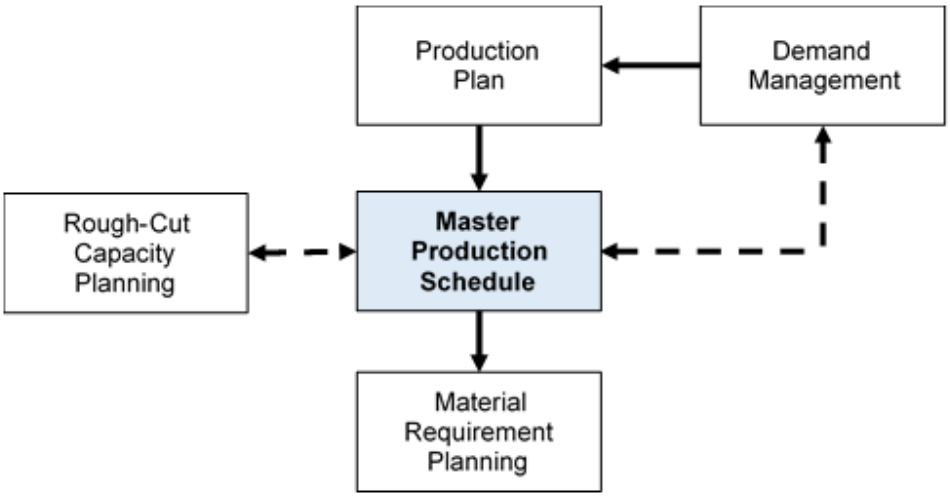


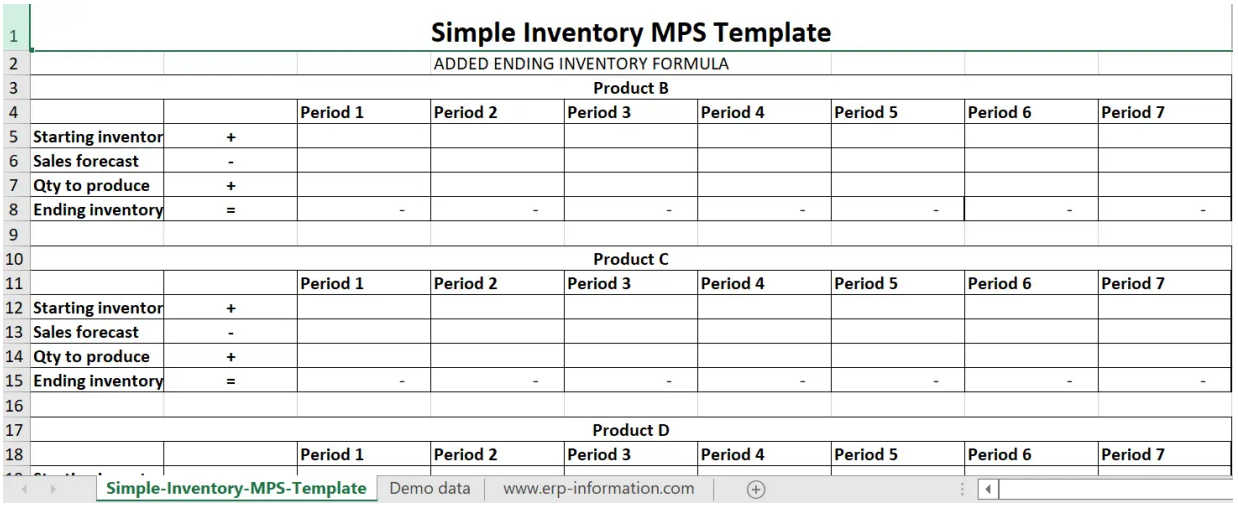
Figure 2.3. Master Production Schedule (MPS) in factory' planning system[29]

There is a conceptual difference between production planning and production scheduling: [25]

- Production planning is the *process of determining the quantities of goods and services* that an organization will produce over a specified period of time. The planning process determines the *quantities of resources* (raw materials, labour, capital, etc.) needed to achieve the desired output, and also defines the production processes, creates production schedules, and coordinates the activities within the production process.
- Production scheduling is the *process of organizing and planning the sequence of production operations and activities* needed to achieve the planned result within the established time frame. Same, scheduling includes the *order in which resources will be allocated*, what the *sequence of tasks* will be. This means that the production schedule will describe when each step of the production plan will be carried out, and therefore which resources will be used and how. For this purpose, production schedules are created, which also provide for the coordination of activities within the production process.

In other words:

- While production planning provides *a general picture of what a company intends to do*, production scheduling provides a more *detailed picture of how it will do it*.
- Production planning is the step before the Master Production Schedule [29]. It determines the total volume of production and the smallest details.
- while Production Planning determines *how much* product should be produced, Master Production Schedule determines and specifies *the amount* of product *to be produced* in a given period of time.



Simple Inventory MPS Template

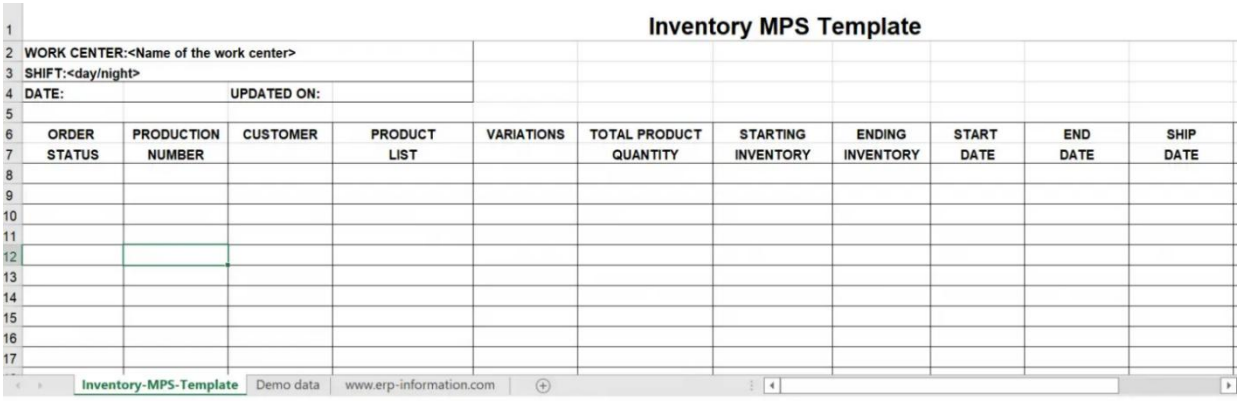
ADDED ENDING INVENTORY FORMULA

		Product B						
		Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7
Starting inventor	+							
Sales forecast	-							
Qty to produce	+							
Ending inventory	=	-	-	-	-	-	-	-

		Product C						
		Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7
Starting inventor	+							
Sales forecast	-							
Qty to produce	+							
Ending inventory	=	-	-	-	-	-	-	-

	Product D						
	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7

Simple-Inventory-MPS-Template | Demo data | www.erp-information.com

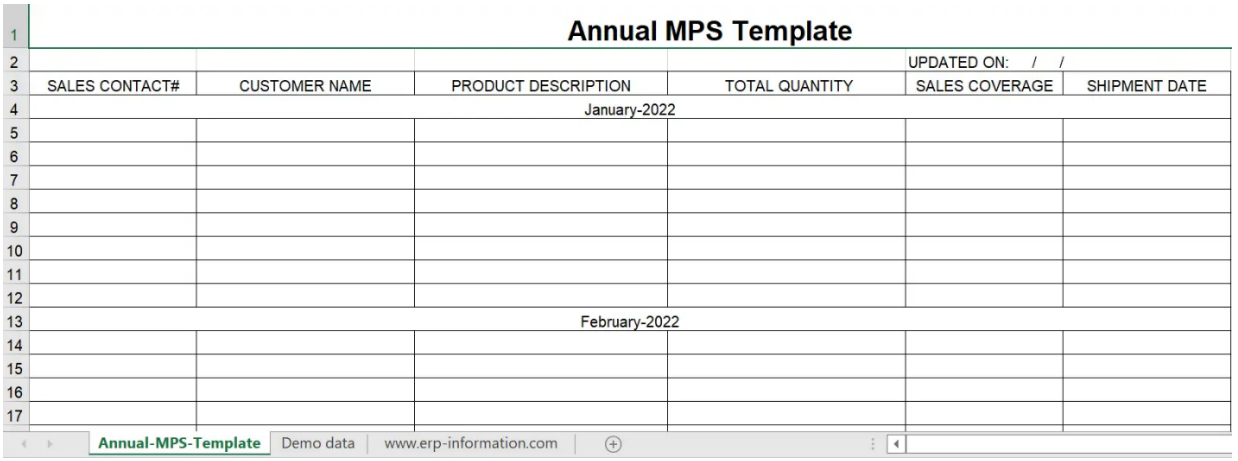


Inventory MPS Template

WORK CENTER:<Name of the work center>
SHIFT:<day/night>
DATE: UPDATED ON:

ORDER STATUS	PRODUCTION NUMBER	CUSTOMER	PRODUCT LIST	VARIATIONS	TOTAL PRODUCT QUANTITY	STARTING INVENTORY	ENDING INVENTORY	START DATE	END DATE	SHIP DATE

Inventory-MPS-Template | Demo data | www.erp-information.com



Annual MPS Template

UPDATED ON: / /

SALES CONTACT#	CUSTOMER NAME	PRODUCT DESCRIPTION	TOTAL QUANTITY	SALES COVERAGE	SHIPMENT DATE
January-2022					
February-2022					

Annual-MPS-Template | Demo data | www.erp-information.com

Fig. 2.4. Samples of Master Production Schedule (MPS) Templates[29]

The Master Production Schedule (MPS) does not contain detailed information such as what materials will be used in production or which employees will perform which tasks [24], but it serves as a link between the sales and production departments and thus helps to balance supply and demand by determining the required production volumes and the timing of their completion. A typical MPS is a plan that is prepared separately for each product for a period of three months to two years, divided into weekly intervals [24] (Fig. 2.4).

Finally, the *Master Production Schedule* (MPS) and the *shop floor scheduling* ensure that everyone in the plant is working toward the same goal. The information they provide helps the plant know when to reduce or increase production [24].

A Master Production Schedule (MPS) is the backbone of any manufacturing enterprise [24], helping to:

- Adapt to fluctuations in demand
- Prevent stock-outs
- Improve efficiency
- Control costs effectively

The process of creating a Master Production Schedule involves two main steps that company managers must go through in order to develop an MPS proposal: [24]

1) Creating a demand map and then creating a demand plan.
2) Determining the required raw materials and then establishing a supply chain using production planning processes.

When a company has a Master Production Schedule, every employee on the shop floor knows exactly what needs to be produced each week.

2.3. Shop floor scheduling.

Based on the Master Production Schedule, the enterprise develops *shop floor scheduling*, which is the process of breaking down a work order into individual operations and assigning each operation a theoretical start and finish time. Usually, a shop floor scheduling is done by looking at the delivery date promised to the customer and then working backwards from there to determine when the operation should begin. This approach is known as "*backward scheduling*" [26].

It is important to note the disadvantage of "backward scheduling", which is that *it schedules each work order as if it were the only one in production* [26]. Therefore, it is important to emphasize that capacity management plays an important role in production scheduling because it helps determine the amount of equipment and labour needed to complete production tasks. This understanding is essential for production scheduling [26].

When planning a shop floor schedule, everything related to production is taken into account, including inventory, resources and capacity constraints. All of these elements are then coordinated to form a Master Production Schedule (MPS) [24].

The MPS is sometimes also referred to as *Shop Floor-level Management*, or *Shop Floor Management*, and *Shop Floor Control*.

Using the *input data* (forecast demand, production costs, cash on hand, customer requirements, inventory build progress, supply, lot size, lead time, and production capacity) used to make decisions, the MPS generates a set of *output data* [5].

- The *input data* of MPS may be:

a) generated automatically by an ERP system that links the sales department with the production department. For example, when the sales department records a sale, the forecast demand may be automatically adjusted to meet the new demand,
b) entered manually from forecasts that were also calculated manually.

- The *output data* of MPS may include production quantities, headcount, quantities available to promise, and forecasted available stock. The output data may be used to create a Material Requirement Planning (MRP) schedule.

Modern Advanced Planning and Scheduling (APS) systems use Master Production Schedule (MPS) software [17] (Fig. 2.5).

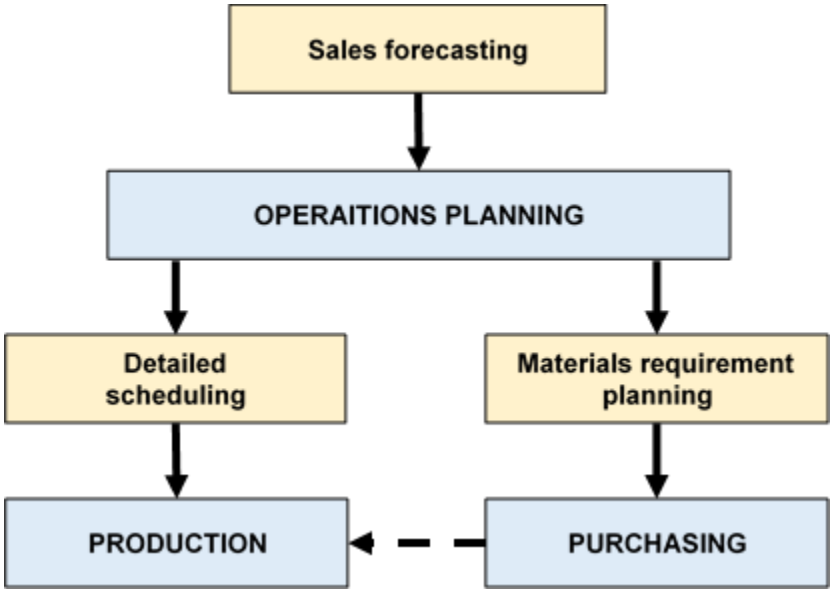


Fig. 2.5. General concept of a Master Production Scheduling (MPS) software[18]

The MPS software is designed to respond quickly to changes in demand or capacity. It extracts actual order and capacity data to ensure that the master production schedule is based on the most current information, taking into account forecasts, known and expected orders, key capacity constraints, inventory levels, buffer stock requirements, and departmental requests [18].

Even though the software automatically generates the master production schedule, it also allows manual adjustments to be made to meet specific needs or objectives [18].

With this feature, planners can evaluate alternatives within the schedule.

Additionally, MPS software allows to override the planned production volume with the scheduled one. After that, the master production schedule is recalculated taking into account the current conditions.

This software is used for interactive schedule visualization where data can be presented in the form of inventory profile graphs and capacity utilization graphs [18]. The Master Production Schedule can be changed by simply clicking and dragging a point on the inventory or capacity graph. Similarly, the production of a certain item can be moved to another production period using the interactive graph and this change will be reflected in the master production schedule [18].

2.4. Enterprise Resource Planning (ERP).

The automotive industry involves many complex manufacturing processes, which, along with dynamic supply chains and continuous innovation, are combined into a single, integrated system that uses a specialised software.

ERP software integrates all departments and functions of an organization into a single IT system. Businesses use ERP systems to manage day-to-day activities such as accounting, purchasing, project management, risk management and compliance, and supply chain operations. A complete ERP suite also includes an enterprise performance management system, software that helps plan, budget, forecast, and report an organization’s financial performance [7]. This allows employees to make decisions across the entire enterprise by viewing information about all business operations.

An ERP solution is a centralized data warehouse (repository) that unites all departments of an organization and provides access to all corporate information [15]. Modern ERP solutions for the automation of manual tasks, consolidate all information about stocks, products, production and distribution, ensuring the success of the enterprise in the digital economy (Fig. 2.6).

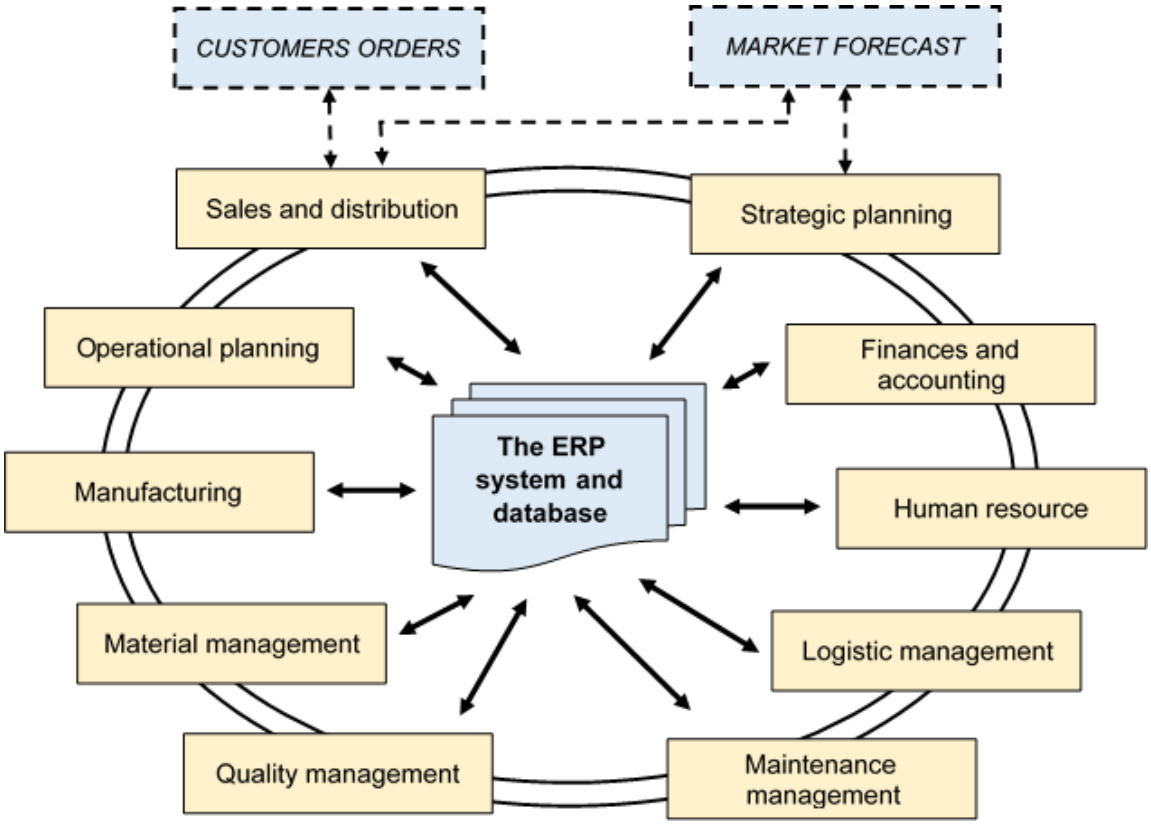


Fig. 2.6. General concept of the Enterprise Resource Planning (ERP) system[*adapted and completed by author from source* [14]]

The purpose of ERP systems is to create a standardized database that all departments of a company can work on. This ensures more efficient interaction and coordination between departments, as well as faster and more accurate information exchange.

ERP systems are usually modular, which means that they consist of different modules that can be combined according to the needs of the company [9]. This allows companies to adapt the ERP system to their individual requirements and develop it as the company grows. The most frequently requested and customized modules typically include accounting, human resources, manufacturing, customer relationship management, and inventory management.

It is very important that an ERP software shall be able to meet the following requirements:

- Flexibility – the ability to adapt to changing business requirements.
- Scalability – the ability to evolve quickly and scale standardization across the organization.
- Simplicity – the ability to easily implement, customize, quickly deploy, and maintain the software.
- Integration – the software should be open and able to integrate well with other company IT systems.
- Ease of use – the software should be easy to use and learn (e.g. intuitive user interface, self-service capabilities, built-in features).
- Deployment model – the software should be cloud-based or on-premises (some automotive companies need to store sensitive data locally).

- Priority functional requirements – the ERP system should fully meet specific business requirements (e.g. manufacturing management, finance and accounting, advanced reporting).
- Industry focus – the software should have specific features needed to operate in the automotive industry.

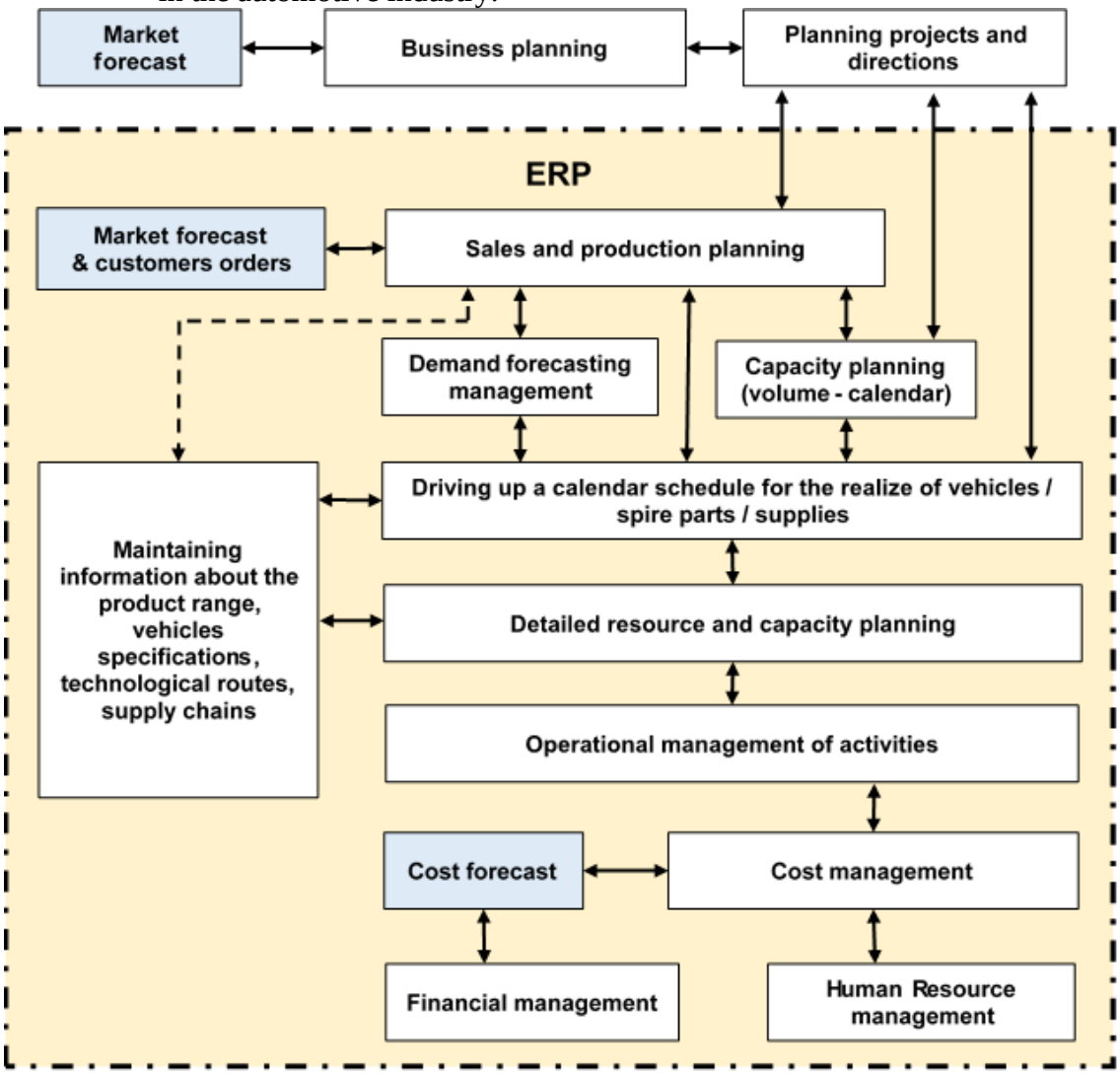


Fig. 2.7. General scheme of the ERP*[adapted and supplemented by the author from the source* [16]]

Actually, the top of most popular ERP software systems for the automotive industry includes Odoo, Epicor. Infor CloudSuite, Net Suite, Plex, QAD:

- **Odoo** [19] - an open-source, scalable, and flexible ERP solution that can meet the needs of automotive manufacturers, auto repair companies, and car dealers.
- **Oracle Netsuite** [20] - a cloud-native ERP suite that automotive companies can use to automate and streamline core business processes and workflows.
- **Acumatica** [1] – offers a complete ERP suite for companies across industries, including automotive aftermarket distributors and manufacturing companies, to be deployed in the cloud or on-premises.
- **Epicor** [8] - offers a range of products to meet the needs of the automotive aftermarket, automotive part manufacturing, automotive service and repair companies, and commercial vehicle parts distributors.
- **Plex** [21] - a cloud ERP solution primarily focused on companies in the automotive industry.

- **Infor CloudSuite** [13] - offers an industry-specific cloud-based ERP suite for customers in multiple verticals, including automotive: automotive suppliers, tire suppliers, original equipment manufacturers (OEM), specialty vehicles, after-market parts and services.
- **QAD** [22] - offers a portfolio of ERP solutions primarily targeted at manufacturing companies across industry verticals, including ERP systems for automotive businesses.

A general scheme of ERP in automotive industry is presented in Fig. 2.7.
Enterprise resource planning (ERP) software not only helps manufacturers quickly adapt their business processes, increase productivity and operational efficiency, optimize supply chains, which ultimately helps to keep leading positions in the market and attract new customers.

Also, the ERP approach and digital transformation in the automotive industry stimulates innovation and contributes to the development of intelligently connected cars, improves passenger and vehicle safety.

Finally, the use of ERP systems and digital transformation in the automotive industry play a key role in meeting changing consumer demands, and contribute to the sustainable development of enterprises and maintaining their competitiveness in a rapidly changing market.

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Chapter 3. Activity planning software

3.1 Review of software products for enterprise operations

The issue of selecting the right tools for proper business operations can be overwhelming – especially considering the need to optimize every aspect of operations from the first working day. Finding the right software solution becomes crucial for the processes optimization and enhancing of their productivity.

Investing in business operation support software offers numerous advantages, ensuring the efficiency and accuracy of operations. By automating routine tasks, the appropriate software can free up valuable time, allowing employees to focus on more critical aspects of the business.

Effective enterprise activity management involves managing a project efficiently from start to finish — planning, organizing and executing tasks. Developing an app, launching an online store, creating a business from the very beginning, organizing a conference — all these are examples of projects. Projects can vary in complexity, be budget-friendly or expensive, short-term or long-term. Regardless of their complexity or field, every project requires planning first, followed by management — that is coordinating actions, aligning deadlines and budgets, monitoring progress.

Planning projects and subsequently managing them is convenient with the help of specialized software, most often in the form of task-trackers [1, 2]. Project planning tools are visual, simple and intuitively understandable for all team members.

Software for activity management enhances teamwork, tracks tasks and helps team members communicate and share materials. However, not all project management software is the same; it varies in price, features and how well it integrates with other tools.

Moreover, the individual software solutions can improve cross-team collaboration, provide in-depth analytics and support scalable growth. Enterprise Resource Planning (ERP) is a type of software that organizations use to manage their day-to-day business activities, such as accounting, procurement, projects, risk management, norms and rules compliance and operations in logistic chain. A comprehensive ERP suite also includes enterprise performance management software, which assists in planning, forecasting, reporting and budgeting the organization’s financial results [5].

Enterprise resource planning systems integrate numerous business processes and facilitate data exchange between them. By consolidating shared transactional data from various sources, ERP systems eliminate data duplication and ensure data integrity through the use of a single source of truth.

Today ERP systems are absolutely essential for managing thousands of enterprises of all sizes across various industries. For these companies, an ERP system is as indispensable as electricity, without which the lights wouldn’t turn on.

Enterprise resource planning systems are either local or cloud-based integrated platforms designed to manage all aspects of a manufacturing or distribution business. Additionally, ERP systems support all areas of financial management, human resources, logistic chain and production together, with accounting as a key function.

ERP systems will also provide transparency across the entire business process, allowing for tracking of all aspects of production, logistics and finance. These integrated systems act as a central hub for all business workflows and data, granting access to various departments.

ERP systems and software support a wide range of functions for corporations, medium-sized enterprises and small businesses, as well as customization tailored to the specific needs of different industries.

Let's take a look at some of the most popular and widely used software products for enterprise activity in the world:

1. Asana is a powerful task management software that effectively helps companies and teams organize their tasks, collaborate efficiently and track progress. With its user-friendly interface and robust features, Asana is an excellent solution for optimizing project management and enhancing productivity.

Key features of the program include task creation and assignment; project organization; collaboration tools; Kanban boards and timeline views; integration with other tools.

The advantages include:

- Teams can easily and quickly adapt to and start using the software effectively.
- It helps customize the tool to meet the specific needs of the business.
- The drawbacks include:
- For some users, mastering the advanced features may take time.
- It has limitations on the number of users and features.

2. Slack is a leading workplace chat software that enables effective real-time communication within teams and organizations. By focusing on enhancing collaboration and reducing communication barriers, Slack has become an essential tool for modern workplaces.

The features of the software include: channels and direct messaging; file sharing; integration with other applications; search functionality; customizable notifications.

The advantages include:

- Organized channels and instant messaging in Slack enable quick and direct communication, reducing clutter in email.
- Ability to integrate various applications and tools into Slack creates a centralized hub for information and updates.

The drawbacks:

- While the basics are easy to understand, mastering the advanced features may take some users time.
- In large teams, the high volume of channels and messages can lead to information overload and reduced focus.

3. Canva is a premier design tool perfect for creating attractive graphics, documents and presentations. With a variety of design elements, Canva enables users to bring their creative visions to life.

Key features include: simple drag-and-drop design; wide range of templates; vast library of images and icons; real-time collaboration; seamless export and sharing options.

The advantages:

- User-friendly interface,
- Variety of templates for all needs,
- Rich collection of media elements,
- It facilitates real-time collaboration.

The drawbacks:

- Limited additional features,
- Customization is limited to templates,
- Discrepancy between free and paid elements.

4. Notion serves as a dynamic software known for enhancing workspace productivity through seamless organization, collaboration and information management.

Key features include: integrating notes, tasks, databases and more on a single platform; access to ready-made templates for various applications; ability to create structured databases for efficient data processing; fostering real-time collaboration to improve teamwork and communication; easy integration with external sources and connection to other tools.

The advantages:

- Consolidates multiple tasks in one environment.
- Customizes layouts and features according to personal preferences.
- Simplifies group projects and shared information.

Easily integrates external sources and interfaces with external applications.

The drawbacks:

- Advanced features may require time to fully master.
- Dependence on an internet connection for real-time updates.
- A large number of options can overwhelm simple tasks.

5. HubSpot is renowned for its robust customer relationship management (CRM) capabilities. It centralizes all customer interactions, providing an integrated platform to support and enhance customer relationships.

Key features include: contact and lead management; email tracking and automation; integration with marketing and sales tools; analytical insights.

The advantages:

- User-friendly interface,
- Extensive integration capabilities,
- Scalability for businesses of all sizes.

The drawbacks:

- Some functions require additional training,
- Premium functions can be expensive.

The use of various types of software has also extended to the field of automotive transportation. To facilitate the operations of auto shops and service stations while maintaining an adequate customer base, numerous programs have been developed for the seamless, quality and professional functioning of businesses in the automotive service industry.

Software for planning the activity of service stations (ST) should facilitate effective management of workflows, inventory, customers and resources [3, 4, 6]. Here are a few programs suitable for this purpose:

AutoRepair Cloud: A program for managing service stations with features for scheduling repairs, inventory management, CRM (customer relationship management) and integration with other systems.

Mitchell 1: A comprehensive tool for managing automotive businesses. It offers capabilities for workflow management, documentation handling and features for estimating repair costs.

CarBook: Cloud-based software for service stations that provides solutions for managing parts, customer communication and tracking technician performance.

AutoFluent: A program for managing service stations that includes features for inventory management, invoicing, CRM and reporting.

AllData: It offers solutions for diagnostics and technical information, enabling quicker identification and resolution of automotive issues.

AutoSelling: A cloud platform that provides spare parts management, including order processing, inventory tracking, customer communication and reporting.

One of the primary tasks that software for auto parts stores should address is the selection of spare parts based on the VIN (Fig. 3.1), by the original part numbers and the TecDoc tree. AutoSelling has access to the official TecDoc catalog and features a large database of cross-references that significantly exceeds the TecDoc database. Additionally, the system integrates original catalogs, allowing users to find the vehicle component scheme and the required original part number and with a click, users can access all supplier offers in the market for that specific number. The software provides well-integrated price lists from all major suppliers, showcasing all market price proposals across all known regional warehouses, including different currencies. Furthermore, the system displays offers from other AutoSelling customers who have the required spare part in stock and have published their proposal, enabling users to contact them and order directly.

This system operates simultaneously on multiple servers located in different data centers across Western Europe and is available 24/7. The process of searching for and selecting parts through cross-references can almost always be completed without leaving the system, allowing users to see all supplier offers in real-time (Fig. 3.2). If a product is out of stock, it can be ordered with a single click from the supplier. For frequently sold items, the software automatically suggests that they should be added to the inventory.

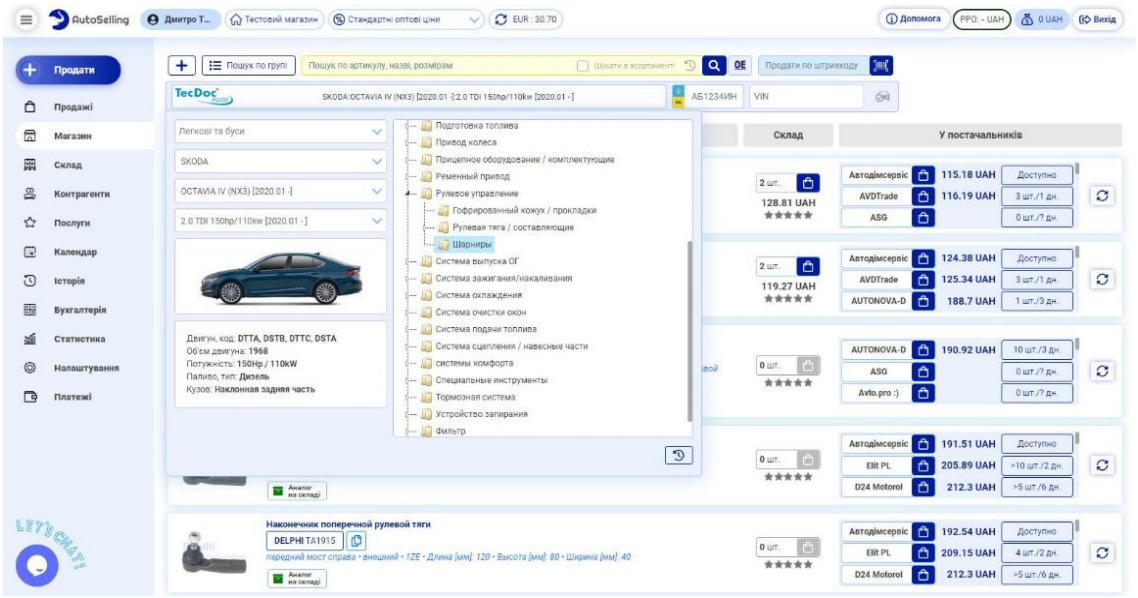

Figure. 3.1 Interface of the AutoSelling program

The software is designed in such a way that the recognition of articles and brands is performed automatically, making it immediately clear which supplier offers the best price and where the required item can be delivered the fastest.

The file formats for invoices from over sixty Ukrainian suppliers are already configured, allowing for the import of invoices with just a few clicks. The largest suppliers are already integrated with Web API, enabling automatic retrieval of invoices from the supplier's account on their website with a single click. The product catalog of all well-known suppliers is already integrated into the system.

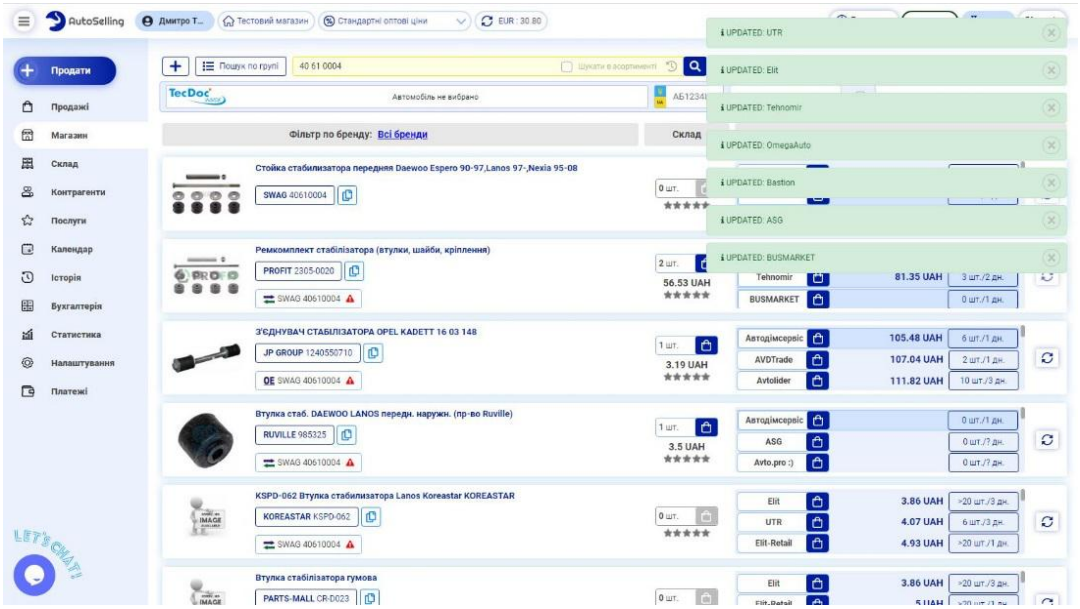

Figure. 3.2 Supplier offers for auto parts

The system is connected to the official TecDoc catalog, which is the most comprehensive universal search system for various car brands. It consolidates information about hundreds of

independent auto parts manufacturers. TecDoc essentially functions as a part search tree based on vehicle parameters: its make, model, engine modification and body type.

AutoSelling is integrated with a number of different parts suppliers and other services. For example, the system can send online inquiries about prices and availability of auto parts to the websites of all suppliers that support this feature (around ten in Ukraine) and display a consolidated result. The automation program can receive invoices online from the top five suppliers. To do this, you only need to go to the invoices section, and the system will automatically request new documents for you. The program is integrated with Nova Poshta, the largest logistics service provider in Ukraine. Goods transportation invoices (ig. 3.3) are created directly in the program, the exchange rate is updated automatically, SMS notifications and IP telephony are also available in the system.

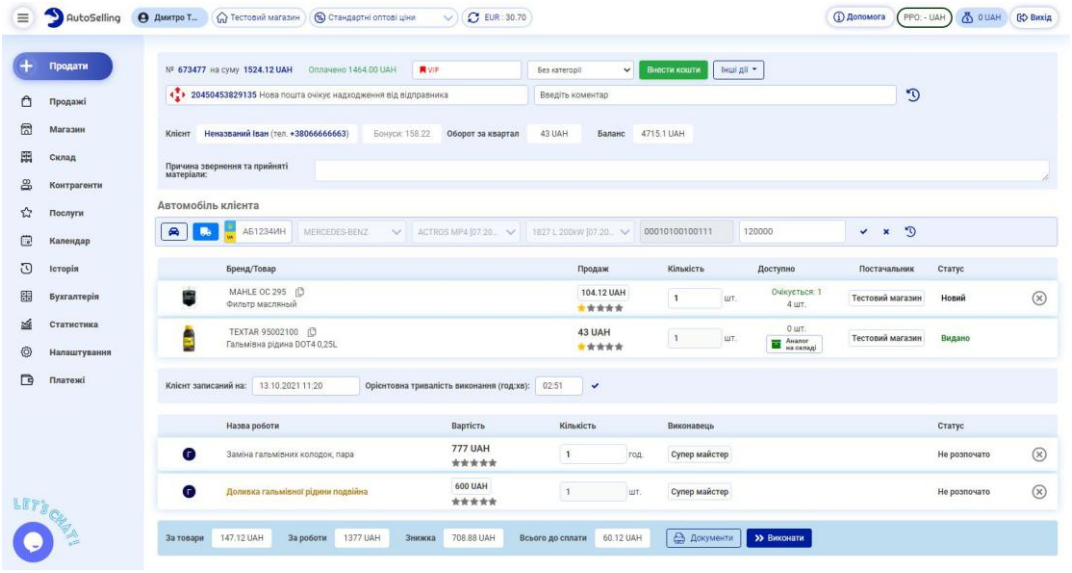

Figure. 3.3 Example of order creation and integration with Nova Poshta

AutoSelling is a specialized program for the operation of an auto service, making it significantly easier to manage the accounting of parts, materials, issuing documents for clients, financial accounting.

However, to ensure that this section of the book does not appear as an advertisement for a specific specialized auto service program, let's consider another popular program in Ukraine in the field of automotive transport: CarBook. In 2023, representatives from CarBook kindly provided access to the program for educational purposes to the students of Lutsk National Technical University who are studying Automotive Transport. So, what exactly is CarBook and how can it be used – let's explore further.

3.2 Software for planning service stations

One of the most important aspects of successful operation for service stations is data security and protection. The use of cloud solutions and the CarBook software ensures a high level of security. Protection against unauthorized access is implemented at various levels, creating a multi-layered defense that guarantees system security and keeps data safe. Utilizing cloud solutions also provides independence from electricity supply and avoids issues associated with in-house servers, ensuring system resilience to various unforeseen situations. This approach is

made possible by CarBook software, which guarantees the reliability and protection of your information.

The primary function of the software is to schedule clients for diagnostics or maintenance of their vehicles. Booking an appointment (Fig. 3.4) at the service station is a crucial step before the technical maintenance of a car, allowing clients to choose a convenient time and date for their visit. This is important for avoiding queues and ensuring high-quality service for the vehicle.

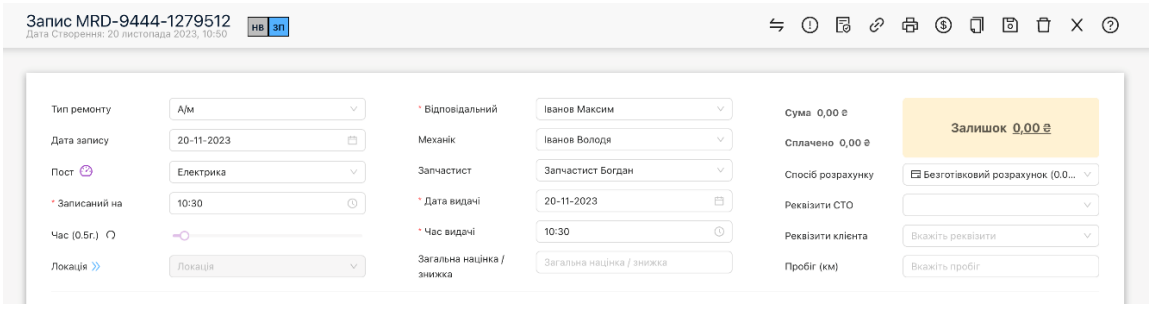

Figure. 3.4 Example of an appointment at a service station

When scheduling a client for service at the desired time, it is possible to specify the vehicle and leave a comment, or even create a preliminary calculation in just a few clicks (Fig. 3.5). The data is entered once and can be edited and supplemented by the station employees later.

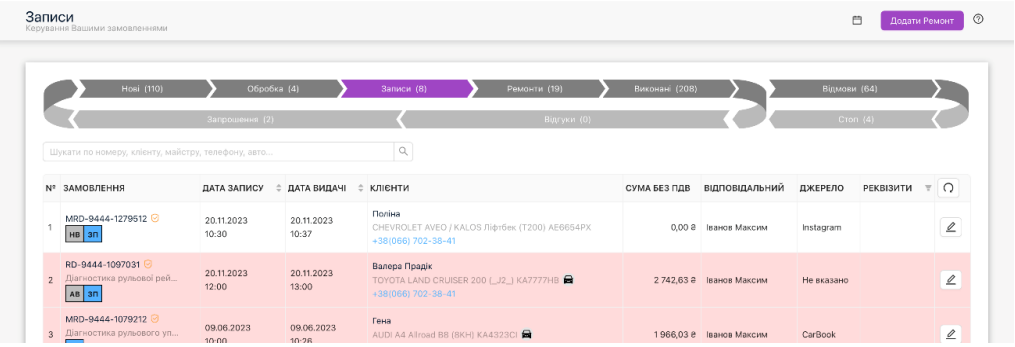

Figure. 3.5 Example of calculation

Before the vehicle enters the service station, it undergoes an inspection and registration of its current condition by the vehicle reception specialists. After that, the vehicle is handed over to the specialists who carry out repairs or maintenance according to the list of work agreed upon with a client. In the CarBook system, this can be done directly within the program.

To leave a comment, for example, if the vehicle has damage, you need to double-click on the necessary area of the vehicle and choose a quick option or type the comment manually (Fig. 3.6), that will be automatically added to the vehicle acceptance and transfer act, displaying a marker on the vehicle.

After adding the remarks to the system, a ready acceptance and transfer act for the vehicle is printed and signed by the client and the responsible person from the service station.

For a vehicle that has arrived at the service station for scheduled maintenance, spare parts are selected. For a vehicle that has come in for a comprehensive diagnostics, the repair process is slightly different and will be described below.

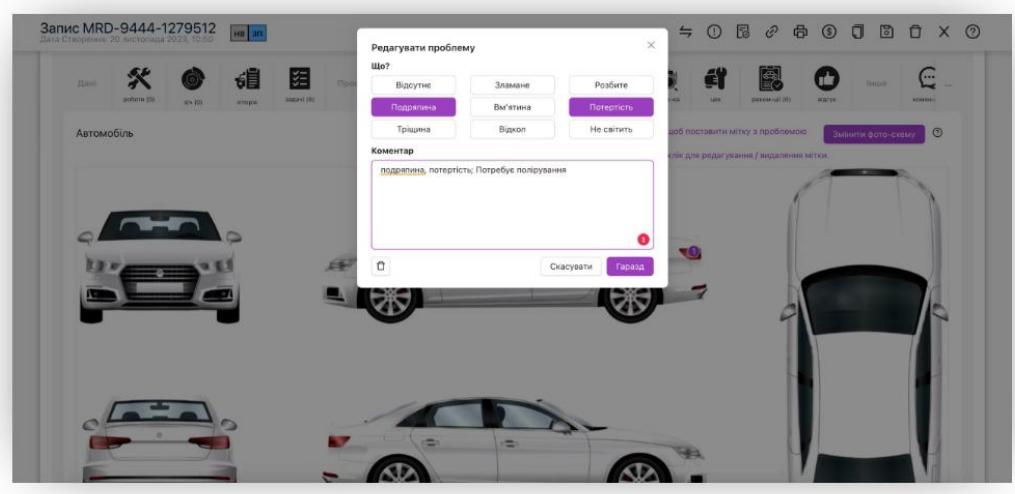

Figure. 3.6 Detection of external damages on the vehicle during acceptance

In the CarBook software, just like in AutoSelling, the user has the ability to perform four main actions when selecting parts using supplier APIs (Fig. 3.7). First of all, he can easily retrieve up-to-date purchase prices for goods by sending the product code in the supplier's format.

1	**Simple Inventory MPS Template**								
2	ADDED ENDING INVENTORY FORMULA								
3	**Product B**								
4			**Period 1**	**Period 2**	**Period 3**	**Period 4**	**Period 5**	**Period 6**	**Period 7**
5	**Starting inventor**	**+**							
6	**Sales forecast**	**-**							
7	**Qty to produce**	**+**							
8	**Ending inventory**	**=**	-	-	-	-	-	-	-
9									
10	**Product C**								
11			**Period 1**	**Period 2**	**Period 3**	**Period 4**	**Period 5**	**Period 6**	**Period 7**
12	**Starting inventor**	**+**							
13	**Sales forecast**	**-**							
14	**Qty to produce**	**+**							
15	**Ending inventory**	**=**	-	-	-	-	-	-	-
16									
17	**Product D**								

Figure. 3.7 Checking the price of a spare part via API

In addition, the user can check the availability of a specific item at different branches by using its unique code. Another important feature is the ability to place an order with a supplier, where the user can specify the item code, quantity and price to quickly and efficiently make a purchase. CarBook also allows the user to retrieve a list of outgoing invoices from the supplier to the service station and download the selected invoice into the inventory receipt document via the supplier's API. This feature provides detailed information about the item, including its code, purchase price and quantity, for further use in the internal accounting of the service station.

The VIN-code diagnostic tool provides access to vehicle schemes and the necessary steps for diagnostics. After inspecting the system, detailed information with original part numbers will be available for further use in repairs.

Additionally, chassis diagnostics are offered, providing a detailed analysis of the suspension, steering and braking systems. The ability to perform diagnostics on a vehicle using its VIN-code allows for identifying the unique code of the original part (Fig. 3.8), which can be

replaced immediately or at a later time. This interface enables the marking of specific points and instantly retrieving the original part code from the VIN-code diagrams.

Figure. 3.8 Determining the original part code

In the “VIN Diagnostics” section, the diagnostic zones’ graphical structure is displayed on the order sheet (Fig. 3.9). The system allows you to work directly from the program or print the sheet for manual inspection.

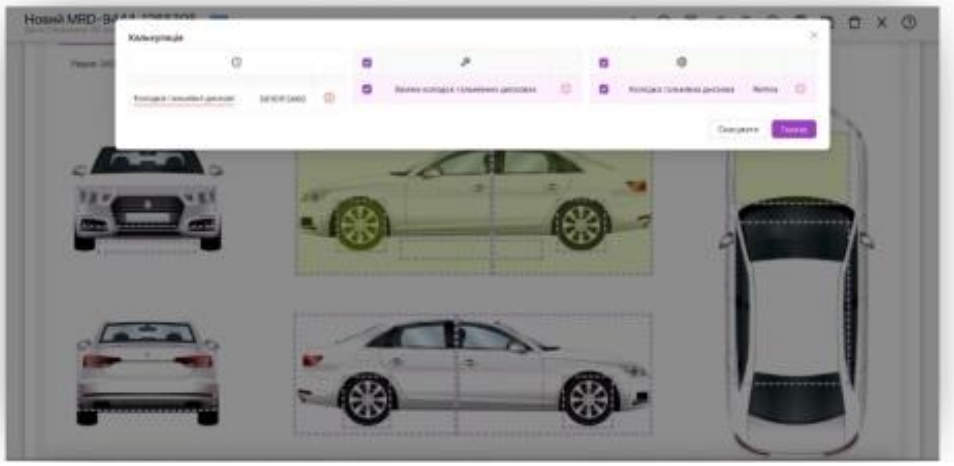

Figure. 3.9 Graphical diagnostic zones of the vehicle

A comprehensive diagnostics of the chassis are also offered (Fig. 3.10), providing a detailed analysis of the suspension, steering and brakes.

The comprehensive diagnostics of the chassis include:

Universal graphic scheme of the suspension, steering and brakes,

Logical grouping car parts for diagnostics: right front wheel (part numbers 1-28), right rear wheel (part numbers 29-60), left rear wheel (part numbers 61-92), left front wheel (part numbers 93-120), center (121-135),

Each part is selected specifically (right front shock absorber, not just any shock absorber),

Four statuses for each part (replace, attention, okay, missing), along with the option to leave a comment,

Automatic calculation creating,

Printing results for a client,

Two modes – online and offline.

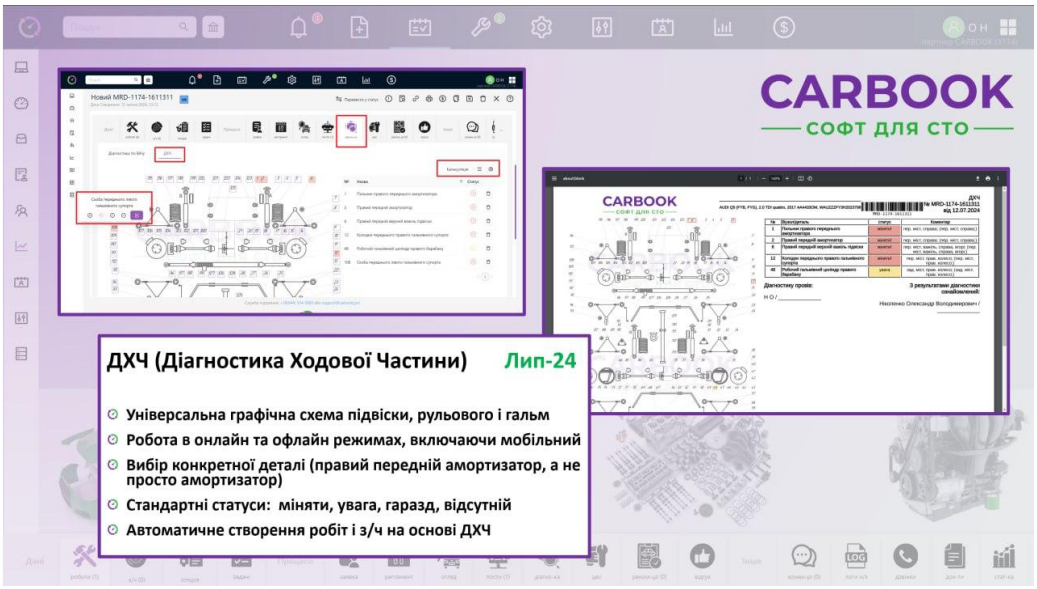

Figure. 3.10 Diagnostics of the chassis

After adding works and spare parts to the work order, to agree on the scope with the client, click “Send Calculation for Approval”. The client receives an SMS message with a link (Fig. 3.11), which, when opened, will show the proposed scope of work and spare parts, as well as the brands and prices.

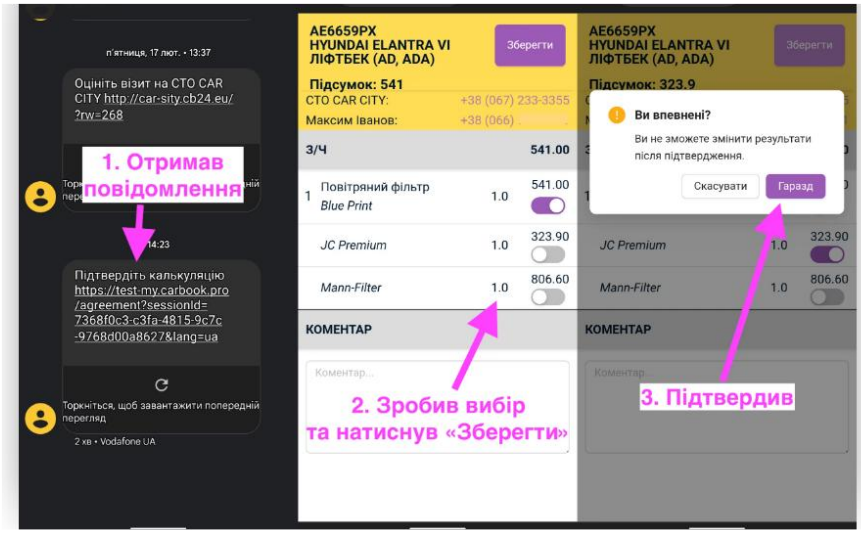

Figure. 3.11 Sample of SMS notification to the client

Thus, the client can approve specific work or parts while physically being far from the service station. The link can be sent via any available communication tool. An example of what the

client will see when he opens the SMS link to the calculation is shown in Figure 3.11. From the suggested spare parts, the client can choose only one option from several for each item.

After completing the work agreed upon with the client, the maintenance log for the parts replaced in the vehicle is entered. The maintenance schedule at the service station is an important action plan that defines the frequency and scope of the vehicle's technical service. It includes recommendations for replacing oils, filters, belts, as well as checking fluid levels and the operation of key systems in the vehicle. Regular maintenance according to the schedule promotes the long-term and effective functioning of the vehicle, preventing potential breakdowns and ensuring safety on the road.

In addition to the aforementioned features, the CARBOOK software is user-friendly for the manager of the auto service. It allows for the organization of efficient operations at the service posts, determining workers' salaries based on completed tasks, generating reports and KPIs, and monitoring VAT and taxes.

The program's functionality enables the organization of the workload at the service station by planning the gradual assignments for the mechanics. The service manager can view the daily workload of the posts and the created work orders that have not yet been assigned to a specific post. All posts are displayed on a single screen, with different colors indicating various statuses of automotive repairs (Fig. 3.12). From the planner, one can quickly navigate to the work order or obtain complete information about the repair.

The program allows for planning by mechanics. A mechanic can clearly track the vehicles scheduled for repair today, tomorrow and in the future. The assigned worker can be changed by simply dragging the card from one row to another. The execution time can be adjusted by resizing the card in the corresponding row. Hovering the cursor over a specific card provides information about the task and the vehicle for which the work is to be performed.

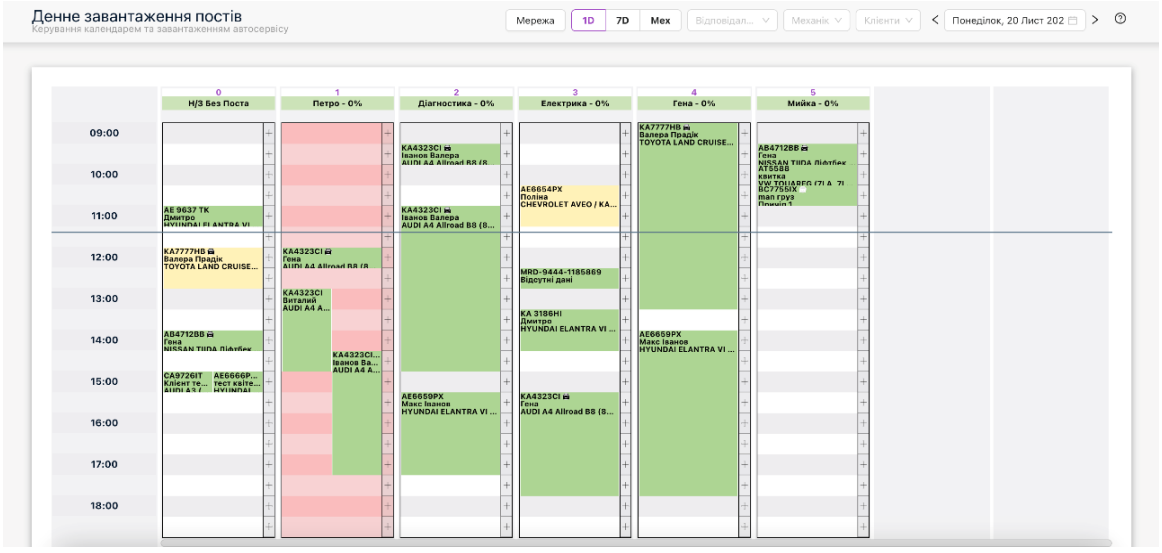

Figure. 3.12 Daily workload of service posts

The automatic salary calculation program offers flexible payment rule settings. This allows for the combination of different rules for a single employee, keeping records within the program and exporting data in Excel format. The SAL document enables the calculation of salary for a specific period and records the payment made to the employee. Thus, the mechanic has the

motivation to service or repair a larger number of vehicles. The more you work, the more you earn.

Reports generation in CarBook is a tool that allows for quick and convenient access to comprehensive information about the station's operations. Reports can be created in just a few clicks, enabling the business manager to obtain data regarding the technical condition of vehicles, completed repairs, maintenance, inventory reports, CRM, work orders and accounting (Fig. 3.13). This tool facilitates effective fleet management by providing up-to-date information for making informed managerial decisions.

Figure. 3.13 Report generation for business manager

VAT at service stations plays a key role in the financial process (Fig. 3.14). The registration of incoming VAT includes the receipt of tax invoices for purchased materials or services, which are part of vehicle servicing at the service station. The outgoing VAT is generated according to the operations related to the provision of vehicle maintenance services, including repairs, technical servicing and spare parts. Reflecting these operations in the appropriate tax documents is an important component of the fiscal activities at the service station.

Figure. 3.14 Registration of incoming and outgoing VAT

Thanks to the CarBook software, managing a service station becomes highly efficient, enabling the generation of all necessary reports for analyzing the station's operations and making informed decisions to optimize profits. One of the key advantages of the software is its flexibility. The service manager can effectively organize the work of mechanics, plan

maintenance, manage inventory of spare parts and carry out repairs. The system's flexibility allows it to be adapted to individual needs, providing an optimal working environment even as the workload increases.

CarBook is not just software for service stations, it is a tool that helps elevate the level of service and communication efficiency with clients to a whole new level.

One of the key aspects of CarBook is the ability to enhance communication with clients through automation and personalization. The system provides a convenient interface for communicating with clients via SMS, email or other preferred communication channels. With CarBook software, it is possible to impress clients not only with the quality of repairs but also with a new level of communication and service, raising the service station's competitiveness in the automotive maintenance market.

The software for planning service station activities is used to optimize and automate many processes that ensure the effective operation of the service station. The main reasons for using such software include:

1. Organization of the work process. The software helps plan and monitor the work of technicians, distribute tasks, track the schedule of tasks and avoid overload.

2. Inventory management. The inventory management tools allow you to monitor the availability of necessary spare parts and materials, replenish stocks in a timely manner and avoid shortages.

3. Customer service. The software includes CRM systems for maintaining a customer database, tracking service history, scheduling visits and automating communication with clients (reminders, offers, satisfaction assessments).

4. Financial accounting. Tools for bookkeeping, invoicing, payment processing and generating financial reports simplify financial management.

5. Diagnostics and documentation. The software can provide access to technical documentation, repair instructions and diagnostic tools, which facilitates the work of technicians and improves the quality of services.

6. Reporting and analytics. Automation of reporting allows for easy analysis of performance, income, expenses and other key metrics that aid in managerial decision-making.

7. Improved communication. Tools for internal communication help coordinate a work between different departments of the service station, promoting more effective collaboration.

The planning software helps organize tasks, projects and time management. Each of the discussed tools has its own features and is suitable for different types of activities and team sizes. For an effective activity planning, it is important to choose software that specifically meets your needs. The choice of a particular tool depends on the volume of tasks, the required level of collaboration and personal preferences in using the software.

The software for service stations significantly enhances operational efficiency and productivity, reduces the time spent on routine processes, improves customer service quality and contributes to business growth.

Referece

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Chapter 4. Motivation and coordination of activities

Organizational management is a complex field of research, focused on the study of managerial processes and relationships within organizational systems, with the aim of identifying the laws and principles that govern them. Based on these foundations, modern management systems, methods, techniques and modalities are designed to ensure the achievement, maintenance and enhancement of organizational competitiveness.

The defining elements of the science of organizational management are management processes and relationships, which must be clearly delimited from economic relations and processes — the latter having a fundamentally different content — as well as from the other components of the enterprise, be they economic, technical or human.

A specific aspect of management science consists in placing the individual at the center of analysis, both as a subject and as an object of managerial processes. This approach involves the integration of the individual's personal objectives in interdependence with the objectives, resources and means of the organizational system of which he is part. Thus, management is configured as a humanistic and systemic science, which explores the complexity of interactions between people, structures and goals.

As is evident from modern definitions of management, its essence is represented by its fundamental functions. Understanding these functions is an essential premise for deciphering the content of management science and practice, as well as for the effective adoption of specific systems, methods, techniques, procedures and tools.The essential contribution in identifying and analyzing the basic functions of the management process belongs to *Henri Fayol*, who defined five fundamental functions: forecasting, organizing, commanding, coordinating and controlling. Subsequently, various specialists have reformulated these functions in partially different ways. For example, *Justin Longenecker* and *Charles Pringle* have structured the management process into four distinct functions: planning and decision-making, organizing for effective performance, directing and motivating and, finally, controlling the results.

In contemporary specialized literature, both national and international, the management process is frequently divided into five main functions, given the nature of the tasks involved and the way they are carried out:

- *Foresight* – anticipating future developments and developing strategic plans;
- *Organizing* – structuring resources and activities to achieve objectives;
- *Coordination* – harmonizing activities and resources within the organizational system;
- *Training and motivation* – mobilizing human resources through influencing and stimulating;
- *Evaluation and control* – monitoring results and correcting deviations from the proposed objectives.

These functions should not be viewed as rigid stages, but as dynamic and interdependent processes, which manifest themselves cyclically and continuously in managerial activity [1].

4.1. The managerial function of motivation and training

Motivating employees is a key factor for success in any industry, but especially in automotive manufacturing, where quality, safety, and efficiency are vital. Employees who are motivated tend to perform better, stay longer, and contribute more to the organization's goals. But how can you motivate employees in automotive manufacturing, where the work can be repetitive, stressful, and demanding? Here are some effective ways to boost employee motivation in this sector.

1. Recognition and reward for performance – an essential motivational tool. Recognition and reward for achievements are some of the simplest and most effective methods of motivating employees. They can target both individual and team performance and can take various forms: verbal appreciation, constructive feedback, bonuses, incentives, promotions or certificates of merit.

To be truly effective, recognition and rewards must meet certain essential conditions: they must be offered at the *right time*, be *specific* in relation to the achievement obtained, *fair for all* employees and *consistent* over time.

The consistent application of these practices contributes significantly to increasing professional satisfaction, loyalty to the organization and employee morale. In addition, they stimulate the desire for continuous improvement and performance improvement, thus strengthening the organizational culture oriented towards results.

2. *Provide opportunities for learning and growth.* For some employees, the opportunity to learn, improve, and develop both professionally and personally can be considered motivation. Learning and growth can include training, coaching, mentoring, cross-functional projects, or career development plans. This opportunities for learning and development of the skills and competencies can help employees acquire new knowledge, skills, and competencies, as well as expand their horizons and potential. Learning and growth can also enhance employee engagement, creativity, and innovation, as well as reduce boredom and turnover.

3. Creating a favorable work environment. Another way to motivate employees can be achieved by creating a favorable or employee-pleasing work environment, where they will feel appreciated, respected, and supported. A positive work environment can include a clear and shared vision, a strong and ethical culture, a collaborative and communicative atmosphere, and a safe and comfortable physical space. Creating a positive work environment can foster employee trust, commitment, and belonging, as well as reduce stress, conflict, and absenteeism.

4. *Empower and involve employees.* A fourth way to motivate employees is to empower and involve them in decision-making, problem-solving, and improvement processes. Empowering and involving employees can include giving them autonomy, responsibility, and authority, as well as soliciting their feedback, suggestions, and opinions. Empowering and involving employees can boost employee confidence, ownership, and accountability, as well as stimulate their critical thinking and creativity.

5. *Balance work and life.* A fifth way to motivate employees is to balance work and life, by ensuring that they have enough time, energy, and resources to fulfill both their personal and professional needs and goals. Work-life balance includes flexible working conditions: such as

remote work, flexible work schedules or shorter work weeks, and the provision of various benefits such as health insurance, wellness programs, and childcare support. Balancing work and life can improve employee well-being, happiness, and productivity, as well as prevent burnout and fatigue. Motivating employees in automotive manufacturing can have significant benefits for both the employees and the organization.

4.2. Defining motivation and motivation process

The term motivation comes from the Latin word movere, which means "to move" or "to move". In a psychological and organizational context, motivation is defined as the totality of internal and external forces that initiate, guide and sustain human behavior towards achieving a goal.

At the heart of human behavior are motives, which reflect the needs and expectations of individuals, as well as their reaction to various forms of reward or stimulation. Thus, motivation is a dynamic process that involves both internal (psychological) factors and external influences from the social or organizational environment [2].

In Joe Kelly's vision, motivation is defined as "Motivation is a process where by needs instigate behavior directed towards the goals that can satisfy those needs [3]."*Michael J. Jucius* defines motivation as "Motivation is the act of stimulating someone or oneself to get a desired course of action, to push the right button to get a desired result [3]."

According to *W. G. Scot,* "Motivation means a process of stimulating people to action to accomplish the desired goals [3]."

Needs are perceived by the individual as states of deprivation, which generate tension and determine the initiation of behavior aimed at satisfying them. They are classified into two main categories:
Primary (physiological) needs – such as food, sleep, shelter – which are essential for the biological survival of the individual and the human species.
Secondary (social and psychological) needs – related to intellectual, emotional and social development, such as the need for belonging, esteem, personal achievement or autonomy.
Expectations are the individual's beliefs about the relationship between the level of effort exerted, the performance achieved, and the possible rewards. They play an essential role in shaping motivation, as they determine how much the individual is willing to invest in achieving a goal.

Rewards are what an individual perceives as valuable or meaningful to them. They can vary considerably from person to person, depending on their value system, experiences, and personal goals.

Rewards can be classified into two broad types:

Internal incentives – psychological and emotional satisfactions obtained from the activity itself, such as a sense of accomplishment, skill development, autonomy, or congruence with personal values.

External incentives – material or social benefits provided by the organization, such as salary, promotion, free time, work environment, work relationships, status symbols, and professional prestige [4].

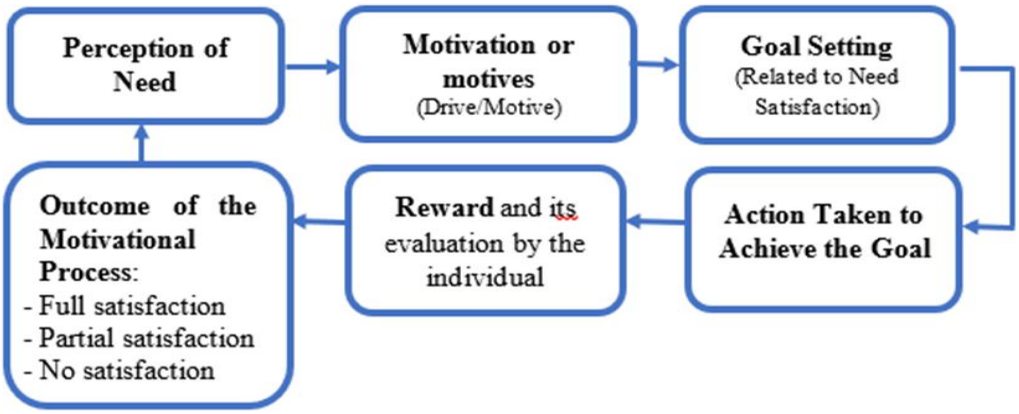

Fig. 4.1. Process of motivation[*adapted by author from source* [5]]

The motivational process is a set of interrelated stages:
1) a sense of need;
2) an incentive (motive) to satisfy it;
3) developing a goal that is related to satisfying the need;
4) taking actions to achieve the goal;
5) receiving a reward and its assessment by the individual, depending on which the result of the motivational process is formed: satisfaction of the need, partial satisfaction, lack of satisfaction [5].

The performance of any employee depends on three elements (at least): his professional ability, his motivation and the image he has of his own role within the organization.

Motivation is a fundamental factor that influences the performance of each individual. It can be approached as an internal state, which drives the person to act in a certain way and to pursue the achievement of certain objectives. Therefore, motivation is the internal psychological mechanism that determines the direction, intensity and persistence of behavior.

In a managerial context, motivation is the process by which the leader influences employees to achieve an optimal level of performance. This process involves identifying and providing clear reasons – whether material or symbolic, individual or collective – that stimulate involvement, effort and responsibility in carrying out tasks.

Thus, an effective manager is not limited to assigning tasks, but creates an environment in which employees feel motivated to achieve their potential, by aligning personal needs with the objectives of the organization.

Most motivational theories try to explain human behavior on the basis of satisfying people's needs.

In this context, need represents a psychological or social requirement or desire that can be satisfied by achieving a desired objective.An unsatisfied need causes the individual a state of inner discomfort – whether physical, psychological or social – which motivates him to adopt a

behavior aimed at fulfilling that need. Through his action, the person aims to reduce the tension felt and restore the state of internal balance [6].

In the modern view, individual motivation is affected by three notions: interests, attitudes, and needs.

Interests - reflect the direction in which a person's will is oriented, depending on what they consider useful, necessary, or beneficial. In practice, managers can stimulate employee motivation if they take their interests into account when deciding on hiring, promoting, or distributing tasks.

Attitudes - represent the way in which individuals perceive and react to people, objects, situations, or events. These are reflected in thinking, behavior, and personal style and directly influence motivation.

Needs - are the individual's desires or necessities, whether physical or psychological. They form the basis of most motivational theories.

The way in which the needs inter-relate with the other components in the process of satisfying them is represented as follows:

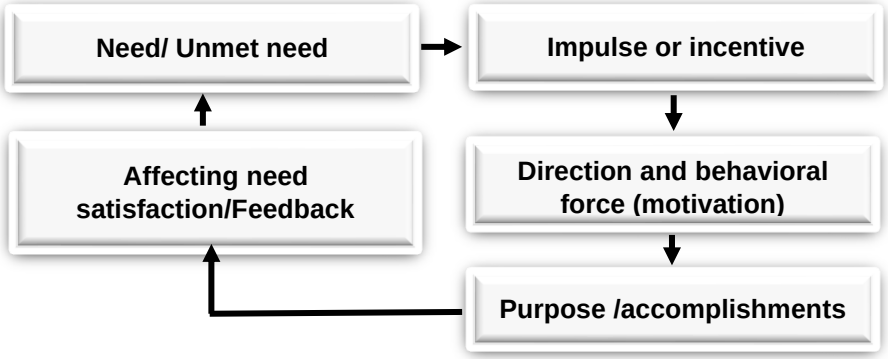

Fig. 4.2. The process of satisfying needs [*adapted by author from source* [7]]

As we can see from the figure above, in order to satisfy needs, a multi-stage process is carried out that leads to achieving objectives. This process starts with the first stage - the existence of a need, followed by the stage in which the motivation mechanism is identified to achieve the proposed objectives and finally, the existing need is satisfied. In this process, the only variable is the need, but the stages are similar for several motivation processes [7].

Types of motivations:

1. *Achievement motivation.* This form of motivation expresses a person's desire to achieve their goals and personal and professional growth. Highly motivated people strive for excellence not only for the sake of external reward, but for the internal satisfaction of achieved success.
2. *Belongingness motivation.* This type of motivation is associated with the need to establish and maintain positive social relationships. People motivated by belonging prefer to work in a team, respond positively to recognition from colleagues, and are inspired by cooperation and harmony in the group. Social support and recognition of their contribution to the team increase their level of involvement.
3. *Competence motivation.* Reflects the desire of employees to acquire and demonstrate skills, perform work at a high level of quality. People motivated by competence strive to solve

complex problems, strive for continuous learning, personal growth and development, are proud of their ability to solve problems and show a creative approach to difficulties.

4. *Power motivation.* It is focused on power and influence on others, as well as the ability to change situations or organizational structure. People motivated by power seek to exert significant influence in the organization, take risks, and assume responsibility in decision-making. This type of motivation can be constructive, especially in leadership positions.

5. *Attitude Motivation.* This refers to how a person thinks and feels about themselves, their work, and life in general. A positive attitude, self-confidence, and an optimistic outlook on the future contribute significantly to high levels of motivation and performance.

6. *Reward Motivation.* This is based on offering specific benefits – material or symbolic – in exchange for performing an action. It is also known as extrinsic motivation and follows the principle of "do it and get something in return." Bonuses, prizes, or other forms of external reward are often used to encourage extra effort, especially in the short term.

7. *Fear Motivation***.** This form of motivation is based on avoiding negative consequences. It is coercive in nature and forces a person to act quickly, sometimes against their will. While it may be effective in the short term to achieve immediate results, frequent use may reduce intrinsic motivation and impact organizational climate [3].

4.3. Motivational theories

Management practice is based on theories of motivation, which fall into two groups. Conceptual (content) theories try to find out the reasons for a certain human behavior. These are often called "need theories". Process theories focus on the question: how does a certain type of behavior arise?, what directs it?, maintains it and stops it? [5]

Conceptual theories of motivation are based on the idea that people act in a certain way to satisfy certain needs. These theories aim to understand what needs employees have and how rewards – whether internal (such as personal satisfaction) or external (such as salaries or awards) – can be used correctly and effectively to motivate them to work better.

Conceptual theories of motivation include:

- Maslow's hierarchy of needs theory;
- McClelland's acquired needs theory;
- Herzberg's dual factor theory;
- Alderfer's ERG theory [4].

Process theories of motivation focus on understanding how a person directs their effort to achieve certain outcomes and how they come to choose a certain behavior. These theories do not exclude the importance of needs, but emphasize that motivation depends on how the individual perceives the situation, their expectations, and the consequences they anticipate from the chosen behavior:

- Victor Vroom's theory of expected performance.
- Theory X and Y of McGregor.
- The equity theory of S. Adams [4].

There are other criteria according to which theories and empirical research on work motivation can be classified. Classification of motivational theories into three main groups:

- content theories
- process theories

theories of reinforcement

Table 4.1. Classification of motivational theories [7]

Categories	Characterize	Theories	Examples
Content theories	it targets the factors that contribute to or initiate motivated behavior	Hierarchy of needs X-Y ERG Acquiring successes	Motivation through money, social status and achievements
Process theories	it targets the factors that direct behavior	Expected performance Porter-Lawler Equity Setting goals	Motivation through the individual's inner drive for work, performance and recognition
Theories of reinforcement	it targets the factors that determine the repetition of a behavior	operant conditioning	Motivation by rewarding behavior

Motivation theory offers the possibility of understanding the set of motives that underlie human behavior, highlighting how these motives influence the actions of the individual, both personally and professionally.

Although motivation plays an essential role in all areas of society, it is very important in managerial practice in all areas. A motivated employee tends to be more productive, which directly contributes to increasing the efficiency and success of the organization.

The most applicable and with the most positive results are the following theories:

4.3.1. Maslow's Theory of Hierarchical Needs

In Abraham Maslow's vision, an employee can only be motivated when all his needs are satisfied. People work not only to be safe or to be remunerated, but also to be part of the team and, through their skills and competencies, to contribute to the effectiveness of this team. Maslow's famous pyramid showed that depending on how motivated people are, it depends on how they climb the steps of the pyramid and move from one level to another, thus satisfying their needs. The pyramid is divided into two levels: the lower level of the pyramid includes basic needs and, if these needs are not satisfied, people will not be motivated to work better to satisfy higher-level needs.

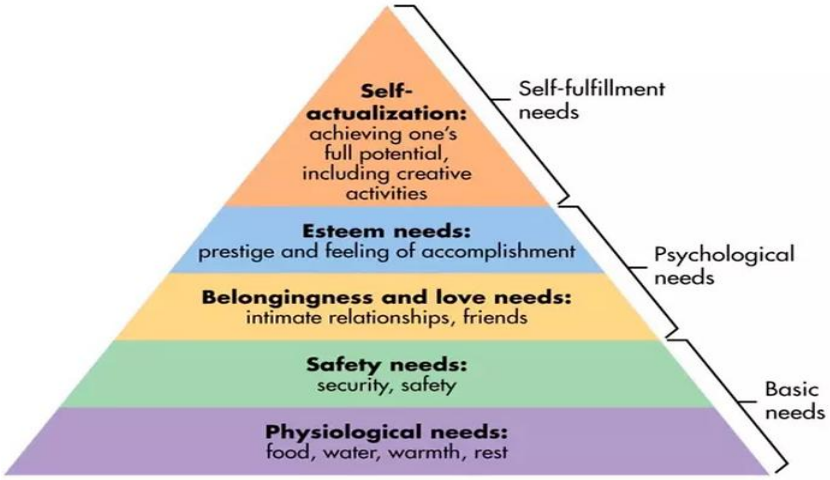

Fig. 4.3. Maslow's Hierarchy of Needs [8]

Below is the hierarchy of needs:

- Physiological needs: are basic needs for survival such as air, sleep, food, water, clothing, sex, and shelter.
- Safety needs: Protection from threats, deprivation, and other dangers (e.g., health, secure employment, and property).
- Social (belongingness and love) needs: The need for association, affiliation, friendship, and so on.
- The need for self-esteem: which involves self-appreciation and is formed from success, from obtaining social status, from the recognition of results by other people.
- The need for self-realization and self-perfection: are considered higher spiritual needs, which consist of the possibility of personal development, the development of one's own talents and vocations.

A manager or leader must understand the current level of needs of each team member and support them in fulfilling these needs. As these needs are met, people will become more motivated and will begin to achieve better results. Once one level of need is fulfilled, they will begin to pursue the fulfillment of a higher level, as presented in the pyramid of needs [9].

4.3.2. Hertzberg's two-factor Theory

One of the most well-known and widely practiced theories of motivation is Frederick Herzberg's two-factor theory. This theory can also be found under other names: dual theory, motivational-hygiene theory, or maintenance and motivation theory. This theory has been widely accepted in managerial practice as an effective tool for understanding and stimulating human behavior in the organizational environment.

According to Herzberg's vision, there are two distinct categories of factors that influence employee behavior at work, but in different and independent ways:

Contextual factors (also called extrinsic or hygiene factors) are those that, when absent or perceived as inadequate, generate dissatisfaction among employees. These include elements such as: organizational politics, leadership and supervision style, interpersonal relationships with colleagues and subordinates, working conditions, salary, professional status, and job

security. The presence of these factors does not automatically lead to increased motivation, but their absence causes dissatisfaction.

Content factors (also called intrinsic or motivational factors) are directly associated with professional activity and with personal satisfaction derived from work. They include personal achievements, recognition of merit, opportunities for advancement, degree of responsibility, nature of tasks and potential for professional development. These factors are essential for generating authentic motivation and for improving individual performance.

Thus, Herzberg's theory emphasizes the importance of differentiating between what prevents dissatisfaction and what generates motivation, providing a useful framework for designing effective human resource policies [10].

The research carried out by Frederick Herzberg (1959) on 200 accountants and engineers, using the critical incident method, materialized in a new theory of motivation called "motivation - hygiene theory". Subjects answered questions such as: "Can you describe in detail when you feel exceptionally good at work?" or on the contrary "Can you describe in detail when you feel the worst at work?" [11].

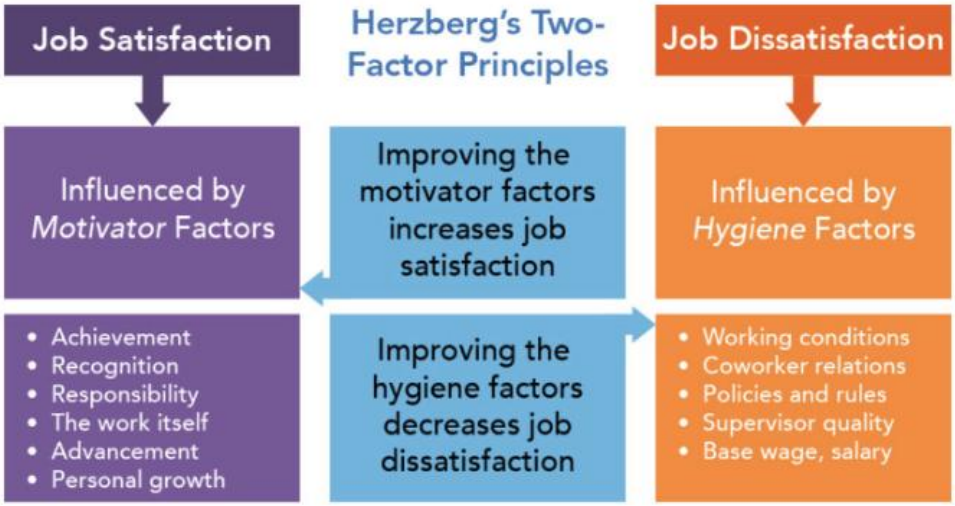

Fig. 4.4. Herzberg's Motivation-Hygiene Theory [12]

The results from this inquiry form the basis of Herzberg's Motivation-Hygiene Theory (sometimes known as Herzberg's "Two Factor Theory"). Published in his famous article, "One More Time: How do You Motivate Employees," the conclusions he drew were extraordinarily influential, and still form the bedrock of good motivational practice nearly half a century later [12].

4.3.3. McClelland's Theory of Needs

David McClelland of Harvard University has done extensive research on the concepts of need for Achievement, need for Power and need for Affiliation. This theory is also called three-needs theory [13].

According to David McClelland, each person is influenced by three main motivational factors. However, one of these factors tends to become dominant in the individual's behavior. The dominance of one of these factors is mainly shaped by the person's life experiences.

The three motivators are:

Achievement: a need to accomplish and demonstrate own competence. People with a high need for achievement prefer tasks that provide for personal responsibility and results based on their own efforts. They also prefer quick acknowledgment of their progress.

Affiliation: a need for love, belonging and social acceptance. People with a high need for affiliation are motivated by being liked and accepted by others. They tend to participate in social gatherings and may be uncomfortable with conflict.

Power: a need for controlling own work or the work of others. People with a high need for power desire situations in which they exercise power and influence over others. They aspire for positions with status and authority and tend to be more concerned about their level of influence than about effective work performance.[1]

4.3.4. Victor Vroom's Expectancy Theory.

The pillar of this theory is the postulate that the expectation that an individual has regarding obtaining certain elements or achieving certain situations constitutes the main motivational force. According to this theory, motivation is a function of three variables (1):

1) the expectation regarding work expenses and the result, the effort - performance relationship *E--P*

2) the expectation regarding performance - reward *P--R*

3) the valence is the assumed level of satisfaction or dissatisfaction arising from receiving a reward, *V:*

$$M = (E - P)^* (P - R)^* V^2 \qquad (1)$$

Victor Vroom's expectancy theory emphasizes that employee motivation is influenced by their expectations regarding effort, performance, and rewards. According to this theory, people are motivated to work harder when they believe that their effort will lead to good performance, that this performance will be recognized and rewarded, and that the reward is valuable to them. Thus, the theory provides a logical and applicable framework for understanding and managing motivation in organizations, emphasizing individual perceptions and the clear relationship between work, outcomes, and rewards.

4.3.5. McGregor's Theory X and Theory Y

The motivational theory "Theory X and Theory Y" was developed in the 1960s by social psychologist Douglas McGregor and published in the work "The Human Side of Enterprise". This theory represents two opposing views on human nature and employee motivation, which directly influence the leadership style adopted by managers.

Thus:

Theory X – Authoritarian leadership style

View of employees:

They do not like work and avoid it whenever they have the opportunity.

Lack internal motivation.

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[1] Abey Francis, Motivations - definitions, process, types, features and importance.
https://www.mbaknol.com/management-concepts/motivation/#google_vignette

[2] Serduni S., Management (note de curs), Editura ASEM, Chișinău 2010, p.113

Avoid responsibility.
They need constant supervision and strict control.
They are not able to make decisions or self-evaluate.
Managerial implications:
Authoritarian, centralized leadership style.
The manager practices micro-management.
Emphasis on rules, imposed tasks and external control.
Suitable in environments with repetitive activities or where employees lack initiative.

Theory Y – Participatory Leadership Style

Vision about employees:
Work is seen as a source of satisfaction and development.
People are motivated, take responsibility.
They seek challenges and learning opportunities.
They can self-evaluate and work independently.
They want to contribute to the success of the organization.
Managerial implications:
Participatory, decentralized leadership style.
Encouraging employee involvement in decision-making.
Emphasis on autonomy, trust and personal development.
Favorable in creative, dynamic and innovation-oriented environments.
This approach of McGregor is still relevant and very current in contemporary management.[3]

4.3.6. Alderfer's ERG Theory

American psychologist Clayton P. Alderfer adapted and simplified the hierarchical model of needs proposed by Abraham Maslow, developing his own theory known as the ERG theory. This theory groups human needs into three fundamental categories:

Existence Needs (E – Existence)

These include the basic material and physiological needs necessary for survival, such as: food, water, air, sleep, clothing, shelter, physical safety and financial security (e.g. a stable job). They correspond to the first two levels of Maslow's pyramid: physiological needs and safety needs.

Relationship Needs (R – Relatedness)

These refer to the individual's desire to establish and maintain meaningful relationships with others. These needs include social interactions, a sense of belonging, friendship, family support and recognition from others. They correspond to the needs for belonging/love and social esteem in Maslow's theory.

Growth Needs (G – Growth)

Represents the aspiration for personal development, self-efficacy, and achievement. This category includes needs related to self-esteem, self-confidence, personal success, creativity, morality, and the desire to reach one's full potential. They reflect partly the esteem needs and fully the self-actualization needs of Maslow's model [14].

[3] https://www.knowledgehut.com/tutorials/project-management/motivation-theories

4.4. Motivation systems and the digitization of the motivation system

Reward system in employee motivation is a plan implemented by organizations with the aim of keeping their employees satisfied. Specifically, it has the following role in a company:

- decrease in the rate of unmotivated absenteeism at work;
- increasing the level of employee loyalty;
- by motivating employees increases the company's performance potential.

To be effective, developing a strategy to maintain staff motivation must include both non-financial and financial benefits that help maintain a modern lifestyle for your employees. So, we conclude that motivation is the process by which a person chooses a certain type of behavior to achieve personal goals, while also achieving the goals of the organization. It involves internal factors (desires, needs, values) and external factors (working conditions, rewards), which determine the direction, intensity and persistence of the effort put into an activity.

In essence, we deduce that motivation:

- starts from unsatisfied needs (stimuli);
- determines active behavior;
- involves resources (energy) to achieve a goal;
- and if the goal is achieved, the need is satisfied and the initial behavior ceases.

G.A. Cole emphasizes that motivation involves choosing between alternative forms of behavior, depending on what the individual wants to achieve. Complementarily, Mathis, Nica and Rusu define motivation as "the sum of internal and external energies that initiate and direct behavior towards a goal that, once achieved, leads to the satisfaction of a need."

Motivational theories show that people are different and are influenced by a wide range of needs – from material to social and personal. These needs evolve over time, depending on both personal development and changes in the professional or social environment. In this context, employees do not work only for money, but also for other forms of satisfaction, such as: professional and personal learning and development; personal autonomy and initiative; positive social relationships; a sense of belonging and recognition; job security and future.

Thus, effective staff motivation cannot be reduced to an attractive salary alone. Although financial rewards remain essential, they must be complemented by other forms of recognition and stimulation – such as promotion, positive feedback, participation in decisions or improved working conditions.

Therefore, rewards management must take into account the complexity of human motivation, and salary and benefit systems must be adapted to both the material needs of employees, as well as their psychological and social ones [15].

According to specialized literature, there are different approaches to the content of reward systems a employees. Next, we will present some models of staff reward systems developed by well-known specialists in this field of activity.

The figure below shows the content of the staff reward system according to C. D. Fisher, L. F. Schoenfeldt and J.B. Shaw [16]:

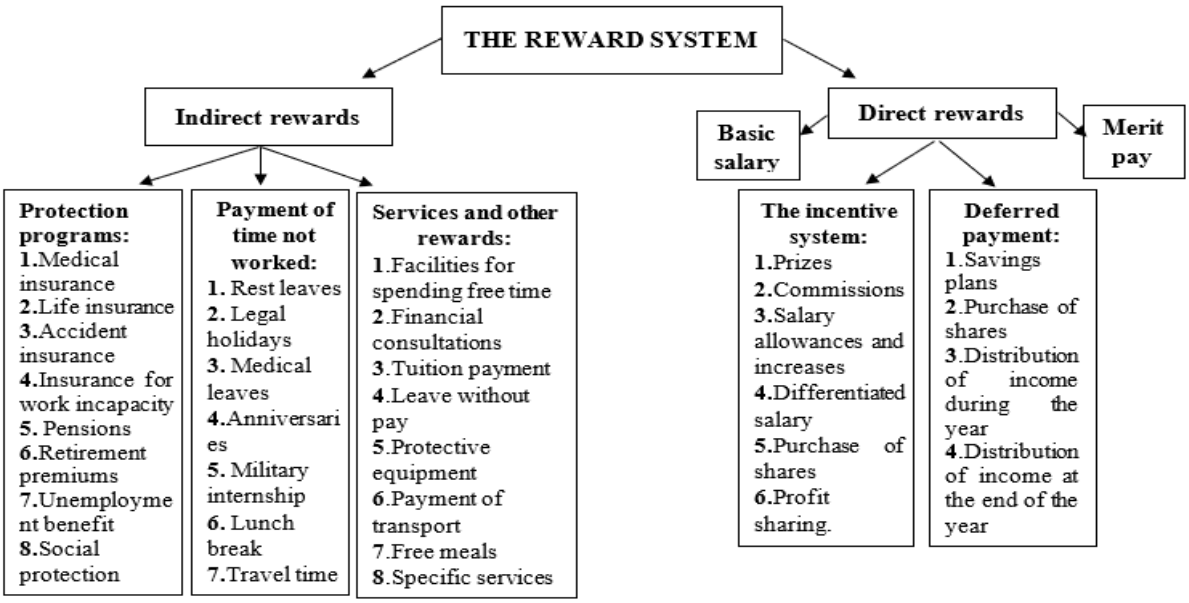

Fig. 4.5. The personnel reward system after C. D. Fisher, L. F. Schoenfeldt and J. B. Shaw [16]

The personnel reward system cannot be developed in the abstract. The decisions regarding the strategic reward of the staff are based on a set of objectives that derive from the business strategy of the organization, from the nature of the employees and from the particularities of the environment in which they evolve. Personnel reward policies represent for the organization's top management a privileged way to face various situations and to act in accordance with the strategy, degree of maturity, management style, organization culture, etc [17].

In order to systematize and streamline the entire human resources management process within an industrial organization, modern digital processing systems are used, centralizing information about employees and all processes related to human resources management

Several human resources software are adapted and used for the automotive industry, which essentially contribute to the efficient management of human resources and the correct motivation of employees. In the automotive industry, the use of dedicated HR software has a positive impact on several processes, such as employee attendance management, payroll administration and access to ESS (Employee Self-Service) platforms. It also helps reduce human error and the risk of security breaches regarding personnel documents. The most effective HR software solutions for the automotive industry are presented in detail below:

FactoHR Software – Digital Solution for Human Resources Management in Industry.FactoHR is a dedicated human resources (HR) management software, developed to automate and streamline administrative processes in companies. It is widely used in industries such as automotive and manufacturing, where efficient workforce organization is essential.

Application areas: factoHR is mainly used by industrial enterprises, including:

- Automotive industry – to manage a large and complex workforce, active in multiple shifts;
- Manufacturing and processing sector – where accurate attendance tracking, clear performance records and compliance with legal labor regulations are required.

Main functionalities (Specifications):

- Payroll processing – automates the calculation and delivery of salaries, ensuring accuracy and compliance with legislation.
- Attendance management – monitors employee working hours, tardiness and absenteeism.
- Leave management – tracks leave requests and automatically balances days off.
- Employee Self-Service (ESS) platform – provides employees with access to their own data (timesheets, salary, requests, etc.), reducing the workload of the HR department.
- Performance evaluation – allows for objective monitoring of employee performance, based on productivity indicators.
- Recruitment – helps manage the entire selection and hiring process.
- Compliance support – ensures compliance with legal regulations (GDPR, labor legislation).
- Employee document management – archiving and secure access to personal files, contracts, etc.
- Reporting and analysis – provides relevant analysis for management decision-making.
- Mobile application access – facilitates mobility and digital interaction with employees.

Benefits for industrial enterprises:

- Reduction of human errors in administrative processes.
- Saving time and resources by automating repetitive tasks.
- Increased productivity through better work organization and clear performance evaluation.
- Improving internal communication through ESS functionality.
- Increasing transparency in the employee-employer relationship.
- Flexibility and scalability, adaptable to the needs of a growing company.
- Increased security of employee data, reducing the risks of IT breaches.
- Support for strategic decision-making based on clear data and real-time analysis [18].

Elite HRMS software aims to improve HR capabilities. It is highly flexible in terms of adapting to any industry with little customisation and delivering the required results.
The system helps HR to manage all the operations without any unnecessary hassle. It sends alerts and notifies HR for all the important tasks. It comes with powerful employees and managers self-service that are integrated with the system. Apart from all this, you can access the system on your smartphone, which elevates its accessibility.

Elite HRMS – Digital solution for human resources management in industry.Elite HRMS is a Human Resource Management System (HRMS) software, designed to improve the capabilities of the human resources department by automating and digitizing all essential processes. It stands out for its high flexibility, being easy to adapt to any field of activity, including industrial sectors.

Elite HRMS can be successfully applied in:

- Industrial enterprises (automotive, manufacturing, construction, etc.);
- Large and medium-sized companies with a complex personnel structure;
- Organizations with multiple departments or locations, where effective coordination between HR, management and employees is required.

Benefits for industrial enterprises:

- Complete automation of HR activities, reducing the volume of manual work.
- Increased operational efficiency through automatic notifications and alerts for important tasks.
- High flexibility in integration and customization, adaptable to various industries without high additional costs.
- Mobile accessibility, which allows human resources management from anywhere and anytime.
- Reduction of errors in payroll, timesheets and document management.
- Transparency and autonomy for employees through the ESS platform.
- Efficient resource management (equipment, budgets, human resources).
- Increased employee satisfaction thanks to an organized, easy-to-use and predictable system [19].

Smart HRMS – Advantageous HR Solution in Industrial Environment. Smart HRMS is a complete cloud-based system designed to automate and digitize HR department processes. The platform is easily customizable and adaptable to different industries, including the industrial and manufacturing sectors, offering an intuitive interface and easy access to up to hundreds of employees.

This software is suitable for:

- Industrial companies with large volumes of employees;

-Complex organizational structures with repetitive activities (production line, automotive industry, factories, etc.);

- Organizations that want to reduce manual work and optimize HR processes.

Benefits for industrial enterprises:

- Reduction of human errors by automating routine activities (time and attendance, payroll, taxes).
- Increased efficiency for HR departments, with time and resource savings.
- Reduced operating costs – elimination of manual processes, digitization of administrative flows.
- Transparency and autonomy – employees can check their own personal data, requests and reports.
- Control and security – role-based permissions, cloud backup and protected access.
- Scalability – usable even by organizations with thousands of employees, without altering the performance of Smart HRMS Cloud.

  Flexibility – easy to customize for any industry, without major additional costs.Support for strategic data-driven decisions – dynamic, aggregated reports and powerful analysis [20].

BambooHR – A smart solution for human resources management. BambooHR is a complete cloud-based human resources management platform, aimed primarily at small and medium-sized enterprises. This software helps companies efficiently manage everything related to employees: recruitment, onboarding, performance, payroll, time and attendance, and essential personnel data. It is used internationally in numerous industries, including the manufacturing sector, where automation of HR processes is essential for efficiency and control.

Main features of BambooHR:

- HRIS – Employee Information System
- Centralizes and manages all employee data in one place (personal data, professional history, documents, etc.).
- Recruitment and Onboarding
- Performance Management
- Time and Attendance Management
- Payroll & Benefits (in some regions)
- Analytics and Reports
- Mobile Access and Employee Self-Service (ESS) [21].

Gusto. Gusto – Complete HR, Payroll, and Benefits Platform. Gusto is an all-in-one cloud software, specializing in human resources management, payroll, benefits, and legal compliance. It is used especially by small and medium-sized businesses, offering user-friendly and automated functionalities for employee management.

Gusto is used in various sectors, including: Manufacturing and production industry; Construction and logistics; Professional services (accounting, marketing, etc.); Retail and e-commerce; Technology and startups.

Main functionalities: Payroll (Automatic payroll); Automatic calculation of salaries, withholdings, and taxes; Integration with banking systems and tax authorities; Time & Attendance; Tracking of time worked, digital timekeeping, vacations, and breaks; Digital Onboarding; Rapid integration of new employees (signing contracts, filling in data, etc.).

Benefits for industrial companies:

- Efficiency in managing payroll for shift or hourly workers
- Gusto automates payroll for production employees who work shifts or overtime.
- Reduction of human errors
- Automating processes reduces the risks of miscalculation or omission of legal obligations.
- Mobile access and flexibility
- Employees can access documents, schedule leave and see payments directly from the application.
- Ease of tax and legal compliance
- Gusto provides automatic updates on applicable taxes and labor laws.
- Easy integration with other systems
- Can connect with accounting applications (QuickBooks, Xero), CRMs and other industrial platforms.
- Savings of time and resources

  HR department can focus on strategy and development, not just on administrative operations [22].

Humi HR – integrated HR solution for dynamic industries. Humi is a complete cloud platform for human resources management, created for small and medium-sized companies, mainly in Canada. It integrates HR, payroll, benefits and performance management modules, centralizing all employee information in a single system.

Ideal for companies in the industrial sector, such as manufacturing, logistics or construction, where the complexity of personnel and repetitive processes pose organizational challenges.

Also suitable for organizations with multiple structures or employees in shifts, also providing support in the management of work schedules and shifts

Main functionalities:

- Unified employee database: personal data, professional history, documents, payslips.
- Recruitment and onboarding: publishing ads, tracking applications, rapid digital integration of new employees.
- Attendance and leave management: digital timekeeping, approval of requests, leave records.
- Automated payroll: salary calculation, taxes, declaration submission, electronic archiving.
- Benefits administration: medical and other program management, self-service through a dedicated portal.
- Performance evaluation and career management: objectives, feedback, periodic reviews.
- Reports and decision-making analysis: key indicators such as retention, salary costs, productivity.
- Mobile access and self-service (ESS): employees can manage personal data and leave requests online.
- Security and compliance: encryption, backup, access control and automatic legislative updates [23]

Savvy HRMS is created by Orasis Infotech Private Limited, initiated in 2015 by IT experts with the aim of simplifying human resource management — from recruitment to retirement. The platform supports hiring, performance development and automation of HR processes in a comprehensive way. This software aims to eliminate excessive bureaucracy in the HR field. It has an intuitive interface and integration between various modules, provides a complete tool for legal and efficient management of human resources and is suitable for both small and medium-sized organizations, as well as for large ones. It is most often used by over 700 companies, mainly in India, but also internationally.

Savvy HRMS includes a multitude of interconnected modules that cover the entire employee life cycle: recruitment-integration (Posting jobs, tracking candidates, automatic generation of offers and digital onboarding); attendance and leaves (Integration with biometrics / facial recognition, leave requests and tax reports); Automatic calculation of salaries, taxes and duties; performance management; credit management, expenses and travel, internal surveys, training and task management [24].

Intelliob Technologies Pvt. Ltd. offers software solutions for human resource management (HRMS), payroll, time & attendance and financial accounting, available both on-premises and in the cloud. The company is ISO 9001:2008 certified and a Microsoft ISV partner, with presence in various industries such as e-government, healthcare, manufacturing, education and public sector. It is most often used by organizations in the corporate sector, SMEs and government or educational institutions. Functionality: Complete module: recruitment, performance, ESS, employee relations; Automated payroll, quick setup, tax reports; Integrated biometric/web time attendance, error reduction, daily reporting; Complete financial management: payments, invoicing, inventory [25].

BrightHR is a cloud-based platform (online software) designed especially for small and medium-sized companies in the UK, Ireland, Canada and Australia. Used by over 100,000 companies globally, BrightHR combines employee management, timekeeping, shift planning, leave and document management.

The most important advantages of this platform: it can be used by small-medium companies in fields such as education, healthcare, retail, construction, IT, advertising, recruitment or consulting services; it is easy and fast to implement (the platform can be ready for use in 24 hours). Complete HR accessory: combines HR, payroll, healthcare and legal modules supported by mobile applications and dedicated portals [26].

ZeroCodeHR is a company specialized in rapid and agile HR application development, using low code / no code technologies. It allows traditional, non-technical IT users to create customized HR applications without complex coding. The company's mission is to make digital application development accessible to HR professionals everywhere — fast, elegant and at low cost, offering savings of up to 80% compared to traditional platforms. ZeroCodeHR offers a suite of fully configurable solutions for different HR needs, structured as reusable modules: Compensation Administration (automates the calculation and distribution of bonuses, merits and actions for employees); Performance Management (Enables continuous feedback, goal assessment and team collaboration); Planning & Calibration Scenarios (helps compensation teams create predictive models to optimize the salary budget); Pay Equity Analysis (analyzes salary differences in real time, identifies gaps and provides budget estimates for necessary adjustments); Allows building your own solutions for: Employee Self Service, time & payroll, learning platforms, document management, remote staff management, *etc*. [27]

PossibleWorks is a modern performance and talent management platform, built around the concept of skills (skill-based) and a single screen interface, similar to a chat conversation. It is designed to replace traditional annual review processes with an agile system, focused on continuous feedback, objectives (OKR/BSC) and analysis of competencies linked to organizational results.

Main users: small and medium-sized companies, non-profit and public administrative organizations that need an agile system for employee evaluation and development.

Platform specifications:

- Support the culture of continuous feedback.
- Real-time visibility on the progress of objectives.
- 360° assessments for professional development.
- Easy-to-adopt platform without intensive IT training [28].

Decision Plus HRMS. The flexible system comes with all the facilities to manage HR tasks efficiently. It features several modules like administration, performance management, attendance and leave management, payroll portal, employee management helpdesk, HRIS, recruitment, and budget planning and management. Moreover, the secure system is in compliance with all the labour laws.

Specifications:

- Comprehensive solution for managing the workforce.
- Strengthened HR processes within the organization.
- Better Employee Connect through Self Service Portal.

- Powerful querying and reporting features.
- Robust but easy-to-use Payroll package.
- Labour law compliant [29].

Some of the most popular and effective HR software for the automotive sector have been outlined above, including their features. Regardless of company size, it's worth investing in an HR system that offers features like payroll management, leave management, data analytics, industry compliance, and secure employee documentation.

There is no universal software, but based on the needs, objectives and size of the company, the most suitable software can be chosen. Automated HR processes save a lot of time and effort and also ensure better productivity and employee satisfaction in the long run.

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Chapter 5. The function of control and evaluation in entrepreneurship

The modern challenges faced by enterprises that produce goods and/or provide services require new approaches to ensuring the quality of products and services. Enterprises operating in the field of automotive transport, particularly those providing services for diagnosing, maintaining, repairing vehicles, are under special scrutiny, as, besides other factors, the outcomes of such enterprises are directly linked to road, passengers, and pedestrians safety. Therefore, for such enterprises, the issue of controlling and assessing the results of their work is particularly pressing.

The analysis of research results indicates that control functions at the enterprises are directly related to management, both in current and strategic planning [1].

In a research work [2] the authors conducted research on control management systems used by organizations for managing and assessing sustainable development. Similar studies that examine combinations of management control are presented in [3]

The functions of control at the enterprises are interpreted in various ways. On one hand, control is defined as the observation and verification of the enterprise activities (production, economic, financial, *etc*.). [4]. On the other hand, control functions are viewed as the management activity of the enterprise aimed at identifying the possibility of the organization achieving its goals, with the aim of making operational adjustments to plans. [5].

Despite the numerous interpretations of the concept of control at enterprises, the primary objective of control is to monitor the processes operating within the enterprises in order to assess the achievement of set goals. For this reason, control functions have a managerial aspect and are inextricably linked to the evaluation of enterprise activity. [6].

Today, various management systems (quality management) are actively developing and being implemented at the enterprises around the world, which actually ensure the control and assessment of production.

The main standard regarding quality management systems is ISO 9001 standard. ISO 9001:2015 – Quality management systems. Requirements. ISO 9001 standard establishes requirements for the quality management systems of organizations, enterprises, institutions of any ownership form, type or size, regardless of the products they manufacture or the services they provide. An organization that complies with all the requirements of ISO 9001 standard without exception may receive a conformity assessment (certificate of conformity to the ISO 9001 requirements).

It is also advisable for automotive transport enterprises to implement additional management systems (such as environmental, energy, information etc.), thereby introducing the integrated management systems. Below there are shown some standards that are advisable to implement at automotive transport enterprises.

ISO 14001 – Environmental management systems. Requirements with guidance for use. ISO 14001 standard contains a general framework for the activities of organizations, enterprises and institutions aimed at environmental protection, timely response to changes in environmental conditions, improving the ecological effectiveness of the organization, promotes a systematic management of its environmental components.

The standard is intended for organizations of any type and size, regardless of geographical, cultural or social conditions. The successful implementation depends on the commitments

made at all functional levels of the organization, and particularly on those made at the highest management level.

An organization that complies with all the requirements of ISO 14001 standard without exception may receive a conformity assessment (certificate of conformity to the ISO 14001 requirements).

Standard ISO 45001 – «Occupational health and safety management systems. Requirements with guidance for use». The occupational health and safety management system should be implemented at the organizations that aim to minimize risks related to the health and safety of their employees and customers. ISO 45001 standard is focused on improving a workplace safety, which is a legal requirement at the organizations of all sizes and industries, regardless of their location.

The implementation of the occupational health and safety management system is intended to reduce the number, severity and consequences of workplace injuries, accidents, occupational diseases, thus increasing the likelihood of uninterrupted supply of goods (or services).

The standard is intended for organizations of any type and size, regardless of geographical, cultural or social conditions. The successful implementation depends on the commitments made at all functional levels of the organization, particularly those made at the highest management level.

An organization that complies with all the requirements of ISO 45001 standard without exception may receive a conformity assessment (certificate of conformity to the ISO 45001 requirements).

ISO 50001 – «Energy management systems. Requirements with guidance for use». This standard aims to enable organizations to develop the systems and processes necessary for improving energy performance, encompassing energy efficiency, usage and consumption. It is expected that the implementation of this standard will lead to a reduction in greenhouse gas emissions and other environmental impacts, as well as a decrease in energy costs through systematic management of energy resources. The standard is intended for organizations of any type and size, regardless of geographical, cultural or social conditions. The successful implementation depends on the commitments made at all functional levels of the organization, particularly those made at the highest management level.

An organization that complies with all the requirements of ISO 50001 standard without exception may receive a conformity assessment (certificate of conformity to the ISO 50001 requirements).

ISO/IEC 27001 – Information technology. Security techniques. Information security management systems. Requirements. This standard is created to define the requirements for the development, implementation, functioning, monitoring, review, maintenance and continual improvement of an information security management system (ISMS). Adopting an information security management system is a strategic decision for an organization. The information security management system ensures the confidentiality, integrity and availability of information through the implementation of a risk management process and provides assurance to interested parties that risks are being appropriately managed. The standard defines requirements for the design, implementation, maintenance and continual improvement of the information security management system, taking into account the organization's circumstances. This standard also includes requirements for assessing and treating information security risks related to the needs of organization. The requirements specified in this standard are generic and can be applied to all organizations, regardless of type, size or nature.

An organization that complies with all the requirements of ISO 27001 standard without exception may receive a conformity assessment (certificate of conformity to the ISO 27001 requirements).

Enterprises, institutions and organizations can combine (integrate) their management systems in such a way as to ensure compliance with several or even all of the aforementioned standards, in this case, the organization may receive a certificate for an integrated management system.

ISO/IEC 17025 – General requirements for the competence of testing and calibration laboratories. The standard establishes the requirements for the competence of testing and calibration laboratories. This standard is applied to confirm to clients the technical competence of the organization that conducts product testing or measurements of its characteristics. In other words, compliance of the enterprise with this standard indicates the reliability of the testing (measurement) results it produces.

If an organization operates in accordance with the requirements of ISO/IEC 17025, it generally means that the organization also meets the requirements of ISO 9001. However, a compliance with the requirements of ISO 9001 does not mean that the organization complies with the requirements of ISO/IEC 17025.

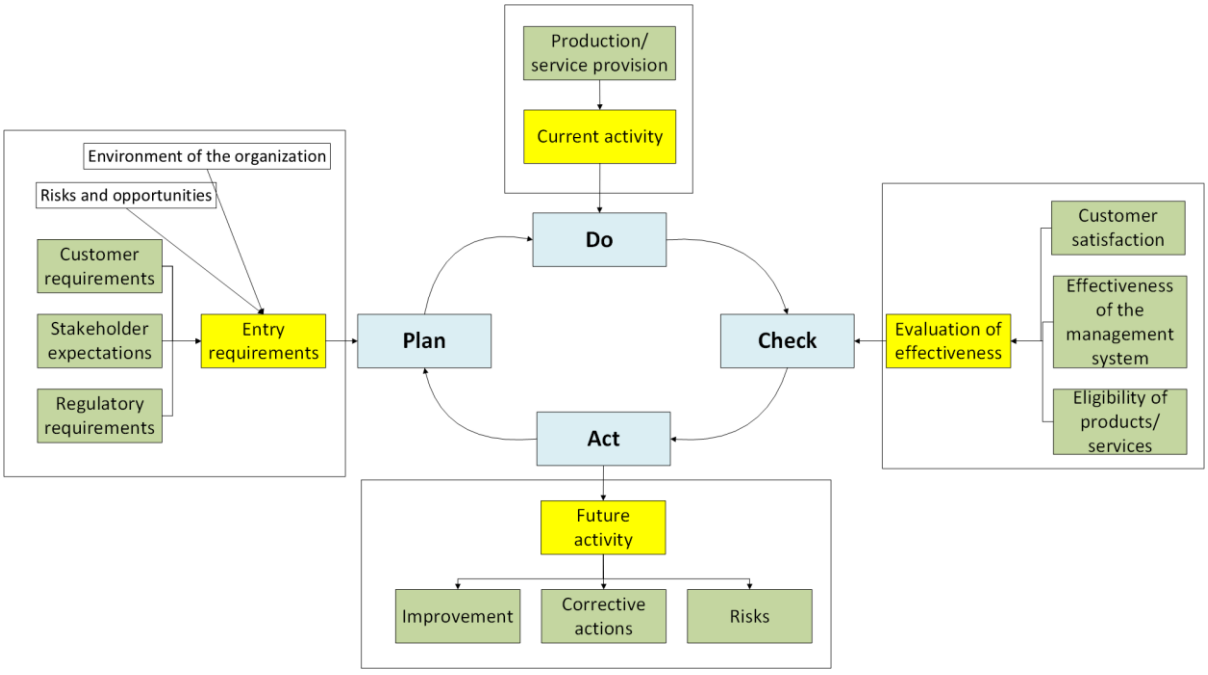

Fig. 5.1 – Cycle PDCA

In addition to the main standards that regulate the requirements for various management systems, the International Organization for Standardization ISO has developed and implemented a number of standards aimed at promoting a better understanding of the requirements, providing guidelines and recommendations for the successful implementation of management systems. An organization cannot in any form declare compliance of its management system with the standards listed below.

The effective implementation of control and evaluation functions at enterprises can be carried out using the core principles of ISO 9001.

As practice shows, the most effective approach to the enterprise management is the process-based approach [7].

The process-based approach involves a clear and systematic identification of all processes, levels of their interactions and their subsequent management, with the goal of achieving planned results.

A process management at enterprises is generally effectively carried out through the application of the PDCA cycle (Plan – Do – Check - Act) [8], [9], [10], [11].

Figure 5.1 illustrates the application of the PDCA cycle at an enterprise.

At a planning stage, an assessment of external requirements is carried out: regulatory requirements, customer requirements, stakeholder expectations, as well as internal requirements, such as the enterprise's capabilities. The results of this assessment serve as the basis for activity planning.

During production or service delivery, an assessment of current activities is conducted: evaluating the quality of products or services, the effectiveness of processes, the effectiveness of a system performance.

The assessment of customer satisfaction, of compliance of products/services with established requirements, of effectiveness of the management system are elements of the «CHECK» stage, aimed at evaluating the overall effectiveness of the enterprise's functioning.

Based on the obtained assessment of the overall effectiveness of the enterprise, a plan for further actions is formulated, aimed at improving the functioning of the enterprise, implementing corrective actions, managing risks.

The PDCA cycle can be characterized as a spiral movement, where the enterprise continuously progresses to a new, higher level.

Figure 5.2 demonstrates the place of the evaluation process within the PDCA cycle.

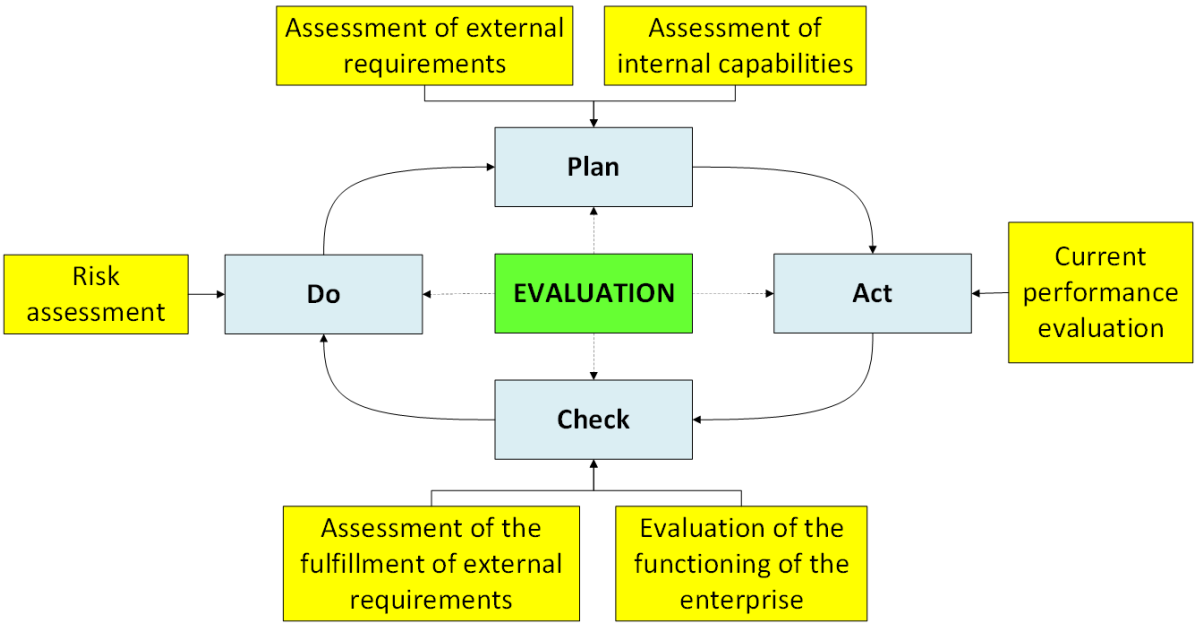

Fig. 5.2 – Evaluation process within the PDCA cycle

As Figure 5.2 shows, the evaluation process is present in varying degrees across all subsystems of the PDCA cycle.

As mentioned earlier, the evaluation process is inextricably linked to the management process and is a part of it. Figure 5.3 presents the main stages of management within the PDCA cycle.

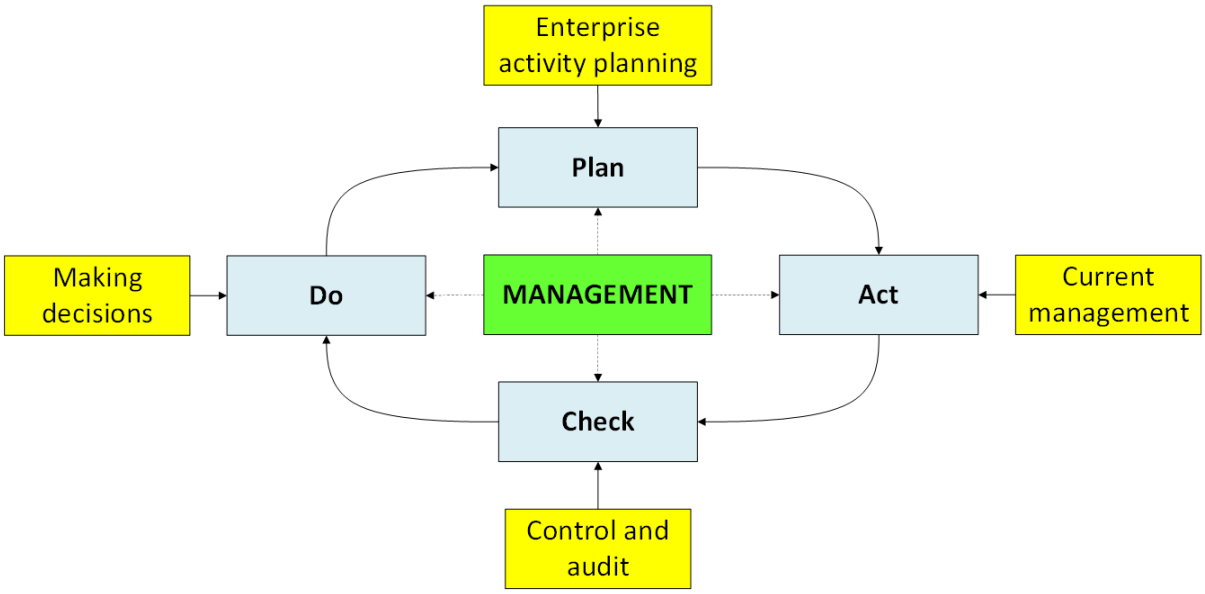

Fig. 5.3 – Management stages within the PDCA cycle

Thus, the evaluation process is not only one of the functions of management, but also a prerequisite for making management decisions and ensuring the further effective functioning of an enterprise (Fig. 5.4).

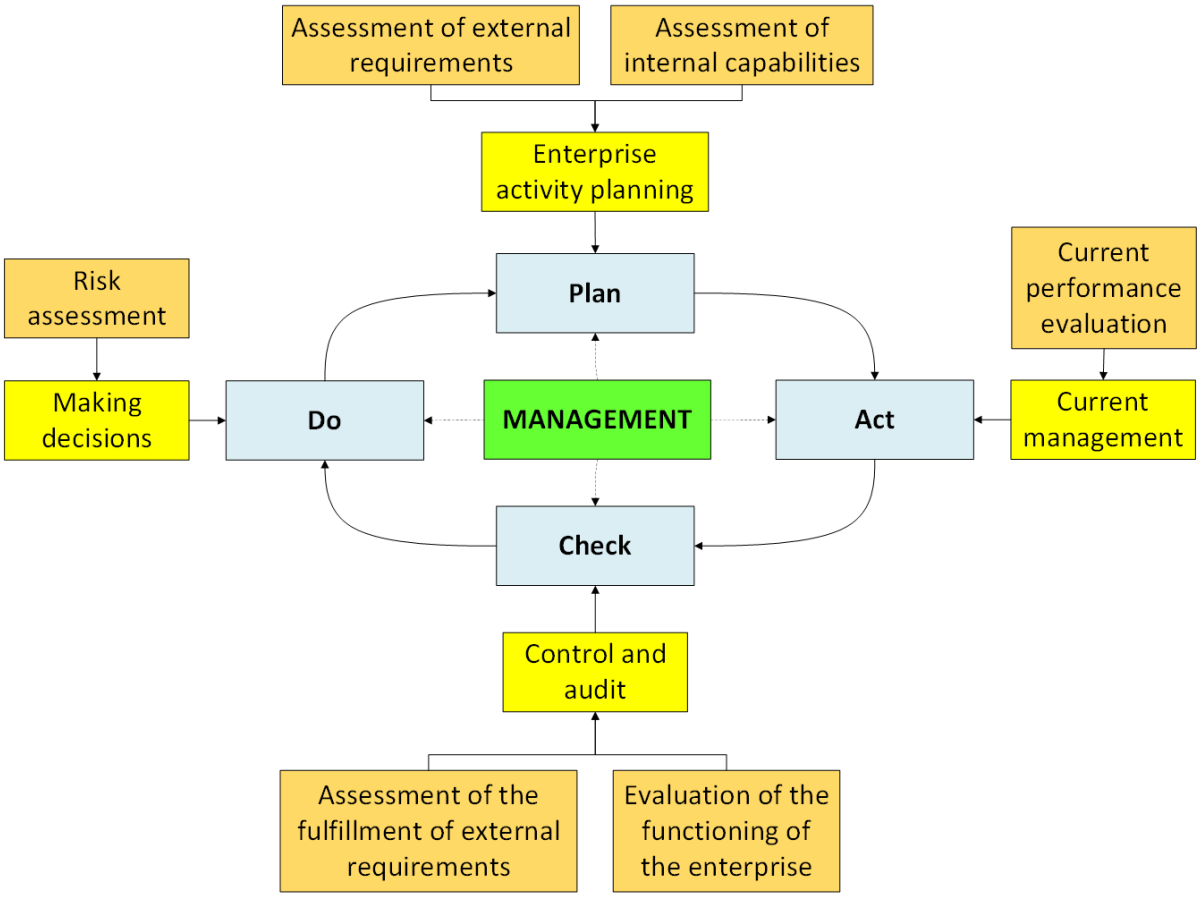

Fig. 5.4 – Complex control and evaluation scheme

As though various types of evaluations are necessary for making effective management decisions (see Fig. 5.4), it is advisable to consider the evaluation methods used in management activities.

5.1. Evaluation methods

During an enterprise business planning, the external requirements are primarily assessed, including customer requirements, stakeholder requirements, as well as various legislative requirements and the company's internal capabilities evaluation that is made in odrer to determine its ability to carry out certain activities (to produce goods and/or to provide specific types of services).

The customer requirements are assessed at the initiation stage of operations. Subsequently, the level of customer satisfaction is evaluated. Similarly, the requirements of stakeholders are examined. The most appropriate way to conduct such evaluations is through surveys, followed by determining the level of satisfaction among consumers of products/services or stakeholders.

ISO 10004 provides the recommendations for determining customer expectations, the methods for evaluating customer satisfaction, a developing of survey questionnaires, an analyzing of the collected data, the using of information related to customer satisfaction. In the standards ISO/TR 10017 and ISO/TR 13425 the statistical methods for analyzing customer expectations and customer satisfaction levels are outlined.

The following methods for evaluating customer requirements and satisfaction level have gained the most widespread use:

- score-based evaluation of satisfaction level [12];
- satisfaction evaluation based on a multi-attribute product model [13];
- calculation of the customer satisfaction index (CSI) [14];
- calculation of the net promoter score (NPS) [15];
- calculation of the quality index (SERVQUAL) [16].

In the references provided above, next to the methods of evaluating customer requirements and satisfaction levels, one can familiarize themselves in detail with the principles of surveying and the methodologies for the corresponding calculations. The development of the survey questionnaire for customers is carried out after selecting the evaluation method, as the chosen survey method influences the list of questions.

In general, it is important to remember that any survey questionnaire, in addition to the main question block, should include the following elements:

- An annotation that requests participation in the survey, provides a brief description of the purpose of the survey, indicates the estimated time required to answer the questions and expresses gratitude for participating in the survey.
- The respondent profile consists of a series of questions aimed at the obtaining of information about the respondent that may be important for the further interpretation of the results: age, gender, field of activity, duration of cooperation with the organization, etc.
- A block of open-ended questions (included if necessary), where respondents have the opportunity to freely provide their suggestions, feedback and recommendations.
- A concluding section in which gratitude is expressed for the time and participation in the survey.

The evaluation of legislative, regulatory and other requirements is conducted based on the review of relevant documents by a group of specialists and by comparing the established requirements with the actual condition (level) of the products/services.

To evaluate the internal capabilities of the enterprise, an analysis of the needs required to ensure the production of goods/services in accordance with the requirements of customers, stakeholders and regulatory documents, is conducted, along with a comparison of these needs with the available resources of the enterprise.

During an ongoing operation, a current evaluation of the enterprise's performance is conducted. This evaluation includes: assessing the availability and adequacy of resources, handling complaints and non-conforming products, evaluating the quality of products/services, and so on. The methods for such evaluations will vary depending on the tasks set, however, they will generally include the statistical collection of relevant information.

Control and audit are the stages in the PDCA cycle that involves two types of evaluations: assessing compliance with external requirements and evaluating the functioning of the enterprise. Overall, this stage can be regarded as conducting an internal audit in accordance with ISO 9001 [ISO 9001]. If, during the planning stage of the enterprise's activities, the evaluation of customer requirements, stakeholder expectations and legislation was carried out, then at this stage, the evaluation of compliance (satisfaction) with these requirements is conducted. The process of evaluating the functioning of the enterprise essentially involves summarizing current activities, identifying potential problems and exploring areas for improvement.

The final stage of the PDCA cycle aims to evaluate risks and to plan corrective and preventive actions to minimize these risks. Risk evaluation is based on prior assessments of the enterprise's functioning and serves as the foundation for planning future activities. Upon completion of this process, the enterprise simultaneously reaches a new level and returns to the first stage of the PDCA cycle. Thus, the PDCA cycle can be described as a continuous spiral movement with ongoing improvements to the management system.

As mentioned earlier, the implementation of a quality management system in accordance with ISO 9001 [ISO 9001] ensures the effective functioning of an enterprise. This standard also provides for a number of evaluations. To assist organizations in identifying the statistical evaluation methods that may be useful during the development, implementation, maintenance and improvement of the quality management system, the ISO/TR 10017 standard was developed, it is intended to provide recommendations and guidance to organizations in considering and selecting statistical methods.

ISO/TR 10017 standard recommends the use of the next statistical methods or their combinations that can help an organization to evaluate its performance:

- descriptive statistics;
- planning of experiment;
- hypothesis testing;
- measurement analysis;
- process capability analysis;
- regression analysis;
- reliability analysis;
- sampling methods;
- simulation modeling;
- statistical process control charts (SPC charts);
- constructing confidence intervals;
- time series analysis.

Examples of the use of key evaluation methods are provided below in the table 5.1.

Table 5.1. Examples of the use of key evaluation methods

Evaluation method	Field of application	Advantages	Limitations and precautions	Application
descriptive statistics	Data summarization	Effective way to present data and share information	Limitations related to sample size	Applicable in all fields where quantitative data is obtained
planning of experiment	Confirmation of compliance with established requirements, investigation of complex systems	High effectiveness and cost-efficiency when studying the impact of a significant number of factors	Certain data variability may occur, extrapolation or interpolation requires caution	Checking products against established requirements
hypothesis testing	During decision-making	Expressing a statement with a known confidence probability	Careful approach to sample formation, taking into account independence and randomness	Verification of product and/or process characteristics, etc.
measurement analysis	Evaluation of the suitability of measurement systems	Quantitative and economical way to select a measuring instrument	Method should be used by qualified specialists	Evaluation of measurement uncertainty, selection of measurement methods, evaluation of measurement quality
process capability analysis	Evaluation of the process capability to deliver results that meet established requirements	Ability to assess the costs to the organization associated with non-conforming products (services)	Applicable only to processes under statistical control	Evaluation of product suppliers and the capability of machines to produce goods
regression analysis	Forecasting values	Identifying relationships between different factors	Challenges in accounting for the influence of factors, issues with data availability	Modeling production characteristics of systems

Evaluation method	Field of application	Advantages	Limitations and precautions	Application
reliability analysis	Forecasting and assessing failure-free operation	Obtaining a quantitative measure of the performance of products (services) until failure	Complexity of assessment in the presence of a significant number of failure types	Verifying that products and services meet established reliability requirements, forecasting reliability indicators
sampling methods	Quality control of products and services	Resource savings	Careful approach to sample formation, taking into account independence and randomness	Market research, incoming and outgoing product inspection
simulation modeling	Complex or little-known objects	Resource savings, the ability to solve complex problems	It can always replace real research and experiments	Applicable in all fields
statistical process control charts (SPC charts)	Detection of changes in processes	Ability to identify changes in processes and respond to them in a timely manner	Used with caution for short-term processes	Detection of non-conforming products
constructing confidence intervals	In the case of combining many individual components into one module	Ability to use broader tolerances, allowing for the use of simpler and more cost-effective production methods	Complexity in application if the product is in a development stage	Applicable in the machine engineering, energy and chemical industries
time series analysis	Forecasting the future, control area, automated processes	Ability to compare planned indicators with forecasted ones, understanding causal models	Challenges in accounting for the influence of factors, issues with data availability	Evaluation of customer complaints, non-conforming products, test results, forecasting resource needs, etc.

Table 5.1 provides a brief description of the evaluation methods, and a more detailed characterization of these methods is presented in ISO 10017.

The list of evaluation methods presented in table 1 is not exhaustive, an organization may apply other evaluation methods if it considers them acceptable.

It is important to note that management processes and quality management systems are quite dynamic and develop rapidly, so periodic staff training in quality and management systems is crucial for the successful functioning of the enterprise.

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Chapter 6. Ecological aspects and sustainability

6.1. Introduction to Ecology and Sustainability

In the 21st century, the conversation around ecology and sustainability has taken center stage in both global and local forums. The health of our planet, the well-being of future generations, and the survival of countless species hinge on how we approach these critical issues today. Ecology, the study of interactions among organisms and their environment, provides the foundational knowledge needed to understand the complex web of life on Earth [1]. Sustainability, on the other hand, is the guiding principle that seeks to meet the needs of the present without compromising the ability of future generations to meet their own needs [2,3,4].

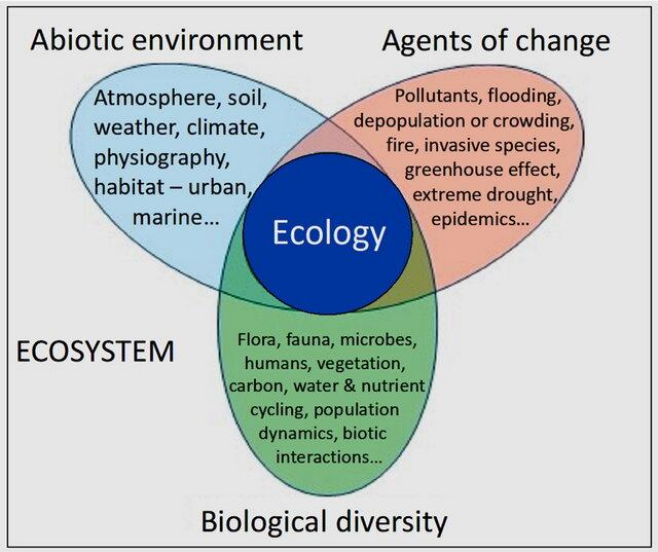

Fig. 6.1. Ecology

Historically, human activities have often prioritized short-term gains over long-term ecological balance [5,6]. However, as the impact of climate change, pollution, and resource depletion becomes more evident, the need for sustainable practices has never been more urgent [7,8]. This chapter explores the intricate relationship between ecological systems and sustainability, examining how we can harmonize human activities with the natural world to create a viable future for all life forms.

Ecology is a vast and intricate field, encompassing everything from microscopic organisms in the soil to the global cycles that govern climate patterns. At its core, ecology studies ecosystems—communities of living organisms interacting with each other and their physical environment [1]. These interactions are vital for the maintenance of life on Earth, providing essential services such as air purification, water filtration, and nutrient cycling.

Ecosystems and Biodiversity

Biodiversity, or the variety of life within an ecosystem, is a crucial indicator of ecological health. High biodiversity often equates to resilient ecosystems capable of withstanding disturbances like disease outbreaks or climate shifts. Conversely, low biodiversity can lead to ecosystem collapse, where the loss of key species triggers a domino effect that can be catastrophic.

The protection of biodiversity is a cornerstone of sustainability. For example, tropical rainforests, which harbor an immense variety of plant and animal species, are vital for regulating global climate and supporting indigenous communities. However, deforestation for

agriculture and logging has decimated these ecosystems, highlighting the urgent need for sustainable land management practices.

Natural Resources and Their Management

Natural resources such as water, soil, minerals, and forests—are the building blocks of human civilization [9,10]. Yet, these resources are finite and increasingly under pressure from over-exploitation. Sustainable management of natural resources involves balancing human needs with the preservation of ecosystems. This might include implementing practices like sustainable forestry, water conservation, and soil regeneration techniques.

Human Impact on the Environment

The modern era has seen unprecedented levels of industrialization, urbanization, and population growth, all of which have had profound impacts on the environment. Pollution, deforestation, and climate change are some of the most pressing ecological challenges we face today [11].

Pollution: Air, Water, and Soil

Pollution is a major environmental issue that affects all forms of life. Air pollution, largely driven by the burning of fossil fuels, contributes to respiratory diseases in humans and acid rain, which harms ecosystems. Water pollution, caused by agricultural runoff, industrial discharges, and plastic waste, contaminates drinking water sources and disrupts aquatic ecosystems. Soil pollution, often a result of pesticide use and industrial waste, reduces soil fertility and can lead to toxic crops [12,13].

Addressing pollution requires a multi-faceted approach, including the adoption of cleaner technologies, stricter regulatory frameworks, and public awareness campaigns. For instance, cities that have implemented comprehensive recycling programs and transitioned to renewable energy sources have seen significant reductions in pollution levels.

6.2. From Ecology to Sustainability: A Journey Towards a Greener Future. Understanding the Connection

Ecology, the study of the relationships between organisms and their environments, provides the foundation for understanding sustainability. Sustainability, in essence, is about meeting the needs of the present without compromising the ability of future generations to meet their own needs. It's a delicate balancing act that requires careful consideration of ecological factors [4,14].

Key Ecological Concerns

- Biodiversity Loss: The decline of species and ecosystems due to human activities such as habitat destruction, pollution, and climate change [15].
- Climate Change: The long-term shift in global weather patterns, primarily caused by human activities, with far-reaching ecological consequences.
- Pollution: Contamination of air, water, and soil with harmful substances, leading to degradation of ecosystems and threats to human health [12,13,15].
- Resource Depletion: Overexploitation of natural resources, such as forests, fisheries, and minerals, leading to scarcity and ecological imbalances.

Sustainability Principles

- **Reduce, Reuse, Recycle:** Minimizing waste and conserving resources through these practices [16].
- **Renewable Energy:** Transitioning to energy sources that can be replenished naturally, such as solar, wind, and hydro power [17].
- **Sustainable Industry:** Promoting industrial practices that protect the environment, conserve resources, and maintain soil health.
- **Conservation and Restoration:** Protecting ecosystems and restoring degraded areas to maintain biodiversity and ecosystem services [16].

Challenges and Opportunities

- **Economic Growth vs. Environmental Protection:** Balancing the need for economic development with the preservation of the environment.
- **Technological Advancements:** Harnessing technology to develop sustainable solutions and improve efficiency.
- **Policy and Governance:** Implementing effective policies and regulations to promote sustainability.
- **Public Awareness and Engagement:** Raising awareness about environmental issues and fostering public participation in sustainable initiatives.

The Path to Sustainability

- **Individual Actions:** Reducing personal carbon footprint, conserving resources, and supporting sustainable businesses.
- **Business Practices:** Adopting sustainable practices, investing in green technologies, and promoting corporate social responsibility.
- **Government Policies:** Implementing environmental regulations, promoting renewable energy, and investing in sustainable infrastructure.
- **International Cooperation:** Addressing global challenges through international agreements and collaborations.

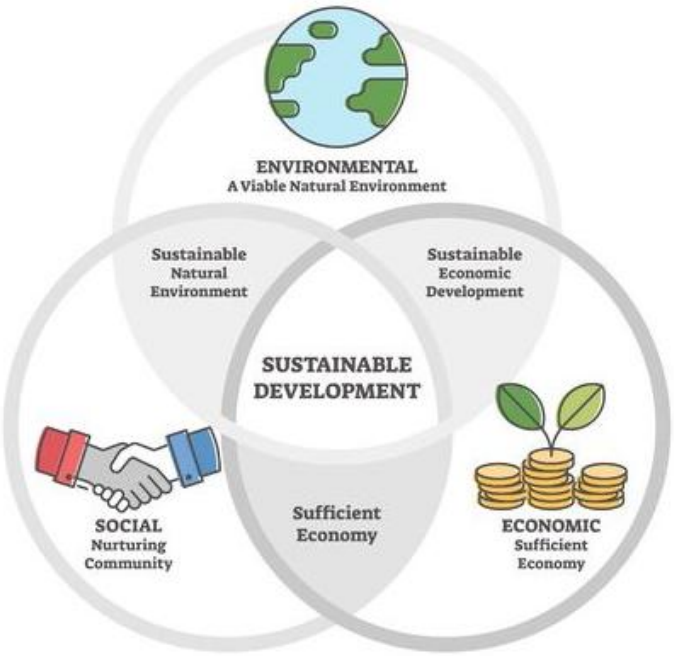

Fig. 6.2. Sustainability framework

The United Nations defines sustainable development as meeting present needs without compromising future generations' ability to meet their own needs: *"Sustainable development has been defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. For sustainable development to be achieved, it is crucial to harmonize three core elements: economic growth, social inclusion and environmental protection. These elements are interconnected, and all are crucial for the well-being of individuals and societies."* [3,4,14]. Applying this definition, we evaluate sustainability in the consumer products and retail sector specifically along these environmental, social, and economic dimensions [7]

6.3. Ecological Aspects and Sustainability in Industry

The intersection of industry and ecology presents a complex landscape where the pursuit of economic growth often clashes with the need to protect the environment. Sustainability, a concept that seeks to balance economic development with environmental protection and social equity, has become increasingly important in recent years. This paper will explore the ecological aspects of industrial activities and discuss strategies for achieving sustainability in various sectors [18,19].

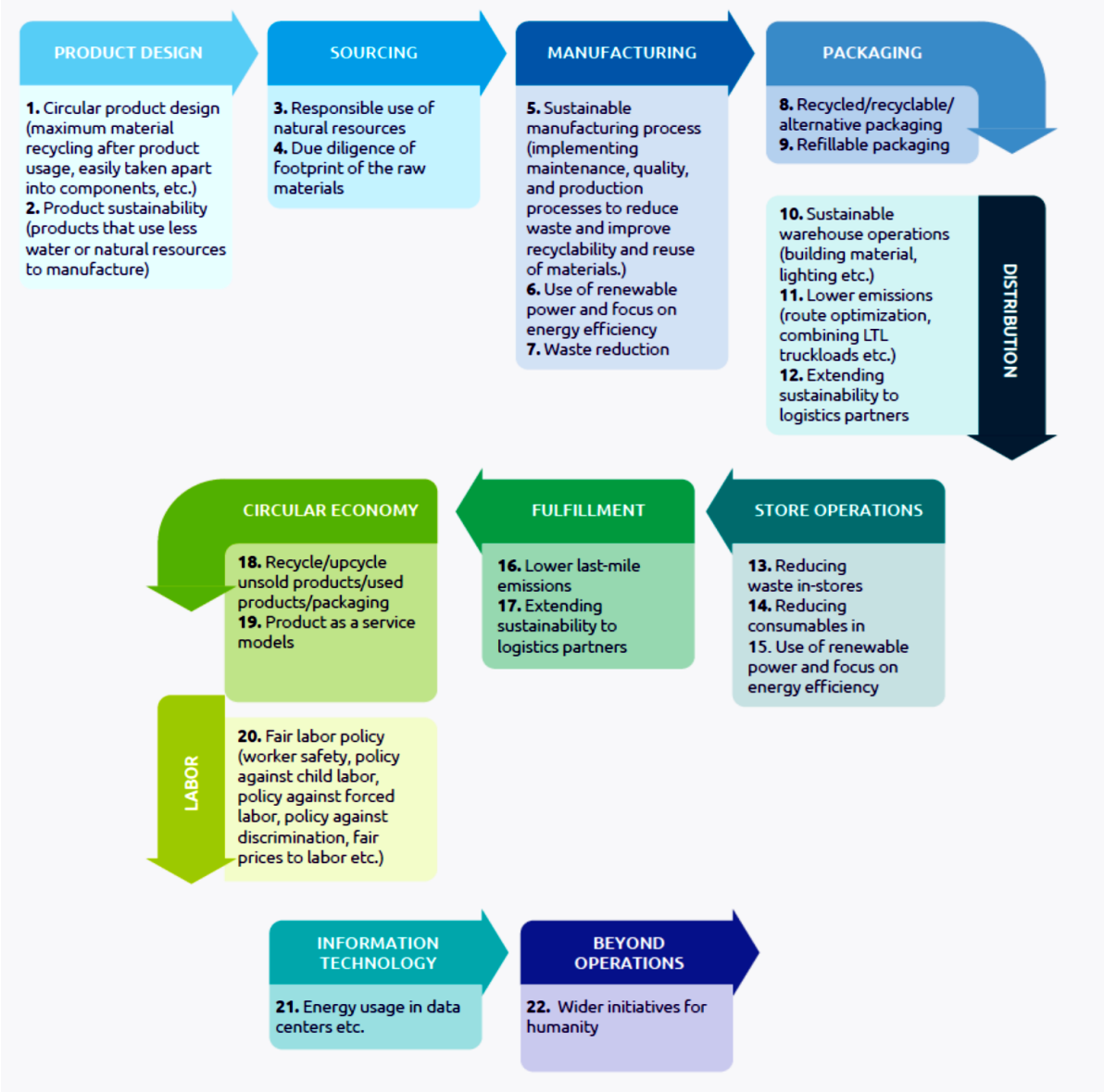

Fig. 6.3. Sustainability across the value chain [7]

Ecological Challenges in the Automotive Industry

The automotive industry is one of the most significant sectors in the global economy, driving innovation, employment, and mobility for billions of people. However, the environmental footprint of this industry is substantial, making the integration of ecological aspects and sustainability a critical priority. With the world grappling with climate change, resource depletion, and pollution, the automotive industry stands at a crossroads where sustainability is not just an option but a necessity [20,21].

The environmental impact of automobiles spans their entire lifecycle—from the extraction of raw materials to manufacturing, usage, and eventual disposal. Traditional internal combustion engine (ICE) vehicles contribute significantly to greenhouse gas emissions, air pollution, and resource depletion. As the global community becomes increasingly aware of these challenges, the automotive industry is being pushed to innovate and adopt sustainable practices that minimize its ecological footprint [22].

The environmental impact of the automotive industry is multi-faceted, affecting the planet in several ways:

1. 1.*Greenhouse Gas Emissions*. The transportation sector is one of the largest contributors to global greenhouse gas (GHG) emissions, with traditional vehicles being the primary culprits. Carbon dioxide (CO2) emissions from the burning of fossil fuels in internal combustion engines contribute significantly to global warming and climate change. Reducing GHG emissions from vehicles is one of the most pressing challenges for the industry, necessitating a shift towards low-emission and zero-emission technologies [1,22].
2. *Resource Depletion*. The production of vehicles requires vast amounts of raw materials, including metals like steel, aluminum, and lithium, as well as water and energy. The extraction and processing of these resources have significant environmental impacts, including habitat destruction, water pollution, and energy consumption. Moreover, the growing demand for electric vehicles (EVs) has led to increased pressure on resources such as lithium and cobalt, which are essential for battery production [23].
3. *Air and Water Pollution*. Automobile manufacturing and usage contribute to air and water pollution through emissions of harmful substances like nitrogen oxides (NOx), sulfur dioxide (SO_2), and particulate matter (PM). These pollutants can cause respiratory problems, acid rain, and water contamination, adversely affecting human health and ecosystems. Additionally, the automotive industry's use of toxic chemicals and solvents in production processes can lead to water pollution if not managed properly [24].
4. *Waste Generation*. The automotive industry generates significant amounts of waste, both during the manufacturing process and at the end of a vehicle's life. Manufacturing waste includes scrap metal, plastics, and chemicals, while end-of-life vehicles (ELVs) contribute to the growing problem of automotive waste. Sustainable waste management practices, such as recycling and reusing materials, are essential to reduce the industry's environmental impact.

Sustainable Manufacturing Practices

To mitigate the ecological challenges discussed above, the automotive industry is increasingly adopting sustainable manufacturing practices [19,23]:

1. *Adoption of Lean Manufacturing Techniques***.** Lean manufacturing focuses on minimizing waste and maximizing efficiency in the production process. By streamlining operations, reducing energy consumption, and optimizing resource use, automotive manufacturers can significantly lower their environmental impact. Lean principles also encourage continuous improvement, making sustainability a core component of the production process [23].
2. *Energy-Efficient Production Processes***.** Manufacturers are investing in energy-efficient technologies and practices to reduce their carbon footprint. This includes the use of energy-efficient machinery, lighting, and heating systems, as well as the implementation of energy management systems to monitor and optimize energy usage. Some companies are also exploring innovative techniques like 3D printing, which can reduce material waste and energy consumption [19,25].
3. *Use of Recycled and Sustainable Materials***.** The automotive industry is increasingly turning to recycled and sustainable materials to reduce its reliance on virgin resources. For example, manufacturers are using recycled steel and aluminum, bioplastics, and natural fibers in vehicle production. These materials not only reduce the environmental impact of resource extraction but also contribute to a circular economy, where materials are reused and recycled rather than discarded [25,26].

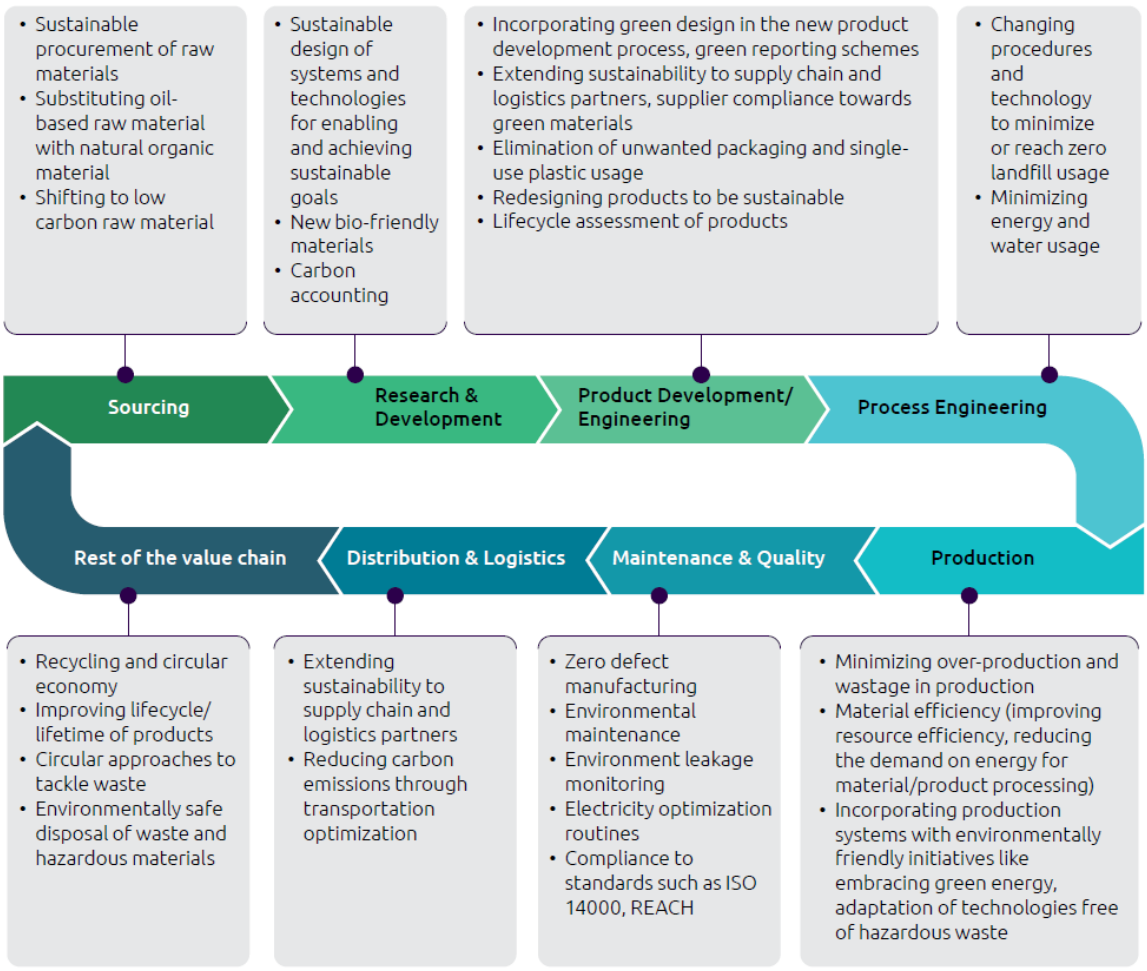

Fig. 6.4. Sustainable manufacturing practices across the manufacturing operations value chain [19]

4. *Waste Reduction and Circular Economy in Manufacturing.* A circular economy approach is being embraced by the automotive industry to minimize waste and promote resource efficiency. This involves designing vehicles for disassembly and recycling, as well as creating closed-loop systems where materials are continuously reused. By reducing waste and maximizing the use of resources, the industry can significantly lower its environmental impact and contribute to a more sustainable future [27,28].

6.4. Circular Economy

The concept of a circular economy aims to shift away from the traditional linear model of production and consumption, which heavily relies on finite resources and generates significant waste. Instead, a circular economy seeks to create a regenerative system where products, materials, and resources are kept in use for as long as possible. The circular model emphasizes reducing waste, reusing and recycling materials, and regenerating natural systems. This shift is crucial for addressing the pressing challenges of resource depletion, environmental degradation, and climate change [16,27].

Fig. 6.5. Defining circular economy [27]

Consumer Awareness and Behaviors

It stands outa growing consumer awareness of the environmental impacts associated with waste and resource depletion. Consumers are particularly concerned about issues like food and plastic waste, with a significant majority acknowledging the scale of these problems. Moreover, there is a strong consumer interest in adopting more sustainable consumption practices. Many consumers express a willingness to reduce consumption, buy durable products, and engage in recycling and repurposing activities. However, there are practical challenges and motivational barriers that hinder the widespread adoption of circular practices, such as the perceived inconvenience and cost associated with renting or leasing products [18].

Organizational Challenges and Opportunities

Despite growing consumer expectations, many organizations are still in the early stages of integrating circular economy principles into their operations. The report finds that while some companies are making progress, there is a general lack of investment in circular initiatives. Organizations need to rethink their business models, focusing on alternative revenue streams that are not solely dependent on product sales. Embracing circular design principles, enhancing collaboration across the value chain, and leveraging emerging technologies such as IoT, blockchain, and AI are critical steps for businesses to advance in their circular economy journeys [25].

Benefits of the Circular Economy

The circular economy offers significant environmental and economic benefits. By reducing reliance on raw materials and minimizing waste, organizations can lower costs and create new economic opportunities. For example, companies like Philips and Ford have seen substantial revenue growth from green and circular products. Additionally, the European Commission estimates that greater efficiency in the supply chain could lead to significant savings for European industries by 2030 [4,27].

The Role of Consumers

Consumers play a vital role in enabling the transition to a circular economy. Their purchasing decisions, usage patterns, and disposal behaviors can significantly influence the success of circular initiatives. The report underscores the need for organizations to educate and engage consumers, making it easier for them to adopt circular practices. By providing more

information, building trust, and fostering a circular mindset, businesses can encourage greater consumer participation in the circular economy.

For these reasons it is required the urgency of transitioning to a circular economy. This shift is not only necessary for sustainable development but also offers a pathway to mitigate the impacts of climate change and resource scarcity. Organizations, consumers, and governments must work together to drive this transition, ensuring a sustainable future for all [27].

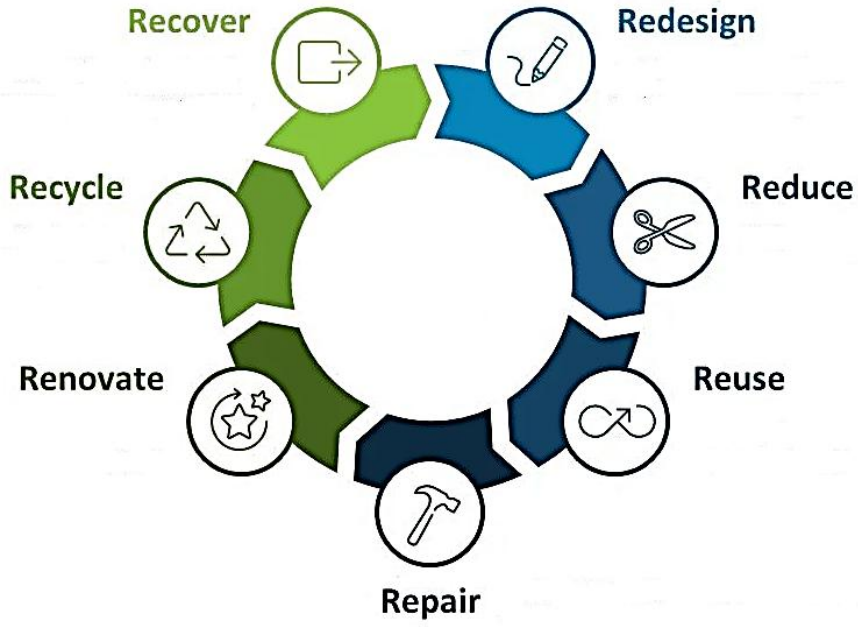

Fig. 6.6. Principles of circular economy [27]

The Future of Sustainable Automotive

The automotive industry is a significant contributor to environmental issues due to its dependence on petroleum-based fuels, high vehicle ownership, and substantial global growth. The industry faces pressure to reduce its environmental impact and develop sustainable vehicles. Designing for sustainability involves balancing social, ethical, and environmental issues alongside economic factors. It aims to meet the needs of both businesses and society while protecting ecosystems.

The automotive industry faces growing pressure to address sustainability due to rising climate concerns, stricter regulations, and stakeholder demands. Despite the industry's awareness of sustainability as a strategic issue, the actual implementation of initiatives remains fragmented and underfunded. A significant investment of $50 billion is required over the next five years to meet long-term sustainability targets, beyond the current investments in electric vehicles (EVs), autonomous vehicles (AVs), and digital mobility services. Companies like Volvo and GM are aggressively pursuing electrification and net-zero targets, yet challenges such as sustainable supply chains and the environmental impact of EV battery production remain significant [21,22,23].

Current State of Sustainability in Automotive. The progress on sustainability within the automotive industry has been slow over the past three years, with the industry not on track to meet the Paris Agreement targets. Investment in sustainability has decreased from 1.22% of revenue in 2019 to 0.85% currently, with larger organizations reducing their spending more

than smaller ones. The implementation levels for key sustainability initiatives, such as sustainable supply chains and environmentally responsible sourcing, have either seen marginal improvements or declines. Less than 10% of automotive organizations are classified as "Sustainability Leaders," who are advanced in both their sustainability strategies and implementation. In contrast, 62% of organizations fall into the "Laggards" category, showing limited progress in both areas [23].

Challenges to Implementation. Several challenges are hindering the implementation of sustainability initiatives:

- Integration with Day-to-Day activities: The biggest challenge is linking sustainability with everyday operations. 73% of executives report that the adoption of sustainability practices in daily activities has either stagnated or only increased marginally.
- Performance management: There is poor integration of sustainability key performance indicators (KPIs) into performance management systems, particularly at lower organizational levels. Only 10% of organizations align performance objectives with sustainability goals for non-managerial employees.
- Data management: Difficulty in collecting, managing, and analyzing sustainability data is another significant barrier. Only 12% of organizations have fully deployed platforms to measure, monitor, and report on sustainability initiatives [25].

Benefits for Sustainability Leaders. Organizations identified as "Sustainability Leaders" have seen significant benefits, including a 9% improvement in emissions since 2018 compared to a 5% industry average. These leaders are on track to meet the Paris Agreement target by reducing greenhouse gas (GHG) emissions by 35% by 2030, compared to a projected 19% reduction across the industry. Additionally, these organizations have strengthened their employer brand, seeing an 18% increase in their attractiveness to talent due to their sustainability efforts, compared to a 10% increase for the rest of the industry [19].

Recommendations for Accelerating Sustainability. To accelerate sustainability efforts and meet regulatory targets, the automotive industry needs to:

- Innovate in products and services: Focus on faster decarbonization of vehicle fleets, develop new services and business models, and ensure the sustainability of EV batteries throughout their lifecycle.
- Enhance processes: Integrate sustainability into day-to-day activities, incorporate sustainable design principles, and adopt new tools for managing the transition to net zero.
- Focus on people: Align organizational objectives with sustainability goals, upskill the workforce, and foster a culture of collaboration to drive systemic sustainability changes.

Key Areas of Focus:

- Sustainable R&D and Product Development: Reducing environmental impact through design and recyclability.
- Product Sustainability: Transitioning to fuel-efficient or electric vehicles.
- Sustainable Supply Chain: Environmentally conscious operations in logistics and sourcing.
- Sustainable Manufacturing: Reducing waste and improving recyclability.
- Circular Economy: Maximizing resource use through re-use and regenerative practices.

- Emissions Management: Addressing Scope 1, 2, and 3 emissions, with a focus on indirect emissions from the value chain.

Automotive Life Cycle Assessment (LCA)

- Life Cycle Assessment (LCA) is a key tool used to evaluate the environmental impacts of a vehicle throughout its life cycle, from raw material extraction to disposal.
- LCA studies help identify areas where environmental improvements can be made, such as reducing emissions, energy consumption, and waste generation [29].

Design for Sustainability (DfS)

- Design for Sustainability (DfS) in the automotive industry involves incorporating sustainability principles into the design process. It includes strategies like:
  - Design for Manufacturing (DfM): Focuses on improving manufacturing processes to reduce resource use, energy consumption, and waste.
  - Design for Recyclability: Ensures that vehicle components are easily recyclable at the end of their life.
  - Design to Minimize Material Usage: Involves using lightweight materials and optimizing material usage to reduce the vehicle's overall environmental impact.
  - Design for Durability: Aims to increase the lifespan of vehicles and their components, reducing the need for frequent replacements.
  - Design for Energy Efficiency: Focuses on improving the vehicle's energy efficiency, both in terms of fuel consumption and overall energy use during manufacturing and operation [29].

Vehicle Design for End-of-Life

- The end-of-life phase of a vehicle's life cycle is crucial for sustainability. Effective design can ensure that vehicles are easier to disassemble, recycle, and dispose of in an environmentally friendly manner.
- Strategies include designing vehicles with fewer materials, reducing hazardous substances, and ensuring that components can be easily separated for recycling [29].

Fuel Economy and Air Emissions

- Improving fuel economy and reducing air emissions are critical aspects of sustainable vehicle design. This includes developing more efficient engines, using alternative fuels, and reducing the overall weight of vehicles.
- Regulations and standards, such as those set by governments, play a significant role in driving improvements in fuel economy and emissions.

Automotive Design and Material Selection for Sustainability

- Material selection is a critical aspect of sustainable vehicle design. The use of sustainable materials, such as recycled or renewable materials, can significantly reduce the environmental impact of a vehicle.
- Various models and tools are used to assess the sustainability of materials and guide decision-making in the design process.

Sustainability Measures and Models in the Automotive Industry

- The automotive industry uses various sustainability measures and models to track and report on its environmental performance. Examples include Environmental Product Declarations (EPD) from Volvo and the Product Sustainability Index (PSI) from Ford of Europe.
- These measures help companies evaluate the environmental impact of their vehicles and identify areas for improvement.

The automotive industry is making strides towards sustainability by incorporating various strategies into the design and manufacturing processes. Life cycle assessment, design for sustainability, and material selection are key areas of focus.

Ongoing efforts are needed to further reduce the environmental impact of vehicles, with a strong emphasis on innovation and the adoption of sustainable practices throughout the industry.

Thus, while some organizations are making strides towards sustainability, the overall industry must accelerate its efforts to meet global targets and address the challenges posed by climate change and regulatory demands [29].

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Chapter 7. Information Technology Integrated (Digital) Information Systems

7.1. Modern information technologies for business support

The current business environment is one of fast technological changes and increased competitiveness. The tools that enable organizations to re-engineer and improve operations for productivity gains and a competitive advantage in such an environment are information technologies. With businesses having to deal with the effects of globalization, remote work, and growing need for swiftness plus efficiency IT has transitioned from just being a support function but an enabler channeling innovation and growth.

Information technologies enable businesses to automate routine tasks, analyze vast amounts of data in real time, and facilitate seamless communication and collaboration across geographically dispersed teams. They also provide the infrastructure necessary for scaling operations, managing resources efficiently, and ensuring that organizations can adapt quickly to changing market conditions. In essence, modern information technologies are not just tools for improving business operations—they are the backbone of digital transformation, helping companies reimagine their business models and value propositions in a digital-first world.

Of all these technologies, the Microsoft ecosystem is at the forefront of delivering far-reaching integrated solutions that can meet virtually any type of business need. The set of tools and platforms from Microsoft—comprising cloud computing, artificial intelligence, data analysis, and collaboration technologies—is aimed at helping companies, both big and small, to bring innovation and efficiency without having to be heavily skilled in technology. These tools provide an uncommon blend of being easy to work with yet robust so that technical staff as well as general users can effectively apply advanced technologies in addressing intricate business issues.

In this section, we explore key components of the Microsoft platform that play a vital role in supporting modern businesses: MS Power Platform, MS SharePoint, MS Power Automate, and MS AI-Power. These technologies not only enable businesses to meet their immediate operational needs but also position them to capitalize on future opportunities by creating a flexible, scalable, and resilient digital infrastructure. As organizations continue to navigate the complexities of the digital age, the ability to leverage these tools effectively will increasingly become a key determinant of success.

7.1.1. MS power platform

Developed by Microsoft, the modern and unique Power Platform combines four innovative applications: Microsoft Power BI, Microsoft PowerApps, Microsoft Power Automate (Flow), and Power Virtual Agents, which allow real-time analysis, visualization, and automation of data acquisition in any dimension required by the business [1].

The MS Power Platform is a comprehensive suite of tools designed to empower users—ranging from developers to business analysts - to create applications, automate workflows, and analyze data with minimal coding. This platform represents a cornerstone of Microsoft's broader vision to democratize access to powerful digital tools. By making these technologies accessible to both technical and non-technical users, Microsoft enables businesses of all sizes to innovate, optimize their operations, and remain competitive in an increasingly digital world.

The Power Platform is composed of four key elements: Power BI, Power Apps, Power Automate, and Power Virtual Agents. While each of these tools is purposely built to address unique business needs, they are also deeply integrated and allow a user to create end-to-end

extensive solutions resulting in increased productivity that drive efficiency and under opportunistic decision-making.

Power BI is just what you need for robust business intelligence; users can transform raw data into interactive dashboards and reports. Power BI supports quite a number of data sources, from Excel spreadsheets to very complex databases and to cloud-based sources like Azure and on-premises SQL servers. Such flexibility allows businesses to centralize aggregated data across the organization for deep dives into operations.

One of the key strengths of Power BI is its user-friendly, drag-and-drop interface, which makes it accessible to users with varying levels of technical expertise. Users can create complex data visualizations without needing to write code, making it possible for business analysts and other non-technical staff to participate in data-driven decision-making. Additionally, Power BI's support for natural language queries allows users to interact with their data in a more intuitive way. By simply typing a question in plain English, users can quickly generate visualizations that answer their business queries, making data analysis more accessible and efficient.

Apart from being easy to use, it has more advanced features that could meet the data analysis requirements of more advanced users. For example, it has data modeling capabilities where users can create relationships between different datasets and create complex calculations using Data Analysis Expressions.

Data Analysis Expressions (DAX) is a library of functions and operators that can be combined to build formulas and expressions in Power BI, Analysis Services, and Power Pivot in Excel data models[2].

It also supports real-time data streaming, allowing its users to watch key metrics and KPIs take place live. This is important for making time-sensitive decisions in areas like finance, logistics, and manufacturing based on what is currently happening.

Power Apps is another critical component of the Power Platform, enabling users to build custom applications without needing to write extensive code. This low-code development environment is particularly valuable for organizations that have unique business processes that cannot be fully supported by off-the-shelf software. With Power Apps, users can create custom applications tailored to their specific needs, whether it’s a mobile app for field workers, a customer-facing portal, or an internal tool for managing operations.

Power Apps can work with a lot of data sources and services, making it very easy to use both within and outside the Microsoft ecosystem. For example, a firm could use Power Apps to create a mobile app where its field workers report issues on equipment which is then updated in real-time within an ERP system already in place at the company; this is achieved by connecting these two applications. The final effect is that processes become more effective due to reduction in manual work for entering data, decrease in mistakes, and cutting down on operational efficiency leaks.

Besides, custom business logic can be further supported by Power Apps through Power Automate and Azure Functions. Allowing the developers to extend their applications' functionality beyond what is offered in the low-code environment. This brings a lot of versatility to Power Apps. Applications developed can range from simple forms and workflows up to very complex, enterprise-grade apps that do not run short of features based on this low-code environment.

Power Automate [3] is designed to streamline business processes by automating repetitive tasks. The tool connects to over 300 different applications and services, allowing users to create workflows that integrate multiple systems and automate tasks across these platforms. Power

Automate's flexibility and ease of use make it an ideal solution for businesses looking to improve efficiency and reduce the manual workload.

Users have the flexibility to begin automating their workflows in two distinct ways: by starting from scratch with a blank project or by leveraging a pre-built template. This versatility allows users to tailor their automation experience according to their specific needs and level of expertise.

Starting from a blank project offers complete freedom to design custom workflows from the ground up, making it ideal for more complex or unique automation scenarios. On the other hand, templates provide a helpful starting point, especially for common tasks or those new to automation, by offering pre-configured workflows that can be easily modified and deployed.

As shown in Figure 7.1, users can choose between these two options when creating a new flow, enabling them to either build a fully customized solution or quickly adapt a template to meet their requirements. This dual approach ensures that Power Automate can cater to both novice users and advanced professionals, making workflow automation accessible and efficient for a wide range of scenarios.

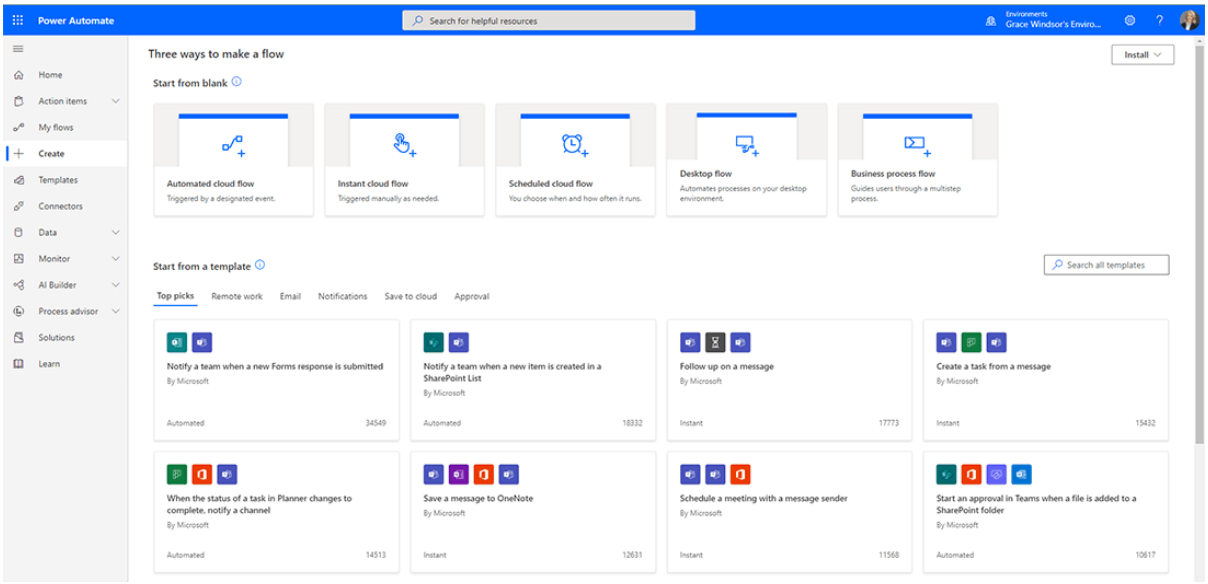

Figure 7.1. Power Automate dashboard [4]

Take, for instance, a workflow in Power Automate that has the capability to produce a report whenever a new row is added to a spreadsheet. It can be related with more steps, like sending an email notification when some specific condition within the CRM system is met, updating records in a database, or even initiating actions in third-party applications such as Salesforce or Google Drive. The AI Builder integration with Power Automate further enriches its functional capabilities by allowing users to bring machine learning models into their workflows. This results in more advanced automation, like classifying emails automatically or extracting information from documents based on some pre-set criteria — even predicting outcomes from historical data.

Power Virtual Agents allows users to create intelligent chatbots without needing to write code. These bots can be deployed across multiple channels, including websites, social media platforms, and messaging apps. Power Virtual Agents are designed to handle a wide range of tasks, from answering frequently asked questions to guiding users through complex processes. This capability is particularly valuable in customer service environments, where chatbots can

provide instant support to users, reducing the need for human intervention and allowing support teams to focus on more complex issues.

The integration of Power Virtual Agents with other Microsoft services, such as Dynamics 365 and Azure Cognitive Services, enables businesses to create highly sophisticated bots that can understand natural language, process complex requests, and provide personalized responses. For example, a bot created with Power Virtual Agents could be integrated with a company's CRM system, allowing it to access customer data and provide tailored responses based on the customer's history and preferences. This not only enhances the customer experience but also improves the efficiency of the support process.

When all automation capabilities are fully utilized, the impact on business processes can be substantial. As shown in Figure 7.2, an expense reporting process can be significantly improved using Power Automate. By automating data entries, streamlining approvals, and optimizing resource allocation, the process enhances throughput and overall efficiency, demonstrating the power of automation in driving business performance.

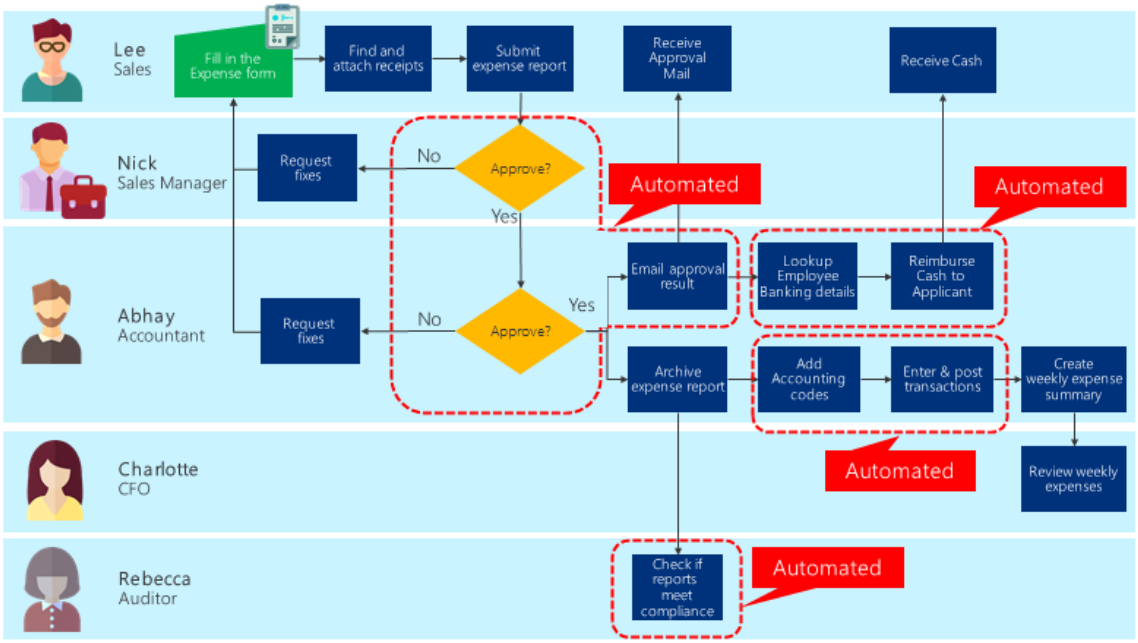

Figure. 7.2. Example of workflow automation diagram by Power Automate [5]

One of the key strengths of the Power Platform is its seamless integration with other Microsoft services, such as Dynamics 365, Azure, and Office 365. This integration allows businesses to create end-to-end solutions that span multiple systems, enabling seamless workflows and processes. For example, data collected through a Power App could be analyzed in Power BI, with the results automatically triggering actions in Dynamics 365 via Power Automate. This level of integration ensures that data flows smoothly between systems, reducing the risk of errors and ensuring that all parts of the business are aligned.

The capability to integrate with third-party applications through connectors further extends the platform. Businesses can connect the Power Platform with their systems, both cloud or on-premises, standard and personalized to create specially functional, customized solutions for what they need. This flexibility is very valuable for many companies that have invested in legacy systems but still want to take advantage of modern applications that are based in the cloud.

The Power Platform has seen wide adoption in different industries, proving its versatility and how effective it can be. A case in point is how a global manufacturing company used Power Apps to build a mobile application that allowed its field workers to report equipment issues at that time, with the application integrating into the company's existing ERP system in real-time update support tickets and reducing time to resolution. It did improve operational efficiency but also contributed as far as this firm's ability to maintain its equipment and bring downtime down is concerned.

Similarly, a financial services firm used Power BI to create dashboards that provide real-time insights into key performance metrics, enabling managers to make data-driven decisions that improve business outcomes. By leveraging the capabilities of Power BI, the firm was able to monitor its operations more effectively, identify trends and opportunities, and respond to changes in the market with greater agility.

The adoption of the Power Platform by companies across diverse industries highlights its potential to drive innovation and optimize business processes. Whether it's through the creation of custom applications, the automation of workflows, or the analysis of data, the Power Platform provides businesses with the tools they need to succeed in a competitive, digital-first world. As more organizations recognize the value of these tools, the Power Platform is likely to become an increasingly integral part of the digital transformation strategies that define the future of business.

7.1.2. MS SharePoint

SharePoint is a Microsoft web-based application that has existed since 2001 that allows organizations to store and organize any content and information. That includes documents, images, videos, news, links, lists of data, web pages, and tasks. Think of SharePoint as a one-stop shop for any content you have [6].

Microsoft SharePoint is a platform designed to facilitate collaboration, content management, and business process automation. Since its inception in 2001, SharePoint has evolved from a simple document management system into a comprehensive platform that supports a wide range of business activities. Today, SharePoint is used by organizations of all sizes to create intranets, manage documents, automate workflows, and foster collaboration among employees.

SharePoint, in its core, offers a central repository for storage, organization, and secure sharing of documents within an organization. Its version control feature enables users to monitor changes to documents over time to make sure that each one of them is the latest edition available — this is very essential for workgroup environments. Metadata tagging is also supported by SharePoint which greatly eases the search and retrieval of tagged documents particularly in large organizations with copious amounts of content.

In addition to its robust content management and collaboration features, Microsoft SharePoint also allows users to upload and store documents securely within the platform. SharePoint's document libraries provide a centralized location where files can be easily uploaded, categorized, and accessed by authorized personnel. This ensures that all relevant documents are available in a single, organized repository, which can be accessed from anywhere, fostering seamless collaboration across teams. As shown in Figure 7.3, uploaded files are displayed within the SharePoint document library, illustrating how documents are stored and managed within the platform, further enhancing the efficiency of document handling and retrieval in an organization.

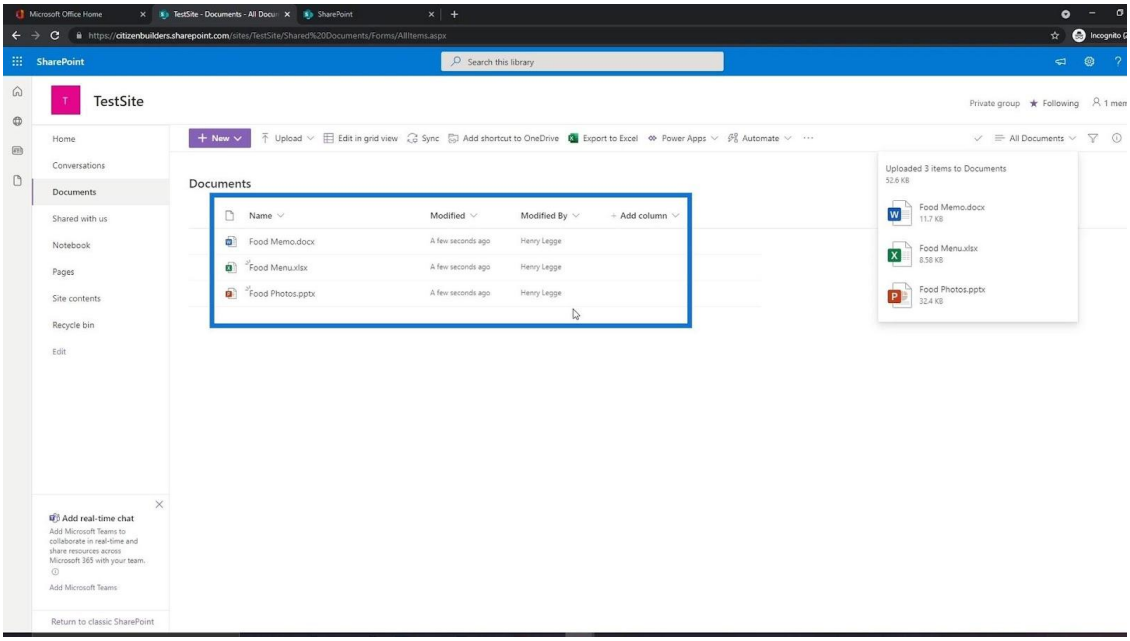

Figure. 7.3. SharePoint's document management [7]

SharePoint's collaboration capabilities are further enhanced by integration with Microsoft Teams, which provides a single platform for communication, document sharing, and collaboration. An outline of this integration and an example are shown in Figure 7.4. For example, documents stored in SharePoint can be accessed and edited directly within Teams, enabling team members to collaborate in real-time. Additionally, SharePoint supports the creation of intranets and communication sites, which serve as central hubs for employees to access company news, resources, and tools, and for disseminating information across the organization.

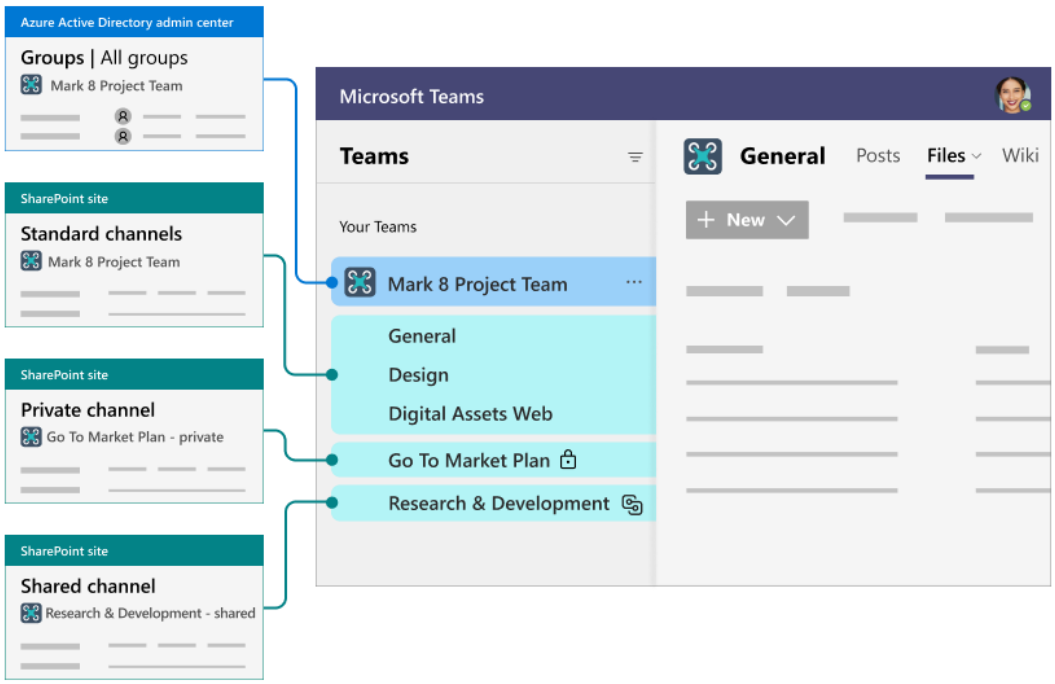

Figure. 7.4. SharePoint's integration with Microsoft Teams [8]

The platform helps in workflow automation to enable organizations to automate their business processes by streamlining how things like document approval, content publishing, and notification management are done. Workflows may be custom-built using tools like Power Automate and SharePoint Designer with the ability to create sophisticated workflows that can integrate with other systems. For example, one could create a workflow that automatically creates a contract in Word, sends it for approval within SharePoint, then stores the approved document in a document library.

SharePoint Designer is a tool used for creating and customizing SharePoint sites and workflows. It allows users to design and modify the look, layout, and functionality of SharePoint sites.

Apart from document management, SharePoint supports extensive enterprise content management that includes document retention policies, eDiscovery, and records management to ensure or reinforce how organizations adhere to related requirements and manage their content lifecycle. This could mean setting up a policy for document retention within an organization that would automatically delete or archive documents after some time, therefore reducing storage costs and cutting legal risks.

Security is a critical concern for organizations using SharePoint to store and manage sensitive information. SharePoint provides a range of security features, including role-based access control, data encryption, and multi-factor authentication, to protect content. Additionally, the platform supports compliance with industry regulations and standards, such as GDPR and HIPAA, through features like audit logs, data loss prevention, and eDiscovery.

SharePoint's versatility and integration capabilities have made it a popular choice for organizations across various industries. For example, a global pharmaceutical company used SharePoint to create a centralized document management system for its research and development department, allowing researchers to store and share documents related to drug development while maintaining strict version control and security standards. Another example is a government agency that used SharePoint to create an intranet serving as a central hub for employees across multiple locations, improving communication and engagement.

7.1.3. MS Power Automate

MS Power Automate is a cloud-based service that revolutionizes the way organizations approach workflow automation. As a key component of the MS Power Platform, Power Automate provides businesses with the tools they need to streamline processes, reduce manual workloads, and enhance overall productivity. By offering a user-friendly, low-code interface, Power Automate makes it possible for a broad spectrum of users—from IT professionals to business analysts—to create and manage workflows without requiring deep technical expertise.

Power Automate is a Drag and Drop / low code solution that allows users to automate repetitive chores and business processes using feeds. It is built to create fast results and be easy to use. In use, it is possible to automate everything from small activities to large-scale systems, which results in the opportunity to have more time for more qualified work[9].

Power Automate’s core strength lies in its ability to connect a vast array of applications and services, enabling users to automate processes that span multiple systems. Whether it's automating routine tasks, integrating data across platforms, or implementing complex business logic, Power Automate is designed to handle a wide range of scenarios with ease. Its drag-and-drop interface simplifies the workflow creation process, allowing users to visually map out the steps of their automation, connect various services, and set up triggers and actions with minimal effort.

Power Automate is one of its kind in supporting workflow automation. It allows its users to automate various tasks that have been noted to be very repetitive in nature and would need manual intervention such as sending of emails, updating records and processing approvals. For instance, a workflow could be designed for sending an email thank-you automatically after customers make a purchase, thus ensuring uniformity and timeliness of communication. Another example would be the common use case where it helps in routing customer support tickets to the right team depending on priority or category of issue, therefore simplifying support but most enhancing response times.

Integration with multiple services is another critical aspect of Power Automate. The platform supports connections to over 300 different applications, including popular Microsoft services like Office 365, Dynamics 365, and Azure, as well as third-party applications such as Salesforce, Slack, and Google Drive. This extensive integration capability ensures that Power Automate can be seamlessly incorporated into existing business ecosystems, allowing for the automation of processes that involve multiple systems. For instance, data from a CRM system can be automatically synchronized with a marketing platform, ensuring that customer information is consistent and up-to-date across all touchpoints.

A Power Platform connector allows the underlying service to talk to Microsoft Power Automate, Microsoft Power Apps, and Azure Logic Apps. It provides a way for users to connect their accounts and leverage a set of prebuilt actions and triggers to build their apps and workflows[10].

In addition to its built-in connectors, Power Automate supports the creation of custom connectors, enabling organizations to integrate with proprietary or legacy systems that may not have standard connectors available. This flexibility allows businesses to extend the reach of their automation efforts, ensuring that even the most specialized systems can be included in automated workflows. Custom connectors can be particularly valuable for organizations that rely on industry-specific applications or have invested heavily in legacy systems that lack modern integration capabilities.

Power Automate also has AI-driven automation where users can merge machine learning models in their workflows with the help of AI Builder. Organizations using AI Builder can automate much more complicated tasks such as sorting emails into different categories based on the sentiment, pulling data out from documents, or what future trends will be based on history. For instance, an AI-infused workflow could automatically categorize incoming emails as positive, negative or neutral. This would enable a customer service team to prioritize responses.

The addition of Robotic Process Automation (RPA) further enhances Power Automate's capabilities, allowing users to automate tasks that involve interacting with legacy systems or applications that do not have APIs. RPA enables the creation of bots that can mimic human interactions with software, such as clicking buttons, entering data, and navigating through screens. This is particularly useful for automating processes that involve older systems, where traditional automation methods may not be feasible. By leveraging RPA, organizations can achieve end-to-end automation, even in environments where modern integration options are limited.

The benefits of using Power Automate are numerous. Increased efficiency is perhaps the most immediate and noticeable advantage, as automating repetitive tasks allows employees to focus on more strategic, value-added activities and others shown in Figure 7.5. This not only improves productivity but also reduces the risk of errors associated with manual processes. By eliminating the need for manual data entry, report generation, and other routine tasks, Power

Automate frees up valuable time and resources that can be redirected toward more critical business objectives.

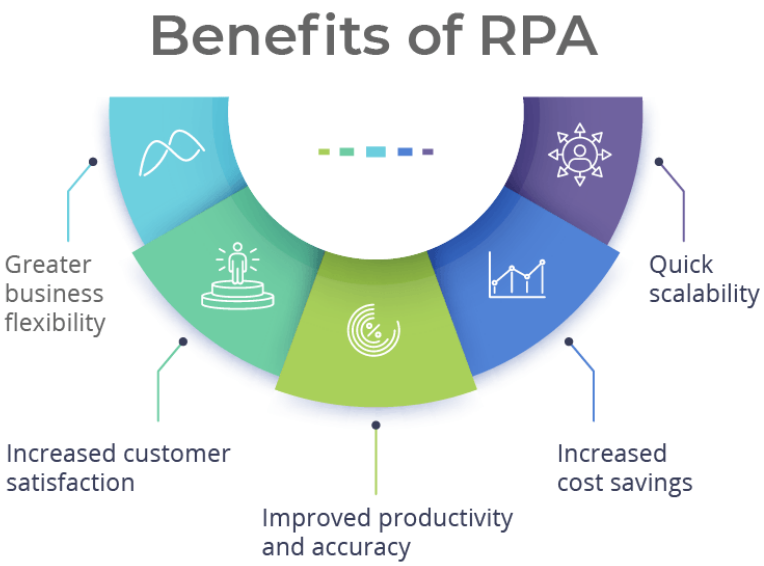

Figure 7.5. Benefits of RPA [11]

Cost savings are another significant benefit, as automation reduces the need for manual labor and minimizes the time required to complete tasks. For organizations that rely heavily on human resources for routine operations, the cost savings from automation can be substantial. Additionally, by streamlining processes and reducing the time required for task completion, Power Automate helps organizations deliver products and services more quickly, potentially leading to increased customer satisfaction and revenue growth.

Enhanced compliance is a critical benefit, for automated workflows can as well ensure adherence to inner policies and outer regulations. A case in point is creating workflows with Power Automate that make sure all approvals are in place before the publication of a document or that bring about the handling of sensitive information under data protection regulations. By automating these processes, it reduces the chances of non-compliance for an organization and also ensures that their activities are in line with all laws and regulations that are applicable.

Power Automate is a cloud service; therefore, it scales easily to cater to larger organizations. When an organization grows, this is what makes the cloud service an ideal application. Power Automate can scale from handling a couple of simple tasks to thousands of workflows without flinching. It does this without degrading performance in any way. Workflows can also be modified or expanded quite easily due to the platform's agility toward new business requirements or changes in operational processes.

Accessibility is a final benefit worth noting. Power Automate’s low-code interface makes it accessible to a wide range of users, including those without technical backgrounds. This democratization of automation tools enables business users to create and manage their workflows, reducing the burden on IT departments and fostering a culture of innovation and continuous improvement across the organization.

However, while Power Automate offers many advantages, organizations should be aware of potential challenges. The complexity of workflows can sometimes be a hurdle, particularly for larger or more intricate processes. As workflows become more complex, they can be difficult

to manage and troubleshoot, requiring careful planning and governance to ensure they remain efficient and effective.

Integration with legacy systems can also pose challenges, especially when dealing with older technologies that lack modern APIs or other integration options. While custom connectors and RPA can help bridge these gaps, they may require additional development effort and resources.

Considerations of security and data privacy prove equally vital when automation is applied. Organizations should see to it that their automated workflows adhere to security policies and, more especially, in the handling of sensitive data. While Power Automate has robust security capabilities such as role-based access control and data encryption, other precautions like data masking and secure storage need to be executed for effective protection from malicious attackers. Information disclosure can also lead to loss of intellectual property or competitive advantage.

These challenges can only be met by forcing organizations to adopt the best practices in workflow design and governance. This involves laying down clear rules for the creation of workflows, carrying out periodic reviews to make sure that workflows do not run against efficiency and not in line with business goals, and extending continuous training and support to the users. With these steps, organizations will reap all the benefits that Power Automate has to offer while encountering minimal risks and challenges.

In summary, MS Power Automate is a powerful tool that enables organizations to automate a wide range of tasks and processes. By providing a user-friendly, low-code platform with extensive integration capabilities, Power Automate empowers businesses to improve efficiency, reduce costs, and enhance productivity. As organizations continue to embrace digital transformation, Power Automate will play a crucial role in helping them navigate the complexities of modern business operations and achieve their strategic goals.

7.1.4. MS AI-Power

Artificial intelligence (AI) is rapidly transforming the way businesses operate, offering new opportunities for innovation, efficiency, and growth. MS AI-Power refers to the suite of AI tools and services provided by Microsoft, designed to help organizations infuse AI into their applications, workflows, and processes. These tools make it easier for businesses to harness the power of AI, even if they lack the technical expertise to develop AI solutions from scratch.

Microsoft AI is tech developed by Microsoft that enables machines and software to do tasks that require human intelligence. This field of AI attempts to replicate human-like abilities, like speech recognition, image recognition, natural language processing and problem-solving.

Users can benefit from Microsoft AI in many industries. For example, in healthcare, it can help doctors with data analysis for diagnoses and treatment plans. In retail, it can improve personalized shopping experiences, suggesting products based on individual preferences and browsing history[12].

Azure AI encompasses a comprehensive suite of AI services, AI infrastructure, and AI tools, providing a powerful platform for building, deploying, and managing AI solutions. These components work together to offer end-to-end support for organizations looking to integrate AI into their operations. Azure's AI services include pre-built models for vision, speech, language, and decision-making tasks, enabling developers to add intelligence to their applications with minimal effort. The AI infrastructure provides the scalable computing power necessary to train and deploy AI models, while the AI tools offer the frameworks, development environments, and utilities required to build custom AI solutions. As shown in Figure 7.6, these

three elements—AI services, AI infrastructure, and AI tools—form the core of Azure AI, demonstrating the platform's capability to support a wide range of AI-driven applications.

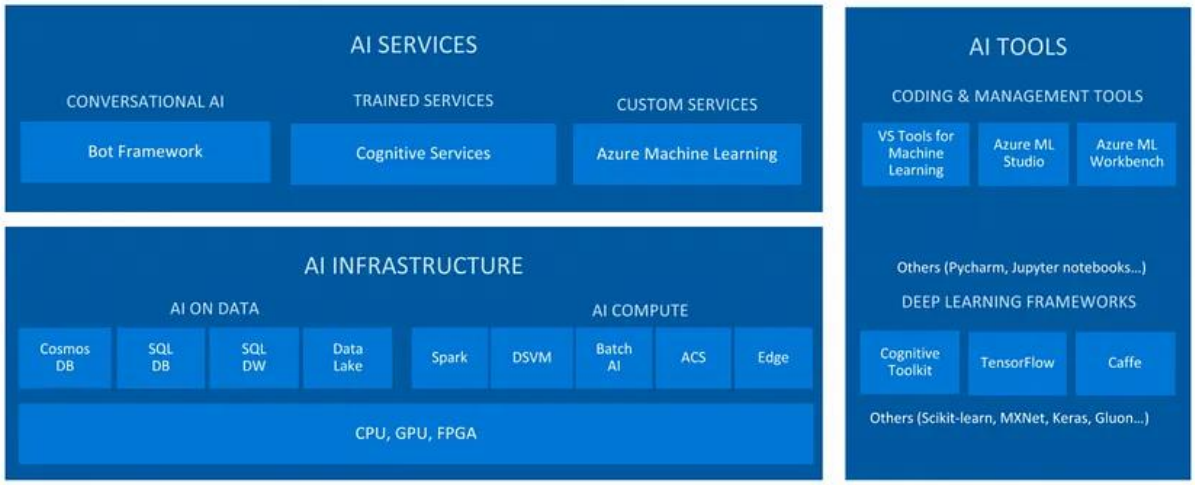

Figure. 7.6. Azure AI components [13]

Microsoft's AI offerings are housed within the Azure cloud platform. This provides a range of services for building, deploying and managing AI models. Azure AI includes Azure Machine Learning, Cognitive Services and Bot Services. Users can build, train and deploy machine learning models at scale with Azure Machine Learning. It provides tools for data preparation, model training and model deployment. APIs for vision, speech, language understanding and decision-making are provided by pre-built offerings from Cognitive Services; thus, it becomes easy to add AI functionality to applications without having had to build models from scratch. Bot Services enables the building, deployment and management of chatbots with the ability to integrate with Cognitive Services for natural language understanding and speech capabilities.

AI Builder is a key component of MS AI-Power, integrated into the Power Platform. It allows users to create custom AI models directly within Power Apps and Power Automate, without needing to write code. AI Builder provides pre-built templates for common AI tasks, such as text classification, object detection, and form processing, as well as the ability to create custom models. This makes AI accessible to non-technical users, enabling organizations to incorporate AI into their business processes.

AI Builder is a Microsoft Power Platform capability you can use to bring the power of Microsoft AI to your organization, without the need for coding or data science skills[14].

MS AI-Power is deeply integrated with Microsoft 365, providing AI-driven insights and automation within popular applications like Word, Excel, and Outlook. For example, AI-powered features in Excel can automatically detect patterns in data and suggest formulas or visualizations, helping users analyze data more effectively. In Outlook, AI can help prioritize emails based on their importance, reducing the time spent managing email and improving productivity.

MS AI-Power is leveraged by organizations in every industry to solve all types of business problems. For example, in the case of the banking sector with AI-powered chatbots and virtual agents, they make pre-sales and after-sales processes more efficient by instantaneously responding to typical questions and guiding users through complex processes or even facilitating transactions. Manufacturers and energy companies apply it to predict when equipment will fail so that maintenance can be pefrormed proactively and not have any production stoppages as a result Companies within Financial Services use AI for detecting fraudulent transactions through the analysis of patterns of behavior along with red flags which

indicate an anomaly, consequently being far quicker than traditional methods in getting on top of fraud detection and response Residential & e-commerce use it for tailoring user experiences which leads to increased sales volumes by looking at browsing behavior plus purchase histories among other data points.

As AI becomes more prevalent in business operations, ethical considerations and governance are increasingly important. Microsoft has been a leader in promoting responsible AI, emphasizing the need for transparency, fairness, and accountability in AI systems. Azure AI provides tools for managing and mitigating bias in AI models, ensuring that AI-driven decisions are fair and unbiased. Organizations using AI-Power should establish AI governance frameworks to oversee the development, deployment, and use of AI systems, defining ethical guidelines, ensuring compliance with regulations, and monitoring AI systems for potential risks.

MS AI-Power represents a significant advancement in making artificial intelligence accessible to businesses of all sizes. By providing a comprehensive set of tools and services for building, deploying, and managing AI solutions, Microsoft has empowered organizations to harness the power of AI to drive innovation, improve efficiency, and enhance customer experiences. As AI continues to evolve, organizations that leverage AI-Power will be well-positioned to stay ahead of the competition and achieve long-term success.

7.2. On-line marketplace solution for business collaboration support

In today's dynamic business environment, the management of development projects demands a sophisticated approach that combines efficiency, collaboration, and adaptability. The advent of online marketplace solutions for development projects has revolutionized how organizations plan, execute, and oversee their projects. These digital platforms provide a centralized hub where project teams, stakeholders, and external contributors can seamlessly collaborate, track progress, and ensure that projects are delivered on time and within budget.

Marketplace solutions for development project management are designed to address the complexities typical of large-scale and multi-faceted projects. By integrating and simplifying various tools and features, these solutions make workflows—from planning to delivery—more effective. A significant advantage of these platforms is their support for instant interaction between team members, irrespective of their geographical location, enabling real-time collaboration across distributed teams.

7.2.1. General architecture

To address the complex task of developing an online marketplace solution for development projects, particularly in the context of Microsoft 365, a comprehensive and scalable architecture is essential. This architecture must integrate various tools and services that support the entire lifecycle of project management, ensuring effective collaboration, secure information storage, and ease of access to project-related data.

The architecture is designed around SharePoint, which functions as the primary content management and collaboration platform. SharePoint's role is to provide a centralized repository for all project documentation, including project plans, budgets, technical specifications, reports, and other critical documents. The platform supports version control, ensuring that team members always have access to the latest document versions while maintaining a history of changes for auditing purposes. Furthermore, SharePoint's document libraries and metadata tagging allow for easy organization and retrieval of documents, which is essential for large projects that generate vast amounts of data.

In addition to document management, SharePoint also supports the creation of interactive web portals tailored to specific projects. These portals serve as a hub for project activities, offering

dashboards that provide real-time updates on project status, task progress, and resource utilization. The portals can be customized to include various web parts, such as calendars, task lists, discussion boards, and news feeds, which enhance team collaboration and keep all stakeholders informed.

Developing an information and communication portal on the SharePoint platform as part of Microsoft 365 to support municipal environmental initiatives is a complex task. The main goal is to create an integrated system that will allow different stakeholders to effectively interact, exchange information, and coordinate their actions to achieve common environmental goals as shown in Figure 7.7.

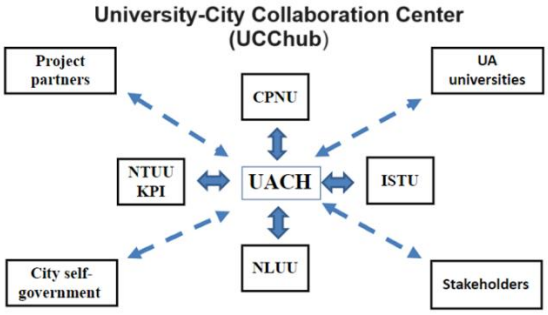

Figure. 7.7. Structure and information flows that ensure coordination and knowledge exchange between different stakeholders

Key participants in such projects include educational institutions, government bodies, businesses, NGOs, investors, and various other organizations.

Educational institutions play a critical role as providers of scientific knowledge, research proposals, and innovative ideas. They use the platform to submit research proposals and projects that contribute to sustainable development, share knowledge and experience between different institutions, and organize joint research initiatives. Each institution can have its own channel on the platform, where they post resources and invite participants to discuss and collaborate. Additionally, institutions can subscribe to other channels and participate in broader discussions and projects.

Government bodies are vital partners in implementing these initiatives. They use the platform to submit requests and proposals for projects aimed at improving sustainability, coordinate actions between different departments and services, and collaborate with other organizations to implement joint projects. Government authorities have access to a common channel where they can interact with other project participants, discuss ideas, and plan joint actions.

Stakeholders such as businesses, NGOs, investors, and other interested organizations also play an important role. They use the platform to provide financial support for projects through grants, investments, and other financial instruments, collaborate with other participants on joint initiatives, and propose new technologies and innovative solutions. Stakeholders engage in discussions, debates, and joint projects through the platform, ensuring their active participation in the implementation of various initiatives.

Project partners can include a variety of organizations that support these development projects. These can be both local and international partners who provide expertise, resources, and knowledge for the successful implementation of projects. They use the platform to support and advise on project implementation, provide access to modern technologies and innovations, and

facilitate the exchange of experience and best practices between different participants. Project partners can create their own channels on the platform where they interact with other participants, exchange information, and plan joint actions.

The integration diagram of different organizations shows how these groups interact with each other through the platform. Each member has its own channel where it can post resources, share information, and interact with other members. Interaction occurs through discussing ideas and projects in chats and forums, posting and sharing documents, organizing online meetings to discuss projects and coordinate actions, and using analytics tools to assess project progress and results.

Thus, the platform ensures effective integration and interaction between different organizations, contributing to the successful implementation of various development projects.

7.2.2 Technological basis of implementation

The implementation of a portal on SharePoint involves several key steps. First, define the portal's objectives, including the specific business needs it aims to address and the key features it should include. Next, design the portal's architecture, considering the overall site structure, navigation, and content organization. This step also involves determining the appropriate permissions and user roles. After that, set up the SharePoint environment, including the creation of sites, subsites, and libraries as per the architectural design. Implement customizations as necessary, such as branding, themes, and the development of custom web parts or apps using SharePoint. Configure workflows, forms, and automation using Power Automate, Power Apps, or SharePoint Designer as required. Integrate with other Microsoft 365 services like Teams, Outlook, and OneDrive, ensuring seamless collaboration and communication across the organization. Finally, conduct thorough testing, including user acceptance testing, and provide training to end users to ensure they are comfortable using the portal. Monitor the portal post-launch for performance and security, making adjustments as needed to optimize the user experience.

The technological basis for implementing an online marketplace solution for development project management hinges on leveraging cloud technologies, advanced collaboration tools, and robust data management platforms, all of which are integral to Microsoft 365. These technologies are designed to provide a scalable, secure, and flexible environment that can support a wide range of project management needs, from small teams to large, multi-stakeholder initiatives.

At the core of the implementation is Microsoft Azure, Microsoft's cloud computing platform. Azure provides the underlying infrastructure that supports the scalability and flexibility of the marketplace solution. It offers a range of cloud services, including computing power, storage, and networking capabilities, which are essential for hosting the various components of the marketplace solution. Azure's scalability allows organizations to adjust resources dynamically based on project demands, ensuring that there is always enough capacity to handle peak loads during critical project phases.

Azure also offers high availability and disaster recovery features, ensuring that the marketplace solution remains operational even in the event of hardware failures or other disruptions. With its global network of data centers, Azure can provide geo-redundant storage and backup services, enabling organizations to protect their data and recover quickly from any unexpected incidents. These capabilities are particularly important for large-scale development projects that require continuous uptime and data integrity.

Microsoft Office 365 is the primary platform for document management, communication, and collaboration within the online marketplace solution. Office 365 includes a suite of

applications such as Word, Excel, PowerPoint, and Outlook, which are widely used for creating, editing, and sharing project-related documents. The integration of these applications with cloud storage solutions like OneDrive ensures that documents are accessible to all project participants, regardless of their location. This is particularly valuable for distributed teams that need to collaborate in real-time on documents, spreadsheets, and presentations.

One of the key features of Office 365 is its support for collaborative editing, which allows multiple users to work on the same document simultaneously. This feature is essential for development projects that require input from various stakeholders, as it enables real-time collaboration and ensures that everyone is working with the most up-to-date information. Moreover, Office 365's version control features help track changes, revert to previous versions if needed, and maintain a complete history of document edits, which is crucial for auditing and compliance purposes.

The marketplace solution also relies heavily on SharePoint, which serves as the central hub for content management and collaboration. SharePoint's capabilities go beyond simple document storage; it allows for the creation of customized sites and portals tailored to specific projects or teams. These sites can host a variety of content types, including documents, lists, calendars, and discussion boards, providing a comprehensive platform for managing all aspects of a development project.

SharePoint's integration with Power Automate further enhances its utility by enabling the automation of routine tasks. For example, workflows can be created to automate document approval processes, send notifications when tasks are completed, or synchronize data across different systems. This automation reduces the administrative burden on project teams, allowing them to focus on more strategic activities, such as planning and decision-making.

The Power Platform—comprising Power Apps, Power Automate, and Power BI—is another critical technological foundation for implementing the marketplace solution. Power Apps enables the creation of custom applications without the need for extensive programming knowledge. These applications can be tailored to meet the specific needs of a project, such as tracking project milestones, managing resources, or collecting data from field operations. Power Apps can connect to a wide range of data sources, including SharePoint, Microsoft Dataverse, and external databases, ensuring that all relevant data is captured and integrated into the project management process.

Power Automate plays a crucial role in streamlining workflows across the various components of the marketplace solution. It allows users to create automated workflows that integrate with other Microsoft 365 applications, as well as third-party services. For instance, Power Automate can be used to automatically update project dashboards in SharePoint based on data inputs from Excel, send reminders via Outlook for upcoming deadlines, or trigger alerts in Microsoft Teams when specific project milestones are achieved. This level of automation helps ensure that all team members are kept informed and that critical tasks are not overlooked.

Power BI, the business analytics service within the Power Platform, provides powerful tools for data visualization and reporting. Power BI enables project managers to create interactive dashboards that display key performance indicators (KPIs), project timelines, resource utilization, and financial performance. These dashboards provide a real-time view of project status, allowing stakeholders to quickly identify potential issues, assess project health, and make informed decisions. The ability to drill down into specific data points also allows for more detailed analysis, helping teams to uncover insights that can improve project outcomes.

Another essential aspect of the technological basis for implementation is security and compliance. Microsoft 365 includes a range of security features designed to protect project

data from unauthorized access and ensure compliance with industry regulations. These features include multi-factor authentication, data encryption, and advanced threat protection. Multi-factor authentication ensures that only authorized users can access sensitive project information, while data encryption protects data both at rest and in transit. Advanced threat protection helps detect and mitigate security threats, such as phishing attacks or malware, that could compromise project data.

In addition to these security features, Microsoft 365 offers tools for managing data compliance and governance. For example, Microsoft Compliance Manager helps organizations assess their compliance with various regulations, such as GDPR or HIPAA, and provides actionable insights for improving their compliance posture. Data Loss Prevention (DLP) policies can be configured to prevent the accidental sharing of sensitive information, while eDiscovery tools enable the search and retrieval of data for legal or regulatory purposes. These compliance and governance tools are essential for organizations that operate in highly regulated industries or that handle sensitive project data.

The technological foundation of the online marketplace solution is further strengthened by its ability to integrate with other enterprise systems. Microsoft 365 supports a wide range of API integrations that allow the marketplace solution to connect with CRM systems, ERP platforms, accounting software, and other business tools. This integration capability ensures that data flows seamlessly between different systems, reducing the need for manual data entry and minimizing the risk of errors. For example, integration with a CRM system can help track client interactions and manage project-related sales activities, while integration with an ERP platform can support financial management and resource planning.

Lastly, the marketplace solution is designed to be adaptable and future-proof, ensuring that it can evolve with changing project requirements and technological advancements. Microsoft regularly updates its cloud services, adding new features and capabilities that enhance the functionality of the marketplace solution. This ongoing innovation ensures that organizations using the solution can stay ahead of the curve, adopting new tools and practices that improve project management efficiency and effectiveness.

In conclusion, the technological basis for implementing an online marketplace solution for development project management is built on a robust and integrated set of cloud-based tools and services provided by Microsoft 365. From the foundational infrastructure of Microsoft Azure to the collaboration and productivity tools within Office 365, and the automation and analytics capabilities of the Power Platform, these technologies work together to create a comprehensive, secure, and scalable environment for managing complex development projects. The flexibility, security, and integration capabilities of these tools ensure that the marketplace solution can meet the diverse needs of modern project management while providing a solid foundation for future growth and innovation.

7.2.3 Application to support eco-projects

The practical application of online marketplace solutions for development project management is vividly exemplified by their role in supporting eco-projects, which are increasingly vital in today's efforts to promote environmental sustainability. One such example is the UCChub project, whose main page is shown in Figure 7.9, a comprehensive platform developed on the SharePoint and Microsoft 365 ecosystem, specifically designed to facilitate collaboration among various stakeholders working on environmental initiatives aimed at making cities more sustainable.

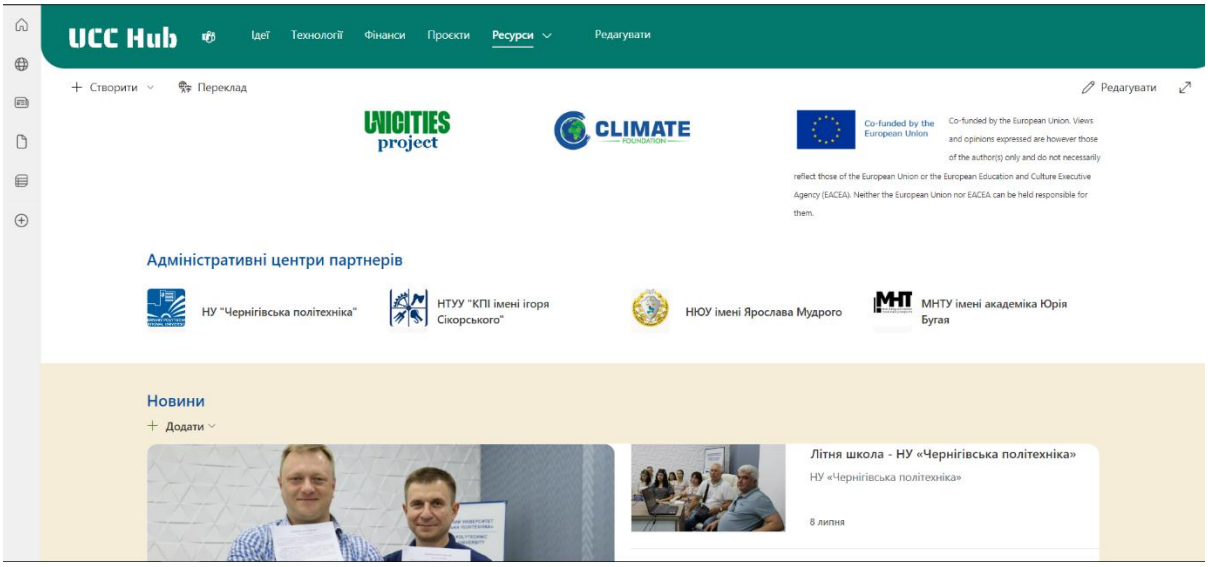

Figure. 7.9. Main page of the UCC Hub

The UCChub platform serves as a central hub for coordinating activities, sharing resources, and managing projects that focus on environmental sustainability. The platform's architecture, which leverages the robust capabilities of Microsoft 365, is tailored to meet the unique challenges of eco-projects, such as the need for extensive collaboration across multiple organizations, the integration of diverse data sources, and the requirement to manage complex, multi-stakeholder initiatives.

A key feature of UCChub is its Ideas component, which is designed to facilitate the generation and sharing of innovative solutions for environmental challenges. This component allows participants—including universities, NGOs, businesses, and city governments—to submit their proposals for new eco-projects. These proposals can range from technical innovations, such as new methods for reducing carbon emissions, to social initiatives aimed at increasing green spaces or improving waste management practices. The Ideas component provides a structured framework for participants to present their proposals, helping to organize and evaluate the submissions while ensuring that all critical aspects of the project are considered from the outset.

Once submitted, ideas are open for discussion and feedback from other platform participants, enabling a collaborative process that refines and enhances proposals. The platform includes features such as voting and ranking systems, which enable participants to prioritize the most promising ideas for further development. This collaborative nature is particularly valuable in eco-projects, where the complexity of environmental issues often requires input from a broad range of disciplines, fostering a multidisciplinary approach to problem-solving.

The UCChub platform's architecture facilitates interaction between diverse groups of stakeholders. Universities, city governments, businesses, NGOs, and project partners are interconnected through the platform, each contributing their unique resources and expertise to advance environmental initiatives.

After an idea is refined and selected for implementation, it transitions into the Projects component of the UCChub platform. This component is equipped with tools designed to streamline the management and execution of environmental initiatives, ensuring that they are delivered on time, within budget, and to the desired quality standards. Project managers can define the scope, objectives, and deliverables of the project, establish timelines, assign tasks,

and allocate resources. These tools are particularly important for eco-projects, which often involve complex logistics and require careful coordination among various stakeholders.

The UCChub platform integrates with tools such as Microsoft Planner and Project, which provide detailed project planning and scheduling capabilities. These tools allow project managers to create Gantt charts, assign tasks to team members, set deadlines, and track progress in real-time. The integration with Microsoft Teams ensures that all communication and collaboration related to the project take place in a centralized environment, reducing the risk of miscommunication and ensuring that all team members are aligned on the project's goals and progress. Additionally, the Projects component supports document management through SharePoint, ensuring that all project-related documents—such as contracts, technical specifications, reports, and meeting minutes—are stored in a centralized, accessible location. This feature is particularly valuable for eco-projects, which often require extensive documentation and regulatory compliance.

The UCChub platform also provides a streamlined interface for project management as illustrated in the visual overview of the Projects section as shown in Figure 7.10. This interface facilitates the centralization of project details, scheduling, and task management, ensuring that stakeholders can easily monitor progress and make informed decisions.

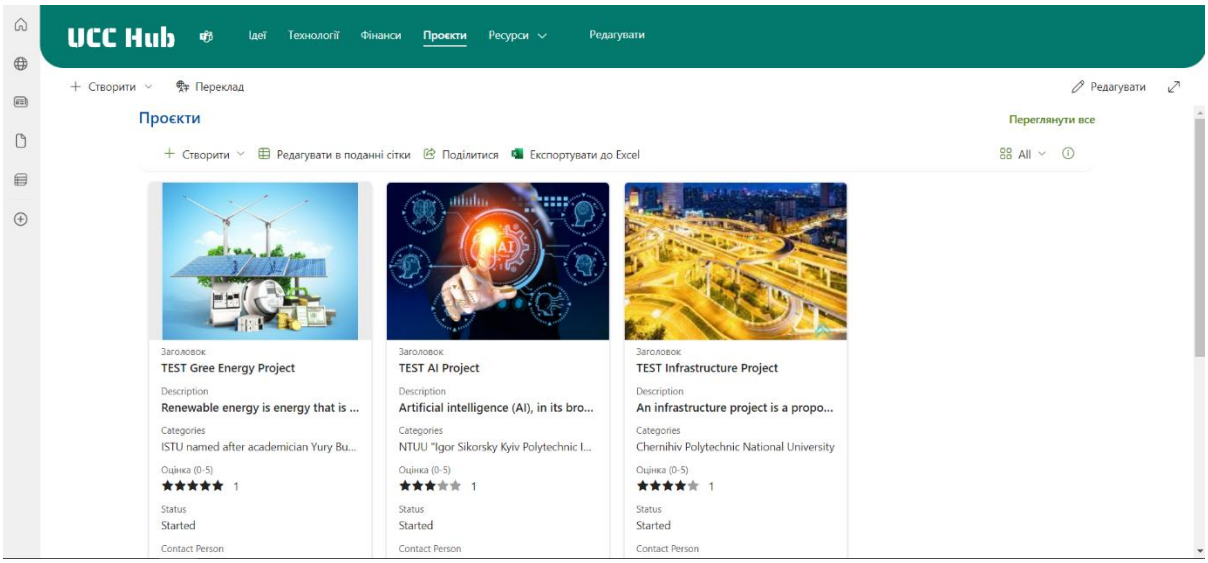

Figure. 7.10. Projects section

Another critical aspect of UCChub is its Technology component, which provides access to a wide range of modern innovations and technological solutions that can be integrated into eco-projects. The platform includes a catalogue of green technologies, such as energy-efficient building materials, renewable energy systems, and advanced waste management solutions. These technologies are evaluated based on criteria such as cost, environmental impact, and feasibility, allowing project teams to select the most appropriate solutions for their specific needs. By providing access to cutting-edge technologies and expert advice, the Technology component ensures that eco-projects can leverage the latest advancements to achieve their environmental goals.

The UCChub platform has been successfully applied in several real-world eco-projects, demonstrating its effectiveness in supporting complex, multi-stakeholder initiatives. One notable example is its use in a project aimed at improving urban sustainability through the implementation of green infrastructure. In this project, the UCChub platform was used to coordinate activities among various stakeholders, including city governments, environmental

NGOs, academic institutions, and private sector partners. The Ideas component facilitated the generation of innovative proposals for green infrastructure, such as the development of urban green spaces, the installation of green roofs, and the enhancement of public transportation systems.

Once the ideas were selected, the Projects component provided the tools needed to plan and execute the initiatives. Project managers used the platform to assign tasks, allocate resources, and monitor progress, ensuring that all aspects of the project were managed efficiently. The integration with Power BI allowed stakeholders to track the impact of the green infrastructure on key environmental indicators, such as air quality, energy consumption, and biodiversity. The Technology component played a crucial role in identifying and integrating advanced solutions into the project, such as innovative materials and construction techniques for green roofs, which were implemented in several pilot projects across the city.

Through its application in the UCChub project, the online marketplace solution has proven to be a powerful tool for managing eco-projects. By providing a comprehensive platform for collaboration, project management, and technology integration, UCChub has enabled stakeholders to work together effectively, achieve their environmental goals, and contribute to the sustainable development of cities.

In conclusion, the UCChub platform exemplifies how online marketplace solutions can be applied to support eco-projects, addressing the complex challenges of environmental sustainability. By leveraging the full suite of Microsoft 365 tools, UCChub provides a scalable, secure, and collaborative environment that enhances the effectiveness of environmental initiatives. As the need for sustainable development continues to grow, platforms like UCChub will play an increasingly important role in coordinating and managing the efforts of diverse stakeholders, ensuring that cities can meet the environmental challenges of the future.

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Chapter 8. Information Security, Computer and Network security: Confidentiality and Integrity

8.1 Overview

Today, organizations in private and public sectors are increasingly relying on information and communication technologies (ICT) to increase productivity, offer new services and lower their operational expenses. At the heart of ICT infrastructures there exist information systems that store, process and exchange data over intranets and interconnected networks. The use of information systems, however, makes the organizations face security risks associated with threats stemming from unauthorized access to various system resources like hardware, software and data. These threats can be intentional (i.e., originating from malicious users or opponents) or unintentional (e.g., due to software bugs).

Examples of security threats include the following [1]:

- destruction of information and/or other resources
- corruption or modification of information
- theft, removal or loss of information and/or other resources
- disclosure of information
- interruption of services

Threats, and correspondingly the means to realize intentional threats (i.e., security attacks), can be categorised as passive or active. Passive threats or attacks do not result in modification of the information contained in the system and the operation or the state of the system remains unaffected. Interception (or eavesdropping) over a communication link results in unauthorized data disclosure and is a typical example of passive attack. Another example of security attack is traffic analysis, in which the opponent tries to infer information by monitoring the characteristics of traffic flows (duration, size, pattern etc).

On the contrary, active threats or attacks involve alteration of the information contained in the system or changes to the state or operation of the system. Examples of active attacks include:

- Masquerade
- Replay
- Modification of messages
- Denial of service

In this context, Information Security addresses the protection of information and information systems from unauthorized access, use, disclosure, disruption, modification, or destruction in order to ensure confidentiality, integrity, and availability [2]. These main security objectives or services, which are commonly referred to as the CIA triad, are briefly described below.

Confidentiality preserves authorized restrictions on information access and disclosure, including means for protecting personal privacy and proprietary information.

Integrity protects against improper information modification or destruction and ensures information non-repudiation and authenticity. Non-repudiation is the property according to which the sender cannot falsely deny sending a data object, while authenticity it the property of being genuine and able to be verified and be trusted [3].

Availability ensures that timely and reliable access to and use of information is provided to authorized users of the system.

Security services are implemented by security mechanisms. Many of these mechanisms rely on cryptography, which involves the principles, means and methods for the transformation of data in order to hide its information content, prevent its undetected modification and/or prevent its unauthorized use. Examples of security mechanisms include [1]:

- Encipherment. It is often used as a synonym for encryption and addresses the transformation of a plain text (usually data in intelligible form) into a ciphertext (data in non-intelligible form). The transformation may or may not depend on encryption keys that are special input parameters used to vary the outcome of transformation function. The encipherment can be reversible (i.e., the plaintext can be recovered from the ciphertext) or irreversible.
- Digital signature. It involves data appended to, or a cryptographic transformation of a data unit that allows a recipient of the data unit to prove the source and integrity of the data unit, and protect against forgery e.g., by the recipient.
- Access control. The prevention of unauthorized use of a resource, including the prevention of use of a resource in an unauthorized manner.
- Data integrity. This mechanism assures that data has not been altered or destroyed in an unauthorized manner.
- Authentication exchange. A mechanism intended to ensure the identity of an entity by means of information exchange.
- Traffic padding. The generation of spurious instances of communication, spurious data units and/or spurious data within data units in order to defend against traffic analysis attacks.
- Routing control. The application of rules during the process of routing so as to choose or avoid specific networks, links or relays.
- Notarization. It involves the use of a trusted 3rd party which holds the necessary information to assure several properties of data communicated between two parties including its integrity, origin, time and destination. The mechanism is notably used to provide non-repudiation.

In the rest of this chapter, we focus on cryptography-based mechanisms that can be used in the realization of several security services, notably in the assurance of confidentiality and integrity.

8.2 Symmetric encryption

Symmetric encryption is a reversible encipherment mechanism in which the transformation of an input data unit (plaintext) into an output data unit (ciphertext), as well as the inverse

transformation of ciphertext into the original plaintext are accomplished with the use of the same secret information (key). The transformation is provided by an encryption algorithm parametrized by the encryption key. Knowledge of this algorithm and of the secret key are necessary for the decryption of the message. In this way, symmetric encryption provides confidentiality of messages since, ideally, only authorized users (owners of the single key) can have access to sensitive information encoded into the ciphertext. Due to the use of a single key, symmetric encryption is also called single-key or secret-key encryption. A basic model of symmetric encryption is shown in Fig. 8.1.

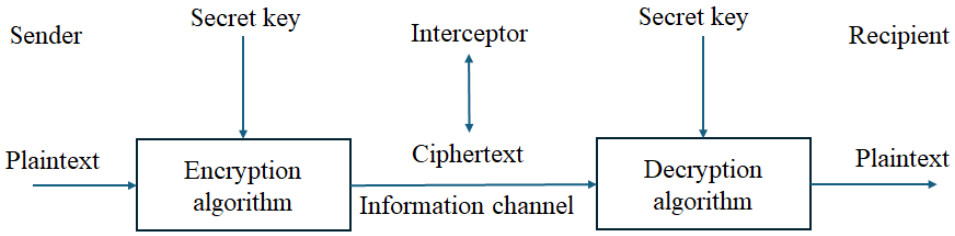


Fig. 8.1 Basic model of symmetric encryption

As it is the case with all types of encryption, the plaintext can be in readable form (e.g., intelligible text that can be understood by humans or a program that can run on a computer) or it may include unintelligible data (e.g., data that are already encrypted). In any case, the output of the encryption process is a ciphertext that aims to not have any obvious resemblance to the original plaintext and look like a collection of randomized data. The goal of an attacker/interceptor, who is supposed to know the encryption algorithm and have access to (at least) the ciphertext, is to figure out the key and decrypt the message. Usually, the strength of modern ciphers is evaluated under stricter requirements stating that an interceptor should not be able to discover the key even if he is aware of a number of pairs of plaintext and ciphertext produced with that key. Thus, defend against eavesdropping relies on strong encryption algorithms and on the secure generation, storage and distribution of the secret key.

Symmetric encryption is the oldest and most widely used type of encryption. It has a lifetime for over 20 centuries going from simple substitution techniques like Caesar cipher through multiple-letter encryption mechanisms like Playfair, polyalphabetic substitution ciphers like Vigenere and Vernam, transposition techniques, rotor machines like Enigma and up to modern times with dozens of symmetric ciphers available including the most widely known standardised algorithms DES, 3DES and AES [4].

There are two classes of symmetric ciphers that differ on the way the plaintext data are grouped to feed the encryption mechanism. In block ciphers, the data are grouped in blocks and the encryption is performed on whole blocks. In stream ciphers, on the other hand, the encryption is performed on a bit-by-bit or byte-by-byte basis. Stream ciphers are generally considered faster, but block ciphers can offer a higher level of security and are more versatile (a block cipher can even operate as a stream cipher while the opposite is not possible).

8.2.1 Block ciphers

Block ciphers group the bits of the plaintext into blocks of fixed size (e.g., 64 or 128 bits) and encrypt each block to produce an output (ciphertext block) of the same size. If the last block of the plaintext is not complete, it is filled up with padding bits prior to encryption.

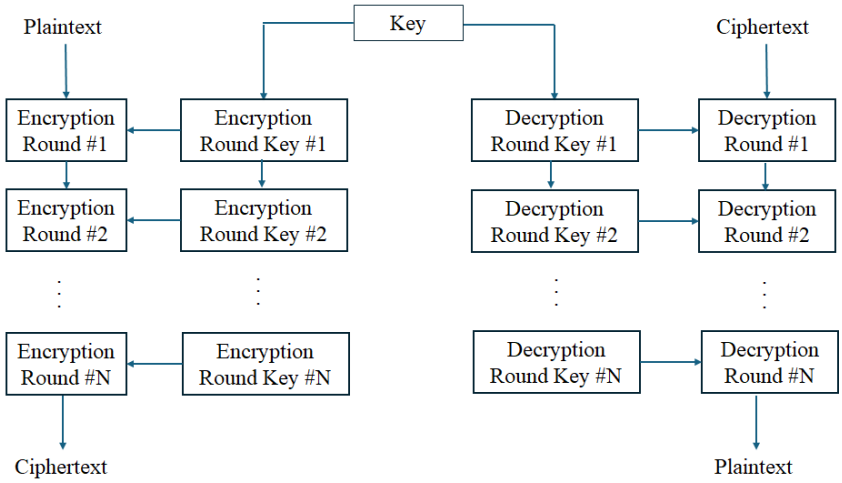


Fig. 8.2 Simplified model of a product cipher

Many modern block ciphers are based on the notion of product ciphers. A simplified model of a product cipher is shown in Fig. 8.2. In this model, the encryption of the plaintext and correspondingly the decryption of the ciphertext is performed in multiple consecutive stages called rounds. Every round involves the same set of cryptographic operations like substitutions and permutations, as well as the Exclusive OR (XOR) function. The idea behind a product cipher is that although the functions performed in each round are relatively simple and, thus, if applied once, cannot provide an adequate level of security, repetitive use of the same functions dramatically increases the level of protection. To make the scheme even more secure, different keys are used in each round. All these subkeys are derived from the encryption key.

Table 8.1. Parameters of popular block ciphers

Cipher	Block size (bits)	Key length (bits)	No of rounds
DES	64	56	16
3-DES	64	168	48
AES	128	128 / 192 / 256	10 / 12 / 14
Blowfish	64	32-448	16
Twofish	128	128 / 192 / 256	16

Block ciphers are extensively used in several security protocols and applications. Currently, the gold standard for symmetric block cipher is AES, published by NIST in 2001. AES is a product cipher operating on blocks of 128 bits. The algorithm can be used with 3 different key sizes of 128, 192 and 256 bits. Depending on the key size, different number of rounds are involved (10 rounds for 128-bit key, 12 rounds for 192-bit key and 14 rounds for 256-bit key).

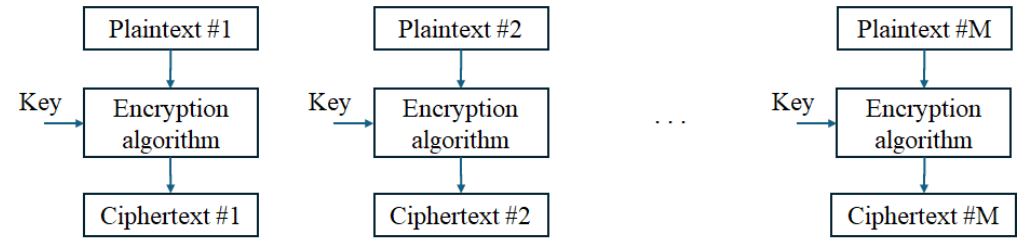
The selection of the key size depends on the level or protection required for the application at hand and the associated security-performance tradeoff; a larger key size results in greater security but incurs a higher execution overhead.

AES was devised to replace the older DES and 3-DES product ciphers. DES, which became a standard in 1976, uses 64-bit blocks and a key size of 56 bits. The encryption involves 16 rounds. The 3-DES was proposed in 1999 as an enhancement to DES. It applies the DES algorithm 3 times to each 64-bit block and, in its more secure version, uses three 56-bit keys. Both DES and 3-DES are now considered insecure, and their use is restricted to legacy applications. The main parameters of AES, DES and 3-DES, as well as of other popular block ciphers like Blowfish and its successor, Twofish, are summarized in Table 8.1.

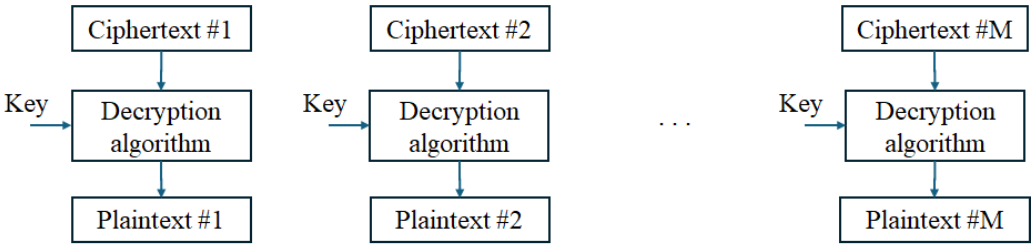
8.2.1.1 Modes of operation

All block ciphers split large plaintexts into blocks that are subsequently encrypted using the chosen underlying algorithm. In the case of block ciphers specified by NIST (like AES or DES), the way multiple blocks are encrypted is determined by the confidentiality mode of operation. Five such modes have been proposed to cover the requirements of different applications [5].

Electronic Codebook (ECB). In this mode of operation, each one of the blocks are encrypted independently of the others using the same key. Decryption works in a similar manner, i.e., each ciphertext block is decrypted independently of the others. The ECB mode is illustrated in Fig. 8.3.



(a) Encryption



(b) Decryption

Fig. 8.3 ECB mode of operation

The ECB is the simplest mode of operation and allows multiple encryption and decryption functions to be computed in parallel. However, in this mode, for a given key, any given plaintext block always gets encrypted to the same ciphertext block. In case of large messages

with identical blocks, an eavesdropper may easily exploit this weakness for information inference purposes.

Cipher Block Chaining (CBC). In this mode, the encryption process features the combining ("chaining") of the plaintext blocks with the previous ciphertext blocks. In this way, repeating patterns of blocks are not exposed to an eavesdropper. This mode is illustrated in Fig. 8.4.

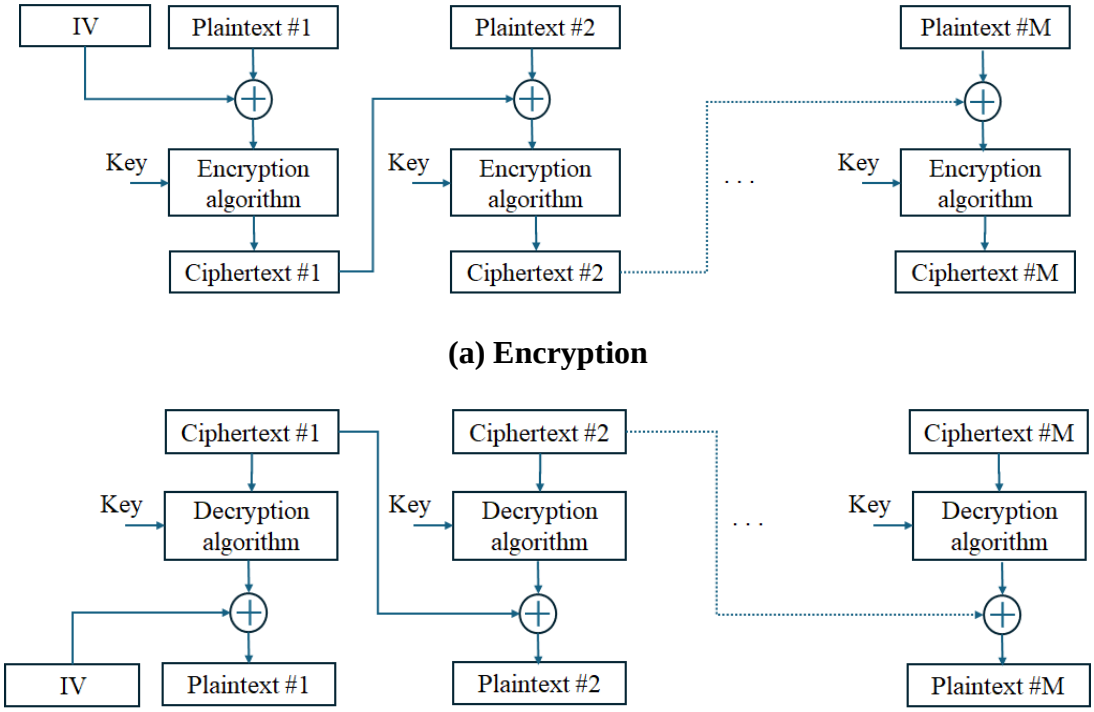


Fig. 8.4 CBC mode of operation

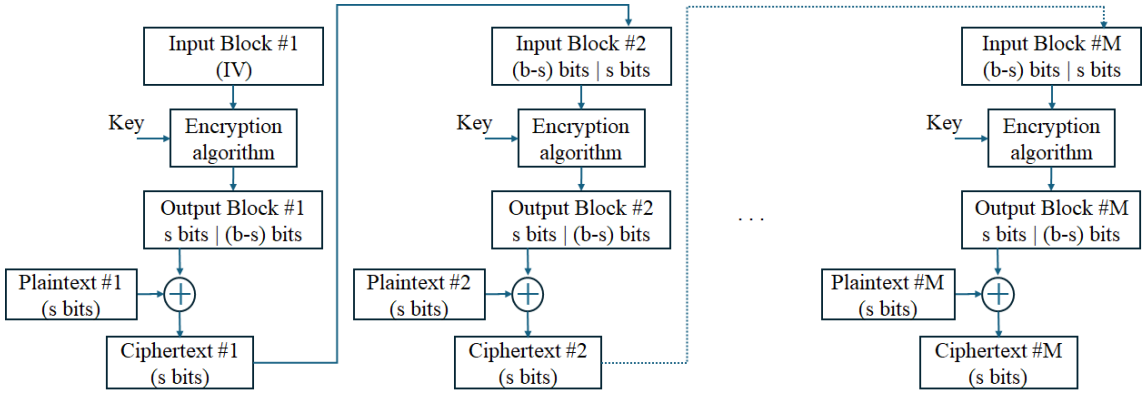
Apart from the secret key, the CBC requires another parameter, namely the Initialization Vector (IV), to be shared among the communicating entities. In the encryption phase, this parameter is combined through an XOR operation with the first plaintext block to produce the input to the first encryption function. At the decryption stage, the same IV is combined through an XOR operation with the output of the first decryption function to provide the first block of the plaintext.

The IV is of the same size as the block and must be generated anew for each execution of the encryption operation. It does not need to be secret, but it should be unpredictable (i.e., look like random), and its integrity should be protected [5].

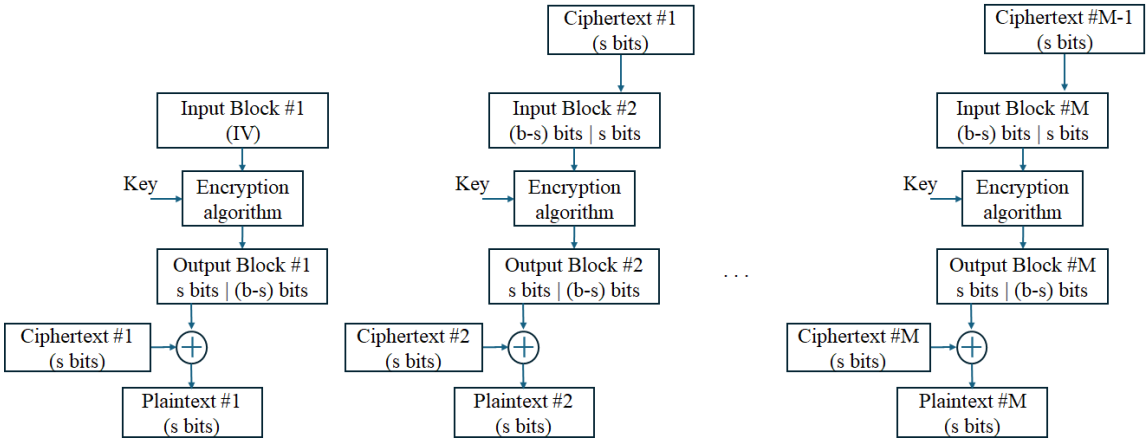
In CBC mode, the input to an encryption operation (except the first one) depends on the output of the previous encryption operation, and, thus, these operations cannot be performed in parallel. In decryption, however, the decryption operations can be performed in parallel since the inputs to these operations, namely the ciphertext blocks, are immediately available.

Cipher Feedback (CFB). In this mode of operation, the plaintext is split in segments of fixed size, denoted by s, such that $1 \leq s \leq b$, where b is the algorithm block size in bits (note: the

segment size is often incorporated into the name of the mode, e.g., 1-bit CFB or CFB1, 8-bit CFB or CFB8 *etc*.). The encryption and decryption operations are then performed on a segment-by-segment basis. Each ciphertext (plaintext) segment is calculated as the XOR of the plaintext (ciphertext) segment and an s-bit value taken from the output of the encryption function (in particular, the s most significant bits of the output are selected). The operation of CFB is shown in Fig. 8.5.



(a) Encryption



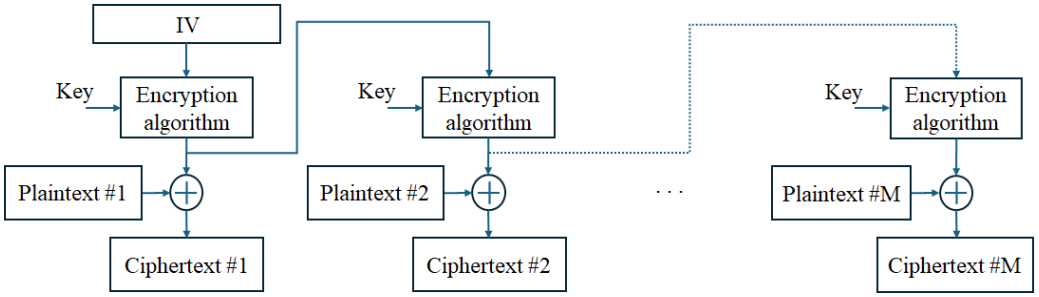
(b) Decryption

Fig. 8.5 CFB mode of operation

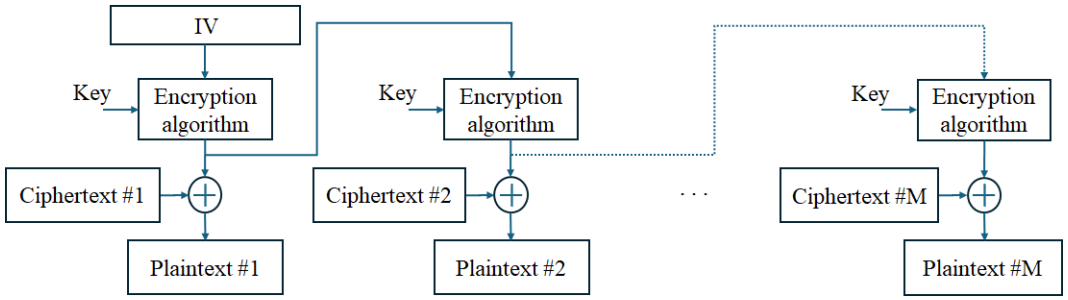
As in all block ciphers, the input to the encryption function (apart from the key) is a block of size b. In CFB, the first input block consists of an IV (note: the IV does not need to be secret, but it must be unpredictable.); the remaining input blocks are formed by concatenating the b-s least significant bits of the previous input block with the s bits of the previous ciphertext segment. In this way, each output (i.e., ciphertext) provides feedback to the input of the encryption function. In the CFB mode, the encryption algorithm of the underlying cipher is used in both encryption and decryption operations. Parallelization in the execution of the cryptographic algorithm (i.e., the encryption algorithm) can be achieved only in the decryption

phase since, in this case, all input blocks are derived from the IV and the ciphertext segments which are immediately available.

Output Feedback (OFB). This mode involves the iteration of the encryption function on an IV to produce a sequence of output blocks that are XORed with the plaintext (ciphertext) to produce the ciphertext (plaintext). This mode is illustrated in Fig. 8.6. Similar to CFB, there is a need to implement only the encryption algorithm of the underlying cipher. In contrast to CFB, the encryption operation is performed on a block-by-block basis (except for the last chunk which needs not be a complete block), the input blocks to the encryption functions do not depend on the ciphertext, and the IV must be unique (equivalently a "nonce", i.e., a value that is used only once) for every message that is ever encrypted under the given key.



(a) Encryption

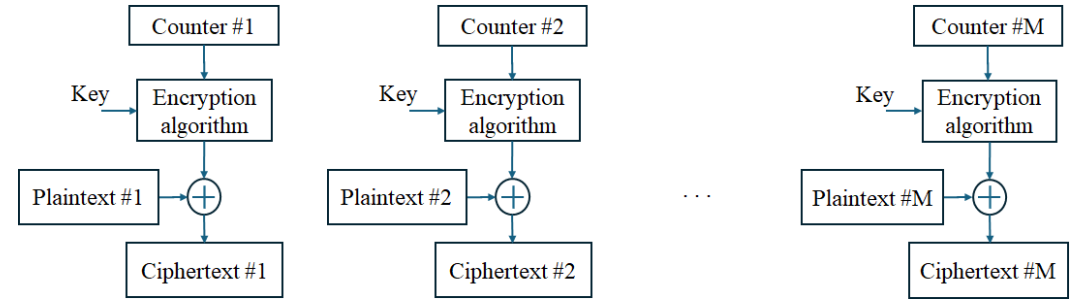


(b) Decryption

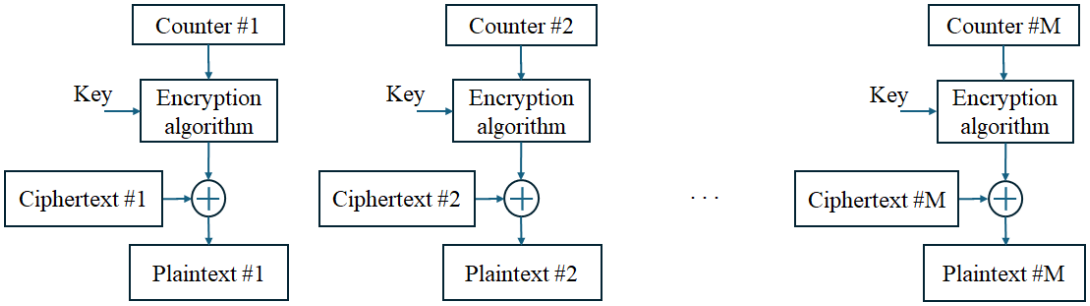
Fig. 8.6 OFB mode of operation

In OFB, parallelization in the execution of the encryption functions (used in both the encryption and decryption operations) cannot be achieved. However, if the IV is available, the output of these functions can be calculated prior to the availability of the plaintext or ciphertext.

Counter (CTR). This mode involves the application of the encryption function on a set of values, called counters, to produce a sequence of output blocks, which, similar to OFB, are XORed with the plaintext (ciphertext) to produce the ciphertext (plaintext). All counters must be distinct; this is required not only for a single message but also for all messages encrypted with a given key. Similar to OFB, the operations are performed on a block-by-block basis (except for the last chunk, which does not need to be a complete block). The CTR mode is illustrated in Fig. 8.7.



(a) Encryption



(b) Decryption

Fig. 8.7 CTR mode of operation

In the CTR mode of operation the encryption functions involved in both the encryption and the decryption operations can be executed in parallel. In addition, if the counters are available, the output of these functions can be calculated prior to the availability of the plaintext or ciphertext.

8.2.2 Stream ciphers

In stream ciphers, the plaintext is organized as a sequence (stream) of symbols (usually of size 1 or 8 bits), with each one of them encrypted independently of the others. In encryption, the ciphertext is produced by combining the bits of the plaintext symbol with the bits of a cryptographic data stream, called keystream. In decryption, the same keystream is combined with the ciphertext to deliver the plaintext. The generation of the keystream depends on the selected algorithm and the secret key. A model of a simple stream cipher, in which the combination of the keystream with the plaintext is done through an XOR operation, is illustrated in Fig. 8.8.

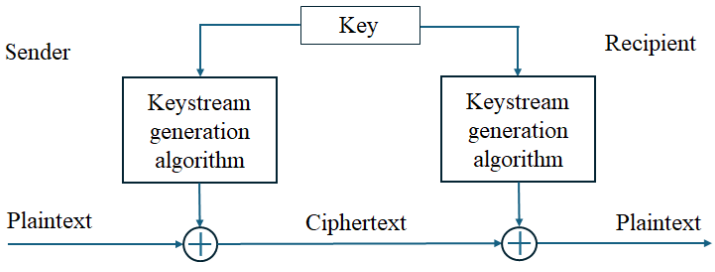


Fig. 8.8 Model of stream cipher

The keystream generator is the most (if not the only) significant part of a stream cipher. Its goal is to produce a sequence of elements that are computationally infeasible to predict without knowledge of the key. Since, for a given key, the same keystream must be used in both the encrypting and decrypting ends, the elements of the keystream must be generated in a deterministic way. Thus, a keystream generator should be able to use a deterministic algorithm and still produce elements (numbers) that look highly random. In addition, it should provide resistance to attacks even if some of the elements of the keystream have become available to an attacker (note: with respect to the model presented in Fig. 8.8, if an attacker has access to a (plaintext, ciphertext) pair, then he can compute the keystream element that was used to produce this ciphertext by simply XORing the plaintext and the associated ciphertext.). Such requirements are satisfied by a type of pseudo-random number generators (PRNGs) that are called cryptographically secure PRNGs.

PRNGs can be implemented in different ways [4]. However, not all of them are secure enough to be used in cryptographic applications, with the well-known linear congruential generators being a notable example. Cryptographic PRNGs include two types of algorithms. The first involves algorithms especially designed to provide pseudorandom bit streams. Examples in this category include the Blum Blum Shub generator (which, however, becomes very slow if high levels of security are required) and the keystream generation algorithm used in the RC4 stream cipher.

The other type of cryptographic PRNGs include algorithms that are based on existing cryptographic primitives like block ciphers and hash functions. Such schemes exploit the capabilities of these primitives to transform an input to a seemingly random, and, thus, not easily predictable output. Examples of such cryptographic PRNGs include number generators based on DRBG (Deterministic Random Bit Generators) specified by NIST [6]. In particular, a DRBG uses an algorithm that produces a sequence of bits from an initial value. This value is determined by a seed that must contain sufficient entropy to provide an assurance of randomness. The seed is composed of the output of an entropy source and possibly other information like time, a nonce or a personalization string. Once the initial value is determined, the DRBG may be used to produce output, i.e., pseudorandom bits. If the seed is kept secret, and the algorithm is well designed, the bits output by the DRBG will be unpredictable.

The publication [6] specifies three types of DRBGs. The first, called Hash_DRBG, is based on hash functions like SHA-256 or SHA-512, which are repeatedly called on changing input. The second algorithm, called HMAC_DRBG, is based on Message Authentication Codes (MACs) that are implemented with keyed hash functions. The last mechanism, called CTR_DRBG, is based on the use of block ciphers like DES or AES operating in the CTR mode. As depicted in Fig. 8.7, this mode of operation involves the encryption of successive counter values. Since the counters are independent from the plaintext, this iterative encryption process can be used to generate a keystream. In this way, the use of the CTR mode can convert a block cipher into a stream cipher. In CTR_DRBG, the value of the first counter, as well as the secret key, are derived from the seed. Unless reseeding is needed (which results in new counter and key values), all encryptions are performed with the same key, and the value of the counter is

incremented by one for each iteration. Although not specified in [6], the OFB mode of operation can also be used for keystream generation, and, thus, to convert a block cipher to a stream cipher.

Stream ciphers have several attractive properties including no error propagation, speed, on-the-fly encryption and efficient implementation in hardware [7]. This makes them appropriate for several real-time network applications. However, specialized stream ciphers have received less attention compared to block ciphers. This is most likely due to the fact that block ciphers are more versatile, since they can be a) used in a broader range of applications involving data at rest or data in transit, b) converted into efficient stream ciphers, and c) used not only for encryption but also to implement other cryptographic primitives like hash functions and MACs.

Notable examples of specialized stream ciphers include the RC4 and ChaCha20 algorithms. RC4 was used in the WEP and WPA protocols to provide confidentiality over WiFi networks and in the SSL/TLS protocol to provide Internet security. However, nowadays, its use is discouraged in favour of more secure algorithms. ChaCha20, a specific instance of the ChaCha algorithm [8] with 20 rounds, is a high-speed stream cipher that is considerably faster than AES in software-only implementations. The algorithm can be used in several protocols including the Internet Key Exchange (IKE), IPsec, TLS and Datagram Transport Layer Security (DTLS) protocols [9, 10].

8.3 Public-key encryption

Public-key (or asymmetric) encryption is a reversible encipherment mechanism that provides confidentiality using public-key cryptography. This type of cryptography involves cryptographic methods that use pairs of mathematically related keys. One of these keys, the private key, is kept secret by the issuer, while the other one, the public key, can be disclosed freely to other entities. The keys are generated in a way that a) makes it relatively easy to calculate the public key from the private key, and b) makes it computationally infeasible to derive the private key from the public key. Apart from encryption, public key cryptography is notably used in digital signatures and in key agreement protocols through which communicating entities collaboratively establish a common key over insecure network connections (i.e., connections that are not encrypted).

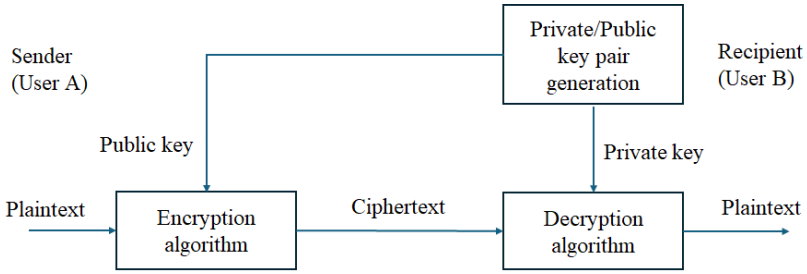


Fig. 8.9 Model of public-key encryption

The model of public-key encryption is illustrated in Fig. 8.9. User B who wants to be able to receive encrypted messages from User A (as well as from any other user), creates a pair of

keys consisting of a private and a public key. The public key is made known to User A. The plaintext that this user wants to send, is first converted into a number and then used along with User B's public key as input to the encryption algorithm. The output of the algorithm, i.e., the encrypted message, is transmitted to User B, who decrypts it with the use of the private key. The decrypted ciphertext is a number which is then converted back to the plaintext.

An interceptor cannot decrypt the ciphertext, since this requires knowledge of the private key. As mentioned earlier, it is almost impossible to derive the private key from knowledge of the public key. Furthermore, random guess of the private key is not easier either, because of the very large size of the key (e.g., 256 or 2048 bits, depending on the algorithm). A public-key encryption scheme with suitable key sizes is secure, provided that the private key is kept secret and there is assurance that the public key indeed belongs to the claimed entity (i.e., there is a need to verify the authenticity of the key).

The most widely used public-key encryption algorithm is RSA, named after the inventors Ron Rivest, Adi Shamir and Leonard Adleman, who publicly described it in 1977. The algorithm is based on the properties of prime numbers and modular arithmetic, which are topics studied in the branch of mathematics called number theory. Calculations for the encryption of the plaintext and the decryption of the ciphertext involve exponentiations in modular arithmetic with the modulus being a very large number (e.g., of size 1024 - 4096 bits (note: a number with 1024 binary digits has over 300 decimal digits, while a 4096-bit number has over 1200 decimal digits.). Often, for practical reasons, the exponent used in the encryption (public exponent) is relatively small. This makes the exponent used in the decryption (private exponent) be of a very large size (comparable to the size of the modulus).

The use of such large numbers makes RSA computationally intensive. Furthermore, the value of the modulus provides an upper bound on the size of the data that can be encrypted in a single operation of the algorithm. For example, for an RSA modulus of 2048 bits, the size of this data, without counting any padding (overhead) that may be included, cannot exceed 256 bytes. Larger plaintexts can, in theory, be encrypted by splitting them in chunks of smaller size and exercising the RSA on each one of them separately. However, this means that the already computationally expensive algorithm needs to be executed multiple times. For this reason, RSA is almost never used to encrypt large messages (instead, it can be used as part of a hybrid cryptosystem to encrypt secret keys that will subsequently be used in symmetric ciphers for the encryption of large messages).

The strength of RSA lies in the difficulty of finding the prime factors of very large numbers (prime factorization). In the case of RSA, the large number of interest is the modulus discussed before. This modulus is created by the issuer of the keys as the product of two large prime numbers of approximately equal size, which are kept secret. Knowledge of these primes makes the generation of the pair of public and private exponents practically feasible. These exponents, together with the modulus, constitute the public and the private key, respectively. An interceptor with access to the public key, i.e., to the modulus and the public exponent, has no easier way to derive the private exponent than finding the prime factors of the modulus.

However, for very large such numbers solving this problem is considered to be computationally infeasible.

Apart from the RSA, other well-known public-key encryption algorithms include Elgamal and schemes based on Elliptic-Curve Cryptography (ECC). The strength of these algorithms lies in a different problem, which has to do with the difficulty of calculating discrete logarithms. Like any other public-key cryptosystem, their realization requires a great deal of computational resources. However, ECC can provide the same (or comparable) level of protection as RSA or Elgamal using much smaller keys (e.g., 256-bit key for ECC versus 2048-bit key for RSA) and, thus, is better suited for applications in resource-constrained environments.

8.4 Data integrity

Data integrity is the property that data has not been changed, destroyed, or lost in an unauthorized or accidental manner since it was created, transmitted or stored. In case of data transmission, for example, if accidental errors occur (due, for example, to noise in a communication channel or in an electronic device), corruption of data may be detected through error detection mechanisms like parity bits and simple checksums like Cyclic Redundancy Checks (CRCs). However, these mechanisms cannot offer protection against deliberate message modification, since an attacker intercepting and modifying the message could easily compute a new, valid error detection code and send it together with the modified data.

One could argue that, in this example, the modification of the message goes unnoticed because the attacker is able to manipulate the error detection code at will. However, even if this code was transmitted intact, there would still be no guarantee that the message content is unmodified. This is because the attacker could easily form a new message, having the same error detection code as the original message, and send this new forged message together with the original code. To defend against such types of attacks there is a need for strong, cryptographically secure checksums, as well as for protection mechanisms that would make it very hard for an attacker to modify them in a controllable manner. Encryption is a notable example of such a protection mechanism.

In information security, data integrity is primarily supported by strong checksums implemented through cryptographic hash functions. These functions, together with MACs and digital signatures are used to provide protection against malicious actions like message modification, impersonation and repudiation attacks. In this way, these cryptographic primitives ensure data integrity including support for data origin authentication (message authentication) and non-repudiation. Hash functions and MACs are discussed in this section, while digital signatures are presented in section 8.5.

8.4.1 Cryptographic hash functions

A hash function is a mathematical function H that maps an arbitrary, variable-length bit string x, to a fixed-length string h = H(x). The output, called hash or digest, is typically much shorter than most of the inputs and, thus, there may be many inputs that map to same output. A desirable property of a hash function is to distribute the results evenly (and apparently at random) over the output range.

In addition to this, hash functions used in security applications (called cryptographic hash functions), also have the one-way property and one of the two collision-free properties:

- "One-way property" or "preimage resistant": Given H and a hash value h, it is computationally infeasible to find any input x such that H(x) = h. On the contrary, given H and an input x, it should be relatively easy to compute H(x).
- "Weakly collision-free property" or "second preimage resistant": Given H and an input x, it is computationally infeasible to find a different input, x', such that H(x) = H(x').
- "Strongly collision-free property" or "collision resistant": Given H, it is hard to find any pair of inputs x and x' such that H(x) = H(x'). This property is stronger than the previous one, since a cryptographic hash function that is collision resistant is also second preimage resistant (the reverse is not necessarily true).

Cryptographic hash functions are probably the most versatile cryptographic primitive. It can be used in several security applications like password storage protection, file integrity assurance and message authentication, and as internal component of security primitives like MACs, digital signatures and stream ciphers. The use of hash functions in pseudo random bit generators and stream ciphers has been discussed in section 8.2.2. The rest of the hash functions applications are briefly described in the following (digital signatures are discussed in section 8.5).

Hash functions are irreversible encipherment mechanisms that do not use a key. The fact that they operate without a key means that when they are used to detect unauthorized data modification (including data insertion, deletion and replay), protection against manipulation of hashes should be put in place. Protection measures depend on the application and may take several forms. For example, let us consider how hashes can be applied to secure storage of passwords at a server and what kind of protection must be provided for password files. User passwords, being sensitive information, are never saved in plaintext form. Rather, when a password is created, what is stored in the system is the result of applying a hash function over the password, i.e., the password hash (note: in practice, a password can be combined with additional information prior to hashing; however, such details are not relevant for our discussion and can be safely omitted.). This is done in order to protect the user accounts from accidental disclosure of the password file; even if an attacker gets read access to the password hash, he has no easy way to determine the password itself, since this would imply reversing the hash function (which, in accordance with the preimage resistant property, is computationally infeasible). On a login attempt, the password transmitted by the user (usually through a secure connection) is hashed at the server side, and the result is compared with the stored password hash. If the two values match, the user is admitted to the system; otherwise, access to the system is not granted.

Obviously, the file containing the hashes of user passwords should be protected, so that an unauthorized entity cannot modify the hash values. This protection is delivered by the operating system provided that appropriate access rights for the password file are in place (in this case, write access should be granted only to authorized users). For higher protection, however, the system should not allow an unauthorized entity to even view the contents of the

password file (note: recall from the previous discussion that knowledge of a password hash does not imply knowledge of the password itself. Nevertheless, if an attacker knows a list of hashes, he can work offline hoping to reverse the hash function, and, thus, find a matching password.).

Cryptographic hash functions may also be used to verify the integrity of files in a computer system. In this case, a hash is extracted from each file of interest using a hash algorithm. The computed hashes need to be secured against unauthorized manipulation (e.g., they can be stored in a CD-ROM or DVD). If there is suspicion that a file has been modified by an unauthorized entity (e.g., a virus), its hash is compared against the hash of the original file. If they match, there is strong evidence that the file has not been modified. The difficulty that an attacker faces in finding another file with the same hash as the original file is due to the second preimage resistance property of the hash function.

In data communications, hash functions can be used to detect both accidental errors and intentional modifications. In both cases, the hash of the message is computed before it is transmitted over a communications link or network. If the goal of using a hash function is to provide (unintentional) error detection, the hash is simply sent together with the message. At the receiver side, the hash of the message is calculated and compared against the hash that had been transmitted with the message. If there is a matching, the integrity of the message is verified.

If, on the other hand, protection against intentional message modifications is required, the hash value is encrypted prior to transmission. In theory, any encryption mechanism that supports confidentiality or non-repudiation can be used to secure the hash. In practice, however, data integrity is provided in combination with data origin authentication. In case of this combined service, called message authentication, the hash is protected through symmetric encryption (Note that public-key encryption, discussed in section 8.3, provides confidentiality but not data origin authentication, since anyone can use the receiver's public key to encrypt the hash.). If, in addition to message authentication, support for non-repudiation is also required, the hash is protected through a digital signature. At the receiving end, the encrypted hash is decrypted before it is compared against the hash value that is calculated over the bits of the received message.

Examples of widely used hash functions include Secure Hash Algorithm (SHA) and Message Digest 5 (MD5). The SHA is a family of cryptographic hash functions standardized by NIST. The first version, known as SHA-0, was published in 1993. Due to security concerns, SHA-0 was shortly replaced by the slightly revised version SHA-1. Both SHA-0 and SHA-1 produce a message digest of 160 bits. Starting in 2001, NIST defined four new variants, namely SHA-224, SHA-256, SHA-384 and SHA-512, with message digests of 224, 256, 384 and 512 bits, respectively. These variants belong to the so-called SHA-2 family. Currently, SHA-2 algorithms with hashes of at least 256 bits are considered secure and used extensively in security applications and protocols including SSL/TLS, SSH and IPsec. In 2015, NIST published new variants for the SHA-3 family of hash functions. These variants, namely SHA3-

224, SHA3-256, SHA3-384 and SHA3-512, produce message digests of the same size as the SHA-2, but their internal structure differs significantly from the previous versions.

The MD5 [11] is a well-known message-digest algorithm producing a hash of 128 bits. The algorithm, specified in 1992, is now considered cryptographically insecure; however, it is still widely used to hash passwords in legacy systems and authenticate files downloaded from servers.

8.4.2 Message Authentication Code

A Message Authentication Code (MAC) is a condensed, fixed-size representation of a message calculated with the use of a secret key. Often called cryptographic checksum, a MAC is used to prevent forgery by providing data integrity and data origin authentication in a single function. A simple model of a MAC is illustrated in Fig. 8.10.

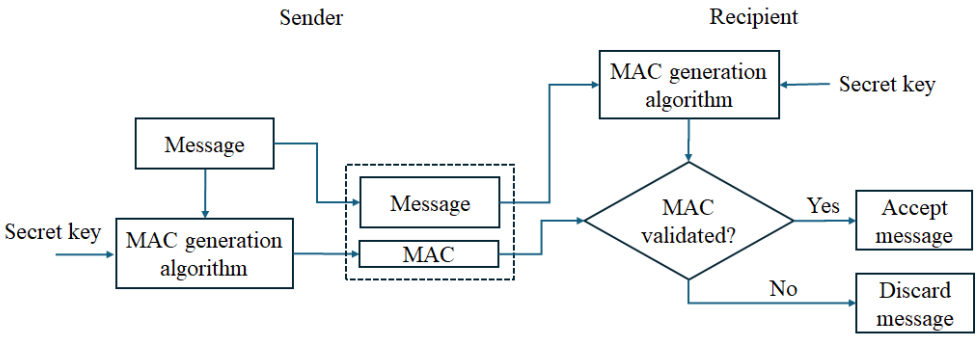


Fig. 8.10 Model of a MAC

At the sender side, the message and the secret key are used as inputs to the MAC algorithm. The output of this algorithm, i.e., the MAC, is appended to the message and the whole data block (message in plaintext form plus MAC) is transmitted over an insecure channel. At the destination, the received message together with the secret key are used as inputs to the same MAC algorithm. The output of this algorithm, i.e., the MAC of the received message, is compared against the MAC that had been sent along with the original message. If there is a matching between the two MACs, the receiver can be assured that the message has been sent by the claimed entity (holder of the secret key) and that the content of the message has not been modified (due either to accidental errors or deliberate manipulation). Without knowledge of the secret key, an interceptor who alters the message will not be able to provide a valid MAC for it, and, thus, fool the receiver into thinking that the received message is authentic.

MACs are commonly built on either block ciphers or hash functions. Examples of MACs based on block ciphers include the Cipher Block Chaining MAC (CBC-MAC) and the CMAC. The former is calculated according to the process of encrypting a message with the use of a block cipher (like DES or AES) operating in the CBC mode (Fig. 8.4). In the case of CBC-MAC, however, the IV used in the CBC mode is set to zero and all ciphertexts, expect the last one, are discarded after they have been delivered to the XOR function used to prepare the input for the next encryption block. The whole (or part) of the last ciphertext (i.e., output of the last

encryption block) is kept as the MAC. Security deficiencies of the CBC-MAC are addressed in a variation that is called CMAC [12]. The use of AES in CMAC is specified in [13].

The most popular approach for building MACs on top of cryptographic hash functions is the HMAC specified in [14]. This scheme primarily aims to a) use available hash functions as black boxes (i.e., without modifications), b) retain almost all the security of the underlying hash function, and c) allow easy replaceability of the hash function in case more secure or more efficient hash functions are required [15, 14]. The HMAC construction can be used with any hash function where data is hashed by iterating a basic compression function on blocks of data. Both MD5 and SHA satisfy this requirement, and, thus, can be used to implement an HMAC.

8.5 Digital signatures

In a setting with two communicating entities (like that used for the discussion in the previous section), a MAC provides data integrity and origin authentication but is not able to support non-repudiation. This is because MACs are based on symmetric cryptographic techniques in which the communicating parties share the same secret key. This means that in case of dispute, a user cannot prove to a third party that, for example, a message with a valid MAC was in fact sent by the other entity (and not by himself or someone he shared the key with). Non-repudiation can be provided by MACs; however, this requires a more complicated setting that involves a trusted third-party offering arbitration services [7].

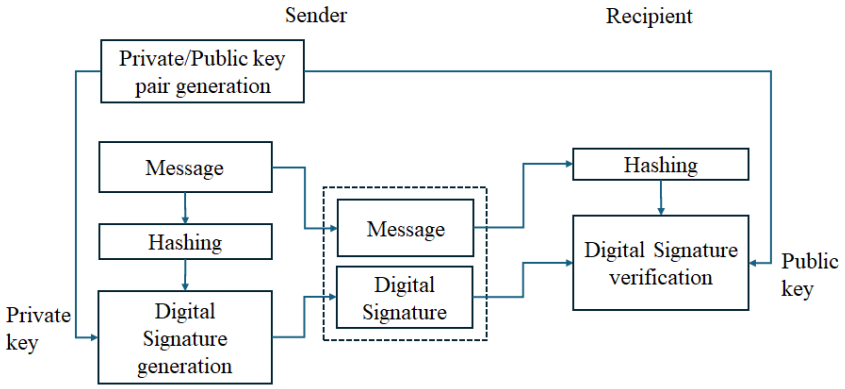


Fig. 8.11 Model of digital signature

A more efficient way to provide data integrity and origin authentication including support for non-repudiation is to use public-key cryptography to implement digital signatures. A digital signature is a value (or a set of values) calculated using the sender's (signer's) private key and, in its simplest form, appended to a data object so that any recipient can verify the signature using the signer's public key. Verification of the signature proves the source and the integrity of the data object. Compared to MAC, the use of private key in the signing process allows to uniquely identify the sender; in this way, digital signatures can provide the additional service of non-repudiation of the message origin and contents.

The model of the digital signature scheme is illustrated in Fig. 8.11. As in the case of public-key encryption, the sender creates a pair of private and public keys according to the cryptographic algorithm in use. The message that is to be digitally signed is first hashed to

reduce the size of the data over which the public-key cryptographic mechanism is exercised. The digest of the message together with the signer's private key are then used in the relevant algorithm to generate the digital signature. The signature is appended to the message and the new data block is transmitted. The receiver computes the hash of the received message and uses it along with the signer's public key in the signature verification algorithm. If the signature is verified, the receiver is assured that the message has been transmitted by the holder of the associated private key and that its content has not been altered. For any signature algorithm to be of practical use, the following requirements must be satisfied: a) it should be computationally easy to generate and verify a digital signature, and b) it should be computationally infeasible for an interceptor with no access to the signer's private key to forge a digital signature.

Digital signatures can be created with a variety of algorithms. The most widely used ones include the Digital Signature Algorithm (DSA), and schemes based on RSA and ECC. Several of these schemes are now part of NIST's suite of standards for digital signatures (DSS). The DSA is a variant of the Elgamal and Schnorr signature schemes and was first standardized by NIST in 1994 [16]. The standard was further revised in 1996, 1998, 2000, 2009 and 2013. The use of RSA for digital signatures is specified in an ANSI standard [17], several IETF publications [18–21], and NIST standards [22–24]. Standardized RSA-based schemes notably include RSASSA-PKCS1 and RSASSA-PSS. Schemes based on ECC include the Elliptic Curve Digital Signature Algorithm (ECDSA), specified in [25, 26, 22–24], and the more recent Edwards-curve Digital Signature Algorithm (EdDSA), specified in [27] and [24].

8.6 Secret key establishment and authentication of public keys

The secure establishment of keying material (including key generation and distribution) is essential for the operation of any secret key-based cryptographic mechanism like symmetric encryption and MACs. Key establishment can be provided by key transport or key agreement. In a key transport scheme one entity generates the secret key and shares it with the other communicating entity (or entities), while in a key agreement mechanism the entities jointly establish a shared secret key over an insecure channel. In either scheme, once a secure connection is established using the initial secret key (master key), additional, temporary keys (session keys) may be distributed over this connection, as needed.

Regarding key transport, if the number of master keys that must be shared is limited (as is the case for link encryption, where only one key is required to protect the communication between the two ends of the link), manual delivery of the keys is a viable option. However, for end-to-end encryption, where an entity may need to communicate securely with many other remote entities over a network, the required number of master keys may easily become very large, and, thus, manual delivery of them is hardly possible.

In such cases, a practical alternative is to let a third party (called Key Distribution Center – KDC), acting as a mediator, to generate and distribute the initial keying material needed for the secure communication between the interested parties. This requires that the KDC be trusted by all communicating entities and that secure connections between the KDC and each one of

these entities be established prior to the delivery of the keying material. Such a secure connection between the KDC and an entity is implemented by a symmetric encryption scheme. This means that there is still a need for the entity and the KDC to share a common (master) key; however, since only one key per entity is required, the total number of master keys that need to be initially delivered for the secure communication among many entities is significantly reduced.

The problem of initial secret key transport (either in a centralized setting with a KDC or in a distributed environment where no mediator is used) can be addressed by encrypting that using a suitable public-key cryptosystem like RSA. In this case, the secret key generated at the sender is encrypted with the public key of the recipient. Since only the recipient can decrypt this secret key (using its private key), confidentiality in the key distribution process is ensured.

Public-key cryptography can be also used to establish secret keys through key agreement. In contrast to key transport, key agreement does not involve sending the key from one entity to the other; instead, the secret key is generated independently at each entity based on public keying material previously exchanged between them and on the corresponding private keys that are kept secret. The most significant such method, which is also known for having laid the foundations of public-key cryptography, is the Diffie–Hellman (DH) key exchange, named after Whitfield Diffie and Martin Hellman who published it in 1976. The mathematical calculations used in the DH key exchange algorithm involve modular exponentiations, where the modulus is a very large prime number (e.g., at least 2048-bit long). The security of the algorithm is due to the computational complexity of the discrete logarithm problem, namely to the difficulty of finding the logarithm of a number in a modular arithmetic with a very large prime modulus and a primitive root of that prime number being the base of the logarithm.

As it happens with all public-key cryptosystems, both RSA-based key transport and DH key exchange schemes are vulnerable to a specific type of active attack (called man-in-the-middle attack), in which an adversary intercepts the public keys exchanged between the communicating entities and substitutes them with public keys generated by himself. By using the adversary's public key instead of the authentic public key, each one of the communicating entities gets involved in interactions with the adversary without realizing it. In case of RSA-based key transport this means that the secret key becomes available not only to the intended recipient but also to the adversary. In case of DH key exchange, the man-in-the-middle attack results in two separate secret keys shared by the adversary and each original entity. In both cases, the security of the key establishment process is violated.

The man-in-the-middle attack exploits the fact that the public keys exchanged over insecure connections are not authenticated (i.e., there is no assurance that a public key indeed belongs to the entity that claims to have generated it). The most efficient way to provide public key authentication is through digital (or public-key) certificates. A digital certificate is an electronic file containing information about the identity of an entity and its public key (i.e., it binds a public key to an entity). To avoid forgery, the certificate is digitally signed by the issuer (which can, for example, be a Certificate Authority). A digital certificate can be freely distributed, and its validity can be checked by verifying its signature (using the issuer's public key).

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Chapter 9. Cybersecurity of SOHO and SMB computer networks

9.1. Cybersecurity challenges for entrepreneurships

Modern cyberattacks are typically well-prepared and carefully planned, utilizing significant resources to bypass security systems. Small office/home office (SOHO) and small to medium-sized business (SMB) networks have recently become particularly vulnerable to cyber threats. These networks, on one hand, are of interest to malicious actors, while on the other hand, they lack the level of security measures found in large corporate networks.

The detection and protection against cyber threats in computer networks are usually ensured by intrusion detection and prevention systems, whose effectiveness is highly dependent on their architecture and placement within the network. Studies of known cybersecurity methods and intrusion detection highlight the need for further development in the implementation of new models, methods, and technologies for network protection and intrusion detection systems. Considering current realities, threats can target all aspects of human activity, making the task of protecting information infrastructure even more critical. It is essential that networks at all levels remain secure, regardless of their size and traffic volume.

9.1.1. Cyberattacks

A cybersecurity incident or cyber incident is an event or a series of adverse unintended events (natural, technical, technological, or due to human error) and/or events that exhibit characteristics of a possible (potential) cyberattack, which pose a threat to the security of electronic communication systems, process control systems, and create the possibility of disrupting the normal operation of such systems (including the disruption and/or blocking of the system's operation, and/or unauthorized control of its resources), thereby endangering the security and protection of electronic information resources [23].

Distinct from a cyber incident, a cyberattack constitutes a deliberate, intentional act within cyberspace, executed via electronic communication mechanisms such as information and communication technologies, software, hardware, and other technical and technological means or equipment. The objectives of a cyberattack typically include, but are not limited to: violating the confidentiality, integrity, or availability of electronic information resources processed (transmitted, stored) within communication and/or technological systems; gaining unauthorized access to such resources; compromising the security, stability, reliability, or normal operational mode of communication and/or technological systems; or leveraging communication systems, their resources, and electronic communication means to launch further cyberattacks against other cybersecurity objects[24].

One of the classifications of security attacks, employed both in X.800 and RFC 4949, is the division into passive and active attacks. A passive attack is aimed at obtaining or utilizing information from a system without affecting its normal operation. An active attack, on the other hand, attempts to modify system resources or influence their operation. Main attack classes are shown on the next figure (Fig. 9.1).

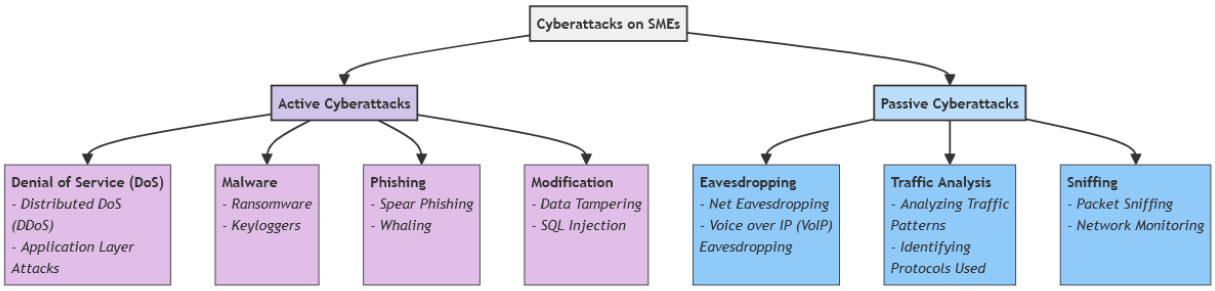

Fig. 9.1 Cyberattacks classification

Passive attacks are characterized by eavesdropping or monitoring transmissions. The primary objective of an attacker in a passive attack is to acquire transmitted information. This category of attack encompasses two main types: message content interception and traffic analysis.

Intercepting message content is the simplest form of passive attacks. A phone conversation, an email message, or a transmitted file may contain secret or confidential information.

Eavesdropping is one of the most common passive attacks, according to Sumi [1]. One reason for this is that such attacks typically take the form of secretly listening in on private exchanges of information between hosts. The attacker attempts to steal information transmitted by the user over the network using a computer, smartphone, or other devices. An attacker can leverage unsecured network communications to access user-transmitted and received data. This attack type is challenging to detect because it does not disrupt network operations. Its primary objective is to acquire confidential information for subsequent exploitation.

A sniffing attack is a type of listening attack where the attacker intercepts and captures network traffic in order to gather delicate facts. A malicious actor may monitor data transmitted by a system, possibly steal confidential information such as a user certificate, plastic money numbers, or private message using a package sniffer. The sniff attack can still be particularly hazardous because it is usually silent, leaving the victim uninformed of the compromise before it is too late.

Traffic analysis represents a more sophisticated type of passive attack. Even when message content or other information traffic is masked (e.g., through encryption), an attacker can still observe communication patterns. By analyzing the location and identity of communicating hosts, along with the frequency and length of exchanged messages, an attacker can infer the nature of the communication, even without decrypting the content [25].

Passive attacks pose significant detection challenges due to their non-interfering nature with transmitted data. Message traffic typically remains undisrupted, precluding both sender and receiver from recognizing the presence of a third-party monitoring or traffic analysis activity. However, the success of passive attacks can be mitigated through the application of encryption. Consequently, defense strategies against passive attacks prioritize prevention over detection. [2].

Active attacks are characterized by either the alteration of data streams or the generation of spurious ones. These attacks are typically categorized into four main types: masquerading, replay, message modification, and denial of service.

Masquerading describes a deceptive tactic where one entity illicitly assumes the identity of another. This attack frequently incorporates other active attack methodologies. For example, an attacker might intercept and replay authentication sequences after a legitimate session has

concluded. This enables an unauthorized entity, initially possessing limited access, to impersonate a privileged entity and thereby gain elevated access rights.

Replay involves the passive capture of a data block and its subsequent retransmission to gain unauthorized access, privileges, or unauthorized execution of certain actions.

Message modification means that some part of a legitimate message is altered, or messages are delayed or reordered, to achieve an unauthorized effect [2].

Using malware for attacking network infrastructure can also be classified as active attack. Malware is a term used to refer to various categories of harmful programs created specifically to gain unauthorized access into computer systems. These malicious programs may vary from those that are capable of stealing sensitive information to those that may corrupt files or even block users from accessing their systems using ransomware. In other words, it can be said that malware includes viruses, worms, Trojan horses, spyware and adware just to name a few. Malware often spreads via e-mail attachments, infected downloads or software applications vulnerabilities.

Denial-of-Service (DoS) attacks, including their distributed variant (DDoS), represent a prevalent form of active cyberattack. A Distributed Denial-of-Service (DDoS) event manifests when numerous compromised systems collectively overwhelm a target system's bandwidth or resources, commonly affecting web servers. The objective is to incapacitate or overload the targeted machine or network, thereby rendering it inaccessible to legitimate users. This is achieved by flooding the target with excessive traffic or by sending malformed data that induces system failure. As each server possesses finite bandwidth and processing capacity for incoming requests, exceeding these limits inevitably leads to a service disruption. Consequently, legitimate visitors are unable to access services hosted on the affected server. DDoS attacks primarily fall into two categories: Bandwidth Exhaustion: Characterized by saturating the network with high volumes of traffic, leading to network infrastructure failure. Resource Exhaustion: Involves depleting critical system resources such as CPU cycles, memory, or connection tables, thereby disrupting normal server operation.[26]

Typically, these attacks originate from multiple sources targeting a single entity. While less common, attackers may also launch multi-target attacks by manipulating routing information through forging, modification, or replaying techniques.

On the other hand, F. Sumi [1] identifies two general methods of DDoS attacks: "service flooding" or "service crashing," based on the cause of the service failure. Service flooding attacks occur when the system receives too much traffic, forcing the server to buffer it, leading to service slowdowns and crashes when the buffer overflows. Service crashing occurs when the attacker sends traffic containing incorrect data that causes the server to crash. This classification is more relevant when considering the protection of network services against DDoS attacks, as reliable protection requires the most detailed information about the attack vector.

Another popular type of active attack is phishing, a form of attack aimed at fraudulently obtaining money or confidential information. Phishing is a trap that deceitfully asks people to enter their personal information for account access [1]. Users are directed to a fraudulent copy of an institution's website, for example, by clicking a link in an email, and enter their information without realizing they have fallen victim to a scam. The scammer then gains access to the victim's online bank account and funds, or other sensitive data, which can be resold or used for other malicious purposes.

Direct access attacks are also considered active and occur when attackers obtain personal data directly through the user's physical device. Users are often unaware of the attack. Direct access

can be applied not only to mobile devices but also to insufficiently protected server infrastructure.

Another widely used type of active attack is the creation of botnets. Users unknowingly download malicious software, such as Trojan horses, which may be sent as email attachments, and infect their computers. The attacker gains control over these zombie computers and can use them for their purposes. According to Thanh Vu [3], such botnets are used for conducting DDoS attacks, cryptocurrency mining, or stealing valuable information, often unnoticed by the user.[4]

A distinct category of attacks specifically targets web resources, encompassing cross-site scripting (XSS) and clickjacking. Cross-site scripting vulnerabilities arise in web applications, enabling adversaries to inject malicious code into web pages displayed to other users. The exploitation of XSS vulnerabilities allows attackers to circumvent access controls. Fundamentally, an XSS attack is an injection attack where malicious scripts are embedded within ostensibly trusted and reliable websites[26].

Clickjacking is a deceptive technique in which an attacker manipulates users into clicking seemingly innocuous, visually engaging elements on a webpage. Unbeknownst to the user, who intends to interact with the visible content, their click is instead registered on an concealed button or link from a different, underlying webpage. This manipulation is achieved through the use of multiple transparent or opaque layers [5]. The attacker's objective is to compromise the user's personal account or illicitly perform an action on the user's behalf when they interact with the attacker-controlled overlay.

Computer networks vary in size, purpose, composition, and technologies used. These differences also affect the methods and technologies used to protect networks from intrusions. First and foremost, protection methods are influenced by the amount of traffic on the network, which usually depends on the size of the network and the available network services.

One criterion for classifying networks is their scale. According to the physical size of the network, networks can be classified as:

- Personal Area Networks (PANs) are designed for a single person or a small group of people, such as a family. A typical example of a PAN is a home wireless network. The key feature of PANs is the ability to allow devices to automatically detect and connect to each other.
- Local Area Networks (LANs) are small networks that cover only a few buildings or an area up to a few kilometers in size. LANs are widely used to connect personal computers and workstations in offices, enterprises, and universities for sharing resources and information. A typical example of a LAN is the shared use of printers in a lab or department.
- Metropolitan Area Networks (MANs) can cover an area of less than 100 km. The most well-known example of MANs is cable television networks. High-speed wireless internet access is another example of a MAN. ─Wide Area Networks (WANs) cover large geographic areas, often countries or continents. They contain millions of machines connected by communication subnets. The Internet is the largest global network ever created.

It is also worth noting corporate networks, which are characterized by providing services only to users—the employees of the enterprise using the network. Bondarev, in his book [6], notes that unlike communication operators' networks, enterprise networks typically do not provide services to other organizations or users. For corporate networks utilizing global Internet technologies, the term Intranet is often used. Depending on the size of the enterprise, as well

as the complexity and diversity of the tasks to be solved, there are networks for departments, campus networks, and enterprise-scale networks. In the context of corporate networks, network size can be classified as follows: ─SOHO networks—home or small office networks (closest to PAN but can also include small LAN networks). This category may also include workgroup networks. These typically include up to 15-20 users and do not have servers with configured network services, usually limited to using Windows workgroups for file sharing, with most services used by users hosted on the Internet or a higher-level network. These networks are characterized by simplicity and homogeneity. Since these networks do not contain a large number of services accessible from outside, they do not require complex intrusion detection systems. Typically, a properly configured firewall and, if necessary, a simple intrusion detection system are sufficient. ─ Departmental networks—differ from SOHO networks by a larger number of users. These networks typically include one or more servers.

9.1.2. Network Security

It is often believed that network security primarily depends on the software and hardware protection measures used. However, even a superficial review of statistical data reveals that security is a complex concept, and no single component alone can guarantee reliable protection. Therefore, before securing a network, it is essential to identify the key security factors.

According to CyBOK 1.1 [7], security factors can be divided into two categories:

- Factors related to protection against attacks and intrusion prevention;
- Factors related to human resources, organization, and legal aspects.

Information security is considered in terms of three main components:

- Infrastructure security;
- System security;
- Application and platform security.

Infrastructure security involves the use of protection measures for communication channels and the organization of physical-level security for the infrastructure. Although physical attacks are costly and more common in large networks and enterprises, poor protection of SOHO and SMB networks may also provoke a malicious actor to attempt a physical attack. Therefore, a basic level of infrastructure security for such networks should include the use of cryptographically secured network connections and restricted physical access to critical network nodes, such as servers.

System-level security involves the use of secure operating systems, safe methods of authorization, authentication, and accounting, both at the individual node level and at the level of distributed systems if they exist. For small networks, this level of security requires the use of up-to-date operating systems with installed security updates, encryption of valuable data stored on the network, and the use of available AAA (authentication, authorization, accounting) mechanisms.

Application and platform security involves the use of secure software, meaning that network software should be up-to-date and have security patches installed. Additionally, attention should be paid to the lifecycle of the software used and timely responses to the decommissioning of certain software versions.

Factors related to human resources can be divided into several groups, with the primary group concerning user behavior, as behavior directly affects network vulnerabilities. Human factors often lead to a weakening of network security and information leaks. In such cases, the concept of information security culture becomes paramount [7]. Since attackers often use human-

centered threats, such as phishing emails, malicious links, fake profiles, etc., that users may encounter during their work, carelessness on the part of a user can lead to serious damage and information loss. According to Niekerk [8], this is primarily due to the fact that users typically lack sufficient knowledge of information security, as it is not directly related to their job functions. Therefore, educating users on the basics of information security is an important factor in ensuring the security of enterprise networks, particularly SOHO and SMB networks.

From the above, it follows that network protection must be comprehensive and take into account all available levels and factors. At the same time, network protection should be implemented both at the level of security policies and through security solutions. A security solution fundamentally differs from a security policy. While a solution functions to support the policy, it does not act as a substitute. This distinction, despite its apparent clarity, often becomes muddled during the design phase, particularly if an enterprise lacks a well-defined security policy.

Small and medium-sized businesses that do not have sufficient resources to ensure internal network security likely do not have a security policy and may delegate the task of developing a security policy to the personnel responsible for developing security solutions [9]. While both tasks are necessary for reliable protection, the development of a security policy may have different legal implications than the development of a security solution to implement it, and the absence of a policy can negatively impact the quality of the developed solution.

Another important group consists of personnel responsible for network security, usually system administrators or security administrators. Their qualifications and diligent work determine the proper configuration and operation of both the network and its protective measures.

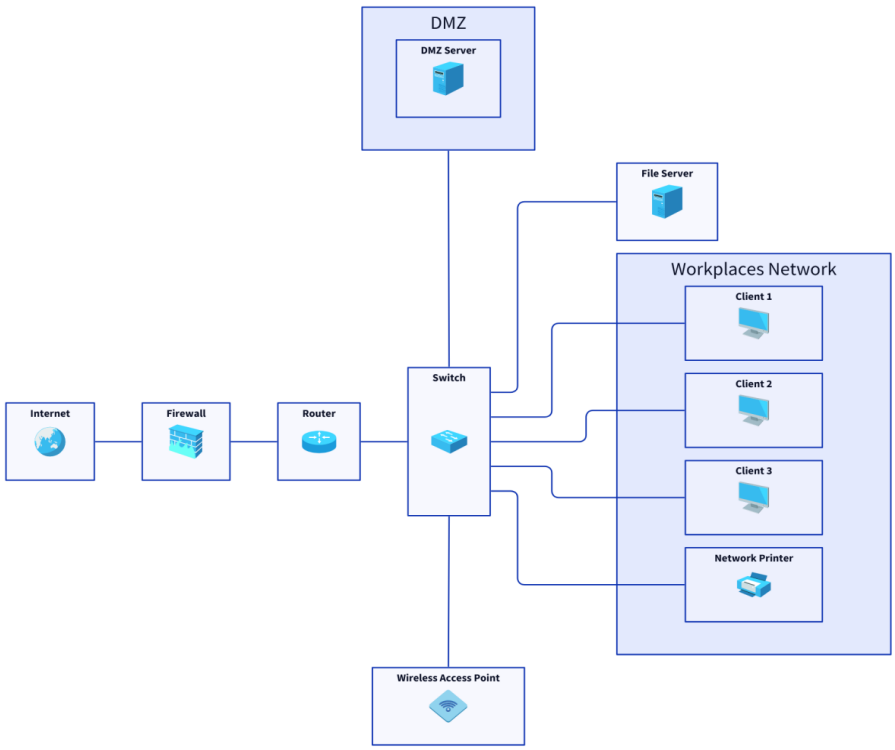

Fig. 9.2 - Typical SMB network structure

In addition to the human factor, the architecture of the network has a significant impact on its security. Large networks typically have a tree structure and are divided into domains where security policies are configured according to the network's requirements and functions. However, SOHO and SMB networks generally do not include a large number of nodes, making their architecture much simpler. When such networks are connected to the global internet, they usually have a firewall or a router with firewall functionality responsible for filtering malicious traffic from outside. Additionally, if separate zones are present, the function of network segmentation is also entrusted to the firewall. For example, a web server that needs to be accessible from outside should be placed in a demilitarized zone (DMZ) from which there is no access to the main network, preventing attackers from using the server as a foothold for attacking other network nodes. Other nodes in such networks are typically connected through a series of switches and wireless access points [10]. The structure of a typical SMB network is shown in Figure 9.2, where, in addition to the web server located in the demilitarized zone, there is a file server and a network printer connected to the main network zone.

The Demilitarized Zone (DMZ) network typically functions as a perimeter network, fortifying an organization's internal local network against untrusted external traffic. This subnet is strategically positioned between the public Internet and private networks. As noted by Alvarez [11], the core objective of a DMZ is to enable an organization to interact with untrusted networks, such as the Internet, while simultaneously safeguarding its private or local area network. Organizations commonly deploy external-facing services and resources within the DMZ, including servers for the Domain Name System (DNS), File Transfer Protocol (FTP), email, proxy services, Voice over Internet Protocol (VoIP), and web hosting. These assets are carefully isolated with restricted access to the internal network, ensuring they remain Internet-accessible without granting direct entry to the internal infrastructure. Consequently, the DMZ architecture significantly complicates direct unauthorized access to an organization's data and internal servers from the Internet for malicious actors.

The DMZ is segregated by a security gateway, such as a firewall, which meticulously filters traffic between the DMZ and the internal local network. Frequently, DMZ servers receive additional protection from a second security gateway that filters inbound traffic from external networks [12]. Ideally, the DMZ resides between two distinct firewalls. Should an attacker succeed in breaching the external firewall and compromising a DMZ system, they would still need to circumvent the internal firewall to access sensitive corporate data.

The primary benefit of a DMZ is its ability to provide an elevated level of security for the internal network by restricting access to sensitive data and servers. The DMZ enables external visitors to access designated services while serving as a buffer between them and the organization’s private network. This arrangement also yields further security advantages, including: [13]

- *Enabling Access Control:* Enterprises can grant users access to services outside their network via the public Internet. The DMZ provides access to these services by implementing network segmentation, making it more difficult for unauthorized users to access the private network . The DMZ may also include a proxy server that centralizes internal traffic flow and simplifies monitoring and logging of this traffic.
- *Preventing Network Reconnaissance:* By providing a buffer between the Internet and the private network, the DMZ prevents malicious actors from conducting reconnaissance activities that they use to find potential targets and vulnerabilities. Servers in the DMZ are open to everyone, but the firewall enforces a different security policy that prevents attackers from seeing the internal network. Even if the DMZ system is compromised, the

internal firewall separates the private network from the DMZ to ensure its protection and complicate external reconnaissance.

- *Blocking Internet Protocol (IP) Spoofing:* Malicious actors try to find ways to gain access to systems by spoofing an IP address and posing as an approved device on the network. The DMZ can detect and stop such spoofing attempts, as another service verifies the legitimacy of the IP address [14]. The DMZ also provides network segmentation to create space for organizing traffic and access to network services away from the internal private network.

9.2. Main features of SOHO and SMB cybersecurity

9.2.1. Key factors of SOHO and SMB cybersecurity

At first glance, it may seem that the primary targets for hacker attacks are typically large corporate networks, and that the threats to SOHO (Small Office/Home Office) and SMB (Small and Medium-Sized Businesses) are so minimal that such networks do not require additional specialized methods and means of protection. However, after analyzing current reports on detected cyberattacks, we see that SOHO and SMB networks, which usually have limited resources, are increasingly becoming targets of cyberattacks. Moreover, statistics from recent years show that a significant portion of cyberattacks are directed against networks of this class. It is important to note that cyber threats can have serious effects like financial losses, damage to reputation and even closure of the company. Therefore, understanding the main factors affecting network security is a prerequisite to ensuring an adequate level of protection.

Several key factors contribute to the attractiveness of SOHO and SMB networks to malicious actors:

- SOHO and SMB networks are far more numerous than large corporate networks, giving attackers a wide range of targets. These networks are found across most sectors of human activity.
- Human factor is a critically important element in cyber security system. People working within the company can either be a strong champion or the weakest link in the security architecture. Low levels of staff awareness on matters pertaining cyber-threats like phishing and social engineering can lead into successful attacks.
- Low level of information security culture, leading to employees not participating in processes of ensuring the security of information infrastructure, fearing made mistakes, not reporting suspicious actions, suspicious software operation, and the behavior of others.
- The absence of a clear regulatory framework governing cybersecurity and security policies leads to ad-hoc security measures and sometimes contradictory decisions.
- An unfounded confidence in the security of one's own infrastructure, a belief that "it won't happen to us," and a belief that the information is not of interest to malicious actors.
- An unfounded confidence in the security of one's own infrastructure, a belief that "it won't happen to us," and a belief that the information is not of interest to malicious actors.
- The lack of specialized hardware or software intrusion detection and protection systems [15], as attackers often choose the path of least resistance.

- The absence of qualified specialists. In lot of cases system administrator is responsible for cybersecurity of company. But such dual job does not allow to pay full attention to setting up secure environment and keeping it up to date.

According to reports such as The State of Cloud Security 2021 Report [16] and the Cybersecurity INSIDERS Cloud Security Report 2021 [17], approximately 36-50% of companies using cloud-based network security tools faced data breaches or security gaps due to incorrect cloud configuration. As of 2023, the situation is improving (according to the Cybersecurity INSIDERS 2023 Cloud Security Report [18]), and data leaks are no longer the primary threat. However, about 24% of organizations still encountered cyber incidents related to the use of cloud resources, with a significant percentage of incidents linked to improper configuration or compromised accounts.

While cloud resources may seem to offer absolute and reliable protection at first glance, there are indications that this is not the case. Although cloud resources can mitigate many risks, primarily those associated with physical security and equipment safety, the use of cloud resources still requires the implementation of proper approaches to enterprise information security.

As we can see, due to the rapid increase in the number of cyberattacks, nearly sixfold during the COVID-19 pandemic and the shift of much business activity online, and with the onset of the full-scale invasion in February 2022, the number of cyberattacks on Ukrainian networks has significantly increased. SMB networks, in particular, are at high risk. Statistics indicate that approximately 70% of such networks are completely unprepared for these attacks. Furthermore, about 51% of small businesses do not allocate any budget for cybersecurity. About 20% of small and medium-sized enterprises do not use any network security measures, and about 33% rely solely on free tools. The need for financial investment in security leads to a lack of personnel with the necessary qualifications, as well as a lack of hardware and software protection tools. It should be noted that free software designed for home use is not well-suited for enterprise networks, as it is primarily designed to protect local computers from threats commonly faced by home users. The threats directed at enterprise networks are typically of a different nature and are often aimed at disrupting service operations, with 34% of cases taking more than a week to recover from such cyberattacks.

Sometimes, companies exhibit a careless attitude toward information security, believing that the lack of attractive resources reduces the interest of malicious actors. However, even if the potential loss of personal data or intellectual property is not considered, a company can still hold value as an intermediary for compromising third-party partners [19].

Thus, SOHO (Small Office/Home Office) and SMB (Small and Medium-sized Business) networks are currently at high risk and require increased attention to security in its comprehensive sense. Special attention should be paid to network security software and hardware, as these networks require simple, easy-to-deploy, and effective security solutions.

9.2.2. Threat cases for SOHO and SMB cybersecurity

The Check Point Cyber Security Report for 2023 analyzes the volatile cybersecurity landscape of 2022, a year marked by unprecedented levels of cyberattacks, largely influenced by the Russia-Ukraine conflict. The education and research sectors continued to experience the highest targeting frequency. Concurrently, attacks against the healthcare sector saw a substantial 74% increase compared to 2021. Globally, the total volume of cyberattacks surged by 38% in 2022 relative to the preceding year [20].

Key points from the 2023 Cyber Security Report:

- Ransomware and Uncontrolled Data Wiping: Identifying ransomware operations and tracking threat actors may become even more challenging. Instead, the focus will shift towards detecting data wiping and leakage.
- Hacktivism: A blurring of boundaries has emerged between state-sponsored cyber operations and hacktivism, as nation-states have increasingly engaged in cyber activities under a veil of anonymity, thereby mitigating fears of direct retaliation. Concurrently, non-state hacker collectives exhibit enhanced organizational structures and amplified effectiveness.
- Cloud: Third-Party Threats: There was a significant increase in attacks on cloud networks per organization, rising by 48% in 2022 compared to 2021, indicating a worrying trend.
- Weaponizing Legitimate Tools: To combat advanced cybersecurity solutions, attackers are weaponizing built-in capabilities and operating system tools already installed on target systems, as well as leveraging popular IT management tools, which are less likely to raise suspicion when detected.

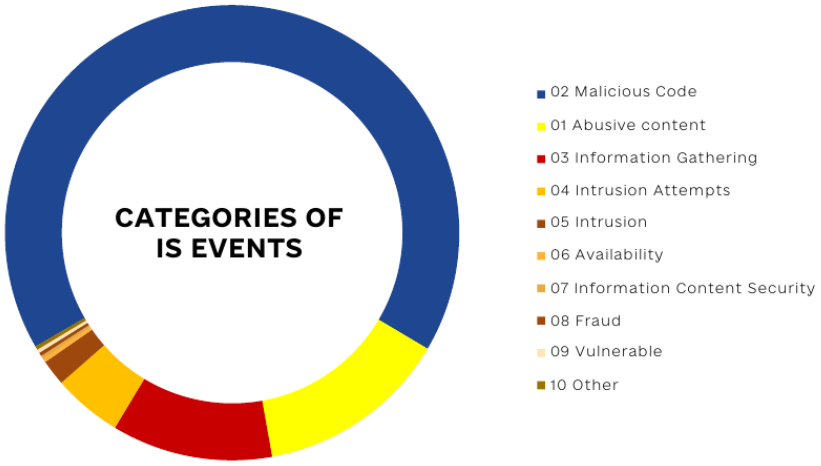

Fig. 9.3 - Cybersecurity events by categories [21]

The diagram (Fig.9.3) provided shows a cyberthreat classification and target details. It highlights several dominant threat categories:

- Malicious Code: A wide range of threats, including viruses, worms, ransomware, and spyware, are included in this category of malicious code. They constitute a mainly useful part of the table, expressing concern that malicious code remains a major concern for associations.
- Abusive Content:The abuse content includes a wide range of harmful content, including content promoting of terrorism, the dissemination of false or misleading information.
- Information Gathering: The current class of data collection includes undertakings such as reconnaissance and social technologies used by attackers to gather information on their target prior to the establishment of a more sophisticated attack.
- Intrusion Attempts: The present class focuses on the persistent efforts of a malicious actor to gain illicit access to the frameworks and systems. The large representation of this group underlines the importance of robust margin defense and invasion detection systems.

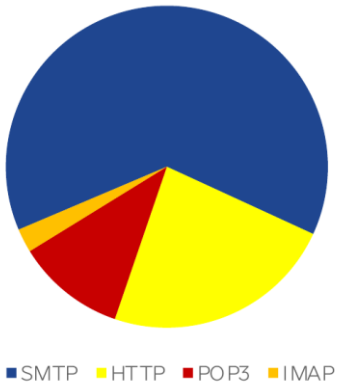

Fig. 9.4 - Ways of malware propagation[21]

The pie chart (Fig. 9.4.) provided shows the movement of malware through several Internet protocols. SMTP (Simple Mail Transfer Protocol) is the dominant vector for disseminating malware. HTTP (Hypertext Transfer Protocol) also plays a huge role and proposes that web attacks are widespread. POP3 (Post Office Protocol version 3) and IMAP (Internet Message Access Protocol) have a smaller part, implying that email vulnerabilities are exploited for dispersal. And one of the reasons for this is that using email letters is the simplest way to distribute malicious files. Usually attackers use some stolen official email addresses to send spam emails with some fake reports, billings or something similar that contains malware downloader. And when people see email messages that looks like official ones they usually open them and then download and run infected files.

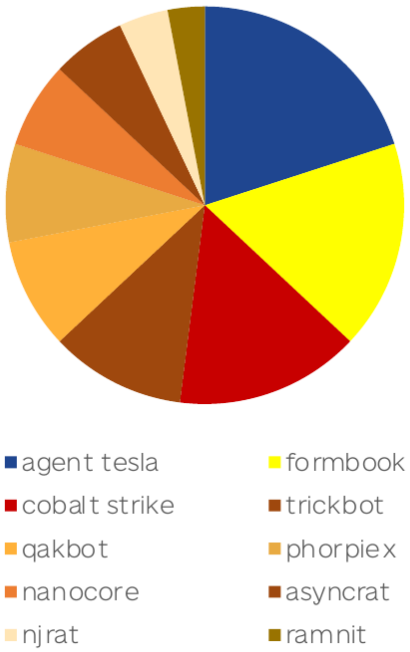

Fig. 9.5 - Main malware families [21]

Now let's take a look on malware that was frequently distributed. The map (fig. 9.5.) shows the relative frequency of different malware families used during cyberattacks on Ukrainian infrastructure in 2023. It seems that the mainly universal tribes are:

- Agent Tesla take major part of chart, so it's used for attacks very often.

- The cobalt strike occupies a large part of the diagram, assuming that it is also popular software used as an attack tool.
- The Qakbot also has a powerful aura, which speaks of its widespread use by hackers.
- Trickbot has also got a big part to play, focusing on the danger zone.

Other kinds of malware are Agent tesla, Formbook, Phorpiex, Nanocore, Njrat, Asyncrat, and Ramnit, although their representation is changing.

Now let's take a more detailed look at all of this malware families and their main features:

- Agent Tesla: is well known for its keylogging, money management Trojan, and information stealing abilities.
- Cobalt strike: is basically a legitimate penetration test tool, but it is often misused by the attackers.
- Formbook: Primarily a banking trojan designed to steal financial information.
- Trickbot: A banking trojan with information stealing and botnet capabilities.
- Qakbot, which was originally a financial management Trojan, evolved into a modular malware platform that delivered more malware tools.
- Phorpiex: A network worm and botnet known for distributing spam and malware.
- Nanocore: Remote Access Trojan (RAT) provides device operator functionality for attackers.
- Njrat: Another RAT with similar capabilities to Nanocore.
- Asyncrat: A relatively newer RAT gaining prominence.
- Ramnit: A banking trojan with information stealing capabilities.

9.2.3. Recommendations for SOHO and SMB on providing of cybersecurity

Sufficient cyber security measures are necessary to enhance the security position of small enterprises. Nevertheless, small enterprises are able to significantly reduce their challenges by adopting appropriate leading techniques in cyber security. The following are essential plans for strengthening your firm against potential threats [22]:

- Employee Training and Awareness. In an organization, a useful share of the data breach is normally payable due to unintentional or negligent conduct of employers. An employer may unwittingly expose the company to digital perils by losing equipment, accidentally sharing certificates, or, alternatively, being a victim of phishing attacks. Consequently, comprehensive cyber training that teaches team members about the importance of strong passwords, acknowledges phishing attempts, and adheres to procedures for safeguarding delicate intelligence is necessary.
- Comprehensive Risk Assessment. It is important to move away from a thorough liability assessment in order to identify and assess the challenges to the fact arrangements of industry. Organization is aware of the manner in which the data is stored, who have access to it, and the various ways in which the adversary might use the system in order to breach them. Alternately, an insurance proposal that successfully addresses the vulnerabilities assessed using the expertise gained from the new appraisal may be developed and promoted. The current procedure is ensured to remain secure against the increasing danger by regularly updating it.
- Deployment of Antivirus Solutions. A robust antivirus software is essential for safeguarding all equipment against diverse threats, encompassing viruses, spyware, ransomware, and phishing attacks. It is important to keep updated antivirus software in order to fight against current online threats and patch each confirmed vulnerability.

- Regular Software Updates. In addition to anti-virus patches, it is essential to ensure systematic improvement in the use of all software. Software sellers frequently abandon updates that deal with security vulnerabilities. Some software, similar to Wi-Fi router firmware, may require a manual update, which should be quick enough to close all security holes.
- Regular Data Backups. Keeping your data backup is a key defense mechanism against data loss due to cyberattacks. The use of an automated backup software ensures that, in the case of an attack, such as ransomware, your data can be restored from a secure backup, minimize downtime, and prevent data loss. It is recommended to store backups offline to prevent them from being harmed.
- Data Encryption. Encoding is an essential safeguard for companies managing responsive information, such as financial data. Encoding information into an indecipherable code makes it useless for unauthorized users, even if they steal it. Because of the increasingly widespread information stealing, this layer of protection is particularly important.
- Access Control. Restricting access to essential information to only those workers who require it reduces the risk of a fundamental data breach. Establishing clear recommendations for those who have access to a given type of data ensures responsibility and minimizes the risk of unauthorized data collection.
- Securing Wi-Fi Networks. It is compulsory that your company obtains a Wi-Fi Grid with an up-to-date protocol, such as WPA2/WPA3, otherwise the following version. Moreover, changing the default configuration of the router, such as the Support Establishment Identifier (SSID) and applying a complex passphrase enhances the security of the system against illegal access.
- Strong Password Policies. Good way to increase the security level is the use of robust, complex passwords and using standards that require regular updates of passwords. Multi-factor authentication (MFA) usage is also a good practice.
- Password Managers. Given the complexity and variety of robust passwords, a password manager can remain an invaluable tool for both safety and convenience. The above devices and software can securely store and manage passwords, thereby reducing the risk of weak passwords and increasing the overall security position.
- Using Firewalls. Firewalls serve as a serious defensive mechanism, defending hardware and software by filtering traffic and overcoming system gridlock. The regular updating of the firewall software ensures that it is capable of resisting new and evolving threats.
- Virtual Private Networks (VPNs). An additional layer of security, especially for team members who access the work place or some company resources remotely, is provided by a VPN. VPNs encrypt network traffic and protect data from interception, especially on unencrypted public networks.
- Physical Security Measures. In addition, the protection of the physical devices (hardware) that store and process your data is one of the main protection measures for your business. In order to prevent unauthorized and illegal access, the current measures may involve applying physical securing for sensitive hardware or even installing track devices on the hardware. Remote wiping is also good technique to delete data on devices which were stolen.
- Mobile Device Security. Mobile devices introduce significant security challenges, particularly when they store sensitive information or can access an organization's corporate network. Transportable devices are frequently overlooked in cyber security systematic planning, as they can pose essential hazards unless they are properly procured. Asking employers to use robust passwords, and encryption of statistical data

prevent sensitive information from being compromised. Ensure that clear reporting procedures are established for lost or stolen phones and tablets.

- Evaluating Third-Party Security. Measures must be in place for all third parties to which company belongs. In order to ensure the correctness of retention contracts, it is essential to ensure that associates and contractors comply with strict digital protection standards. Small enterprises can competently defend their operations from the increasing threat of cyberattacks, thus ensuring a secure and hard business environment.

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Chapter 10. On-line Marketplaces platforms

10.1 General overview On-line Marketplaces platforms

Today, you will not surprise anyone with the purchase of goods and services on the Internet. Therefore, when most people hear the name On-line Marketplaces platforms, they immediately imagine websites where they made online purchases. Amazon, EBay, AliExpress, Temu, Airbnb, Etsy, Uber are just some of the most famous marketplaces in the world. There are marketplaces that are more focused on specific countries, for example, in Ukraine the most famous ones are Rozetka, Prom.ua, Bigl, Zakupka. Individual store chains also often have their own marketplace, for example, in Ukraine the most famous ones are Epicentr Marketplace, Allo, Brain.

A marketplace is a place where sellers (service providers) and buyers (customers) meet and interact with each other [1]. A marketplace provides tools to facilitate transactions between the parties. The parties themselves interact according to the following most popular business models:

- B2C (business-to-consumer) is a business where companies sell goods or provide services directly to consumers without intermediaries. This type of business is the most popular, it is focused on a mass audience of customers with fast sales and the ability to scale.
- B2B (business-to-business) means a business where companies sell goods or provide services to other companies. Often focused on complex and long-term interaction with advanced payment methods.
- C2C (consumer-to-consumer) is a business in which a consumer sells or exchanges goods with another consumer. This method is more common on classifieds marketplaces (dating sites, exchange sites).

The successful functioning of a marketplace usually depends on the satisfaction of three parties: businesses (sellers), consumers, and the owner of the marketplace itself. This satisfaction is primarily measured by the income of the business and marketplace, and the savings of consumers.

For consumers, a marketplace also brings satisfaction from the shopping process itself. Consumers can easily find the product they need, or even find a new type of the desired product. The functions of filtering, comparing, and selecting offers allow you to find the best option. Online payment, ordering additional delivery services allow you to shop without leaving home. Marketplaces can additionally attract consumers with a discount system, games, and quizzes, which also affect the final price of purchases. But sometimes interesting, additional, convenient features of a marketplace can lead to a negative dependence on the shopping process.

Sellers, using a marketplace, get the opportunity to expand their business, increase their customer base, and find new partners or suppliers. Equally important is the savings due to reduced costs for advertising products or your company, physical rental of resources, and the need to use your own software.

Marketplace owners benefit from monetization for their services. The marketplace's revenue is determined by its business model, and as practice shows, different business models or their combinations are required to effectively support different directions of the marketplace and models of interaction between participants.

The implementation and operation of a marketplace has a number of well-known problems that need to be addressed.

The chicken and egg problem [2]. This is the problem of initial deployment of a marketplace in the absence of an initial number of sellers or buyers. How can sellers start successful work when there are no buyers on the marketplace yet, and at the same time how can buyers buy goods when there are no sellers on the marketplace yet? The experience of developing modern successful marketplaces allows us to formulate several universal solutions to this problem:

- It is necessary to start with a very small market niche.
- First, you need to attract sellers, show them the potential benefits of the platform and business growth.
- It is necessary to attract enough buyers (customers) that they correspond to the initial small group of sellers. Only then is it balanced to increase the number of participants.

Liquidity problem. Marketplace liquidity is the probability that a seller and a buyer will complete a transaction. That is, it is a problem of matching supply and demand.

Platform leakage problem. If the marketplace functions do not satisfy users, they may leave the platform in whole or in part. For example, participants may make their first contact on the platform, but all subsequent transactions may be carried out through other platforms or directly among themselves. In this case, the marketplace does not receive any income.

Therefore, the owners and support team of the marketplace must constantly monitor the use of the platform and timely implement any changes for its further effective functioning: introduce new functions, services, discounts and bonuses, and finally even switch to using a different business model.

Sharetribe studied the 100 best marketplaces in the world for the use of marketplace business models and identified interesting dependencies between the type of marketplace and the choice of business model [3]. As of 2024, nearly two-thirds of marketplaces are focused on providing services (33%) and selling physical goods (26.6%) (see Figure 10.1). A third of the market will be occupied by marketplaces for selling digital goods (11.7%), rentals (13.8%), and delivery (14.9%).

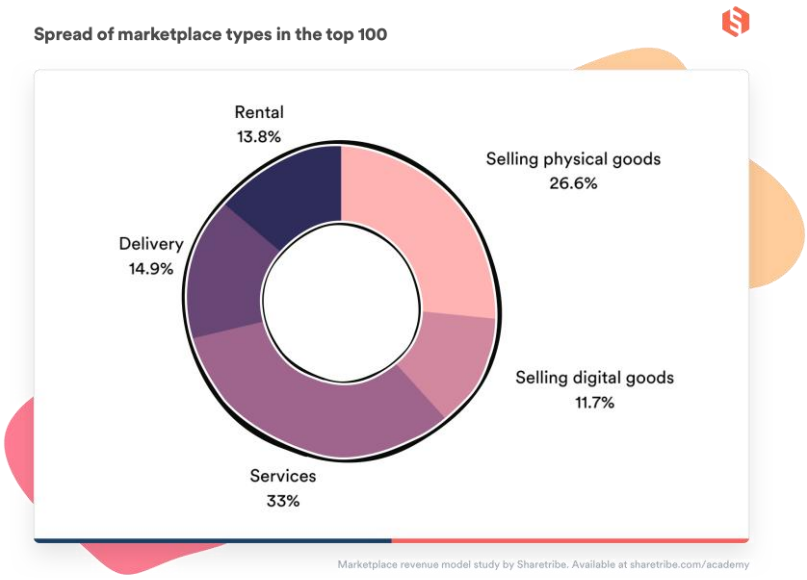

Fig. 10.1. Spread of marketplace types in the top 100 [3]

The most effective business models for these types of marketplaces can be seen in Figure 10.2. It can be concluded that the most popular and effective business models for generating marketplace revenue are using transaction fees (92% for rental marketplaces, 80% for physical goods marketplaces) or a combination of fees and subscriptions.

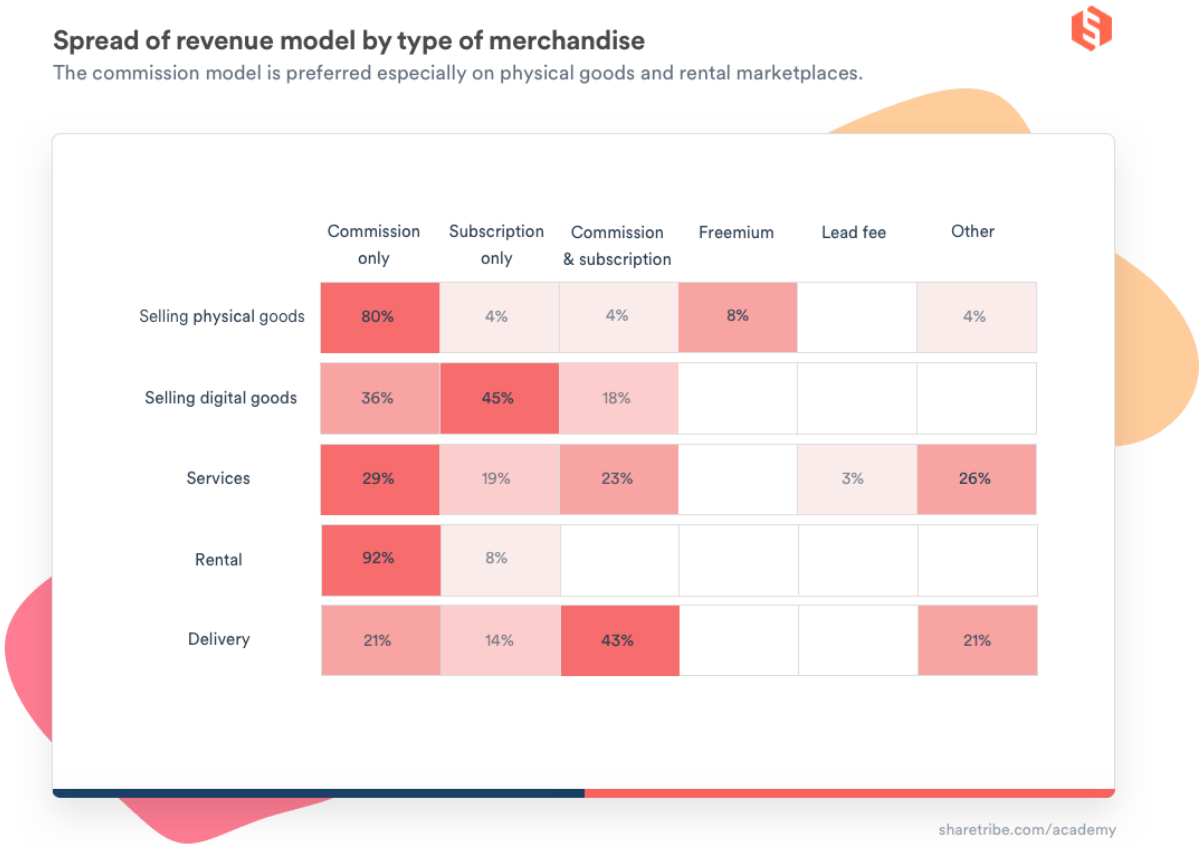

Fig. 10.2. Spread of revenue model by type of merchandise [3]

According to research by Sharetribe, 6 business models have gained the most popularity in marketplaces [1]:

- Commission.
- Membership/subscription fee.
- Listing fee.
- Lead fee.
- Freemium.
- Featured listings and advertising.

Commission. Used as a percentage or a fixed amount that a marketplace charges for a transaction. This business model is very often used on marketplaces. Platforms like Airbnb, Etsy, eBay, Uber use it as a primary source of revenue.

Advantages of the commission: convenience for users. Users use the platform for free, and pay a commission only when they make a transaction. For a marketplace, income from commission directly depends on the number of transactions: the more goods or services are sold, the greater the commission income.

Disadvantages of the commission: it is necessary to constantly maintain the interest of sellers and buyers in conducting transactions through the marketplace. Otherwise, if users bypass the marketplace payment system and use some of their own method of mutual settlements, the marketplace will not receive income. This interest support includes many options for actions and proposals from the marketplace: determining the size of the commission, exempting some participants from the commission, applying a flexible system of increasing/decreasing the commission depending on the time spent on the platform or the number of transactions or their total value, etc. In other words, platform participants should feel comfortable, interested, and satisfied with the functionality and business processes of the system, they should have the impression that for a small commission they can get something much more from the marketplace.

There are several scenarios where the commission model does not work properly [1], in which case you need to look for a different marketplace business model:

- When the transaction size is very large, for example, when selling cars or real estate.
- The offers can be very different, so it is sometimes very difficult to develop some kind of value system and determine the size of the commission. Example: classifieds marketplaces.
- A complex invoicing process, where it is also difficult to develop a commission system. This is a common phenomenon in B2B models.
- The platform does not have an exchange of money. For example, these can be marketplaces for dating, finding people for hire, free exchange.

Membership/subscription fee. This is a regular fee for using the marketplace or some of its specific functionality. The fee can be charged to all participants or to some. The fee is a good and simple way in cases where it is difficult to determine the size of the commission. The disadvantage of this method is the need to ensure that there is a sufficiently large number of sellers and buyers on the platform. This is necessary so that existing and new participants agree to a mandatory payment in order to access the marketplace community and join the functionality that is offered.

Typical marketplaces that successfully use the subscription model are:

- Consumer-to-consumer (C2C) marketplaces, such as home exchange sites and dating sites.
- Recruitment marketplaces, such as LinkedIn, StackOverflow. In B2C companies, the platform is usually free for customers, and companies are charged a subscription fee to access the customer base.
- Marketplaces that are starting their business and do not yet have a developed commission charging system.

Listing fee. This is a classifieds marketplace model. Marketplaces charge sellers a commission when they publish new listings. If sellers only need to sell products occasionally, this method will be more profitable than a permanent membership fee.

Since the probability of selling the product is low, the commission should not be high either. Therefore, marketplace owners cannot expect large profits from this model. And for this to be a sustainable business model, a large volume of listings is needed.

This model is used on C2C (Craigslist), B2B (Mascus) classifieds marketplaces, and on other marketplaces in combination with other models (Etsy).

Lead fee. Combines a listing fee and a commission. Unlike a listing fee, the fee is charged only when a supplier contacts a potential customer. Customer information comes from inquiries that

customers place on the platform. There can be ongoing interactions between a customer and a supplier, either for a single deal or for multiple agreements. Such interactions can be implemented in B2C or B2B models. An example of this model is the Thumbtack marketplace, which presents various services that can be provided in a given area. The disadvantage of the model is that once a connection is established, participants can leave the platform and continue the interaction outside of it.

Freemium. This is a model that charges a fee for additional features and services. Example: C2C platform Peerby. In this case, using the platform itself may be free. And for additional services, such as delivery, insurance or something else, a small commission may be charged. The problem with this model: it is necessary to create an attractive system of additional services and interest customers so that they choose these services. For example, Mascus offers its customers premium website services and receives an additional listing fee. Etsy offers premium services such as direct order processing, promotion in the listing and privileges for the best sellers.

Featured listings and advertising. This is the promotion of sellers, products, and ads in the top list. Placing information on the platform is usually free, but if the seller wants to place his ad somewhere in a specific place on the marketplace, then this service is already paid. This business model also has problems, which consist in the need to have a large number of platform users and lists, as well as a reasonable balance between imposing advertising and using it as a way to convey information. Many users are annoyed by advertising, but it also provides information and creates demand among customers. This business model can be applied to classifieds sites, real estate marketplaces, free sharing platforms.

10.2 Overview of platforms for creating marketplaces

There are currently many platforms for creating marketplaces. Many of them are open-source platforms. The following is a description of some of the platforms, without ranking by popularity:

Sharetribe. The platform is positioned as a "no-code" marketplace builder. It offers fast and easy creation of scalable marketplaces [4]. Sharetribe offers its customers its own cloud infrastructure for hosting.

Sharetribe offers different options for creating marketplaces:

Rental marketplace. Creating systems for companies to rent out premises, vehicles, equipment or anything else to consumers or each other (B2B and B2C rentals).

Service marketplace. Creating systems to support local services (helping local service providers such as nannies, cleaners or hairdressers to sell their services online), negotiations and bidding (helping customers get quotes from software developers, electricians or accountants, etc.), virtual services (booking online sessions or event venues).

Product marketplaces. Creating systems for selling used goods (people can earn money by selling things they no longer need), digital goods (people can access content or other digital files). Also creating marketplaces for complex B2B transactions that require negotiations, contracts and bulk orders.

Other marketplaces: ads and catalogs, partner search and recruitment (job board, dating site), multi-stream marketplaces (services, rental, sale of goods on one marketplace), barter and gifting (exchange of things or services).

There is also an older open source marketplace software called Sharetribe Go available in the Github repository. However, Sharetribe Go is no longer actively supported.

Bagisto. It is a system for organizing electronic commerce. It is open source software, which means that it is available for free to users and also has a set of additional plugins to perform various functions. In this system, sellers can organize a shopping cart for buyers with a fairly large set of functionalities. Sellers themselves also receive extensive functionality for managing the store, the ability to create mobile applications, blockchain. The system also supports the use of headless commerce [5].

Headless commerce is a popular eCommerce architecture where the frontend is separated from the backend. The frontend is responsible for the appearance of the site and interaction with the user, in other words, it is the environment that the user sees. The backend is the functionality of the server part, used to develop processes in the system. The connection between frontend and backend is carried out via API (Application Programming Interface). Headless commerce provides systems with a number of advantages: flexibility and customization (you can configure different parts of the system independently), scalability (growth in both the amount of data and functionality), rapid adaptation to changes in technology or market requirements. Headless commerce is supported by many systems, such as Magento, Shopify, BigCommerce.

Shopify. A builder for e-commerce platforms (eCommerce). Very well suited for direct sales systems or brand-oriented marketplaces, i.e. for creating an online store with a single supplier. Has reliable support, a large plugin market. At the same time, it has difficulties in building multi-vendor platforms, taking into account market dynamics and providing flexible transaction types. For these purposes, you need to use additional plugins [6, 7].

Softr. This system allows you to quickly and easily create portals, marketplaces, resource directories, online communities, etc. No code required. To create sites, an editor with templates for the following components is used: pages, blocks, theme, data, and settings. Applications and sites in Softr are created with the help of integration with Airtable, where the database of the created application is maintained and input and output data are configured [8].

Magento (new name: Adobe Commerce) [9]. This is a very popular system for organizing e-commerce on the Internet. It is also open source software. Magento, known for its scalability, customization and flexibility. The number of users of the platform can be measured in millions. Magento is used by such popular global brands as Nike, Coca-Cola, Samsung. Magento is a powerful tool for building and scaling traditional e-commerce stores, but core functionality can extend with third-party plugins to create full-fledged multi-vendor marketplaces.

There are two versions of Magento:

- Magento Commerce. - is a paid version designed for large companies;
- Magento Open Source - is a free version, but it contains all the necessary tools for creating and maintaining a shop.

Magento has a large number of features, such as:

- Catalog management. There is a large list of features for managing products: creating products with a developed attribute system; dividing products into types with their own sets of attributes; categorizing products; a pricing system using different prices, for example, a special price, cart price rule, catalogue price rule, prices for user groups.
- Order management. You can control and track each stage of an order: creating an order; fulfilling and sending an order (you can separate the fulfillment of orders by creating one or more invoices, shipments or refunds), generating reports on order stages for sellers and customers; refunds (credit memo) in online or offline mode; managing sales channels (multi-source inventory).

- User management: creating user accounts; managing functionality for users (wishlists, order history and order status monitoring, the possibility of pre-ordering, etc.); dividing users into groups with different access rules to system functions; user notifications.
- SEO (Search Engine Optimization): favorable URLs and canonical tags (you can customize and change any URL for a product, category or page in the store); web page metadata (titles, descriptions and keywords for each web page); additional data in Google search results (rich snippets), sitemap generation (XML sitemap).
- Marketing and promotion: product recommendations (adding related products, cross-sell and up-sell products to encourage customers to buy more); personalization of discounts, messages to increase customer loyalty; emails and mailings.
- Payment and shipping: various payment methods using different currencies; various shipping methods, including integration with the most popular delivery services, such as DHL, UPS, USPS, FedEx.

CS-Cart. It`s a powerful B2B/B2C Marketplace Builder [10]. It is a proprietary platform, you need to purchase a license to use it. It also offers cloud tools and hosting. It allows you to create various marketplaces: from small online stores to powerful shopping malls.

CS-Cart also offers several ready-made marketplace templates: Multi-vendor marketplace for organizing sales from different sellers (the number of sellers is unlimited, this is a solution for online retail sales), B2B Marketplace Platform, Apparel & Shoes (e-commerce platform in the fashion sector), Electronics Marketplace (electronics is now a very popular market. CS-Cart offers tools for full migration of marketplaces from other platforms while preserving products, suppliers and customers, scaling and additional features to develop business. Options are offered for creating a Consumer Electronics Marketplace similar to Amazon for various types of electronics, B2B Electronic Marketplace for wholesale trade, Refurbished Electronics Marketplace with supplier verification and guarantees, Electronic Component Marketplace, Gaming & Niche Electronics Marketplace for different customer communities, Multi-Store & Multi-Region Electronics Marketplace with the ability to manage multiple stores from one admin panel), Grocery & Food for the growing market of online food sales, Home & Garden, Health & Beauty, Digital Products (digital products are things that a buyer can download: e-books, computer games, music, videos, software, etc.).

Powerful CS-Cart tools allow you to make the marketplace very attractive to customers, for example:

- Filters. Filters for product catalogs that allow customers to find products with the necessary attributes faster.
- Variations. Product variations based on their characteristics. Variations look like a variant of one product to buyers, but the seller can manage them as separate products with different attributes.
- Product reviews. Customer reviews play a very important role in building buyers' trust in products and sellers. Positive and reliable reviews attract more buyers.
- Micro-stores. A very popular functionality for suppliers who sell certain products and want to design their micro-store in a certain appropriate style. For example, products of a certain brand will be designed in a micro-store with brand attributes.
- Product bundles. This feature can increase sales. Customers will spend less time searching for related products. They may also be happy to pay more for a bundle of products if they are given some discount.

WooCommerce. This is an open-source e-commerce plugin for WordPress [11]. WordPress is not a dedicated marketplace development system, but rather a versatile and very popular

website builder. However, its functionality can be extended with plugins. The most popular plugins for marketplace development are WooCommerce and Dokan Multivendor. WooCommerce has all the necessary tools to manage an online store. This is a versatile plugin that allows you to scale your business, sell different types of products (physical, digital), organize sales of services, subscriptions, and reservations. The plugin has many extensions (paid and free) that allow you to increase functionality and integrate with many tools and systems. Another feature of WooCommerce, thanks to its open source code, is the large active community of developers who work on improving the plugin and creating new extensions.

Among the features of WooCommerce for managing an online store are the following:

- Product management. Products can be assigned various attributes, products can be grouped by categories.
- Order management. Tracking orders by status (paid, fulfilled, returned, etc.), refunds.
- Integration with various payment systems.
- Delivery organization. Support for various delivery options (free delivery, self-pickup, etc.), integration with various delivery systems.
- Analytics. Tools for tracking and analyzing various indicators, generating reports. Integration with other systems, for example, Google Analytics, CRM and CDP.

BigCommerce. This is one of the popular systems for creating online stores. The system offers the use of cloud hosting using the SaaS (Software as a Service) model. That is, customers do not need to install the software themselves, everything is in the cloud according to the purchased tariff plan [12]. BigCommerce has a fairly convenient control panel with all the necessary sections of the product catalog, orders, customers, marketing, analytics, and others. The page builder allows you to quickly and conveniently develop your site. To expand the functionality and integrate with other systems, you can install additional programs directly from the control panel: PayPal, Stripe, LiqPay, Facebook Pixel, Google Analytics, and many others. These programs allow you to implement both well-known functionality and those that are needed by specific customers. For example, the Retail by BigCommerce program allows you to connect POS (Point of Sale) to automate the work and synchronize data of retail points of sale. Another useful function is dropshipping: direct deliveries of goods from sellers to buyers, bypassing the warehouse. This is implemented through integration with well-known platforms, such as AliExpress, Modalyst, and others.

BigCommerce allows you to work with physical and digital goods, make payments in different currencies through different payment systems. SEO promotion and analytics tools allow you to optimize your online store and make it quite popular.

Yo!Kart. Positioned as an effective, scalable and easy-to-use e-commerce solution with a minimum of programming, which will primarily be useful during the initial deployment of a business. The platform is paid, but technical support is also offered.

The platform offers the following ready-made solutions for different types of marketplaces [13]: B2C Marketplace, B2B Marketplace, C2C Marketplace, Aggregator Marketplace (the marketplace is offered to small sellers as a common brand to sell their products), Dropshipping Marketplace, BOPIS (Buy Online Pay At Store) Marketplace (this is an option where customers make a purchase online and pick it up directly in the store. For example, if you like a particular model of shoe in the store, but the size you need is not available, you can order that shoe in the size you need and pick it up in the store later), Service Marketplace, Subscription Marketplace, Digital Downloads Marketplace.

OpenCart. This is an open source system for creating online stores. OpenCart is distributed under the GNU General Public License. OpenCart has a fairly large community of developers who have created many free extensions. These extensions increase the functionality of the system and its integration with other systems.

The advantages of OpenCart are reliability and efficient use of resources of a separate server, a fairly large functionality, scalability, multilingualism, support for different currencies and payment systems. The functionality of OpenCart is constantly developing, which attracts customers to use this platform in their business.

In addition to the version of OpenCart for a separate server, customers are also offered the OpenCart Cloud solution. This cloud solution has high speed and performance indicators, and may interest many customers to organize support for their business. OpenCart Cloud has several offerings, allowing customers to find their option that best meets their needs. [14].

Odoo. This is not so much a separate platform for creating marketplaces, but a set of applications to meet the needs of the company: CRM, e-commerce, accounting, manufacturing, warehouse operations, point of sale, project management, etc. [15]. These applications allow you to create business solutions in many areas: services, retail, construction and real estate, health and fitness, and many others. Odoo can be purchased in an open source version (Odoo Community) or a licensed version (Odoo Enterprise). In addition to several dozen core applications created directly in Odoo, there are a huge number of additional applications created by the Odoo community. One of such additional applications, which is designed specifically for creating marketplaces, is Odoo Multi Vendor Marketplace. Highlighted Features of this program [16]:

- Manage Multiple Vendors - admin can manage multiple sellers and their products.
- Selected Vendor - admin can allow only approved sellers and products to be shown on the marketplace.
- Manage commissions Easily - the admins can manage the commission on vendor's sales, set a different commission for each seller.
- Manage Terms and Conditions - admin can put terms and conditions on their respective seller registration forms.
- Internal Categories - admins can create custom categories for all marketplace products.
- Analytics Dashboard - the dashboard allows Admins and Sellers to track sales, monitor performance, and analyze trends for better decision-making.
- Approval Management – the admin can configure approval of the seller’s product and its quantity.
- E-Mail Alerts - when a buyer places a new order, a corresponding notification is generated for the seller.
- Contact with Seller - admin can allow customers to contact the seller through the 'Email to Seller' button.
- Unique Seller Profile - the seller has their own unique profile page with many attributes.
- Seller Dashboard - the seller dashboard gives a complete view of shop-related details, like product approval requests and seller payments.
- Manage Visibility of Information - admins can control info about sellers shown on the website, like sales and product counts. Sellers choose whether to display their policies.

- Preferred payment method – the seller can choose their preferred payment method for hassle-free transfers.
- Seller Benefits - the website allows sellers to add products, set prices, and assign categories, and sellers publish or unpublish any product.
- View the sales report - allows to view total sales and manage all orders in their store.
- Custom Reports & Insights - users can generate custom reports based on date range, product category, and revenue trends to optimize their selling strategies.
- Multi-Language, Odoo Marketplace Hyperlocal System, Odoo Marketplace Advance Commission, Odoo Marketplace SMS Notification, Odoo Marketplace Shipping Per Product and many other features.

10.3 Collaboration Portal as an on-line marketplace

Marketplaces are largely portals for collaboration. Sellers and buyers interact when exchanging goods or services, communicate using chats, forums. If you supplement the marketplace with additional functions, you can get a portal for collaboration between employees and clients of an organization, a group of companies, project teams. Moreover, if you install additional functions that are inherent in the educational process, you can get a marketplace with a learning management system (LMS), which ultimately provides a portal for collaboration between teachers and students. An example of such portals are modern Massive Open Online Course (MOOC) systems: Coursera, Udemy and others.

So, a collaboration portal is an online platform where users can work together on goods, services, projects, exchange resources, communicate effectively. It can include features such as collaboration and document sharing tools, discussion forums, shared calendars, project management systems, instant messaging, video conferencing, and many other collaboration features [17].

Thanks to the portal for collaboration, work productivity increases, less time is spent on creating documents, exchanging information. Documents are stored centrally (this is how users perceive it, although physically the data may be distributed in the cloud), data protection is organized to prevent loss from unauthorized access [18]. An important function of portals or hosting is information backup. The system can also automatically maintain the integrity of documentation, which prevents data loss due to accidental and wrong user actions. Automatic tracking of document change history also allows you to restore the necessary data if some document processing processes turn out to be incorrect.

Participants have access to various types of communication: chats, forums, online meetings. Taken together, this encourages the emergence of new ideas, more intensive work, and reduces communication costs. Thanks to project management tools, the manageability of work processes and the overall efficiency of the functioning of teams and organizations increases.

An important function of collaboration portals is the organization of access to information. The following access options can be defined:

Public access: access to information for all users, including anonymous ones. Usually, information of an introductory, advertising, educational nature, news and general messages are publicly available. Such information attracts customers and increases the number of visitors to the portal.

Personal access: access using personal data (login, password, phone number) and obtaining personalized functions to meet specific needs. In this case, you can configure the parameters and functionality for each user.

Limited access: is a development of personal access. You can assign roles and access rights, thanks to which the user can access certain information.

Platforms for creating collaboration portals can be specialized systems for marketplaces with additional plugins, general content management systems also with additional plugins (WordPress and others), cloud environments with a set of integrated tools, such as Microsoft 365, Google. The latter option is attractive because it has a number of programs that implement ready-made communication solutions and have a high level of integration and interaction [19]. This allows you to significantly reduce the effort to create a portal, to a large extent to do without coding programs. But at the same time, there are almost no open source tools, and the cost of licenses can be too high for small or low-budget organizations.

10.4 Creating a collaboration portal with Microsoft 365 tools

The opportunities for creating various systems have become much greater with the advent of cloud technologies. Cloud platforms are becoming a powerful environment for designing, modeling and implementing various data processing and interaction processes within specific information systems. The Microsoft 365 cloud environment has a large number of tools (SharePoint, Microsoft Teams, Power Apps, and many others) that can be used in combination to develop various options for collaboration platforms. [20].

Microsoft 365 has a number of programs and services that can be used to create an environment for exchanging various information, a kind of marketplace where information is a commodity, and all interested parties are participants in the exchange process. What is especially important is that to develop such a system, at least in its basic version, it is not at all necessary to be a specialist in coding programs; it is enough to have only basic knowledge and skills in information technology. This is a rather important argument when operating small projects, workgroups and organizations. Here, the important thing is not a thousand system functions that a special IT specialist can perform, but rather the support of simple and understandable processes to ensure the most effective solution to current tasks, organization of document flow, reporting, notifications and meetings.

Collaboration portals are an important tool for collective interaction to achieve various goals. An example of such a goal is environmental protection, where a collective approach is very important. Today, one of the directions of environmental protection is the development of climate-neutral cities. [21].

A similar collaboration portal was developed as part of the UniCities project “Unlocking the transformative potential of Ukrainian universities for building climate-neutral and sustainable cities”. The project is implemented within the framework of the Erasmus+ program. [22].

The goal of the portal is to unite the efforts of stakeholders to promote sustainable development of the urban environment [23]. The portal allows you to structure a complex cloud-based collaboration system, aggregate information, ensure interaction between different project participants in decision-making processes.

The portal contains collaboration centers where regional project participants can interact: universities, local governments, business representatives, and others. The work of the centers is supported by Ukrainian universities - Chernihiv Polytechnic National University (CPNU), Academician Yuriy Bugay International Scientific And Technical University (ISTU), Yaroslav Mudryi National Law University (NLUU) and National Technical University of Ukraine Igor Sikorsky Kyiv Polytechnic Institute (NTUU KPI). University centers are focused on solving regional problems, but also interact with each other. The functions of supporting the general interaction of the centers are performed by the Unicities Collaboration Centers Hub (see Figure 10.3).

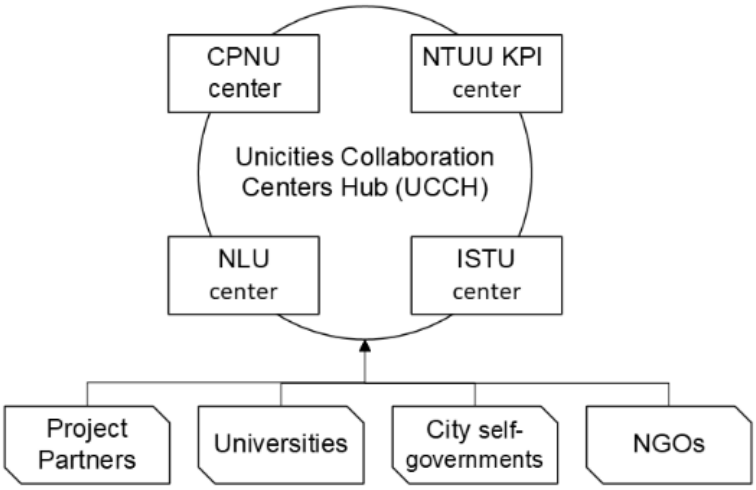

Fig. 10.3. UniCities project Collaboration Centers Hub structure

Each university in this structure manages the work of its center and provides access to information from other centers. The centers generate ideas and proposals for urban development, organize discussions and debates in the form of posts, forums and live online meetings, accumulate scientific, research, technical and financial information, which is then used to generate new projects.

The participation of the city government consists in placing requests for projects, coordinating actions and interacting with all stakeholders to organize and implement joint environmental projects. An important element of the centers is providing the city government with the opportunity to interact with universities and stakeholders, discuss ideas and plan joint actions.

Stakeholders have the opportunity to actively participate in discussing ideas, innovations, proposals, consultations on financial and technical issues, exchange of experience, support of projects.

Local and international organizations as project partners can facilitate the exchange of knowledge and the organization of joint events, offer expertise, modern technologies and resources.

Interaction between all participants of the portal occurs through online communication channels, exchange and sharing of documents in the cloud, analytics tools for monitoring progress. These services are included in the Microsoft 365 cloud, they do not require special programming, they only need to be included in the portal and configured. Thanks to Microsoft 365 cloud services, there is no need to program many functions that must be present in a modern portal. These functions are already integrated into Microsoft 365. For example, functions for protecting data from loss and unauthorized access, which include multi-level user authentication, a system of data access rights, encryption, backup. Cloud technologies also provide scaling of resources for project development.

Microsoft 365 tools allow you to model different architectural designs, create different functionality that would meet the needs of different users during their interaction. Figure 10.4 shows the basic set of tools that was used during the creation of the portal.

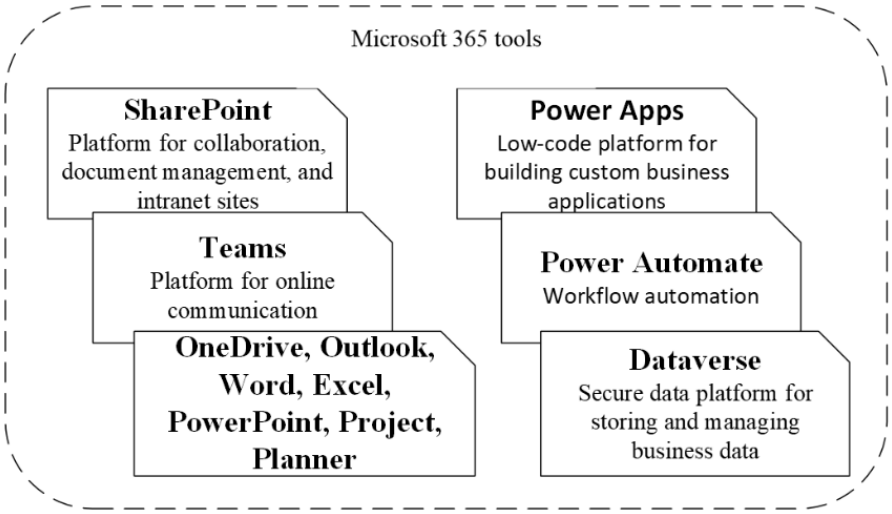

Fig. 10.4. Microsoft 365 tools

SharePoint is the main tool for organizing content management and building a web interface for a portal. It also supports access to document storage, organization of documents into libraries, and allows you to set access rights to documents and thus protect them from unauthorized access. Another important feature of SharePoint is document version tracking, which allows you to track document history and avoid situations where important information is lost.

SharePoint is an important tool that allows you to create a developed infrastructure for working with data, which includes functions of storage, access, display, exchange between different services. SharePoint allows you to develop your projects from start to finish [24,25]. SharePoint components allow you to form the architecture of portals in a simplified mode. It is enough to formulate the necessary tasks (define entities, relationships, access control levels, user roles) and select the necessary components to solve them.

The UCCHub collaboration portal was built using SharePoint, which allowed for easy integration with other Microsoft 365 applications. Portal visitors can access the necessary information from university centers, view available documents, participate in discussions and online meetings.

Microsoft Teams is the main means of online communication in real time. Users are divided into teams (groups) that work on some common topic. In turn, within teams, separate communication channels can be created for some team members. Both teams and channels can be closed, that is, accessible only to users who are registered by the team/channel owner. Each channel has its own resource support: a separate file space and chat. A developed security system both protects against unauthorized access to documents and meetings, and allows you to flexibly configure access to them for specific users who are not team/channel members.

In addition to team communication, Microsoft Teams provides the ability to organize personal or group chats at the level of modern specialized messengers, such as WhatsApp, Facebook Messenger, Telegram, Viber, and others. And the wide integration of Microsoft Teams with other Microsoft 365 applications can make this program a functional center of some complex systems.

Power Apps is a rapid development environment for your own applications. It has many application templates and includes tools for interacting with data platforms and other Microsoft

365 applications. With templates, applications can be created with minimal effort for programming operations.

Dataverse is essentially a database. Data is stored in the form of tables. There is a set of template tables for various applications. Operations on data in tables can be organized using Power Query, Power Apps, Power Automate.

Power Automate is a system for automating the execution of various processes (tasks). Each process is considered as a flow consisting of defined actions. The developer's task is to select defined actions, set parameters for their execution, and specify the sequence of actions. This is similar to creating macros and also uses the creation of "no-coding" programs.

A number of Microsoft 365 programs remain traditionally important office tools. Word, Excel, PowerPoint are designed for working with documents, spreadsheets, presentations, respectively, and remain important tools for working with project documentation. Outlook is a program for working with email, calendar, and meeting scheduling. OneDrive is a cloud storage for files.

The UCCHub portal has several components that can be called analogues of goods on the marketplace. Only these components are more focused on the sphere of human initiatives, including environmental ones. But the properties of these components are similar to the properties of goods: they can be created, evaluated, sold (transferred), new objects can be created on their basis. These are: «Ideas», «Finance», «Technology» and «Projects» (see Figure 10.5).

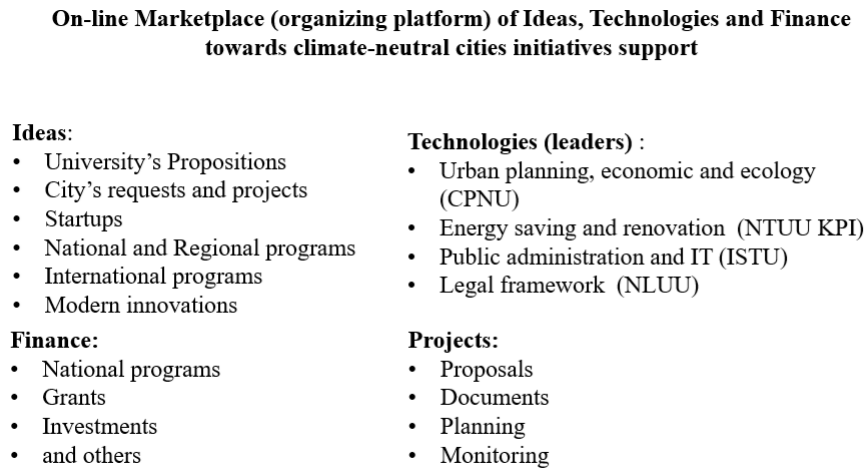

Fig. 10.5. Collaboration portal functioning components [22]

The «Ideas» component is used to generate proposals in the field of ecology. Users can create a description of the idea that they believe will improve the ecology of their city. Ideas can be based on information provided in the technological and financial components. This is not only formalized in plain text, but files of various formats, including pictures, audio and video files, can be attached to the proposal. The user community can comment on ideas, discuss, and rate them, thereby forming an idea rating. Proposals with a high rating can later turn into a full-fledged project with its own working group and resources.

The «Technology» component acts as a directory of modern technologies in various areas, such as energy conservation, waste management, and others. Having such a directory, one can expect the emergence of more new ideas. Given the data on efficiency, cost and environmental impact that technological solutions will contain, idea authors and project implementers can more effectively determine the optimal solutions.

The «Finance» component also has the function of a catalog, like the «Technology» component, but contains information about the specifics of project financing: grants, investments, budgets, features of financial accounting. Users and project participants can find data on investors, various international, state, local programs, sources of funding, recommendations for the distribution of funds and expenses. Information about technology and finance will allow you to create a more realistic idea, which can then be transformed into a project.

The «Projects» component is designed to house project documentation that can be created from ideas. The information in this component can define project goals, deadlines, and resources. This information, in turn, is a source for specialized project management programs. Microsoft 365 has many such programs, such as Project, Project Plan, Planner, Project Insight, and others, which can integrate with Microsoft Teams, SharePoint, and work directly from these programs. Project management programs allow you to assign tasks, track progress, and resolve issues. Such collaboration of different programs and their use in real time contributes to the effective implementation and monitoring of project tasks.

If we consider the movement of information on the UCCHub portal, we can distinguish several stages of data collection, processing and storage. This allows us to simplify data processing, define typical sets of data operations, and develop interaction processes between participants (see Figure 10.6).

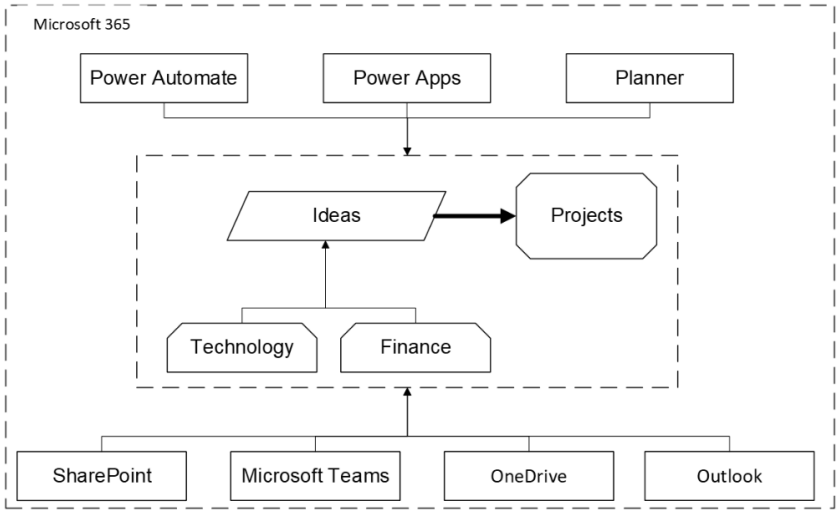

Fig. 10.6. Collaboration portal data flow diagram

Data collection. Portal visitors create a description of their ideas in the field of environmental initiatives. Each idea can contain files of text documents, tables, presentations, videos, which are also uploaded to the portal. Ideas are evaluated by other visitors, discussed in forums and video conferences organized in Microsoft Teams.

Data storage. This refers to the organization of file storage and a database. Data storage is organized in cloud storage, accessed through SharePoint. Data access is governed by permissions: personal or group. There is also support for version control for data. Processes created using Power Automate are also used to automatically perform operations to maintain data integrity, send notifications, and generate reports.

Information sharing. It's not just about sending messages, it's also about organizing access rights to document files in the cloud. Using OneDrive and SharePoint to share documents allows you to share them or create the impression of sharing. Microsoft Teams also provides

access to documents, but in terms of their belonging to channels in teams or chats, which also contributes to the distribution of data between Unicities project participants.

The aforementioned components «Ideas», «Technology», «Finance», «Projects» are implemented in SharePoint in the form of lists. These lists are actually a simplified version of the database with many ready-made functional add-ins. In addition to the ease of creating and configuring lists, SharePoint offers a high level of integration of lists with other Microsoft 365 applications.

The standard list view is almost enough to display a lot of data. But SharePoint also provides additional options for editing lists: the list structure (add/remove fields) can be changed in the standard settings; the appearance of individual fields and the list as a whole can be changed by editing the JSON code and CSS in the element formatting (see Figure 10.7). The portal uses two types of list formatting: formatted list (see Figure 10.8) and cards (see Figure 10.9).

- **List creation**

	A	B	C	D	E	F	G	
1	Заголовок	Оцінка (0-5)	image	Description	Categories	Кількість оцінок	DiscussID	DiscussURL
2	Test Idea 1	2.00000000000000	{"type":"thumbnail","fileName":"unicities	First Idea for testing	Chernihiv Polytechnic National University	3	1	https://chntu.sharepoir
3	Test Idea 2	3.00000000000000	{"fileName":"20230419_092458.jpg","serverRelativeUrl":"/sites/uac-hub/SiteAs	NTUU "Igor Sikorsky Kyiv Polytechnic Institute"	2	3	https://chntu.sharepoir	
4	Test Idea 3		{"fileName":"1000020-scaled.jpg","serverR	Here you can enter idea	Chernihiv Polytechnic National University		8	https://chntu.sharepoir
5	Захист ВКР бакал	1.00000000000000	{"fileName":"photo_2024-07-02_11-50-21.	27 червня 2024 року відбувся	Chernihiv Polytechnic National University	1	9	https://chntu.sharepoir
6	РОЗРОБЛЕННЯ НОВОГО ЕКОЛОГОСРІ		{"fileName":"Рис. 2 (1).jpg","serverRelativ	Здобуваачем вищої освіти НУ	Chernihiv Polytechnic National University			
7	Dissemination of the project results b		{"fileName":"Банер.jpg","serverRelativeU	The presentation includes information about the project results and is accompanied by photographs	Chernihiv Polytechnic National University		11	https://chntu.sharepoir

- **List formatting**

Fig. 10.7. A list edit [22]

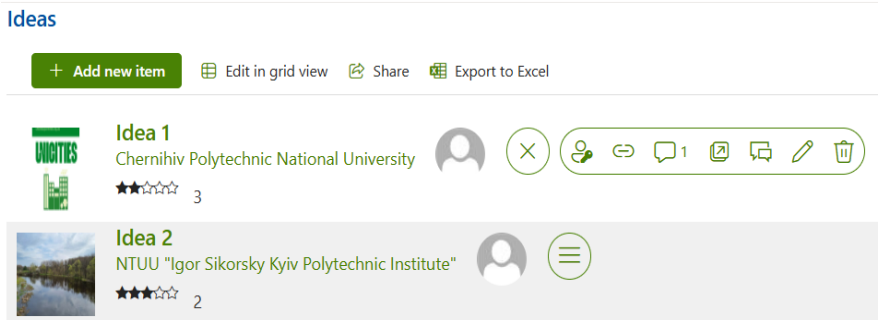

Fig. 10.8. Formatted list view [22]

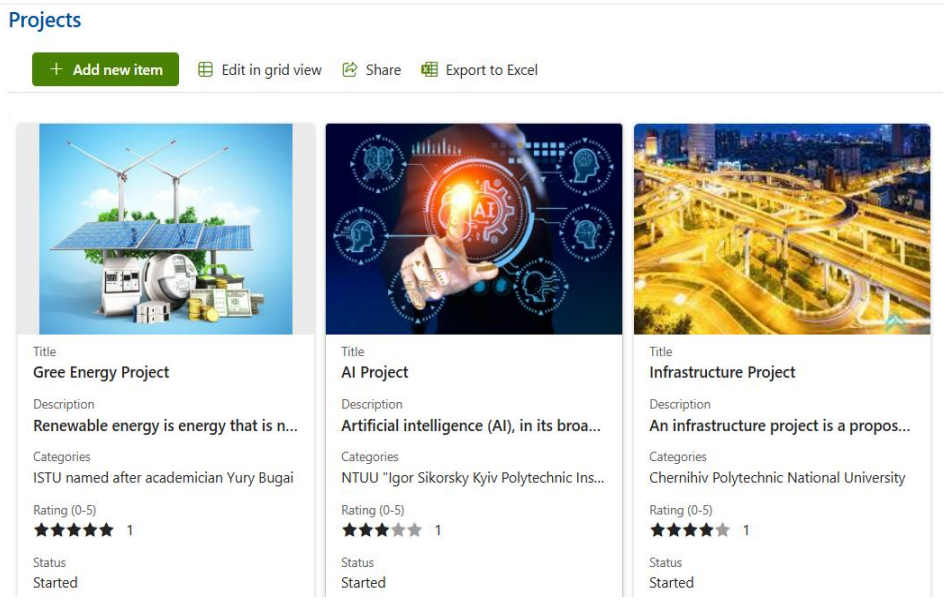

Fig. 10.9. List view in Card format [22]

The UCCHub portal home page is implemented using SharePoint web pages. It displays general information about the UniCities project, a menu for accessing the portal components and functions, and quick access buttons to university centers. (see Figure 10.10).

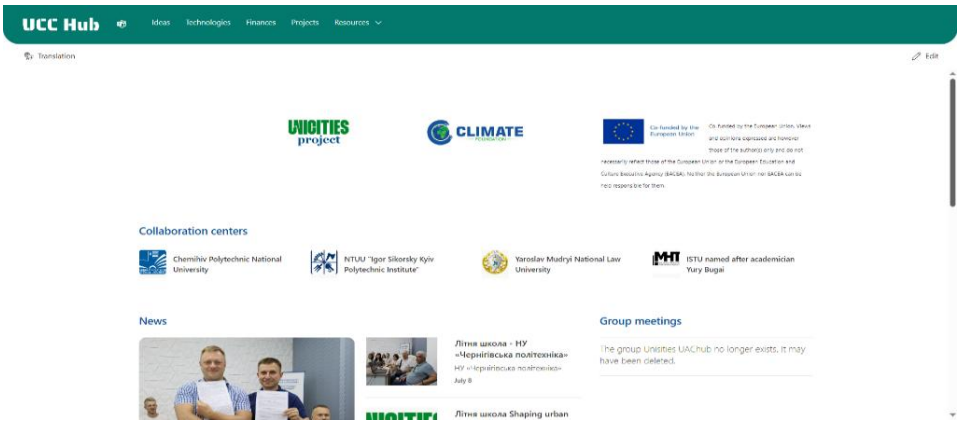

Fig. 10.10. Collaboration portal home page view [22]

As with lists, you can create a web page from standard blocks in the designer, and for many sites this will be enough. For additional formatting of the page using HTML code, you need to use additional blocks. A very convenient additional block for these tasks is the Modern Script Editor.

Not only its functioning is important for the portal. Monitoring and control are no less important, as they allow you to quickly respond to various events and plan activities for the development of the portal. Microsoft 365 collects various statistics on the basis of which you can analyze the effectiveness of the portal (see Figure 10.11). There are standard reports that display data traffic, the number of site visits, the time spent by users on the site, content rating, and more.

An important function of the portal is visitor communication, which largely occurs through Microsoft Teams. The Teams Admin Center has a number of reports that provide statistics on user actions during meetings, such as the number of meetings organized, attendance, number of posts published in the chat, duration of video viewing, and others.

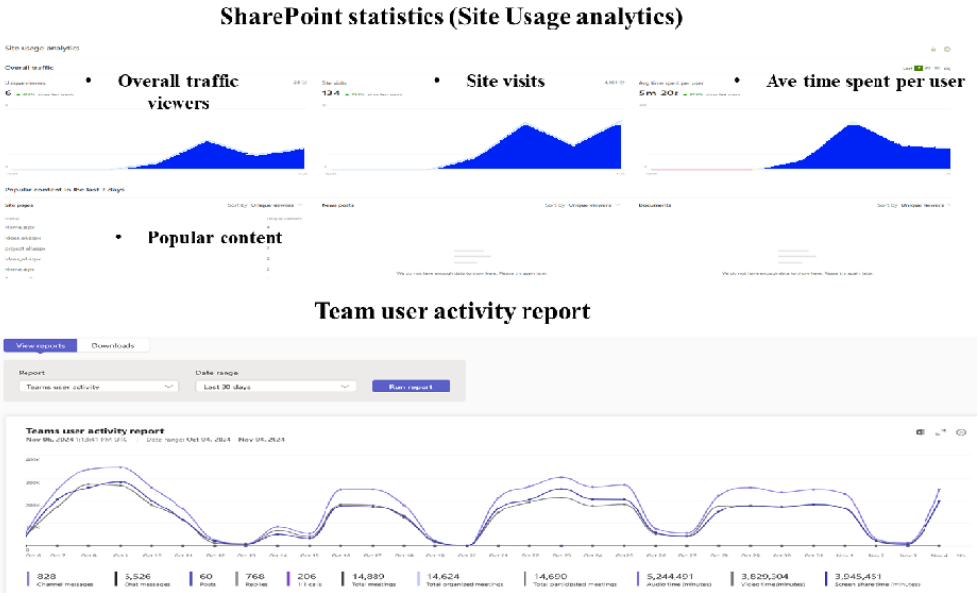

Fig. 10.11. The Collaboration portal statistics [22]

For each of the portal components «Ideas», «Technologies», «Finances», «Projects», visitors can give their rating in the form of the number of stars (see Figure 10.9). Based on these ratings, a corresponding rating is formed. The collection of statistics can also include the collection of likes in forums (see Figure 10.12). All these tools are also popular in trading marketplaces.

Fig. 10.12. Collaboration portal forum statistics [22]

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