# NANCY

**An Artificial Intelligent Aided Unified Network for Secure Beyond 5G Long Term Evolution [GA: 101096456]**

# Deliverable D1.8

# Market Analysis, Roadmap and Business Modelling Report

## Document Control Page

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## List of Acronyms

| Acronym | Explanation |
|---------|-------------|
| 4/5G | 4/5 Generation |
| AHP | Analytic Hierarchy Process |
| AI | Artificial Intelligence |
| APM | Asset Performance Management |
| AR/VR | Augmented Reality/ Virtual Reality |
| AWS | Amazon Web Services |
| B2B | Business to Business |
| B2C | Business to Customers |
| B5G | Beyond 5G |
| BFSI | Banking, Financial Services, and Insurance |
| B-RAN | Blockchain Radio Access Network |
| CA | Consortium Agreement |
| CAGR | Compound Annual Growth Rate |
| CAPEX | Capital Expenditure |
| CPU | Central Processing Unit |
| CSP | Communication Service Providers |
| D2D | Device to Device |
| DeFi | Decentralized finance |
| DLT | Distributed Ledger Technology |
| EB | Exabytes |
| eMBB | Enhanced Mobile Broadband |
| EU | European Union |
| GA | Grand Agreement |
| GDPR | General Data Protection Regulation |
| GPT | Generative Pre-trained Transformer |
| GPU | Graphics Processing Unit |
| IaaS | Infrastructure as a Service |
| IBBIC | Indian Banks' Blockchain Infrastructure Co |
| ICT | Information and Communications Technology |
| IM | Innovation Manager |
| IoT | Internet of Things |
| IPR | Intellectual Property Right |
| IT | Information Technology |
| KER | Key Exploitable Result |
| KPI | Key Performance Indicator |
| LTE | Long-Term Evolution |
| M2M | Machine to Machine |
| mMTC | Massive Machine Type Communications |
| NB-IOT | NarrowBand-Internet of Things |
| NFT | non-Fungible Tokens |
| NR-RedCap | New Radio Reduced Capability |
| OER | Other Exploitable Results |
| OPEX | Operational Expenditure |
| O-RAN | Open Source – Radio Access Network |
| PaaS | Platform as a Service |
| QKD | Quantum Key Distribution |
| QoS | Quality of Services |

| R&D | Research and Development |
|------|--------------------------|
| R&I | Innovation and Development |
| RAN | Radio Access Network |
| RFID | Radio Frequency Identification |
| ROI | Return on Investment |
| SaaS | Software as a Service |
| SDGs | Sustainable Development Goals |
| SQL | Structured Query Language |
| SWOT | Strength, Weakness, Opportunity, Threat |
| USD | United States Dollar |

# Executive summary

To guarantee the strategic direction and operational success of NANCY, the current deliverable lays out all the necessary foundations. Starting with a comprehensive review of recent trends in market analysis, it delves into market dynamics, new opportunities, and possible threats. By providing a detailed analysis of the market landscape, this document envisions aiding the partners to make improved decisions and come up with more aggressive and informed strategies.

We conducted an extensive market analysis that examined the worldwide and European landscapes of the sectors that are crucial to the innovative aspects of our proposal. Through a thorough analysis of industry trends and dynamics, we were able to uncover possible possibilities and obtain significant insights into consumer behaviour, competitive landscapes, and upcoming technologies. Our comprehensive knowledge has enabled us to strategically position our inventions, take advantage of market opportunities, and customize our offerings to cater to the specific requirements and preferences of target audiences in both the global and European markets.

Building upon the robust market analysis, the project focuses on commercializing the groundbreaking innovations developed by NANCY. These innovations form the cornerstone of the project and are poised to demonstrate their market potential. To ensure the optimal exploitation of these intellectual assets, the project has dedicated significant attention to intellectual property rights (IPR) management. Comprehensive procedures and policies have been established to safeguard the project's IP while maximizing its financial value. By mitigating risks of infringement and theft, this deliverable aims to create a robust framework for IPR management.

In this direction, revisiting, reviewing and identifying critical business domains and using the appropriate tools for the upcoming phases of NANCY is an integral part of the strategic framework. Such tools are expected to play a key role in improving operational efficiency, optimising resource allocation, and enabling smooth project execution. One of the objectives of the deliverable "D1.8-Market Analysis, Roadmap and Business Modelling Report" is to simplify processes and create the conditions that lead to achieving the project results pathway towards the market.

A thorough evaluation of all internal and external factors impacting the course of the NANCY project results towards the market is also part of the deliverable. This analysis provides a comprehensive view of possible drivers and obstacles by utilizing the Strengths, Weaknesses, Opportunities, Threats (SWOT) and Political, Economic, Social, Technological, Legal, and Environmental (PESTLE) frameworks. The consortium can capitalize on strengths and minimize vulnerabilities by recognizing critical elements that are expected to affect project results and then developing adaptive strategies accordingly. As our innovations mature in the next project phase, we will leverage the business tools outlined in this deliverable to extract deeper insights into the project's commercial aspects.

Moreover, we have identified several initial competitors at both the project and business levels. We diligently observe their progress and integrate this information into our objectives. As the project progresses and our comprehension of our innovation deepens, we will undertake a more comprehensive examination of the competitive landscape.

Last but not least, this deliverable is about creating a well-defined plan that helps NANCY stay on track with what the market needs, make the most of our intellectual assets, and use the most appropriate and state-of-the-art business tools to maximize the efficiency of this task. With careful analysis and forward-thinking planning, this document will help decision-makers face obstacles, take advantage of opportunities, and keep the project on track for long-term success in a fast-paced corporate world.

# 1. Introduction

## 1.1.	Purpose of the document

The purpose of the current deliverable is to provide a strategic framework that guides the project's direction in the next phase, ensuring alignment with market demands, effective management of IPRs, and the utilization of appropriate business tools. This deliverable presents some preliminary findings obtained utilizing these tools. In addition, we present more business tools that will be used in the future when the project is more developed and can offer more valuable information.

This deliverable also aims to present a thorough analysis of current market trends, highlight key strategies for safeguarding and exploiting our intellectual assets, and outline the advanced business tools that will be employed to streamline operations, enhance collaboration, and drive data-driven strategies. In this direction, this deliverable serves as a roadmap for navigating the current market landscape, optimizing the commercial potential of our innovations, and achieving sustainability and success.

The document takes as input D1.1 'Project and Risk Management Handbook', D1.3 'Plans for Publicity, Dissemination and Exploitation', D1.6 'Initial Impact Creation', and D3.1 'NANCY Architecture Design' and will be used as an input to D1.11 'Techno-economic Analysis and Commercialization Plans'.

## 1.2.	Structure of the document

The deliverable is structured as follows:

- **Section 1 - Introduction** provides the introduction regarding the scope of the deliverable, emphasizing the motivation that led to the creation of this document.
- **Section 2 – Business Methodology** pertains to the business tools used within NANCY as part of its commercialization and business strategy.
- **Section 3 – Market Analysis Report** presents a market analysis with emphasis on the NANCY technologies and expected outcomes.
- **Section 4 – Competitive Landscape** describes the current competitive landscape.
- **Section 5 – Exploitation Plans & IPR Management** covers the IPR management focusing on the identified innovations and technologies of NANCY, along with the complete exploitation plan of the project.
- **Section 6 – NANCY Market Position** provides an overview of the current market status of NANCY innovations, including an initial SWOT and PESTLE analysis.
- **Section 7 - Conclusion** summarizes the main findings of the deliverables, the key remarks, and concludes the deliverable.
- **Annex A - Exploitation & IPR Management Questionnaire Template** presents the questionnaire template that was filled in by the consortium partners.

# 2. Business Methodology

## 2.1.     Business Modeling objectives

Business tools designed specifically for businesses are crucial in the modern day for effective management and expansion. Covering everything from project management to e-commerce, these solutions streamline operations, enhance efficiency, and provide valuable insights for decision-making and commercialization. They offer a comprehensive overview of the current market state and help identify internal and external factors that can positively or negatively impact a project, ultimately boosting overall business performance. The business analysis will be conducted at the next phase of the project.  At first, we will distribute questionnaires to all partners, soliciting them to furnish the requisite information. Once we receive and evaluate the completed surveys, we will transition to the analysis phase. Here, we will leverage the business tools described below for a thorough examination. Finally, we will present the results in D1.11 'Techno-economic Analysis and Commercialization Plans', providing valuable insights gleaned from the partner input.

### 2.1.1.   SWOT analysis

SWOT analysis is a framework for strategy analysis and strategy development used to evaluate the strengths, weaknesses, opportunities and threads that are identified in an organization or in a project [1]. Strengths and weaknesses are the internal factors that have been identified. Strengths are all the internal attributes and capabilities that are helpful to achieving the goal(s). On the other hand, weaknesses are all internal factors or constrains, which might be harmful to achieving goal(s) [2]. By definition, the internal factors analysis arises from within the organization studied.

Regarding the external factors that can affect a project, that are opportunities, which are all the conditions and features that can facilitate the exploitation of organization objectives. On the other hand, threats are all the environmental conditions and features that have the potential to harm the achievements of an organization or project. By definition, the external factors are independent of the organization itself.

SWOT analysis answers some of the crucial questions that affect the business plan of an organization, or project for every one of the internal and external factors. Such questions are the following:

- **Strength:**
  - o   What are the characteristics that add value differencing from similar solutions?
  - o   What are the advantages against the competition?
  - o   What makes it more effective and more efficient compared to competitors?
- **Weakness:**
  - o   What are the situations that offer the same solution?
  - o   What are the disadvantages compared to competition?
  - o   What makes it less attractive to similar offers?
- **Opportunities:**
  - o   The time is offered to achieve the goal(s)?
  - o   The situation is offered to achieve the goal(s)?
- **Threats:**
  - o   Are there situations that can jeopardize the project?
  - o   Are there imminent changes that can affect the project?

SWOT analysis is often represented by a four-square template as the one shown in Figure 1. The squares are presented horizontally and vertically.

| Internal Factors | Strengths | Weakness |
|---|---|---|
| | • What we do well?<br>• What we do different?<br>• What are our assets? | • What we lack?<br>• What others do better?<br>• Limitations? |

| External Factors | Opportunities | Threats |
|---|---|---|
| | • Market trends<br>• Market needs<br>• Few Competitors | • Lot of competitors<br>• Regulations<br>• Market demands |

Figure 1: SWOT Analysis Template

### 2.1.2. Lean Canvas

The Lean Canvas [3] is a succinct business plan template designed specifically for startups that follow the principles of the Lean Startup process. This tool condenses conventional business plans into a succinct one-page structure, placing great importance on the core assumptions and verifying their accuracy before committing substantial resources. In essence, it provides a succinct and pragmatic structure to analyze your business concept and its underlying assumptions, eliminating the necessity for long paperwork. The Lean Canvas promotes an adaptable strategy, allowing you to modify your business model according to the insights acquired during validation. The use of a single-page format facilitates efficient communication and coordination among team members and prospective investors. The Lean Canvas, like a financial analyst, is tailored for startups and emphasizes problem validation and client groups.

The LEAN canvas comprises the following elements, as shown in Figure 2:

**Problem:** This section seeks to precisely outline the three primary problems that your product or service intends to resolve. Gaining a profound comprehension of your customer's areas of dissatisfaction is crucial for establishing a flourishing organization.

**Solution:** This part explains how your product or service efficiently addresses the previously stated concerns. This is essentially the core benefit offered to the consumer, providing a concise description of how their problem is resolved and value is delivered.

**Unique Value Proposition:** This section surpasses the scope of your solution. Within this document, you will discover a comprehensive elucidation of the unique qualities and distinguishing factors that set our solution apart from our competitors. What distinguishes you from other alternatives in the market?

**Customer Segments:** Identify the demographic or psychographic characteristics of your target audience. What is the specific demographic or group of people that you are aiming to reach with your product or service? This can encompass a broad range of categories or be further divided into more precise user demographics.

**Unfair Advantage:** This part is entirely discretionary, although exceedingly potent. Do you have a unique advantage that is challenging for competitors to imitate? These elements may encompass distinctive technological innovations, a firmly established brand reputation, or exclusive access to important resources.

**Channels:** What is your plan to efficiently engage with your intended audience? This section provides an overview of the several channels that will be used to distribute your product or service and effectively convey its distinctive value. This can be accomplished through diverse means, including internet platforms, physical storefronts, strategic partnerships, or a combination of these alternatives.

**Revenue Streams:** This section provides a comprehensive explanation of the various methods via which your firm will make cash. There exist multiple techniques to earn revenue, including product sales, subscriptions, advertising, or other means.

**Cost Structure:** Determines the primary expenses linked to operating your organization, similar to how a financial analyst would analyze them. These expenses include several components of the firm, such as production, marketing, salaries, and rent. Acquiring a comprehensive understanding of your cost structure is essential for attaining profitability.

**Key Metrics:** Determine the fundamental performance indicators (KPIs) that will allow you to track and assess the progress of your firm. These metrics can be utilized to assess the efficiency of your efforts and identify areas that could be improved.

| Problem | Solution | Unique Value Proposition | Unfair Advantage | Customer Segments |
|---------|----------|--------------------------|------------------|-------------------|
| List the top 3 problems | Outline a possible solution for each problem | Single, clear, Compelling message that states why you are different and worth paying attention | Something that can't be easily copied or bought | Target customers and users |
| | **Key Metrics** | | **Channels** | |
| **Existing Alternative** | | | | **Early Adopters** |
| How these problems are solved today | List the key numbers that tells you how your innovation is doing | | Path to customers | List of ideal customers |
| **Cost Structure** | | **Revenue Streams** | | |
| Customer acquisition costs. Distribution costs, hosting people etc. | | Revenue model, Lifetime Value, Revenue, Gross Margin | | |

Figure 2: Lean Canvas Template

### 2.1.3. Fuzzy Analytical Hierarchy Process (AHP) analysis

Another aspect of the business analysis involves presenting a roadmap that aims to offer a comprehensive grasp of the elements influencing NANCY's market acceptance and the corresponding technological advancements. This also functions as a method of prioritizing various competing solutions that are expected to have a substantial impact. The fuzzy AHP has been chosen as an appropriate approach to support decision-making in multicriteria contexts for NANCY's technology innovations, due to its capacity to handle the predicted number of innovations and the various paths they may follow in their evolution The AHP, devised by Thomas Saaty in the early 1970s, was originally designed for military purposes. AHP is widely acknowledged as a process for making decisions that involve multiple factors. Throughout the years, it has been widely used in many fields such as

education, engineering, industry, manufacturing, and resource allocation. In recent times, AHP has been widely employed in the information and communications technology (ICT) sector to choose and prioritize alternatives. AHP is a systematic method created to tackle intricate decision-making situations. The framework offers a logical and thorough structure for breaking down an issue that lacks organization and is intricate, into a hierarchy consisting of interconnected criteria, sub-criteria, and decision options. The integration of qualitative and quantitative criteria in AHP allows for the effective quantification of decision-makers' preferences. The ultimate relative priorities of the criteria, sub-criteria, and options are established by mathematically combining these diverse evaluations.

The fuzzy AHP offers a systematic approach to analyzing intricate problems by establishing criteria and sub-criteria and then comparing them in pairs. The outcome of the aforementioned comparison is expressed through the assignment of weights to each criterion and sub-criterion. These weights are then arranged in hierarchical order based on their significance. The image illustrates the rationale and mechanism of an AHP [4].
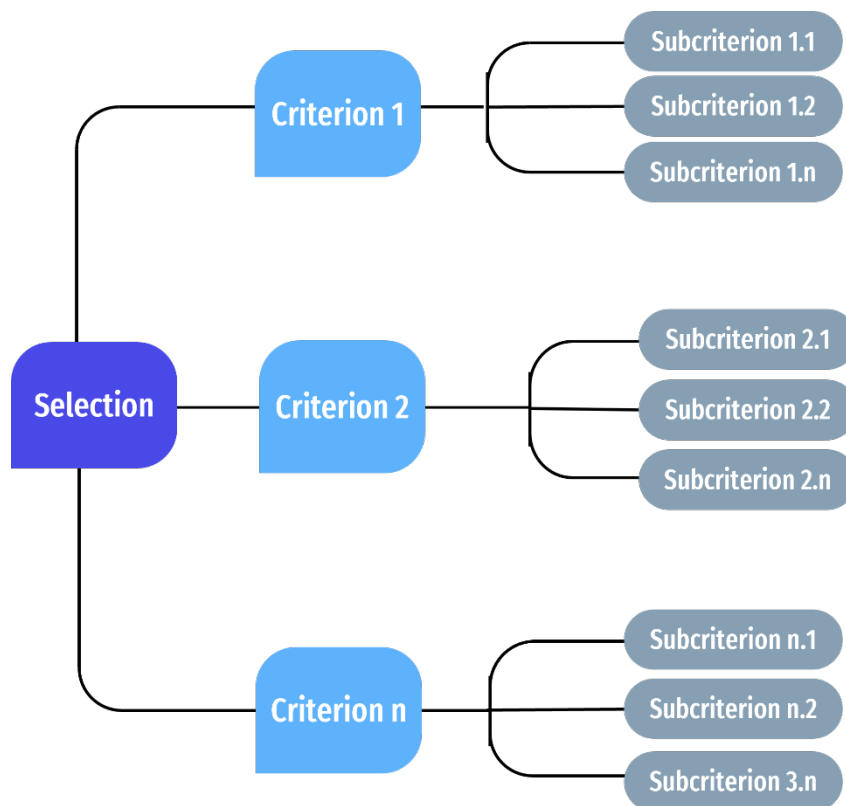


Figure 3: Fuzzy AHP template

# 3. Market Analysis Report

This section focuses on the market study related to the technologies used in the NANCY project. This report provides vital insights into the present market sector that directly impacts the commercial development of the NANCY project. Through the analysis of market trends, technical breakthroughs, and competitive landscapes, our objective is to offer a comprehensive comprehension of how these aspects influence the project's advancement and possible achievement. The report emphasizes significant potential and challenges in the sector, providing a strategic viewpoint on efficiently navigating market dynamics. The market analysis revolves around NANCY innovation sectors which are the 5G and Beyond 5G mobile networks, the Cloud/IoT/Edge network continuum, the Blockchain and cybersecurity market as well as the Artificial Intelligence market.

## 3.1. 5G/Beyond 5G Market

The deployment and adoption of 5G mobile networks have dominated the telecommunications industry in recent years. 5G is the most recent operational generation of wireless and wired technologies, and it offers a number of advantages over 4G, most notably faster download rates, more bandwidth, and lower latency. 5G networks are expected to assist a wide range of industries, particularly IoT and AI applications that require real-time data transfers. More broadly, the introduction of 5G is likely to coincide with rising data use around the world, with predictions predicting mobile data traffic of about 330 exabytes per month by 2028, more than three times the volume consumed in 2022 (Figure 4) [5].
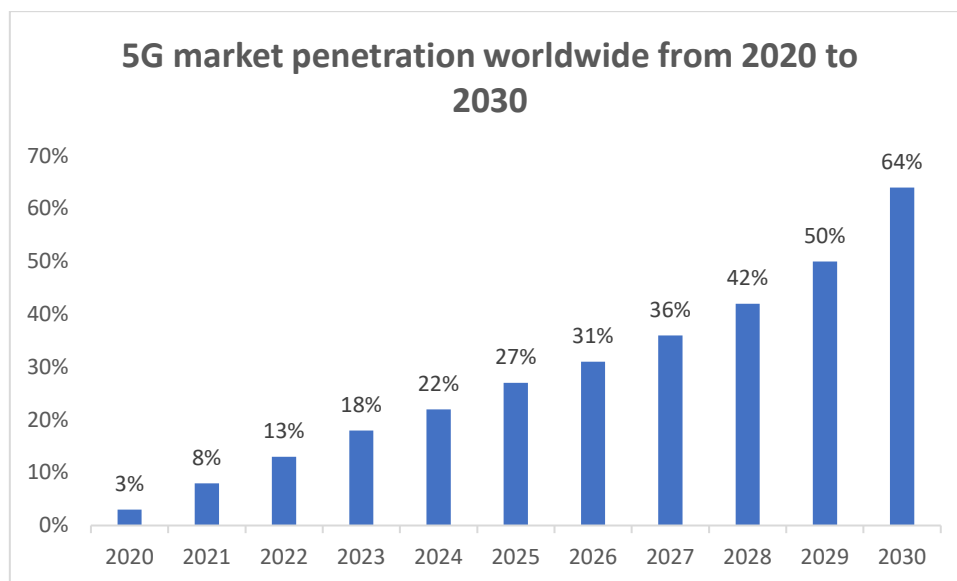


Figure 4: 5G market penetration worldwide from 2020 to 2030[1]

According to [6], the 5G market is estimated at USD 98.3 billion in 2023 to USD 427.7 billion by 2028 at a Compound Annual Growth Rate (CAGR) of 34.2%, The integration of 5G technology in environmental monitoring and sustainability initiatives serves as a significant driver for the 5G market and the future 6G market. The high-speed, low latency capabilities of 5G networks enable real-time data collection and analysis, fostering more efficient resource management. This and a number of market dynamics create an ideal environment for solutions like NANCY.

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[1] https://www.statista.com/statistics/1338464/5g-market-penetration-worldwide

### 3.1.1. 5G/B5G Market Dynamics

The 5G market is characterized by a complex interplay of technological advancements, economic factors, and regulatory landscapes. This section delves into the key dynamics shaping the 5G industry, exploring the multifaceted opportunities and challenges that stakeholders face. From the promise of revolutionary applications to the hurdles of infrastructure deployment, we examine the forces driving 5G adoption and the obstacles impeding its progress. By analysing market restraints, growth drivers, and emerging trends, we aim to provide a comprehensive overview of the current state and future trajectory of the 5G ecosystem.

*Rising Mobile Network Data Traffic*

According to the Ericsson Mobility report published in June 2023 [7], overall mobile data traffic is expected to reach about 93 Exabytes (EB) per month by the end of 2022, and 329 EB per month by 2028. Between 2022 and 2023, mobile network data traffic grew by approximately 36%. Traffic growth is caused by an increase in the number of smartphone subscriptions as well as an increase in the average data volume per subscription, which is mostly driven by an increase in video content viewers. Video traffic currently accounts for 71% of all mobile data traffic, with a projected increase to 80% by 2028. The number of mobile phone users is continuously expanding around the world. In recent years, there has also been an increase in the use of smartphones in developing nations. 5G's share of mobile data traffic was roughly 10% in 2021, and it is expected to increase to 60% by 2027. By the end of 2028, 5G subscriptions are estimated to total 4.6 billion globally.

*5G Implementation Hurdle: Substantial Deployment Expenses*

Research in [6] also emphasizes that the high cost of establishing 5G technology sometimes poses a challenge for wider adoption, mostly due to the fact that 5G and especially beyond 5G are expected to be radio resource hungry, request higher levels of reliability etc. Modifications will be required for the switch from present networks to 5G and beyond 5G, which include the installation of numerous small cells and the use of more resource-hungry technology, which could impose a significant financial strain on telecommunications service providers. These expenses include not only the purchase and installation of 5G-compatible technology but also the development of a resilient and secure network infrastructure capable of fulfilling increased demands for speed and connectivity. Such financial issues may serve as a barrier, particularly for smaller operators or those with limited resources, delaying the smooth and rapid adoption of 5G technology into global telecommunications ecosystems.

*Mobile Data Surge Drives Small Cell 5G Network Expansion*

A significant opportunity for NANCY arises with the extensive deployment of small cell 5G networks has been pushed by the exponential increase of mobile data traffic, which has also significantly boosted the 5G market. Small cell deployments enable tailored coverage and capacity enhancements, but typical microcellular networks are unable to handle rising data demand. When these micro cells are put in congested areas or interior spaces, they reduce network congestion and improve the user experience by providing better data rates and lower latency. Also, small cell installations allow spectrum resources to be used more efficiently, improving network capacity without incurring major infrastructure costs. Small cells are an important aspect of the 5G network design because of their scalability and adaptability, particularly in metropolitan regions with high data demand. Thus, as the deployment of small cell 5G networks grows, it not only meets the demand for more data capacity, but also propels the overall 5G market forward, supporting innovation and economic development in sectors such as the Internet of Things, self-driven cars, and smart cities [8].

*Spectrum Synchronization Lag: A Global 5G Challenge*

Delays in attaining spectrum harmonization across varied geographic locations pose a substantial obstacle to the smooth deployment and optimization of 5G networks. Spectrum harmonization entails synchronizing frequency bands globally for 5G use, encouraging interoperability, and ensuring reliable network performance. The lack of synchronized spectrum distribution hinders attempts by telecommunications operators and equipment manufacturers to create cohesive and efficient 5G ecosystems. This delay not only limits 5G devices' worldwide roaming capabilities, but it also diminishes the potential economies of scale that may be achieved by uniform spectrum deployment. Furthermore, a lack of harmonization presents barriers for multinational businesses, necessitating device and network configuration changes to operate in different regions. As a result, it is critical to develop international collaboration and accelerate the harmonization process in order to realize the full potential of 5G technology on a global scale and ensure its seamless integration across borders [6].

### 3.1.2. 5G/B5G Market Trends

The 5G landscape is rapidly evolving, driven by technological advancements and changing consumer demands. This section explores key trends shaping the future of 5G technology and its applications. We examine the surge in mobile broadband consumption, the transformative potential of combining 5G with artificial intelligence, and the emerging synergies between 5G and blockchain technologies. These trends not only highlight the diverse applications of 5G but also underscore its role as a catalyst for innovation across various sectors, promising to redefine connectivity and digital experiences in the coming years.

*Surge in High-Speed Mobile Connectivity*

With the introduction of 5G, mobile bandwidth is predicted to increase, ushering in a new era of immersive experience and connection. 5G is planned to enhance 4G long-term evolution (LTE) connections by providing better download and upload rates. The race to build up 5G wireless service extends beyond mobile devices to encompass home broadband services. Also, 5G technologies in mobile broadband services use millimeter wave bands, resulting in a larger spectrum, higher traffic capacity, and quicker download speeds than LTE. Likewise, as emerging markets recognize the societal benefits of 5G technologies, several countries are adopting strategic broadband plans to accelerate the deployment of fixed and mobile broadband infrastructures [9].

*AI Acceleration through 5G Networks*

5G will play an important role in democratizing the usage of AI, as almost all apps and services will require some level of AI capabilities in the future. Both technologies will benefit from one another, but their combination will generate new experiences and reshape the way people live, work, and play. 5G will also have a significant impact on how AI is implemented, allowing for the development of new AI paradigms based on a hybrid of distributed collaborative and personalized techniques. NANCY incorporates a plethora of AI driven components that are enabled due to advancements in 5G/6G and aim to enhance current 5G capabilities, like resource orchestration and advanced analytics tools.

The 5G revenue mix will begin to incorporate enterprise vertical revenue, particularly in use cases that integrate the latest cellular generation with AI. According to [10], 5G services would generate almost USD 4 trillion in direct income by 2035, driven by use cases such as Enhanced Mobile Broadband (eMBB), Massive Machine Type Communications (mMTC), and Ultra-Reliable Low-Latency Communication (URLLC). On the other hand, the AI market is predicted to increase dramatically in the future years, reaching USD 1.5 trillion by 2035. By 2035, 55% of the market value (USD 855 billion) will be attributed to AI infrastructure suppliers, with the remainder going to AI cloud service providers employing AI-as-a-Service.

Overall, the combination of AI and 5G will generate USD 5.5 trillion immediately by 2035. The 5G ecosystem will account for a considerable portion of 5G and AI's market contribution, given that telecommunications equipment requires far more capital expenditure (CAPEX) and operational expenditure (OPEX) than cloud infrastructure.

*Blockchain's Evolution in the 5G Era*

With its promising security properties, blockchain promises to provide a new set of innovative solutions for 5G networks and services for better security, privacy, decentralization and transform the network management architectures for improved QoS as well as better 5G performances. In that regard, NANCY uses the benefits of blockchain to accommodate flexibility and security in providing mobile network services and ubiquitous coverage.

More specifically, blockchain promises to enhance the security and privacy of 5G ecosystems, by offering many promising technical properties such as decentralization, privacy, immutability, traceability, and transparency. Blockchain can eliminate the centralized network management concept by decentralizing the network infrastructure where there are no third-party authorities needed. As an example, the concept of blockchain-based cloud computing enables decentralization of cloud/edge 5G networks which removes centralized control at the core network and provides a decentralized fair agreement with blockchain consensus platform, which eliminates single point failure bottlenecks and improves significantly system trust. Besides, the security of D2D communication can be achieved by building a peer-to-peer network via blockchain, which transforms each D2D device into a blockchain node to hold a ledge copy with the ability to verify and monitor transactions for better system transparency and reliability.

The use of blockchain also potentially improves the performance of 5G systems. In comparison to traditional database platforms such as SQL, blockchain can provide better data storage and management services with low latency data retrieval. In fact, resource requests (i.e. data access) can be verified by decentralized blockchain nodes with the support of intelligent smart contracts without passing a centralized authority, which is promising to reduce network latency. Moreover, motivated by the removal of centralization, blockchain is able to establish direct communications between 5G service providers and mobile users so that the management cost can be significantly reduced. This would provide a much more flexible and efficient data delivery model for 5G ecosystems but still meet stringent security requirements.

Finally, it is believed that blockchain can simplify the 5G network deployments thanks to its decentralized architectures. Indeed, by leveraging blockchain, mobile operators now can have no worries about the establishment of centralized control servers. The 5G service delivery can be achieved by the blockchain network where user access, service responses and service trading (i.e. resource trading and payment) can be implemented on the decentralized ledgers among network participants including service providers and mobile users without the need for additional management infrastructure [11].

## 3.2.  Cloud/IoT/Edge Continuum Market

NANCY, as a cutting-edge platform designed to revolutionize 5G infrastructure, seamlessly integrates Cloud, Edge, and IoT technologies to create a robust and efficient network ecosystem. At its core, NANCY leverages the power of Blockchain Radio Access Networks (B-RAN) along with a suite of advanced features to enhance 5G capabilities. The platform's cloud component hosts sophisticated AI decision engines as services, which play a crucial role in optimizing various aspects of the 5G network, from resource allocation to performance tuning. Complementing the cloud services, NANCY

incorporates edge nodes that facilitate improved User Equipment (UE) connectivity, reducing latency and enhancing the overall user experience. Furthermore, NANCY is architected to support the ever-expanding IoT ecosystem, providing the necessary infrastructure to manage and process data from a multitude of connected devices. This holistic approach, combining cloud-based AI, edge computing, and IoT support, positions NANCY as a comprehensive solution for next-generation 5G networks, capable of meeting the diverse and evolving demands of modern telecommunications. In this chapter, we will describe the market landscape for these technologies, exploring their current state, potential impact, and future prospects within the context of NANCY and the broader 5G ecosystem.

### 3.2.1. Cloud Computing Market

Gartner predicts that 95% of new workloads will be cloud-based by 2025. Businesses must adapt to capitalize on the cloud's flexibility and cost-efficiency. Cloud services infrastructure spending will exceed USD 700 billion globally by 2024. This growth is being driven by various cloud computing trends, including the desire for new platforms and as-a-service offerings, notably those powered by artificial intelligence. Businesses are increasingly seeing the cloud as both a cost-cutting strategy and a strategic weapon for unlocking innovation, enhancing agility, and attaining success across industries [12].

At a compound annual growth rate (CAGR) of 15.1%, the worldwide cloud computing industry is projected to reach USD 1266.4 billion by 2028 from USD 624.4 billion in 2023. The retail and consumer goods, healthcare, and life sciences sectors are driving the expansion of the cloud computing market. Because AI, ML, Big Data, edge computing, and 5G technologies are being adopted more widely, this sector has grown at a rapid level. The ability of cloud computing to handle Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) is a major factor in the adoption of these technologies.

Due to its many advantages and quick adoption, cloud computing has emerged as a crucial component of modern company operations. Because of its adaptability, cloud computing is being used in a wide range of sectors and use cases. Businesses no longer need to invest in and manage on-premises storage infrastructure because cloud storage services like Amazon S3, Microsoft Azure Blob Storage, and Google Cloud Storage offer scalable and secure storage for data of all kinds, including documents, photos, videos, and files. By giving developers access to a cloud-based platform for creating, launching, and managing apps, PaaS relieves companies of the financial burden of maintaining development infrastructure [13].

### 3.2.2. Tiers of cloud computing

*Platform as a service*

Platform as a service (PaaS) is one of the three main cloud computing layers, along with infrastructure as a service (IaaS) and software as a service (SaaS). It gives companies the chance to reallocate funds to other business requirements in place of paying for IT infrastructure, software, and labor. PaaS solutions are typically utilized for DevOps tools, cross-platform application development, and mobile applications.

Despite a minor dip in 2021 and 2022, the global market for cloud computing is expected to rise during the coming years. Simultaneously, it is anticipated that the worldwide market for public cloud services will surpass 675 billion dollars by 2024. Although the SaaS category represents the majority of the cloud services market, PaaS makes for approximately 20% of the total. The public cloud PaaS market topped 145 billion USD in sales in 2023 [14].

The leading companies in the global PaaS industry are Google Cloud Platform, IBM Cloud, Amazon Web Services, and Microsoft Azure. Over 80% of the worldwide IaaS and PaaS market is jointly held by Microsoft and Amazon. According to recent studies, a large number of consumers are either planning to use these service providers' platforms, are currently testing them, or are already running apps on them. Alibaba, Salesforce, Oracle, and Rackspace are a few more companies operating in this industry [14].

*Software as a service*

Software as a service (SaaS) is one of the three main cloud computing tiers, along with PaaS and IaaS. It enables companies to reallocate funds to other business requirements in place of paying for IT hardware, software, and employee expenses. The leading players in the SaaS industry now are Google, SAP, Oracle, Salesforce, Microsoft, and SAP.

Approximately two-thirds of the revenue generated by the public cloud services market accounted for around 197 billion US dollars generated by the worldwide SaaS market in 2023 [15]. SaaS revenue growth is expected to keep increasing in the upcoming years, but its market share of cloud services as a whole is anticipated to decrease due to the expansion of cloud platform and infrastructure services. SaaS applications are used by a diverse range of users, including business users, IT specialists, and individual users. As a result, a wide variety of goods are available, including cutting-edge IT tools, file hosting services like Dropbox, and streaming media like Netflix.

Significantly, unlike IaaS and PaaS products, SaaS products are sold to both B2B and B2C users. This suggests certain drawbacks and issues with SaaS products. Companies rely on numerous outside vendors to handle their software. This could make it more difficult for customers to utilize SaaS products if the vendor experiences service outages or security lapses. Additionally, all customers receive updates to their apps, which can necessitate additional training costs for businesses. Finally, because a lot of data needs to be moved, switching vendors might be difficult [15].

*Infrastructure as a Service*

Infrastructure as a service (IaaS) is one of the fundamental cloud computing service frameworks, alongside SaaS and PaaS. Customers (often businesses rather than individuals) are allowed to create and access virtualized hardware and resources including servers, networks, storage, or virtual machines under the IaaS model.

Moreover, the customer is free to concentrate on managing higher-level resources, such as the platform, operating system, or required software, rather than worrying about creating or maintaining these resources. Customers only pay for what they really consume in this fashion. Providers are also allowed to sell assets that are not in use, which presents a significant chance for both parties to save resources and increase efficiency.

According to [16] in 2021, more than 25% of the total cloud computing market was made up of IaaS. Revenues from public cloud infrastructure as a service (IaaS) are predicted to grow dramatically over the next several years, from around 115 billion dollars in 2022 to more than 150 billion dollars by 2023. Nonetheless, it is anticipated that the market share of cloud infrastructure will decline in favor of the market's anticipated robust growth in PaaS. However, with more than 197 billion dollars in yearly revenue, SaaS is and will remain the largest category in the entire cloud computing business.

The biggest players in the IaaS space in terms of revenue are Alibaba, a multinational Chinese technology company, Microsoft (Azure), Google (Compute Engine), and Amazon (Web Services). Amazon is by far the biggest provider of cloud infrastructure, but as Google and Microsoft gain ground, it may lose market share. According to studies, cloud service providers are competing for a share of the cloud IaaS market. By 2024, it is anticipated that yearly spending on cloud-based IT infrastructure will have increased by more than 110 billion dollars. Original design makers account for about one-third of the market, which means they are also very important [16].

### 3.2.3. Cloud computing market dynamics

The cloud computing market is evolving rapidly, influenced by various factors that shape its growth and trajectory. Key drivers include the accelerated spending on cloud services, as businesses increasingly rely on cloud solutions for efficiency and scalability. However, the market faces significant restraints, such as a widespread lack of technical knowledge and expertise, which can hinder adoption. Despite these challenges, there are substantial opportunities, particularly with the rising adoption of IoT and connected devices, which require robust cloud infrastructure. Nonetheless, the complexity of managing a multi-cloud model poses challenges, adding layers of difficulty for organizations navigating this landscape.

*Catalysts: Increased Cloud Investment*
Companies aim to get a large market share and grow rapidly. Streamlining activities by guaranteeing data is easily accessible at every touchpoint is necessary to achieve this goal. Cloud computing services enable information access across all devices at any time and from any location, which simplifies company functions. The demand for cloud computing services is rising, and their dependability is increasing, as organizations adapt to meet the needs of their clients. According to [13] the first quarter of 2020 saw a 37% increase in cloud spending, reaching USD 29 billion. The need for cloud computing services is being driven by the growing requirement for off-premises resources that are scalable, secure, dependable, and reasonably priced. Even though IT investment fell by 8% in 2020, cloud spending rose by 19% despite the expected economic slowdown brought on by the pandemic. Corporate cloud expenditure is expanding at double-digit rates, according to recent research, as chief information officers and other digital leaders select more expensive, cutting-edge capabilities like artificial intelligence (AI) than traditional business software. The present financial climate is causing cloud leaders to use cloud-based services more frequently (42%), plan to switch from legacy software to cloud-based solutions (33%) and move workloads from on-premises to the cloud (32%).

*Limitations: Shortage of Technical Skills*
Technically skilled employees are needed by organizations to deploy, handle, evaluate, and protect cloud technologies. Nonetheless, IT professionals are severely lacking in technical abilities, especially in cloud computing. Due to this ignorance, businesses are losing out on the advantages of emerging technologies and the cloud, which will eventually result in a drop in market share and income. Due to a number of issues, including quick hiring procedures, high pay for seasoned cloud workers, and trouble finding people who fit with the company's culture, hiring managers have a hard time finding qualified applicants. Should the scarcity of cloud personnel continue, the company's expansion engines may break. Even though over 90% of IT leaders intend to accomplish this aim, 80% of them acknowledge that firms are unable to extend their modern software engineering and cloud environments due to a shortage of trained staff [13].

*Opportunities: Expansion through IoT Adoption*

The world of technology is always changing as new inventions are introduced. IoT and cloud computing are two upcoming internet technologies that are intimately tied to one another. The success of cloud computing is facilitated by IoT. Data from IoT devices needs to be gathered and handled either locally or remotely on a server. Remote data hosting and analytics are more sensible and economical options in many IoT applications. Edge computing is becoming more and more popular as cloud computing and IoT proliferate. By pre-filtering data and only transferring a portion of it to remote servers, edge computing can assist in lowering the demand for cloud storage.

*Obstacles: Navigating Multi-Cloud Complexity*

When it comes to solving their present problems, lean IT teams are up against new obstacles. Traditionally, businesses have prioritized process optimization, cost reduction, and efficiency enhancement. They had to prioritize deployments owing to the pandemic, though, and as a result, they rushed into public cloud solutions without doing enough research. This led to increased complexity, higher costs, and less flexibility, with little emphasis on reaching key business goals. A recent study found that 87% of participants agreed that successfully utilizing multiple clouds requires managing mixed-cloud architecture. Managing cloud resources presents several issues for enterprises as multi-cloud deployments increase in frequency. It is challenging to employ cloud computing in multi-cloud settings because it runs at several levels, each with its own best practices and deployment guidelines. With every additional cloud environment used, the difficulty of managing cloud resources rises. Because there are no established industry standards, the management load also grows as more public cloud vendors are used. Therefore, before committing to multi-cloud services, it is essential to examine each vendor's security procedures and comprehend the scope of their protections [13].

### 3.2.4. Cloud Computing Market Trends

The cloud computing landscape is continuously evolving, driven by emerging technologies and shifting business priorities. This section explores the latest market trends that are reshaping the industry. The rise of Generative AI (GenAI) supporting infrastructure is revolutionizing how data and AI workloads are handled. The growing focus on FinOps reflects the increasing need for cost management and optimization in cloud environments. As organizations seek flexibility and resilience, hybrid and multi-cloud adoption is becoming more prevalent. The integration of edge computing is bringing computational power closer to data sources, enhancing real-time processing capabilities. Moreover, the demand for real-time cloud infrastructure is rising, catering to applications that require immediate data access and response. Finally, cloud security remains a critical concern, driving innovations and best practices to protect sensitive data and ensure compliance.

*Emergence of Infrastructure for Generative AI*

To make accessible AI and realize its full social and economic potential, the cloud is positioned to play a critical role according to David Linthicum of Deloitte. Large-scale AI models, such as the one behind ChatGPT, need enormous amounts of data and processing power, which are beyond the means of most companies. But cloud platforms are intervening, providing AI-as-a-service, and making this game-changing technology accessible. The emergence of GenAI on the cloud and elsewhere is what's driving this trend in cloud computing. Companies are moving from proof-of-concept to production systems, and they will be constructing the necessary infrastructure to facilitate this change by 2024. This covers both brand-new AI applications and ones that are already in use but have been enhanced with AI

features. It also covers a variety of platforms, such as edge computing, public clouds, data centers, and mobile devices.

However, considerable infrastructural modifications are needed to enable the rise of GenAI. Scaling database storage for training data and supporting both structured and unstructured forms are key components of GenAI system sizing. Because cloud platforms are easy to provide and scale, they are likely to be the preferred battleground. Combining data prior to training often proves to be more efficient.

Furthermore, GenAI necessitates distinct computing requirements. GPU allocation is common and in great demand, since they are essential for AI processing. Yet, traditional CPUs continue to have a place, and the simplest way for many businesses to use GenAI may be through specialized cloud services. In 2024, cloud providers will see phenomenal growth driven by this AI surge. Conventional computer and storage platforms, however, will not become obsolete. Many companies may choose to keep their effective AI systems on-site because security and cost-effectiveness are their top priorities. In the end, both cloud and on-premises solutions will benefit from this rising wave of AI [17].

### Financial Operations in Cloud

Since cloud computing accounts for a significant portion of IT expenses for businesses, C-suite executives now place a high premium on using cloud resources effectively and optimally. As a result, FinOps—a framework, mindset, and culture—has emerged. Its main objective is to maximize the return on cloud expenditures by optimizing cloud costs. Key drivers of the rise of FinOps in cloud computing in 2024 include:

- Macroeconomic pressures: Concerns about recession and inflation incentivize businesses to seek efficiency in cloud spending.
- Cloud waste: Unsustainable spending and lack of cost transparency drive the need for better cloud cost management.
- Lack of insights: Complex and dynamic cloud resource use necessitates better data and best practices for optimization.
- Need for better planning and forecasting: Rising cloud costs and dynamic demand for cloud resources require improved budgeting and forecasting.

Approximately 52% of European organizations are adopting FinOps, with many still in the early stages. IDC predicts that 70% of Global 1000 companies will increase FinOps maturity by the end of 2024 [17].

### Expansion of Hybrid and Multi-Cloud Strategies

A major development in cloud computing for 2024 is the move toward ubiquitous computing, which involves rejecting the public cloud model and utilizing the best platform for each task and type of data. Deloitte claims that while this progression builds upon the multi-cloud concept, it also offers even more opportunities.

Shifting the focus beyond public clouds: For years, computing was dominated by public clouds. However, ubiquitous, and heterogeneous computing is becoming a new paradigm. Companies are no longer confined to a single platform; instead, they are weighing all their options and distributing workloads and data in the most advantageous ways. This entails making use of on-premises infrastructure, edge computing, multi-cloud environments, and even "microclouds" tailored to particular industries.

Drivers and impacts: Falling hardware costs, high public cloud charges, and the desire for maximum efficiency and performance are driving the move away from public clouds. This will show itself in 2024 with the return of some workloads to conventional data centers and the adoption of non-cloud platforms like edge computing and mobile. Businesses are able to maximize cost-effectiveness and exploit resources no matter where they are located, even though some benefits of the public cloud are lost in the process.

This trend points to a more complex and decentralized computing environment in the future, where companies will be able to manage their data and workloads with more efficiency, flexibility, and control [17].

*Edge computing integration*

By 2024, companies will be looking beyond centralized data centers and embracing a varied ecosystem of resources, which will result in the cloud's dominance as the only computing environment to diminish. Mobile and edge computing platforms are becoming more powerful due to falling hardware costs and the introduction of 5G and other high-speed networks. This change is about utilizing the most economical and effective solution for each data stream, not about rejecting the cloud. Large venues and businesses also join the party, utilizing edge servers to handle data and distribute content inside their physical limits without depending on backhaul networks that are far away. A new era of distributed computing has begun with the emergence of ubiquitous access and resources, both inside and outside the cloud. This allows businesses to fully utilize the power of data, no matter where it may be located [17].

*Development of Real-Time Cloud Infrastructure*

In 2024, real-time cloud architecture is anticipated to be a major development in cloud computing. Companies now demand real-time data processing and action; they can no longer wait for insights. Cloud technology needs to advance as well in order to stay up. Enter real-time cloud infrastructure: a revolutionary architecture designed for dynamic, immediate access to resources and services. This is achieved through a powerful combination of technologies:

- Serverless computing: Removes the need for server management and enables immediate code execution upon trigger, making it ideal for real-time processing.
- Edge computing: Brings data processing closer to the point of origin, saving bandwidth and latency for applications that need to be completed quickly.
- Flash and solid-state storage: Provides unmatched data access speeds, enabling analysis and decision-making in real time.

Dynamic scalability to manage varying data loads, quick replies for improved customer service, and quick decision-making fueled by real-time insights are just a few benefits of real-time cloud architecture. By digitizing key systems, it enables firms to adopt innovation, optimize workflows, and possibly achieve cost and resource savings [17].

*Advancements in Cloud Security*

The increasing adoption of cloud computing brings significant benefits and amplifies existing security risks. In 2024, three critical measures will mitigate these risks and ensure continued trust in the cloud: data encryption, robust authentication protocols, and comprehensive disaster recovery plans.

Data encryption: Sensitive information saved in the cloud is protected by data encryption in an era of ever-increasing cyber dangers. Even if unwanted parties manage to access cloud storage systems, they

are essentially locked out by transforming data into an unclear format. The demand for improved encryption algorithms—including ones that can withstand possible threats from quantum computing—will only increase as more complex hacking tactics surface.

Authentication: Robust authentication systems regulate access to cloud resources, while encryption protects data while it's in the background. The new norm will be multi-factor authentication (MFA), which will use extra elements including voice recognition, biometric verification, and user behavior analysis in addition to the conventional password-based verification. The likelihood of social engineering or brute-force attacks succeeding is significantly decreased by this graded strategy.

Disaster recovery: Unpredictable incidents like hardware failures or natural disasters might impair cloud operations even with strong security measures. Plans for disaster recovery are an essential safety net that guarantees data security and business continuity. Reducing downtime and data loss will need geographically distributed cloud infrastructure, automated data replication, and seamless failover systems.

It is crucial to understand that cloud providers are not the only ones accountable for cloud security. Companies need to actively participate in security best practices, which include developing employee training programs, conducting frequent vulnerability assessments, and keeping up with the most recent threats and mitigating techniques. Building confidence and fostering a secure cloud ecosystem will need cooperation and transparency between cloud providers and their clients [17].

*Key players in the market*

With 31% of total spending, Amazon Web Services (AWS) [18] dominated the market for cloud infrastructure services in 2023. Following a few quarters of decreasing growth, AWS experienced a slight resurgence, with sales rising 13% annually. The backlog of future committed spending by customers on AWS as of 2023 was USD 155.7 billion, representing a year-over-year increase of more than USD 45 billion. It is anticipated that AWS's growth rate will continue to increase through 2024. In line with its rivals Microsoft Azure and Google Cloud, it announced a drop in AWS Marketplace listing costs for SaaS and data offerings from 13% to 3% in December 2023. This move demonstrates AWS' growing strategic emphasis on its marketplace as a means of enabling partner revenue generation and consumption, as opposed to a stand-alone source of income. In December 2023, AWS opened its second infrastructure region in Calgary, Canada, making history as the first significant cloud service provider to open an infrastructure region in Western Canada.

The market share of Microsoft Azure, the second-biggest cloud service provider, increased from 23% in 2022 to 26% in 2023 [18]. Compared to 2022, Azure's revenue increased by 30% due to the rapid adoption of AI. Azure now offers fine-tuning features in addition to enhanced support for OpenAI's most recent models, which include GPT-4 Turbo, GPT-4 with Vision, and Dall-E 3. More than one-third of the 53,000 Azure AI clients it has gained were added in the last year. Azure is anticipated to maintain its growth momentum due to its AI advantage. It declared that Copilot for Microsoft 365 will be widely accessible through all sales channels on January 16, 2024. The goal of this action is to give clients more access and give the partners that serve them more chances.

In 2023, Google Cloud held the third position in the market, having grown by 26% to represent 10% of the total. The need for AI propelled Google Cloud onto a new growth trajectory. Google Cloud's revenue backlog increased from USD 64.3 billion at the end of 2022 to USD 74.1 billion as of December 31, 2023. With the release of its Gemini large language model, Google intends to take the lead in the

artificial intelligence sector. Google unveiled Gemini 1.5, its replacement, in February 2024, just two months after it launched. It is intended primarily for developers and business customers, but a wider consumer release is scheduled very soon. In order to promote growth, Google Cloud has continued to place a high priority on growing channel relationships. Since 2022, the amount of co-sell agreements with partners has increased three times [18].

### 3.2.5. IoT Market

The term Internet of Things (IoT) refers to a network of physical and virtual devices which can communicate independently with one another via the Internet Protocol. The physical devices are outfitted with sensors, software, and communication capabilities that allow them to collect and exchange data via the internet. It covers a wide spectrum of use cases, from home items to complicated industrial applications. The Internet of Things Market size is estimated at USD 1.17 trillion in 2024 and is expected to reach USD 2.37 trillion by 2029, growing at a CAGR of 15.12% during the forecast period (2024-2029) [19].

IoT technology serves as the cornerstone for many firms' digital transformation, enabling them to improve their current procedures by developing and monitoring new business models. Businesses and service providers view IoT as a key tool for enhancing digital transformation and releasing operational efficiencies. The market is expanding as a result of the increasing usage of IoT technology in end-user sectors like manufacturing, the automobile industry, and healthcare. The IoT is driving the next industrial revolution of intelligent connectivity as the traditional manufacturing sector undergoes a digital revolution. This is causing industries to reconsider how they handle ever-more complicated machine and system processes in an effort to increase productivity and decrease downtime.

Smart industrial automation, which refers to new technology ways of designing, producing, and controlling the entire logistics chain, is largely dependent on Industry 4.0 and the Internet of Things. Large-scale changes in manufacturing triggered by Industry 4.0 and the adoption of IoT demand that businesses adopt more creative, intelligent, and flexible approaches to advancing production through robotics-assisted human labor and the reduction of process-related industrial accidents. The industrial sector has generated a large amount of data points due to the rapid adoption of connected devices and sensors, as well as the opening of M2M communication. These data points can take many different forms, from a simple measure that indicates how long it takes a material to go through a manufacturing cycle to more complex ones that determine the material stress capability in the automotive sector.

The market is predicted to grow even more as a result of developments in field devices, sensors, and robotics. The manufacturing sector's shortage of personnel is being overcome via IoT technologies. An increasing number of enterprises are integrating Industry 4.0 technology, such as robotization, into their daily operations. The International Federation of Robotics projects that in just two years, the market for collaborative robots will grow to a value of USD 12.3 billion. Most manufacturing workers can program intelligent robots to perform the most repetitive, laborious jobs with accuracy and work alongside humans. Because they are simple to train and may replace humans in potentially hazardous situations, they are being used more and more in the manufacturing sector. Robots are incredibly cooperative and trainable, and they also create safer working environments for people by taking human positions when necessary or in unsafe situations. For example, operators can operate autonomous dump trucks at mining sites remotely, doing away with the requirement for human drivers [19].

### 3.2.5.1. IoT market dynamics

*Drivers: Availability of affordable, energy-efficient sensor technology*

The most crucial parts of Internet of Things devices are the sensors. They aid in the creation of data regarding a physical occurrence or condition. Sensors are capable of measuring a wide range of environmental factors, including orientation, motion, light, sound, humidity, temperature, and biometrics like heart rate and blood pressure. These sensors will boost the Internet of Things viability for many application domains across industry verticals. It is also expected that ongoing advancements in sensor technology will increase IoT possibilities. Industry adoption of IoT devices was first hindered by the quite high cost of sensors employed in these devices. However, the rate at which IoT is being used by businesses has significantly increased as a result of a significant drop in the cost of these sensors. In the last ten years, there has been a notable decrease in the price of some low-frequency passive Radio Frequency Identification (RFID) tags and sensors. Furthermore, from USD 1.3 per unit in 2004 to USD 0.38 per unit in 2020, the average cost of sensors has dropped. The widely used, inexpensive sensors and gadgets are unlikely to be seen as technological advances as the IoT market expands [20].

*Restraints: Concerns regarding security, data integrity, and privacy in connected devices may hinder growth*

IoT technology has several uses, from monitoring related equipment via cloud platforms and communication networks to collecting biometric data through wearable devices. Due to their unique IP addresses, these devices can connect and communicate with one another as well as share data. However, the need for data protection and privacy only increases with the number of platforms, mobile devices, smart gadgets, and other connected devices. Attackers may be able to access sensitive and personal data on certain devices and networks. The increasing reliance on linked devices, the replication of design routines, and the vulnerabilities of linked devices can all lead to data misuse. Market development may be limited by such restrictions on the security and privacy of customers' personal data [21].

*Opportunities: Expansion of connected devices expected to boost IoT growth*

Organizations have enormous opportunities to extract important data, such as consumer behavior in stores, for real-time marketing research, sensor-driven decision analytics, and instantaneous control response in complex autonomous systems due to internet connectivity and linked devices. IoT gives businesses and governments access to real-time location-based data and connects them to all smart prospects, including smart transportation, smart utilities, and smart cities. High-speed network connectivity has also made it possible for several industries, including transportation, energy, healthcare, and other utility sectors, to monitor and control the entire infrastructure more effectively. Electronic personal health records, virtual health kiosks and portals, and remote consultation and monitoring are just a few of the application areas where the healthcare industry has already started implementing IoT. IoT-based solutions are being used by the energy sector for a variety of purposes, including security, mobile workforce management, predictive maintenance, asset performance management (APM), and field surveillance and monitoring. IoT in the transportation industry aids in reducing crime, maintaining safety, managing traffic, and controlling congestion. To enable ubiquitous public mobile IoT, 4G networks are transformed into NB-IoT networks. They pay particular attention to low cost, high connection density, extended battery life, and interior coverage. Smart parking, smart

energy, smart infrastructure, and environment monitoring are just a few of the many applications for them in smart city initiatives [20].

*Challenges: Limited public awareness of IoT and smart city concepts*

The government's infrastructure initiatives and industries benefit greatly from Internet of Things programs in every sector, including building, transportation, utilities, and citizen services. They can be more empowered with improved equipment and service control and monitoring due to clever solutions in these areas. To fully utilize the advantages of IoT, industries must direct their resources. A tiny portion of the workforce is reported to be aware of the functions and advantages of IoT across a variety of businesses. One significant element impeding the growth of the smart environment is public ignorance. Additionally, people in many regions lack knowledge of smart city projects, which reduces the government's motivation to put smart city solutions into action [20].

### 3.2.5.2.    IoT Market Trends

#### Edge AI boosts IoT efficiency

Among the IoT trends for 2024, edge AI—which puts AI capabilities right on devices that are producing data—is becoming increasingly popular. This method, sometimes referred to as edge IoT or intelligent edge, tackles the increasing latency and data volume issues with conventional cloud-based AI. In order to facilitate real-time analysis and decision-making at the endpoint, OEMs and semiconductor manufacturers are strongly creating AI models and inference chipsets for edge devices. Faster response times for applications like AR/VR gaming, enhanced data privacy and security, less data transfer costs, and even sustainability benefits owing to decreased computational demands are just a few of the perks that come with local processing. Although the energy capacity of many edge devices is limited, edge AI is rapidly being adopted across a variety of industries due to its compelling advantages [22].

*Increased prioritization of privacy and security*

Weak data encryption and constrained device processing capacity lead to security risks in the rapidly growing Internet of Things. Hackers take advantage of these flaws and target appliances like webcams and routers. Additionally, as the number of linked devices increases, bottlenecks in the centralized server appear. A potential solution is blockchain technology, which is well-known for its safe record-keeping in cryptocurrencies. Its distributed ledger solves scalability and security issues by removing single points of failure and supplying tamper-proof data.

Concerns regarding data privacy and security issues are raised by the increasing number of IoT-dependent smart home appliances. Citizens are vulnerable to cyberattacks due to centralized data storage. One possible approach is to use blockchain technology, which is renowned for its decentralized and impenetrable record-keeping. Utilizing blockchain's distributed ledger technology and outfitting smart homes with a specialized "miner" device can greatly improve data security, confidentiality, and integrity. Comparable blockchain uses are also being investigated for eHealth systems, where they protect patient privacy and enable safe medical data administration. Blockchain allows for decentralized, tamper-proof financial transactions in Internet of Things payments. All things considered, blockchain technology has the potential to enhance the security and privacy features of the Internet of Things [22].

*5G technology propels IoT growth*

IoT success depends on pervasive and reliable connectivity. Large amounts of data are fed into AI/ML algorithms by this essential component, which helps them learn, develop, and solve challenging

business issues. When it comes to scalability, security, and a variety of protocols which can accommodate different device needs and remote deployments, cellular technology stands out as a reliable option. For continuous data flow and optimal AIoT effectiveness, selecting the right connectivity mix—whether it be low-power LTE-M or high-speed 5G—requires professional advice.

Strong cellular IoT growth is predicted by the Ericsson Mobility Report, with 3 billion connections expected by 2023 and a 12% CAGR through 2029. The rising need for reliable communication and innovations such as NR-RedCap (New Radio reduced capability), an affordable fix for low-complexity devices, are driving this increase. Furthermore, 5G Advanced's improved features and fast data rates open up new application opportunities. It is anticipated that communication service providers (CSPs) will give infrastructure investments in 5G Advanced and NR-RedCap top priority, enabling them to extend the capabilities and reach of their IoT networks.

At the same time, OpenRAN, an open and modular architecture for 5G networks, is rapidly expanding due to its affordability, flexibility, and vendor diversification potential. CSP interest in OpenRAN solutions is fueled by factors including the prohibition on Huawei equipment and growing component costs; more testing and deployment are anticipated in 2024. OpenRAN and vRAN developers may find new opportunities as a result of this development, which has the potential to threaten the dominance of conventional infrastructure companies [22].

### The trend towards smart cities is on the rise

The combination of IoT with AI is one of the IoT topics that has the most promise for creating sustainable smart cities. IoT is becoming a vital technology as cities all over the world work to achieve the Sustainable Development Goals (SDGs) of the UN. City planners may track progress towards sustainability key performance indicators including energy efficiency, pollution reduction, and traffic optimization due to dense networks of sensors collecting data on a variety of urban factors. Artificial Intelligence (AI) and Machine Learning (ML) are critical for automating processes and generating greater value from the growing amount of sensors and generated data in urban areas. For instance, real-time and historical traffic data can be combined by AIoT technologies to anticipate and reduce congestion. Similar to predictive maintenance in manufacturing, artificial intelligence (AI) can help make more precise predictions about potential hazards, such as natural disasters, and downtimes/failures in city services, like waste management and water delivery [22].

### Growing popularity of wearables and voice assistants

Voice assistants are becoming more and more commonplace in daily life, as seen by the 85% of consumers who used a Capgemini poll indicating that they influence early purchasing decisions. Despite sporadic context problems, in-car assistants mainly provide music, navigation, and convenience functions while fostering user confidence in recommendations. In the same way, customers appreciate linked experiences (health, retail, entertainment, and travel) enough to pay for them or to remain loyal, and health wearables are becoming more and more popular (33% owned, 29% planned purchases). This Internet of Things trend points to a time when technology permeates every part of life and influences consumer behavior, including brand loyalty and purchase decisions.

Although fitness trackers and smartwatches are now commonplace, wearables of the future may be found inside our bodies. Brain-computer interfaces present possibilities that appear futuristic today, such as direct thought control over machines. It may still be years before widespread adoption occurs, but in 2024 and beyond, this IoT trend is sure to take center stage in discussions [22].

### 3.2.5.3. IoT Market Insights

*Component Insights*

The global IoT market is divided into hardware, software, and services segments based on the components. Throughout the projection period, the software segment is anticipated to maintain its dominant market share, which it held in 2023. This can be linked to the rise in artificial intelligence and machine learning software, the spread of cloud software deployments, and the growing need for visibility and control over data management. IoT software is required for data collection and transfer on connected devices in order to provide real-time data that computers and apps can process and display as information. Software integrations are diverse and constantly changing to stay up to date with emerging technologies [23].

*Deployment Insights*

The global IoT market is divided into cloud and on-premises segments based on deployment. Over the duration of the forecast period, the cloud segment is anticipated to dominate the market. IoT solutions depend on cloud computing to function. It offers the scalability, security, cost-effectiveness, infrastructure, data processing capacity, and scalability required to manage the enormous volumes of data produced by IoT devices and offer insightful information to consumers and companies. Cloud services will probably continue to be an essential part of IoT ecosystems as the market for IoT devices grows. As a result, during the projected period, this is anticipated to propel market expansion [23].

*Platform Insights*

The device management, application management, and network management sectors of the worldwide IoT market are split based on the platform. Over the duration of the forecast period, the device management sector is anticipated to dominate the market. The effective and safe management of a broad variety of IoT devices, sensors, and endpoints makes device management a crucial part of the IoT business. For IoT implementations to be scalable, secure, and reliable, effective device management is necessary.

The process of provisioning and onboarding IoT devices onto the network is made easier by this solution. This involves setting up device settings, allocating distinct identities, and guaranteeing safe connectivity. In addition, thorough inventory management is necessary for extensive IoT installations, particularly in sectors like manufacturing and logistics. Device management solutions provide precise asset management by keeping track of the kinds, locations, and statuses of devices and therefore, promoting the expansion of the segment [23].

*Technology Insights*

The global IoT market is divided into five segments based on technology: near-field communication, data processing, network communications, pressure sensors, and radiofrequency identification. Over the course of the forecast period, the network communication segment is projected to develop at the fastest rate. The IoT sector is largely dependent on network communication since it allows endpoints, sensors, and devices to connect, share data, and communicate with one another and with central systems [23].

*Industry Vertical Insights*

The global IoT market is divided into several segments based on industrial verticals, including manufacturing, e-commerce, energy & utility, healthcare, transportation & logistics, IT & telecom, and others. Over the duration of the forecast period, the e-commerce industry is anticipated to increase at

the greatest CAGR. IoT integration in e-commerce is revolutionizing how companies run by increasing consumer satisfaction, streamlining the supply chain, and facilitating more individualized purchasing experiences. E-commerce businesses will probably look into creative methods to use IoT technology as the market for IoT grows in order to obtain a competitive edge and satisfy the shifting needs of online customers, therefore promoting market expansion [23].

### 3.2.6. Edge Computing Market

The acceptance of cloud computing, the growth of IoT devices, and the growing need for low-latency applications are some of the major reasons driving the exponential growth of the global edge computing market. Solutions utilizing edge computing have the potential to greatly benefit industries like manufacturing, healthcare, transportation, and telecommunications. Leading companies in the industry provide a wide range of solutions, such as data centers, gateways, and edge servers, fostering innovation and market growth.

The market for edge computing was estimated to be worth USD 16.45 billion in 2023, and between 2024 and 2030, it is projected to expand at a compound a CAGR of 36.9%. Organizations become more sophisticated as a result of edge computing, which makes it possible for a wide range of stakeholders to manage software development, traffic distribution, IT infrastructures, networking, and service administration. In order to address different use cases in numerous industries, Edge additionally integrates networking architecture, hardware solutions, and software. We are still in the early stages of developing edge computing. Although edge computing's deployment and operating models are still in the early stages of development, new players should soon have substantial growth opportunities in this market [24].

#### 3.2.6.1. Edge Computing Market Dynamics

*AI/ML Integration: Catalyst for Global Edge Computing Growth*
Real-time data analytics and decision-making at the network edge are made possible by the integration of AI and ML algorithms into edge computing devices. Applications of edge-based AI/ML, like anomaly detection, personalized content delivery, and predictive maintenance, take advantage of local processing power to analyze data in almost real-time, giving businesses the ability to get practical insights and increase productivity. Because AI/ML integration enables real-time data analysis and decision-making at the edge, it drives the edge computing business. Organizations can improve user experiences, accelerate the extraction of key insights, and optimize operations by implementing AI and ML algorithms in closer proximity to the data generation source. Additionally, by limiting latency and bandwidth needs and reducing the need for massive data transmission to centralized cloud servers, this integration enhances the overall effectiveness and responsiveness of edge computing solutions [25].

*Edge Computing Complexity: A Barrier to Widespread Adoption*
It is frequently necessary to make large infrastructure investments in order to implement edge computing solutions. This includes purchasing edge devices, networking hardware, and management software. Adoption by enterprises without the necessary resources or skills to install and manage edge computing environments may be limited by this complexity. The worldwide market is constrained by the complexity of the infrastructure needed to implement edge computing solutions. Establishing and maintaining the necessary edge devices, networking components, and management systems can be difficult for organizations. Adoption may be hampered by complexity, especially for companies without

the knowledge or resources to deal with the difficulties involved in setting up and maintaining edge computing infrastructures [25].

*Sector-Specific Edge Solutions: Driving Adoption and Innovation*

Tailoring edge computing solutions to the unique needs of different businesses offers a big chance for market expansion. Tailored edge computing solutions can efficiently meet the unique difficulties and demands of several industries, including manufacturing, healthcare, transportation, and logistics. For example, edge computing can help with real-time data analysis and remote patient monitoring in the healthcare industry, as well as production process optimization and predictive maintenance in the manufacturing sector. In the retail industry, edge computing can improve client experiences by providing individualized services and effective inventory control. Edge computing providers can open up new channels for adoption and innovation and push the market forward by meeting the needs of this industry [25].

## Compatibility and Interoperability: Hurdles in Edge Computing Integration

Interoperability issues may arise from the heterogeneous nature of edge computing ecosystems, which include a range of devices, protocols, and standards. The scalability and flexibility of edge computing deployments can be limited by the significant customization and integration work needed to integrate heterogeneous edge devices and systems from various manufacturers. This may impede smooth data transfer and inter-node cooperation, hence reducing the overall effectiveness of edge computing solutions. One major obstacle facing the worldwide edge computing sector is interoperability. Making sure that all of the hardware, software, and networking components used in edge solutions are compatible with each other without any issues becomes essential. Compatibility problems resulting from non-standard protocols and interfaces across systems and devices can impede the scaling and integration of edge computing deployments. This obstacle makes adoption more difficult and can discourage businesses from purchasing edge computing solutions [25].

### 3.2.6.2. Edge computing market trends

*Acceleration of Digital Transformation Strategies*

The market is being driven by the growing number of digital transformation efforts. Edge computing appears as a key enabler as companies in a variety of industries attempt to improve their operations and realize the potential of cutting-edge technologies. Effective and quick data processing is required due to the shift to digital processes, data-driven decision-making, and the growth of IoT devices. The capacity of edge computing to process data closer to the source is ideal for meeting the demands of an ecosystem that has experienced a digital transformation. Adoption of it enables enterprises to easily manage and analyze data in real time, increasing customer satisfaction and operational effectiveness. The need for edge solutions is rising as more businesses see how edge computing can assist them in their paths toward digital transformation [26].

*Industry 4.0: Driving the Next Industrial Revolution*

The market is being stimulated by the rise of Industry 4.0. Manufacturing and operations are being transformed by this industrial revolution, which is defined by the convergence of digital technology, automation, and data interchange. The integration of artificial intelligence, big data analytics, IoT, and smart devices improves productivity, efficiency, and connectedness. The need for edge computing is growing as more businesses adopt Industry 4.0 concepts. The capacity of edge computing to process data at or close to its source fits very well with Industry 4.0's real-time demands. By enabling local data

analysis, factories and industrial facilities may cut down on latency and make quick decisions. Edge computing is crucial for Industry 4.0 in order to utilize the massive volumes of data produced by networked equipment and gadgets. By extracting actionable insights at the edge, it helps enterprises optimize workflows and allow predictive maintenance. Thus, as companies look to realize the full potential of this industrial revolution, Industry 4.0's development is driving edge computing adoption [26].

*Expansion of R&D Investments in Edge Technologies*

The market is being supported by the increased focus on research and development (R&D) efforts. Institutions and organizations are devoting more and more funds to investigating new technology, improving current procedures, and creating innovative solutions to challenging problems. The market for edge computing is directly impacted by this increased emphasis on R&D since it promotes the development of edge-related technologies. Better hardware, enhanced software frameworks, and improved data processing techniques are the results of the ongoing research and improvement of edge computing capabilities. These advancements address the changing needs of companies looking for flexible and quick data processing solutions. Beyond simple technological advancement, edge computing and expanding R&D efforts support each other. It also includes developing specialized programs, tools, and strategies that make use of edge computing's advantages. The advancement of edge computing is fueled by research and development (R&D) activities, which also make its deployment more practical, effective, and industry-aligned [26].

### 3.2.6.3. Edge computing market ecosystem

*Based on components*

A wide range of tools and devices are essential for facilitating distributed computing closer to data sources in the edge computing market's hardware sector. This comprises sensors, switches, routers, edge servers, gateways, and specialized computing chips. These hardware elements are made to handle and analyze data at the edge with efficiency, which lowers latency and improves the ability to make decisions in real time. The need for scalable and optimized hardware solutions is growing as edge computing spreads throughout sectors, spurring investment and innovation in this market area [25].

*Based on application*

Processing and analyzing data gathered from linked devices and sensors at the network edge is required for using IoT and sensor data in edge computing. By processing data closer to the source, organizations can reduce latency, enhance real-time decision-making, and maximize bandwidth utilization. Faster insights and actions are made possible by this, improving productivity and operational efficiency. Organizations can also optimize asset performance, minimize downtime, and save maintenance costs by utilizing IoT and sensor data at the edge to extract insightful information, identify abnormalities, and forecast maintenance needs. All things considered, leveraging IoT and sensor data in edge computing effectively encourages innovation, accelerates digital transformation, and yields visible commercial benefits [25].

*Competitive landscape*

Top companies actively support market expansion with calculated moves and creative solutions. The leaders in the field are continuously funding R&D, which propels the advancement of edge computing applications and technologies. They play a crucial role in establishing industry standards and best practices, guaranteeing the efficiency, security, and scalability of edge computing deployments. These

enterprises are also encouraging partnerships with cloud providers, technology partners, and organizations in different industries. Offering all-inclusive solutions that combine cloud resources and edge computing, they make it possible to build hybrid environments that meet a range of operational requirements. Leading businesses also take the lead in creating customized software and hardware that meets the particular needs of edge data processing. Their contributions to thought leadership, industry events, and educational activities help spread the word about the advantages of edge computing [26].

## 3.3.   Blockchain Market

The size of the worldwide blockchain technology market was projected to be USD 4.8 billion in 2022 and is expected to reach over USD 2,334.46 billion by 2032. Over the forecast period of 2023 to 2032, the market is expected to develop at a compound annual growth rate (CAGR) of 85.7% (Figure 5). The market is expanding as a result of the growing need for safe and transparent transactions in numerous industries. Blockchain is particularly attractive to industries like supply chain management, banking, and healthcare because of its decentralized and immutable ledger system, which guarantees the integrity and transparency of transactions. Companies operating in these fields are progressively incorporating blockchain-based technologies to improve their operational security and transparency [27].
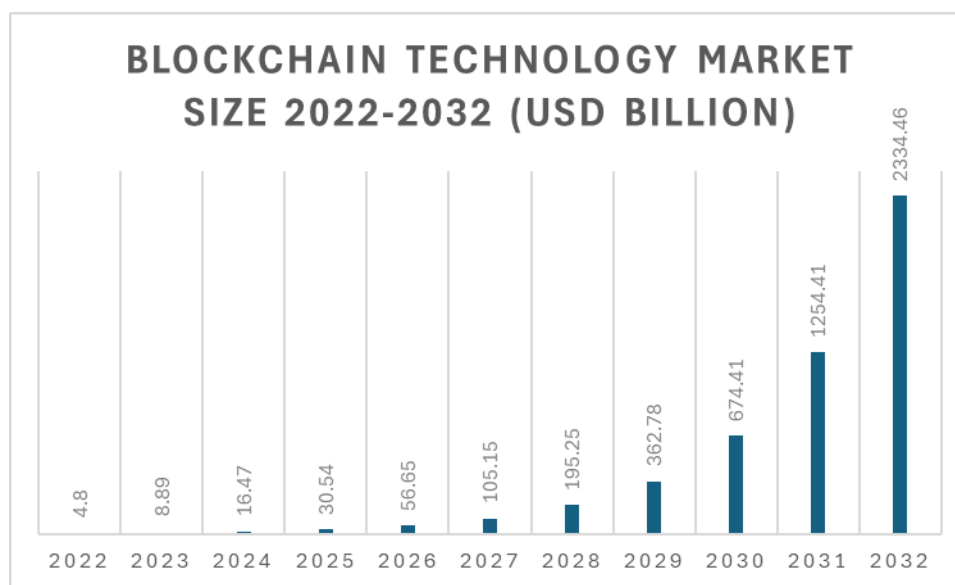


Figure 5: Blockchain market size 2022 to 2032 in USD Billion[2]

One of NANCY'S most innovative characteristics is the use of blockchain technologies and how these technologies are utilized inside the 5G infrastructure. Since we have already showcased how pivotal blockchain will be for the future of 5G in chapter 3.1.2, we can now focus on the blockchain itself. The blockchain market is expanding at a rapid rate and is currently in a high stage with constant developments due to innovations like cryptocurrencies, non-fungible tokens (NFTs), tokenization of assets, blockchain-as-a-service, and the fusion of blockchain and AI. These revolutionary developments are changing the financial environment of today by providing novel accessibility, security, and convenience features which will eventually be integrated into NANCY.

One such feature is the increasing need for e-identity. Applications for blockchain-based identification systems have started to become increasingly popular in both commercial organizations and nations.

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[2] Source: Precedence Research

Many governments have implemented market demand-based identity systems utilizing Blockchain technology at the national level to encourage safe transactions in both the public and private sectors. Over the past few years, a number of countries have integrated blockchain technology into their e-citizenship initiatives. These nations have thus been able to lower bureaucracy and create identity-related processes independently. Furthermore, by using a secure digital identification, this technology has assisted them in digitizing all types of public transactions. NANCY's utilization of blockchain for these purposes make it a highly advanced product for the markets of the future.

Furthermore, digital ledger technology is being adopted by Banking, Financial Services, and Insurance (BFSI) organizations to protect end-user identification and financial data. Within the Banking, financial services and insurance sector, technological applications such as trade finance platforms, digital identity verification, cross-border transactions, clearing and settlements, and credit reporting are becoming more and more popular. This should encourage market expansion. To secure transactions, shorten transaction processing times, and expedite the letter of credit process, major Indian banks, including the State Bank of India (SBI), HDFC, ICICI Bank, and others, joined forces in June 2021 to establish Indian Banks' Blockchain Infrastructure Co (IBBIC), a private limited company [28]. NANCY takes these trends under consideration, by creating innovative and trustworthy monetary incentives i.e. smart pricing, marketplace etc. These aim to benefit both ordinary users as well as telecommunication providers who will eventually adapt and familiarize themselves with blockchain-based financial transactions.

NANCY goes one step further by just simply incorporating blockchain features in its architecture by adopting B-RAN. B-RAN is the evolution of O-RAN and leads towards the fusion of Radio Access Networks with Blockchain. In B-RAN, the blockchain is expected to have several key roles, like decentralized network management, transparent and immutable record keeping, tokenization of network resources, identity management etc. NANCY will also incorporate a framework that will accurately model and estimate the achievable performance of B-RAN, enabling stakeholders to conduct pre-deployment evaluations and make informed decisions, thereby minimizing unnecessary expenses and optimizing resource use.

### 3.3.1. Blockchain Market Dynamics

*Driver: Increasing venture capital funding and investments in blockchain technology*
Of course, the main factor backing our belief that NANCY's blockchain characteristics fit in the markets of the future is the size of investments and capital directed to this technology. Over the past two to three years, the use of blockchain technology solutions has become increasingly popular for a variety of commercial applications, including payments, exchanges, smart contracts, documentation, and digital identification. In the first half of 2022, venture capitalists made more investments in blockchain technology. A total of USD 30.5 billion was invested in the blockchain space in 2021. By July of 2022, this amount had been exceeded, with 31.3 billion USD invested in blockchain technology. In 2022, Web3 ranked first among the blockchain industry's sectors for investment with 616 deals, followed by DeFi with 299 deals. A blockchain business called Diamond Standard is another example; in a funding round headed by Left Lane and Horizon Kinetics, the company raised USD 30 million. In 2022, investments decreased in the second half. Venture investments in the blockchain ecosystem have slowed down, partly due to significant disruptions in the crypto asset markets [29].

*Restraints: Lack of skilled personnel and scalability*
The blockchain sector is constrained by a lack of a highly qualified labor supply and unclear regulations. Blockchain is being used by industries like supply chain management, gaming, and digital identity to improve security and transparency. Furthermore, as more people and businesses invest in digital

assets and use them for routine transactions, the use of cryptocurrencies has increased. The increasing need for decentralized financial solutions and the incorporation of blockchain technology into numerous industries has resulted in a notable increase in the demand for blockchain developers. Because blockchain technology is still in its infancy, especially in the telecommunications domain and remains fairly sophisticated, a shortage of qualified personnel can make it difficult to carry out initiatives such as NANCY [30].

In addition, scalability is a significant barrier that the blockchain technology market is facing. The networks are seeing more congestion, slower transaction speeds, and higher fees as blockchain technology is being used by more businesses, especially financial services, and supply chain management. This scalability issue may prevent blockchain from being widely used, particularly if high transaction volumes are anticipated. Especially in the radio access networks of the future, where the amount of data circulating the network is projected to skyrocket, such a fresh technology is to be tested. Blockchain engineers and innovators are hard at work developing scalability ways to get around this limitation. By processing transactions off the main blockchain, layer 2 solutions—like Ethereum 2.0—aim to increase scalability by easing congestion and lowering costs [31].

*Opportunity: Increasing government initiatives to boost demand for blockchain platforms and services*
Blockchain technology has caught the interest of several stakeholders from a variety of verticals in the past few years. Because of the growing interest in this technology, several government agencies are funding research projects to develop blockchain solutions; daily, the government sector sees a number of transactions and information exchanges. This data could have to do with payments, purchases, sales, fees, penalties, approvals, or certificates. Government organizations from all around the world have begun implementing blockchain technology to increase operational efficiency and transparency while also improving the public service delivery experience. Because distributed ledgers can record transactions thanks to blockchain technology, government organizations can use this to improve operational efficiency, reduce fraud, and increase transparency [29]. Having blockchain-friendly nations could allow the easier communication of paradigms such as NANCY in the communication network of the said nations.

*Challenge: Security, privacy, and control of blockchain transactions*
Transforming and revolutionizing transactions, blockchain technology requires enterprises to overcome key security, privacy, and control concerns before they can reap these benefits. There is a distributed public ledger where the transactions are documented. Expanding the attack surface can help hackers access sensitive and important information. Replicating the file can provide hackers more chances to access sensitive contracts or payment data that is stored using a blockchain-based system. By gaining access to the key, hackers can gain access to both distributed and hub-and-spoke databases. The primary cause of the decreased use of cryptographic solutions is issues with privacy in blockchain systems [29].

## 3.4.   Cybersecurity Market

The Quantum Key Distribution (QKD) market is experiencing robust growth, driven by the rising need for secure communication systems in the face of escalating cyber threats. According to [32], this market is valued at approximately USD 2.10 billion in 2023, the market is projected to reach around USD 7.88 billion by 2031, growing at a compound CAGR of about 22.2% from 2023 to 2030. This growth is primarily attributed to the increasing recognition of QKD's ability to offer unbreakable encryption by leveraging quantum mechanics, which is seen as essential for safeguarding sensitive data against potential quantum computer attacks.

The financial sector represents a significant segment of the QKD market due to its high demand for secure transaction methods and data protection. QKD is extensively used to secure internet banking, trading, and to protect sensitive information like credit card details and passwords. The government and defense sectors also significantly contribute to market growth as they require secure communication channels for protecting classified information and critical infrastructure. In healthcare, QKD helps secure patient information and test results, thereby preventing unauthorized access to medical data [33].

Regionally, North America dominates the QKD market, driven by substantial investments in quantum technology R&D and a strong cybersecurity landscape. The U.S. and Canada are at the forefront, with key players and government agencies actively developing and deploying QKD solutions [33]. The region accounted for the largest share of the global market, largely due to the high demand from the government and defense sectors. Europe is the second-largest market, propelled by the increasing adoption of quantum technologies and heightened cybersecurity concerns. The Asia-Pacific region is the fastest-growing market, with significant investments from China, Japan, and South Korea, aiming to enhance their cybersecurity frameworks with QKD solutions. China's extensive investment in quantum research and its initiatives to develop quantum networks are notable drivers of market growth in this region.

Technological advancements are pivotal to market expansion, with ongoing improvements in integrating QKD systems into existing optical fiber networks making these solutions more accessible and cost-effective. Innovations such as satellite-based QKD networks and the development of new QKD protocols that are more secure and resilient to attacks further bolster the market. However, the high cost associated with implementing QKD systems remains a significant challenge, particularly for large-scale deployments. Addressing this cost barrier is crucial for wider adoption across various sectors.

NANCY aligns with this trend by offering a plethora of quantum cryptography features and solutions. The importance of quantum solutions in NANCY is evident since a number of the project's KERs fall under the umbrella of post-quantum cryptography (PQC). KERs 3,4,5 incorporate PQC and QKD technologies, enhancing significantly the security posture of NANCY especially in the fields of secure communications and blockchain authentication.

Key players in the market, including ID Quantique, Toshiba, and Quintessence Labs, are focusing on partnerships, new product launches, and mergers and acquisitions to gain a competitive edge. For instance, ID Quantique's launch of a more efficient and cost-effective QKD system in 2022 is a significant step towards making QKD technology more accessible to a broader range of industries.

Overall, the QKD market is set to grow substantially, driven by the need for advanced cybersecurity solutions and supported by continuous technological advancements and strategic initiatives by key market players.

The blockchain in the security market is experiencing robust growth, driven by increasing adoption across various sectors due to its potential to enhance security and transparency. According to a report by Market Research Future [34], the global blockchain in the security market is projected to reach a significant valuation by the end of the forecast period. This growth is attributed to the rising need for secure and tamper-proof systems in industries such as finance, healthcare, and government. The technology's ability to provide decentralized and immutable records makes it a key solution for mitigating risks related to fraud, data breaches, and identity theft.

In terms of market size, the report highlights that the blockchain in the security market was valued at approximately USD 3.15 billion in 2024 and is expected to grow at a compound CAGR of 44.2% during the forecast period, reaching USD 58.86 billion [34]. This rapid expansion is fueled by increased investments in blockchain technology, advancements in regulatory frameworks, and the growing trend of digital transformation across enterprises. North America currently holds the largest market share, driven by early adoption and significant investments in blockchain technology. However, the Asia-Pacific region is expected to witness the highest growth rate, supported by the increasing adoption of blockchain solutions in countries like China and India.

## 3.5.    AI Market

Artificial Intelligence (AI) is used to make machines or computer systems act like human beings. AI adoption enables machines to learn and develop problem-solving abilities, comprehend human language, and identify and analyze the gathered data. To identify patterns and reach logical conclusions, AI can integrate massive datasets with processing methods like ML and deep learning (DL). AI is being increasingly used in many different industrial sectors to increase productivity, efficiency, and service quality while lowering human error. AI is transforming a number of industries and establishing itself as a major force behind the development of cutting-edge technologies like telecommunications, big data analytics, IoT etc. Additionally, the popularity of generative AI tools like ChatGPT and AI art generators emphasizes how widely accepted AI is. Given its current trajectory, the AI sector is expected to continue as a potent technical innovator, driving breakthroughs for the foreseeable future.

The global AI market size (Figure 6) was valued at USD 454.12 billion in 2022 and is expected to hit around USD 2,575.16 billion by 2032, progressing with a compound CAGR of 19% from 2023 to 2032. The North America artificial intelligence market was valued at USD 167.30 billion in 2022 [35].
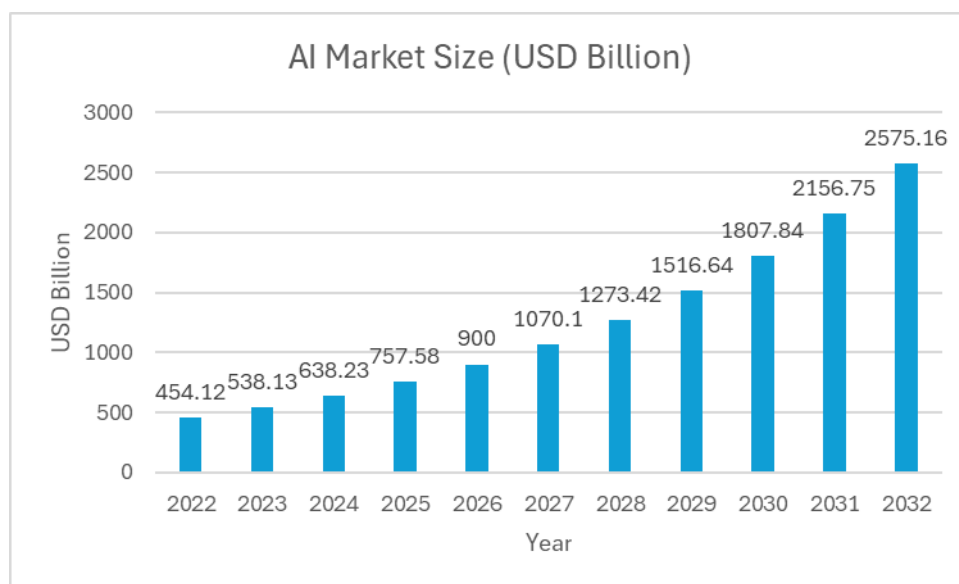


Figure 6: Global AI market[3]

The integration of AI and ML into 5G networks is a quickly evolving market trend. The heterogeneous and complicated nature of 5G networks, which include different access technologies, frequency bands, and cells, poses substantial problems to wireless carriers. To address the complexity of 5G networks, the industry is moving toward "end-to-end" orchestration models that use automation to deliver

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[3] Source: Precedence Research

critical insights into network performance and service assurance. AI orchestration promotes scalability and growth in 5G networks by helping to operationalize AI for tasks such as data preparation, model building, deployment, and insight generation [36].

The global AI orchestration market is expected to reach $17.1 billion by 2028, expanding at a 20% CAGR from 2022 to 2028. From 2022 to 2031, the market is predicted to increase at a CAGR of 21.5%, reaching $35.2 billion. This rapid expansion is being driven by the increased use of AI orchestration to streamline business processes and operations in areas such as telecom, manufacturing, healthcare, and retail [37].

As the industry evolves AI technology, there is an increasing trend toward greater industry specification, both in standards and open-source, for a common AI/ML functional architecture for training, inference, data management, and data collecting. Furthermore, telecom service providers are progressively incorporating AI technology into their 5G networks, shifting away from non-time-critical activities and toward more sensitive network components that have a direct impact on user experience. AI can enhance the capabilities of many network operations while also enabling new system functions and methodologies, such as optimizing resource allocation for differentiated network slices [36].

### Growth factors

Over the past few years, the worldwide artificial intelligence market has grown dramatically due in large part to the rapid spread of the internet and digital technologies. The IT companies' substantial R&D expenditures are driving ongoing technological improvements across a range of industries. The growing need for artificial intelligence across multiple end-use sectors, including healthcare, banking & finance, manufacturing, food & beverage, logistics, and retail, is anticipated to propel the global artificial intelligence market expansion in the upcoming years. In most industries, technological developments have always played a significant role. Furthermore, companies in specialized areas requiring high ability are projected to adopt AI solutions, which is expected to provide considerable future potential for the AI market [38].

#### 3.5.1. AI Market dynamics

### Driver: Growth in the adoption of autonomous AI

The increasing application of autonomous AI is driving the growth of the AI industry. The advancements in machine learning, natural language processing, and algorithms that enable the development of sophisticated autonomous AI systems are the driving forces behind this movement. The development of sophisticated autonomous AI systems is made feasible by the improved accuracy and dependability these systems offer. Companies from many industries are drawn to these solutions because they are more dependable and accurate. Autonomous AI optimizes operations, reducing expenses and increasing productivity. It has applications in the financial, healthcare, transportation, and manufacturing sectors. The industry's automation-driven cost reduction is a driving force behind the deployment of autonomous AI. Adhering to this trend NANCY incorporates many features that allow the 5G/6G network to self-adapt and act autonomously according to current network conditions. The market for AI is anticipated to expand as more sectors recognize its benefits and as technology advances, opening new possibilities for innovation and expansion [39].

### Restraint: Issues related with data availability and quality

Data availability and quality are critical factors in limiting the growth of the AI business. Limited data availability, particularly in niche businesses or specialized domains, impedes the development and deployment of AI technology. Without access to a large and diverse dataset, AI algorithms lack the essential training to make correct predictions and judgments. Furthermore, the quality of data is

critical to the effectiveness of AI development systems. Inaccurate, inadequate, or biased data produces erroneous results and untrustworthy AI models. Data quality needs thorough data cleaning, preparation, and validation processes, all of which take time and resources. Organizations with limited resources struggle to achieve these standards, which impedes the development and deployment of AI solutions. These restraints are even more present in the telecommunication sector, where it is more difficult to acquire data from functional networks. On many occasions this is due to legal and commercial reasons, with big telecommunication providers being reluctant to share or make public network data. The dynamic nature of 5G itself with vast amounts of data and users moving constantly makes accurate data collection a difficult task. To overcome these difficulties, it is critical to foster data sharing alliances, invest in data collection and preprocessing skills, and set industry-wide standards for data quality and privacy. These actions will increase data availability, improve data quality, and provide a more conducive climate for AI sector growth [39].

*Opportunity: Rapid growth in the digital data from various sources*

While some data are restricted, the trend of gathering digital data from many sources is growing exponentially in the AI business, offering immense prospects. An unparalleled amount of data is produced daily by the spread of 5G simulation environments and testbed topologies, linked devices, and sensors. The abundance of data provides AI algorithms with an extensive and varied resource to work with. NANCY algorithms are to be trained with such data collected from testbeds and simulations of 5G scenarios. Since AI is data-driven; big, diversified datasets are necessary for AI systems to learn, evaluate, and forecast with precision. AI systems become increasingly adept at recognizing patterns, trends, and correlations as more data becomes available. This enables companies and organizations to boost innovation, make data-driven decisions, and obtain insightful knowledge. Moreover, the expansion of digital data drives the advancement of AI solutions and technology. Investment in AI research and development is boosted by the growing availability of data, which results in improvements to data processing methods, machine learning models, and algorithms [39].

*Challenge: Concerns related to inaccurately and bias generated output*

Bias and incorrectly generated output are important obstacles to the expansion of the AI sector. When AI algorithms have biases or are trained with biased data, they perpetuate discriminatory practices or exacerbate societal prejudices. For example, biased facial recognition systems have produced higher error rates for women and those with darker skin tones, potentially leading to misidentification and prejudice. Such biases undermine trust and impede the adoption of AI systems, especially in sensitive sectors like recruiting, law enforcement, and healthcare. Furthermore, incorrectly generated output from AI systems has major implications. For example, in the healthcare sector, if an AI system incorrectly diagnoses a medical problem or advises inappropriate therapies, it endangers individuals' health and safety. Such occurrences, although irrelevant to NANCY's purpose, create a historical precedent that weakens trust in the AI growth rate and hinders its adoption. Although AI is not tested so thoroughly as a predictive and decision-making tool for 5G/6G networks, it is almost certain that some mistakes will happen during the initial adoption of such tools. Addressing these difficulties will necessitate continual efforts to detect and reduce AI algorithm bias, improve data quality, and increase the accuracy and openness of AI market systems to foster trust and assure responsible AI deployment [39].

### 3.5.2. Global AI Market Revenue

*Technology Insights*

In 2023, the deep learning sector held the greatest market share based on technology. Its sophisticated data-driven applications, like text, video, and audio recognition, are responsible for its domination. The difficulties brought on by the large amounts of data are anticipated to be solved by the deep

learning field's growing technological breakthroughs. Moreover, throughout the forecast period, the growing use of deep learning technology in the medical area is anticipated to support the segment's expansion.

The adoption of AI technology in a variety of applications, including hypothesis generation, clustering, modifying, tagging, filtering, visualization, and navigation, is being fueled by the significant portion of machine learning investments in total AI technology investments. This encourages the development of cognitive solutions. The proliferation of cloud computing platforms and on-premises technology for processing and storing massive amounts of data has played a major role in propelling the growth of data analytics platforms. The leading tech companies' increasing expenditures on innovation and research are anticipated to support the AI market's future expansion [35].

In Table 1 we present some of the AI subfields that will be widely used in the NANCY components. For example, KERS 7, 8, and 12 and many more will rely heavily on machine learning and deep learning to achieve their goals, making them increasingly relevant in today's AI-driven world. NANCY will mainly use these technologies to create more insightful analytics tools and enhance the network with self-management capabilities. AI orchestrators are a primary example, where AI will be used to make decisions and parameterize the network based on its current state. Furthermore, dynamic offloading of resources is a pivotal feature of NANCY, enabling maximum optimization in resource management decisions.

Table 1: AI market revenue by technology, 2023-2032 in USD Billion[4]

| Technology | 2023 | 2027 | 2032 |
|---|---|---|---|
| Deep Learning | 196.83 | 392.57 | 948.24 |
| Machine Learning | 145.43 | 290.57 | 703.50 |
| Natural Language processing (NLP) | 108.31 | 215.94 | 521.48 |
| Machine Vision | 87.57 | 171.01 | 401.95 |

Table 2 demonstrates the market revenue by end user in different market sectors [35].

Table 2: Market revenue by end user, 2023-2032 in USD Billion[5]

| End User | 2023 | 2027 | 2032 |
|---|---|---|---|
| Healthcare | 76.35 | 152.36 | 369.22 |
| BFSI | 86.13 | 172 | 416.49 |
| Law | 19.02 | 38.65 | 95.47 |
| Retail | 52.13 | 105.03 | 257.43 |
| Advertising | 74.97 | 149.59 | 362.07 |
| Transportation | 53.84 | 107.81 | 260.74 |
| Agriculture | 34.78 | 70.02 | 171.16 |
| Manufacturing | 51.58 | 103.75 | 252.81 |
| Other | 89.34 | 170.89 | 389.77 |

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[4] Source: Precedence Research
[5] Source: Precedence Research

# 4. Competitive Landscape

## 4.1. Relevant Projects and Trends

The following projects are identified as relevant due to their integration of blockchain technologies and AI/ML techniques within RAN architectures.

**TALON**

The primary objective of the TALON[6] project is to create an artificial intelligence orchestrator that will improve Industrial 5.0. This will be achieved by utilizing edge networks, adaptive sensors, and blockchain technology. The AI orchestrator efficiently manages edge and cloud resources to achieve optimal system performance, while simultaneously guaranteeing security and anonymity through the use of blockchain technology. This technique allows for adaptable and fast AI implementations while also accommodating new service models. TALON's objective is to establish an environmentally friendly and secure industrial setting characterized by a high level of trust and transparency.

**Comparison with NANCY**: TALON is focused on specific industries, including manufacturing and industrial activities, whereas NANCY is designed for a wider range of telecommunications applications. Both projects utilize artificial intelligence (AI) for orchestration. However, NANCY's implementation of federated learning and AI for network security is more sophisticated and cutting-edge. TALON primarily emphasizes edge and adaptive sensor networks, while NANCY encompasses new networking protocols such as P2P and mesh networking.

**5G-ZORRO**

With an eye on zero-touch automation for network management and security in multi-stakeholder environments, the 5G-ZORRO[7] project seeks to develop 5G networks. Using Distributed Ledger Technologies (DLTs), such as blockchain, smart contracts for business agility, and artificial intelligence/machine learning for automated network operations, it supports trustworthy and safe communications, By means of end-to-end network slicing, the project aims to create a common network architecture supporting various applications, therefore enabling several operators to effectively distribute resources including virtualized components and spectrum.

**Comparison with NANCY**: Both projects utilize blockchain technology to provide security and trust. However, NANCY goes a step further by incorporating AI more extensively for orchestration. Additionally, NANCY incorporates federated learning to improve privacy. Regarding the management of resources. NANCY prioritizes AI-driven optimization and federated learning, whereas 5G-ZORRO places emphasis on DLT for dynamic and decentralized resource management. NANCY has a wider range of applications, including novel designs for connecting devices, whereas 5G-ZORRO is primarily focused on operator resource sharing and automation.

**5G-MoNArch**

The objective of the 5G-MoNArch[8] project is to create a 5G network architecture that is versatile, adjustable, and capable of being programmed. The focus is on advances such as inter-slice control, cross-domain administration, and a protocol stack enabled for cloud computing. The project showcases these concepts by utilizing two primary testbeds: the Smart Sea Port in Hamburg and the

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[6] https://talon-project.eu/
[7] https://www.5gzorro.eu/
[8] https://5g-monarch.eu/

Touristic City in Turin. These testbeds demonstrate the practical implementation of network slicing, resilience, and resource flexibility in real-world settings.

**Comparison with NANCY**: Both projects prioritize adaptable network structures, while NANCY incorporates blockchain and AI more extensively for enhanced security and coordination. While 5G-MoNArch showcases its capabilities through targeted real-world testbeds, NANCY takes a comprehensive approach, focusing on diverse and inventive network architectures. In comparison to 5G-MoNArch's emphasis on slicing and administration, NANCY's utilization of federated learning and AI-driven security models offers a more sophisticated and safe network solution.

## 4.2.    Relative Business Solutions

Currently, the telecommunications industry has not extensively investigated the use of blockchain technology in RAN installations. Although progress is being made in RAN technology and preparations for networks beyond 6G, the widespread use of blockchain to improve security, decentralized management, or trust mechanisms is still not popular. Several telecommunications businesses primarily focus on conventional RAN technologies like network slicing and edge computing, but they do not integrate blockchain because of concerns regarding scalability, interoperability with current systems, and regulatory difficulties.

**Airspan-Altiostar Collaboration**

Airspan and Altiostar [40] have formed a partnership to utilize their specialized knowledge in telecommunications technologies. Airspan provides its small and smart radio systems, enhanced by Altiostar's sophisticated virtualized RAN technology. They have a shared goal of transforming network infrastructures by implementing completely cloud-native, modular, and scalable solutions.
The cooperation aims to achieve a 40% reduction in both capital investment and operational expense by leveraging Open RAN designs. This strategy enables operators to circumvent vendor lock-in and choose the most superior solutions customized to their requirements, hence augmenting freedom in network implementation and administration.
Airspan and Altiostar provide scalable Open RAN solutions, having demonstrated their success in constructing the world's initial commercial open cloud-scale web-based virtual RAN network with Rakuten Mobile in Japan. By addressing the severe demands of modern telecommunications networks worldwide, they establish themselves as dependable partners [41].

**Casa Systems' Small Cells and Apex 5G Metro Solution**

Casa Systems has created sophisticated small-cell solutions to tackle the coverage and capacity obstacles linked to 5G networks, especially in densely populated urban areas where conventional macro cells may have difficulties. The primary product in their portfolio is the Apex 5G Metro solution [42], specifically engineered to deliver robust, efficient, and economical 5G coverage.

**Overview of Casa Systems' Small Cells**

These are low-powered cellular radio access nodes that enhance cellular coverage and capacity in smaller, more targeted locations in contrast to conventional macro cells. Casa Systems' small cells are components of the Apex RAN portfolio, which offers a range of deployment choices suitable for various urban and suburban situations. These compact cells are specifically designed to be installed at ground level on structures such as utility poles, rooftops, and lamp posts. This deployment approach greatly decreases expenses in comparison to conventional tower-mounted macro cells.

**Apex 5G Metro Solution**

This solution is a robust 4T4R (4 transmit / 4 receive) radio that is specifically engineered to efficiently manage a large quantity of New Radio (NR) and LTE devices. It offers connectivity in highly populated city areas and is cost-efficient because it can be installed on existing infrastructure at the street level. This minimizes the requirement for conventional and frequently pricier macro locations. The Apex 5G Metro combines the Baseband Unit and Remote Radio Unit into a single box, offering versatile options for external antenna setups. The system facilitates the use of O-RAN-specified open interfaces for centralized and virtualized RAN deployments, hence improving adaptability and expandability. The primary focus of the Apex 5G Metro is on sub 6 GHz bands, with future intentions to incorporate millimeter wave bands. These millimeter wave bands are essential for supporting high-speed 5G applications. The main objective of the Apex 5G Metro is to tackle the coverage and capacity limitations in metropolitan areas. Casa Systems seeks to decrease deployment expenses and exploit pre-existing street-level infrastructure, thus enhancing the accessibility and efficiency of 5G technology. Casa Systems' commitment to providing adaptable, expandable, and economical solutions is highlighted by these breakthroughs, placing them at the forefront of 5G network infrastructure technology.

**Altiostar's Use of AI and Machine Learning Techniques in O-RAN**

Altiostar is now incorporating AI and machine learning into its O-RAN architecture with the aim of achieving notable improvements in network automation and efficiency. Altiostar's O-RAN systems are explicitly engineered to facilitate complete automation, commissioning without human intervention, and swift network restoration. This technique enables effortless expansion and flexible control of network resources, which is crucial for contemporary 5G implementations. The company's partnership with prominent telecommunications companies, such as Dish and Rakuten Mobile, emphasizes its leadership in developing cloud-native, scalable network solutions that utilize these cutting-edge technologies [43].

**Comparison with NANCY**

Many companies are currently investigating the incorporation of AI techniques and blockchain technology in O-RAN structures to improve network efficiency and security. Nevertheless, only a small number of individuals embrace a comprehensive strategy akin to that of NANCY. NANCY distinguishes itself by seamlessly incorporating artificial intelligence for coordination and deploying blockchain for improved security and trust mechanisms within its O-RAN framework. This comprehensive approach not only tackles traditional network difficulties but also integrates federated learning for privacy and employs DLT for dynamic resource management.

NANCY distinguishes itself by its capacity to integrate these cutting-edge technologies into a cohesive approach designed to expand the limits of telecommunications infrastructures. While some organizations may prioritize specific areas like AI-driven optimization or blockchain-based security, NANCY's all-encompassing strategy positions it as a leader in innovation. NANCY showcases its leadership in shaping the future of O-RAN architectures by providing a comprehensive solution that includes AI orchestration, federated learning for privacy protection, and blockchain-based trust mechanisms. This solution prioritizes flexibility, scalability, and strong security measures.

# 5. Exploitation Plans & IPR Management

Section 5 of this report refers to the Exploitation Plans and Intellectual Property Rights Management set by each partner for the first time period of the project, until M18 (June 2024). There are 2 main types of results, namely Key Exploitable Results (KERs) and Other Exploitable Results (OERs), which are distinguished as follows:

- KERs are identified main interesting results which have been selected and prioritized due to their high potential to be "exploited" – meaning to make use of and derive benefits-downstream the value chain of a product, process or solution, or act as an important input to policy, further research, or education. Usually, they are clarified in the GA from the beginning of the project.
- OERs refer to results that were not initially foreseen or planned at the start of the project but emerged during its course, with exploitation potential (either commercial or not).

The two basic issues that will be thoroughly analyzed are Exploitation and Intellectual Property Rights (IPR). More specifically:

- Exploitation refers to the use of results in further research and innovation activities other than those covered by the project's action that generated the results (European Commission, 2024). Its objective is to effectively use project results through scientific, economic, political, or societal exploitation routes aiming to turn Research and Innovation (R&I) actions into value and impact for society, whilst it focuses on making concrete use of research results [44]. Exploitation could potentially lead to new legislation and recommendations or help tackle a specific problem. It could also respond to an existing demand, or even cause a significant impact on the economy, the society and even the innovation domain [45]. Exploitation is differentiated from dissemination as, according to the IPR Helpdesk [46], the latter refers to the public disclosure of the results by appropriate means, other than resulting from protecting or exploiting the project outputs.
- IPR management involves the deliberate and organized management of intellectual property assets within a company or a project. Intellectual property rights are private legal rights that protect the creation of the human mind: inventions, literary and artistic works, and symbols, names, images, and designs used in commerce. They are commonly divided into two categories: Industrial Property Rights (e.g. patents, trademarks, industrial designs, geographical indications) and Copyright and Related rights (e.g. rights of the authors/creators and those of performing artists in their performances, producers of phonograms in their recordings, and those of broadcasters in their radio and television programmes) [44]. The goal of effective IPR management is to safeguard these assets, optimize their worth, and leverage them to enhance the company's or project's competitiveness and capacity for innovation.

The KERs of the project, as cited in Section 5.2.1 "Innovation and exploitation plans" of the GA, are gathered in Table 3:

Table 3: Key Exploitable Results (KERs) of NANCY

| KER Number | Name | Involved Partners |
|---|---|---|
| 1 | NANCY architecture and approach | UOWM, UBITECH, TECNALIA, i2CAT, ITL, INTRA, 8BELLS, TDIS, DRAXIS, OTE, VOS, IJS, CRAT, Bi2S, INNO, CERTH, SID, UMU, SSS |

| | | |
|---|---|---|
| 2 | Novel trustworthy grant/cell-free cooperative access mechanisms | 8BELLS, VOS, IJS, INNO, SID, UMU |
| 3 | A novel security and privacy toolbox | UOWM, MINDS, UBITECH, TECNALIA, NEC, ITL, TDIS, DRAXIS, CRAT, TEI, INNO, SID, UMU, SSS |
| 4 | Realistic blockchain and attacks models | UOWM, MINDS, UBITECH, NEC, INTRA, 8BELLS, TDIS, OTE, IJS, CRAT, TEI, Bi2S, INNO, CERTH, SID, UMU, SSS |
| 5 | A novel quantum key distribution mechanism | UOWM, MINDS, UBITECH, NEC, ITL, TDIS, INNO |
| 6 | AI-based B-RAN orchestration with slicer instantiator | i2CAT, ITL, INTRA, 8BELLS, IJS, CRAT, Bi2S, INNO, CERTH, SID, UMU, SSS |
| 7 | A novel AI virtualiser for Underutilized computational & communication resource exploitation | i2CAT, INTRA, 8BELLS, VOS, IJS, TEI, INNO, CERTH, SID, UMU, SSS |
| 8 | Novel self-evolving AI model repository | i2CAT, ITL, INTRA, 8BELLS, IJS, CRAT, Bi2S, INNO, CERTH, SID, UMU, SSS |
| 9 | Semantic & goal-oriented communication schemes for beyond Shannon performance | UOWM, MINDS, 8BELLS, INNO, SID, UMU |
| 10 | An explainable AI framework | MINDS, UBITECH, TECNALIA, NEC, INNO, SID, UMU |
| 11 | Next-generation SDN-enabled MEC for autonomous anomaly detection, self-healing, and self-recovery | MINDS, TECNALIA, NEC, i2CAT, DRAXIS, CRAT, INNO, SID, UMU, SSS |
| 12 | A computational offloading mechanism with novel resource-aware/provision scaling mechanisms and novel battery as well as computational-capabilities aware offloading policies | i2CAT, 8BELLS, OTE, VOS, IJS, CRAT, Bi2S, INNO, SID, UMU, SSS |
| 13 | User-centric caching mechanisms | 8BELLS, VOS, IJS, Bi2S, INNO, SID, UMU, SSS |

In order to designate the leaders of each KER, collaboration and regular feedback needed to be established, as will be further explained in the Methodology section 5.1. However, since the project is still in the middle of its completion, it is quite likely that significant modifications will occur in the final version as the technologies being tested continue to advance. Exploitation is thus a dynamic process, subject to change until the project's completion.

Some of the partners, namely INTRA, ITL, CRAT and SID, have stated that, for this stage of the project, they have no exploitation activities revolving around the exploitation of KERs neither would they like to provide any new updates (for OERs) based on the responses that they submitted in D1.6 "Initial Impact Creation Report".

## 5.1. Methodology

This sub-section aims to provide a comprehensive framework detailing the systematic processes and strategies employed to achieve the project's Exploitation & IPR objectives. Also, it outlines the specific steps and approaches used to identify, protect, and manage intellectual property assets, ensuring that all innovations and results are effectively leveraged and secured (for this stage of the project). By defining clear procedures for exploitation, including stakeholder engagement, time scheduling and commercialization plans, the methodology ensures that the project's outputs are maximized in terms of their commercial and societal impact. Additionally, it addresses compliance with relevant legal and regulatory frameworks, ensuring that the project's activities align with EU policies and best practices in intellectual property management.

### 5.1.1. Glossary – Agreements

Exploitation & IPR Management includes a number of different terms that need to be clearly defined before moving on to the analysis. More specifically:

- *A patent* is an exclusive right granted for the protection of inventions (products or processes) offering a new technical solution or facilitating a new way of doing something.
- *Copyright (or author's right)* is the term used to describe the rights that creators have over their literary, scientific, and artistic works.
- *A utility model* is an exclusive right granted for an invention, which allows its owner to prevent others from commercially using the protected invention, without their authorisation, for a limited period of time.
- *A trademark* is an exclusive right over the use of a sign in relation to the goods and services for which it is registered.
- *A trade secrets* agreement offers rights holders protection when it comes to confidential information that can be sold or licensed.
- *A sui generis protection* protects the content of a database preventing the extraction and/or reuse of the whole or substantial part of its content when the structure of a database is not an original creation [47].

Moreover, the following issues will be covered:

- **Background IPR:** According to the GA Article 16.1, 'Background' refers to any data, know-how or information - whatever its form or nature (tangible or intangible), including any rights such as intellectual property rights - that is:

(a) held by the beneficiaries before they acceded to the Agreement and

(b) needed to implement the action or exploit the results.

If the background is subject to the rights of a third party, the beneficiary concerned must ensure that it is able to comply with its obligations under the Agreement.

- **Foreground IPR:** According to the GA "Impact" Section, 'Foreground' refers to knowledge that is generated during the course of the project. It includes any new data, knowledge, or information that is developed or discovered during the project.

- **Exploitable Results:** According to the GA Article 16.2, 'Results' means any tangible or intangible effect of the action, such as data, know-how or information, whatever its form or nature, whether or not it can be protected, as well as any rights attached to it, including intellectual property rights.

Besides the terminology, it is essential to clarify how some specific situations (like a Joint Result) will be addressed throughout the project. In particular:

1. In case of **Joint Ownership** of a project result, the Consortium Agreement (CA) Results shall be owned by the Party whose employee(s) generated them, or on whose behalf such Results have been generated. Two or more Parties shall own Results jointly if:

(a) they have jointly generated them; and

(b) it is not possible to:

      (i) establish the respective contribution of each Party; or

      (ii) separate them for the purpose of applying for, obtaining, or maintaining their protection

The joint owners must agree — in writing — on the allocation and terms of exercise of their joint ownership ('joint ownership agreement'), to ensure compliance with their obligations under this Agreement.

Unless otherwise agreed in the joint ownership agreement or consortium agreement, each joint owner may grant non-exclusive licenses to third parties to exploit the jointly-owned results (without any right to sub-license), if the other joint owners are given:

- at least 45 days advance notice and

- fair and reasonable compensation.

The joint owners may agree — in writing — to apply another regime other than joint ownership.

If third parties (including employees and other personnel) may claim rights to the results, the beneficiary concerned must ensure that those rights can be exercised in a manner compatible with its obligations under the Agreement. The beneficiaries must indicate the owner(s) of the results (results ownership list) in the final periodic report.

If third parties (including employees and other personnel) may claim rights to the results, the beneficiary concerned must ensure that those rights can be exercised in a manner compatible with its obligations under the Agreement. The beneficiaries must indicate the owner(s) of the results (results ownership list) in the final periodic report.

2. For the **Protection of Results** and **Transfer & Licensing of Rights**, Article 14 of the GA clearly states the obligations that each partner has in the specific instance. In brief, the beneficiaries must adequately protect their results for an appropriate period and with appropriate territorial coverage while they may also transfer ownership of their results, provided this does not affect compliance with their obligations under the Agreement.

3. According to Article 16 of the GA, Beneficiaries who have received funding under the grant must, **up to four years** after the end of the action, use their best efforts to **exploit their results** directly or to have them exploited indirectly by another entity, in particular through transfer or licensing.

If, despite a beneficiary's best efforts, the results are not exploited within one year after the end of the action, the beneficiaries must (unless otherwise agreed in writing with the granting authority) use the Horizon Results Platform to find interested parties to exploit the results.

### 5.1.2. Methodological Approach

In order to carry out the Exploitation of the project results as well as the IPR Distribution, a diverse set of actions was employed. The approach for developing the Exploitation / IPR Management Plan is structured into two phases:

First and foremost, there was a major issue in the matching of the KERs to their leader, as the GA only provides a general description of the participants that can be potentially involved in the KER. Hence, in the plenary meeting that was held in Athens from the 12th to the 13th of December 2023 (M12) a KER Matching Matrix was presented to the consortium. The beneficiaries were asked to fill in the gaps, based on the knowledge they bring to NANCY and their contribution. The Matrix is presented in Figure 7.

| No. of Result | Name of Result | UOWM | UBITECH | TECNALIA | NEC | I2CAT | ITL | INTRA | 8BELLS | TDIS | DRAXIS | OTE | VOS | IJS | CRAT | TEI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | B-RAN architecture | | | | | | | | | | | | | | | |
| 2 | Novel trustworthy grant/cell-free cooperative access mechanisms | | | | | | | | | | | | | | | |
| 3 | A novel secutiry and privacy toolbox that contains lightweight consensus mechanisms, and decentralized blockchain components | | | | | | | | | | | | | | | |
| 4 | Realistic blockchain and attacks models and an experimental validated B-RAN theoretical framework | | | | | | | | | | | | | | | |
| 5 | A novel quantum key distribution mechanism to boost end-user privacy | | | | | | | | | | | | | | | |
| 6 | Smart pricing policies | | | | | | | | | | | | | | | |
| 7 | AI-based B-RAN orchestration with slicer instantiator | | | | | | | | | | | | | | | |
| 8 | A novel AI virtualiser for underutilized computational & communication resource exploitation | | | | | | | | | | | | | | | |
| 9 | Novel self-evolving AI model repository | | | | | | | | | | | | | | | |
| 10 | Experimentally-driven reinforcement learning optimization of B-RAN | | | | | | | | | | | | | | | |
| 11 | Semantic & goal-oriented communication schemes for beyond Shannon performance | | | | | | | | | | | | | | | |
| 12 | An explainable AI framework | | | | | | | | | | | | | | | |
| 13 | Next-generation SDN-enabled MEC for autonomous anomaly detection, self-healing and self-recovery | | | | | | | | | | | | | | | |
| 14 | A computational offloading mechanism with novel resource-aware/ provision scaling mechanisms and novel battery as well as computational - capabilities aware offloading policies | | | | | | | | | | | | | | | |
| 15 | User-centric caching mechanisms | | | | | | | | | | | | | | | |
| | Coordinator | | | | | | | | | | | | | | | |
| | Beneficiary | | | | | | | | | | | | | | | |
| | Not listed in the email we sent / Extra Results | | | | | | | | | | | | | | | |

Please mark with "X" the corresponding box that is referring to your KER of interest

Figure 7: Key Exploitable Results (KERs) Matching Matrix

The cells highlighted in "red" refer to the project's Technical Advances, which were deemed essential to include in this procedure. The main objective of this initiative was to determine if the partners' exploitation intentions aligned with any of the listed KERs, in order to avoid any unnecessary contact with partners that were not involved at this venture. However, after talks with the partners during the plenary and due to some complications revolving the rationale behind the matrix, the matrix was not filled out. It was decided instead to proceed with the drafting and sending of the Exploitation Questionnaire to all partners, along with additional instructions to clarify any questions that arose during the interactive session, as well as to enhance efficiency and not miss out on any important information.

In the weeks that followed, DREVEN started working on the questionnaire that would be later shared with the rest of the partners. A number of multiple questions addressing key aspects, like the Background and Foreground Information of the partners and the Commercial Intentions, were included in this survey. In fact, an extra column named "Instructions" was added at the end and next

to each question, with the aim being to give the best help possible to the participants. The template of the questionnaire is presented in Annex A.

After internal discussions and refinements of the structure, the questionnaire was sent for the first time to the partners at the beginning of M13 (January 2024). The partners were informed to fill in all the required cells, based on the work they have implemented so far or the work that would follow in the upcoming months. The partners would either refer to KER or an OER with their responses. Nevertheless, it is important to note that at the current stage of the project, a respectable amount of the respondents do not possess all the necessary knowledge to complete the questionnaire as the TRL of some technologies tested or the integration level of other objectives is rather low. These issues or gaps will be explored and addressed in the final deliverable set for M36.

The questionnaire was divided into 4 parts, as follows:

- **Introduction:** In this segment, a brief description of the questionnaire's purpose and structure is provided;
- **Partner's Info:** This section includes the contact information of the respondents, including the organization they represent;
- **Exploitation:** This section aims at recording the exploitation plan of each partner, while giving specific details as to what should be filled out in each part;
- **IPR Considerations:** This section intends to clarify the background and foreground property of each respondent, as well as take into consideration the potential for joint exploitation results.

Taking into consideration that it is yet too early for some of the partners to be fully aware of their potential for exploitation, they were given the opportunity to declare "no exploitation intentions" for this stage of the project and revise their contribution in the final deliverable. In the end, a total of 18 responses were collected from the questionnaire with 4 partners (INTRA, CRAT, SID and ITL) declaring no exploitation plan for either the KERs of the project or their individual efforts.

DREVEN analyzed the key characteristics of the questionnaire that was sent out and based mainly on keywords or the general concept described in the response, matched each response to either a KER or an OER. To enhance this initiative, DREVEN presented to all partners the matching results, asking for a final confirmation before starting the Exploitation Analysis.

In the sub-sections that follow, the following issues will be addressed by order:

1. Presentation and Analysis of the Exploitation-IPR Questionnaire Responses based on whether they refer to a KER or an OER.
2. An early Exploitation Strategy proposed by DREVEN.
3. Next steps to be followed for the upcoming semester and until the end of the project.

The analysis of the questionnaires aims at defining the percentage of results that have been identified as capable of commercial exploitation and those that did not, clarifying the IPR intentions of each partner, presenting the technical advantages of the proposed solutions and lastly providing an early timeline for the exploitation roadmap and the tools that will be utilized in order to achieve it.

However, it is important to mention once again that the maturity level at this stage of the project does not allow for a comprehensive and finalized suggestion, as there will be a lot of changes in the dynamics of the project's technologies and components.

## 5.2. Results Analysis (Exploitation Results/ Background/ Foreground)

The purpose of this sub-section is primarily to present and briefly describe all NANCY results, including Key Exploitable Results (identified before the start of the project / cited above) and Other Exploitable Results that were generated during the project implementation. Also, it aims to present the initial exploitation strategy of the project's results as well as their IPR management both in the background and foreground.

To allow a better characterization of the project results, the following grouping into eight distinct categories (types) has been proceeded with:

1.  Technological Solutions (e.g., hardware, infrastructure, equipment, product, software).
2.  Methods (methodologies, protocols, operational procedures, processes).
3.  Models and Algorithms.
4.  Skills and Know-how (expertise in carrying out assessments/analyses, etc.).
5.  Guidelines and Recommendations (for policy, society, industry, etc.).
6.  Plans and Strategies.
7.  Data.
8.  Standards (standardization activities).

However, as mentioned in the Methodology of Section 5.1, due to the maturity level of the project at the time of writing, it is not yet feasible to provide a clear and safe distinction on whether a partner is related to a KER or not. Hence the approach is mostly empirical, and the partner(s) designated as KER leaders may differentiate from the ones cited as per the GA.

For the four partners that did not provide an answer to the Exploitation questionnaire and based on the Consortium Agreement, INTRA, CRAT & ITL explicitly stated that they do not bring any kind of background while SID declared the following:

A)  SiVi tool
B)  AI4CI Toolkit
C)  SiPentest tool
D)  SDN-INSIGHT tool
E)  HoneyPots tool,

with:

- *Specific limitations and/or conditions for Implementation*: "Closed-source, Propriety" – applicable to all.
- *Specific limitations and/or conditions for Exploitation*: "Closed-source, License scheme applies" – applicable to all.

### 5.2.1. KERs

In this sub-section, the analysis of the results that appertain to the category of KERs is being explored. In the NANCY case, the KERs do not have a significant leader by default. It is quite possible that multiple organizations contribute with their different components to the realization of one specific KER. Hence, in some cases that will be presented below, more than one partner is designated in the same KER category, and not always by the same name as the KER, rather than the name of the technology/component they bring. However, there are examples (like KER #7) where the responding

partner has stated his result as a complete match with the KER, and therefore no further title is given at the beginning of the table.

One of the major issues at the time of writing is the fact that the vast majority of the partners could not provide detailed answers to their IPR considerations and exploitation plans as their TRL is quite immature and subject to change in the upcoming stages of the project. Thus, some responses include missing data or incomplete information due to the unknown intentions of the responding partners. It is important to note that in the final deliverable (D1.11) major refinements shall be applied, such as the final exploitation intentions of the selected results as well as the IPR distribution among the partners which contribute to the same KER with their results.

In order to mitigate the possibility of misplacing a partner to a KER they do not belong to, personal communication to each one of the below-mentioned beneficiaries has been established to confirm that, at least for this deliverable, they have been mapped in the right category, without this meaning that there cannot be a reordering in the next version. Table 4 presents in brief the final results, while the details for each KER are shown from Table 5 to Table 17.

Table 4: List of Key Exploitable Results (KERs) by partner

| KER Number | Partner Name |
|---|---|
| KER #1 | SSS |
| KER #3 | TDIS, NEC (in collaboration with TDIS), TEI |
| KER #4 | INNO |
| KER #5 | INNO |
| KER #7 | i2CAT |
| KER #8 | IJS, CERTH |
| KER #9 | INNO |
| KER #10 | MINDS |
| KER #12 | VOS, UBITECH |

Table 5: Presentation of KER#1 - SSS Plan

| KER #1 | NANCY Architecture and Approach – Hierarchical SCHED_DEADLINE with Kubernetes integration – SSS |
|---|---|
| Type of Result | Technological Solutions |
| Problem | The result addresses the issue of poor isolation and interference among co-hosted containers on shared physical cores, which leads to unpredictable execution times and performance degradation. |
| Suggested Solution | To enhance isolation at the Linux kernel level using the Hierarchical SCHED_DEADLINE policy and provide an API for easy adjustment of CPU reservation parameters, ensuring consistent performance and adaptability. |
| Main Features, Objectives & Innovations | The main features include the Hierarchical scheduling policy, the Noisy Neighbors's issue mitigation and the framework Integration Capability<br><br>The main objectives are to improve execution time predictability of containers hosted on shared physical cores, to provide better isolation among co-hosted containers and guarantee lower latencies, to better exploit underlying computational resources without overprovisioning and to enable dynamic adjustment of allocated CPU resources in response to workload variations. |

| | The main innovations include a novel approach to scheduling that enforces maximum CPU time reservations to mitigate noisy neighbors and an API that allows for runtime changes in resource allocation, adapting to changing requirements or workloads. |
|---|---|
| **Value Proposition** | It ensures lower latencies and more predictable execution times for applications in containers. Also, it reduces the need for overprovisioning by better utilizing computational resources and offering flexibility in resource management. |
| **Target Audience** | Industrial stakeholders, mainly based on a collaboration with many mainline developers with established relationships over the years. |
| **Early Adopters** | None identified |
| **Exploitation Type** | Non-Commercial |
| **Roadmap and IPR** | |
| **Methods, Tools & Activities** | Mainly partnerships and collaborations, as the plan is to provide the new scheduler as patches for the relevant open-source projects and contact the development community to discuss with them the possible integration in mainline, as it previously happened with other proposed features (e.g., the original version of SCHED_DEADLINE in mainline since version 3.14) |
| **Timing** | Not decided yet |
| **Background IPR** | None |
| **Foreground IPR** | None |
| **Exclusive Ownership** | Yes |

Table 6: Presentation of KER#3 - TDIS Plan

| KER #3 | A novel security and privacy toolbox –PQC Signature Solution - TDIS |
|---|---|
| **Type of Result** | Technological Solutions |
| **Problem** | The vulnerability of current Public Key Infrastructure (PKI) systems to new threats posed by quantum computing. As quantum computing advances, traditional cryptographic methods used in PKI systems are at risk of being compromised, potentially leading to significant security breaches and loss of data integrity. |
| **Suggested Solution** | The plan to address this problem is by integrating quantum-resistant digital signature algorithms into all Thales smartcard products across various business segments, including identity cards, SIM cards, and bank cards. This proactive approach not only mitigates potential risks but also aligns all products with future security standards, providing robust and reliable protection for all applications. |
| **Main Features, Objectives & Innovations** | The main features of the Signature Solution include a PQC Signature Token, which integrates a quantum-resistant digital signature algorithm, and a PQC Signature Driver, which provides minimal services to the applications for interfacing with the Token. |
| | The primary objective of the PQC Solution is that it aims to enhance PKI applications such as identity cards and corporate security systems within closed groups. Also, by leveraging quantum-resistant algorithms, the solution offers a robust method for maintaining data integrity and authentication. |
| | The main innovations are the integration of post-quantum cryptographic algorithms on smart card devices (which represents a significant advancement |

| | in security technology), and the support of a hybrid PKI concept (combining classical and post-quantum cryptography) known as crypto agility which allows the system to adapt to evolving security needs and ensures long-term viability. |
|---|---|
| **Value Proposition** | The PQC Signature Solution provides a future-proof, smart card-based PKI system with quantum-resistant algorithms, ensuring data integrity and authentication. Its hybrid cryptography approach allows seamless adaptation to evolving security needs for agencies in the US and Europe. This solution aligns with major security recommendations, offering robust protection for identity cards and corporate security applications. |
| **Target Audience** | Public Sector stakeholders like security agencies |
| **Early Adopters** | None Identified |
| **Exploitation Type** | Commercial |
| **Roadmap and IPR** | |
| **Methods, Tools & Activities** | No specific method will be applied rather than the commercialization through Thales DIS traditional sales channels. |
| **Timing** | The product is expected to complete its certification and industrialization phases by the end of 2024 |
| **Background IPR** | None |
| **Foreground IPR** | None |
| **Exclusive Ownership** | Yes |

Table 7: Presentation of KER#3 - NEC Plan

| KER #3 | A novel security and privacy toolbox – Blockchain wallet with SSI and PQC capabilities – NEC |
|---|---|
| **Type of Result** | Technological Solutions |
| **Problem** | Digital privacy prevents the illegitimate use of users' personal data and automatically improves the blockchain owner's reputation. On the Web3, protecting a user from having non-necessary information shared with third parties without their consent or knowledge is of fundamental importance. In this regard, at least two customer segments can be highlighted: the end users of the blockchain and also the blockchain owner/provider. In addition "there is a current risk of Harvest Now, Decrypt Later (HNDL) attacks being used by attackers to steal encrypted sensitive information with a long shelf life, such as personal health, confidential product data or financial records. The attackers can hold onto the information until a quantum computer with enough power becomes available to break its encryption. If this occurs before the data's expiration, it could lead to significant breaches in the future"[9]. |
| **Suggested Solution** | Being able to register to the blockchain using post-quantum cryptography material is an improvement over the state of the art that can help prevent malicious use of previous non-quantum crypto keys. Again, in this case, the two main customer segments are the end users (users of the blockchain) and the blockchain owner/provider. |
| **Main Features, Objectives & Innovations** | The main features are the inclusion of Self-Sovereign Identity (SSI) and Post-Quantum Cryptography (PQC) capabilities in a wallet for blockchain clients. |

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[9] PQC and How Organizations are Preparing for the Quantum Security Era (cryptomathic.com)

| | |
|---|---|
| | The main objective is to improve privacy and security in the utilization of similar digital privacy solutions.<br><br>The main innovation is that both SSI and PQC are recent technologies that are still in progress. Incorporating them into a wallet solution is beyond the state of the art. |
| Value Proposition | PQC will shortly become one of the main cryptography standards and SSI has not been integrated into a blockchain wallet yet, at least to the current knowledge. |
| Target Audience | Private Sector Companies and Stakeholders in the Digital Privacy Sector that can permit the testing in a permissioned blockchain. |
| Early Adopters | None Identified |
| Exploitation Type | Commercial |
| **Roadmap and IPR** | |
| Methods, Tools & Activities | Not decided yet at this stage. |
| Timing | Not decided yet at this stage. |
| Background IPR | Previous Knowledge about Blockchain and SSI. Protected with Patent. |
| Foreground IPR | Too soon to decide at this stage but there is a protection intention. |
| Exclusive Ownership | No<br><br>TDIS efforts deliver the PQC capabilities for signature that the wallet would use through a SW adaptor, which they will create. |

Table 8:Presentation of KER #3 - TEI Plan (1)

| KER #3 | A novel security and privacy toolbox – Post Quantum Cryptography (PQC) secure communication – TEI |
|---|---|
| Type of Result | Models and Algorithms, Skills and know-how |
| Problem | Secure communication against the potential threat posed by both quantum and classical computers. |
| Suggested Solution | Integrate Post-Quantum Cryptography (PQC) within a 5G network scenario using digital signature tokens, providing enhanced security and authentication for massive IoT communications. |
| Main Features, Objectives & Innovations | The main features include PQC Communication in 5G Massive IoT Scenario and the PQC Digital Signature Token Integration.<br><br>The main objective is to strengthen the security framework of IoT devices in 5G networks against future quantum threats by providing Post Quantum Assurance to Device Communications, while also being able to provide secure end-to-end communication.<br><br>The main innovation is the PQC Prototyping and Algorithm Comparison in 5G and the Integration of PQC Digital Signature Tokens. |
| Value Proposition | This solution develops and tests various PQC algorithms within a 5G environment to identify the most effective solutions and combines PQC technologies with existing digital infrastructure to create a secure, scalable communication framework. |
| Target Audience | Industrial Stakeholders like IoT Device Manufacturers and Cybersecurity Firms. |
| Early Adopters | None Identified |

| Exploitation Type | Commercial |
|---|---|
| **Roadmap and IPR** ||
| Methods, Tools & Activities | Not decided yet at this stage. |
| Timing | Not decided yet at this stage. |
| Background IPR | None |
| Foreground IPR | None |
| Exclusive Ownership | Yes |

KER #3 is exploited by 3 partners (namely TDIS, NEC and TEI). They have declared rights to different results-components which essentially fall under the umbrella of KER 3 "A novel security and privacy toolbox". Hence, they are presented separately, as it is yet unknown how the result can be mutually exploited by the 3 partners.

The same thing applies to KER #8 with IJS & CERTH claiming their individual contributions with different modules in this result, as well as KER #12 with VOS & UBITECH respectively.

Table 9: Presentation of KER#4 - INNO Plan (1)

| KER #4 | Realistic blockchain and attacks models – B-RAN Theoretical Framework – INNO |
|---|---|
| Type of Result | Models and Algorithms |
| Problem | The B-RAN Theoretical Framework aims to reduce development and deployment costs. |
| Suggested Solution | The framework will accurately model and estimate the achievable performance of B-RAN, enabling stakeholders to conduct pre-deployment evaluations and make informed decisions, thereby minimizing unnecessary expenses and optimizing resource use. |
| Main Features, Objectives & Innovations | The main features include models that simulate the performance of B-RAN (Beyond Radio Access Network) across various scenarios. It includes tools and algorithms to assess network behavior under different conditions, facilitating comprehensive performance analysis.

The primary objective is to accurately model and estimate the achievable performance of B-RAN. This involves creating detailed simulations that reflect real-world conditions, enabling stakeholders to predict how the network will perform before actual deployment.

The framework introduces a novel approach to modeling B-RAN performance. Unlike existing models, it integrates cutting-edge techniques and advanced algorithms to provide more precise and reliable predictions, catering to the unique challenges of next-generation networks. |
| Value Proposition | By enabling pre-deployment evaluation and design, the B-RAN Theoretical Framework allows for customized development of B-RAN solutions based on specific client needs. |
| Target Audience | Industrial Stakeholders of any kind that try to deploy private or public B-RAN. |
| Early Adopters | None Identified |

| | |
|---|---|
| **Exploitation Type** | Commercial |
| **Roadmap and IPR** | |
| **Methods, Tools & Activities** | Theoretical modeling based on queueing theory and Markov chains to simulate network performance accurately will be followed. Additionally, AI and machine learning tools will be integrated to enhance the precision of these models, allowing for adaptive and optimized performance predictions. This combination ensures a comprehensive analysis of B-RAN, facilitating informed decision-making and cost-effective pre-deployment evaluations. |
| **Timing** | ❖ M1-M24: Development and Refinement<br>❖ M24-M36: Identification of key stakeholders<br>❖ M36+: Market analysis |
| **Background IPR** | None |
| **Foreground IPR** | Patent |
| **Exclusive Ownership** | Yes |

Table 10: Presentation of KER#5 - INNO Plan (2)

| KER #5 | A novel quantum key distribution mechanism – QKD Simulation Framework – INNO |
|---|---|
| **Type of Result** | Models and Algorithms |
| **Problem** | The QKD Simulation Framework aims to achieve close to real-life performance and allows for planning and estimating the performance of QKD communications without the need for expensive QKD equipment. |
| **Suggested Solution** | In order to achieve that, the framework simulates the performance of QKD communications, providing accurate and reliable performance assessments without requiring any physical equipment, thus reducing costs, and making QKD research more accessible. |
| **Main Features, Objectives & Innovations** | The main feature is the simulation of performance of Quantum Key Distribution (QKD) communications, allowing users to assess and analyze QKD systems without requiring physical equipment.<br><br>The primary objective is to achieve simulation results that closely mirror real-life performance of QKD communications. This ensures that stakeholders can rely on the framework to make accurate predictions about the behavior and effectiveness of QKD systems.<br><br>The main innovation of this framework is its ability to be validated against actual experimental data during the project. This ensures that the simulation results are not only theoretical but have practical relevance and accuracy, bridging the gap between simulation and real-world implementation. |
| **Value Proposition** | The framework allows users to plan and estimate the performance of QKD communications without the need for expensive equipment. This significantly reduces costs, making advanced QKD research and development accessible to more organizations and projects. |
| **Target Audience** | Industrial Stakeholders of any kind that try to deploy private or public B-RAN. |
| **Early Adopters** | None Identified |
| **Exploitation Type** | Commercial |
| **Roadmap and IPR** | |

| Methods, Tools & Activities | The QKD Simulation Framework will utilize advanced simulation techniques to replicate the performance of QKD communications without the need for actual equipment. This approach includes detailed modeling of quantum communication protocols and their behaviors under various conditions, ensuring accurate and reliable performance assessments. |
|---|---|
| Timing | ❖ M1-M24: Development and Refinement<br>❖ M24-M36: Identification of key stakeholders<br>❖ M36+: Market analysis |
| Background IPR | None |
| Foreground IPR | Patent |
| Exclusive Ownership | Yes |

Table 11: Presentation of KER#7 - i2CAT

| KER #7 | A novel AI virtualiser for underutilized computational & communication resource exploitation – i2CAT |
|---|---|
| Type of Result | Models and Algorithms |
| Problem | Inter-slice resource conflict and underutilization. It occurs when multiple network slices, which are virtualized network partitions tailored for specific applications or services, compete for the same physical resources. This can lead to inefficiencies where some slices may not get the necessary resources, while others may not fully utilize the allocated capacity. As a result, the network's overall performance and efficiency suffer, leading to potential service degradation and increased operational costs. |
| Suggested Solution | Develop a multi-agent communication protocol learning to establish collaboration between concurrent slices. This protocol will allow the slices to dynamically negotiate and allocate resources, reducing conflicts and improving overall resource utilization. |
| Main Features, Objectives & Innovations | The main features include mechanisms for mitigating inter-slice conflict and addressing resource underutilization through dynamic resource allocation and intelligent management protocols.<br><br>The primary objective is to achieve efficient resource exploitation across the RAN-Edge-Cloud continuum, ensuring optimal performance and utilization of network resources in a seamless and integrated manner.<br><br>The main innovation is the use of protocol learning, where AI agents are trained to dynamically manage and optimize network resources through learned protocols |
| Value Proposition | The value proposition lies in its ability to efficiently utilize resources, thereby maximizing the return from leasing infrastructure to multiple tenants. By optimizing resource allocation and minimizing conflicts, a higher performance and a better service quality for tenants is enabled, making the infrastructure more attractive and profitable. |
| Target Audience | Researchers in the fields of network architecture, AI, and blockchain technology would be interested in this result. |
| Early Adopters | None identified |
| Exploitation Type | Non-commercial |
| Roadmap and IPR | |

| Methods, Tools & Activities | <ul><li>**Multi-agent Communication:** To enable collaboration and efficient resource allocation between network slices.</li><li>**PyTorch:** For developing and training AI models that will be integral to the resource management and optimization protocols.</li><li>**Docker:** To containerize applications and ensure consistent deployment across different environments, facilitating scalability and flexibility.</li><li>**Kubernetes:** For orchestrating containerized applications, ensuring efficient resource management and high availability in a multi-tenant infrastructure.</li></ul> |
|---|---|
| **Timing** | <ul><li>M6-M9: Design of the AI virtualizer</li><li>M10-M12: Implementation of the AI virtualizer in simulation</li><li>M13-M16 Dockerization of the AI virtualizer</li><li>M16-M19: Integration with the slice manager</li><li>M20-M24: Testbed validation</li></ul> |
| **Background IPR** | Slice Manager protected with License |
| **Foreground IPR** | None |
| **Exclusive Ownership** | Yes |

Table 12:Presentation of KER#8 - IJS Plan

| KER #8 | Novel self-evolving AI model Repository – Automatic Machine Learning Model Development and Management – IJS |
|---|---|
| **Type of Result** | Technological Solutions |
| **Problem** | The growing need for AI and intelligence in modern networks. As 5G and beyond networks become more complex, there is a pressing demand for advanced solutions that can optimize network performance, manage vast amounts of data, and support a wide range of applications from IoT to smart cities. Traditional methods of network management are insufficient to handle these complexities and scale effectively, necessitating the integration of intelligent, automated systems. |
| **Suggested Solution** | The Automatic Machine Learning Model Development and Management system aims to simplify and enhance the integration of AI into network operations. |
| **Main Features, Objectives & Innovations** | The main features include a comprehensive pipeline that includes data and model versioning, as well as automatic training and management of machine learning models.<br><br>The primary objective of the system is to leverage state-of-the-art cloud-native technologies to enhance the intelligence and efficiency of 5G and beyond networks, aligned with the AIMLFW specification of O-RAN.<br><br>The innovation of the system is that it introduces zero-touch model training and management for cellular networks, a novel approach that automates the entire lifecycle of machine learning models. This innovation reduces the need for manual intervention, significantly enhancing the efficiency and scalability of deploying AI solutions in telecommunications. |
| **Value Proposition** | The system supports the integration of advanced intelligence in 5G and beyond networks, facilitating applications in core networks as well as verticals like IoT, vehicular communications, and smart cities. |

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| **Target Audience** | Researchers in the fields of ML &AI, Networks and IoT |
| **Early Adopters** | Researchers in the fields of ML &AI, Networks and IoT |
| **Exploitation Type** | Non-Commercial |
| **Roadmap and IPR** | |
| **Methods, Tools & Activities** | 1. Result Refinement: Continuous enhancement of the system by integrating feedback from real-world deployments and advancements <br><br> 2. Partnerships and Collaborations: Establishment of strategic alliances with industry leaders, research institutions, and technology providers. <br><br> 3. Continuous Monitoring and Improvement: Ongoing monitoring of the deployed models and system performance to identify areas for improvement, ensuring the solution remains effective and up-to-date. |
| **Timing** | The module is expected to be ready by month 24 and it will be exploited within NANCY activities until M36 and in other research activities once the project is finalized. Therefore: <br> ❖ M12-M24: Result refinement <br> ❖ M12-M36: Partnerships and Collaborations <br> ❖ M24-M36: Continuous monitoring and improvement |
| **Background IPR** | None |
| **Foreground IPR** | None |
| **Exclusive Ownership** | Yes |

Table 13: Presentation of KER#8 - CERTH Plan (1)

| **KER #8** | **Novel self-evolving AI model Repository - AI Outage Probability Module - CERTH** |
|---|---|
| **Type of Result** | Models and Algorithms |
| **Problem** | Low network availability and poor Quality of Service (QoS) in 5G networks. |
| **Suggested Solution** | By predicting outages, the module will assist decision-makers in allocating resources more efficiently, ensuring network service reliability and meeting the QoS demands of network users. |
| **Main Features, Objectives & Innovations** | The main features of the AI Outage Probability Prediction Module include the employment of advanced machine learning algorithms to analyze historical data and specific network characteristics, and training models to predict the probability of outages or availability in 5G/B5G networks. <br><br> The primary objectives are to enhance network reliability and availability and to support network administrators in decision-making related to signal processing and resource allocation. <br><br> This module introduces innovative approaches to mitigating performance degradation through proactive decision-making. It leverages machine learning to predict potential outages, allowing for timely interventions and adjustments. |
| **Value Proposition** | The AI Outage Probability Prediction Module provides accurate predictions of network outages, enabling the creation of a robust network information framework. This helps decision-makers proactively manage and allocate |

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| | network resources for signal processing, ensuring efficient and reliable network performance. |
| **Target Audience** | Telecom vendors can use the AI Outage Probability Prediction Module to improve spectrum management and network design. IoT operators and smart cities can optimize their infrastructure to meet connectivity demands more effectively. Corporations can manage their private networks efficiently, streamlining supply chains. End users benefit from reliable and fast connectivity, enjoying higher-quality services. |
| **Early Adopters** | None Identified |
| **Exploitation Type** | Non-Commercial |
| **Roadmap and IPR** | |
| **Methods, Tools & Activities** | An initial market analysis will be conducted. During the testing, there will be a continuous monitoring process in order to implement improvements enhancing the quality of the product and the overall market placement. <br> These activities are also based on the expected TRL of the overall tools of NANCY. |
| **Timing** | Development: <br> ❖ M16: AI module for Outage Probability <br> ❖ M17: AI model implementation <br> ❖ M18: AI model testing (Outage) <br> During the aforementioned activities the initial market analysis will be performed. <br> ❖ M17: Throughput forecast service implementation & testing for first prototype for review <br> ❖ M18-M19: Throughput forecast service testing <br> ❖ M30-M36: NANCY Pilot Tests <br> The market analysis will continue based on the testing and the piloting results |
| **Background IPR** | The predictive analytics and forecasting framework has been developed in the course of previous research activities under different domains focused on crime risk projection. This framework has been extended and adapted properly to cover different needs such as cyberattack prediction. In NANCY this framework will be used, and it will be adapted properly to cover the needs of the project. It is protected with Copyright. |
| **Foreground IPR** | Copyright |
| **Exclusive Ownership** | Yes |

Table 14: Presentation of KER#9 - INNO Plan (3)

| KER #9 | Semantic & goal-oriented communication schemes for beyond Shannon performance – Semantic Communications Framework – INNO |
|---|---|
| **Type of Result** | Models and Algorithms |
| **Problem** | The result aims to address the need to increase energy and data efficiency, pushing the current state of the art (SoTA) of networks towards greater sustainability. |
| **Suggested Solution** | The framework plans to solve this problem by intelligently reducing the amount of data transferred in the network. |
| **Main Features, Objectives & Innovations** | The main feature is that this framework is designed to enable next-generation energy and data-efficient communications. It incorporates advanced AI and conventional techniques to optimize the transmission of information. |

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| | The primary objective is to intelligently reduce the amount of data transferred across the network. By focusing on the semantics of the information rather than raw data, the framework aims to minimize data redundancy and improve efficiency.<br><br>This framework's main innovation is a novel approach by integrating AI with traditional communication methods. This combination allows for smarter data handling, ensuring only the most relevant information is transmitted, thus enhancing overall network performance. |
| **Value Proposition** | It significantly increases energy and data efficiency within networks. By reducing unnecessary data transfer, it not only conserves energy but also optimizes bandwidth usage, contributing to more sustainable and cost-effective network operations. |
| **Target Audience** | Industrial Stakeholders of any kind that try to deploy private or public B-RAN. |
| **Early Adopters** | None Identified |
| **Exploitation Type** | Commercial |
| **Roadmap and IPR** | |
| **Methods, Tools & Activities** | The Semantic Communications Framework will employ a novel approach that combines AI with conventional communication techniques. This includes developing algorithms to interpret and prioritize the semantics of data, thereby reducing the amount of data that needs to be transferred. |
| **Timing** | ❖ M1-M24: Development and Refinement<br>❖ M24-M36: Identification of key stakeholders<br>❖ M36+: Market analysis |
| **Background IPR** | None |
| **Foreground IPR** | Patent |
| **Exclusive Ownership** | Yes |

Table 15: Presentation of KER#10 - MINDS Plan

| KER #10 | An explainable AI Framework – MINDS |
|---|---|
| **Type of Result** | Models and Algorithms |
| **Problem** | The low clarity and understandability of AI-enabled components' decisions pose significant challenges in various domains. When AI systems make decisions, especially in complex tasks or critical contexts, the lack of clarity can impede trust, comprehension, and accountability. This opacity may stem from the intricate inner workings of deep learning models, the black-box nature of certain algorithms, or the absence of transparent decision-making processes. |
| **Suggested Solution** | The aforementioned problem can be addressed by providing an easy-to-understand visualisation of the main findings and insights of the XAI algorithms in order for non-expertise personnel to be able to benefit from them. |
| **Main Features, Objectives & Innovations** | The main features include AI-driven Anomaly Detection and AI models within 5G networks.<br><br>The primary objective is to provide clear insights into the decision-making mechanisms of AI models, enabling a deeper understanding of their rationale and improving trust in AI-driven anomaly detection.<br><br>The main innovation of this framework is that it uniquely tailors AI interpretability techniques to the complexities of 5G networks, addressing a |

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|---|---|
| | critical gap by providing specific interpretations suited for modern network environments. |
| **Value Proposition** | By making AI models understandable to network administrators, regardless of their AI expertise, the framework helps optimize and effectively manage 5G networks, enhancing operational efficiency and reliability. |
| **Target Audience** | Industrial Stakeholders like Telco companies and Network Equipment Manufacturers. |
| **Early Adopters** | None Identified |
| **Exploitation Type** | Commercial |
| **Roadmap and IPR** | |
| **Methods, Tools & Activities** | 1. Thorough Analysis of the needs of the market, 2. First Results published, 3. Collaboration with project partners leveraging their expertise and experience 4. Possible IPR Protection, 5. Dissemination and Improvements |
| **Timing** | ❖ M01-M36:Thorough Analysis<br>❖ M09-M12: First Results<br>❖ M01-M36: Collaboration<br>❖ M27-after: IPR Protection<br>❖ M27-after: Dissemination/Improvements |
| **Background IPR** | None |
| **Foreground IPR** | Cannot be decided at this stage of the project. |
| **Exclusive Ownership** | Cannot be decided at this stage of the project. |

*Table 16: Presentation of KER#12 - VOS Plan*

| **KER #12** | **A novel security and privacy toolbox – Virtio-based cross-world transport layer – VOS** |
|---|---|
| **Type of Result** | Technological Solutions |
| **Problem** | Currently, there are limited options for implementing a software stack where multiple operating systems can co-execute on the same platform, often addressing tasks with varying levels of criticality. In such scenarios, companies, typically system integrators, are compelled to adopt expensive virtualization solutions. These solutions often come bundled with proprietary software and tools, creating a vendor lock-in situation for the implementer. Consequently, the software stack is designed around the purchased virtualization solution rather than being tailored to the specific use case. |
| **Suggested Solution** | The virtio-based technology with VOS' VOSySmonitor offers a more flexible alternative. This solution is particularly attractive due to its highly adaptable business model, which can be customized to meet the needs of diverse customers. VOS will offer development services to customize its technologies to the specific needs of each customer, with the ultimate goal of delivering precisely what the customer requires, rather than an all-inclusive, proprietary solution. |
| **Main Features, Objectives & Innovations** | The main features include a Virtio transport layer that allows to configure virtio backend and frontend in different worlds of a TrustZone-enabled ARM system. More specifically it enables to run the backend of a virtio device in the secure world and the frontend in the non-secure world.<br><br>The main objective is to provide extreme flexibility when the execution of multiple operating systems on the same platform is required. In these cases, the multiplexing of physical resources must be performed in an extremely efficient way and this result is a key component to achieve that. |

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| | The main innovation is the specific way in which virtio is used in a non-virtualized environment. In detail, this virtio-based transport layer does not rely on a type-1 or type-2 hypervisor, thus involving less virtualization overhead, making it suitable for embedded use-cases where a careful handling of the available resources is needed. |
| **Value Proposition** | This result enables the implementation of powerful software stacks for ARM systems featuring the TrustZone extension that can rely on different operating systems to address tasks of diverse criticalities, all sharing a set of resources in an efficient way. |
| **Target Audience** | Industrial Stakeholders like Telco Companies and Electronics Manufacturers |
| **Early Adopters** | None identified yet |
| **Exploitation Type** | Commercial |
| **Roadmap and IPR** | |
| **Methods, Tools & Activities** | Although the exact plan and timeline are not yet known, the identified methods are:<br><br>1. Partnerships and collaborations: VOS has started discussions with possible industrial partners that are willing to share the costs to be sustained to enrich the technology offer.<br><br>2. Sales and price strategy: VOS has a flexible marketing strategy that does not enforce a specific business model, but rather tailors it to the customer. |
| **Timing** | Currently, the only timing available is the one regarding the TRL of VOS's transport layer:<br>❖ M18 TRL → 3-4<br>❖ M36 TRL → 6-7 |
| **Background IPR** | VOSySmonitor for ARM is a system partitioner for ARMv7 and ARMv8 embedded systems. This background IP has been licensed to customers in the past with VOS being the copyright owner of the IP. Moreover, a patent has also been filed to protect the technological core of the IP. |
| **Foreground IPR** | Copyright |
| **Exclusive Ownership** | Yes |

Table 17: Presentation of KER#12 - UBITECH Plan

| KER #12 | A novel security and privacy toolbox – AI-based Energy-Efficient RAN Orchestration Solution – UBITECH |
|---|---|
| **Type of Result** | Technological Solutions |
| **Problem** | Energy Inefficiency: Traditional radio access network (RAN) orchestration methods may lead to inefficiencies in energy usage, contributing to increased operational costs and environmental impact. The AI-based solution seeks to optimize energy consumption, reducing both costs and environmental footprint.<br><br>Security and Privacy Concerns: With the increasing complexity of telecommunications networks, ensuring robust security and privacy measures is crucial. The solution integrates advanced security and privacy features to mitigate risks associated with unauthorized access, data breaches, and privacy violations. |

| | |
|---|---|
| | Competitiveness in the Market: In a rapidly evolving technological landscape, companies need to stay ahead of the competition by offering innovative solutions. The AI-based RAN orchestration solution enhances UBITECH's competitiveness by providing cutting-edge technology that addresses critical industry challenges, such as energy efficiency and security. |
| **Suggested Solution** | Advanced Technology Integration: UBITECH can leverage its expertise in telecommunications to integrate advanced AI algorithms into the RAN orchestration process. By consuming machine learning and optimization techniques, the solution can dynamically adjust network parameters to maximize energy efficiency while maintaining optimal performance.<br><br>Enhanced Security and Privacy Measures: UBITECH can integrate NANCY's robust security and privacy features into the solution, such as encryption protocols, access controls, and anomaly detection mechanisms. By implementing these measures at the service and network orchestration level, UBITECH can mitigate security risks and ensure compliance with regulatory requirements, thus safeguarding sensitive data and protecting user privacy.<br><br>Collaboration and Technology Transfer: UBITECH can collaborate with industrial partners, vendors, manufacturers, and network operators to identify opportunities for technology transfer and future collaborations. By leveraging its extensive network and expertise, UBITECH can explore synergies with partners to enhance the scalability, interoperability, and commercial viability of the solution, thereby accelerating its adoption in the market.<br><br>Customization and Tailored Solutions: UBITECH can offer customizable solutions tailored to the specific needs and requirements of its clients in both the public and private sectors. By understanding the unique challenges and constraints faced by different organizations, UBITECH can tailor NANCY's AI-based RAN orchestration solution to optimize energy efficiency, enhance security, and improve overall network performance, thus delivering maximum value to its clients." |
| **Main Features, Objectives & Innovations** | The main features include the Utilization of AI algorithms for efficient radio access network (RAN) orchestration and the enhancement of security & privacy measures within RAN operations<br><br>The primary objective is to reinforce UBITECH's portfolio by leveraging acquired knowledge and technological advancements, to increase competitiveness in the market (particularly in the domains of AI, cybersecurity, and radio access networks), and to identify opportunities for technology transfer and future collaborations with industrial partners.<br><br>The main innovation is the integration of artificial intelligence into RAN orchestration for energy efficiency, while it also focuses on improving security and privacy within RAN operations. |
| **Value Proposition** | It provides an advanced solution for optimizing energy efficiency in RAN orchestration, while it enhances security and privacy measures, addressing critical concerns in network operations. |
| **Target Audience** | Industrial Stakeholders |
| **Early Adopters** | Other HEU projects |

| Exploitation Type | Non-commercial |
|---|---|
| **Roadmap and IPR** | |
| Methods, Tools & Activities | Partnerships & Collaborations: These will include forming strategic alliances with industry leaders in AI, cybersecurity, and telecommunications to leverage cutting-edge technologies and expertise. |
| Timing | The timeline is not yet decided at this stage of the project |
| Background IPR | Maestro Service Orchestor, protected with Copyright. Intention to become open source in the future. |
| Foreground IPR | None |
| Exclusive Ownership | No<br><br>Other NANCY partners from WPs 2, 3 and 4 which cannot be decided at this stage. |

Regarding the markets that the above-described solutions could be matched with, based on the responses received a possible mapping for the KERs of the project could be as follows:

- 5G/Beyond 5G Market: KER #3 – TEI, KER#4 – INNO
- Cloud/IoT/Edge Continuum Market: KER #1 – SSS, KER #9 – INNO, KER #12 – VOS
- Blockchain Market: KER #3 – NEC
- Cybersecurity Market: KER #3 – TDIS, KER #5 – INNO
- AI Market: KER #7 – i2CAT, KER #8 – IJS, KER#8 – CERTH, KER #10 – MINDS, KER #12 – UBITECH

### 5.2.2.  OERs

In this sub-section, the analysis of the results that appertain to the category of OERs is being investigated. Table 18 provides an overview of the beneficiaries whose results were matched to this category, rather than the KERs of the project, while details for each OER are shown from Table 19 to Table 27. However, this does not mean that they are not involved in other activities or collaborating with partners who are currently listed in the KER category or have a different result than their own. For example, TECNALIA (who are placed in OER section) possess a QKD experimentation platform that assists INNO in the exploitation of their result "QKD Simulation Framework" placed in KER #5, yet it was agreed that for this stage their platform is not mature enough to be examined under the specific KER.

In general, the analysis of the results heavily relied upon the answers that the partners provided in the Exploitation Questionnaire and not "what could be" exploited later in the project or in some other way that was not explicitly stated.

Table 18: List of Other Exploitable Results (OERs)

| OER Number | Partner Name |
|---|---|
| **OER #1** | DRAXIS |
| **OER #2** | Bi2S (in collaboration with UMU, IJS) |
| **OER #3** | TECNALIA (in collaboration with NEC) |
| **OER #4** | UMU |
| **OER #5** | UOWM |
| **OER #6** | OTE |

| OER #7 | CERTH |
|--------|-------|
| OER #8 | 8BELLS |
| OER #9 | TEI |

Table 19: Presentation of OER#1 - DRAXIS Plan

| OER #1 | Smart contracts – DRAXIS |
|--------|--------------------------|
| **Type of Result** | Technological Solutions |
| **Problem** | Automation and Efficiency: Smart contracts eliminate the need for intermediaries and streamline the contract execution process, reducing delays, errors, and manual processes involved in traditional agreements.<br><br>Trust and Transparency: Smart contracts operate on decentralized blockchain platforms, ensuring transparency and immutability. All parties involved can verify and trust the terms and conditions encoded in the contract, reducing the risk of disputes. |
| **Suggested Solution** | By using docker container technology for creating, compiling, simulating, deploying, and monitoring the smart contracts. In the context of automation, Docker containers can be used to create self-contained and isolated environments for running automated tests or processes. These containers can be easily created, updated, and destroyed as needed, providing a consistent and predictable environment for automation tasks. |
| **Main Features, Objectives & Innovations** | The main features include Automation in creating, compiling, simulating, and deploying a SC. Also, the smart contracts will enable the secure relay of data among users while limiting data access only to the authorized user(s).<br><br>The main objective is to develop a software component for addressing the above (under the scope of the NANCY project). This will also be used to promote and build confidence in open markets.<br><br>The main innovation is that the smart contracts will be used to explain the radio access network (RAN) user's needs and to enforce the service level agreement (SLA). |
| **Value Proposition** | The value proposition of a smart contract lies in its ability to automate and enforce the execution of an agreement or contract without the need for intermediaries. |
| **Target Audience** | Private Sector companies and entrepreneurs |
| **Early Adopters** | None identified |
| **Exploitation Type** | Non-commercial |
| **Roadmap and IPR** | |
| **Methods, Tools & Activities** | A detailed market analysis will be conducted in order to identify the most prosperous markets and individuals that could be interested in the Smart Contracts technology security and efficiency while also evaluating the biggest competitors in the field. |
| **Timing** | ❖ M28: Beginning of Analysis<br>❖ M36: End of Analysis |
| **Background IPR** | None |
| **Foreground IPR** | None |
| **Exclusive Ownership** | Yes |

Table 20: Presentation of OER#2 – Bi2S Plan

| OER #2 | Machine learning models for decision-making – Bi2S |
|---|---|
| **Type of Result** | Models and algorithms |
| **Problem** | Telecommunication service providers*:* NANCY's "Machine learning models for decision-making" solve the issues of computational offloading in Edge ecosystems. The main problem is the optimal use of Edge computational resources that maximize the Quality of Service and reduce the computational complexity for each end user.<br><br>Telecommunication Infrastructure providers: The main problem that NANCY's "Machine learning models for decision-making" solve is the reduction of computational resources required for AI model training. |
| **Suggested Solution** | The proposed solution for this result is to adopt novel approaches to optimize the computational resource utilization of the Edge with respect to the Quality of Service of the network. To achieve this, NANCY employs an AI approach which makes on-the-fly decisions on what type of services to offload to the Edge of the network. This decision-making process is conducted while taking into account several network parameters. A novel machine learning training framework guarantees the minimization of computational requirements of the models, during the AI training process. |
| **Main Features, Objectives & Innovations** | The main features include AI training framework, novel AI model architecture, Deep Neural Network models, machine learning algorithms, and an innovative reinforcement learning approach.<br><br>The main objective is to improve the State-of-the-art in the corresponding domains, to increase the efficiency of ML models, and to achieve near-optimal performance in computational offloading tasks in next-generation 5G/6G networks.<br><br>The main innovation is that existing AI models/methodologies consider only a few factors to perform policy optimization for data offloading in contrast to NANCY's machine learning models which consider a significant number of parameters to do so and thus, they manage to properly select the optimal policies. |
| **Value Proposition** | The value proposition lies in the increased Quality of Service within the network, increased computational distribution between Cloud and Edge, Real-time adaptation, and computational offloading provisioning under diverse operating scenarios. |
| **Target Audience** | Industrial Stakeholders like Telecommunication Companies and Cloud Service Providers, which have been already contacted and asked for pertinent information for the Machine Learning Models. |
| **Early Adopters** | None identified |
| **Exploitation Type** | Commercial |
| **Roadmap and IPR** | |
| **Methods, Tools & Activities** | 1. A continuous improvement of the machine learning models by regularly updating the models with new data, refining algorithms, and incorporating the feedback received by the identified stakeholders for accuracy and efficiency. |

| | |
|---|---|
| | 2. Also a comprehensive market analysis will be conducted to help understand the needs, challenges, competitive landscape and trends in AI and ML. |
| **Timing** | ❖ M18-M22: Market analysis<br>❖ M19-M36: Forging partnerships<br>❖ M18-M36: Continuous development<br>❖ M36-3 years after NANCY ends: Continuous development / Continuous integration |
| **Background IPR** | Reinforcement learning AI models and AI training framework. Not protected. |
| **Foreground IPR** | None |
| **Exclusive Ownership** | No<br><br>UMU and IJS, as WP Leaders, are also contributing to this result as it is part of larger components of the NANCY architecture. UMU and IJS provide data and developing guidelines on how smaller software components should communicate and coordinate with each other. |

Table 21: Presentation of OER#3 - TECNALIA Plan

| OER #3 | Market Place – TECNALIA |
|---|---|
| **Type of Result** | Technological Solutions |
| **Problem** | The marketplace addresses the challenge of consolidating offers from different operators into a single, accessible platform |
| **Suggested Solution** | The intention is to develop a centralized platform based on blockchain technology. This platform will serve as a hub for facilitating requests, both for publishing and requesting resources, from various operators. Leveraging blockchain ensures transparency, security, and efficiency in managing these requests and subsequent contract negotiations, thereby streamlining the process for all parties involved. |
| **Main Features, Objectives & Innovations** | The main features include Centralized Platform, Request Registration, SLA Generation and Contract Management.<br><br>The main objective of the marketplace is to provide an accessible platform for users to access 5G resources anytime and anywhere. This platform will be able to register all requests from different operators, both to publish or request resources and generate Service-Level Agreement (SLA) before establishing the contract. After signing the contract, the marketplace will support the management of these contracts between providers and consumers.<br><br>The main innovation is the utilization of the blockchain technology for this venture while ensuring interoperability and scalability. |
| **Value Proposition** | The value proposition of this result lies in its ability to streamline and simplify the process of accessing 5G resources for users, operators, and providers alike whilst improving the contract management process with clarity and security. |
| **Target Audience** | Industry Stakeholders like Telecommunication Companies and Cloud Service Providers |
| **Early Adopters** | None Identified |
| **Exploitation Type** | Not decided yet. TECNALIA will analyse the commercial exploitation of this result in a later phase of the project. |
| **Roadmap and IPR** | |

| Methods, Tools & Activities | Not fully decided yet. An early understanding could be Result Refinement, where regular feedback sessions to improve the marketplace will be conducted, and the Identification of Partnerships and Collaboration with potential users to gather insights and validate assumptions to co-create the marketplace solution. |
|---|---|
| Timing | ❖ M24-M36: Partnership and collaboration<br>❖ M30-M36: Result refinement |
| Background IPR | None |
| Foreground IPR | Copyright |
| Exclusive Ownership | No<br>NEC provides infrastructure and contributes to the design |

Table 22: Presentation of OER#4 - UMU Plan

| OER #4 | MultiRAT-Nomadic Connectivity Provider – UMU |
|---|---|
| Type of Result | Technological Solutions |
| Problem | The primary problem addressed by this device is the limited 5G coverage in certain scenarios, such as Remote Areas, Temporary Events like crowded festivals and conferences, and Urban Dead Zones which may have poor 5G signal strength due to obstructions or dense building structures |
| Suggested Solution | The MultiRAT-Nomadic Connectivity Provider will tackle this problem by using different radio interfaces (e.g., LTE, Wi-Fi) to provide access to the 5G infrastructure, ensuring connectivity even in areas with weak or no 5G signal, while also employing intelligent management of radio resources to maintain optimal connectivity and performance, regardless of the existing network infrastructure |
| Main Features, Objectives & Innovations | The main features include Multi-Radio Access Technology, Portability and Dynamic Connectivity through the portable device that is designed to provide dynamic access to the 5G infrastructure.<br><br>The primary objective is to extend 5G connectivity by leveraging both 5G and non-5G technologies. This can be done by expanding the coverage infrastructure of 5G as well as by enhancing the overall user experience.<br><br>The major innovation of the MultiRAT-Nomadic Connectivity Provider lies in its MultiRAT capabilities to extend 5G coverage. |
| Value Proposition | The MultiRAT-Nomadic Connectivity Provider offers significant value by delivering a low-cost and portable solution to extend 5G network coverage |
| Target Audience | Researchers interested in telecommunications, wireless networks, and mobile communications. |
| Early Adopters | Researchers interested in telecommunications, wireless networks, and mobile communications. |
| Exploitation Type | Non-Commercial |
| Roadmap and IPR | |
| Methods, Tools & Activities | 1. Result Refinement by collecting user feedback and protype testing to ensure robustness,<br><br>2. Partnership Establishment with telecommunication companies and research institutions |

| | |
|---|---|
| | 3. Continuous monitoring and improvement by employing software updates and quality assurance |
| **Timing** | The module is expected to be ready by month 24 and it will be exploited within NANCY activities until M36 and in other research activities once the project is finalized. In brief:<br>❖ M12-M24: Result refinement<br>❖ M12-M36: Partnerships and Collaborations<br>❖ M24-M36: Continuous monitoring and improvement |
| **Background IPR** | None |
| **Foreground IPR** | None |
| **Exclusive Ownership** | Yes |

Table 23: Presentation of OER#5 - UOWM Plan

| OER #5 | Laboratory Testbed – UOWM |
|---|---|
| **Type of Result** | Testbed |
| **Problem** | Not applicable as it is a Research & Development activity |
| **Suggested Solution** | Not applicable as it is a Research & Development activity |
| **Main Features, Objectives & Innovations** | The testbed leverages Ettus Research USRP devices to deploy 5G base stations. The srsRAN software is used to manage the USRP devices, while the Open5GS software provides 5G Core Network functionalities.<br><br>The testbed aims to test and evaluate scenarios where a user/consumer can provide coverage extension to a main base station. Therefore, the user serves as an intermediate node offering connectivity to other users.<br><br>The main innovation is that it enables consumers to become connectivity providers, thereby realizing the prosumer concept. |
| **Value Proposition** | The aforementioned scenarios can potentially lead to new business models both for the operators and for the consumers. |
| **Target Audience** | Research Institutions, Universities, SMEs, and Industrial Organizations |
| **Early Adopters** | None Identified |
| **Exploitation Type** | Non-Commercial |
| **Roadmap and IPR** | |
| **Methods, Tools & Activities** | Result Refinement & Continuous Monitoring and Improvement |
| **Timing** | ❖ M12-M36: Result refinement by continuously improving the result based on feedback received by early adopters, pilot users, market needs and communication with the partners & Continuous Monitoring and Improvement by regularly assessing performance metrics and making adjustments for optimization |
| **Background IPR** | None |
| **Foreground IPR** | None |
| **Exclusive Ownership** | Yes |

Table 24: Presentation of OER#6 - OTE Plan

| OER #6 | Exploitation of Blockchain technology powered by AI/ML algorithms in the field of 5G and Edge Computing – OTE |
|---|---|

| Type of Result | Technological Solutions |
|---|---|
| **Problem** | This section's information is currently unavailable based on the partner's response. |
| **Suggested Solution** | This section's information is currently unavailable based on the partner's response. |
| **Main Features, Objectives & Innovations** | The main features include Artificial Intelligence, Machine Learning, Blockchain, Radio Access Networks (RAN).<br><br>The main objective is the utilization of Blockchain and AI-based energy-efficient RAN orchestration in 5G networks and beyond. It also aims at the provision of advanced security, energy efficiency and new business models in this regard.<br><br>The main innovation is the integration of B-RAN in 5G networks and beyond, as it can have a significant improvement in both communication and computation overheads compared to the current technologies. |
| **Value Proposition** | OTE will exploit NANCY results with regard to the exploitation of Blockchain and ML methodologies in 5G networks by assessing its efficiency in the network and testing its performance. Blockchain will enable innovations in beyond 5G networks, boosting the dynamic scalability of network, providing at the same time trust, security and privacy through post-quantum cryptography and introducing new business models. |
| **Target Audience** | None identified |
| **Early Adopters** | None identified |
| **Exploitation Type** | Commercial |
| **Roadmap and IPR** | |
| **Methods, Tools & Activities** | This section's information is currently unavailable based on the partner's response. |
| **Timing** | This section's information is currently unavailable based on the partner's response. |
| **Background IPR** | None |
| **Foreground IPR** | None |
| **Exclusive Ownership** | Yes |

Table 25: Presentation of OER#7 - CERTH Plan (2)

| OER #7 | Throughput Forecasting Service – CERTH |
|---|---|
| **Type of Result** | Models and Algorithms |
| **Problem** | The result is aimed at addressing the issue of low Quality of Service (QoS) in 5G networks. In the fast-paced environment of wireless communications, maintaining high QoS is challenging due to fluctuating demand and resource availability. |
| **Suggested Solution** | The plan is to enhance QoS by predicting throughput in a 5G network using advanced predictive analytics algorithms. These algorithms analyze historical data and current trends to forecast network performance accurately. Specifically, the solution tracks the optimal network path and considers various user activities, such as walking and driving, to provide dynamic adjustments in real-time. By anticipating network congestion and resource needs, we can proactively allocate resources, reduce downtime, and optimize |

| | |
|---|---|
| | operational efficiency, ultimately improving the overall performance and reliability of the 5G network. |
| **Main Features, Objectives & Innovations** | The main features include advanced predictive analytics algorithms that analyze historical data and current trends to accurately forecast throughput in a 5G network.<br><br>The main objective is to enhance overall operational efficiency, reduce downtime, and boost resource allocation.<br><br>The main innovation is proactive decision-making, which allows to allocate resources efficiently and improve overall productivity. |
| **Value Proposition** | The throughput forecasting service significantly enhances 5G network performance through accurate predictive analytics. By forecasting throughput, it enables efficient resource allocation, reducing downtime and operational costs. This adaptability to dynamic network environments ensures stakeholders can streamline operations and boost productivity effectively. |
| **Target Audience** | Telecom vendors can use the Forecasting Service to improve spectrum management and network design. IoT operators and smart cities can optimize their infrastructure to meet connectivity demands more effectively. Corporations can manage their private networks efficiently, streamlining supply chains. End users benefit from reliable and fast connectivity, enjoying higher-quality services. |
| **Early Adopters** | None Identified |
| **Exploitation Type** | Non-commercial |
| **Roadmap and IPR** | |
| **Methods, Tools & Activities** | An initial market analysis will be conducted. During the testing there will be a continuous monitoring process in order to implement improvements enhancing the quality of the product and the overall market placement.<br>These activities are also based on the expected TRL of the overall tools of NANCY. |
| **Timing** | Development:<br>❖ M13-M14: Throughput forecast service design<br>❖ M15: Throughput forecast service design and development<br>❖ M16: Throughput forecast service development<br>During the aforementioned activities, the initial market analysis will be performed.<br>❖ M17: Throughput forecast service implementation & testing for first prototype for review<br>❖ M18-M19: Throughput forecast service testing<br>❖ M30-M36: NANCY Pilot Tests<br>The market analysis will continue based on the testing and the piloting results. |
| **Background IPR** | The predictive analytics and forecasting framework has been developed in the course of previous research activities under different domains focused on crime risk projection. This framework has been extended and adapted properly to cover different needs such as cyberattack prediction. In NANCY this framework will be used, and it will be adapted properly to cover the needs of the project. It is protected by Copyright. |
| **Foreground IPR** | Copyright |
| **Exclusive Ownership** | Yes |

Table 26: Presentation of OER#8 – 8BELLS Plan

| OER #8 | Smart Pricing Policies – 8BELLS |
|---|---|
| Type of Result | Models and Algorithms |
| Problem | The Smart Pricing module facilitates the transition of User Equipment (UE) from being merely consumers to providers of communication services, and it promotes cooperation between infrastructure elements of different providers. |
| Suggested Solution | Introduce new monetary incentives for entities acting as providers. The Smart Pricing module enables dynamic pricing and fosters collaboration between different providers, serving as the crucial link for this transition. |
| Main Features, Objectives & Innovations | The main feature is the integration into NANCY's architecture<br><br>The main objective of this solution is to calculate tailored prices for services, ensuring maximized through precise pricing strategies.<br><br>The main innovation is that this pricing model incorporates auction and game theoretic methods, providing a novel approach to setting prices that reflect market conditions and service value accurately. |
| Value Proposition | The Smart Pricing module offers a tailored pricing mechanism that maximizes provider profits and minimizes losses, creating new monetary incentives for both providers and users. |
| Target Audience | Private Sector Companies and Entrepreneurs |
| Early Adopters | None Identified |
| Exploitation Type | Commercial |
| **Roadmap and IPR** | |
| Methods, Tools & Activities | A detailed market research to understand pricing trends and customer demands, an IPR protection plan and lastly a continuous performance monitoring |
| Timing | ❖ M11-M36:Detailed Market Analysis<br>❖ M11-M36:Continuous Monitoring and Improvement<br>❖ Intellectual Property Protection: Not Decided yet |
| Background IPR | None |
| Foreground IPR | Copyright |
| Exclusive Ownership | Not decided at this stage |

Table 27: Presentation of OER#9 - TEI Plan (2)

| OER #9 | Big Data Platform for self-healing and self-recovery – TEI |
|---|---|
| Type of Result | Models and Algorithms, Skills and know-how |
| Problem | The exploitable output aims to address the challenge of ensuring the robustness and reliability of 5G. |
| Suggested Solution | Implement a Big Data Platform for self-healing and self-recovery. This platform will utilize advanced technologies and techniques to effectively manage and process massive volumes of data while it will also enable proactive measures to maintain network integrity and availability. |
| Main Features, Objectives & Innovations | The main feature of the platform is the management of vast amounts of data required by self-healing and self-recovery algorithms. |

| | |
|---|---|
| | The primary objective is to implement scalable big data management mechanisms that allow the system to handle and process massive datasets efficiently, enabling the effective deployment of self-healing and self-recovery techniques.<br><br>The main innovation is the novel multi-broker approach for implementing federated learning algorithms enables the platform to distribute and process data more effectively, enhancing the scalability and responsiveness of self-healing and self-recovery processes. |
| **Value Proposition** | This platform ensures the efficient management of large amounts of data, significantly improving the reliability and availability of 5G networks through advanced self-healing techniques. |
| **Target Audience** | Industrial Stakeholders like Telco Companies, Cloud Service Providers |
| **Early Adopters** | None Identified |
| **Exploitation Type** | Commercial |
| **Roadmap and IPR** | |
| **Methods, Tools & Activities** | Not decided yet at this stage. |
| **Timing** | Not decided yet at this stage. |
| **Background IPR** | None |
| **Foreground IPR** | None |
| **Exclusive Ownership** | Yes |

Regarding the markets that the above-described solutions could be matched with, based on the responses received a possible mapping for the OERs of the project could be as follows:

- 5G/Beyond 5G Market: OER #4 – UMU, OER #9 – TEI
- Cloud/IoT/Edge Continuum Market: OER#2 – Bi2S, OER #5 – UOWM, OER #7 – CERTH
- Blockchain Market: OER #1 – DRAXIS, OER #3 – TECNALIA
- Cybersecurity Market: OER #6 – OTE
- AI Market: OER #8 – 8BELLS

## 5.3. Joint Exploitation Strategy Approach

This section's goal is to present the initial strategy set to be followed for the NANCY Joint Exploitation planning. The focus is to make concrete use of results (mainly KERs) that could be jointly exploited, having as target audience the project partners themselves, as well as stakeholders in the telecommunication sector such as telecommunication companies, network equipment manufacturers, cybersecurity firms, and other user groups outside the project.

The overarching aim is to deliver a collective exploitation plan for NANCY's outputs as a whole, that far outlasts the duration of the project and is sustainable far into the future. More specifically, the main objective is to effectively examine the project results that can be jointly exploited through scientific, commercial, and societal exploitation routes, aiming to turn NANCY innovation action into concrete value and impact for society and the involved stakeholders of the networking sector. This way the project can contribute significantly to economic growth, societal prosperity and policy-making.

NANCY aims to introduce a secure and intelligent architecture for beyond the fifth generation (B5G) wireless networks. This ambitious goal necessitates a Joint Exploitation Strategy that integrates diverse

project results into a unified, comprehensive solution. Such an approach not only maximizes the potential of individual outcomes but also amplifies their collective impact. In the context of European projects, the exploration of Joint Project Exploitation has evolved into an underlying goal, epitomizing collaboration and partnership throughout the project's lifecycle and beyond. This approach significantly enhances the exploitation potential of the project's outcomes, fostering deeper integration and maximizing the impact of shared resources and expertise. By pursuing this venture, NANCY's impact becomes more robust, presenting a well-founded solution underpinned by shared expertise and knowledge.

The proposed Joint Exploitation Strategy will facilitate the integration of innovative solutions developed within NANCY into the broader networking ecosystem. This strategy should be built upon the technical outcomes that are produced in the action which ultimately realize the NANCY B-RAN Architecture. It will thus ensure that the project's outcomes are not only utilized by the project partners but also by a wider range of stakeholders in the networking sector. It aims to create pathways for the adoption of NANCY's innovations in real-world applications, fostering advancements in telecommunications, network security, and equipment manufacturing.

The main challenge is the lack of technological maturity in the majority of the components tested in the project at this stage, hence creating an issue regarding the finalized strategy. These issues need to be addressed to ensure that the joint exploitation plan is both viable and effective for the later stages, as well as beyond the project's duration.

To address these challenges, several mitigation measures could be potentially implemented:

1. **Expert Consultations**: Engaging with external experts and stakeholders through platforms such as the Horizon Results Booster will yield valuable insights and recommendations. These consultations will aid in identifying gaps, refining exploitation strategies, and enhancing the commercial and societal value of the project's key outcomes. However, this approach has not yet been implemented due to the current immaturity of the project solutions. The responses we seek must be well-defined and pertain to end products or results that require minimal refinement. Otherwise, the information will need constant updating, rendering this measure difficult to maintain.

2. **Regular Reviews and Updates**: The joint exploitation plan will be reviewed and updated regularly to incorporate new information, feedback, and changing market dynamics. This iterative approach can ensure that the plan remains relevant, adaptable, and aligned with the latest developments in the networking sector.

3. **Capacity Building**: Comprehensive training sessions and hands-on workshops could be organized for project partners to deepen their understanding of exploitation strategies, intellectual property management, and market dynamics. These activities will not only build their theoretical knowledge but also provide practical tools and techniques for effective implementation. Participants will have the chance to engage in real-world scenarios and case studies, empowering them to actively contribute to joint exploitation efforts and drive tangible results. Additionally, follow-up support and mentoring can be built, which will ensure sustained capacity development and practical application of the acquired skills.

4. **Stakeholder Engagement**: Continuous engagement with stakeholders from the networking sector shall be maintained to gather their inputs, understand their needs, and align the project outcomes with market demands. Regular consultations should be held to ensure that the exploitation plan is grounded in real-world requirements, increasing its chances of successful implementation. In fact, to enhance market acceptance, key players of the sector can be invited to participate in the next plenary meetings. These industry leaders will provide critical

feedback, share their perspectives, and monitor the project's progress. Their involvement will not only validate the project outcomes but also help in refining the exploitation strategies to better meet market expectations. This collaborative approach will facilitate the smooth integration of the project results into the market, fostering greater acceptance and adoption.

By implementing these mitigation measures, NANCY aims to overcome the challenges related to the vagueness of different characteristics around the KERs and OERs (in addition to the low TRL), ensuring a robust and sustainable joint exploitation plan that maximizes the impact of its innovative solutions in the networking sector.

# 6. NANCY Market Position

## 6.1.    Objectives of the roadmap to market

We have identified the NANCY project's primary exploitable assets and are now placing them in the 5G market to maximize their potential and innovation. Our initial SWOT and PESTLE analyses examined the project's strengths, weaknesses, opportunities, and threats, as well as the political, economic, social, technological, legal, and environmental factors that could affect it. These assessments have helped us discover asset leverage opportunities and hurdles to project commercialization. Understanding our environment helps us strategically position our assets to optimize market effect. These studies will generate a detailed and strong project strategy for the following phase, ensuring we address potential problems and maximize market opportunities. Navigating the 5G market and commercializing the NANCY project's technologies requires this strategic strategy.

## 6.2.    Roadmap to Market Methodologies

To determine what internal and external variables might affect the NANCY project's business plan, we conducted an initial SWOT and PESTLE analysis in this section. We want to identify what the preliminary aspects are so the consortium can be ready for what's to come and see what opportunities are out there. D1.11, the next deliverable, will provide an all-inclusive business model and plan.

### 6.2.1.    Initial SWOT analysis

The initial SWOT analysis was undertaken in partnership with the consortium to comprehensively identify and assess both internal and external elements that could potentially affect the NANCY project. By engaging the consortium in this SWOT analysis, we ensured a wide array of viewpoints and specialized knowledge were considered, resulting in a stronger comprehension of the aspects that could impact the project's achievement. The SWOT details, gathered in Figure 8, are as follows:

**Strengths:** Several important features put the NANCY project ahead of the curve when it comes to technological advancement. It guarantees the confidentiality and integrity of data by utilizing the strong privacy and security features of blockchain technology. The project is protected from any dangers posed by quantum computing in the future thanks to the inclusion of quantum safety procedures. Performance and adaptability are optimized by intelligent resource management, flexible networking, and orchestration. Enhanced energy efficiency highlights the project's dedication to environmental responsibility. The potential for O-RAN and commercial 5G to work together allows for smoother network integration and communication. To encourage new entrants and maintain a healthy level of competition, innovative business models are being introduced.

**Weaknesses:** A number of weaknesses in the project's design and execution are concerning. The technology is still in its early phases of development and may require significantly more research and validation, as indicated by its low TRL. Another obstacle is the precise coordination and integration of several advanced technologies that are required by the whole NANCY ecosystem. On top of that, getting widespread implementation requires a lot of work, which in turn requires a lot of time, money, and experience. All of these things make it hard to move the project forward and make it scalable.

**Opportunities:** Given the present state of technology and regulations, the project has excellent prospects for taking advantage of a number of favourable chances. The project's expansion and adoption are being supported by numerous governments' active investments in O-RAN architecture. The global movement towards stronger privacy and security, propelled by laws like GDPR, is in perfect harmony with the project's emphasis on strong data protection protocols. Staying ahead of the curve

in telecom innovation is guaranteed by the project's alignment with the newest breakthroughs in beyond 5G and 6G technologies. In addition to satisfying the rising need for ecologically responsible technology solutions, the project's adherence to sustainable development and operational principles puts it in a strong position to succeed in a sustainability-focused market.

**Threats:** There are a number of major risks to the project's success and sustainability that need to be addressed. Some of the created components may become outdated or non-compliant due to future standards in the quickly changing telecoms industry, which could affect their continuous relevance. Market entrance and operation could be hindered by regulatory and compliance hurdles, as regional requirements vary, and legislation is always changing. Gaining momentum is already challenging enough without having to contend with well-established commercial firms, who may have more resources and a larger footprint in the industry. The project's economic model also runs the danger of being too optimistic about adoption rates in the future, which could cause expectations to be unmet and funds to be insufficient. To lessen the blow of these dangers, vigilant surveillance and well-thought-out preparation are required.

**Verdict:** The NANCY project's success hinges on taking proactive measures to address its shortcomings and risks, notwithstanding its tremendous potential and alignment with growing industry trends and regulatory frameworks. The project's full potential can only be realized by concentrated efforts towards technology maturation, ecological simplification, and realistic commercial planning.



**STRENGTH**
- Security Privacy with blockchain, quantum safety mechanisms
- Intelligent (AI) resource management, flexible networking and orchestration
- Increased energy efficiency
- Interoperability for O-RAN & commercial 5G
- Novel business models to attract new players

**WEAKNESS**
- Low TRL at the current stage
- High complexity of the complete NANCY ecosystem
- Increased effort for large scale deployment

**OPPORTUNITY**
- Focus in 0-RAN architecture (EU, USA, China)
- Push towards security and privacy by GDPR and similar legislations
- Alignments with current trends in advancements in b5g and 6g
- In accordance with sustainable development and operation principles

**THREATS**
- Future standards may impact the viability of the developed components
- Regulatory and Compliance challenges
- Competition from commercial players
- Optimistic business model for future adoption

Figure 8: NANCY Platform SWOT analysis

### 6.2.2. Initial PESTLE Analysis

PESTLE analysis is a strategic tool used to identify and analyze the external factors that can impact an organization or a project. It stands for:

1. Political: Government policies, political stability, and regulations that might affect the project.

2. Economic: Economic conditions, funding, and financial aspects that are influencing the project's success.
3. Social: Societal trends, demographics, and cultural aspects that can affect the project.
4. Technological: Technological advancements, innovation, and research and development activities relevant to the project.
5. Legal: Laws, regulations, and legal constraints that the project must adhere to.
6. Environmental: Environmental considerations, sustainability, and ecological impacts of the project.

*Political analysis*

**Regulatory Environment**: The European Union (EU) has a complex regulatory system that is known for its strict data privacy requirements, particularly the General Data Protection Regulation (GDPR). Strict compliance with these laws is essential for the successful implementation of B-RAN. Furthermore, it is crucial to take into account factors such as spectrum allocation, data protection (such as GDPR), and security standards in order to ensure compliance with the existing regulatory framework.

**Government Support**: EU member states typically demonstrate a positive attitude towards blockchain technology and digital innovations, which can lead to advantageous policies and prospective financing prospects. The European Union has constantly supported and advocated for the adoption of blockchain technology and its various potential applications. The project may benefit from significant financing prospects through financial assistance initiatives such as Horizon 2020 and the Digital Single Market Strategy.

**Political Stability**: The political stability within the European Union fosters a favorable climate for the advancement and implementation of technology initiatives. Nevertheless, the ongoing deliberations regarding digital sovereignty and cybersecurity could impact the execution of B-RAN. The political environment in Europe is frequently divided, which can provide difficulties in obtaining permission and guaranteeing consistency with the varied national policies of member states.

**Verdict**: While navigating regulatory complexities and political dynamics, B-RAN stands to benefit from supportive policies and funding opportunities within the stable EU environment, provided it adheres to stringent regulatory requirements and addresses emerging challenges effectively.

*Economic Analysis*

**Funding and Investment**: Investors are crucial in driving the progress of B-RAN ventures. The economic feasibility of the project is crucial, as it is necessary to attract investment and provide a return on investment (ROI) for stakeholders.

**Economic Conditions**: Economic conditions have a substantial influence on the level of investment in emerging technologies. Periods of economic decline can restrict the amount of capital that is accessible for such endeavors.

**Cost Efficiency**: B-RAN has the capacity to decrease expenses for telecommunications providers by distributing infrastructure, thereby resulting in economic advantages and promoting competitive pricing.

**Market Competition**: Market competition may arise from both established telecom providers and potential new entrants who leverage blockchain-based solutions, posing a substantial challenge.

**Spectrum Availability**: Spectrum availability is a crucial issue that must be taken into account for the project to succeed. The availability and cost of spectrum allotment are important considerations.

**Verdict**: B-RAN ventures show promise in reducing telecom infrastructure costs and fostering competition. However, challenges include economic fluctuations impacting investment, intense competition from established players and blockchain-based newcomers, and the critical issue of spectrum availability. Success hinges on navigating these challenges while capitalizing on B-RAN's potential economic benefits.

*Social Analysis*

**Public Perception**: The ubiquity and endorsement of blockchain technology are crucial. Erroneous beliefs regarding blockchain, namely its connection to cryptocurrencies, could hinder its widespread acceptance. Ensuring public confidence in the security and privacy of a blockchain-powered Radio Access Network (RAN) is of utmost importance.

**Digital Literacy**: The efficacy of the Blockchain-based Radio Access Network (B-RAN) relies on the level of digital literacy possessed by both the workforce and customers. Improved digital literacy can expedite the process of adopting technology at a faster pace. The initiative must focus on bridging the digital gap in order to guarantee fair and equal access to the network.

**Urban vs. Rural Adoption**: Differences in existing infrastructure and internet connectivity levels may result in varying adoption rates across urban and rural locations.

**Workforce Skills**: The project may necessitate a proficient labor force with specialized knowledge in blockchain and telecommunications.

**Verdict**: The strategic emphasis on education, perception management, and infrastructural equality has the potential to bring about positive social outcomes in the long run, notwithstanding the obstacles that must be addressed, especially in the areas of labour readiness and rural adoption.

*Technological Analysis*

**Innovation and Development**: Europe is a leading hub for technical innovation, characterized by a robust emphasis on research and development. This fosters an environment that is favorable for the progress of innovative technologies like Blockchain-based B-RAN. Given the ongoing development of blockchain technology, it is crucial for the project to consider the level of advancement and preparedness of the technology for widespread use.

**Interoperability & Scalability**: Attaining compatibility with current telecoms infrastructure and other blockchain systems is a significant technical obstacle. The blockchain network must possess scalability to accommodate a growing user base while maintaining interoperability with existing network architecture.

**Cybersecurity**: Although blockchain technology is inherently secure, its integration within a RAN setting requires the development of strong security protocols to address potential weaknesses.

**Standardization**: The lack of defined protocols for blockchain-based RANs might present considerable difficulties, requiring the creation and implementation of consistent standards to guarantee smooth integration and operation.

**Verdict**: The effective adoption of Blockchain-based Radio Access Networks will depend on resolving issues with interoperability, scalability, cybersecurity, and standardization; nonetheless, the technical landscape in Europe is conducive to innovation and development. For these advanced technology solutions to be widely adopted and operated effectively, it is essential to address all of these concerns.

*Legal Analysis*

**Data Protection Laws**: Compliance with the GDPR and other applicable data protection laws is essential. The intrinsic unchangeability of blockchain technology poses possible difficulties regarding data privacy and the right to be forgotten. The project must guarantee complete adherence to European data privacy standards, including the GDPR, and incorporate rigorous security mechanisms to protect user data.

**Intellectual Property**: Safeguarding the intellectual property linked to B-RAN technology is crucial, especially in a fiercely competitive market. It is crucial to explicitly define the ownership and licensing rights of all intellectual property created during the project.

**Telecommunications Regulations**: Ensuring adherence to both national and European Union telecommunications rules is crucial for the effective use of B-RAN technology.

**Verdict**: Attention to detail in implementing GDPR-compliant measures despite blockchain's characteristics will be crucial to ensure legal compliance throughout the project lifecycle.

*Environmental Analysis*

**Energy Consumption**: Blockchain technology sometimes necessitates significant energy resources. It is crucial to guarantee that B-RAN implementations are specifically crafted to be both energy-efficient and environmentally sustainable. This study aims to develop techniques that can effectively reduce its ecological footprint, considering the substantial energy consumption commonly connected with blockchain technology.

**E-Waste**: Like any technological undertaking, the proper handling of electronic waste and the sustainable disposal of outdated electronics is a major issue. The project must take into account the complete lifecycle of the hardware used and provide a thorough strategy for the appropriate management of electronic waste.

**Sustainable Development Goals**: Ensuring that B-RAN projects are in line with the European Union's sustainability objectives will greatly improve the project's acceptance and attract wider support.

**Verdict**: Because they are proactive in addressing energy efficiency, e-waste management, and compatibility with sustainable development objectives, these characteristics are likely to be seen favorably by the legal analysis. In addition to improving compliance with regulations, this method bolsters larger social and environmental duties, which are taking center stage in numerous legal systems.

# 7. Conclusion

This deliverable is part of WP1 'Project, Innovation & Data Management'. The main objective of this report is to present a comprehensive exploitation plan designed to facilitate the use of project results and ensure the sustainability of NANCY beyond the project's conclusion. The aim is to ensure the efficient utilization of project outcomes, creating a significant impact on academia, policymaking, and the market. Furthermore, this document outlines the initial exploitation roadmap, detailing the planning and timing while explaining the IPR intentions for each result.

The main insight from this report is that the project has produced more results than initially anticipated by the Grant Agreement and the original list of Key Exploitable Results. Specifically, there are nine additional results (OERs) that can be exploited either commercially (4 out of 9, or 44%) or non-commercially (4 out of 9, or 44%). It is important to note that one of these nine results (TECNALIA – 11%) has not yet determined the type of exploitation, as the commercial potential of this result will be assessed in a later phase of the project.

Another significant discovery is that out of the 13 KERs listed in the Grant Agreement, 9 of them (69%) have been aligned with at least one partner contributing to them, either through an independent component or by exploiting the KER as a whole. Among these, the majority of the identified and mapped KERs (6 out of 9, or 66%) are intended for individual exploitation by the partners, with only a few (3 out of 9, or 33%) planned for joint exploitation involving up to three partners at most. It's important to note that due to the low TRLs of the components contributing to the joint results, the distribution of rights among the involved partners has not been examined in this deliverable. Refinements are expected in key characteristics, and this issue will be addressed in the final version, where each partner will have a clearer understanding of their intentions, and more pertinent information on the matter will be available.

Within these 9 KERs, a total of 13 different components or results have been identified. Out of these 13, the consortium partners intend to utilize 8 of the results (61%) for commercial uptake beyond the project's conclusion, while it is anticipated that the remaining 5 (38%) will undergo non-commercial exploitation. It's noteworthy that there is alignment among partners for 2 out of the 3 KERs regarding exploitation intentions. Specifically, all three partners involved in KER #3 aim to proceed with commercial exploitation. Similarly, the two partners involved in KER #8 agree on their preference for non-commercial exploitation. However, there is a misalignment in KER #12, where VOS is exploring the commercial potential of their result, while UBITECH has stated their intentions for non-commercial exploitation.

Another important finding is that more than half of the KERs (8 out of 13, or 61%) and OERs (6 out of 9, or 66%) have not yet indicated Foreground Intellectual Property (IP) for their intended commercial exploitation. Among the results that have identified foreground protection, patents are predominant for KERs (3 out of 13, or 23%), followed by copyright (2 out of 13, or 15%). For the OERs, only copyright has been declared as a form of protection (3 out of 9, or 33%). It is important to note that without Foreground IP identification, the ownership of intellectual property rights may be unclear, potentially creating legal and commercial challenges when attempting to commercialize the results. Therefore, the absence of Foreground IP identification for some results is a significant challenge that needs to be addressed in the upcoming deliverable (D1.11 – Techno-economic Analysis and Commercialization Plans) to ensure the successful commercialization or scientific exploitation of the project results, depending on the stated intentions.

Regarding the background of the results, an updated version of what was initially agreed in the Consortium Agreement (CA) reveals that there is a lack of background protection for the majority of KERs (8 out of 13, or 61%) and OERs (8 out of 9, or 88%). Among the remaining results that are protected, copyright leads for KERs (3 out of 13, or 23%), followed by patent and license, each with one result (1 out of 13, or 8%). Specifically, VOS's results exhibit all three protection measures, with copyright being the primary one. For the OERs, only one result (1 out of 9, or 11%) has been stated to have background protection, namely copyright.

An additional interesting finding that applies to both the KERs and OERs is that the majority of Target Audience and Early Adopters are Industrial Stakeholders or Private Sector Firms in the Telecommunication and Digital Privacy sector. Another major focus group in these 2 categories are Researchers in the same fields of interest like wireless networks, AI and privacy.

It should be noted that there is still some missing or entirely absent information regarding the exploitation roadmap planning, intentions, and timing. Nevertheless, the majority of the results have demonstrated at least an initial plan for both KERs (10 out of 13, or 77%) and OERs (7 out of 9, or 77%). Many partners have declared multiple methods for implementing their related tasks.

Regarding the KERs of the project, the most selected categories were, in order (in brackets the times the methods was declared): 1. Continuous Monitoring and Improvement (5), 2. Result Refinement (5), 3. Partnerships and Collaborations (5), 4. Market Analysis (1), 5. Sales and Price Strategy (1), 6. IPR Protection (1).

Concerning the OERs of the project, the most selected categories were, in order: 1. Continuous Monitoring and Improvement (5), 2. Market Analysis (4), 3. Result Refinement (3), 4. Partnerships and Collaborations (2), 5. IPR Protection (1).

It is crucial to have these sections updated in the finalized deliverable to provide a detailed description of the intentions and actions that will be employed to exploit the project's potential from this point onward and even after the project's conclusion.

All of NANCY's assets and Key Exploitation Results are offered in this deliverable to provide a comprehensive view of the project's resources and achievements. Each partner has carefully planned how to exploit and profit from these assets. Thorough market research was conducted to identify trends and opportunities that the NANCY project might utilize for commercial success. To fully understand the business landscape, the analysis examined market dynamics, competition actions, and client needs.

Additionally, a SWOT analysis was performed to determine the NANCY project's strengths, weaknesses, opportunities, and threats. This analysis illuminated key internal and external factors affecting the project's success. Furthermore, a PESTLE analysis was conducted to examine political, economic, social, technical, legal, and environmental aspects that could affect the project's commercialization. These assessments have been instrumental in identifying barriers and potential for the NANCY project, and preparing for the challenges of bringing the project to market.

## 7.1.    Way Forward

Moving forward, as mentioned in previous parts of the deliverable, there is an updated version of this document due for the last month of the project (M36). Hence, it is expected that some refinements shall take action over the next months, particularly regarding the joint results as well as the rights protection intentions. More specifically, partners are expected to review, update or/and provide feedback on the proposals and future considerations presented in this document regarding their final exploitation activities and IPR agreements. This input will inform the development of D1.1 'Techno-economic Analysis and Commercialization Plans'.

Over the following period and until the end of the project, one of the primary issues that need to be addressed is the Joint Exploitation Potential for some or all of the project's results. To achieve this objective, the plan is to apply to the Horizon Results Booster platform (or similar platforms) to propose the most significant outcomes (2 or 3) of the project for further exploitation investigation. This application will serve as a strategic step to leverage expert insights and recommendations, ensuring that the project's results are positioned for maximum impact and utility.

Upon receiving feedback from the experts, it is imperative to meticulously address all their suggestions and refine the exploitable results to enhance their potential for commercialization and broader exploitation. This process will involve a thorough review and adjustment of the results to align with the expert recommendations, ensuring that they meet the highest standards of clarity and feasibility in terms of their market potential and risk mitigation. It will also serve as a basis for the potential of 1 joint exploitation plan.

Additionally, it is crucial to resolve any missing information or progress related to the current TRL for the finalized version of the exploitation plan. The plan must be grounded in concrete, accurate information across all relevant fields to ensure its robustness and reliability. To this end, the idea is to contact all participants with exploitable results once again, seeking any new information that could enhance or ameliorate their exploitation intentions. This step is vital to gather the latest data and insights that may have emerged since the initial information was collected.

Participants will be asked to either complete a new questionnaire from the beginning or update specific sections of their previous responses, depending on the nature of the feedback provided for the first version. This iterative process will ensure that all exploitable results are thoroughly vetted and optimized for exploitation.

Throughout this process, particularly in addressing the joint exploitation issue, regular and structured communication between key project stakeholders will be essential. This includes ongoing discussions between the Innovation Manager, the Coordinator, the Task Leader, and potentially the Technical Manager. These regular talks are designed to establish common ground regarding the approach and methods to be followed, ensuring a cohesive and coordinated effort towards resolving the exploitation challenges.

These discussions will focus on aligning strategies, sharing progress updates, and collaboratively overcoming any obstacles that may arise. By fostering a collaborative environment and maintaining open lines of communication, it is possible to ensure that all stakeholders are fully engaged and informed, ultimately leading to the successful exploitation and commercialization of the project's results. This holistic and proactive approach will maximize the impact of the project's outcomes, ensuring that they deliver tangible benefits and advancements in their respective fields.

Before concluding this section, it is crucial to address the significance of clear communication and collaboration among project partners regarding the identification, protection, and utilization of intellectual property assets for the upcoming stages of the project. Establishing transparent processes for the management of background and foreground intellectual property, as well as exploitable results, fosters trust and alignment among consortium members. Furthermore, proactive measures to handle potential conflicts or issues related to intellectual property rights early in the project lifecycle can mitigate risks and enhance the overall success of the collaboration. Effective Exploitation and IP management goes beyond mere compliance with regulations, as it entails proactive engagement, strategic planning, and ongoing communication to maximize the value of the project's results and drive innovation.

All of the above analyses and preparations show that NANCY has commercial potential. Its assets and strategic orientation match market conditions, indicating a bright future. Detailed commercialization tactics will be the next project emphasis. Refinement of the market entrance strategy, identification of target audiences, and creation of customized marketing and sales plans will be carried out. The project's assets' potential for commercialization will also be explored to optimize their value. The goal is to position the NANCY project for market success by focusing on these areas.

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## Annex A: Exploitation & IPR Management Questionnaire Template

*Introduction Section*



*Partner's Info Section*

*Exploitation Section*

| EXPLOITATION | INPUT FROM PARTNER X |
|---|---|
| **Identification of exploitable results** | |
| Does any project result, connected to the activities of your organization in the project, have potential for exploitation? | *Please select* |
| If yes, how many exploitable results can you identify? | *Please select* |
| If no, please explain why. | |
| | **Exploitable result No 1 (Title)** |

| GUIDANCE |
|---|
| |

**Project results:** Results are any tangible or intangible effects of the project's action, such as data, know-how or information, whether or not they can be protected, as well as any rights attached to them, including intellectual property rights. Project results can be reusable and exploitable (e.g. inventions, prototypes, services) as such, or elements (knowledge, technology, processes, networks) that have potential to contribute for further work on research or innovation. A **Key Exploitable Result (KER)** is an identified main interesting result which has been selected and prioritised due to its high potential to be "exploited" – meaning to make use and derive benefits- downstream the value chain of a product, process or solution, or act as an important input to policy, further research or education.

If you have identified two or more exploitable results, please copy the entire column B & C on the right side and reply to the following questions seperately for each exploitable result

## Exploitation of results

| | | |
|---|---|---|
| Please select among the available exploitable result types, the one that best matches your exploitable result. | *Please select* | *If other/more than one, please briefly explain:* |
| Please provide a title and a short description of your exploitable result, including its main features and value proposition. | *Title:*<br>*Main features:*<br>*Objectives:*<br>*Value proposition:*<br>*Advantages:*<br>*What is new:*<br>*Why is it important:* | |
| What problem your exploitable output is trying to solve? | | |
| How do you plan to address this problem with your exploitable result? | | |
| What is the intended type of exploitation (e.g. commercial, non-commercial). If other, please briefly explain. | *Please select* | *If other, please briefly explain:* |

To allow a better characterization of the project results, we have proceeded with the below grouping into 8 distinct categories.
Options: **Technological solutions** (e.g. hardware, infrastructure, equipment, product, software); **Methods** (methodologies, protocols, operational procedures, processes); **Models and algorithms; Skills and know-how** (Expertise in carrying out assessments/analyses e.g. carbon footprint, water footprint, climate risk, running models, etc.); **Guidelines and recommendations** (for policy (e.g. for legislation), society (e.g. a nutritional guide), industry, etc.); **Plans and strategies; Data; Standards** (Standardization activities).

Use approximately 150 words to describe your project result elaborating on its main features, its objectives, what is new about it, why it is important, and what needs it meets.

Use a maximum of 100 words to describe the problem you are trying to solve.
Each customer segment you identify will have a set of problems that need solving. In this box try listing one to three priority problems that each end-user segment has. Without a problem to solve you don't have a product/service to offer.
Use maximum 100 words to explain how do your exploitable output is solving this problem.
How is your product/service solving the problem? Consider the main features and benefits of your result.

Options: **Commercial exploitation - Monetization of result** (such as developing, creating, manufacturing and marketing a product or process, creating and providing a service, or in standardisation activities);
**Non-commercial - No monetization of result** (policy-making, policy advice; further research; educational purposes; etc.);
**Other** (any other possible exploitation that partners envision for their output)

## Early adopters and End-users

| Who are the main potential stakeholder groups who could be interested in this result? Please describe in detail. | *Please select* | *If more than one, please indicate:*<br><br>*Please describe your selected options:* |
|---|---|---|
| Do you have an established and maintained relationship with your intended stakeholder segment(s)? Do you have early adopters for your exploitable result? If yes, describe who they are, how they benefit from your output and their feedback regarding your result. | *Established relationship: Please select*<br><br>*Early adopters: Please select* | Please elaborate: |

You can describe customer/end-user segments. I.e. if you have chosen municipalities or ministries as your customers/end-users you could name some of the municipalities and ministries that you aim to approach.

The term early adopters refers to anyone that has used your exploitable result so far.

## Exploitation Roadmap

| What methods, tools and activities are you planning to utilize for the success of your exploitable result? In an attempt to create an initial exploitation roadmap for your exploitable result, how would you organize these activities over the project's timeline? | *Methods, tools and activities:* | Timeline:<br>- M1-MX:...<br>- MX-MY:...<br>- ...<br>- MZ-M36:... |
|---|---|---|

The methods, tools and activities intended for leveraging our exploitable result may involve a range of strategies such as:

1. Detailed market analysis: identifying target demographics, trends, and consumer needs, competition, regulatory compliance,
2. Marketing Strategies: Implementing effective marketing campaigns, including digital marketing, social media, and targeted advertising.
3. Result (Product/service/solution, etc.) refinement: continuously improving the result based on feedback received by early adopters, pilot users, and/or based on market needs.
4. Partnerships and Collaborations: Forming alliances with complementary businesses or influential entities, investors to expand reach and scale-up of the result
5. Intellectual Property Protection: Securing patents, copyrights, or trademarks where applicable to safeguard unique aspects of the offering.
6. Sales and price strategy: Deploying effective sales channels and competitive pricing for maximum market penetration.
7. Continuous Monitoring and Improvement: Regularly assessing performance metrics and making adjustments for optimization.

Please provide a timeline for each one of your planned activities, specifying their duration. (e.g., M1-M12: Identification of key stakeholders, M13-M17: Market Analysis etc).

*IPR Considerations Section*

| IPR CONSIDERATIONS | INPUT FROM PARTNER X | |
|---|---|---|
| **Ownership and protection of the results** | | |
| Is there any background Intellectual Property (IP) related to the exploitable result? If yes, | *Please select* | |
| a. Please describe backround IP | | |
| b. Is your background IP protected with some form of Intellectual Property Right (IPR)? | | |
| c. If yes please indicate how | *Please select* | *If other please specify:* |

| GUIDANCE |
|---|
| |
| **Intellectual Property** refers to the creations of the mind, such as inventions; literary and artistic works; designs; and symbols, names and images used in commerce. |
| **Backgroung IP** refers to any IP that is held by project beneficiaries before entering into the agreement and that is needed to implement the project or to exploit project results. |
| |
| Intellectual Property Rights are private legal rights that protect the creation of the human mind: inventions, literary and artistic works, and symbols, names, images, and designs used in commerce. |
| Intellectual Property Rights (e.g. patents, copyright and related rights, trade marks, trade secrets etc.). More specifically, a **patent** is an exclusive right granted for the protection of inventions (products or processes) offering a new technical solution or facilitating a new way of doing something, **copyright** (or author's right) is the term used to describe the rights that creators have over their literary, scientific and artistic works, a **utility model** is an exclusive right granted for an invention, which allows its owner to prevent others from commercially using the protected invention, without their authorisation, for a limited period of time, a **trade mark** is an exclusive right over the use of a sign in relation to the goods and services for which it is registered, a **trade secrets** agreement offers right holders protection when it comes to confidential information that can be sold or licensed, a **sui generis protection** protects the content of a database preventing the extraction and/or reuse of the whole or substantial part of its content when the structure of a database is not an original creation. For further information you may consult Your Guide to IP in Europe of The European IP Helpdesk (link https://intellectual-property-helpdesk.ec.europa.eu/system/files/2021-01/european-ipr-helpdesk-your-guide-to-ip-in-europe.pdf). |

| Are you the exclusive <u>owner</u> of the exploitable result? | *Please select* | |
|---|---|---|
| If no, please name the other partner(s) that are owner(s) of this result. | | |
| How have they contributed to the development of your exploitable output so far? | | |
| Do you intend to protect your result with some form of Intellectual Property Right (IPR)? | *Please select* | |
| If yes, please specify how. | *Please select* | If other please specify: |

Results are owned by the beneficiary that generates them. Two or more beneficiaries own results jointly if: (a) they have jointly generated them and (b) it is not possible to: (i) establish the respective contribution of each beneficiary, or (ii) separate them for the purpose of applying for, obtaining or maintaining their protection. If yes, do please check the Glossary and the GA for additional information regarding the exploitation of the result.

Have they provided you with essential input (e.g. data) for your exploitable output?

Intellectual Property Rights are private legal rights that protect the creation of the human mind: inventions, literary and artistic works, and symbols, names, images, and designs used in commerce.

Intellectual Property Rights (e.g. patents, copyright and related rights, trade marks, trade secrets etc.). More specifically, a **patent** is an exclusive right granted for the protection of inventions (products or processes) offering a new technical solution or facilitating a new way of doing something, **copyright** (or author's right) is the term used to describe the rights that creators have over their literary, scientific and artistic works, a **utility model** is an exclusive right granted for an invention, which allows its owner to prevent others from commercially using the protected invention, without their authorisation, for a limited period of time, a **trade mark** is an exclusive right over the use of a sign in relation to the goods and services for which it is registered, a **trade secrets** agreement offers right holders protection when it comes to confidential information that can be sold or licensed, a **sui generis protection** protects the content of a database preventing the extraction and/or reuse of the whole or substantial part of its content when the structure of a database is not an original creation. For further insight on the matter you may consult Your Guide to IP in Europe of The European IP Helpdesk (link https://intellectual-property-helpdesk.ec.europa.eu/system/files/2021-01/european-ipr-helpdesk-your-guide-to-ip-in-europe.pdf).