UNIVERSITATEA POLITEHNICA BUCUREȘTI

Școala Doctorală din Facultatea de Antreprenoriat,
Ingineria și Managementul Afacerilor

DOCTORAL THESIS

RESEARCH ON INNOVATIVE SOLUTIONS IN SMES MANAGEMENT IN THE CONTEXT OF SOCIETY 4.0

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PURCĂREA

ABSTRACT

Răspândirea IT-ului și a aplicațiilor sale a fost extraordinar de rapidă, iar globalizarea a accelerat schimbarea tehnologiei. Întreprinderile de tip IMM dispun de resurse restrânse, reprezentând o adevărată provocare să fie competitivi într-o piață în continuă schimbare. Pentru a putea să își desfășoare activitatea eficient și să reziste concurenței, firmele trebuie să aducă elemente de noutate și să implementeze tehnologii de ultimă generație. Totuși, aceste tehnologii presupun costuri ridicate și personal calificat special instruit în utilizarea lor.

Obiectivul general al tezei de doctorat constă în realizarea unei soluții informatice inovative proprii pentru management - Econtract care permite firmelor să își organizeze, manipuleze și semneze cu semnătură digitală contractele. Utilizarea aplicației facilitează pentru firme procesul de transmitere și manipulare a diferitelor tipuri de contracte în mediul digital, oferind măsuri sigure pentru protejarea datelor cu caracter privat. Acest proces a fost proiectat să fie facil, atât din punct de vedere al fluxului de acțiuni necesare, cât și al interfeței utilizatorilor, menținând o transparență ridicată prin informarea constantă a acestora cu privire la statusul unui contract.

Cercetarea bibliografică realizată a condus la identificarea evoluției societății până la Industria 4.0, precum și principalele perspective ale acestei industrii din perspectiva liderilor de companii la nivel mondial. Au fost determinate principalele tehnologii și dispozitive care definesc tehnologia informației. Statisticile cu privire la securitatea în companiile din UE a permis documentarea principalelor tipuri de atacuri cibernetice precum și interesul acestora de a adopta aplicații și măsuri care să le protejeze datele. Astfel, a fost întreprinsă o cercetare primară, în România, în IMM-uri cu diferite domenii de activitate cu scopul de a determina nivelul de cunoaștere al principalelor concepte de securitate de către directorii generali și intenția acestora de a adopta o soluție inovativă de management, care să permită și semnarea documentelor cu semnătură digitală. Declanșarea pandemiei COVID-19 a creat un context prielnic pentru accelerarea digitalizării și adopției de soluții informatice inovative care să permită instituțiilor publice și private să își continue activitatea.

Rezultatele obținute prin implementarea soluției de tip aplicație web EContract au fost prezentate într-un studiu de caz care a constat în implementarea propriu-zisă asupra unei companii și urmărirea scenariilor de utilizare a acesteia, evidențiind beneficiile aduse.

Cuvinte cheie: soluție inovativă de management, societatea 4.0, IMM-uri, aplicații de securitate

The spread of IT and its applications has had an extraordinarily growth, and globalization has accelerated technological change. SMEs have limited resources, making it a real challenge to be competitive in a constantly changing market. In order to be able to carry out their activity efficiently and withstand the competition, companies must bring new elements and implement state-of-the-art technologies. However, these technologies require high costs and qualified personnel specially trained in their use.

The general objective of the doctoral thesis is to create an innovative IT solution for management - Econtract which allows companies to organize, manipulate and sign their contracts with a digital signature. The use of the application facilitates for companies the process of transmitting and handling different types of contracts in the digital environment, offering safe measures to protect private data. This process was designed to be easy, both in terms of the flow of necessary actions and the user interface, maintaining high transparency by constantly informing them about the status of a contract.

The bibliographic research carried out led to the identification of the evolution of society up to Industry 4.0, as well as the main perspectives of this industry from the perspective of global company leaders. The main technologies and devices that define information technology have been determined. Statistics on security in EU companies allowed the documentation of the main types of cyber-attacks as well as their interest in adopting applications and measures to protect their data. Thus, primary research was undertaken, in Romania, in SMEs with different fields of activity with the aim of determining the level of knowledge of the main security concepts by the general directors and their intention to adopt an innovative management solution, which also allows the signing of documents with a digital signature. The outbreak of the COVID-19 pandemic has created a favorable context for the acceleration of digitization and the adoption of innovative IT solutions that allow public and private institutions to continue their activity.

The results obtained by implementing the EContract web application solution were presented in a case study that consisted of the actual implementation on a company and the tracking of its use scenarios, highlighting the benefits brought.

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INTRODUCTION

Information technology is a determining factor in the globalization process. Improvements in hardware, software, and telecommunications in the early 1990s greatly increased people's ability to access information and economic potential. Advances in Internet-based tools over the past five to ten years, such as social networking sites and other Web 2.0 applications, have changed the way people use and share information for personal, political, and commercial purposes. These developments have facilitated efficiency gains in all sectors of the economy. IT technology drives the innovative use of resources to promote new products and ideas across nations and cultures, regardless of geographic location. By creating efficient channels for information exchange, IT has been the catalyst for global integration.

IT-based or IT-enhanced products are used in almost all aspects of life in contemporary industrial societies. The spread of IT and its applications has been extraordinarily rapid, and globalization has accelerated technological change. Every day a new technological innovation is created. The pace of change is exponential and forces companies to purchase or upgrade the devices and software programs used in doing business.

SMEs have limited resources, making it a real challenge to be competitive in a constantly changing market. In order to be able to carry out their activity efficiently and withstand the competition, companies must bring new elements and implement state-of-the-art technologies. However, these technologies require high costs and qualified personnel specially trained in their use. For this reason, MIS (Management Information Systems) solutions can be difficult to acquire due to the increased complexity and implicit costs. However, the major benefit brought by the use of these solutions consists in the automation of certain activities by defining procedures, thus general directors and employees in management positions being able to allocate their time in directions that contribute to the growth of the company and the fulfillment of objectives. Since we are dealing with the manipulation of various data that are private, it is imperative that the IT management solution be a secure one.

The main objective of the doctoral thesis is to create an innovative IT solution for management - Econtract that allows companies to organize, manipulate and sign their contracts with a digital signature. The use of the application facilitates for companies the process of transmitting and handling different types of contracts in the digital environment, offering safe measures to protect private data. This process was designed to be easy, both in

terms of the flow of necessary actions and the user interface, maintaining high transparency by constantly informing them about the status of a contract.

The secondary objectives of this doctoral thesis supported the achievement of the general objective and consisted of:

O1 - Identifying the evolution of society up to Industry 4.0

O2 - Determination of the main statistics of the companies regarding the defining perspectives of Industry 4.0

O3 - Evolutionary organization of the main technologies and devices that define information technology

O4 - Identification of the main security measures implemented by SMEs in Romania

O5 - Design of an innovative web application-type program product regarding the secure handling and signing of contracts in the online environment, with a digital signature

O6 - Case study: Implementation of the proposed program product

The developed doctoral thesis is based on a research methodology in order to achieve the general objective:

1. **Bibliographic research**, carried out to achieve Objectives 1 and 3.

2. **Statistical analysis** of the main perspectives related to Industry 4.0 to achieve Objective 2.

3. **Structured research** through quantitative research methods to fulfill Objective 4.

4. **Web design and technical implementation** to meet Objective 5.

5. **The case study** confirming the web application proposal under Objective 6.

In order to be able to achieve the general objective of the thesis, its organizational structure was formed by 5 chapters, as follows (Figure i.1):

In the **first chapter**, based on bibliographic research, the evolution of society from the first industrial revolution to the present (industry 1.0 to industry 4.0 – correspondent for society 4.0) was illustrated. Also here are presented key elements (strategies, social impact, talents, technology) on Industry 4.0 worldwide from the perspective of companies that have different fields of activity.

In the **second chapter**, bibliographic research was carried out on the specialized literature, which aimed to define the main concepts related to the field of information technology, starting with the evolutionary presentation of the main technological milestones. Also, in the chapter, the computer systems that represent innovative business management solutions were classified and detailed.

The **third chapter** aimed to identify and define a set of security solutions and types of web attacks aimed at companies. Primary research was created that had the survey as an

instrument to present at the level of Romania, Bucharest, the degree of knowledge and their implementation. The questionnaire was created using the Google Forms tool and distributed online by email. The responses of the respondents (IMMs) were analyzed and processed using the statistical analysis tool SPSS.

In the **fourth chapter**, an innovative IT management solution was designed and implemented that can be accessed from any electronic device connected to the Internet, by having a set of credentials (username and password). The technologies that underpinned the development of this IT solution are presented, as well as the activity flows that a user can undertake.

Chapter five presents the organization and context within which the innovative Econtract management solution was validated. Test scenarios deal with all the activities a user can perform and their various results. Thus, contracts can be signed online with a digital signature, after entering private data into the platform. Throughout, the user is notified by email, in order to avoid delays or situations that may have a negative impact on the company.

The research included in this doctoral thesis brought an element of novelty through the implementation of an innovative web application type management platform. The application brings new functionalities such as allowing the signing of contracts with a digital signature in the online environment, in a secure environment, the transmission of status based on email, predefined templates. It has implemented security measures to protect private data constantly used by companies. The IT solution is intended for SMEs, mainly, that have a low budget and want to automate the various document processing processes. This predominant need in companies with low capital was the starting point for the design of a management IT solution. Through its contributions, the thesis presents both a scientific and a practical value due to the presentation of company-level statistics in relation to Industry 4.0, security measures and the proposed software solution. The information discussed can be used by both scientific researchers and practitioners.
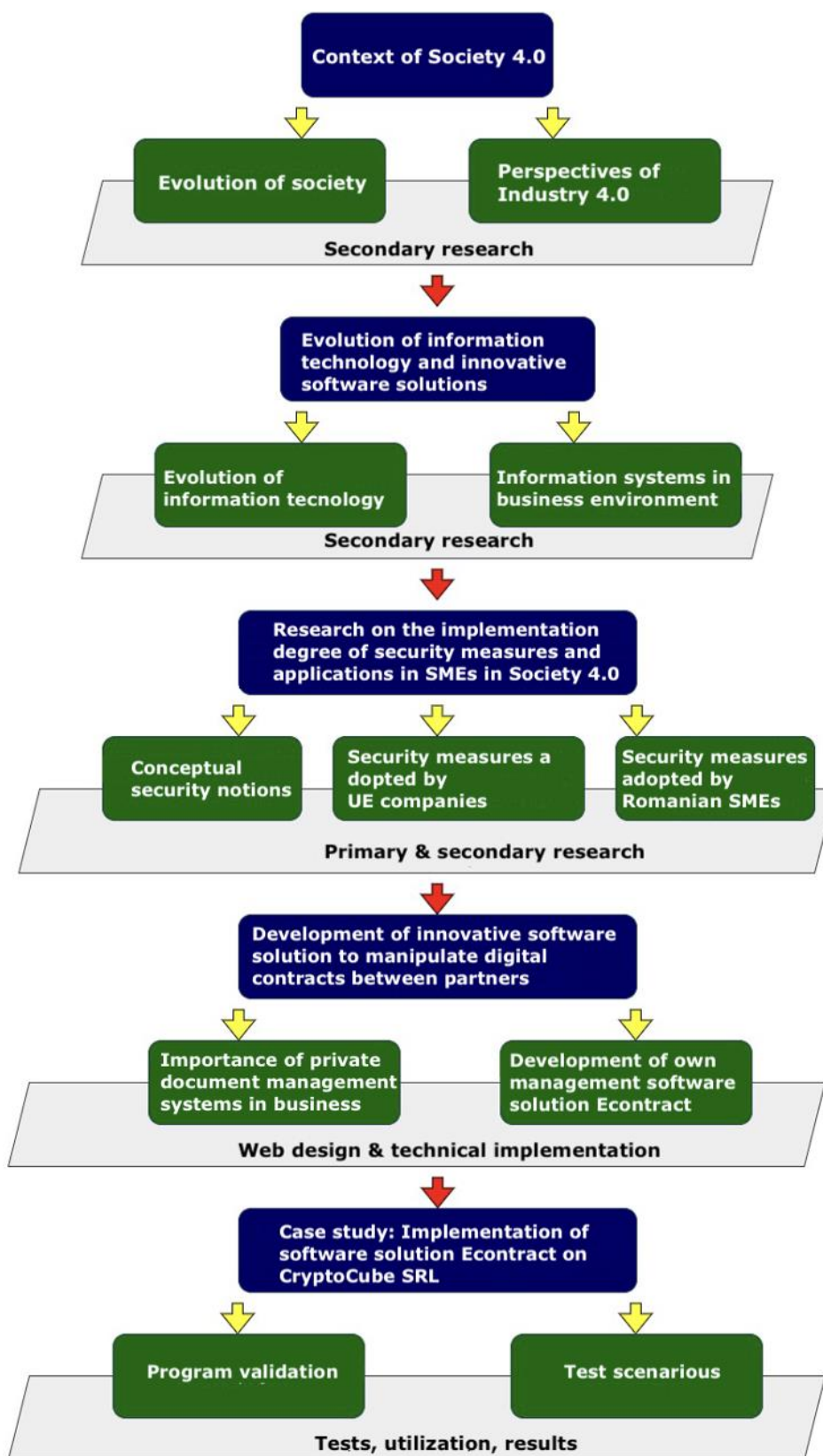
Figure i.1 Logical scheme of the doctoral thesis

CHAPTER 1.

DEFINING THE EVOLUTION OF SOCIETY AND INDUSTRY 4.0

Brief history of society development from the first industrial revolution Society 1.0 to Society 4.0

The industrial revolution began in the 18th century, covering the period between 1760 and 1840. It was characterized by major transitions that changed the existing economies on different continents. Before the industrial revolution, most economies were based on simple crafts and agriculture. However, as the revolution began, economies began to rely on new factory systems, large-scale industries, and mechanized production. New industries also developed, and these featured modern energy sources, modern machinery, and even new strategies for organizing different departments in industries.

The transitions of the Industrial Revolution were mainly evident in three different regions: the United States, Great Britain, and continental Europe. However, by the 20th century, the revolution had already spread to almost every other part of the world, ushering in a new era of modern industry. These changes did not happen in one fell swoop. Rather, the transitions happened gradually, each stage improving into a better, modern and innovative stage.

The industrial revolution can be divided into four stages (Figure 1.1), namely:

· The first industrial revolution (Industry 1.0)

· The second industrial revolution (Industry 2.0)

· The third industrial revolution (Industry 3.0)

· The fourth industrial revolution (Industry 4.0)

So far, three industrial revolutions have passed: Industry 1.0, Industry 2.0 and Industry 3.0, being the middle of the fourth industrial revolution (industry 4.0). Next, all four stages of the industrial revolution are analyzed, what each involved, and the type of technologies that characterize each revolutionary era.

Technological innovations are becoming even faster by the day, which suggests that Industry 4.0 will not be the last of the industrial revolutions.

Meanwhile, the development of factory robots and artificial intelligence will lead to more meaningful interactions between humans, computers and robots, in turn resulting in better manufacturing processes, better living standards and increased sustainability.

Perspectives on Industry 4.0: strategies, social impact, talents, technology

The Fourth Industrial Revolution, also known as Industry 4.0, is about the adoption of digital technologies — the Internet of Things (IoT), artificial intelligence (AI), robots, drones, autonomous vehicles, 3D printing, cloud computing, nanotechnology and more — that communicate, analyze and act on information, enabling organizations, consumers, society to be more flexible and responsive and make smarter, data-driven decisions.

Today, companies are judged against a broader set of environmental, social and governance measures in addition to their financial performance. The World Economic Forum's Davos Manifesto promotes this better form of capitalism, where the purpose of a company is to serve not only its shareholders, but also all its stakeholders – employees, customers, suppliers, local communities and society at large. In addition to exploring the multitude of opportunities that Industry 4.0 brings, leaders are beginning to feel the weight of this responsibility and have defined new priorities (Figure 1.1).

Based on the corporate social responsibility movement of the last generation, a new form of capitalism appears to be emerging, one that considers a wider group of stakeholders and measures social impact alongside financial performance. At the end of the summer of 2019, a statement was drafted by the Business Roundtable and signed by almost 200 multinational organizations. Through it, CEOs promised to govern their companies to the benefit of employees, customers, suppliers and communities. This sentiment was echoed in The Universal, Purpose of a Company in the Fourth Industrial Revolution, a statement provided by the World Economic Forum in December 2019 (source: https://www2.deloitte.com/content/dam/Deloitte/uk/Documents /energy-resources/deloitte-uk-fourth-industrial-revolution.pdf).

As they work to keep pace with the pace of technological change, business leaders are also beginning to appreciate the need to develop a culture of lifelong learning, equipping their workforce with the skills needed to succeed in the future. Due to pressure from customers and employees, executives are expressing deep concern about climate change and resource scarcity, topics that were on the agendas of many executives just a few years ago. The relationship between employee and employer is reproduced through a close collaboration, which can be improved through effective management (Popescu, 2019).

COVID-19 has dramatically altered the business environment, and the short-term impact on organizations and the workforce has been severe. Operations for many businesses in some EMEA (Europe, Middle East and Africa) countries have ceased as social distancing measures

have been implemented, while the impact in other countries has been less drastic. The long-term impact of COVID-19 on the IP (Industrial Products) sector is not yet clear.

While the pandemic has caused major disruptions, many companies have made a radical shift in their use of new digital technology born out of necessity. Digitization has had a much wider impact than just manufacturing: many companies have become better at managing supply volatility and anticipating customer demand.
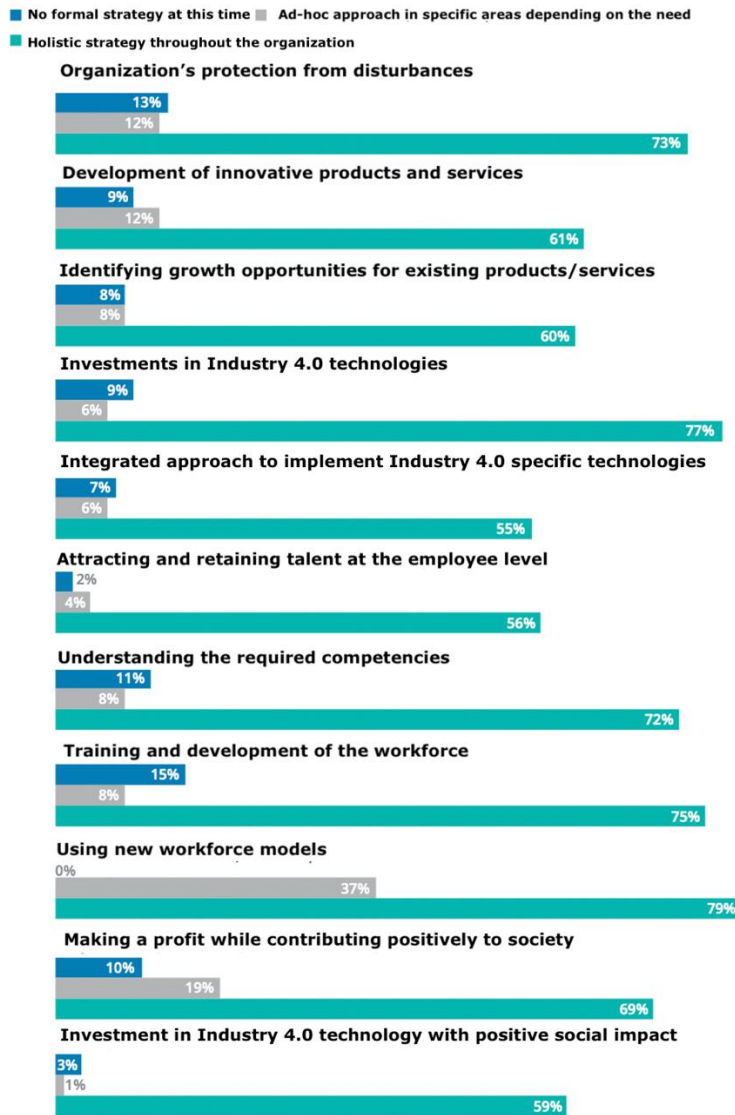
Figure 1.1. Industry 4.0 priorities where organizations have made progress

Source: Deloitte Global Analysis, 2019

CHAPTER 2.
THE EVOLUTION OF INFORMATION TECHNOLOGY AND INNOVATIVE IT SOLUTIONS IN SOCIETY 4.0

Evolutionary presentation of the field of information technology

Man's quest to simplify mathematical calculations has led to extensive research, algorithm development, and other innovations.

The first modern computer appeared in the 1940s. No one person invented the computer, the credit goes to the many inventors who worked on different parts of the computer over the years. The main components of a computer are shown in figure 2.1.
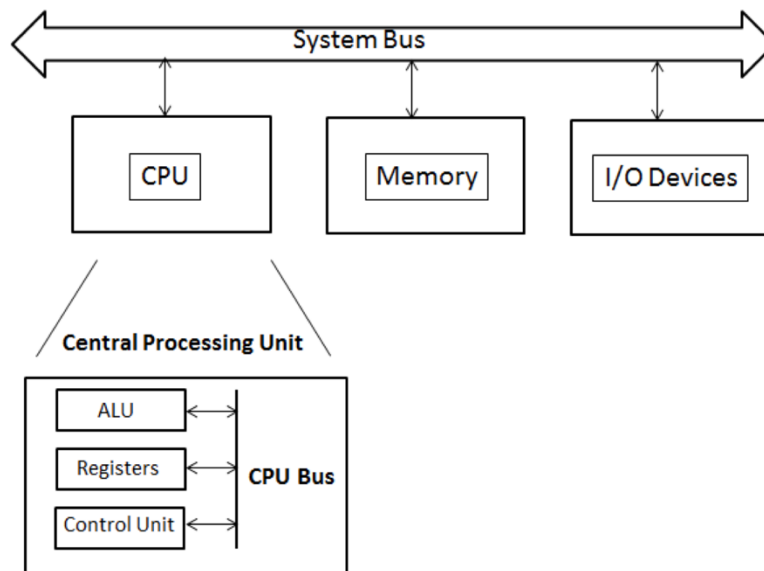
Figure 2.1 The main components of a computer

Source: https://resources.saylor.org/wwwresources/archived/site/wp-content/uploads/2014/07/CS101-1.1-Brief-History-of-Computer-Systems-Software-and-Programming.pdf

The earliest device for keeping track of calculations was an abacus. It was used around 50 BC. and was very popular in Asia.

John Napier, a Scottish mathematician, physicist and astronomer, defined natural logarithms in 1614 to simplify calculations. He also invented Napier's rods, a mathematical tool that used a set of numbered rods to simplify multiplication.

Charles Babbage, a British mathematician and inventor, first proposed the idea of a programmable computer.

The need for programming came with the idea of making general purpose hardware that could be used to perform a variety of tasks. Ada Lovelace, who was the world's first programmer, published a paper demonstrating how Babbage's Analytical Engine could be programmed to perform various calculations.

Another device called a punched card was used in the late 1800s to keep track of data that could be read by machines.

Herman Hollerith applied the idea of representing information as holes in paper cards to speed up the tabulation process in the 1890 US census. Hollerith's work contributed to early programming methods, and punched cards were used to communicate with computers until the 1970s.

In the late 1940s, John von Neumann introduced the idea of a computer architecture based on stored programs.

A set of sequences of 0's and 1's were used to indicate the operations and operands on which these operations would be performed.

It was difficult to program using 0's and 1's because different pieces of code looked similar. Assigning sections of these symbolic numbers 0 and 1 would make the programming task easier because the programmer could focus on data and operations in creating programs. This led to the creation of assembly languages in the 1950s.

The first computer, ENIAC (Electronic Numerical Integrator and Computer), was built by the United States Army Ballistic Research Laboratory in 1946. It was part of research to provide better ballistic missiles to the US military during World War II.

Computers entered American households in the 1980s. In 1975, Bill Gates and Paul Allen co-founded Microsoft to create software for both business and personal computers.

The World Wide Web was first created in 1989 by Tim Berners-Lee and later formed the basis of Netscape, which popularized the use of web browsers.

Founded in 1998, Google has become one of the most recognized technology companies in the world thanks to its search engine, which is used to find information on the Internet. Google's search engine, as well as the company's other products, such as Gmail, Google Maps, Google Books, and YouTube, are web browser-based software applications.

Released in 2007, Apple's iOS, which was previously known as iPhone OS, is a mobile operating system for iPhone and iPod Touch devices. Another top operating system for smartphones and tablets is Google's Android operating system, which is based on Linux.

Presentation of IT systems as innovative business management solutions

In today's information and communication age, there is constant reference to information systems and information systems management. In the digital age, data storage and retrieval are done through different systems and interfaces. A computer system can be defined as a set of coordinated network of components, which act together to produce, distribute and/or process information. The objective of an IT system is to provide users with adequate information, collect data, process data and communicate information to the user of the system (Figure 2.2).
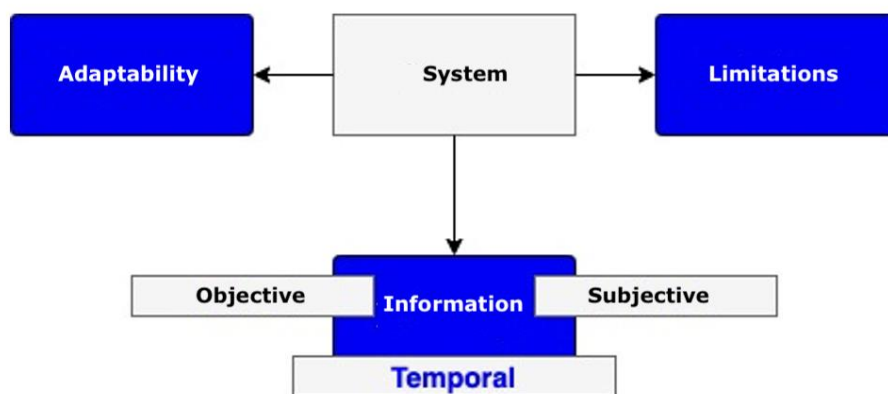
Figure 2.2 Representation model of an IT system

Source: http://www.uky.edu/~gmswan3/777/IS_Book.pdf

In 2019, 77% of EU businesses reported having a website, 36% used enterprise resource planning (ERP) software and 33% used customer relationship management (CRM) (Figure 2.3). Following this concern for ERP-type systems, a study was developed to establish the main functionalities and components of these modern systems and to propose a set of instructions to help identify the right ERP system for each organization (Negoiță, 2020).
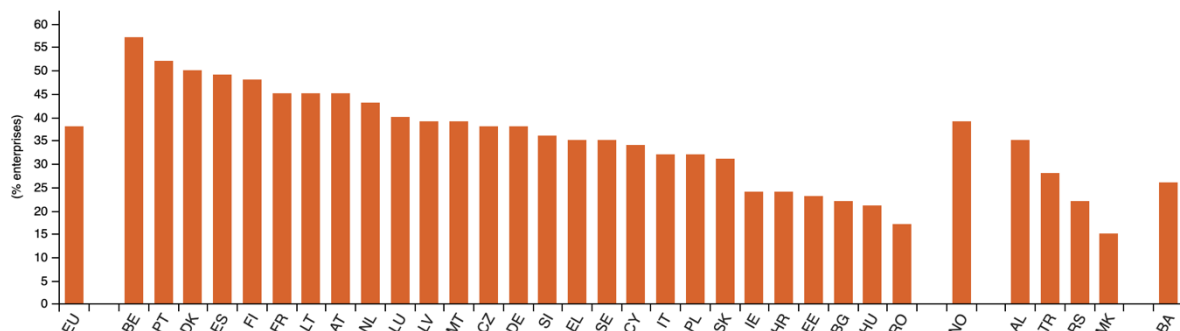
Figure 2.3 Enterprises adopting e-business solutions (%)

The adoption of e-business solutions varies according to the size of the enterprise. Figure 2.4 shows the gap between small and large businesses when referring to ERP, CRM solutions for those with a website. The percentage of businesses with a website ranged from 74% for small businesses to 94% for large businesses, from 30% to 80% for those using enterprise resource planning (ERP) software, and from 30% to 62% for businesses using customer relationship management (CRM) software.
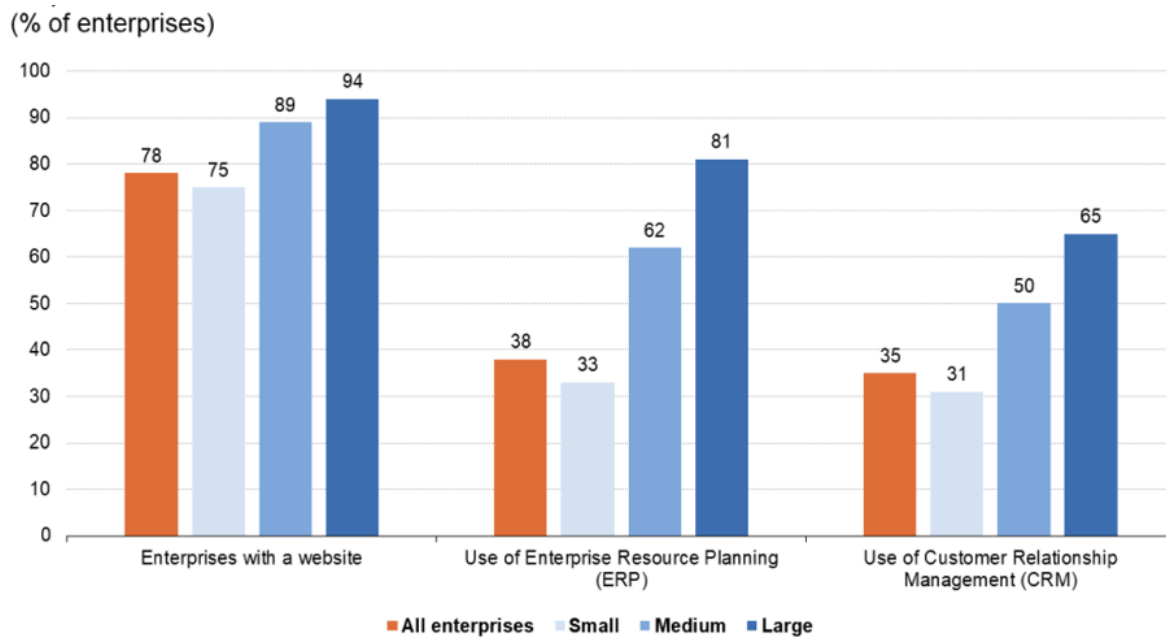
(% of enterprises)

Note: 2021 EU aggregates for website variables excluding Belgium, Denmark and Estonia.
Source: Eurostat (isoc_ciweb) and (isoc_eb_iip)

eurostat

Figure 2.4 Percentage of adoption of e-business solutions in enterprises, depending on the size of the enterprise

IT&C plays an important role in the operation of the enterprise, being adopted alongside new ways of accessing and using the Internet efficiently. It is currently a key element for how organization's structure, plan and carry out their work, communication, how they share information with collaborators, customers, etc. In this context, businesses are particularly concerned with their presence on the Internet through websites and are increasingly using ERP and CRM software applications to organize their internal business processes.

CHAPTER 3.

RESEARCH ON THE DEGREE OF ADOPTION OF SECURITY MEASURES AND APPLICATIONS AT THE LEVEL OF SMEs IN SOCIETY 4.0

Conceptual notions in the field of security

Data security, according to IBM, is the way to protect information in the digital environment from unauthorized access, abuse or theft throughout its life cycle.

The term is an umbrella term for all aspects of information security, including physical security of hardware devices, logical security for software solutions, and organizational policies and procedures (source: https://www.ibm.com/topics/data -security).

Properly applied security strategies lead to the protection of a firm's assets against potential internal or external cyber-attacks. The most common are represented by human errors. Implementing tools and technology that improve corporate visibility into where critical data is and how it is being used is a key component of data security. Favorably, these solutions would be able to automate reporting, streamline audits and adhere to regulatory standards, while applying safeguards such as encryption, data masking and redaction of sensitive information (source: https://www.ibm .com/topics/data-security).

There are three essential elements of data security that all organizations should adhere to: confidentiality, integrity and availability.

• Confidentiality. Ensures access to data only by authorized users with appropriate credentials.

• Integrity. All data stored is reliable, accurate and not subject to unjustified changes.

• Availability. It ensures that data is easily and securely accessible and available for ongoing business needs.

Table 3.1 shows the main data security measures that companies can implement.

Table 3.1 Data security measures

Types of data security measures	Description
Data security in the cloud	Protection that enables safe cloud travel while protecting data in cloud applications.
Data encryption	Data-centric security and tokenization that protects enterprise, cloud, mobile and big data.
Hardware security	Hardware security that protects financial data and meets industry security and compliance requirements.
Management	Data protection and compliance with industry regulations.
Enterprise data protection	End-to-end data-centric approach to enterprise data protection.
Payment security	Full end-to-end encryption and tokenization for retail payment transactions.
Mobile application security	Protect sensitive data in native mobile apps while protecting data end-to-end.
Web browser security	It protects sensitive data captured in the browser from the moment the customer enters cardholder or personal data and keeps it protected through the ecosystem to the trusted host destination.
Email security	End-to-end encryption for email and mobile messaging, keeping personally identifiable information and personal health information secure and private.

Using appropriate data security technologies (Table 3.2) can help the organization prevent breaches, reduce risk and support protective security measures.

Table 3.2 Data security technologies

Data security technologies	Description
Data auditing	Data auditing software solutions capture and report things like data control changes, records of who accessed sensitive information, and the file path used. These audit procedures are vital to the breach investigation process. The right data auditing solutions also give IT administrators visibility into preventing unauthorized changes and potential breaches.
Real-time alerts	By using real-time systems and data monitoring technology, breaches can be discovered more quickly. This will help mitigate data destruction, loss, alteration or unauthorized access to personal data.
Data risk assessment	A complete risk assessment will provide reliable and repeatable steps towards prioritizing and remediating serious security risks. The process begins by identifying sensitive data that is accessed through global groups, stale data, or data with inconsistent permissions. An accurate risk assessment will summarize important findings, expose vulnerabilities, and include priority remediation recommendations.
Data minimization	No more data than necessary should ever be held and data minimization best practices are recommended.
Deleting old data	Using systems that can track file access and automatically archive unused files.

The context of security implementation in commercial companies at EU level

In the context of the business survey, ICT security obviously refers to the measures, controls and procedures applied by businesses to ensure the integrity, confidentiality and availability of data and ICT systems. The relevant statistics are used in the context of the European Cyber Security Strategy, which provides the overall strategic framework for EU initiatives on cyber security and cybercrime (Figure 3.1). Trust and security have been a key pillar of the Digital Single Market strategy and are also an important element of a Europe fit for the digital age. From a legislative point of view, on 7 December 2015, the European Parliament and the Council reached an agreement on the measures proposed by the Commission to increase online security in the EU. The NIS includes common provisions across the Union, addressing national capabilities and preparedness, EU-wide cooperation, uptake of risk management practices, a culture of information sharing and IT incident notification. Furthermore, on 13 September 2017, the Commission adopted the Cyber Security Package. The Cyber Security Act, which has now come into force, sets the core of the package.

(% enterprises)

	Use at least one ICT security measure	Have documents on measures, practices or procedures on ICT security	The enterprise's ICT security documents were defined or reviewed within the last 12 months	Make persons employed aware of their obligations in ICT security	Affected by ICT related security incidents in 2018	Have insurance against ICT related incidents
EU-27	92	33	24	61	13	21
Belgium	94	34	27	57	22	25
Bulgaria	85	18	13	51	16	3
Czechia	94	32	26	76	21	8
Denmark	97	56	42	70	10	56
Germany	97	37	27	68	11	20
Estonia	86	27	18	55	8	7
Ireland	93	54	42	76	18	39
Greece	74	15	10	33	7	25
Spain	92	33	25	54	12	33
France	94	26	18	55	15	39
Croatia	90	41	25	47	19	7
Italy	93	34	28	73	10	13
Cyprus	83	32	24	59	11	13
Latvia	98	42	25	68	12	12
Lithuania	93	36	22	67	16	4
Luxembourg	93	27	22	52	17	26
Hungary	86	17	13	48	15	4
Malta	92	32	25	59	24	29
Netherlands	96	42	32	56	11	26
Austria	91	36	28	63	12	18
Poland	87	23	18	49	13	11
Portugal	98	28	21	54	8	10
Romania	73	17	11	49	11	5
Slovenia	84	35	26	53	14	4
Slovakia	90	28	22	64	15	8
Finland	97	44	35	66	18	28
Sweden	95	52	39	66	35	39
United Kingdom	94	48	40	69	6	46
Norway	94	32	22	61	11	33
Montenegro	69	14	11	48	17	18
Serbia	94	27	16	51	17	15
Bosnia and Herzegovina	88	9	7	43	17	17

Source: Eurostat (online data codes: isoc_cisce_ra and isoc_cisce_ic)

eurostat

Figure 3.1 Security in commercial companies (%), 2019

Source: Eurostat, 2020

Primary research on security implementation in Romanian companies

A challenge in the field of business is currently represented by securing the handling of private data, both in the company's internal environment and in the external one by transferring it using different channels and means. The level of trust in IT systems was analyzed in SMEs in Romania using an online survey (Negoiță, 2021), together with the Security measures adopted to reduce risks (Negoiță, 2021).

The analysis carried out consisted of primary research (Appendix 1) that aims to identify the main data protection methods used by SME companies and the awareness of risks to determine the need to adopt a solution for the management of documents with private access. The research problem is defined:

The problem of increasing the security of confidential data handled by Romanian SME companies is correlated with the degree of knowledge of the main information protection methods, their adoption to reduce the possibility of attacks and the disclosure of data that can have a negative impact on the company.

This problem materialized in the present research and led to the formulation of the following questions:

1. Are the main data protection methods used by companies known?

2. Are these methods currently being implemented in SME companies?

3. Do you want to adopt an IT solution for the management of private documents?

Research methodology

Research objectives

O1. Determining knowledge of the main security concepts

O2. Evaluation of the overall data security strength of the company

O3. Identifying general concern about cyber threats

O4. Determining the main barriers that prevent the company from defending against possible cyber attacks

O5. The main security investments in SMEs.

O6. Identifying the main applications that pose a potential risk to SMEs.

O7. Centralizing the benefits of adopting an IT solution for the organization and protection of confidential data.

Research hypotheses

H1. Security is present in different areas at the company level. (O1)

H2. The degree of confidence in the general security of society is high. (O2)

H3. Security incidents have a negative impact on business. (O3)

H4. The general concern for potential cyber-attacks is present at the level of SMEs (O3).

H4. Sensitive data is an aspect that SMEs are aware of (O3).

H5. The existence of market barriers prevents SMEs from defending against potential cyber-attacks (O4).

H6. SMEs invest in the security of the working environment (O5).

H7. Adopted applications can generate high risks at the level of society (O6).

H8. The types of concerns that companies are exposed to by adopting apps is due to data protection (O6).

H9. Documents that are private are stored in both physical and digital format (O7).

H10. SMEs know and use data protection measures (O7).

H11. The degree of trust in the digital signature is high (O7).

The target group

The respondents were people who work within the management teams or departments of enterprises or own SMEs. The questionnaire was sent to them individually, digitally (email, social media platforms), in the form of a link that directed them to the first page of the questionnaire. Given the number of respondents, this research is exploratory, wanting to highlight trends and represent a starting point for further research within the doctoral thesis.

Regarding security topics familiar to respondents (Figure 3.17), an equal percentage is allocated to Data Protection and Encryption and Identity and Access Management (57.6%). At the top of the ranking is network security known by the majority of respondents (66.7%), followed by application security (63.6%). The degree of knowledge of the subjects that belong to the field of security indicates the interest of companies in this area and the efforts / investment in this direction.

Among the main incidents that can contribute negatively to the commercial company (Figure 3.2), at the top of the ranking are reduced revenues / lost business (66.7%). Lost business has an impact not only on revenue but also on the retention and allocation of employee activities. These are followed by disrupted business activities (51.50%) and increased support time for damage remediation (48.50%). Another important aspect to note is the awareness of the

impact due to the incidents defined in the research by the respondents. So, they can adopt preventive measures according to available resources and priorities.

The digital signature contributes to the validation of documents between entities, being especially useful in the context of distance and space-time limitations. A majority of respondents have a high degree of confidence in this, namely 87%.

Among the main advantages offered by having a digital signature are those presented in figure 3.3. Thus, the respondents gave total agreement, inferring the possibility of having or opting for a digital signature.
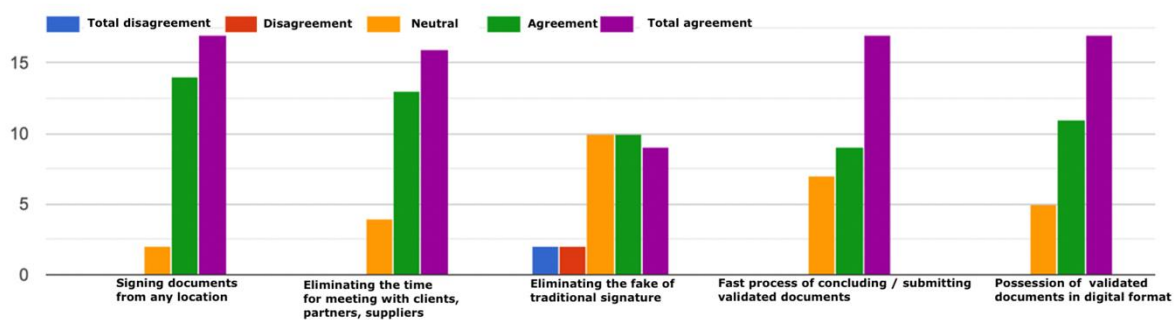

Figure 3.3 Digital signature advantages

There are currently ERP-type applications intended for the processing of various data within commercial companies, but the related costs are high and represent an impediment to their adoption by SMEs. Many of the core modules offered in the business application scheme are complex and cannot be used to their full potential, and customizing them provides an even higher cost than the original one. Thus, the respondents of this study, people who hold management positions within the SMEs they belong to, do not use an application for centralizing information that is private, but intend to use it in the near future. This fact is also due to the advantages brought by this type of application (Figure 3.4).
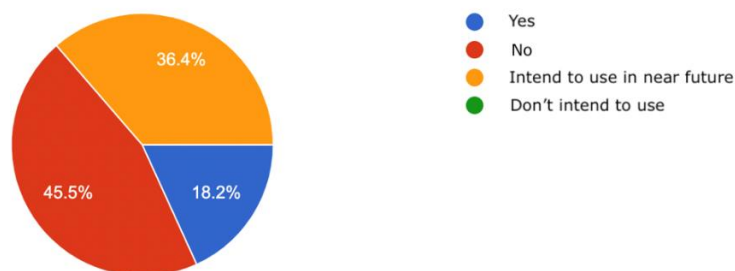

Figure 3.4 Application use of data handling and protection

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CHAPTER 4.

DESIGN OF AN INNOVATIVE IT SOLUTION FOR THE PROCESSING OF DIGITAL CONTRACTS BY PARTNER COMPANIES IN SOCIETY 4.0

The chapter aims to present the current context of SME companies regarding the digitization of processes. The outbreak of the COVID-19 pandemic imposed new safety measures and unprecedented situations that left their mark on the population, but also on the way of carrying out the activity of private companies, state institutions. Technological evolution has contributed to this endeavor in a positive sense, allowing the identification of solutions and the creation of different ways of carrying out activities in the online environment, globally. Companies have begun to adopt an increasing number of innovative IT solutions that allow them to function and continue to carry out their activity in safe conditions. However, some of the SMEs in Romania encountered difficulties due to the limited resources at their disposal. They turned to IT solutions that fit within their budgets and that provide them with positive results from an economic point of view. The process of document digitization has been intensified, starting to develop platforms that allow users to carry out as many activities as possible in the online environment. The demand for digital signatures has also increased, so that companies and individuals can legally express their consent to various types of contracts. Thus, the opportunity to create an innovative IT solution of application / web platform type was noted. This type of solution allows users to use the software product from any type of electronic device, from any location and at any time of the day. The purpose of the application is to facilitate the process of signing contracts with a digital signature between at least two entities, falling under the B2B category. The web application has an intuitive interface that can be easily used even by people without advanced ICT skills. Within it, contracts can be created from scratch, opting for predefined templates or loaded from electronic devices. These contracts can be modified, signed electronically and shared, the process being transparent, supported by email notifications. The design of the IT solution contains several stages shown in figure 4.1.
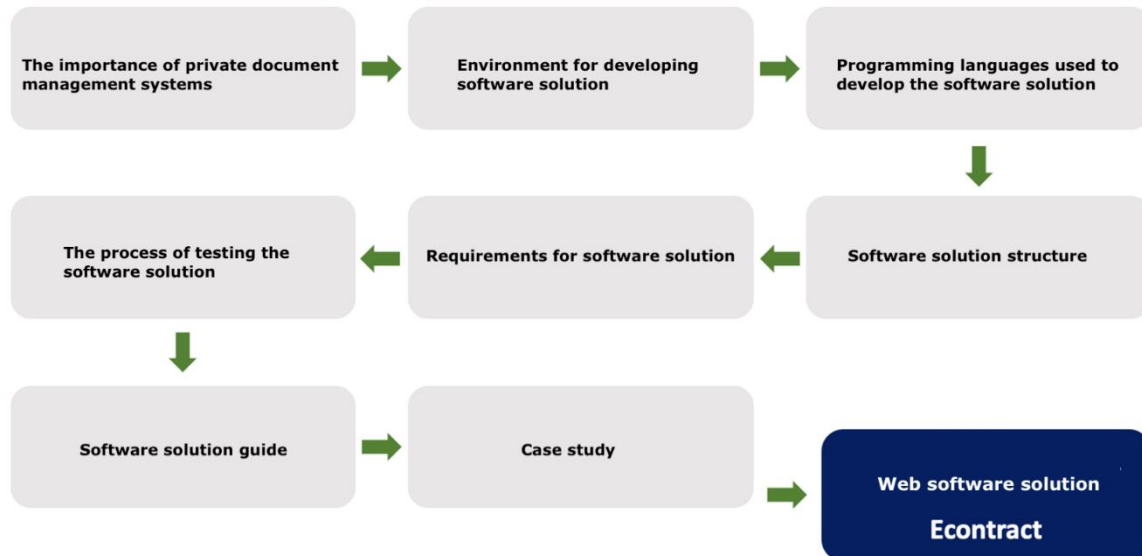
Figure 4.1. Development of the innovative IT solution

The web application is accessed by a user who owns an electronic device such as a smartphone, tablet, laptop or computer that has an internet browser and an active connection, figure 4.2. To be able to reach the start page of the application, use the URL econtracting.ro. The DNS server takes the user's request and identifies the server assigned to this address. There are five servers within this app:

1. The main server that communicates with the other servers locally.

2. The Firewall server which aims to protect requests against cyber-attacks, for example DDOS type ones.

3. The server assigned to the database whose role is to store information about users, files.

4. The signature server that is used to sign PDF documents with digital signatures.
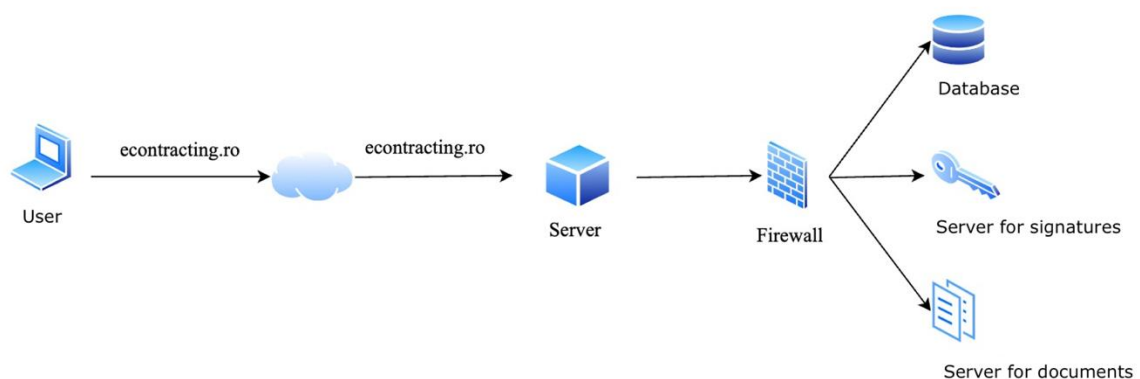
5. The document server used to store documents.

Figure 4.2 Web application structure

The flow of the application is detailed in the figure below (Figure 4.3), showing the correlation between the activities.
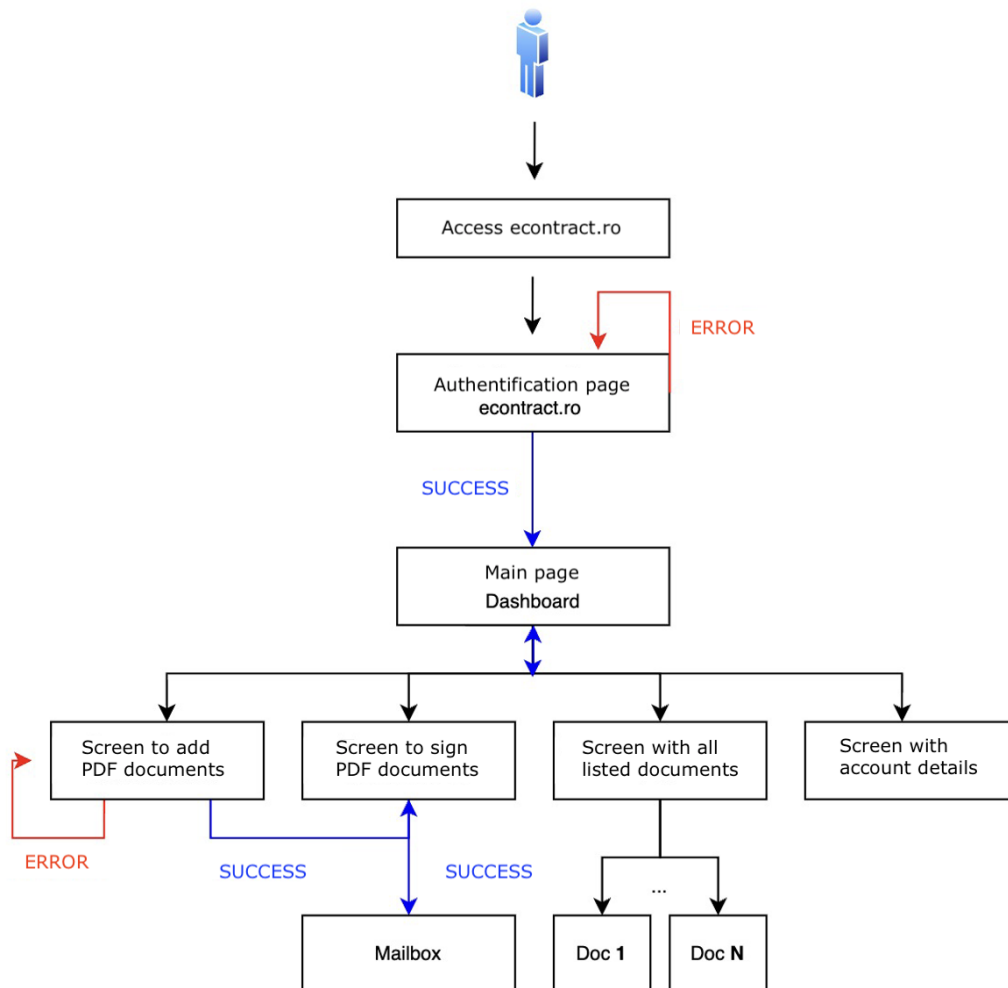

Figure 4.3 Web application traversal flow

The application presents a menu on the left side of the screen (Figure 4.5), presenting the actions that a user can perform from the web application, namely:

• All (all documents, files to which the user authenticated in the platform has access);

• Sent (documents that were sent by him to other users or third parties);

• Signed (the PDF documents that have already been signed by him);

• Drafts (draft type documents, which have not yet been finalized);

• Archived (documents already signed, which have been filed electronically);

• New folder (option to create a new folder for organizing files);
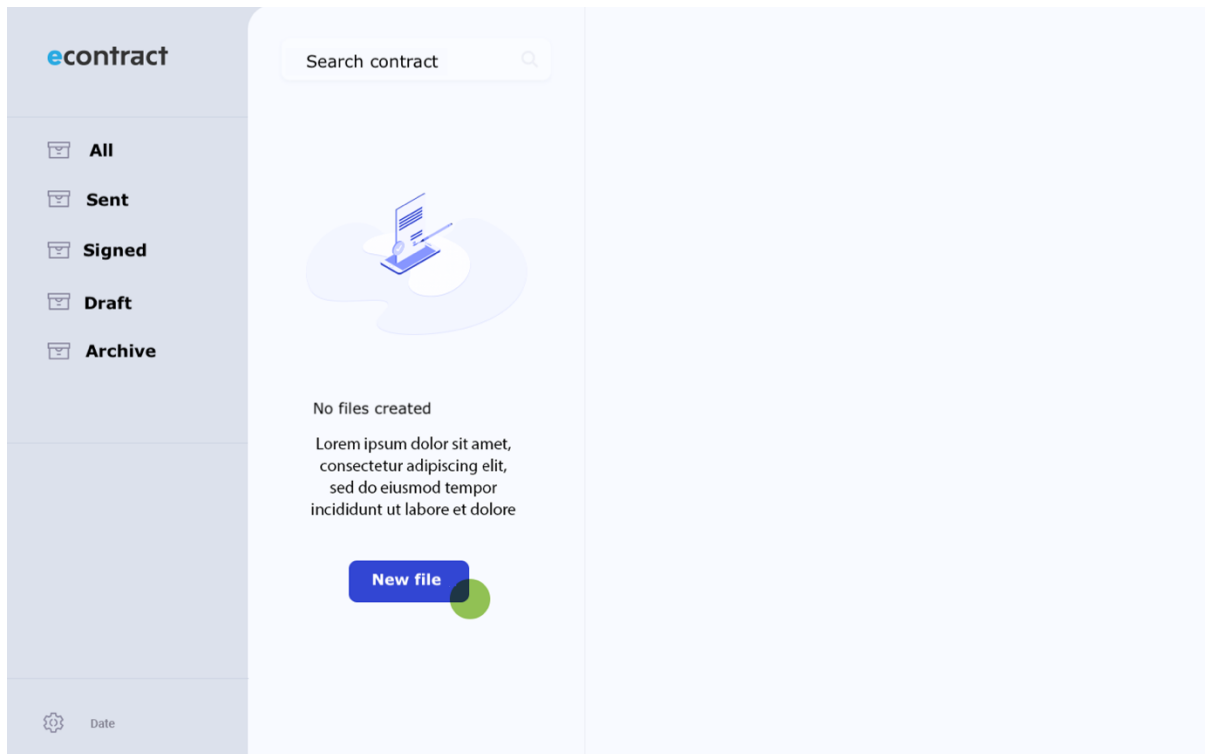
• Data (user's personal data).

Figure 4.5 The main page of the web application

Within a contract there is a predefined flow of steps. Their purpose is to render the status of the contract at every moment of time important to the users. By implementing this transparency, delays or errors can be avoided throughout the digitally signed contract signing process:

1. File initialized – a new contract is created;

2. GDPR – the general manager of company X gives his consent for the processing of private data;

3. Sending the contract to the general manager of company Y;

4. Email notification of the general manager of company X – the general manager of company X is notified that the general manager of company Y has received the contract;

5. The general manager of company Y receives the contract - if he agrees with the past data, he also gives his consent regarding the processing of private data;

6. The general manager of company X receives notification with the consent of the general manager of company Y;

7. Contract signed by the general manager of company X – the general manager of company X signs the contract with the digital signature (Figure 4.6);

8. Notification by email to the general manager of company Y – the general manager of company Y is notified that the contract has been signed by the general manager of company X;

9. Contract signed by the general manager of company Y – the general manager of company Y signs the contract;

10. Notification to the general manager of company X – the general manager of company X receives a notification informing him that the general manager of company Y has successfully signed the contract;

11. Finalization of the contract – the contract is signed by both participating parties and visible without the right to change within the platform interface of the general manager of company X and the general manager of company Y.
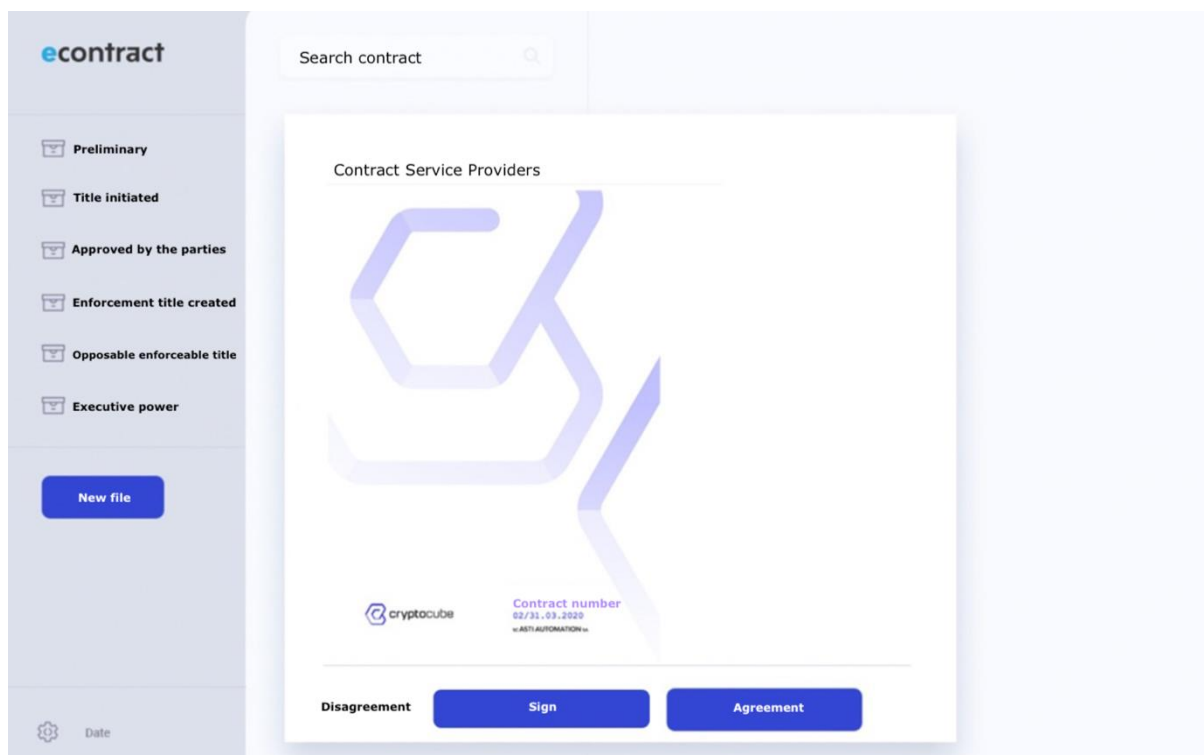

Figure 4.6 Contract signing by the general manager of CryptoCube SRL

CHAPTER 5.

CASE STUDY – IMPLEMENTATION OF ECONTRACT APPLICATION WITHIN THE COMPANY CRYPTOCUBE SRL

To validate the proposed innovative solution, the implementation will be done at CryptoCube SRL. The company is an SME type, established in Romania, Bucharest. Thus, it fits perfectly into the context for which the web application was designed. It begins by describing the evolution of economic data (Figure 5.1) and exposes information related to the internal and external environment to provide an overview. The company was established in 2017, RO CUI 38521995, operating for 5 years in the IT field. Staying competitive in the market and getting contracts was a constant challenge.

Figure 5.1 Evolution of CryptoCube SRL

Within this company, scenarios of using the software solution are carried out, in order to be able to highlight the way to go through the application, the cases in which a user can reach from the moment he wants to create an account to the signing of a digital contract and its storage.

Scenario 1. The CEO of CryptoCube does not have an account in the web platform, the CEO of Y has an account

Scenario 2. The CEO of CryptoCube does not have an account in the web platform, the CEO of Y does not have an account

Scenario 3. The CEOs of CryptoCube and Y have accounts in the Econtract platform

The web application facilitates secure access to documents through credential-based authentication, permissions and constant checks within it through the implemented methods.

Unlike existing applications that only allow document storage, this one comes with new, safety elements through a modern and easy-to-use interface for any type of user:

- Screens and actions depending on the role held by the user: normal user, administrator;
- Organization of documents in folders;
- Quick search of documents;
- Sharing of documents to third parties who hold an account within the platform;
- Signing documents using a digital signature;
- The status of the document signing process based on email notifications;
- Predefined templates for contracts;
- Uploading documents to the platform;
- Editing documents in the platform.

The exposed scenarios bring to the fore the advantages of adopting this innovative solution, which offers a safe environment for keeping and distributing contracts only to authorized persons. The digital signature streamlines the process of signing documents and sending them instantly to recipient entities. Documents are identified and accessed easily, from any place, at any time, which is why users can always benefit from them in the required situations. The steps taken to make a contract are minimal, allowing people who have management positions to allocate their time in directions of company development.

CONCLUSIONS

The doctoral thesis had as its general objective the creation of an innovative software solution for the management of digital contracts, in a secure environment, complying with GDPR rules. The research began by presenting a brief history of society and the evolution of technology. The purpose of this bibliographic research supports the role and importance of technology integration at the level of companies to effectively support their activity.

The newly designed solution was tested within the company CryptoCube SRL, between February and March 2022. The solution aims to protect private data and handle information in a secure online environment. The application is an easy tool for SME companies that want to draw up digital contracts (signed with a digital signature) starting from 0 or from a template, being notified throughout the process of the status of the document. In order to achieve the established objectives, the following activities were undertaken:

1. Collection of information in order to:

> - Determine the main aspects of Industry 4.0 technology and the extent to which these opportunities are used in companies (O1, O2);
>
> - Identify the main technologies and the current state of information technology (O3, O5);
>
> - Determine the notions that are the basis of innovative management solutions, to be able to design a new software solution (O5);

2. Realization of an online questionnaire, which included the main security aspects at company level, in order to be able to determine the degree of knowledge and adoption thereof (O4);

3. Analysis of the results obtained from the respondents using the statistical analysis tool IBM SPSS (O4);

4. Designing the structure of an innovative web application type management software solution, which will contribute to the research goal of protecting and processing private data, while also having a transparent data transfer flow (O5);

5. Development of a web design for all modules and activities within the innovative management solution, which provides a modern and easy interface for the end user (O5);

6. Testing the innovative management solution in the company CryptoCube SRL, to highlight each of its facilities and the flow of activities (O6).

ORIGINAL CONTRIBUTIONS

This doctoral thesis started from the identification of a need among small companies, which consists in digitizing and automating the management of digital contracts, within an environment protected by security methods. The exposed context was favorable for the proposal of the innovative Econtract solution, which involved the realization of multiple studies, offering a series of contributions:

• Determining the main perspectives of Industry 4.0: strategies, social impact, talents, technology and global companies' investment in their aspects;

• Outline a brief history of the evolution of information technology;

• Systematization of the notions that are the basis of IT management solutions and the description of these types of solutions;

• Establishing the degree of investment and concern of companies for Security at the EU level;

• Analysis of the level of knowledge of security concepts and their degree of adoption in SME companies in Bucharest;

• Development of a web application-type IT solution;

• Development of scenarios for the use of the Econtract solution in the company CryptoCube SRL.

FUTURE DIRECTIONS

The research within this doctoral thesis aimed to be representative of the period in which it was carried out, but there are future directions to be able to bring more new results and significant contributions.

A first direction in this sense is represented by the development of two applications for mobile devices, both for Android and iOS systems, so as to serve the entire public of users. Both the innovative web application type management solution and the mobile applications must be used by a representative number of SMEs in Bucharest in order to subsequently develop primary research that analyzes the degree of user satisfaction and the results obtained by throughout a calendar year in which they used this software. Based on the analysis of the answers given by the respondents, the functionalities of the application can be improved and new modules added, depending on the requirements. The application can be expanded both at

a general level, for a majority of companies, and customized for a particular company, depending on demand and needs.