A Comparative Study of the IoT Ecosystem in Finland and Israel

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Abstract

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The Internet of Things (IoT) has fast become a major driver of innovation and economic growth in many countries, including Finland and Israel. While both countries have developed powerful IoT ecosystems, there are differences in their policies, infrastructure, and stakeholder engagement. The purpose of this comparative study is to analyze and compare the IoT ecosystems in Finland and Israel, with a focus on identifying similarities, differences, and best practices.

The objectives of this study are to analyze the current state of the IoT ecosystem in both countries, including the key policies, stakeholders, and infrastructure; compare the similarities and differences between the IoT ecosystems in Finland and Israel, with a focus on identifying best practices and areas for improvement; and eventually provide recommendations for future references that policymakers, industry leaders, and other stakeholders could use to support the growth of the IoT ecosystem in both countries, and for other countries to get inspired by, learn from and adapt the best methods suited for their own ecosystem.

The theoretical framework for this study is based on stakeholder theory, network theory, technology adoption, innovation theory, and economic theory. Data will be collected through document analysis, expert interviews, and then secondary data analysis.

The outcome of this study will be a broad and extensive analysis of the IoT ecosystems in Finland and Israel, including a comparison of their policies, infrastructure, stakeholder engagement, and innovation outcomes. The results of this study will provide valuable insights for policymakers, industry leaders, and other stakeholders on how to best support the growth of the IoT ecosystem in both countries, as well as for researchers interested in the comparative analysis of national innovation ecosystems of two exemplary countries that despite being different from each other in many ways, managed to find their way to a successful hold of the concept – creating and developing a successful and flourishing IoT ecosystem.

Overall, this comparative study aims to advance our understanding of the factors that contribute to the success of IoT ecosystems in different countries, and to provide recommendations for how policymakers and other stakeholders can support the growth of these ecosystems to drive innovation and economic growth.

Key words
IoT (Internet of Things); Ecosystem; Finland; Israel; Industry 4.0; IIoT (Industrial Internet of Things)

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1 Introduction

The Internet of Things (IoT) is an emerging technology that is transforming the way we live and work. It has the potential to drive economic growth and improve quality of life. This is a comparative study type of a bachelor's thesis for the Degree Programme in Business Information Technology in the major specialization of software engineering in the Haaga-Helia University of Applied Sciences. In this chapter I will introduce the background to this topic, as well as problem definition, research questions and objectives.

1.1 Background to the topic

The Internet of Things (IoT) is transforming the way we live and work, creating new opportunities for businesses to innovate and grow. With the escalation of connected devices, sensors, and data analytics, IoT is changing the nature of business operations, supply chains, and customer experiences. As a result, countries around the world are investing in IoT ecosystems to encourage innovation and economic growth. Finland and Israel are two such countries that have emerged as leaders in the IoT space, with strong ecosystems that support startups, research, and industry collaboration.

1.2 Problem Definition

Despite the growing interest in IoT, there is a lack of comparative studies that examine the IoT ecosystems in different countries. While there are several studies that analyze the IoT ecosystem in individual countries, there is a need for research that compares different ecosystems to provide a more comprehensive understanding of the factors that contribute to successful IoT innovation. Furthermore, the literature on the IoT ecosystem in Finland and Israel is limited, with most studies focusing on specific aspects of the ecosystem rather than providing a holistic view.

This thesis aims to address this gap in the literature by comparing the IoT ecosystem in Finland and Israel, with a focus on identifying similarities, differences, and best practices, and providing insights that can inform future policy and strategy.

1.3 Research Objectives

The overall objective of this research is to compare the IoT ecosystem in Finland and Israel and identify the factors that contribute to successful IoT innovation. Specifically, the research aims to:

- Analyze the current state of the IoT ecosystem in Finland and Israel, including the key stakeholders, policies, and infrastructure.

- Compare the similarities and differences between the IoT ecosystems in Finland and Israel, with a focus on identifying best practices and areas for improvement.
- Assess the impact of the IoT ecosystem on innovation and economic growth in Finland and Israel.
- Provide recommendations for policymakers, industry leaders, and other stakeholders to support the growth of the IoT ecosystem in both countries and other countries as well.

1.4 Research Questions

To achieve the research objectives, this thesis will address the following research questions:

- What are the key stakeholders involved in the IoT ecosystem in Finland and Israel, and how do they interact with each other?
- What policies and regulations have been implemented in Finland and Israel to support the development of the IoT ecosystem, and how effective are they?
- What is the current state of the IoT infrastructure in Finland and Israel, and how does it support IoT innovation?
- What are the similarities and differences between the IoT ecosystems in Finland and Israel, and what factors contribute to these similarities and differences?
- What impact has the IoT ecosystem had on innovation and economic growth in Finland and Israel?
- What recommendations can be made for policymakers, industry leaders, and other stakeholders to support the growth of the IoT ecosystem in both countries?

1.5 Table 1: Overlay Matrix

Research Question	Research Objective	Theoretical Framework Components	Research Methods
IQ 1. What are the key stakeholders involved in the IoT ecosystem in Finland and Israel, and how do they interact with each other?	Analyze the current state of the IoT ecosystem in Finland and Israel, including the key stakeholders, policies, and infrastructure.	Stakeholder theory, network theory	Document analysis, expert interviews
IQ 2. What policies and regulations have been implemented in Finland and Israel to support the development of the IoT ecosystem, and how effective are they?	Compare the similarities and differences between the IoT ecosystems in Finland and Israel, with a focus on identifying best practices and areas for improvement.	Policy analysis, comparative analysis	Document analysis, expert interviews
IQ 3. What is the current state of the IoT infrastructure in Finland and Israel, and how does it support IoT innovation?	Analyze the current state of the IoT infrastructure in Finland and Israel.	Technology adoption, innovation theory	Document analysis, expert interviews
IQ 4. What are the similarities and differences between the IoT ecosystems in Finland and Israel, and what factors contribute to these similarities and differences?	Compare the similarities and differences between the IoT ecosystems in Finland and Israel, with a focus on identifying best practices and areas for improvement.	Comparative analysis, innovation theory	Document analysis, expert interviews
IQ 5. What impact has the IoT ecosystem had on innovation and economic growth in Finland and Israel?	Assess the impact of the IoT ecosystem on innovation and economic growth in Finland and Israel.	Innovation theory, economic theory	Expert interviews, secondary data analysis
IQ 6. What recommendations can be made for policymakers, industry leaders, and other stakeholders to support the growth of the IoT ecosystem in both countries?	Provide recommendations for policymakers, industry leaders, and other stakeholders to support the growth of the IoT ecosystem in both countries.	Policy analysis, stakeholder theory	Document analysis, expert interviews

1.6 Key Concepts

Key concept IoT (Internet of Things) refers to the connection of everyday objects to the internet, enabling them to send and receive data. It is a network of physical objects, vehicles, buildings, and other items embedded with electronics, software, sensors, and network connectivity, that enables them to collect and exchange data (Bandyopadhyay & Sen, 2011).

Key concept Ecosystem refers to a network of interconnected elements or components that interact with each other in a particular environment. In the context of IoT, the ecosystem can refer to the network of devices, software, platforms, and services that support the deployment, management, and utilization of IoT applications (Gubbi et al., 2013).

Key concept Connectivity refers to the ability of IoT devices to connect and communicate with other devices, systems, or platforms. Connectivity can be achieved through different means, such as wired or wireless networks, protocols, and standards. It is a critical aspect of IoT, as it enables the exchange of data between devices and systems (Bandyopadhyay & Sen, 2011).

Key concept Digitalisation refers to the process of converting information from analog to digital form. It involves the use of digital technologies to create, store, process, and transmit information. Digitalisation enables new business models, services, and products, and has been a key driver of economic growth and productivity (Brynjolfsson and McAfee, 2014).

Key concept Smart Cities refers to a city that uses digital technologies to enhance its infrastructure, services, and quality of life for its residents. It involves the deployment of IoT sensors, devices, and platforms to collect and analyze data in real-time, enabling better decision-making, optimization of resources, and improved citizen engagement (Caragliu, 2011).

Key concept Cybersecurity refers to the practice of protecting computer systems, networks, and data from unauthorized access, theft, damage, and other forms of cyberattacks. Cybersecurity is critical for ensuring the integrity, confidentiality, and availability of information in the IoT ecosystem (Kagermann, 2013).

Key concept Industry 4.0 refers to the fourth industrial revolution, characterized by the integration of advanced technologies such as IoT, artificial intelligence, and robotics in the manufacturing sector. Industry 4.0 aims to create Smart Factories that are more efficient, productive, and flexible (Kagermann, 2013).

2 Theoretical Background

In this chapter I will give a definition of the concept of IoT and IoT ecosystem, as well as some important, relevant terms and names of features or functions that are related to the concept. I will explain through key points how it came to be, what exactly it is, and its impact on various aspects of life, giving examples from its involvement in our day-to-day activities, industries, and so forth. I will introduce the IoT ecosystem of Finland and Israel, respectively, while I touch pinpoints regarding how these countries, despite being distant from each other physically, and different from each other culturally, are implementing the innovative mindset into their reality.

2.1 Overview on IoT, Finland, and Israel

The Internet of Things (IoT) has become a major trend in recent years, with the ability to connect devices, sensors, and various other objects, tools, and devices to the internet and enable data exchange and automation. This has significant implications for businesses, as it can improve operational efficiency, create new business models, and enhance customer experience. Finland and Israel are two countries with strong technology industries that have been early adopters of IoT, making them good case studies for exploring the potential of IoT for business development.

IoT ecosystem refers to the interconnected network of devices, sensors, and systems that communicate and exchange data with each other. It encompasses various elements such as hardware, software, connectivity, security, and applications that enable the smooth functioning of the IoT environment. Atzori et al., (2010) claimed that “The IoT has the potential to add a new dimension to this process by enabling communications with and among smart objects, thus leading to the vision of anytime, anywhere, anymedia, anything communications.” While according to the IERC (IoT European Research Cluster), IoT can be defined as "a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual things have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network".

In the context of Finland, the IoT ecosystem has been growing rapidly over the past few years. According to a study by Business Finland (2020), Finland has a strong innovation ecosystem that fosters collaboration among companies, academia, and research institutions. This has resulted in the development of various IoT technologies and solutions such as smart cities, healthcare, and industrial applications. Additionally, the Finnish government has been supportive of IoT initiatives and has introduced various policies to promote innovation in the field.

Similarly, Israel has also emerged as a strong player in the global IoT market. According to a report by Deloitte (Tidhar et al., 2018), Israel has a thriving startup ecosystem that has produced several successful IoT companies. Israel's strengths lie in its technological capabilities, particularly in the areas of cybersecurity and artificial intelligence. The government has also been supportive of IoT initiatives and has introduced various policies to encourage innovation and entrepreneurship.

The IoT ecosystem is a dynamic and evolving network of devices and systems that communicate and exchange data with each other. Finland and Israel are both strong players in the global IoT market, with unique strengths and capabilities in different areas of the ecosystem.

2.1.1 Government Initiatives

In both ecosystems, there is financial and creative support of industry by the government. Giving encouragements and incentives to both the public and the private sectors through opportunities to create, develop, as well as receive fundings and mentoring from other key players in the field, conventions, massive scale events both national and international (“Slush” in Finland or “II4” in Israel).

Finland’s IoT ecosystem benefits from a supportive government that recognizes the potential of IoT in driving economic growth and societal well-being. As a socialist country, the ethical code that the Finnish government is following is “we are as strong as our weakest link” which drive the government to support the development of all the different areas of the country equally, investing in digital development, funding, coaching and even relocation incentives in the form of tax relives and grants in order to bring new, hi-tech solutions into all segments of the population, and in every part of the country, in many different ways, e.g. by establishing different programs for different socioeconomic statuses, or running different networks of ICT operators in different regions according to the region’s needs while considering academic institutions in the area, and natural and technological assets and liabilities of it. The "Digital Finland 2025" initiative, launched in 2016, outlines a comprehensive strategy to foster digitalisation and its different aspects, including IoT and IIoT (Mäntylä, 2017). Mäntylä (2017), illustrates the possible scopes of digital solutions in companies in these perspectives (adopted from Hanski et al., 2018):

- “Bottom-up” - IoT focusing on operational benefits inside a company.
- “Customer oriented” - IoT focusing on new functionality and services for users.
- “Digital twin oriented” - IoT coupled with advanced machine learning, AI, and simulation.
- “Value chain oriented” - IoT focusing on benefits in logistics chains across companies.

This program alongside others (e.g., the many different incubators and accelerators in the health sector in the Helsinki metropolitan area alone, Kurmanaviciute, 2021) are a proof that the Finnish government has allocated substantial funding to research and development (R&D) projects (e.g., 5G R&D), facilitating collaboration between academia, industry, and public establishments, sometimes even fusing them into one. On top of all those, Finland's commitment to data privacy, information protection and security has reinforced believe in IoT solutions, significant and even crucial for widespread broad adoption and broad appropriation.

In Israel, the government has played a pivotal role in nurturing the IoT ecosystem. While might derive its motivation or need not necessarily from a social point of view, but a homeland security and sometimes more capitalist approach, The Ministry of Economy and Industry's "Digital Israel" initiative has set ambitious goals for IoT development, emphasizing on fostering innovation and entrepreneurship. Government-backed investment programs and incentives have encouraged startups and established companies to invest in IoT R&D, placing Israel as one of the top countries in IoT experimentation and implementation in the world. From military industries to large contribution in the private sector (e.g., the food industry, farming and agriculture, renewable energy, the pharma industry and biotech) in the form of grants and fundings, as well as publications and reforms of the data collection and storage used by the government itself; A good and unique example for that is the INDA – Israel National Digital Agency, an independent authority that was created and is funded by the government and pilots and promotes a number of diverse projects with the aim to steer a course to a simple, unified, safe, proactive, personalized and accessible public service for everyone – while leveraging the digital revolution to promote sustainable social and economic growth and strengthen public trust in the Government. Israel's emphasis on cybersecurity has also positioned it as a global leader in IoT security solutions with key players like Sternum that started as a project of the intelligence unit 8200 of the Israeli Defense forces before eventually going private in 2018. After receiving the appropriate funds and R&D playroom from the government, Sternum became an Israeli startup that provides an agentless IoT security solution that offers run-time protection for low-resource IoT devices. The startup’s Embedded Integrity Verification (EIV) module uses a patented algorithm to detect flaws, monitor and block attacks, and provide enhanced tracing and logging for real-time analytics without network access or patchwork. Deployed on over 100K IoT devices by 2019, and granted three security patents for flow integrity, code, and memory protection while expending to the EU and US by 2022, the startup’s solution ensures zero or minimum disruptions in IoT devices in hospitals, manufacturing units, and smart cities.

2.1.2 Research and Development (R&D)

As mentioned in the previous section, the Research and Development (R&D) landscape is being boasted by both countries on a vast spectrum from research institutions and universities to companies and start-ups that actively engaged in IoT-related projects.

The Finnish IoT community collaborates on interdisciplinary research, addressing challenges from sensor technology to data analytics. Renowned institutions like Aalto University and VTT Technical Research Centre of Finland have been at the forefront of IoT innovation, contributing to the development of innovative technologies.

Israel's IoT R&D vibrant ecosystem is marked by a strong emphasis on innovation and entrepreneurship. The country's renowned universities, such as the Technion - Israel Institute of Technology, have produced groundbreaking IoT research. Notably, Israel's thriving startup culture has led to the emergence of numerous IoT-focused startups, which often spin off from academic research. These two ecosystems' agility and adaptability have positioned both Finland and Israel together and separately, as global hubs for IoT innovation.

2.1.3 Start-up Ecosystem and Industrial Applications

Finland's start-up ecosystem is blooming, with numerous IoT startups gaining recognition on the global stage. The IoT ecosystem has found significant traction in industrial applications, particularly within the maritime and manufacturing sectors. Companies like Wärtsilä leverage IoT technologies to optimize ship operations, while KONE employs IoT for elevator and escalator maintenance. The adoption of IoT in these sectors has increased efficiency, reduced costs, and improved sustainability.

The startup accelerator, IoT Forge, has played a pivotal role in nurturing IoT startups by providing mentorship and funding opportunities. Notable Finnish IoT startups include Wirepas, a pioneer in IoT connectivity solutions, and Enevo, specializing in waste management optimization through IoT.

Israel's IoT ecosystem is characterized by a diverse range of applications, including agriculture, healthcare, and smart cities. Innovations such as precision agriculture solutions from companies like Taranis and IoT-based healthcare devices from TytoCare demonstrate the broad spectrum of IoT applications. The Israeli ecosystem's versatility is a testament to its ability to address various global challenges through IoT technology. The country's startup ecosystem is renowned for its agility and ability to scale rapidly. IoT-focused accelerators like the ADI IoT Ignition Lab provide crucial

support to startups. Companies like Seebo, offering an AI-powered IoT platform for manufacturers, exemplify Israel's capacity to produce globally competitive IoT startups. Israel's access to international markets through its start-up ecosystem has been a key driver of success.

2.1.4 Overview Comparison Conclusion

It is interesting to witness, how despite the physical distance between Israel and Finland and the differences in spiritual perceptions of more abstract concepts such as work ethics, motivational drives, or even practical varieties of different courses of action while executing one program or another, it is clear that Finland and Israel both exhibit thriving IoT ecosystems, driven by government support, robust R&D activities, diverse industrial applications, and vibrant startup cultures. It is possible to conclude that these four elements combined are creating an important key, a foundation to Israel and Finland’s global success in the field.

Despite similar world-renowned success there are number of ways we can distinguish one country from the other: while Finland excels in industrial applications and collaboration, Israel shines in its entrepreneurial and ambitious spirit and adaptability. By comparing these ecosystems, we can extract valuable insights for IoT development strategies globally.

The success of Finland and Israel in fostering IoT innovation underscores the importance of a comprehensive approach that combines government policies, research excellence, industrial partnerships, and a fully supportive start-up ecosystem.

2.2 Industry 4.0 Overview

Industry 4.0 is the fourth industrial revolution, marked by the integration of advanced technologies into the manufacturing industry. It is a transformative process that involves the digitization and automation of manufacturing processes, resulting in improved efficiency, flexibility, and cost savings. This academic overview examines the pursuit of Industry 4.0 initiatives in Finland and Israel, emphasizing their respective government-led programs and unique strengths and provides a comparative analysis of their Industry 4.0 in the mentioned fields. Finland and Israel are both actively pursuing Industry 4.0 initiatives, recognizing its potential to boost economic growth and competitiveness.

2.2.1 Industry 4.0 Initiatives in Finland and Israel

Finland technology sector is well known, and for several years already multiple initiatives emerged to advance Industry 4.0. An example of these initiatives is Industry 4.0 Smart Factory. This concept

encourages players from different fields such as universities, research institutes, and the companies themselves to develop and test new Industry 4.0 technologies in factories and different manufacturing processes, thus making traditional lines of work, “smarter”. Testing and implementation of various applications of Industry 4.0 elements such as IoT analytics running on Edge cloud (Nokia’s Oulu Factory) and more (e.g., Etteplan’s Smart Factory Solutions, Aalto University’s Aalto Factory of the Future) are being recognized by the country and the global community already. It creates a real-world sandbox of innovation by cultivating development and giving stage for experimentation and refinement. Another initiative is the Digitalisation theme, which is described by Wirén et al., (2019): “Digitalisation is a cross-cutting theme of the strategic programme of Prime Minister Juha Sipilä's Government. Constructing a growth environment for digital business has been set as a key project of the programme, which is aimed at creating a regulatory environment and other conditions supporting innovation and service creation.”.

Israel is also making strides in Industry 4.0, particularly in the areas of cybersecurity and data analytics. The Israeli government has established several programs to support Industry 4.0 innovation. Industry 4.0 and Digital Transformation Fund and the Innovation Authority provide funding and resources to inspire Industry 4.0 development and keep it fresh and in constant movement forward. These programs fuel research, development, and deployment of cutting-edge technologies in manufacturing. In addition, Israel has a strong and vibrant startup culture, which plays a pivotal role in the constant advancement in Industry 4.0. Many emerging companies in Israel are focused on creating novel Industry 4.0 technologies, leveraging their agility and adaptability to drive innovation. This ecosystem provides fertile ground for experimentation and rapid development, and this is just the beginning.

2.3 Industrial IoT (IIoT), Network Technologies and Key Components of IIoT

The Industrial Internet of Things (IIoT) is a rapidly growing technology that is transforming industrial processes around the world. In Finland and Israel, IIoT is being implemented in a variety of industries, including manufacturing, logistics, and energy. Finnish companies have been leaders in the IIoT field, with companies like Konecranes and Wärtsilä developing innovative IIoT solutions for their customers. Israel is also emerging as a hub for IIoT innovation, with startups like Augury and Seebo developing predictive maintenance solutions that use IIoT sensors and machine learning algorithms to optimize industrial processes. This growing prominence of IIoT technology in both Finland and Israel highlights their commitment to staying at the forefront of industrial innovation.

In Finland, initiatives Digitalisation and general push towards a certain concept goal (Smart factory/city etc.) have encouraged collaborative research and development efforts, facilitating the creation of cutting-edge IIoT applications. Similarly, in Israel, government-led programs like Industry 4.0 and Digital Transformation Fund and the Innovation Authority have played a significant role in fostering IIoT innovation. The vibrant startup culture in Israel has also contributed significantly to IIoT development, with companies like Augury and Seebo exemplifying the nation's capacity to harness technology for industrial optimization.

The adoption of IIoT in Finland and Israel is driven by a desire to improve efficiency, reduce costs, and increase productivity in industrial operations. As IIoT technology continues to mature, it is expected to play an increasingly important role in shaping the future of industrial processes in Finland, Israel, and around the world. The synergy between their efforts and the integration of IIoT into various sectors will likely pave the way for even more sustainable, data-driven, and innovative industrial practices.

2.3.1 Key Network Technologies of IIoT

1. **Ethernet:** Ethernet remains a robust and reliable choice for connecting devices within industrial environments. It is particularly valuable for fixed installations and scenarios where high-speed, stable communication is essential. A reliable and cost-efficient networking solution. (Mudoi, U., 2016).
2. **Wireless Communication:** Wireless technologies are predominant in IIoT due to their flexibility and scalability. Wi-Fi, Bluetooth, Zigbee, and cellular networks are commonly used for connecting devices and transmitting data (Presher, A., 2022). As an example, we can differentiate that Wi-Fi is suitable for high-speed data transfer within confined areas, while cellular networks provide broader coverage.
3. **Low-Power Wide-Area Networks (LPWANs):** LPWAN technologies like LoRaWAN (an LPWAN protocol built on top of the LoRa radio modulation technique) and NB-IoT (narrowband IoT) are designed for long-range communication with low power consumption. They are particularly well-suited for applications where devices need to transmit data over extended distances while conserving energy (Md. Noor-A-Rahim et al., 2022).
4. **Security Protocols:** Security is at utmost priority in IIoT, given the sensitive nature of industrial data. Robust security protocols encompass encryption, authentication, access control, and regular software updates to protect against cyber threats (Neuron Team, 2023).

5. **Mesh Networks:** Mesh network topologies are deployed in IIoT to enhance network resilience and redundancy. Devices in a mesh network can relay data through one another, creating self-healing networks capable of withstanding device failures (Presher, A., 2022).
6. **Fog and Edge Computing:** Edge computing is essential in IIoT applications where real-time processing and low latency are crucial. Edge devices, including gateways and controllers, process data locally, reducing the need for transmitting data to distant cloud servers (Shams Forruque, A. et al., 2023). This approach is beneficial for applications like autonomous manufacturing cells.

2.3.2 Key Components of Industrial IoT (IIoT)

1. **Sensors and Devices:** IIoT relies on a wide array of sensors and devices that capture and transmit data from the physical world to digital systems. These sensors can monitor a diverse range of variables such as temperature, humidity, pressure, vibration, and chemical composition (Neuron Team, 2023). For example, in manufacturing, sensors attached to machinery can provide real-time data on equipment performance and wear and tear.
2. **Connectivity:** Seamless connectivity is one of the cornerstones of IIoT, enabling data exchange between devices and centralized systems. Various communication protocols and technologies are harnessed and used, including Wi-Fi, Bluetooth, Zigbee, and cellular networks (2G, 3G, 4G, and 5G) (Neuron Team, 2023). The choice of connectivity depends on factors like expenses, range, data rate, and power consumption.
3. **Cloud Computing:** Cloud-based platforms serve as the backbone for storing, processing, and managing the immense data streams generated by IIoT devices. Cloud solutions provide scalability, accessibility, and the ability to access data from virtually anywhere (Neuron Team, 2023). This cloud infrastructure is essential for IIoT's scalability and remote monitoring capabilities.
4. **Data Analytics:** IIoT produces endless volumes of information. That data and data analytics, including machine learning and artificial intelligence, play a major role in making sense of this information. These technologies can uncover patterns, anomalies, and trends within the data, enabling predictive maintenance, process optimization, and informed decision-making (Neuron Team, 2023).
5. **Edge Computing:** In certain IIoT applications, edge computing is employed to process data locally, closer to the data source or in other words, the "edge" of the network. This approach minimizes latency, reduces bandwidth usage, and allows for real-time decision-making (Shams Forruque, A., et al., 2023). Edge devices, such as gateways and controllers, enable this localized data processing.

2.3.3 In Summary

IIoT's key components and network technologies work in concordance to revolutionize industrial processes and mechanical forms. These advances empower the collection of endless amounts of information and relevant data, its investigation and analysis for significant bits of knowledge and valuable insights, and the secure and proficient exchange of data inside industrial settings. The compelling integration of these components and technologies holds colossal potential for improving efficiency, lessening operational costs, and empowering data-driven decision-making in different businesses and industries.

2.4 Bluetooth and its Use in IoT and IIoT

Bluetooth is a wireless communication technology standard that facilitates short-range data exchange between devices, most commonly between fixed and mobile devices. It operates in the 2.4 GHz ISM (Industrial, Scientific, and Medical) band and is characterized by its low power consumption, making it suitable for various applications, including IoT and IIoT. Bluetooth supports various versions, with Bluetooth Low Energy (BLE) being particularly relevant for IoT and IIoT due to its power efficiency.

IoT applications can be seen in a variety of fields, for instance, in smart home devices. Bluetooth is commonly utilized in smart home IoT devices such as smart speakers, lightning frameworks, and door locks. Its low power consumption and compatibility with smartphones make it an ideal choice for connecting and controlling these devices. Another example is the health and wearables sector: Bluetooth can be seen playing a significant role in connecting a variety of health and fitness wearables to smartphones and other IoT devices. These wearables can monitor vital signs and collect data for analysis. Bluetooth is also used in logistics and supply chain management by being applied for asset tracking in various industries, allowing real-time location tracking of valuable items.

IIoT applications are being used in a similar fashion but for different purposes: in industrial settings, Bluetooth sensors are used to monitor the condition and liability of machinery, tools, and equipment. By detecting issues like vibration or overheating, Bluetooth is enabling predictive maintenance and asset monitoring in manufacturing. Like wearable fitness gear, IIoT applications, Bluetooth-enabled wearables providing real-time location tracking, emergency alerts in dangerous working environments and generally boost the workers safety.

2.5 WLAN (Wireless Local Area Network)

WLAN, often referred to and commonly known as Wi-Fi, is a technology that enables wireless connectivity to the internet or other devices within a local area, such as a home, office, or public spaces like school or shopping center. Wi-Fi uses radio frequency signals to transmit data between devices, allowing for wireless internet access and communication between devices like smartphones, laptops, and smart home appliances like television sets, laundry machines, sound systems and even floor heating and sauna stoves (“kiuas” in Finnish). WLAN networks are based on the IEEE 802.11 family of standards, which define several different physical layers and media access control (MAC) protocols. The most common WLAN standard is IEEE 802.11b, which provides a maximum data rate of 11 Mbps. Newer WLAN standards, such as IEEE 802.11g and IEEE 802.11n, offer higher data rates and support more users (Computer Security Resource Center, National Institute of Standards and Technology, 2017).

While the foundational research and development of Wi-Fi technology occurred primarily in the United States, Israel has been a hub for innovation in wireless technologies. Israeli companies and researchers have made substantial contributions to Wi-Fi technology, including the development of advanced chipsets, security protocols, and optimization techniques. Israel is home to several companies specializing in wireless communication technology, which have played pivotal roles in advancing Wi-Fi technology (Global Expansion, 2022). Israeli companies such as Mobileye and Wi-Fi Alliance are developing innovative WLAN technologies. Finnish companies such as Nokia are also developing and manufacturing WLAN equipment.

2.6 LTE Network (Long-Term Evolution)

LTE is a standard for high-speed wireless communication and mobile broadband. It is commonly associated with 4G and 5G cellular networks, providing faster data transfer rates compared to older 2G and 3G networks. LTE enables mobile devices to access the internet, stream media, make video calls, and more. LTE networks are based on the IEEE 802.16e standard, which offers a maximum data rate of 300 Mbps. LTE networks are also more efficient than previous cellular network technologies, and they can support more users per cell.

Finland and Israel are both among the first countries in the world to deploy LTE networks. In Finland, LTE is now widely used by mobile operators, and it is available in most major cities and towns. In Israel, LTE is also widely used, and it is also available in rural areas. One of the best examples of international fame in the field is the Finnish company Nokia: Finland is globally recognized for its contributions to the development of cellular networks and mobile communications

through Nokia, a Finnish multinational corporation, which has been a global leader in the telecommunications industry for decades. It played a pivotal role in the development and standardization of GSM (Global System for Mobile Communications), which served as the foundation for modern cellular networks, including LTE (4G) and following future generations like 5G (Nokia, 2021). Universities and research institutions in Finland have been actively studying wireless communication. They have contributed to the advancement of communication protocols, antenna technologies, and network optimization techniques, all of which are integral to the development of wireless networks, including Wi-Fi and cellular networks (Wirén et al., 2019).

2.7 ESP-NOW and ESP32

ESP-NOW is a peer-to-peer (P2P) wireless communication protocol defined by Espressif Systems, which enables the direct, quick, and low-power control of smart devices, without the need of a router. ESP-NOW can work with Wi-Fi and Bluetooth LE (Low Energy), and supports the ESP8266, ESP32, ESP32-S and ESP32-C series of SoCs. It's widely used in smart-home appliances, remote controlling, sensors, etc. (Espressif, ESP-NOW, 2023).

The ESP32 is a popular low-cost, low-power microcontroller module developed by Espressif Systems as well. It is widely used in IoT and embedded systems projects for several reasons: it is powerful, flexible, and affordable. The ESP32 is known for its versatility and features, including Wi-Fi and Bluetooth connectivity, dual-core processing, low power consumption, and a wide range of GPIO (General-Purpose Input/Output) pins for interfacing with sensors and other hardware.

ESP32 is supported by a wide range of development tools and libraries, making it easy to get started with development. ESP32 is also supported by a large and active community of developers, who provide support and resources for ESP32 users. In short, ESP32 is a feature-rich MCU (microcontroller unit) with integrated Wi-Fi and Bluetooth connectivity for a wide-range of applications (Espressif, ESP32, 2023).

2.8 STM32

STM32 is a family of 32-bit microcontrollers developed by STMicroelectronics. STM32 microcontrollers are available in a wide range of configurations and applications, with different features and performance levels. STM32 microcontrollers are popular for a variety of fields, including IoT, industrial automation, and consumer electronics.

STM32 microcontrollers come in various series, each designed for specific use cases, and they offer a variety of features such as real-time operating system (RTOS) support, extensive peripheral options, and low-power modes.

2.9 Arduino IoT

Arduino IoT refers to the use of Arduino microcontroller platforms for building, developing, and deploying IoT applications. Arduino IoT is based on the Arduino open-source electronics platform, and it provides a variety of hardware and software tools for developing IoT applications. Arduino offers a range of hardware and software tools that simplify the development of IoT projects. Arduino boards are equipped with various sensors, communication modules (Wi-Fi, Ethernet, Bluetooth), and a user-friendly programming environment. Arduino IoT projects can include smart home automation, environmental monitoring, and more.

2.10 In Summery

WLAN (Wi-Fi) and LTE networks provide wireless connectivity for internet access, while ESP-NOW is a protocol for low-power, peer-to-peer (P2P) communication between ESP8266 or ESP32 microcontroller modules. ESP32 and STM32 are microcontroller platforms used in IoT and embedded systems, with the former offering integrated (hybrid) Wi-Fi and Bluetooth capabilities in one chip. Arduino IoT refers to the use of Arduino microcontroller boards and software for creating IoT applications, leveraging a user-friendly development environment and a variety of hardware options.

3 Research Methods

In this chapter I will explain my research methods, why I chose them and how I used them in my research. To achieve the research objectives and answer the research questions, a mixed-methods approach was used. This approach involves using both qualitative and quantitative data collection and analysis techniques. The methodology is designed to ensure that the research is comprehensive, thorough, and reliable.

3.1 Data Collection and Analysis Methods

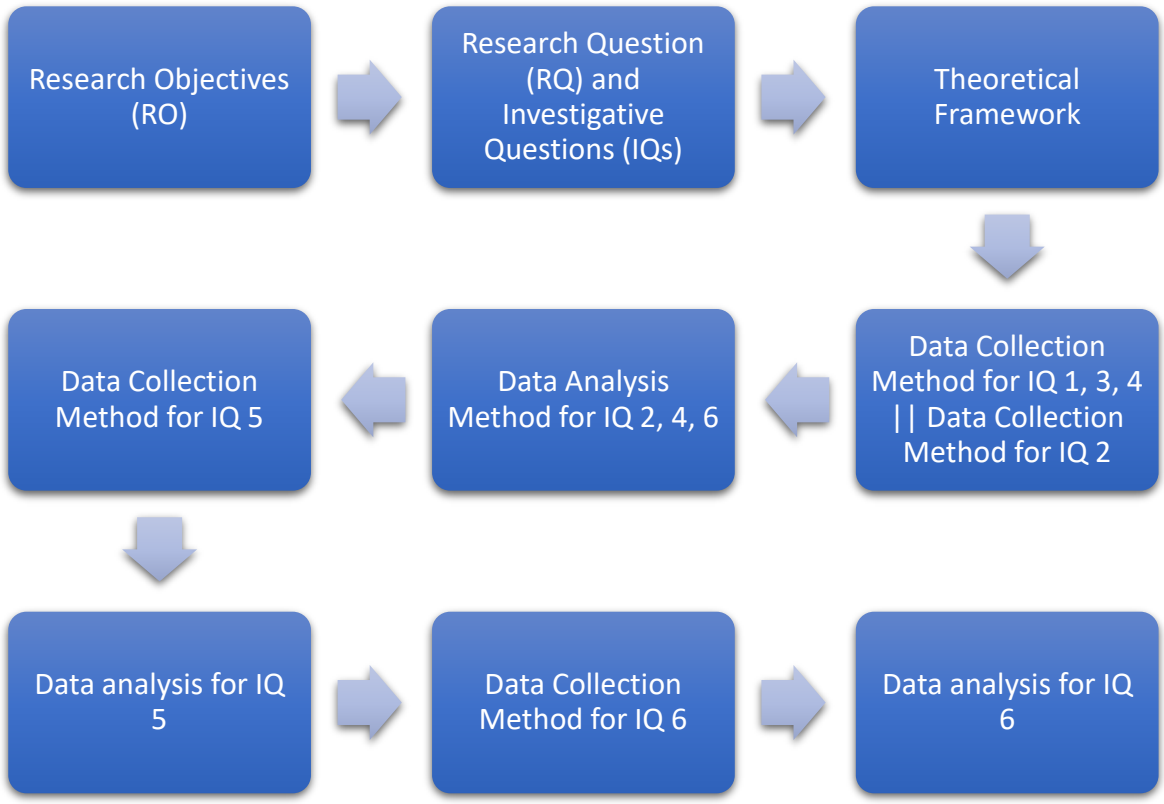
To answer the research questions, a mixed-methods approach was utilized in this study. The research employed document analysis and expert interviews as data collection methods. The document analysis involved a review of policy documents, reports, and other relevant materials to identify policies and regulations that have been implemented in Finland and Israel to support the development of the IoT ecosystem. The review was guided by the policy analysis framework proposed by Sabatier and Mazmanian (1980) and included a content analysis to identify key themes and patterns in the data.

The expert interviews were conducted with key stakeholders involved in the IoT ecosystem in Finland and Israel to gain insights into their perspectives on the current state of the ecosystem, policies and regulations, and infrastructure. The interviews were semi-structured, and the interview questions were developed based on the research questions and the theoretical framework. The stakeholder theory and network theory were used as a theoretical framework to guide the analysis of the data.

The data collected from the document analysis and expert interviews will be analyzed using a mixed-methods approach. The data from the document analysis will be analyzed using quantitative methods, including descriptive statistics and regression analysis. The data from the expert interviews will be analyzed using qualitative methods, including content analysis and discourse analysis.

The strengths of the mixed-methods approach include the ability to collect both quantitative and qualitative data, which allows for a more comprehensive understanding of the research topic. Additionally, the use of multiple data sources and methods enhances the validity and reliability of the findings (Creswell & Plano Clark, 2018).

3.2 Figure 1: Visual Representation of the Research Methods



4 Analysis of the current state of the IoT ecosystem in Finland and Israel

The Internet of Things (IoT) has been a rapidly growing field in recent years, with the potential to revolutionize the way we live, work, and interact with our environment. The IoT ecosystem involves a variety of stakeholders, including government agencies, businesses, and consumers, all of whom interact with each other in many ways. In this chapter, I will analyze the current state of the IoT ecosystem in Finland and Israel, including the key stakeholders, policies, and infrastructure. The IoT ecosystem in both Finland and Israel is comprised of a variety of stakeholders, each of whom plays a unique role in the development and implementation of IoT technologies.

4.1 An in-depth analysis of the IoT Ecosystem in Finland

Finland has a thriving IoT ecosystem, supported by a few key stakeholders including government agencies, private companies, research institutions, and academic organizations. The Finnish government has been particularly supportive of the development of IoT technologies, with several policies and initiatives aimed at promoting the adoption and implementation of these technologies.

One of the key government agencies involved in the IoT ecosystem in Finland is the Finnish Innovation Fund (Sitra), which provides funding and support for innovation projects related to IoT. Sitra has played, and still playing, a particularly important role in supporting the development of IoT technologies in Finland, with a few initiatives aimed at promoting the adoption of IoT technologies in various sectors of the economy.

In addition to Sitra, there are a few private companies in Finland that are involved in the development of IoT technologies. Nokia, the Finnish telecommunications colossus, for example, has been actively involved in the development of 5G technology, which is viewed as a key empowering influence for the far and wide execution of IoT innovations and technologies. Other companies involved in the development of IoT technologies in Finland include Kone and Wärtsilä.

Research institutions and academic organizations have also played an important role in the development of the IoT ecosystem in Finland. The VTT Technical Research Centre of Finland, for example, has been involved in research projects related to IoT, including the development of IoT-based solutions for smart cities and the integration of IoT technologies in industrial processes.

In terms of policies and infrastructure, Finland has taken several steps to help the turn of events and execution of IoT innovations. The Finnish government has carried out various drives pointed

toward advancing the reception of IoT, including the “IoT Finland” program, which provides financing and backing to IoT new businesses, startups, projects, and activities.

In addition to these initiatives, Finland has invested in the development of a robust 5G infrastructure, which is essential for the widespread implementation of IoT technologies. According to a report by the Finnish Transport and Communications Agency, “The 5G Momentum ecosystem, which was created in cooperation with the agencies in the administrative branch, has enabled the creation of new types of innovation and experimentation projects, created new types of networks, and shared operating models. We organized the world’s first 5G Hackathon to create a new way of verifying the development of information security in 5G technology.” (Finnish Transport and Communications Agency Traficom, 2019).

Overall, the IoT ecosystem in Finland is characterized by a high degree of collaboration and cooperation between the various stakeholders involved. This has helped to encourage innovation and the development of new technologies, while also ensuring that these technologies are implemented in a way that benefits all stakeholders involved. As the field of IoT continues to grow and evolve, it is likely that the role of these stakeholders will continue to evolve as well, with new players entering the market and new opportunities emerging for innovation and growth.

4.2 An in-depth analysis of the IoT Ecosystem in Israel

Israel has a strong and thriving technology industry, and the nation has arisen as a key part in the worldwide IoT ecosystem. In recent years, the Israeli government has implemented strategies and initiatives pointed towards advancing the development and reception of IoT technologies, and the country is home to many innovative startups as well as established companies in the field.

One of the key factors contributing to Israel's success in the IoT playground is the country's strong culture of innovation and entrepreneurship. Israel has a highly skilled workforce, with a variety of engineers and technical professionals, in addition to a strong culture of collaboration and knowledge sharing. This has helped to create fertile ground for the development of new ideas and innovative technologies and has led to the creation of a thriving startup ecosystem.

The Israeli government has also been active in promoting the development of IoT technologies. In 2017, the government launched a five-year plan aimed at supporting the development of IoT and other arising advances. The plan includes funding for research and development projects, as well as tax breaks and other inducements for companies involved in the development of IoT technologies.

In addition, the Israel Innovation Authority, a government agency responsible for advocating and nurturing innovation and entrepreneurship, has provided funding and support for a vast range of IoT startups and projects. The Authority has also established several technology incubators and accelerators nationwide, aimed at supporting early-stage startups and helping them to bring their products and services to advertise.

One of the key strengths of the Israeli IoT ecosystem is the country's strong focus on security and privacy. As the use of IoT technologies becomes more popular and accessible, there is a growing concern about the potential security risks associated with these technologies. In response, the Israeli government and industry have fostered a couple of cutting-edge security arrangements pointed toward shielding IoT gadgets and organizations from digital dangers such as cyber threats.

Another area of strength for the Israeli IoT ecosystem is the country's advanced infrastructure. Israel has a highly developed telecommunications network, including a robust 4G network and a growing 5G network. In addition, Israel has invested heavily in the development of advanced sensor technologies, which are critical for the collection and analysis of data from IoT devices.

Despite these strengths, there are also a few challenges facing the Israeli IoT ecosystem. One of the biggest challenges is the high cost of living and doing business in Israel, which can make it difficult for startups and small businesses to thrive. In addition, there is a shortage of skilled workers in certain areas, such as data science and machine learning, which can make it difficult for companies to find the talent they need.

In conclusion, Israel has emerged as a major player in the global IoT ecosystem, with a strong focus on innovation, security, and advanced infrastructure. The government's support for the development of IoT technologies, combined with the country's highly skilled workforce and thriving startup ecosystem, have helped to make Israel a hub that is internationally known for IoT innovation and entrepreneurship. While there are certainly challenges facing the Israeli IoT ecosystem, the country's strengths position it well for continued growth and success in the years to come.

4.3 Policies and Infrastructure

In terms of policies and infrastructure, both Finland and Israel have taken steps to support the development and implementation of IoT technologies. In Finland, the government has implemented several initiatives aimed at promoting the adoption of IoT, including the IoT Finland program, which provides financing and guidance for IoT initiatives and startups.

And as mentioned before, Finland has put resources into the improvement of a strong 5G foundation, which is fundamental for the broad execution of IoT innovations.

In Israel, the government has also implemented policies aimed at supporting the development of IoT technologies. The Israel Innovation Authority, for example, provides funding and support for startups and technology companies involved in IoT. In addition, the Israeli government has invested in the development of a national IoT network, which is expected to provide a foundation for the implementation of IoT technologies throughout the country.

4.4 Industry 4.0 - Synergies and Potential Collaboration Opportunities

Both Finland and Israel are focusing on leveraging Industry 4.0 to improve their manufacturing sectors, and there are several areas where they can collaborate and share best practices. For example, Finland has a strong background in developing clean technologies that can enhance the sustainability of Industry 4.0 applications, aligning with global environmental goals. Israel's cybersecurity prowess is essential in ensuring the security and resilience of connected manufacturing systems. These complementary strengths could be leveraged to develop new Industry 4.0 applications that are secure, efficient, and environmentally friendly.

Finland, a clean technology leader, had stated in a report written by Wirén et al., (2019) and published by the Finnish Ministry of Transport and Communications that: “Publicly or partly publicly funded research and development on wireless 5G networks and services will be continued. Efforts will also be made to promote research and development on the financing, construction, business models, ecosystems and social impacts of optical fibre networks and other communication technologies.”. Finland runs a joint 5G testing ecosystem project that showcases a collaboration between the Ministry of Transport and Communications and several agencies including FICORA, Finnish Transport Infrastructure Agency, Trafi and Finnish Meteorological Institute (Wirén et al., 2019).

Israel’s cybersecurity prowess has achieved global recognition for its cyber and cybersecurity capabilities and realizations. This worldwide acknowledgement stems from its vigorous defense and innovation divisions. This expertise is critical in ensuring the security and resilience of connected manufacturing systems (Halon, 2020). In an Industry 4.0 landscape where data security and privacy are paramount, Israel's cybersecurity strengths become invaluable.

Mutual collaborative efforts between Finland and Israel can result in the development of secure, efficient, and environmentally friendly Industry 4.0 solutions. In the following section I will give several potential examples of how these strengths can be combined.

4.5 Use of Bluetooth in IoT and IIoT in Israel and Finland

Finland has embraced Bluetooth technology for IoT and IIoT applications. Finnish companies like Nokia have contributed to Bluetooth's development almost since its introducing in 1998, and the country is known for its IoT solutions in sectors such as healthcare and manufacturing. For instance, IoT-enabled healthcare devices like blood glucose monitors (GlucoModicum) and wearable fitness trackers are very popular and common in Finland (Finland Health Tech, 2017).

Similarly, in Israel, Bluetooth technology has seen widespread adoption in both IoT and IIoT applications. Israeli startups have been at the forefront of developing innovative Bluetooth-based solutions. For example, startups like Wiliot have developed Bluetooth-enabled battery-less sensors for IoT applications, while Augury uses Bluetooth sensors and AI for predictive maintenance in IIoT (Augury, 2023).

It is relevant to say that both Finland and Israel have a strong foothold in the Bluetooth-enabled IoT and IIoT ecosystem. And once more we can see that while Israel is recognized for its innovative startups, Finland leverages its expertise in healthcare and manufacturing to implement Bluetooth-based solutions.

In summary, Bluetooth technology may be a versatile and flexible communication standard that finds extensive utilize in both IoT and IIoT applications in Israel and Finland. These countries showcase their strengths and qualities in innovation and industry-specific applications, contributing to the worldwide development of Bluetooth-enabled IoT and IIoT solutions.

4.6 Conclusion

In conclusion, the IoT ecosystem in both Finland and Israel is comprised of a variety of stakeholders, each of whom plays a unique role in the development and implementation of IoT technologies. Both countries have taken steps to support the development and implementation of IoT, through policies and infrastructure investments. As the field of IoT continues to grow and evolve, it is likely that the role of these stakeholders will continue to evolve as well.

It shows more and more as we dive further into the details of each phenomenon, and explore the roots of each solution and product, that there are three players that together must cooperate. Enable each other to create and develop to paint the bigger picture: the public sector, the private sector, and the government. Each of them contributes something like the checks and balances system that is used in other ecosystems for example in democracy, one authority checks and balances the

other, in this ecosystem we can see how one player pushes forward or slows down the other, in order to create balance: might it be the motivation to explore, the authorization and legislation of new technologies, the recognition of innovative minds, the encouragement of entrepreneurships, the endorsement of a positive and healthy competition, nationally and internationally, that creates a global community through which everybody benefit.

When the public sector is facing changes or difficulties, they approach the private sector in search of redemption. The private sector comes up with different solutions, builds scientific communities, experiments, collaborates and so on and so forth until a solution to a problem or a modification of one, is offered. When something like that occurs, the government must interfere by creating laws and provide a new standards association stamp which will provide a global recognition of spoken solution. After the solution is already in the works, the government will give incentives to the stakeholders who will update, upgrade, develop, and improve the situation. The public sector will come with different demands like different scales of production, use in different areas, maybe some difficulties that were discovered along the way?

The circle is one and each part needs the other to thrive. This is why the policymakers, industry leaders, key players, and key stakeholders are in constant communication, within their own country, or outside of it.

5 Comparing the similarities and differences between the IoT ecosystems in Finland and Israel

In this chapter I will present the findings of the interviews I conducted with two of the key players in the IoT ecosystem in Finland. The entrepreneurs are having the professional experience gained from involvement with both the Israeli and Finnish ecosystems, as both created, built, and operate their business endeavors in and from Israel and Finland. The results and findings of the qualitative interview research with the focus group will be presented in separate questions based on the titular investigative question. The depiction method is used with tables to document the answers and findings.

5.1 Introduction of the interviewees within the focused group

The respondents are from different backgrounds, but regardless, they are both involved within the IoT ecosystems of both countries. In table 2 I will present their age and career level (meaning their role and educational backgrounds). In table 3 I will present the questions asked, and in table 4 I will present the summarized version of their answers, to show more concise and clear results.

5.1.1 Table 2: The interviewees

Respondent	Gender	Age	Nationality	Job Description	Education
1	Male	36	Israel	Co-founder, CEO	Highschool diploma
2	Male	47	Finland	Chief Technical Officer	PhD in microbiology

5.2 Table 3: Interview Questions

	Questions
1	What are the similarities and differences between the IoT ecosystems in Finland and Israel?
2	Can you identify any better practices in the Finnish IoT ecosystem that could be valuable for Israel to adopt?
3	Can you identify any better practices in the Israeli IoT ecosystem that could be valuable for Finland to adopt?

4	Based on your expertise, what recommendations would you give in order to learn and support the growth and success of the IoT ecosystems in both countries?

5.3 Table 4: Answers

Question	Respondent 1	Respondent 2
1	Similarities: Both countries share a strong belief in technology and innovation within their IoT ecosystems. Differences: Israel's ecosystem is more of cybersecurity expert and focused on addressing security concerns in IoT. Finland's ecosystem covering areas like energy and healthcare.	Similarities: Both share the focus on technological innovation and collaboration. Differences: Finland has a strong presence in sectors like green energy, and healthcare, while Israel's IoT ecosystem is more about cybersecurity, agriculture, and smart cities.
2	Research and development. Also, sustainable technologies.	Collaboration between academia, industry, and government in IoT development.
3	Entrepreneurial culture, early-stage funding, the ability to transform ideas into products faster than anyone else.	Agility, adaptiveness, capable to attract significant venture capital investments.
4	Israel can learn from Finland's expertise in sectors like healthcare and smart manufacturing. Finland has experience in creating sustainable IoT solutions.	Finland can learn from Israel about cybersecurity, and the “brave” approach towards innovation.

6 Discussion

In this chapter I will provide an analysis of the results, connection to theoretical background and recommendations based on the different perspectives of both Finland and Israel regarding the comparison of their IoT ecosystems.

6.1 Analysis of Results

Both Finland and Israel have recognized and acknowledged the importance of the IoT ecosystem and its impact on different sectors and have implemented different policies and initiatives to support its development. Both countries have a strong focus on innovation, collaboration, and investment in advanced infrastructure such as 5G networks. They also have thriving startup ecosystems and government support funding.

On the other hand, despite the many similarities, there are notable differences on areas of focus: Israel stand strong behind the reputation of an entrepreneurial domain and put strong emphasis on security in the IoT ecosystem, which goes hand in hand with Israel's established technology incubators and accelerators to support startups. Finland has serious areas of strength on technology adoption and has invested heavily in catering a solid 5G infrastructure foundation.

6.2 Connection to Theoretical Background

- Innovation Theory: Both Finland and Israel demonstrate a connection to innovation theory. Their emphasis on technological advancements, collaboration between stakeholders, and support for startups aligns with the principles of fostering innovation within the IoT ecosystem.
- Stakeholder Theory: The engagement of various stakeholders, including government agencies, businesses, and consumers, in both Finland and Israel reflects the relevance of stakeholder theory. The way interaction and collaboration intertwine among these stakeholders is crucial for the development and success of the IoT ecosystem in both countries.

6.3 Recommendations

- **Knowledge Exchange**: Finland and Israel can benefit from knowledge exchange initiatives to share what is in their experience and expertise are the best practices in the IoT ecosystem. For example, by creating platforms for different types of collaborative programs, workshops, and conferences both countries can facilitate the exchange of expertise and even more so, promote cross-brainstorm of ideas between the two countries.

- **Talent Development**: Both countries should focus on addressing the shortage of skilled workers in specific areas such as data science and machine learning. Investing in educational programs, training, and talent acquisition strategies will help bridge the skills gap and ensure a sustainable talent pool to drive IoT innovation.
- **Security Measures**: Continuous attention to security is crucial in the IoT ecosystem. Finland and Israel should further invest in research and development of advanced security solutions to safeguard IoT devices and networks from cyber threats. Collaboration between industry and academia can enhance the development of robust security measures.
- **International Collaboration**: Finland and Israel can explore opportunities for international collaboration in the IoT space. Engaging in joint research projects, partnerships, and knowledge-sharing initiatives with other leading IoT ecosystems globally can foster innovation and enhance the global positioning of both countries.

By carrying out these recommendations, Finland and Israel can further strengthen and reinforce their IoT ecosystems, capitalize on their strengths, exploit their assets, and address any challenges they face. This will add to supported development, innovation, and economic advancements in both countries.

6.4 Examples for Potential Collaborations

- Secure Manufacturing Processes: Israel's cybersecurity measures can be integrated into Finland's smart factories and manufacturing processes to ensure data integrity and protect against cyber threats. This collaboration can lead to the creation of highly secure and resilient manufacturing systems and will probably be implemented in both countries.
- Eco-efficient Supply Chains: By combining Finland's proficiency in eco-efficiency with Israel's data analytics capabilities, Industry 4.0 technologies can optimize supply chains for minimal environmental impact. This includes efficient resource utilization, reduced waste, and lower energy consumption.
- Green Data Centers: Israel's expertise in securing data centers can support Finland's efforts to establish environmentally friendly data centers for processing the vast amounts of data generated by Industry 4.0 systems.

These few examples are the future collaboration potential in a nutshell, and the collaboration opportunities between Finland and Israel in the realm of Industry 4.0 are countless. By harnessing Finland's clean technology strengths and Israel's cybersecurity prowess, both nations can contribute to the development of secure, efficient, and environmentally friendly Industry 4.0 solutions. This collaboration not only good and encourage both players to engage in a healthy and mutual

competitiveness, but also aligns with global sustainability goals, ensuring that Industry 4.0 advancements benefit both economies and together with that, the rest of the planet.

By comparing the two countries' state of mind and state of operation, I learned that it is not only about comparisons of positive and negative, right and wrong, but it allowed me to learn a new perspective, new point of view that forced me to open a window into the world of new ideas in which the players are not necessarily "stealing" ideas from each other, and spying on each other in order to cut the competitor out of the race. Of course, this behavior exists as well, but what we can learn about how the future of technology and innovation is shaping to be is almost a utopic reality in which the key players and stakeholders openly approach each other and ask for help, assisting each other in the name of science and in the name of advancement.

7 Conclusions

The objectives of the research were to compare the IoT ecosystems in Finland and Israel, identify similarities and differences, and determine best practices and areas for improvement. To achieve these objectives, an analysis of the IoT ecosystems in both countries was conducted. This analysis included examining key stakeholders, policies, infrastructure, and other relevant factors. Interviews were conducted with industry experts and deep dive into academic sources and scientific articles were consulted to gather insights and data.

The main results of the research indicate that both Finland and Israel have thriving IoT, IIoT, and startup ecosystems with a strong emphasis on innovation, collaboration, and government support. Industry 4.0 already exists, and not just as a concept, but in practice, and some might say that it is in its prime in the exemplary success stories of Finland and in Israel, where the terminology, methods of research and development, checks and balances, synergies between industries and between sectors not only exists but booming and blooming with each passing day. Both countries have invested in advanced infrastructure and have promoted dynamic startup ecosystems. However, there are also differences between the two countries, such as Finland's focus on technology adoption and Israel's emphasis on security measures. To get to the bottom of this matter and explain why so similar yet why so different these two countries are, we should go back. To understand the future, we must learn from the past.

Despite being geographically located in different areas of the world, where cultures per se are basically incomparable, I managed to find some similarities in history that might explain the current state of mind in both countries:

- Finland declared independence in 1917. Israel declared independence in 1948. Both countries are relatively young in comparison to their neighboring countries, or the rest of the world for that matter.
- Prior to the declaration of independence most of Finland was a part of Sweden. For about five hundred years Sweden ruled over Finland. In 1808-1809 Russia invaded the region of Finland and seized it from Sweden, what led to almost hundred more years of living under a foreign regime. Imperial Russia gave autonomy to Finland. Prior to the declaration of independence of Israel, the geographical area was ruled by many different regimes, but the last two regimes were the Ottoman Empire (1517-1917, four hundred years) and then Great Britain took over after World War I ended in victory over the Ottomans, and controlled the

area of what modern day Israel, Jordan and Palestine is. The British controlled the area until World War II ended and Israel became an independent state.

- Both countries changed their borders several times, giving land in exchange for peace with the neighboring countries.
- Both countries promote equal rights to women, and involved them in all types of industries, from politics to business.
- Both countries were built and raised on the values of unwanted wars, persecution and suffrage, and that generation of founders in both countries decided to change the future of the country, when the opportunity rose.
- Basic education (until the age of 18 in both Finland and Israel) is mandatory, offered to all citizens, and is free of charge in both countries.

And there are many more points to compare between. The main deduction is that Finland and Israel were alone, young, and weak among empires. They share a violent history of struggle to survival against all odds and thanks to a resilient state of mind, courage and common beliefs and values in equality and education, progression, and that “never again” attitude, they raised generations that knew that they need to secure a future for their own people, so history would not repeat itself. The main point in which they differ nowadays is that Finland has a more stable relationships with the bordering countries in comparison to Israel, what can explain the differences between attitudes when it comes to innovations in security and cybersecurity areas. Another major difference between the countries is that the population in Israel is very ethnically mixed compared to that of Finland, what effects the different courses of thought of certain individuals that arrive to the melting-pot that is Israel nowadays.

History teaches us more about the “why” and the “how” that lead Finland and Israel to their current state of mind and position among the most technologically advanced countries in the world. The analysis of modern research and this work in particular shed light upon a comparison that no one thought about having and proves that there are more similarities than meets the eye, and cooperation between the countries to learn, discover and achieve is already happening and imminent to continue stronger than ever. It is highly recommended to continue to explore and compare those countries and their achievements. Furthermore, based on the findings, several recommendations can be made: Firstly, knowledge exchange initiatives should be encouraged between Finland and Israel to share best practices and experiences. Secondly, efforts should be made to address the shortage of skilled workers in specific areas, such as data science and machine learning. Thirdly, both countries should continue investing in advanced security solutions for IoT devices and

networks. Lastly, exploring opportunities for international collaboration in the IoT space can further enhance innovation and technology transfer.

Finland and Israel used natural resources and demographics that were found within them to polish a niche expertise that served and is still serving both countries well in the global front, and within the borders of their own home.

Moving forward, it is recommended to conduct more in-depth studies and evaluations to assess the long-term impact of the recommendations and monitor the progress of the IoT ecosystems in Finland and Israel. Continued research and collaboration will contribute to further advancements and continuous improvement in the IoT domains of both countries. More expert interviews will be mandatory, and polls within the policymakers, industry leaders, stakeholders and other key players will be another way to gain specific insights from the people that are involved in the industry in different ways and own the capability to analyze the present and predict the future in their own unique and expert way.

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