MYKOLAS ROMERIS UNIVERSITY

FACULTY OF ECONOMICS AND BUSINESS

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Electronic Business Management

DEVELOPMENT OF INTERNET OF THINGS BUSINESS: WORLDWIDE ANALYSIS

Master's thesis

Thesis supervisor -

assoc. prof. dr. Tadas Limba

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ANNEXES

INTRODUCTION

Relevance of the topic. The Internet of Things (IoT) is a constantly growing (Venčkauskas et al., 2015) technological revolution (Khriyenko et al., 2012) that globally establishes connection between billions of devices (Santhi Sri et al., 2016). The Internet of Things enables innovative applications and services in the majority of economic sectors, offers potential to companies, consumers and public sector (Iivari et al., 2015). Currently, companies in various sectors are already spending billions in order to create new IoT incorporating businesses. The Internet of Things takes part in the on-going big data revolution, which changes the way how business organizations work (Mačiulienė, 2014). The IoT provides businesses a better capability for interaction, measurement, business analysis (Zimmermann et al., 2015), customization and personalization of provided services (Skaržauskienė & Kalinauskas, 2012). The IoT offers a faster and more accurate sensing of our environment, allows cost-efficient tracking in industrial processes (Mazhelis et al., 2012) and automation in almost every industry sector (Chan, 2015). E-commerce companies already take the advantage of the IoT-based knowledge analytics for a transformation of their customer's analytics. Integration of IoT gathered big data with different data sources, creates opportunities for innovative e-business scenarios and strategies (Chang et al., 2015). Following the global growth of the Internet of Things, there is a need for business companies to evaluate ways to adopt IoT in order to enhance their business opportunities (Miorandi et al., 2012).

The concept of the Internet of Things has already been researched and discussed for more than ten years, however, the speed and efficiency of IoT development is slower than expected (Skaržauskienė & Kalinauskas, 2015). Number of connected things is not meeting previous predictions (Palattella et al., 2016). Despite heavy business investments in IoT research and development, consumers have demonstrated the lack of enthusiasm in the IoT products (Chang et al., 2014). Businesses are well aware of potential IoT benefits, however they are not sure how to approach the technology. Companies may see the potential of growing IoT industry and oversee possibilities for growing their revenue, but a shortage of existing data may result in reluctance to jump into the IoT technology (Chan, 2015). As a result**,** companies tend to hesitate to invest in the IoT and that poses a great obstruct to the Internet of Things progress (Zhou et al., 2016).

Novelty of the topic. Despite the high interest from business and researchers, there are plenty of questions yet to answer, existing ambiguity to resolve in the domain of the Internet of Things. The IoT process is just in it's beginning and true research work starts nowadays (Skaržauskienė & Kalinauskas, 2012). Research and development in IoT sphere is still in the infant

stage of growth (Gupta et al., 2015). Especially in a business research field, there is space left to explore. The primary focus in the IoT discussions between academia and business has been related to the technology, infrastructure and technology suppliers In the analysis of IoT growth and emergence from business perspective information technology specialists have been more active than academic management researchers (Andersson & Mattsson, 2015). Technical IoT factors tend be in the main focus of attention, organizational factors oftenly are being overlooked (Zhou et al., 2016). Gupta et al. (2015) have conducted a research of the IoT scientific articles in the Scopus scientific database. The research results indicate that during period of 2005-2014, IoT articles of business, management and accounting themes have generated only 3.73% share of IoT articles amount. Research authors have stated that in the IoT studies, major emphasis has been clearly put on technology. Moreover, there is a lack of information regarding how businesses operate within the IoT ecosystem. IoT itself lacks theory, standards and technology architecture (Chen et al., 2014). Internet of Things needs more industry reviews and real life case studies for an establishment of valid definitions and future guidelines (Mačiulienė, 2014).

Scientific issue. Businesses are well aware of potential IoT benefits, however, they are unsure how to approach the technology (Chan, 2015). **S**tudies about the key success factors for application innovation in the IOT are still at the exploratory stage (Wan & Zeng, 2015). As IoT companies and policy makers are looking for answers how they could facilitate IoT business development, uncertainty level remains high. Thus, the problem in scientific and business communities exists, as it is unclear which criteria have been critical success factors in successful IoT businesses development cases, qualitative success criteria have not been determined. Resulting uncertainty and lack of guidelines may hinder the development of IoT businesses.

The object of the research. Qualitative success criteria for the Internet of Things business development.

Research goal: After analysing theoretical IoT aspects, following the analysis of the worldwide Internet of Things business development, to develop qualitative success criteria of the Internet of Things business development, to present the IoT business development qualitative success criteria application model, that encopasses key success factors of IoT businesses development cases, and could tackle the uncertainty level, provide guidelines for IoT business development.

Objectives:

1) To analyse theoretical aspects of the Internet of Things business development.

2) To identify leading regions of the IoT development and conduct analysis of leading regions' approaches towards a facilitation of the Internet of Things business development.

3) To conduct a qualitative study of the IoT industry experts, from previously identified leading regions, regarding qualitative success criteria of the Internet of Things business development.

4) To design the Internet of Things business development qualitative success criteria application model that is based on the theoretical part analysis and qualitative study results.

Research methods and resources. Scientific literature, documents analysis were done, experts interviews were conducted, scientific modelling was applied. Scientific literature and documents were analysed for the investigation of the theoretical Internet of Things development aspects, identification of global leading regions and for the analysis of leading regions' approaches towards a facilitation of the Internet of Things business development. In the process of the qualitative experts interviews research 13 IoT industry experts, who were working either in business development related or management / strategical level positions, were surveyed. The aim of the experts interview was to identify critical qualitative IoT business development success factors. Based on theoretical analysis and empirical qualitative research results, the Internet of Things business development qualitative success criteria application model was proposed.

Thesis' structure. Master's thesis consists of four parts. The first chapter examines theoretical aspects of the Internet of Things business development: the concept of the Internet of Things, IoT applicability in business development, development of the Internet of Things. The second part is dedicated to the analysis of worldwide Internet of Thing business development efforts. Leading regions: China, United States of America and European Union were identified and analysed. The thirds section covers analysis of IoT industry experts interview, which examines IoT business development qualitative success criteria. Following the theoretical IoT phenomenon analysis and qualitative study, Internet of Things business development qualitative criteria application model is presented at fourth chapter. Thesis ends with conclusions and recommendations. The visual representation of thesis structure is presented at Figure 1.

Practical and theoretical value of the paper. Paper's value is reflected by qualitative success factors of the Internet of Things businesses development, which were identified by international IoT industry experts, by suggested Internet of Things business development application model that could be useful for innovative industry business development. Conclusions and recommendations could be treated as a list of best practises that could be helpful in the process of IoT business development.

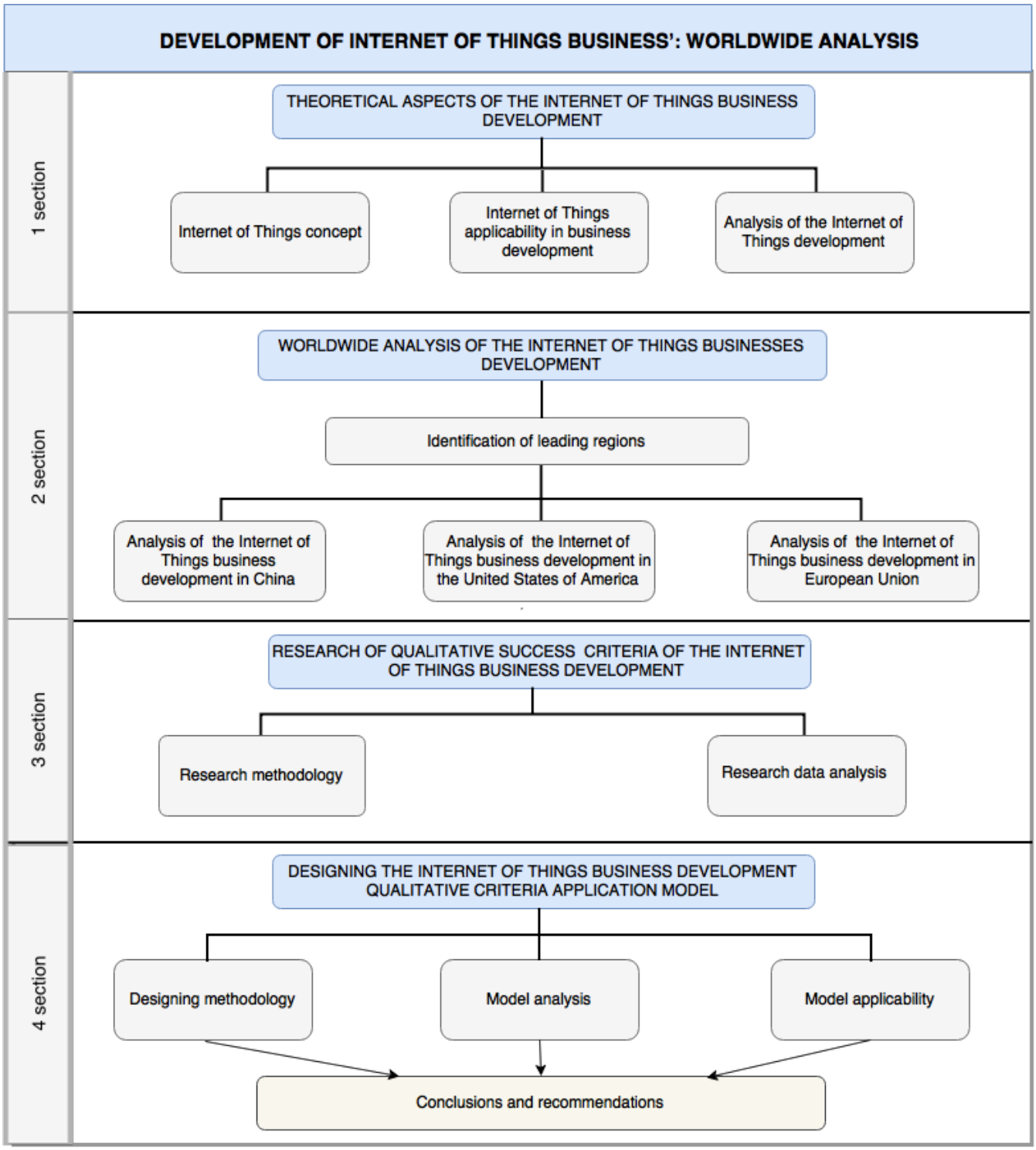


Figure 1. Logical structure of thesis

1. THEORETICAL ASPECTS OF THE INTERNET OF THINGS BUSINESS DEVELOPMENT

1.1. The concept of the Internet of Things

The Internet of Things (IoT) history spans for more than fifteen years. For the first time the term of the Internet of Things was mentioned in 1999, by Kevin Ashton (Ashton see in Iivari et al., 2015), at Auto-ID Center in the Massachusetts Institute of Technology (Chang et al., 2014). In 2002, Forbes Magazine has published article, which was named 'The Internet of Things'. In this article, Kevin Ashton has expressed the need of Internet of Things - a standardized way for computers to understand real world (Ashton see in Gupta et al., 2015). Ashton has generated an idea how to improve efficiency of supply chain by embedding radio-frequency identification (RFID) chips in production (Ashton see in Mačiulienė, 2014). Since then, the Internet of Things is a part of shared vision about the future of the internet (Palattella et al., 2016).

The Internet of Things attracts attention and praise words from scientific authors. Authors argue that the IoT is considered to be one of the major disruptive technological innovations of recent times. Furthermore, IoT could be labelled as the next era in the IT field (Santhi Sri et al., 2016). The Internet of Things is considered to be one of the the emerging trends, that shapes the development of ICT technologies (Miorandi et al., see in Plauska & Damaševičius, 2014). Development of the IoT extends internet based services, expands internet into new fields, it is even speculated that the IoT could become the next evolutionary step for the internet **(**Skaržauskienė & Kalinauskas, 2015). Moreover, the IoT is considered to be not only the next step for the internet, Venčkauskas et al. (2015) state that the Internet of Things represents the future of computing and communication technologies. To a greater extent, the IoT has been declared to be the next advancement of society and economy digitization processes (Rose, see in Tadejko, 2015). Rapid development of the Internet of Things even could be named as the Internet of Everything, since the IoT is connecting things, data, people and processes at an unprecedented scale and scope (Tadejko, 2015). Bold statements like these lead to discussions about the IoT phenomenon both in scientific community and popular media **(**Skaržauskienė & Kalinauskas, 2015) and attracts attention from business industry.

Despite the surrounding interest and the fact, that the Internet of Things has already been discussed for more than fifteen years, a single, universally accepted standard definition of the Internet of Things still does not exist (Iivari et al., 2015; Rong et al., 2015). Analysis of scientific literature provides numerous definitions. 'The white book of IoT industry' released by Chinese Ministry of Industry and Information Technology, defines the IoT as: a network that relies on

technologies of information sensing, processing, transforming, identification, tracing, positioning, monitoring, management and connection safety(Tian et al, 2016). Federal Trade Commision of the United States of America has declared that the IoT refers to the ability of everyday objects to connect to the Internet, send and receive data (Gathani, 2016). Scientific researchers are providing their input into IoT definition development. Iivari et al. (2015) state that a tendency to embed digital technology into previously non-digital products and provide a context, where real, digital and virtual worlds are colliding to create smart environments is often called the Internet of Things. Furthermore, an emerging definition of the Internet of Things defines the phenomenon as a decentralized, loosely combined system of cooperating autonomous, digitally augmented physical smart objects with capabilities of sensing, actuating, storing, processing and networking with other smart objects. humans or electronic devices. Smart objects are exposed to information that is created inside themselves or their near external environment and are able to react according to the information changes in a preprogrammed way (Gupta et al., 2015). Nowadays, expression of Internet of Things is frequently used as an umbrella term for various aspects of the internet expansion towards a physical world. Expansion happens by embedding identification, sensing, actuation (Miorandi et al., 2012), communication and data-collection **(**Oriwoh et al., see in Westerlund et al., 2014) capabilities into physical objects. A cumulative list of the IoT definitions, adapted from Chen et al. (2014) and Mačiulienė (2014) can be seen in Table 1.

Stepping aside from a search of the formal IoT definition, analysis of available definitions and synthesis of their explanations allows us to conclude that the IoT is a far-reaching network (Min & Chai, 2016) that connects heterogeneous devices (Khriyenko et al., 2012) - physical objects that are named as things (Santhi Sri et al., 2016), through the internet, which enables communication between them. The main goal of the communication is the exchange of information in a compliance with agreed set of communication protocols (Chen et al., 2014). Information is gathered through sensors from external or internal (inside) environments. Things are able to interact with external environment (Iivari et al., 2015) of humans and other things (Chan, 2015). Things are uniquely identified and are associated with at least one name and one address. Moreover, they can accept messages and reply to them (Plauska & Damaševičius, 2014), and are enabled to react to information changes in a preformulated way (Gupta et al., 2015). Since, every thing is uniquely identified and accessible to a network, it's position and status are known (Venčkauskas et al., 2015). In the context of the IoT, things are previously non digital products, such as everyday household appliances (Turber et al., 2014), physical objects such as buildings, vehicles, portable devices, other machines such as thermostats, actuators, smart meters, drones or even clothing (Iivari et al., 2015).

Table 1. Definitions of the Internet of Things

Authors	Definitions
CCSA - China Communications Standards Association	'A network, which can collect information from the physical world or control physical world objects through various deployed devices with capability of perception, computation, execution and communication, and support communications between humans and things by transmitting, classifying and processing information.'
ITU-T - International Telecommunication Union	'A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies.'
EU FP7 Project CASAGRAS	'A global network infrastructure, linking physical and virtual objects through the exploitation of data capture and communication capabilities. This infrastructure includes existing and evolving Internet and network developments. It will offer specific object-identification, sensor and connection capability as the basis for development of independent federated services and applications. These will be characterized by a high degree of autonomous data capture, event transfer, network connectivity and interoperability.'
IETF - Internet Engineering Task Force	'A world-wide network of interconnected objects uniquely addressable based on standard communication protocols.'
Chase (2013)	'The IoT creates an intelligent, invisible network fabric that can be sensed, controlled and programmed. IoT-enabled products employ embedded technology that allows them to communicate, directly or indirectly, with each other or the Internet.'
Dlodlo et al. (2012)	'The Internet of Things is what happens when everyday ordinary objects have inter-connected microchips inside them.'
European Commision & CABAS	'Things having identities and virtual personalities, operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental and user contexts.'
Gubbi et al. (2013)	'Interconnection of sensing and actuating devices providing the ability to share information across platforms through a unified framework, developing a common operating picture for enabling innovative applications. This is achieved by seamless large-scale sensing, data analytics and information representation using cutting edge ubiquitous sensing and cloud computing.'
Internet of Things European Research Cluster	'Things' are active participants in business, information and societal processes where they are enabled to interact and communicate among themselves and with the environment by exchanging data and information sensed about the environment, while reacting autonomously to real/physical world events and influencing it by running actions and create services with or without direct human intervention.'
Middleton et al. (2013)	'The Internet of Things is the network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or external environment.'
Tarkoma & Katasonov (2011)	'A global network and service infrastructure of variable density and connectivity with self-configuring capabilities based on standard and interoperable protocols and formats. IoT consists of heterogeneous things that have identities, physical and virtual attributes, and are seamlessly and securely integrated into the Internet.'

Sources: Adapted from Chen et al., 2014, p. 350; Mačiulienė, 2014, p. 171-172

The IoT environment is embedded with the latest technologies from fields of intelligent sensors, communication protocols and RFID (Santhi Sri et al , 2016). After being embedded with a digital technology, things are able to network, communicate, sense information, analyze it and produce new information (Chan, 2015). The IoT enables communication not only between physical objects with physical objects (sometimes referred as Machine to Machine - M2M communication), it also allows the exchange of information between people and objects, people and people (Santhi Sri et al , 2016). The IoT adds a third dimension of physical objects to a two sided human-computer interaction (Atzori et al., see in Chang et al., 2014) thus expanding the concept of the internet.

To summarize, the concept of the Internet of Things has a history of more than fifteen years. Despite the history and interest from scientific community, there is no single standard, universally accepted definition of the phenomenon. Various scientific definitions could be synthesized into the IoT description as a far-reaching network, which connects uniquely identified heterogeneous physical objects (things) through internet and enables communication between them. While communicating according to set communication protocols, things exchange information, which is gathered through embedded sensors. Furthermore, things may conduct information analysis and to react to information in a preprogrammed way. In the IoT context, previously non digital objects are embedded with technologies and are becoming networked things.

1.2. The Internet of Things applicability in business development

The Internet of Things promises significant improvements and opportunities for business sector. Various improvement opportunities are at the core of business sector interest in the IoT businesses development. Business development could be defined as a function of growing business through a range of various activities and the application of particular business model with associated earning logic (Sorensen see in Smyth, 2014, p. 14). Business Development includes all activities that have a goal of:

- Creation of revenue and value potential;
- Development of technologies and companies for their commercialization;
- Relationship building with potential customers, partners and other stakeholders. Maintaining and enhancing relationships for a company benefit (Kind & Zu Knyphausen-Aufsess see in Theryn, 2013, p. 169).

Analysis of scientific literature provide numerous possibilities for IoT applicability in business development. First of all, a communicative linkage between digital and physical objects enables a whole set of new business applications and services (Miorandi et al., 2012) and provides heavy loads of information that is accessible anytime and anywhere (Westerlund et al., 2014). As a result, gathered information could be the enabler of new relationships formation with customers. Types of collected information in the IoT environment are diverse and a combination of diverse data provides high potential for custom services (Min & Chai, 2016). IoT provides a stack of always connected information, gathered from various environments, which helps companies to create customer-oriented services and products. New communication dyads are extended with mobility systems and services from cloud and big-data environments (Zimmermann et al., 2015). One of the most important possibilities that is provided by IoT, is not only ability to connect large amount of data itself, but possibilities for analysis of gathered data (Mineraud et al., 2015).

Furthermore, the IoT is expected to influence products and services (Turber et al., 2014) and provide improved quality of services and greater productivity in the majority of affected sectors (Iivari et al., 2015). The Internet of Things enables responses to a real world condition changes in a rapid fashion (Gupta et al., 2015). McKinsey & Company analysts have stated that objects, that are able to sense their environment and communicate, will become useful tools for understanding complexity and reacting to it rapidly. The awareness of environment enables new products and services, allows businesses to solve problems by making information-based decisions (Mačiulienė, 2014). Intelligent, reasoning systems form the core of the IoT. Systems connects things and data, that are used in decisions making processes, automation, or in business processes improvement (Chui et al., see in Iivari et al., 2015). Moreover, the IoT changes existing businesses capabilities by providing a robust way to interact, operate, measure and analyze (Zimmermann et al., 2015). IoT provided benefits include: higher quality manufacturing, improved patient care (Iivari et al., 2015), environmental monitoring (Santhi Sri et al , 2016), logistics efficiency, hazardous materials safe handling (Dar et al., 2014), cost reduction and risk minimization (K. Rong et al., 2015), automation in nearly every industry, notably, in home automation, healthcare, traffic and utility management and even in smart cities (Chan, 2015) Such IoT applicability possibilities greatly increases revenue and value potential for companies and even creates new commercialization opportunities.

In a response to provided potential, the Internet of Things is applied in a variety of industries. The IoT is becoming accepted in municipal services, crowd management (Bader et al., 2016), e-health, smart cities, smart grids, smart transportation, e-commerce, domains (Santhi Sri et

al , 2016). Huang has summarized areas where the IoT has been applied: power management, traffic safety, environmental protection, health monitoring, logistics management, precision agriculture, public safety, home furnishing security and industrial automation and control (Huang see in Wan & Zeng, 2015). Several authors have presented visual lists of the IoT applicability areas (see Table 2 and Table 3).

Table 2. Summary of IoT applications

		Location sensing and sharing	Environment sensing	Remote controll-ing	*Ad hoc* network	Secure communica-tion
E-health	Monitoring	√	√		√	√
	Home care	√	√			√
ITS	Smart fleet	√	√			√
	Automotive	√	√	√	√	√
Smart city	Environment monitoring	√	√			√
	Safety	√	√			√
	Food traceability	√				√
	Smart agriculture		√	√		√
Industry	Process monitoring		√	√		√
	Logistic management	√				√

Source: Chen et al., 2014, p. 351

Chen et al (2014) have provided the table that displays which functions the Internet of Things applications could cover in different areas. Table covers broad list of areas, including: e-health, intelligent transportation systems, smart city and industry sectors. Communication aspect of networked things is the important factor of this presentation, as IoT applications secure communications in all provided areas. Mačiulienė (2014) has provided a cumulative list of IoT application areas that were mentioned in scientific literature (see Table 3).

Table 3.Application areas of IoT by industries

	Tar-koma & Kata-sonov (2011)	Presser & Krco (2011)	Atzori et al. (2010)	Libe-lium (2014)	Dlodlo et al. (2012)	Mahid-har & Schatsky (2013)
Energy	x	x			x	
Medical technology & health	x	x	x	x	x	x
Buildings	x	x	x	x	x	x
Transportation	x	x	x		x	x
Smart living	x	x	x			x
Cities	x	x		x		x
Retail		x		x	x	
Agriculture		x		x	x	
Factory & industrial control		x	x	x	x	x
Supply chain & logistics		x	x	x	x	
Emergency & security		x		x		
User interaction		x	x			
Culture & tourism		x				
Environment		x		x	x	
Water				x		
Metering						
Animal farming				x		
Insurance					x	
Information security					x	
Education					x	
Telecommunication					x	

Source: Mačiulienė, 2014, p. 173

Presented table illustrates a wide range of possible Internet of Things applicability areas. Companies operating in different sectors, such as education, insurance, animal farming or medical technology & health, could find their own IoT technological advancements applicability options, As a result, the IoT is becoming a vital innovation enabler in various fields (Bader et al., 2016). The IoT enables new possibilities to business models creation (Turber & Smiela, 2014) and enables world observation at previously unreachable level of detail at a reduced price (Gupta et al., 2015). Through the increasing number of connected things, with embedded sensors and analytic technologies, enterprises are presented with an unprecedented ability to track and analyse almost every aspect of their business (Koomey, see in Tadejko, 2015).

In summary, the Internet of Things provides various enhancements for business development. Unmatched quantity of gathered data may be used for a formation of new relationships with customers and creation of customized services. Furthermore, environment awareness, informed decision making, automaton possibilities, quality and efficiency improvements increases revenue and value potentials for companies. As a result, the Internet of Things is applied in various industries.

1.3. Development of the Internet of Things

1.3.1. Enabling factors

In order to properly understand the current development of the Internet of Things, factors that have enabled the phenomenon must be examined beforehand. As the IoT itself is labelled as the umbrella term, it's research takes collaborative efforts from business industry, academics and standardization institutions (Barnaghi & Wang, see in Mačiulienė, 2014). Several authors are listing research fields that are at the foundation of the Internet of Things. Gupta et al. (2015) states that the IoT gathers researchers from computer science, engineering, physics management, social sciences. Tadejko (2015) concluded that multidisciplinary study involves research of communication, networking, data flow, hardware and software engineering fields. Since the Internet of Things encopasses multiple technologies, it's development is also dependant on multiple factors. The IoT is a comprehensive utilization of existing technologies, such as information and communication technologies, cognitive sciences and low-power electronics (Chen et al., 2014). IoT development depends on technical innovations in number of fields, including wireless sensors, mobile devices and nanotechnology (Venčkauskas et al., 2015), wireless network of sensors and actuators (WSAN), machine to machine communication (M2M), ubiquitous computing and others (Mazhelis et al., 2012). Radio Frequency Identification (RFID), which is widely used for object tracking. allows tagging different devices with electronic product code that is used as the unique device ID (Skaržauskienė & Kalinauskas, 2012). Atzori et al. have concluded that enabling factor for IoT was the integration of communication solutions and several technologies: sensor and actuator networks, identification and tracking technologies, enhanced communication protocols (Atzori et al, see in Andersson & Mattsson, 2015). Other authors mention that advances in the internet, computing networking have enabled the development of millions powerful, low-cost, wearable, internet-connected devices, that are equipped with sensors, cameras, RFID (Georgakopoulos & Jayaraman, 2016). Devices' miniaturization and energy efficiency of sensors creates portable devices that results in convenient real time IoT applications (Chan, 2015). Furthermore, the internet connected devices are becoming "smarter", smaller and more aware of their surroundings (Skaržauskienė & Kalinauskas, 2012). This makes it possible to embed things into a variety of everyday objects (Mačiulienė, 2014). Small and cheap computing devices, with embedded sensors and communication capabilities are enabling the realization of the IoT vision (Palattella et al., 2016). In addition to the IoT vision's realization, incorporation of digital technologies enables physical objects to adopt characteristics of digital technology: they become programmable, sensible,

communicable, addressable, traceable, memorable and associable (Yoo et al., see in Turber et al., 2014). Adoption of such characteristics, enables a technological breakthrough that is known as the Internet of Things.

1.3.2. Current development status

Analysis of scientific articles, provides several previously introduced IoT development roadmaps. Report 'Internet of Things in 2020' that was published by the European Technology Platform on Smart Systems (EPoSS) in 2008, has declared that the IoT development could be divided into 4 stages:

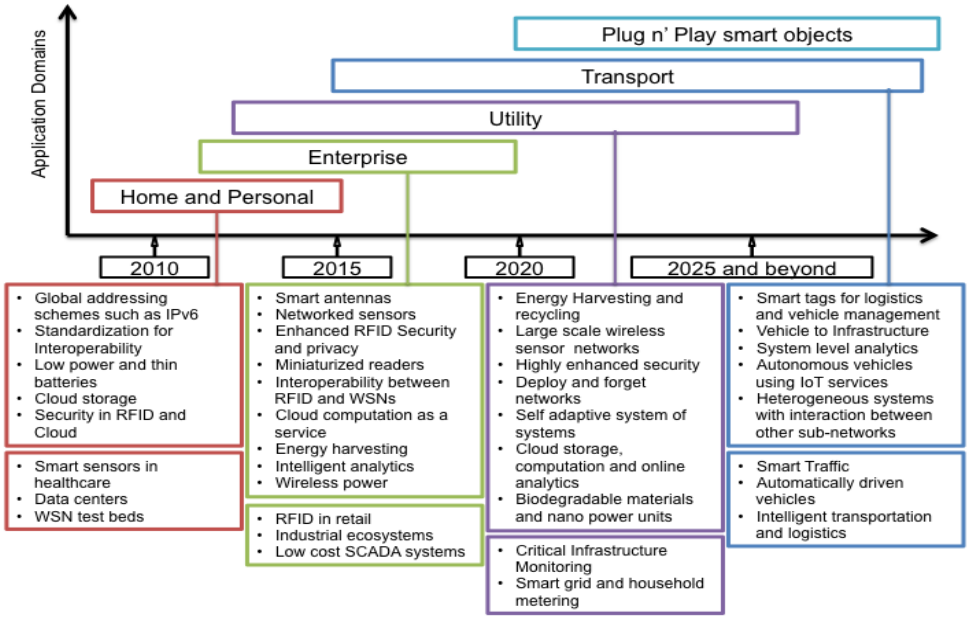
1) The areas of application focus on logistics, retail and pharmacy before 2010;

2) The goal in the time period between 2010-2015 was to achieve the object interconnection;

3) Semi intelligent age should be entered between 2015 and 2020;

4) After 2020 the Internet of Things should enter the intelligence era (Wan & Zeng, 2015).

Gubbi et al., in 2013 have presented the roadmap of key technological developments in the IoT domain (see Figure 2).



Source: Gubbi, et al, 2013

Figure 2. Roadmap of key technological IoT application development

Gubbi et al (2013) roadmap presents a different vision of five-year development plan. As the Internet of Things gets mature, it should move from the applicability in home and personal,

enterprise areas and expand to larger scale, interconnected scenarios of utility systems and transportation management. However, as the IoT applicability scale actually increases, the idea of true, usable, worldwide network of Things is still more a theoretical concept than the reality (Skaržauskienė & Kalinauskas, 2015).

Despite the lagging development of worldwide IoT network, recognition of IoT provided benefits and possibilities make business and academic communities keep their interest in the IoT development. Westerlund et al., argue that a transformation of business attitudes towards the IoT is driven by two underlying changes: 1) Abandoning views of the IoT as solely a technology platform and considering it to be a business ecosystem; 2) Quitting focusing on a single firm business models and starting designing ecosystem business models. However, Westerlund et al. (2014) argue that despite the benefits which IoT already provides for both enterprises and consumers, and despite a wide scope of possible IoT application possibilities, the adoption of technology is relatively modest and IoT growth is still at a very early stage. Business sector may be interested in the Internet of Things and put their efforts in encouragement of the IoT business development, the other important part - consumers not necessary share their interest. Despite the business' heavy investments into the research and development of the IoT, consumers have reportedly demonstrated little enthusiasm about such IoT products as IoT home appliances and IoT mobile phones (Chang et al., 2014).This observation is reinforced by Skaržauskienė & Kalinauskas (2015), as they state that regular consumers are not too interested in a widely discussed technology.

Another aspect that is negatively affecting development of IoT businesses development is fragmentation. Small-scale IoT applications have been successful in some industries, yet they become unsustainable when extended to other industries (Chen et al., 2014). Available fragmented solutions target specific domains and specific types of applications. Current situation results in a variety of proprietary platforms, interfaces and protocols. Solutions of different vendors are hardly compatible. Fragmentation and lack of open standards in sensor networking, keeps prices of components relatively high. Standard interfaces and protocols are being developed, or are already available, but no set of standards has became a dominating one (Mazhelis et al., 2012). There is no common protocol for communication among smart things (Chan, 2015). Despite the increasing number of real-world IoT deployments, the majority of Internet of Things applications are in self-contained, isolated forms. Separate deployments provide devices and protocols that are created for specific customers and are not reusable. For a further development of IoT, multiple parallel platforms must converge to global and linked services. Already existing IoT infrastructures are in need of mechanisms that would prepare them for a common way of sharing their devices and

generated data (Lanza et al., 2016). As the IoT technology gets mature and will be applied in a wide scope of real world cases, the IoT will require a careful standardization process, which could ensure that various devices and applications, that are coming from different regions, could interoperate fluently, and build the foundation for the real a rise of IoT (Miorandi et al., 2012). Furthermore, standardization could reduce a cost of the technology and ensure availability of technology to consumers, who are one of the key elements in the development of technology (Skaržauskienė & Kalinauskas, 2015). Cost reduce and availability could solve the previously mentioned issue of the lack of interest from consumers part and could spur the IoT business development progress.

However, contrary to other researchers, Palattella et al. (2016) argue that there already is a huge supply of standards and technologies available today and they were tested and successfully used in deployments around the world. Palattella et al. (2016) claim that discussions about the lack of technologies or standards for a realization of the IoT potential are invalid. Researchers relate the delayed development of worldwide IoT to a low market demand, which is considered to be normal case with new markets and technologies. Creation of genuine demand between consumers and industries is mentioned to be the biggest commercial challenge for IoT (Palattella et al., 2016). Ghambali et al. (2017) argue that standards and technology are on their way on getting mature, however, there are challenges and opportunities that will be encountered from the business perspective, as there are no predefined processes to follow or established boundaries in the Internet of Things business development.

1.3.3. Development obstacles

As the united, standardized, worldwide network of Things is still unmet target, thorough analysis of IoT development obstacles should be concluded. Analysis of scientific literature suggests several problematic points, as Skaržauskienė & Kalinauskas (2012) state that there are many problematic aspects and research challenges related to the Internet of Things. First of all, the IoT encounters interconnection problems for heterogeneous devices, high computational and energy demands (Gazis et al., 2015). Global interconnection of things is not only a technological challenge, but it also brings issues of standardization, privacy, legal differences among different regions (Smith et al., see in Gazis et al., 2015). Standardization in terms of privacy, security, network architecture is required (Santhi Sri et al., 2016). Large-scale services need to be deployed within a set of standards (Skaržauskienė & Kalinauskas, 2015). Without a global set of standards, IoT expansion cannot reach the global scale. Wider adoption of IoT is suppressed by a lack of unified standards,

dominant design, vendor independent guidelines and resulting high costs (Batten & Wills-Sandford see in Mazhelis et al., 2012). Currently, there is only industry specific incremental innovations with no clear dominant standards or killer application. This situation results in lots of applications that fail to work together (Leminem et al., 2014). In order to progress from current 'Intranet of Things' to te Internet of Things, globally recognised standards must be established. At the moment, no unifying concepts were applied and that leads into isolated solutions that do not support interoperability (Tadejko, 2015). The lack of standards problem is common for widely-used technology based innovations and is a challenge for governmental and industrial bodies (Skaržauskienė & Kalinauskas, 2015). Standardization obstacle is not an easy challenge to solve, because IoT operates in many industries and involves multiple manufacturers, IoT deployments differ in user requirements and usage scenarios. IoT technology has few ways of actualization itself. This raises a true challenge for government and industrial bodies and results in sluggish standardization which, in turn negatively impacts large-scale commercial deployment of IoT services (Skaržauskienė & Kalinauskas, 2012).

The widespread diffusion of research initiatives also is critical to the IoT development. The scattered development elevates the risks of fragmentation and interferes with adoption of adequate standards (Miorandi et al., 2012). Furthermore, Westerlund et al. (2014) have identified three major challenges for designing IoT ecosystem business models: immaturity of innovation, diversity of objects and unstructured and evolving ecosystems. Moreover, IoT development connects market players who previously had no shared business relations. Companies have to apply knowledge and resources from different domains that not necessarily belong to a single industry, therefore cross-industry partnerships are formed. The potential of the IoT is within interactions between players from industries working together for a value co-creation. For a fulfillment of this potential, companies have to look outside their internal business models and explore opportunities of cooperation in order to define business possibilities. Companies need to cooperate and be aware of novel network-centric business models. Key point is to position company within the network in a way that would guarantee profitability as a part of a larger group, not only as a single business entity (Ghambari et al, 2017). Formation of new partnerships requires additional business development efforts and raises uncertainty level. Despite the market potential and the progress of IoT technology, there still is a high uncertainty in doing IoT business (Li et al., 2012). Early adopters encounter benefits of new possibilities, but also face new challenges and unresolved questions to deal with (Skaržauskienė & Kalinauskas, 2015).

Furthermore, IoT related technologies and business models are changing rapidly (Li et al., 2012). At the current early stage of IoT development, business should cautiously consider how they could reduce a risk of possible failure (Chen et al., 2014). The IoT also generates new costs for establishment of new infrastructure, employees hiring and training, cooperation with telecommunication providers. Investments toward emerging technology bring high uncertainty of possible return on investment and need thorough calculations and estimations. Companies hesitate in the investment decisions and that poses great risk and challenge to the IoT business development progress (Zhou et al., 2016). As the Internet of Things encounters various obstacles, it would be beneficial to examine how leading regions of IoT development are facilitating the Internet of Things business development process.

To summarize the section, development of the Internet of Things was enabled by technological innovations in several domains. Technological advancements allow integration of Things into various everyday objects. Even though the IoT applicability scale increases, the goal of worldwide network of Things has not been yet achieved. Despite the lagging worldwide IoT network development**,** business and academic communities are keen on the IoT development. However, consumers may not necessary be interested in IoT production. Furthermore, separate IoT development initiatives result in market fragmentation and lack of standards. However, several researchers argue that the IoT does not suffer from lacking standardization or technologies and it was successfully deployed in various cases. They identify low market demand as the main culprit. Analysis of scientific articles provides information that the development of IoT is indeed obstructed by heterogenous devices interconnection problems, obstacles of lacking standardization, legal differences, privacy issues and immaturity of the market. Furthermore, scattered research and development initiatives increase the risk of market fragmentation and interferes with standardization process. Finally, IoT market players have to engage in new partnerships formation, novel ways of cooperation, deal with uncertainty of new and developing industry, and related investment costs.

2. WORLDWIDE ANALYSIS OF THE INTERNET OF THINGS BUSINESS DEVELOPMENT

The Internet of Things involves multiple stakeholders that are interested in the encouragement of the IoT business development. It is widely acknowledged that technology and innovation are considered to be important parts of business and economy development (Mahmood et al., 2015). In order to successfully tackle challenges that delay the IoT development, various stakeholders, including governments, industrial players and associations are required to be involved in the IoT business ecosystem (Rong et al., 2015). World governmental bodies already support the IoT development through policies creation (Skaržauskienė & Kalinauskas, 2015). Since the IoT is expected to be a cornerstone of ICT industry's growth, it is extremely important to establish policies that are transferable to the global environment (Min & Chai, 2016). Policy makers are well aware of critical importance of strategic policies, that could spur the development of the emerging industries (Spencer et al. see in Tian et al, 2016). However, in order to create successful policies, policy makers must have knowledge in several aspects of the Internet of Things domain, such as: market potential, technological trajectories and industrial actors' capabilities. Unfortunately, while dealing with emerging industries, policy makers cannot learn from others, because all countries are struggling with their own policy-making process (Tian et al, 2016). IoT ecosystem is at its initial developmental phase and that makes identifying cornerstones of ecosystem a challenging task (Sundmaeker et al. see in Mazhelis et al., 2012). Since the development of worldwide IoT network is slower than expected and stakeholders are encountering multiple obstacles, it is critically important to identify leading IoT regions, analyze their basis for IoT business development success, and conclude a list of key success factors. Second chapter of thesis will analyze the Internet of Things business development principles and government initiatives for the encouragement of IoT business development in regions, that will be identified as global IoT development leaders.

2.1. Identification of leading regions

Analysis of the scientific literature provides information that governments around the globe are engaged in the facilitation of the Internet of Things development. Several large-scale initiatives on the Internet of Things are already active worldwide. US, Europe, China, Korea and Japan, among others, are mentionable cases (Miorandi et al., 2012). Governments have successively put forward IoT development strategies like "Smart Planet" and "Sensing China" to seek for new sources of

economic growth (Hvistendahl see in Zhou et al., 2016). Gazis et al. (2015) state that governments around the world, most notably US, Europe, and China have regarded the IoT as one of the top priorities in of research agenda. Moreover, the development of the Internet of Things industry has been raised to a national strategy level by the European Union, China and some other countries (Chang et al., 2014). Min & Chai (2016) consider EU, USA and Japan, as advanced regions that are proactively preparing legal, technical and institutional measures for personal data protections in the IoT context. Additionally, European Union is trying to move towards establishment of IoT standards, covering multiple layers including: technology, operation, and services (Skaržauskienė & Kalinauskas, 2012). In relation to data protection and privacy issues, United States' Federal Trade Commision has released a report 'The Internet of Things: Privacy and security in a connected world', which provides series of concrete steps for businesses, gives advice how businesses can protect their consumers' security and privacy (Tadejko, 2015). The IoT was positioned as one of the strategic emerging industries in China. State council has clearly indicated that the IoT research and application demonstrations will be promoted (Chen et al., 2014). Scientific articles repetitively mention China, United States of America and European Union as frontrunners in IoT development encouragement.

Furthermore, Gupta et al. (2015) have conducted a research of 6800 global, IoT related publications that were published in the peer-reviewed scientific Scopus database (see Table 4).

Table 4. IoT publications in Scopus database during 2005-2014

Country	TP	TC	Percentage of TP	Percentage of TC	RCI	ICP	Percentage of ICP
China	3051	3056	44.87	22.85	0.51	277	9.079
USA	547	1170	8.044	8.746	1.09	259	47.35
Germany	412	861	6.059	6.436	1.06	137	33.25
Italy	353	2275	5.191	17.01	3.28	103	29.18
UK	329	1221	4.838	9.128	1.89	173	52.58
Spain	285	851	4.191	6.362	1.52	109	38.25
France	235	456	3.456	3.409	0.99	104	44.26
Taiwan	172	240	2.529	1.794	0.71	37	21.51
South Korea	159	219	2.338	1.637	0.70	32	20.13
Switzerland	147	885	2.162	6.616	3.06	73	49.66
Finland	138	595	2.029	4.448	2.19	66	47.83
India	127	169	1.868	1.263	0.68	22	17.32
World	6800	13,377					

TP=Total papers, TC=Total citations, ICP=International collaborative papers, RCI=Relative citation index

Source: Gupta et al., 2015, p. 108

Articles that were published at a time period of 2005-2014 were included in the research. Research findings suggest that China has generated 44.87% of publications, the United States of America has accounted for 8.04% of publications. European Union members: Germany (6.06%), Italy (5.19%), UK (4.84%), Spain (4.19%), and France (3.46%) also have presented a significant share of scientific IoT publications (Gupta et al., 2015). In this analysis of the IoT research data, China, the United States of America and Europe remain among the leaders of the scientific IoT research community.

In 2014, International Data Corporation (IDC) market research company has released a forecast for worldwide and regional Internet of Things development (see Table 5 and Table 6).

Table 5. Worldwide Internet of Things Installed Base by Region (Billions)

	2013	2014	2015	2016	2017	2018	2019	2020	2013–2020 CAGR (%)
Asia/Pacific	2.8	3.6	4.4	5.4	6.4	7.6	8.9	10.1	20.1
Central and Eastern Europe	0.3	0.3	0.4	0.5	0.6	0.7	0.8	0.8	15.0
Latin America	0.2	0.2	0.3	0.2	0.4	0.4	0.5	0.6	17.0
Middle East/Africa	0.3	0.4	0.4	0.5	0.5	0.7	0.7	0.8	15.0
North America	3.1	3.8	4.5	5.2	5.9	6.5	7.0	7.5	13.5
Western Europe	2.4	3.1	3.7	4.5	5.4	6.3	7.3	8.3	19.4
Total	9.1	11.4	13.7	16.3	19.2	22.2	25.2	28.1	17.5

Source: International Data Corporation, 2014, p. 23

According to report, in 2013 Asia/Pacific, Western Europe and North America regions had the biggest quantity of installed IoT base and have generated the largest IoT revenue. Forecast has estimated that in the period of 2014-2020 regions of Asia/Pacific, Western Europe and North America will generate the highest numbers of installed IoT base.

Furthermore, IDC have continued researching the IoT market and in 2017 they have forecasted that Asia/Pacific region (excluding Japan) will see the greatest IoT spending, followed by the United States, Western Europe, and Japan. Investments into IoT solutions by China and the United States of America are driving these two countries into double-digit annual growth rates and accounts for over half of the global IoT spending (International Data Corporation, 2017).

Table 6. Worldwide Internet of Things Revenue by Region ($Billions)

	2013	2014	2015	2016	2017	2018	2019	2020	2013–2020 CAGR (%)
Asia/Pacific	600.3	729.5	881.8	1,056.9	1,287.6	1,605.9	2,027.2	2,602.6	23.3
Central and Eastern Europe	57.9	69.0	81.9	96.4	115.0	140.0	172.9	217.1	20.8
Latin America	37.5	42.5	47.2	51.5	56.7	62.9	69.4	76.3	10.7
Middle East/Africa	56.2	63.7	70.8	77.2	85.1	94.4	104.1	114.4	10.7
North America	667.9	775.5	892.7	1,016.8	1,168.8	1,363.2	1,608.0	1,922.1	16.3
Western Europe	507.7	612.1	737.1	880.9	1,069.2	1,325.8	1,667.0	2,132.8	22.8
Total	1,927.5	2,292.3	2,711.5	3,179.7	3,782.4	4,592.2	5,648.6	7,065.3	20.4

Source: International Data Corporation, 2014, p. 23

Asia/Pacific, Western Europe and North America regions were estimated to achieve highest IoT revenue. Central and Eastern Europe region, which includes some of European Union members, was expected to achieve the third biggest Compound Annual Growth Rate (CAGR) of the IoT revenue (International Data Corporation, 2014).

To summarize, a combination of results from scientific articles analysis, research data from Scopus database and reports with forecasts developed by International Data Corporation, allows to identify and recognize China, the United States of America and European Union as global front-runners in the Internet of Things development facilitation and research encouragement. Following three subchapters will provide the overview of the IoT business development facilitation efforts in identified leading regions.

2.2. Analysis of the Internet of Things business development in China

Chinese IoT business development efforts are fueled by growing national ambitions. China aims to transform itself into global manufacturing power and the Internet of Things plays an important part in the planned transformation. Ambitious transformation should be fueled by innovation driven development, that integrates the IoT, cloud computing, mobile internet and big data into modern manufacturing (Wang et al., 2016). In a top-down approach, Chinese government has issued policies for China's industrial development and has provided medium and long term plans for scientific and technological development (Breznitz & Murphree see in Tian et al., 2016) This top-down approach is also visible in China's IoT development facilitation.

Chinese IoT development facilitation are expressed by research encouragement and general innovation funding. The research of IoT sensing network in China dates back to the 1999. In 2010, the IoT was positioned as one of emerging Chinese strategic industries, resulting in an encouragement of IoT research and applications (Chen et al., 2014). Moreover, China identifies the IoT as one of major technological topics (Gazis et al., 2015) and as a new engine for economic growth and technology development. In order to support the IoT development, Chinese government has allocated special funds for research and demonstration projects. In 2011, around 500 millions RMB, from the special IoT fund, was invested into IoT development. Two thirds of investments were transferred to the R&D and IoT applications (Chen et al., 2014). The investments are divided among a perception layer, transport layer, network layer, and application areas. The network technology, that supports IoT applications, is a priority (Gazis et al., 2015). The central government continued to keep the IOT at the center of attention, as two inter-ministerial committees have been made responsible for a coordination of the IOT development, (Tian et al, 2016). Since 2011, Chinese government has supported 22 major national IoT application demonstration projects. In October 2013, China National Development and Reform Commission has made an announcement about organization and deployment of major national pilot demonstration projects, conducted at special regions in period of 2014-2016 (Chen et al., 2014). In the last 15 years, under the government provided innovation policies guidelines, China's IoT industry has resulted in 620 billion Yuan RMB in sales (Tian et al, 2016). In China alone, there are at least 9 billion interconnected devices and, it was prognosed that, by 2020, there will be 24 billion connected devices (Chen et al., 2014). Significant progress in the development of standards and R&D of Wireless Sensor Network, that is one of the main IoT core technologies, has been achieved (Tian et al, 2016).

Governmental funding is backed by policies creation. Previously mentioned top-down approach for pushing the IoT development have been expressed through a Five-Year planning system. Government releases Five-Year Plans for the IoT development, that provide a goal and objectives for a future development and suggests several approaches for reaching a goal. Furthermore, Five-Year plans provide a list of methods to support and promote the IoT industry development. 12th Five-Year plan (2011- 2015) was a first plan that proposed the goal of the IoT development in detail (Chen et al., 2014). The 12th plan has identified the IoT as a sub-industry of a new generation information technology industry and has set goals for the IoT development in four areas: development of standards; R&D of key technologies (for example:. RFID, sensors); promotion of IoT demonstration projects in industries like medical care, electricity, safety; and upbringing of industrial capabilities, such as, key enterprises, IoT industrial parks (Tian et al, 2016).

Following the 12th Five-Year plan, China has completed several demonstrational projects, including a smart city with intelligent transportation system and intelligent coal mine. However, large-scale service deployment yet needs to be framed by a set of standards (Chen et al., 2014). Governmental recognition of the IoT importance and completed progress has encouraged local governments to accelerate the development of their local IoT industries and formulate their local five-year plans. Local engagement has enabled central government to encourage participation of other industry actors. Frequent interactive investigations and inspections have provided a feedback of valuable information about the IoT development. Gathered information has resulted in a policies, that were issued by the central government. Policies stimulate the growth of industry and spur a national deployment of the IoT industry, that is based on a long-term planning. The IoT is regarded as one of their top priority industries by 28 Chinese provinces and it has enthusiastic plans set up for the future development (Tian et al, 2016).

Another approach that is being used for the development of IoT in China is the exploitation of business incubators network. Business and technology incubators are considered to be the backbone for the acceleration of innovation, new businesses development and inception of new ideas. Business incubators are regarded as places where ideas are combined with available resources. The Chinese network of business incubators has been widely used since the mid 1990's (Mahmood et al., 2015). Furthermore, the national level of the Chinese IoT R&D is distributed in a way that enterprises (i.e. vendors and operators) provide systems and operations development. Meanwhile, research institutions and universities provide effort on the key technology research. Standardization issues are covered by standard organizations (Chen et al., 2014). Research organizations are of special importance for China's industrial development, because majority of their enterprises have been established in last two decades and still have a relatively weak capabilities for R&D (Stigson et al.; Hong see in Tian et al, 2016).

In the scientific literature, opinions about Chinese IoT development are diversified. Tian et. al.(2016) state that IoT has been flourishing in China since 2010. On the other hand, the development of Internet of Things in China was considered to be in it's infancy by Wan & Zeng (2015). Authors have mentioned several developmental issues**:** the research and development of core technology was slow; there was a lack of technical standards and guidelines; great industry barriers were felt (Wan & Zeng, 2015). Moreover, according to Wang et al. (2016) current socioeconomic system of China limits innovation in many ways. There is a need for a new type of ecosystem, where whole society encourages innovation and tolerates possible failures.

In summary, the IoT is regarded as one of Chinese strategic industries. Chinese government engages in the IoT business development in a firm top-down approach. Five-year planning is applied, goals for future IoT development are created. Furthermore, heavy investments in IoT development and research are made, as government supports IoT development projects. Recognition of the IoT importance and achieved progress encourages local government bodies to engage in local IoT development encouragement. Cooperation and frequent communication between local and central governmental bodies occurs. which results in policies, that are based on gathered information. Another approach for the development of IoT business is the business incubators network - place where ideas are matched with available resources. Furthermore, various institutions cooperate in a networked ecosystem as enterprises provide systems and operation development, research institutions and universities provide key technology research, standardization issues are covered by standard organizations.

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2.3. Analysis of the Internet of Things business development in the United States of America

As one of the major global markets, the United states of America plays a significant role in the Internet of Things business development. The IoT is affecting millions of United States citizens through health and fitness monitoring, connected cars and household appliances, home security devices and other applications (Federal Trade Commission, 2015a). Meanwhile, the Internet of Things is also applied in business industry, as networked machines fully optimize and automate production in smart manufacturing (Gazis et al., 2015). In order to monitor their key production conditions, shipping time and other important metrics, food and agriculture industry actors are deploying sensors on a growing scale. IoT is also applied on a national scope. In some parts of country, energy consumption is monitored through a base of remote-capable meters that support smart grid app (Verizon, 2016). Furthermore, the United States have registered the biggest amount of IoT intellectual property patents, indicating a top notch research and development in the IoT field (The World Intellectual Property Organization).

The Internet of Things for a while has been regarded as a significant innovation. In 2008, as a response to a growth potential of the Internet of Things, National Intelligence Council has included the IoT into a list of six disruptive civil technologies, that have required potential to impact the US national power (Rong et al., 2015). Federal Trade Commission (FTC) leads the USA progress in finding a solution for IoT security problems. In 2013, FTC has organized a workshop named

‘Internet of Things: Privacy and Security in a Connected World’. In this workshop opinions among relevant industries and experts were exchanged, suggestions for a direction of personal data protection in the IoT field were presented (Min & Chai, 2016). Panels included academics, researchers, representatives from government and industry, consumer advocates. Participants of the workshop have discussed risks and benefits associated with the Internet of Things. Discussion were limited to IoT devices that were sold to or used by consumers, but has not included devices that were sold in business-to-business context. Thus leaving a looser restrictions on the IoT development in B2B context. Opinions regarding the need of legislation over the IoT were divided. Commision itself has expressed an opinion that the IoT industry is still in it’s relatively early stages, potential for innovation is great and IoT specific legislation would be premature. Commision did not state that privacy and security risks needs to be addressed through an IoT-specific legislation. Self-regulatory programs for particular industries are encouraged as a means to stimulate the adoption of security and privacy sensitive practices. Together with urged self-regulatory efforts, FTC staff have recognized their responsibility to continue on enforcing laws, educating business and consumers, encouraging IoT stakeholders involvement in security and privacy protection (Federal Trade Commision, 2015b).

Later in 2015, the Federal Trade Commission has released a series of the best practices and recommendations for companies regarding the Internet of Things phenomenon. Reports series also have included topics of privacy and security risks. Series pledged stakeholders to engage in a consumer and business education, law enforcement and participation in multi-stakeholder groups (Gathani, 2016). Reports enumerated the risks of the standardless IoT, which could increase a risk of unauthorized access and threaten personal safety (Cline, 2015 see in Tadejko, 2015). Commision has re-declared opinion that the IoT-specific legislation would still be premature, given the rapidly evolving nature of the phenomenon. However, the Commission calls for a strong general data security and breach notification legislation. In addition to the report, FTC has released a publication that contains advices for businesses about building security into IoT connected products and encourages companies to use best practises developed by security experts (Federal Trade Commision, 2015). In 2016, the Department of Homeland Security (DHS) has released a document that explains IoT security risks and provides non-binding guide of the best practices and principles for a private and public sectors. DHS has recognized, that the IoT security has not kept up with a rapid development of IoT innovation, resulting in substantial economic and safety risks. As network connections are increasingly integrated into nation’s critical infrastructures and many critical activities are dependant on properly functioning networks, IoT security is considered to be a matter

of nation's security. Furthermore, DHS released document encourages a cooperation between government and industry for ensuring that the IoT will be built on a secure and trustworthy foundation, IoT security will be maximized and risks will be minified. Document labelled itself as a first step to motivate and provide a frame for conversations about positive measures for IoT security among IoT manufacturers, developers, services providers and users. The National Telecommunications and Information Administration (NTIA) has called for a multistakeholder process concerning the upgradability and patching the Internet of Things, bringing stakeholders together to discuss their views on security patching and upgradability and establishing more concrete goals for industry-wide adoption **(**Department of Homeland Security, 2016**).** Another approach for combating vulnerabilities in the IoT connected home devices was taken as FTC in 2017 by engaging wider audience. FTC has challenged public to create an innovative tool that will help to protect consumers from risks of outdated software. Reward $25,000 for the best technical solution was established (Federal Trade Commision, 2017).

In summary, the Internet of Things is affecting United States citizens, businesses and national level infrastructures. United States participation in the IoT development is backed by the highest amount of oT intellectual property patents, indicating a top notch IoT R&D. Furthermore, the Internet of Things is regarded as one of six disruptive civil technologies that have required potential to impact the US national power. In the process of the IoT business development, United States are taking less rigid approach than China. Cooperation between government and business sector is encouraged, workshops for multiple stakeholders, including consumers, are organized. As the Internet of Things security is considered to be a matter of nation's security, security related matters are considered to be of special importance. However, specific IoT legislations are considered to be premature, as it could hinder the IoT business development, which is regarded to have a great innovation potential. Instead, governmental bodies provide lists of best practices, engages in security related education, advices to follow provided guidelines, encourages IoT stakeholders involvement and consumers' education.

2.4. Analysis of the Internet of Things business development in European Union

European Union involvement in the Internet of Things business development facilitation lasts for more than a decade. The European Commission has been providing initiatives related to the IoT since 2005 (Buckley, see in Miorandi et al., 2012). The importance of the Internet of Things for business, information and social processes was acknowledged by the strategic research agenda in

2009 (Westerlund et al., 2014). The European Research Cluster on the Internet of Things puts focus on the development of reliable, open and scalable IoT architectures (Gazis et al., 2015). Moreover, in 2009 the European commission has presented a report named 'Internet of Things', which was considered to be the action plan for Europe (Wan & Zeng, 2015). Furthermore**,** European Union, in the period of 2014 -2017, has invested €192 millions in IoT research and innovation (European Commision, 2016). Finally, in order to accelerate the Internet of Things development, a set of supporting policy actions have been adopted by the European Commission (European Commision, 2017). In order to support the Internet of Things innovation, European Union promotes the idea of open and easy accessible Internet of Things platforms (European Commision, 2016).

In addition to the research funding and policies creation, several IoT focused research projects were financed and conducted as a part of the EU the 7th Framework Programme on European Research (Skaržauskienė & Kalinauskas 2012; Skaržauskienė & Kalinauskas, 2015)**.** European Union has already invested more than 100 millions Euros in the 7th Framework Programme (FP7 for R&D) projects. Those projects are planned to be deployed in the fields of intelligent transportation, smart cities and smart grid (Chen et al., 2014). European Union members are already participating in the development of IoT based smart cities. In the territory of Santander, Spain, an experimental SmartSantander test facility was set up for experimentations and research of key Internet of Things enabling technologies, architectures, applications and services in the smart city context. Network of 12.000 IoT devices covers all area of the city and generates up to 300.000 observations per day (Lanza et al., 2016). Furthermore, the European Commission has launched a call for proposals for large scale IoT pilots in areas of wearables, assisted living, smart agriculture and water management, connected vehicles and smart cities. It is planned that pilots will deliver practical IoT solutions in areas of standardization, applicable technology, security and privacy, business models and usability (European Commision, 2016). Furthermore, sensitive topic of the Internet of Things security is also considered in European Union, as EU provides more initiative in establishment of the IoT security systems than other regions (Min & Chai, 2016).

European Union has identified key industries for IoT business development. Smart agriculture, smart industries, smart cities, as well as sustainable smart water management and smart grids are considered to be strategic IoT areas (European Commision, 2016). The focus of European Union initiatives is set on the adoption of the IoT technologies and services in the enterprise environments, with a goal of increasing the competitiveness of European industry through the adoption of IoT-enabled solutions (Miorandi et al., 2012). In addition governmental efforts, European IoT business development facilitation was reinforced by influential business sector

stakeholders. Some of Europe's largest digital and technological companies, in 2015, have joined European Commission's IoT business development efforts and have joined the European Commision launched alliance, which is named as the Alliance for Internet of Things Innovation (AIOTI). The Alliance expresses European Commission intentions for a close collaboration with all IoT sector stakeholders, encourages formation of new relationships and strengthening of existing ones (Tadejko, 2015). AIOTI supports the creation of innovative and industry driven European Internet of Things ecosystem, development of new business models and establishment of a competitive European IoT market (European Commision, 2017).

Furthermore, The Digital Single Market (DSM), adopted in 2015, pushes European Union a step further in the process of the IoT business development acceleration. The concept of European DSM consolidates the initiatives on security and data protection, which are recognized as critical points for the adoption of the Internet of Things (Skaržauskienė & Kalinauskas, 2015). Moreover, DSM defines efforts in tackling standardization, fragmentation and interoperability issues - some of the major obstacles for the Internet of Things business development (Tadejko, 2015; European Commision, 2017). In order to meet the DSM strategical need and to fulfill stakeholders' requirements for information about upcoming policy, the European Commission, in 2017, has published a working document 'Advancing the Internet of Things in Europe'. Document specifies the IoT vision which is based on three pillars:

- a thriving IoT ecosystem
- a human-centred IoT approach
- a single market for IoT.

Additionally, European Union has set up concrete IoT research and innovation objectives European Commision, 2017).

However, there are alternative opinions in the scientific literature, regarding the European Union efforts in the process of the Internet of Things business development. Tadejko (2015) argues that there has been a lack of European Union focus on IoT development, since the release of the initial 2009 plan 'Internet of Things'.

To summarize, as the union of separate countries, European Union efforts for the Internet of Things business development are largely expressed through encouragement and funding of research initiatives and supportive policies creation. In addition to research initiatives encouragement, European Union provides more initiatives than other regions in the establishment of the IoT security systems. Moreover, The Internet of Things importance for business sector has been

acknowledged by the strategic research agenda and business sector actors. Competitiveness of the European industry is planned to be increased through the adoption of the IoT technologies and services in the enterprise environments. In addition to centralized governmental efforts, the alliance (AIOTI) of some of the largest digital and technological companies has been created. Intentions of close collaboration, that were expressed by governmental body - European Commission, have been supported by business sector alliance. Finally, the IoT business development is further encouraged as Digital Single Market, which provides efforts in tackling critical business development obstacles of standardization, fragmentation and interoperability.

3. RESEARCH OF QUALITATIVE SUCCESS CRITERIA OF THE INTERNET OF THINGS BUSINESS DEVELOPMENT

3.1. Research methodology

Issue of the research. Businesses are well aware of the potential IoT benefits, however, they are unsure how to approach the technology. Studies about the key success factors for application innovation in the IOT is still at the exploratory stage. IoT companies and policy makers are looking for answers how they could facilitate IoT business development. Thus, the problem in scientific and business communities exists, that it is unclear, which criteria have been critical success factors in successful IoT businesses development cases, qualitative success criteria have not been determined. Resulting uncertainty and lack of guidelines may hinder the development of IoT businesses.

The object of the research. Qualitative success criteria for the Internet of Things business development.

Goal of the research. To identify critical qualitative success factors and crucial criteria that, according to global IoT industry experts, play a critical part in successful Internet of Things businesses development cases.

Research tasks:

- To identify whether IoT businesses have benefited from a a cooperation with other institutions (business incubators, workshops, R&D collaboration with universities, alliances with other companies, etc.).
- To gather information about the main obstacles that experts' companies have encountered in the Internet of Things business development.
- To find out ways how governmental bodies could encourage and facilitate the IoT businesses development.
- To identify which recent IoT ecosystem changes have positively impacted the IoT business development and which next steps could facilitate the development even further.
- To determine criteria that could be defined as the critical success factors in a process of Internet of Things business development.

The qualitative research method was chosen, experts opinion was surveyed by questionnaire. Qualitative method was chosen in order to explore the phenomenon, get a deeper domain knowledge. Qualitative methods are used to examine questions that require explanation or

understanding of phenomena and their contexts. Furthermore, qualitative methods are particularly useful in issues, which hold some complexity exploration. The aim of qualitative research is generally directed at providing an in-depth and interpreted understanding (Ritchie et al., 2014, p. 5-22). In order to gain experience based domain knowledge, experts interview was chosen as the research method. Experts were approached by same procedure and were presented with a predetermined set of questions.

The questionnaire was developed in accordance with the **questionnaire designing principles.** Experts were introduced to the aim of research, research reasoning was explained, interviewees were familiar with the topic of research, amount of questions was kept in single digits, questions were oriented to participant experience, difficult and possibly irritating questions were avoided (Kardelis, 2002, p. 93- 94). Experts were encouraged to share their experience and opinions.

Survey questions could be divided into 3 main logical parts (see Figure 3).

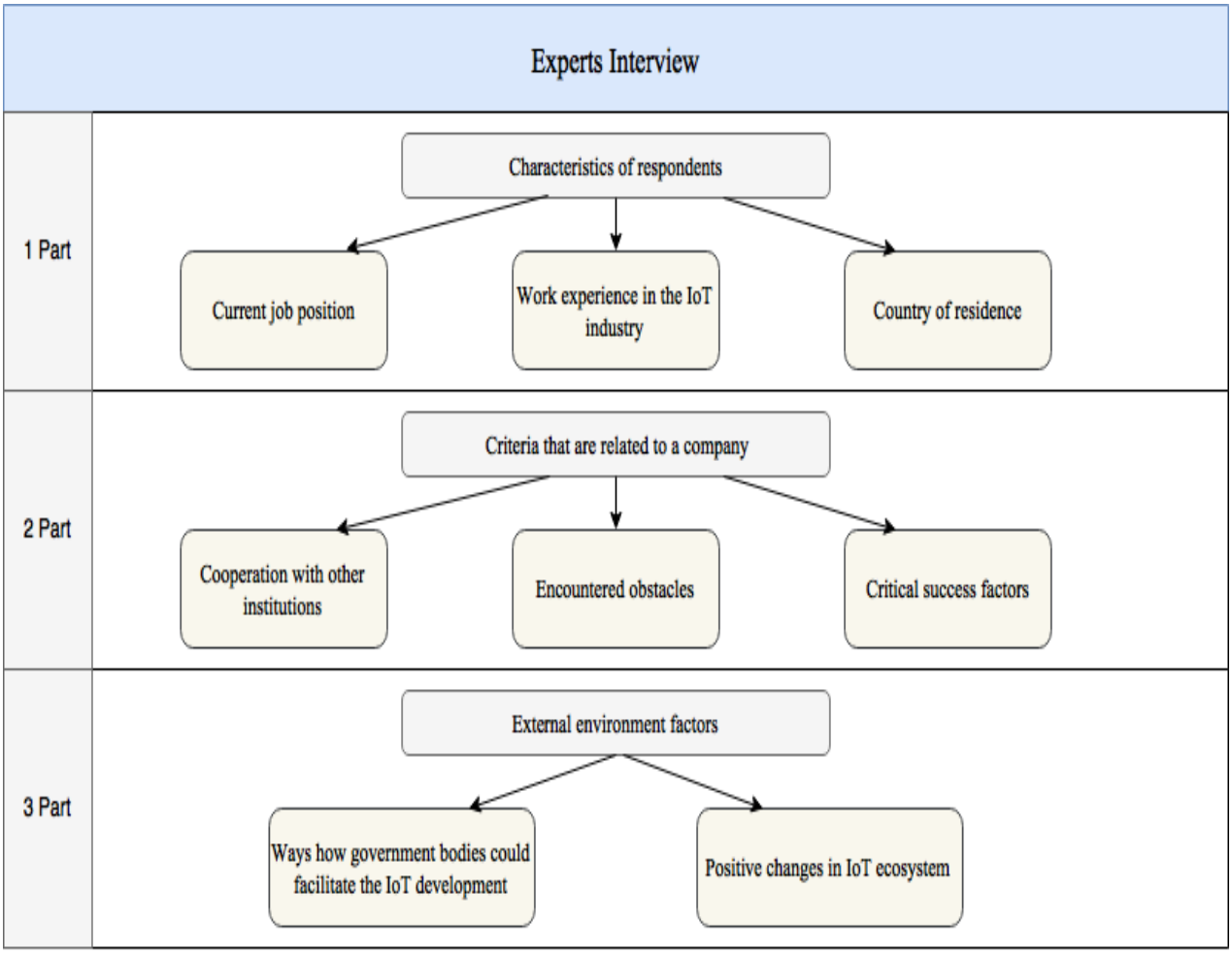


Figure 3. Logical scheme of the questionnaire

Survey questions have explored experts' IoT industry work experience, current job position and country of residence. Furthermore, three questions were related to Internet of Things business development factors that are related to internal company matters: success criteria and encountered obstacles, experience of cooperation with other institution. External environmental factors, that could encourage and facilitate the Internet of Things business development, such was role of government bodies and changes in ecosystem were also analysed. The questions were raised based on theoretical analysis.

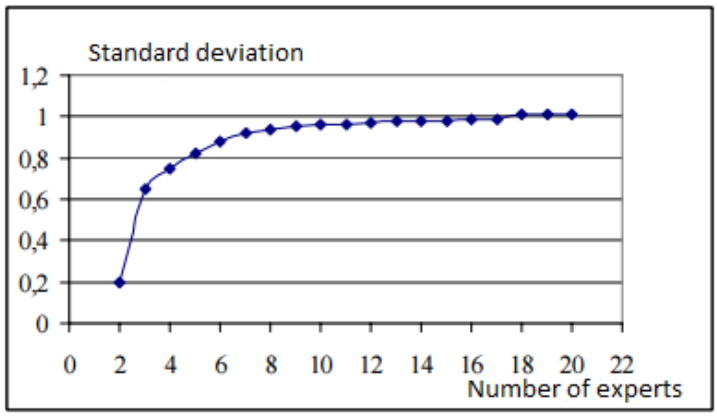
3.1.1. Organization of the research

The surveying process was conducted between 3rd March, 2017 and 14th March, 2017. The Internet of Things industry experts were personally contacted through Linkedin social network. Experts were chosen by evaluating their IoT industry experience, current job position and a country of residence. IoT experts that were working in China, United States or European Union countries, had at least 2 years of the IoT industry or related industries experience and were working in senior business development / sales or strategic level / management positions were targeted. After selecting appropriate candidates, they were contacted with a connection invitation. A follow-up request of participation in the survey was sent upon accepted connection invitation. Interested experts were introduced to the goal of the research - to identify critical success factors of successful Internet of Things business development cases which, according to industry experts, could encourage and facilitate development of new IoT businesses. Experts were encouraged to share their experience and opinions. It was stressed out that survey is confidential, identities of participant will not be disclosed to public.

The questionnaire was hosted on Google Forms and a link to the survey was sent through personal Linkedin social network messages, or to electronic mail inbox of expert, if participant has requested it. The survey has gathered responses from 14 IoT industry experts. However, answers of 1 expert were not analysed, because expert was not residing in a country, that qualifies as a part of the leading IoT business development regions list, which was determined in the section 2.1. As a result, answers of 13 IoT industry experts were analysed.

Adequate research sample size is a prerequisite for a scientific research. Qualitative research samples are usually small in size. That is reasonable, because qualitative research is not concerned about incidence or prevalence statements, quantitative estimates or determination of statistically significant discriminatory variables. Furthermore, information, gathered by qualitative methods,

usually is rich in detail. There will be many important 'bites' of information from each collected data unit. In order to conduct a proper analysis qualitative data sample sizes need to be kept to a reasonably small scale. However, it is also important to ensure that samples are not too small. (Ritchie et al., 2014, p. 83). A determination of the adequate sample size could be based on methodological assumptions from the classical test theory, which states that the reliability of aggregated decisions and the number of decision makers (in this case - experts) is linked by a quickly diminishing nonlinear connection (see Figure 4).



Source: Baležentis&Žalimaitė, 2011

Figure 4. Linkage between standard deviation and number of experts

It is proven that in aggregated experts' evaluation modules with equal weights, decisions and assessments made by smaller experts groups are equally accurate as decisions and assessments made by bigger experts groups (Baležentis & Žalimaitė, 2011.) Based on these assumptions, a number of 9 experts is a threshold for a sample size in research that is applying the experts interview method. Therefore, a number of 13 experts is a sufficient sample for this research for obtaining reliable data.

During the surveying, experts have answered 8 open-ended questions. First 3 questions were demographically oriented, asked in order to confirm that gathered sample of interviewees qualifies as a global group of IoT industry experts, as it was required for a purpose of thesis' research. Latter 5 questions were exploring the qualitative success criteria of the Internet of Things business development:

In the first question interviewees were asked to identify their current job position.

In the second question experts have provided details about their work experience length in the IoT industry.

In the third question interviewees named their current country of residence.

In the fourth question participants were asked if their companies have cooperated with other institutions in the process of the Internet of Things business development. The Internet of Things development connects stakeholders, who previously had no relationships and encourages creation of networked business models (Ghambari et al, 2017). Furthermore, partnering and deal making are critical activities of business development (Houterman et al., see in Theryn, 2013, p. 169). Therefore, cooperation with other institutions may be one of IoT business development success factors.

In the fifth question obstacles, which experts have encountered, were questioned. As development of the Internet of Things is hindered by several obstacles (see Section 1.3.3.), identification of potential struggles and their overcoming may be critical success criteria in business development process.

In the sixth question interviewees were asked to propose ways how government bodies could encourage and facilitate the development of IoT businesses. Governments around the globe are applying different approaches for the Internet of Things business development facilitation (see Chapter 2). It would be beneficial to examine industry experts' expectations and suggestions regarding governmental role in the IoT business development process.

In the seventh question recent IoT ecosystem changes, that have positively impacted the IoT business development, and possible next steps for the future development were identified. The development of the IoT was enabled by innovations from several fields (see Section 1.3.1.) and is affected by external factors. As a result, IoT business developers must be aware of ecosystem advancements, that may be used for creation of revenue and value potential.

In the eighth question experts have identified criteria that could be defined as critical success factors in a new Internet of Things business development process. Answers to the final question are directly related to the Thesis research goal and could provide foundation for the application model development (see Chapter 4).

Full example of questionnaire is presented in **Annex 1.**

3.1.2. Characteristics of participants

According to the research goal of identifying critical qualitative success factors and crucial criteria that impact the IoT businesses development, experts that were working in identified leading global regions of Internet of Things business development - United States, China and European

Union, have been chosen. Furthermore, business development involves sales or marketing as distinct activities, which interfere with other business development activities (Sorensen, see in Smyth, 2014, p. 14). Strategy making is not the direct activity of business development, as it is responsibility of top management. Business development task is to operationalize and implement strategy of company (Houterman et al., see in Theryn, 2013, p. 169). Therefore, experts have been chosen from job positions that directly impact IoT business development activities, either from strategy creation or implementation functions. Chosen experts were working as Business Development and senior Sales experts, were holders of Management or Strategic level roles, or were experienced IoT Consultants. In order to be considered as suitable candidate for experts interview, expert had to fulfill several criteria:

- To be currently working in the Internet of Things industry.
- Have at least two years of industry experience, or experience in related industries.
- Reside in the China, United States of America, or European Union countries.
- Occupy positions that are related to business development activities or strategic decisions making.
- To have a legitimate Linkedin profile - more than 100 connections, thorough description of current and previous workplaces, a profile picture.

In order to fulfill the promise of confidentiality, the experts are coded in an anonymous way, such as: Expert A, Expert B, etc. and their answers to demographic questions are specified. Main characteristics of experts:

- **Expert A** - Leading Technical Product manager for IoT business, working for 2.5 years in the IoT industry, residing in Lithuania.
- **Expert B** - Chief of IoT Academy, who has 2 years of IoT industry experience, from Lithuania.
- **Expert C** - Director for Mobility and IOT, with 3 years of IoT business experience, residing in China.
- **Expert D** - Head of IoT Business Europe, 20 years of IoT industry experience, working in United Kingdom.
- **Expert E** - CEO with 5 years of IOT industry experience, residing in Sweden.

- **Expert F** - Freelance IoT Senior Consultant, who has 7 years of IoT experience, working in Spain.
- **Expert G** - Sales and Business Development specialist, with 2 years of IoT experience, residing in the United States of America.
- **Expert H** - Sales Director IoT Services, who has 10 years of industry experience, from Sweden.
- **Expert I** - Director with 4 years of IoT business experience, from China.
- **Expert J** - Sales Director, with 2 years of IoT experience, residing in China.
- **Expert K** - Head of IoT Solutions, 5 years of Iot industry experience, working in Sweden.
- **Expert L** - IoT Global Service Architect in IoT, with 1 year of industry experience, living in Italy.
- **Expert M** - Senior Vice President of Sales, 12 years of IoT industry experience, residing in USA.

3.2. Research data analysis

Regarding the **first question,** which was aimed to identify experts' *current job positions***,** answers could be divided into two main groups: management or strategic level positions and business development or senior sales specialists (see Figure 5). Full list of interviewees' job positions can be found at Annex 2.

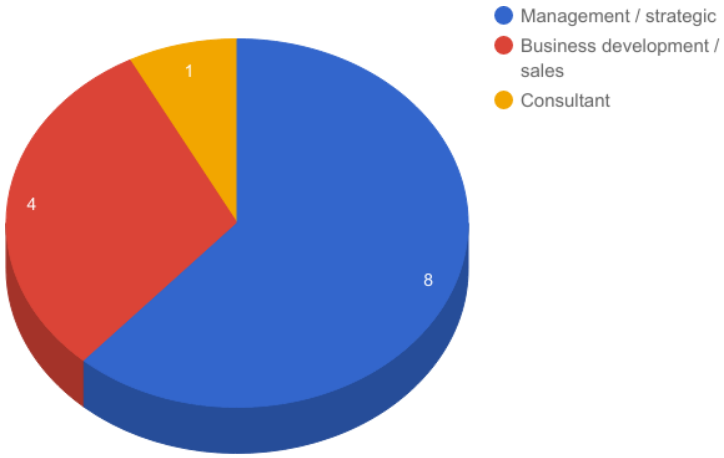


Figure 5. Experts' job positions

Majority of experts (8) are holding management or strategic level positions, 4 interviewees are working in business development or sales roles and 1 participant (Expert F) is a senior freelance

IoT consultant. Therefore, gathered sample of experts is directly related to the process of the Internet of Things business development.

Second question analyses *how long experts have been working in the Internet of Things industry.* Work experience of IoT industry experts varies from 1 year of IoT industry experience of Expert L to 20 years of experience from Expert D (see Figure 6).

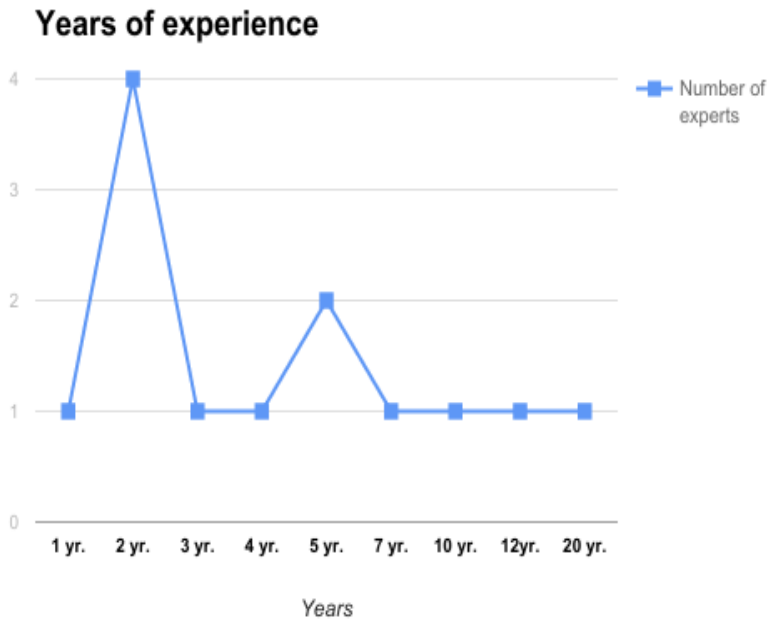


Figure 6. Experts' IoT industry experience

Visual representation of IoT experts work experience distribution shows that the biggest group (4 experts) have 2 years of the Internet of Things industry experience. Average of work experience in the IoT industry is more than 5 years. A median number of experience - 4 years.

Third question explores *experts' current countries of residence* (see Figure 7).

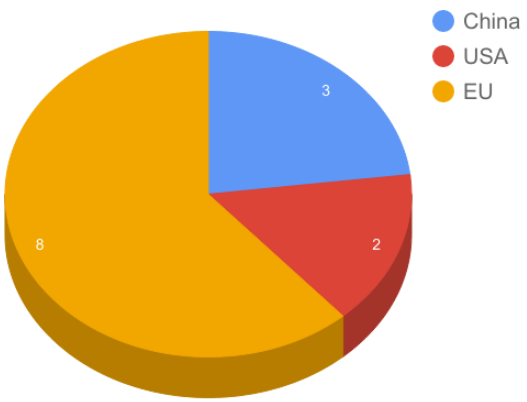


Figure 7. Worldwide locations of IoT industry experts

3 interviewees were residing in China, 2 experts were working in the United States of America, the biggest group of 8 participants were from European Union countries. Figure 7 presents global distribution of experts. Further expanding the analysis of IoT experts' countries of current residence, the biggest group of European Union residents can be examined (see Figure 8).

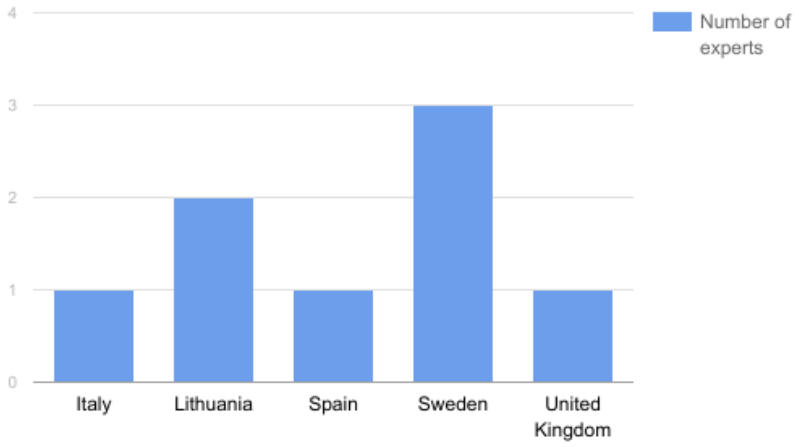


Figure 8. European Union countries where IoT experts were residing

Visual representation of IoT experts locations in European Union shows that the biggest part of experts work in Sweden, as 3 from 8 European Union interviewees were residing in Sweden. 2 experts were from Lithuania. A single expert was residing in Italy, Spain and United Kingdom.

Fourth question examined *whether experts' company has benefited from a cooperation with other institutions* (see Figure 9).

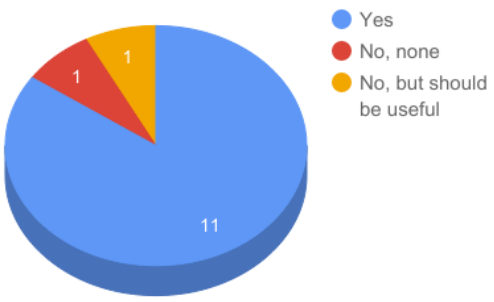


Figure 9. Cooperation with other institutions

Display of answers about the cooperation with other institutions demonstrates that 11 from 13 IoT industry experts have answered that their companies have cooperated with other institutions. Regarding non-positive answers, Expert J has mentioned, that his or her company as the largest electronics manufacturing services (EMS) company has over a million employees and a very strong R&D capacity, but an exchange with other industry players and universities should benefit a brainstorming process. Only Expert E has provided a firm negative answer, mentioning that his or her company has not participated in a cooperation with other institutions.

While sharing their experience about cooperations with other institutions, IoT industry experts have provided several trends of cooperation. First trend could be defined as partnerships with universities (see Table 7).

Table 7. Cooperation with universities

Experts	Answers
B	*'Official Vilnius Gediminas Technical Partners'.*
H	*'Yes the company have benefited from the close cooperation with a nearby University in Boca Raton, Florida, when our training program for developers and System Integrator was being under development. The students were able to give feedback of improvements before we took it to market'.*
M	*'Yes, in the early stages of IoT (then called m2m) I worked with many universities and incubator programs where students and collaborators worked on projects to write code and or case studies for solutions. The outcomes were great and the participants seemed to learn a great deal from each other'.*

Universities could be beneficial with their strong research capabilities and theoretical knowledge. As Expert M has indicated, students could expand mutual knowledge while working on new projects, solutions or case studies. Furthermore, as Expert H has mentioned, universities could be used as a place to test new ideas or processes and gather feedback for improvements.

Second type of cooperation could be defined as alliances with other business entities (see Table 8). Experts have stated that their companies have cooperated with other business entities in order to: generate new ideas; set common guidelines, standards, architectures and strategies; implement technological improvements; create global products; participate in advisory boards;

develop new modules and applications; learn from each other; cooperate regarding hardware and devices topics.

Table 8. Alliances with other business entities

Experts	Answers
A	*'Close cooperation with Start-ups for generating new ideas'.*
C	*'Alliance is pretty important as IoT involved multiple players and they need to agree on a common set of guidelines/standards in order to make the whole system work'.*
F	*'I worked for example in the last years in close cooperation with the GSMA <...>. I was involved in many activities around IoT with many operators and equipment vendors. The subjects and outcomes: <...> Common operator strategies and architectures for the Embedded SIM (remotely managed); use of licensed LPWA (Low Power Wide Area Networks) for different use cases <...>. Security guidelines for IoT to ensure E2E secure communications, authentication and authorisation; analysis a new scenarios of ioT within the automotive and smart energy verticals. I also worked in the IoT World Alliance with 8 different operators defining a global product based on the use of Jasper/Cisco managed connectivity solution with a global SIM for the alliance members.'*
G	*'Yes; we have benefited from partnerships with other companies along with participating on advisory boards and panels'.*
I	*'Yes, cooperation to develop new applications and modules'.*
K	*'Yes, good experience from learning from each other, however difficult to get it to a business were money is earned'.*
L	*'Yes. IOT is still a vertical market and needs for automotive industry are completely/partly different from the needs raised by Oil&Gas industry to smart-meter thei usage. This kind of cooperation is obviously focused in this time more to devices and hardware in general terms. <...>'.*

Furthermore, the trend of business incubators was also mentioned by a couple of IoT industry experts. Expert D has shared his or her experience, that company has engaged in a multiple ways of collaboration and financial operations: *'Yes, seed capital, incubating, acquisitions, educational investment'.* Expert M also mentioned, that he or she has participated in *business incubators with a great success.*

To summarize, the majority of experts (11) have answered that their companies were participating in a cooperation with other institutions during the Internet of Things business development. Three mains streams of cooperation could be identified: partnerships with universities, alliances with other business entities and business incubators. Experts' answers are in agreement with theoretical analysis of scientific literature. Partnerships with universities may provide R&D capacities for organizations. This cooperation method is applied in China as universities and research institutions provide their efforts on technology research (Chen et al., 2014). Changes in the IoT ecosystem not only connects new devices (Things), but also industry actors, who previously had no shared business relations (Westerlund et al., 2014). Therefore, 7 experts have shared their experience of cooperation with other business entities. Following the IoT development, companies have to utilize resources from different domains, cross-industry partnerships are formed. In order to stay competitive in an innovative ecosystem, companies have to look outside their internal business models and engage in opportunities of cooperation to profit from arising business possibilities of being a part of networked larger groups of business entities (Ghambari et al, 2017). Business incubators, mentioned by experts D and M, are widely applied in China as the way of encouragement and acceleration of innovation, new business development and resources sharing (Mahmood et al., 2015).

Fifth question has questioned *the main obstacles that experts' companies have encountered in the Internet of Things business development.* Furthermore, experts were asked to share *how obstacles were solved.* 12 experts have provided their answers to the fifth question. Expert I has answered with *'na'*, which stands for *not available*. Generally, experience of encountered obstacles varies and several clusters of obstacles could be developed. Since the Internet of Things is a technological phenomenon, experts have identified technological IoT business development obstacles (see Table 9).

Table 9. Technological obstacles

Experts	Answers
A	*'IOT platforms integration and analytical tools'.*
B	*'First it is hard to define obstacles in the general position when main activity is IoT / M2M technology. But basically most common problems are associated with security or cloud system integration in existing systems'.*
G	*'We have a very complex solution that is infrastructure agnostic; it takes a long time to move the needle on the sales continuum <...> '.*

IOT platforms integration, cloud system integration in existing systems, security problems, analytical tools, complexity of existing solution were mentioned as technological obstacles.

While answering to the question, three experts have shared their opinions that IoT market currently is immature, fragmented, lacking standards and security framework (see Table 10).

Table 10. Obstacles related to market immaturity, fragmentation and lack of standards

Experts	Answers
C	*'Lack of consistency among different IoT project which makes reusing and scaling very difficult. There is no immediate solution to this, still need to wait for the whole IoT market to grow more mature'.*
F	*'Some obstacles are: The maturity of the market, the lack of standards, the use of licensed IoT communication technologies, rather fragmented market, lack of a security framework for IoT. All of these were tackled in the activities <...> in the GSMA. And <...> by establishing strong operator alliances and vendor alliances (Thingworks, Jasper/Cisco, Masternaut, G&D,...)'.*
K	*'Who should make money on what. IoT is still a bit immature where companies are not sure exactly what part each company shall make business on and instead they are trying to take a too bif part of all'.*

Due to fragmentation and lack of standards, difficulties arise when there is a need to maintain consistency between different projects. Due to market immaturity, as Expert K has mentioned, companies may be unsure about their role in the IoT ecosystem and ways how to should earn money. Expert F has shared that his or her companies tend to overcome obstacles, by forming strong alliances with vendors and operators. Furthermore, obstacles are resolved by activities of GSMA, which represents the interests of mobile operators worldwide (GSMA website).

Moreover, due to market immaturity companies may be undecided upon their value proposal, have not identified exactly what they are offering (see Table 11). Due to this ambiguity, customers on their part may not exactly understand what solutions IoT businesses are offering. Expert L has suggested that his or her company tries to solve, by increasing the interest and improving understanding of potential clients by offering a journey at their demonstrational points.

Table 11. Value proposal obstacles

Experts	Answers
D	*'No one buys IoT, they buy transformation, stop pushing tech and focus on business outcomes'.*
L	*'Knowledge of our proposal was probably the biggest first issue. Only advanced customers knew the word IOT/GDSP* and its benefits for their business. Moreover our references might be not really ready to face this new world. < ...> we have several demo point <..> in which we offer a journey in our solutions to customers who seem to be interested in IOT'.*

**GDSP (Global Data Service Platform) is a service which lets you manage your connected M2M deployments through Vodafone centrally hosted, secure self-service platform (Vodacom website).*

Furthermore, immature, continuously developing and evolving ecosystem suffers from the lack of specialists and general knowledge (see Table 12).

Table 12. Obstacles related to domain knowledge

Experts	Answers
E	*'No IoT business consultants in general'.*
M	*'Knowledge around the ecosystem needed for a successful deployment. Most companies do not realize how many pieces there are to a solution. An IoT deployment almost always requires collaboration or parts of the solution from at least 3 vendors and in some cases it can be many more. These issues are only solved when you find vendors or solution providers that are willing to work together to deliver a result'.*

Experts have mentioned obstacles of lacking IoT business consultants, and importance of knowledge around the ecosystem for successful deployment and helpful assistance from vendors or solution providers as a solution.

In addition to previously mentioned obstacles, experts have raised several other stumbling blocks that were encountered in the Internet of Things business development. Expert G has mentioned that company is *'competing with players that are better-known. We are continually driving brand awareness to narrow the gap'.* Expert H has accented two obstacles: commitment of management - *'For a really successful implementation, besides great technology and so on, is top management commitment. If IoT isn't been given to blessing from the top of the company it has a*

high risk to fail' and changes that are required within organization in order to successfully develop IoT business - *'Then the second biggest obstacle is that the organization doesn't recognize it needs to change their way of doing business in order to leverage the investments in the IoT project'.* Furthermore expert H has provided a suggestion for solving the obstacle of management commitment - *'This requires often an external trustworthy partner that has influence on the management so they understand that just developing an IoT solution will not be enough'.* Yet again, partnerships within the IoT ecosystem are mentioned by experts as a solution for solving current obstacles of Internet of Things business development. Finally, Expert J has mentioned obstacles of cost cutting and being needs driven: *'Need to be needs driven and define specific solution for each application scenario. Additionally is the cost down gradually to meet the ROI'.* Obstacles of management commitment and costs of IoT business development are in alignment with scientific literature. It is known that the IoT generated expenditures combined with high uncertainty of ROI results in companies' hesitation in the investment decisions (Zhou et al., 2016).

In summary, while providing answers to the fifth questions, 3 experts have mentioned technological obstacles. That is understandable, since the Internet of Things is considered to a technological revolution (Khriyenko et al., 2012) and IoT businesses are technologically based. Moreover, 3 experts have brought up topics of the IoT ecosystem immaturity, fragmentation, lack of standards and security frameworks. These obstacles are well documented in scientific literature. The lack of standards is common problematic point for technology based innovations that are widely used (Skaržauskienė & Kalinauskas, 2015). Standardization of security, network architecture and privacy is required for further IoT development (T. Santhi Sri et al , 2016). Furthermore, global adoption of IoT is prevented by the lack of unified standards, vendor independent guidelines, dominant design and resulting high costs (Mazhelis et al., 2012). Immaturity and lack of standards results not only in high costs, but also in lack of domain knowledge - lacking IoT consultants, lack of ecosystem knowledge, that is required for successful deployment. IoT businesses suffer from confusion in assessment of which part of ecosystem to take, inadequate understanding of their business value proposition, or difficulties of explaining value proposition to customers. Furthermore, businesses may not recognize required transformation and needed management commitment. Standards and technology are getting mature, however, businesses still encounter challenges as there are no established boundaries and no predefined processes to follow (Ghambali et al., 2017).

Sixth question has asked experts to *suggest ways how government bodies could encourage and facilitate the development of IoT businesses.* All 13 experts have provided their answers to this

question. Experts have provided various suggestions and some of answers have provided practical suggestions and solutions to obstacles, that were mentioned at fifth question. 3 experts have suggested standardization (see Table 13).

Table 13. Suggestions of standardization

Experts	Answers
C	*'Promoting open standards'.*
D	*'Standards, clear regulation on data, tax breaks beyond R&D'.*
M	'*One of the major obstacles is still standardization, if there were a set of accepted standards for solutions/interoperability it would likely speed up development and time to market <...>.*

2 experts have answered, that not only standardization is lacking, but also governmental policies and regulations would be encouraged (see Table 14).

Table 14. Suggestions of governmental policies and regulations

Expert	Answer
F	*'A common European regulatory framework for ioT in order to surpass issues in permanent roaming, e-call, innovation incentives and data privacy policies commonly approved in Europe and worldwide'.*
G	*'Government bodies already are, in the way of connected and autonomous vehicles and "smart" initiatives (cities, schools, etc.); they are laying out policies around driver safety, vehicle-to-X information exchange and are seeking trusted advisors to help with criteria'.*

3 interviewees have mentioned that there is a need for governmental bodies to take actions of education and knowledge sharing. However, directions of education targets have differed (see Table 15).

Table 15. Experts' answers about needed IoT education

Experts	Answers
A	*'At first government bodies should understand that IOT is not smartphones, PC's and etc. That it's more complex solutions which can be used in a lot of different ways and provide benefits for country, government bodies, business and even regular citizens.'*
B	*'Improve education and science in the field of IoT technologies'.*
K	*'Proof of concept projects to evaluate not only technology, but also the business part. How can each involved part make money?'*

Expert A has suggested that government bodies should improve their understanding of the IoT phenomenon scope. Expert B has mentioned that education and science in the field of IoT technologies need to be improved. Expert K has expressed a desire of proof of concept projects that would include not only technological evaluation, but also a business part and could explain how all involved parties could make profit.

Another common topic among IoT experts was funding and financial incentives (see Table 16).

Table 16. Experts' opinions regarding IoT funding and financial incentives

Expert	Answer
I	*'Funds'.*
J	**'***Some popular way might be Setting Funding to support, but my personal view is that let it be, let the market decide and adjust by itself'.*
L	'*Locally (Italy) government has just issued some financial benefits for company who are going to invest on new technology (IOT environment included) and this is for sure a good way to sponsor our world'.*
M	*'<...>Another way would be to offer an incentive to companies to adopt solutions that deliver efficiency for power consumption or reductions in emissions. Companies are slow to adopt because they do not understand the ROI on productivity and the cost savings on energy use for applications like vehicle tracking or building automation. An incentive program that would offer companies a tax break or some other benefit for implementing a solution would make the decision easier and I think would encourage adoption'.*

Experts have expressed contradictory opinions regarding suggestion of funding.Expert I was pro funding, Expert L has suggested financial benefits for companies who are investing into technologies, Expert M raised a possibility of incentive program for companies that *'adopt solutions that deliver efficiency for power consumption or reductions in emissions'.* However, Expert J was against additional funding and has expressed opinion that market should adjust and sort itself naturally.

Furthermore, Expert H has provided an idea of IoT open data: '*They usually have access to a lot of data and if there was a way to provide that data to the IoT community to explore and develop new services on top of that data combined with other data sources would be a great start'.* Expert E directed his suggestion of improvement toward consumers: *'Improve business benefits for the end-customers'.*

To summarize, answers that were provided by IoT experts are partially related to previously mentioned obstacles. While answering the sixth question, experts have mentioned that they have experienced obstacles of lacking standardization. In a relation to this obstacle, while answering the seventh question, 3 experts have suggested standardization efforts as a way that governments could facilitate the IoT business development. 2 experts have suggested that government bodies should provide IoT policies and regulations. Uncertainty about businesses value proposals and which place to take in the developing ecosystem could be reduced by education and proof of concept projects that are covering business part of the Internet of Things. 3 experts have mentioned a need for a governmental education, however, directions of education recipients differed. For instance, Expert B has suggested improving education and science in the field of IoT technologies. This kind of governmental efforts could reduce the lack of IoT specialists and consultants. While speaking about encountered obstacles, experts have mentioned, that their customers are not always sufficiently informed about benefits that produced solutions are offering. Possible solution for this obstacle could Expert E suggestion about improvement of business benefits toward end-consumers. Topic of funding and financial incentives as the possible way for the IoT business development facilitation has gathered answers from 4 interviewees. 3 experts were for and 1 against additional funding or financial incentives. Finally, Expert H has mentioned, that governmental bodies have access to a large amount of data and open data sharing could be a beneficial move for the encouragement of the Internet of Things business development. It is recognized that open data programs are often driven by motivations of efficiency, increased transparency and creation of economic value, which may include innovation stimulation, new

businesses creation (Johnson, 2016). Business entities could explore shared data, combine open governmental data with other data sources and develop new services based on open data.

In the **seventh question** experts were asked *which recent IoT ecosystem changes have positively impacted the IoT business development.* Additionally experts were asked if they *could name next steps that could facilitate the development even further.* 12 interviewees have provided answers, Expert G has answered with *'n/a',* which stands for - not available. Majority of interviewees (8) have mentioned recent technological changes as positive impacts for a successful IoT business development (see Table 17).

Table 17. Technology innovations that have positively affected ecosystem

Experts	Answers
A	*'Connectivity part'.*
B	*'5G core network will be direct way'.*
E	*'End and target solutions APIs has improved the IoT integrations'.*
I	*'Smart Home'.*
J	*'Many scenarios, in industry sector, it is far from citizens, not well know; But smart home, wearable devices related to daily life, more presents will do better to spread the concept and benefits. But also step by step'.*
K	*'Development of new technologies like LPWAN to make it possible to connect things that was not possible before due to cost. Make sure LPWAN networks is beeing built.'.*
L	*'For sure all the rumors related to IOT NB (Narrow band)launch has increased interest for IOT solutions. Probably the launch of e-sim will accelerate the process of adopting IOT solutions in big companies. Nowadays it's seen as a risk for them the to sign a bid for long time with an operator (local or global) and costs of implementation are high. If for any change of operator, company has to plan a massive campaign to change sims/device, then the cost for IOT solution increase and cannot be monitored effectively by customer'.*
M	*'The cat1 or m1 evolution of cellular network operators and module suppliers will greatly increase the number of applications that can attain a positive ROI in a short amount of time. The new technology will further reduce cost thereby making solutions attractive in areas where they have not previously been. Additional standards could help speed this process up, in the US market everyone thinks that LTE will bring some network standardization but most folks don't understand that every network operator still has a their own set of frequencies etc, and while it helps there is still an added cost to build a module that covers all carriers'.*

IoT experts have reported a wide list of technological innovations, some of them are related to connectivity: 5g network, Low-Power Wide-Area Network (LPWAN) and its stadard Narrowband IoT. Moreover, it was noted that APIs of end and target solutions have improved the integrations of IoT. Furthermore, innovation of smart homes were mentioned several times. Smart wearables were acknowledged to integrate IoT into daily lives of consumers and increase general recognizability of IoT domain. Expert L has mentioned that launch of e-sim could reduce risks of long-term partnerships with a single operator and could encourage the adoption of IoT in big companies. Expert M has expressed opinion that technological improvements will reduce costs and shorten time needed for IoT application to return investments.

Moreover, standardization and regulations were mentioned again (see Table 18).

Table 18. Positive regulation and standardization changes

Experts	Answers
D	*'GDPR'.*
F	*'The standardisation of mobile IoT Technologies was effectively performed in 3GPP and now being rolled out commercially. The same is happening with the M2M Remote Sim provisioning that is slowly ramping up. The biggest next step is to merge the B2B and B2C models to embrace completely the world of IoT. In operators for example this is the next IoT Revolution. IoT can take onboard data form both worlds to construct a service!'*

Two experts have answered that regulations and standardization have provided a positive impact in the Internet of Things ecosystem. Experts D has mentioned General Data Protection Regulation (GDPR), Expert F spoke about a standardization of Mobile IoT technologies in 3GPP - the 3rd Generation Partnership Project that unites seven telecommunications standard development organizations and provides their members with a stable environment to produce the reports and specifications and movement to apply this standardization process in commercial environment (3GPP website).

Furthermore, Expert H has mentioned the cooperation efforts and importance on networked IoT business models : *'One recent change is that the IoT ecosystem have acknowledged the fact that you can't do everything by yourself in an IoT project. So old competitors are now working together on specific projects and that would never happen before'.* Finally, Expert C has recognized increased

Internet of Things recognition among the biggest industry actors: *'IoT platform is getting better recognized among the players (Predix, Bluemix, AWS IoT, Azure IoT...)'.*

To summarize, yet again the majority of experts have mentioned technological aspects of the Internet of Things ecosystem. This results from the fact that IoT is a technological innovation (Santhi Sri et al., 2016) and IoT businesses are enabled by technological innovations. Two interviewees have mentioned that standardization and data protection regulation efforts are making a positive impact in the IoT ecosystem. This is an encouraging change, since several experts have mentioned obstacles of lacking standardization in fifth question. Furthermore, scientific literature suggests that sluggish standardization negatively impacts large-scale commercial deployment of IoT services **(**Skaržauskienė & Kalinauskas, 2012). Moreover, IoT industry experts have mentioned, that IoT ecosystem actors realized that they cannot fulfill entire ecosystem. Business entities that previously were considered as competitors, nowadays are working in common projects. This confirms statements of scientific authors, which declare that IoT development connects industry actors who previously had no shared business relations (Westerlund et al., 2014). Furthermore it is stated that the potential of the IoT lies within the interaction of industry actors working together for a value co-creation. Companies should look outside their internal business models and explore opportunities of cooperation in novel network-centric business models (Ghambari et al, 2017). Finally, positive changes in IoT ecosystem and market development have subsequently improved IoT recognition among the highest calibre industry players.

Eighth question has asked interviewees to share *which criteria could be defined as critical success factors in a process of new Internet of Things business development.* While answering this question, all 13 experts have provided their answers. Experts' answers could be divided into several groups. 3 experts have mentioned technological factors as requirements for successful IoT business development process (see Table 19).

Table 19. Technological IoT business development success factors

Experts	Answers
A	*'Cyber security, connectivity and IOT platforms'.*
B	*'Periodicall technology improvement! New idea implementation in the field of IoT technology'.*
K	*'Coverage of radio networks for IoT, LPAN and/or NB-IoT etc'.*

Security, connectivity, periodical improvement of technologies, implementation of new ideas, radio networks coverage were accented.

Furthermore, 6 experts have mentioned success factors that are related to business processes or company strategy (see Table 20).

Table 20. Business processes and strategies as key IoT success criteria

Experts	Answers
E	*'Cost savings'.*
F	*'There a different angles in the business development for IoT: Vertical solutions (HW&SW), Horizontal solutions (Platforms), overall Solution (communication, platforms: Operators). Good IoT communication frameworks based on well proven and standard solutions, Strong alliance with modem/module vendors being able to adapt new solutions with upcoming networks, Data processing and exploitation strategy, IoT Platform embracing B2B and B2C, compatibility of solutions with the latter, proven security technology for IoT- E2E, allow 3rd parties access to data'.*
G	*'Secure, control, connect, manage, analyze and build'.*
H	*'Top management commitment. A system integrator with a strong IoT ecosystem that can put the solution together. Make sure that you earn money, save money or staying compliant with your IoT business development. Otherwise, don't do it'.*
L	*'Clear and full comprehension of IOT solutions,its benefit and duties related to them to have a good experience with IOT platform'.*
M	*'The most important factor is to gain a good understanding of the entire ecosystem required to deliver a solution BEFORE development starts. That way organizations can develop the solution with a finished product in mind. I have seen many, many organizations develop a solution based on a limited understanding of the marketplace only to re-engineer the solution at the last step. Understanding how data transport works and the cost associated with it for the final solution allows a company to "work backwards" and develop a solution that can go to market in it's first iteration. Failing to do so can result in multiple attempts and those attempts can be so costly and time consuming that the project gets cancelled before it really gets a field trial'.*

Experts have mentioned cost saving, usage of communication frameworks built on proven standard solutions, usage of proven security technologies, strong alliances with vendors, data processing and exploitation strategy, B2B and B2C compatible solutions, allowing 3rd parties access to data, need of top management commitment, importance of integration capabilities. Experts L and M as key IoT business development success factors have prioritised a solid understanding of developed IoT solutions, their provided benefits together with duties and knowledge of the entire IoT ecosystem, which is needed before starting a development process. Expert G has provided concrete steps for success: *'secure, control, connect, manage, analyze and build'*.

Experts C and D have expressed their opinion that in order to be successful, businesses should stop referring the umbrella term of the Internet of Things and should be more specific(see Table 21).

Table 21. Suggestions of dropping the Internet of Things term

Experts	Answers
C	*'This is hard as IoT is too board as a concept. To some extent when people are less talking about IoT but more focus a specific areas such as smart manufacturing, autonomous driving... it indicate a more mature stage. '*
D	*'Stop referring to the internet of things, it's a term that focusses on the wrong end of the value chain and the tech push agenda. Move to a transformation agenda'.*

Expert C stated that focusing on specific area would be a sign of maturity. Expert D suggested that companies should move to prioritising provided transformation.

Finally, 2 experts have mentioned orientation to customer (see Table 22).

Table 22. Orientation to customer as business development success criteria

Experts	Answers
I	*'Ease/friendly of use of IOT'.*
J	*Bring convenience to people. Replacing old generation devices with large quantity of shipment, then could say some success'.*

Expert I has prioritized the easiness and friendliness of use that the Internet of Things brings to people. Expert J stressed out the point of replacing old generation devices as a success factor in IoT business development.

In summary, experts have provided several clusters of key success criteria of the Internet of Things business development. The biggest group of answers is related to business activities and strategies. Before starting the development process, business persons have to have a solid understanding of the entire ecosystem. Otherwise, they may spend time and money developing solutions that will have to be totally reworked on a last minute. Moreover, experts must have clear understanding of IoT solutions. These tasks may be complicated to fulfill, as IoT related business models and technologies are changing at a rapid pace (Li et al., 2012). Furthermore, top level management has to be committed to the IoT business development, companies must engage in cost saving and ensure security, as security problems are one of current problematic point of the Internet of Things **(**Skaržauskienė & Kalinauskas, 2015). IoT businesses are encouraged to adapt frameworks that are based on well proven and standard solutions. Strong alliances with vendors and adaptability to new upcoming solutions are encouraged. Moreover, companies have to establish data processing and exploitation strategies, since big data that is gathered through the Internet of Things, enables new e-business strategies and scenarios (Chang et al., 2015). Moreover, companies have constantly analyze, manage and build in order to earn money and stay compliant with their IoT business development plan. Additionaly, IoT businesses should take a next step of maturity and stop referring to the term of the Internet of Things. Companies should rather prioritize business transformations they are providing or be more specific describing which area of the IoT they are working in. While suggesting technological success criteria, experts have expressed suggestions that cyber security, connectivity, coverage of radio networks, periodical update of technological matters and implementation of new ideas are the key technological success criteria for the IoT business development. Described success factor may not be easy tasks to achieve, since the IoT reportedly generates expenses for new infrastructure, cooperation with telecommunication providers, employees hiring and training (Zhou et al., 2016). Finally, two experts have distinguished orientation to users as the key success factor in the IoT business development process. According to industry experts, companies should prioritize easiness/friendliness of IoT use and convenience brought to people by replacing of old generation devices are important. A human centered approach is in accordance with European Union's IoT vision (European Commision, 2017).

Research part conclusions:

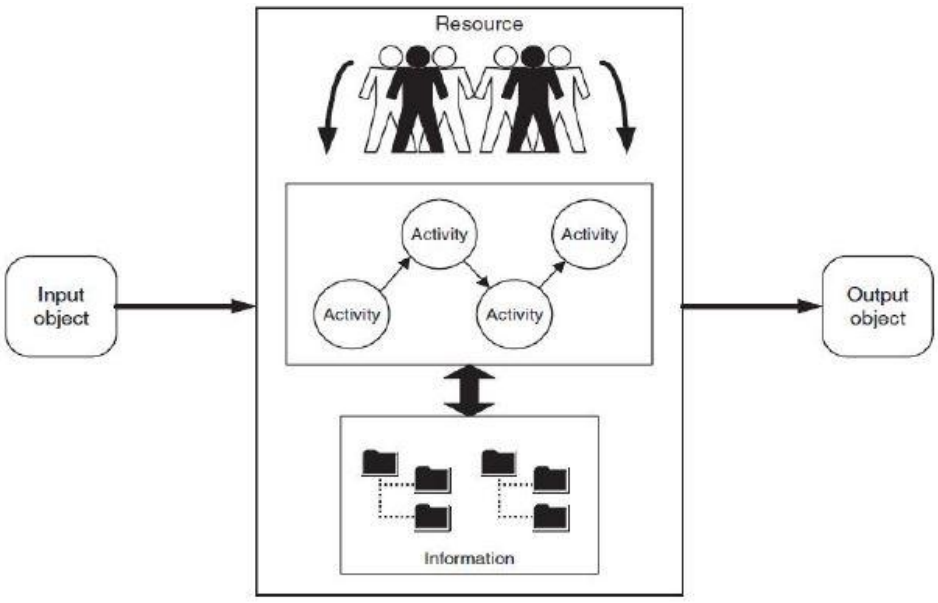
- Majority of companies, where IoT industry experts have been working, have cooperated with other institutions. Mentioned cooperation trends: *cooperation with universities, alliances with other business entities, business incubators.*
- *Technological obstacles* (security, integration, complexity, analytical tools); m*arket immaturity, fragmentation and lack of standards*; *unclear value proposal;* obstacles related to *IoT domain knowledge; management commitment, cost cutting* and *required business transformations* were identified as the main obstacles in the Internet of Things business development.
- While providing suggestions how government bodies could facilitate the Internet of Things business development, industry experts have mentioned: *standardization, policies* and *regulations* creation*, IoT related education, funding* and *financial incentives, open data* initiatives.
- *Technological improvements* (connectivity, Low-Power Wide-Area Network (LPWAN) with Narrowband IoT standard, improved IoT integrations, smart homes and smart wearables)*, General Data Protection Regulation* and *standardization*, *cooperation on specific projects with previous competitors* and *recognition among big companies* were mentioned as recent changes in the IoT ecosystem, that have positively impacted IoT business development.
- The key success factors in new IoT business development were identified as: *criteria related to business activities and strategies* (cost saving, usage proven communication frameworks and security technologies, strong alliances with vendors, data processing and exploitation strategies, B2B and B2C compatible solutions, allowance for third parties to access data, top management commitment, integration capabilities, solid understanding of developed IoT solutions and IoT ecosystem), *technological factor*s (security, connectivity, periodical improvement of technologies and implementation of new ideas, radio networks coverage)*, avoidance of the umbrella IoT term in business development,* and the *orientation towards end user*.

4. DESIGNING THE INTERNET OF THINGS BUSINESS DEVELOPMENT QUALITATIVE SUCCESS CRITERIA APPLICATION MODEL

4.1. Designing methodology

After qualitative criteria were proposed by IoT industry experts, it would be beneficial to create the Internet of Things business development qualitative criteria application model that could further expand the applicability of gathered qualitative data. Models supplement theories, explain details that are related to specific situations. Models are a simplification of reality objects, they are easier to research than objects that are being modelled. However, their similarity to reality objects not only allows the explanation of known phenomenon, but also enables interpretation, forecasting of unknown (Kastickaitė, 2014).

Models could be divided into mathematical, statistical and qualitative (Sidekerskienė see in Limba & Gulevičiūtė, 2014). In this thesis, a qualitative application model will be proposed. Qualitative models describe systematic processes and structures, help in interpreting vague phenomena (Heise & Durig, 1999). Any model development process follow certain set of rules and is full of processes. Every process consists of number of activities, resources and information (Limba & Gulevičiūtė, 2014) Furthermore, an activity will not start without input object or objects, which initiate the process. An output object appears as a result of modelling process (see Figure 10). Output object quality is strongly affected by process (Aytulun & Guneri, 2008).



Source: Aytulun & Guneri, 2008, p. 2745.

Figure 10. The model structure and interaction

4.2. Model analysis

The development of the Internet of Things business development qualitative success criteria application model (see Figure 11) is based on:

- Analysis of the Internet of Things applicability in business (see Section 1.2) and development (see Section 1.3);
- Investigation of global leading regions of the Internet of Things business development (see Chapter 2);
- Qualitative research data analysis (see Chapter 3).

The application model of Internet of Things business development qualitative success criteria starts with an input object - beginning of the IoT business development. While starting IoT business development, **analysis of the external IoT ecosystem** should be firstly conducted. Thorough analysis of external IoT ecosystem provides information related to critical factors, which were mentioned by IoT industry experts. Analysis should influence decisions about which part of IoT market new business should occupy, which IoT area they could be precisely operating in. Examination of the IoT industry maturity level, fragmentation and standardization efforts would provide a list of possible obstacles and opportunities, examination could give overview of current situation in the IoT ecosystem. Ecosystem analysis could provide a critical information regarding existing policies and regulations, should help identifying possible business competitors. Moreover, business developers should conduct analysis on possible technological solutions and obstacles, that would definitely affect a technological business development. Examination of technological base could facilitate a development of ROI estimations for investments in technologies. Identification of existing funding or financial incentives could help establishing and developing the IoT business. Furthermore, businesses should evaluate existing IoT related education, whether it could be directly related to IoT business knowledge or formal domain related education. Finally, business developers could evaluate accessibility to open data if open data could be beneficial for their business goals.

After analysis of external environment, IoT business developers should answer questions related to **internal company matters.** Firstly, businesses should identify how they could respond to environmental factors that were identified at the first step. Before starting business development efforts, business persons should ensure a solid understanding of IoT ecosystem (which should come from external analysis) and knowledge of their own developed solution. Furthermore, business

developers should crystallize their value proposition and decide how business could clearly communicate what benefits they are providing to their end customers. IoT industry experts agree that business development experts should both show the maturity in their proposal identification by being more precise and not relying on the IoT umbrella term, and being oriented toward end customer's experience, provided benefits and easiness. Additionally, business developers should identify domain knowledge actors, as IoT technological solutions have a lot of moving parts and deep understanding is required for successful development and deployment. Moreover, businesses should decide how IoT business could overcome technological obstacles and exploit technological base and innovations for their own advancements. Usage of proven communication frameworks and security technologies is encouraged. Due to a need of investments and periodical improvements, companies should create plans and evaluate possibilities for cost cutting. Furthermore, management commitment is a must for a successful business creation and transformation. Finally, the IoT generates unprecedented amount of real time data and companies should consider data exploitation and processing strategies for a maximum advantage and increased revenue and value potential.

Following internal examination, company should identify possibilities for beneficial **alliances and partnership**. Business developers should identify possible directions and outcomes of cooperation with other institutions. Businesses should decide whether it would be worth to create alliances with other business entities. Decisions should be made which networked cooperation model they could engage into and how business could make profit from arising business possibilities of being a part of networked larger groups of cross-industry business entities. Moreover, businesses should decide upon partnerships with vendors and operators. Business development specialists should examine whether partnerships with universities could provide benefits in R&D, or expand their domain knowledge. Finally, IoT industry experts mentioned business incubators as a factor that could encourage the innovation acceleration.

In summary, the model diagram (see Figure 11) provides guidelines for a qualitative success criteria based Internet of Things business development. Analysis, conducted according to the provided Internet of Things business development qualitative success criteria application model, would provide suggestions for business development, guidelines for further improvement of specific business development case and a checklist for a creation of output object - qualitative Internet of Things business.

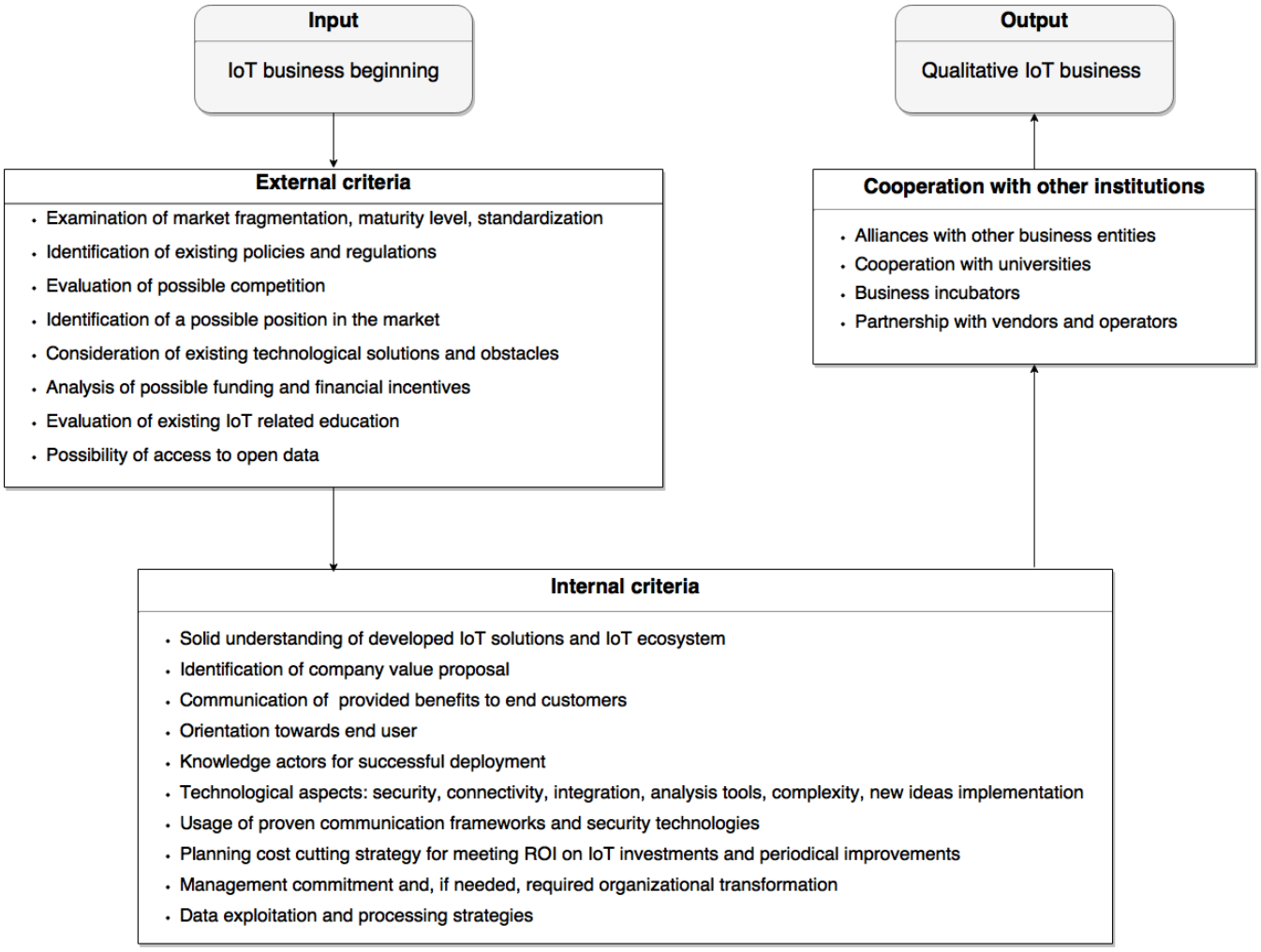


Figure 11. Internet of Things business development qualitative success criteria application model

4.3. Model applicability

The Internet of Things qualitative criteria application model (see Figure 11) could be applied in several cases, where the aim of the case is to develop Internet of Things business that is oriented to IoT business development qualitative success criteria as much as possible. Since, research about the key success factors for IoT application innovation is still at the exploratory stage, this application model could be used for a development IoT businesses that are based on qualitative success factors. Possibilities for the Internet of Things qualitative success criteria application model usage could be divided into two scenarios:

- Developing a new IoT business. When new IoT business is about to be developed, model could be applied from beginning - input stage. At the beginning of IoT business development, analysis of external criteria could be done. After an examination of external criteria, business should adapt gathered knowledge about the

IoT ecosystem for the analysis of company's internal criteria. Analysis of both external and internal success criteria provides basis for a consideration of possible beneficial cooperation with other institutions. Thorough consideration of model guidelines would lead to output object - qualitative IoT business.

- Making improvements to an already existing Internet of Things business. In this case, currently existing business should be analysed according to application model. Analysis should identify existing business development parts that are not compliant with the applicability model. Necessary adjustments in the IoT business development process should be made for a development of qualitative IoT business.

CONCLUSIONS AND RECOMMENDATIONS

1. Theoretical analysis covers the concepts of the Internet of Things; Internet of Things applicability in business development; development of the IoT. Internet of Things is a phenomenon, which was enabled by technological innovations. The IoT provides various enhancements for business development and is applied in numerous industries. Internet of Things business development is challenged by various obstacles, such as lacking standardization, market fragmentation and immaturity, security issues, formation of new business partnerships. Even though the IoT applicability scale increases, the goal of worldwide network of Things has not been yet achieved.
2. After analysis of scientific literature, China, United States of America and European Union were chosen for the analysis of leading Internet of Things business development regions. Selected regions have demonstrated different approaches for IoT business development facilitation. China has applied five-year planning, approach of centralized top-down decision making, communication between local and central governments, heavy IoT investment, orientation towards business incubators and cooperation of institutions. In the United States of America workshops for stakeholders are organized, cooperation between business and government is encouraged. Government bodies provide guidelines and lists of best practises, IoT security related education. Even though security is considered to be a topic of special importance, IoT specific legislation is thought to be premature and preventing innovation development. European Union encourages and finances IoT research initiatives, creates supportive policies, is active in IoT security field. Adoption of the IoT technologies and services in the enterprise environment is encouraged as a way of increasing the European

market competitiveness. IoT development facilitation is supported by business entities, who have joined the business alliance (AIOTI) and promotion of Digital Single Market.

3. Based on qualitative research data, provided by global IoT industry experts, Internet of Things business development qualitative success criteria were determined. Partnerships with universities, alliances with other business entities, business incubators were suggested as possible beneficial directions of cooperation. Technological aspects, market immaturity, lack of standards, market fragmentation, value proposal issues, domain knowledge, required transformation and management commitment were mentioned as IoT business development obstacles. In order to facilitate IoT business development, governmental bodies were advised to promote standardization, initiate IoT policies and regulations creation, encourage IoT related education, provide funding or financial incentives and provide access to open data. Recent technological improvements, data protection regulation and standardization changes, cooperation in networked business models and recognition among big industry actors were mentioned as positive changes in IoT ecosystem that could encourage ecosystem's development. Answers about critical success criteria in IoT business development could be grouped into criteria oriented to business activities and strategy, criteria oriented towards technological factors, orientation towards end customer and suggestions of being more specific and dropping the broad umbrella term of the Internet of Things.
4. Based on proposed qualitative success criteria, Internet of Things business development qualitative success criteria application model was proposed. Model starts with the input object of new IoT business development. At the beginning of the business development process, companies should evaluate external factors which are related to IoT business development. Following external factors analysis, business should evaluate criteria related to company's internal matters. After external and internal factors analysis, business developers should decide about potentially beneficial cooperations with other institutions. Model ends with the output object of qualitative IoT business. While starting a new IoT business development, application model could be applied from the input object. Furthermore, application model could be applied for the improvement of an already existing Internet of Things business.

Recommendations:

- While analysing external environment, pay attention to factors of market maturity and

fragmentation, existing standardization and technological solutions and obstacles, policies and regulations, evaluate possible competitors and partners, funding and financial incentives possibilities, open data accessibility, IoT related education. Decide on which place in the ecosystem to occupy.

- In order to develop success criteria oriented IoT business, create cost cutting and gathered data processing and exploitation strategies, use proven security technologies and communication frameworks, identify domain knowledge experts. Ensure management commitment, ecosystem and developed solutions knowledge, integration possibilities.
- As technological factors are of critical importance to IoT business development, ensure technological security, connectivity, periodically improve technological base and implement new ideas.
- While developing IoT business, apply customers oriented approach.
- Avoid the umbrella term of IoT, be more specific about business activities area and value proposal, furthermore, communicate created value to end customers.
- Evaluate possibilities of beneficial cooperation with other institutions.
- For a development of success criteria based Internet of Things business, apply the Internet of Things business development qualitative success criteria application model.

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Januševičius M. Development of Internet of Things Business: Worldwide Analysis / Master's Thesis in Electronic Business Management. Supervisor assoc. prof. dr. T. Limba. – Vilnius: Mykolas Romeris University, Faculty of Economics and Business, 2017. – 76 p.

ANNOTATION

Master's thesis examines the creation and application of Internet of Things business development qualitative success criteria, analyzes problems and trends of the Internet of Things business development, provides suggestions for a development of qualitative success criteria based Internet of Things business and presents the Internet of Things business development qualitative success criteria application model. The first section examines theoretical aspects of the Internet of Things: concept of the Internet of Things, IoT applicability in business development, development of the Internet of Things. The second part analyzes the worldwide business development of the Internet of Thing in leading regions: China, United States of America and European Union. The thirds section covers analysis of qualitative data that was provided by IoT industry experts with aim of examining IoT business development success factors. Following the theoretical IoT phenomenon analysis and qualitative study, the Internet of Things business development qualitative succes criteria application model is presented at the fourth part.

Keywords: Internet of Things, Internet of Things business development, Internet of Things business development qualitative success criteria, creation of qualitative success criteria application model.

Januševičius M. Daiktų interneto verslo plėtra: pasaulinė analizė / Magistro baigiamasis darbas. Vadovas assoc. prof. dr. T. Limba. – Vilnius: Mykolo Romerio universitetas, Ekonomikos ir Verslo Fakultetas, 2017. – 76 p.

ANOTACIJA

Magistro baigiamajame darbe yra tiriamas daiktų interneto verslo plėtros kokybinių sėkmės kriterijų kūrimas ir taikymas, analizuojamos daiktų interneto verslo plėtros problemos ir tendencijos, pateikiami pasiūlymai sėkmės kriterijais paremto daiktų interneto verslo plėtrai bei yra pristatomas daiktų interneto verslo plėtros kokybinių sėkmės kriterijų taikymo modelis. Pirmoje darbo dalyje yra nagrinėjami daiktų interneto verslo plėtros teoriniai aspektai: daiktų interneto sąvoka, daiktų interneto pritaikymas verslo plėtroje, daiktų interneto raida ir raidos sunkumai. Antroje darbo dalyje yra analizuojama daiktų interneto pasaulinė plėtra, apžvelgiami pirmaujantys regionai: Kinija, Jungtinės Amerikos Valstijos ir Europos Sąjunga. Trečioji darbo dalis apima daiktų interneto ekspertų empirinio tyrimo, siekiančio nustatyti daiktų interneto verslo plėtros kokybinius sėkmės kriterijus, analizę. Atlikus teorinę daiktų interneto reiškinio analizę ir empirinio tyrimo rezultatų analizę, ketvirtoje darbo dalyje pasiūlomas daiktų interneto verslo plėtros kokybinių sėkmės kriterijų taikymo modelis.

Raktiniai žodžiai: daiktų internetas, daiktų interneto verslo plėtra, daiktų interneto verslo plėtros kokybiniai sėkmės kriterijai, kokybinių sėkmės kriterijų taikymo modelio sukūrimas.

Januševičius M. Development of Internet of Things Business: Worldwide Analysis / Master‘s Thesis in Electronic Business Management. Supervisor assoc. prof. dr. T. Limba. – Vilnius: Mykolas Romeris University, Faculty of Economics and Business, 2017. – 76 p.

SUMMARY

Master's thesis analyses qualitative success criteria of the Internet of Things business development, examines their applicability in the global market, proposes the application model. Theoretical aspects of the Internet of Things, Internet of Things businesses development in selected regions from different continents: China, the United States of America and European Union were analyzed.

The aim of the empirical research is to present the IoT business development qualitative success criteria application model that encopasses key success factors from the global Internet of Things market. Key qualitative success criteria of the Internet of Things business development were based on industry experts' experience and opinion. The object of the research - IoT business development application model that encopasses critial success factors in previous successful IoT businesses development cases.

Analysis of scientific literature and document analysis have been applied in the thesis. Following the theoretical literature analysis of the Internet of Things concepts, selected leading regions were analyzed. Furthermore, a qualitative expert survey has been conducted, which gathered responses from 13 international experts. The empirical study has been conducted by applying the experts surveying by questionnaire. After the empirical research, qualitative success criteria for Internet of Things business development have been determined, a qualitative application model was proposed.

Master's thesis consists of four parts. The first section examines theoretical aspects of the Internet of Things: concept of the Internet of Things, IoT applicability in business development, development of the Internet of Things. The second part analyzes the worldwide development of the Internet of Thing in leading regions: China, United States of America and European Union. The thirds section covers analysis of qualitative data that was provided by IoT industry experts with aim of examining IoT business development success criteria. Following the theoretical IoT phenomenon analysis and the qualitative study, the Internet of Things business development qualitative success criteria application model is presented at the fourth part.

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SANTRAUKA

Magistro baigiamajame darbe yra analizuojami daiktų interneto verslo plėtros kokybiniai kriterijai, jų pritaikymas pasaulinėje rinkoje, pristatytas jų pritaikymo modelis. Baigiamajame darbe yra tiriami teoriniai daiktų interneto aspektai, analizuojama daiktų interneto verslo plėtra pirmaujančiuose pasauliniuose regionuose: Kinijoje, Jungtinėse Amerikos Valstijose ir Europos Sąjungoje.

Empirinio tyrimo tikslas yra pristatyti daiktų interneto verslo plėtros kokybinių sėkmės kriterijų pritaikymo modelį, kuris apima kertinius sėkmės faktorius, paremtus tarptautine daiktų interneto rinkos patirtimi. Kertiniai daiktų interneto verslo plėtros kriterijai buvo paremti daiktų interneto industrijos ekspertų patirtimi ir nuomone. Tyrimo objektas - daiktų interneto verslo plėtros modelis, kuris apima kertinius sėkmės kriterijus, paremtus sėkmingų daiktų interneto verslų atvejų patirtimi.

Baigiamajame darbe buvo taikyta mokslinės literatūros analizė ir dokumentų analizė. Atlikus teorinę daiktų interneto mokslinės literatūros analizę, buvo analizuojami pirmaujantys pasauliniai regionai. Taip pat buvo atliktas empirinis tyrimas - kokybinis ekspertų interviu, kuriame buvo apklausti 13 tarptautinių daiktų interneto ekspertų. Ekspertų tyrimas buvo atliekamas klausimyno pagalba. Išanalizavus ekspertų pateiktus kokybinius kriterijus, buvo nustatyti kokybiniai sėkmės kriterijai daiktų interneto verslo plėtroje. buvo pasiūlytas kokybinių sėkmės kriterijų pritaikymo modelis

Magistrinį darbą sudaro keturios dalys. Pirmoje darbo dalyje yra nagrinėjami daiktų interneto verslo plėtros teoriniai aspektai: daiktų interneto sąvoka, daiktų interneto pritaikymas verslo plėtroje, daiktų interneto raida ir raidos kliūtis. Antroje darbo dalyje yra analizuojama daiktų interneto pasaulinė plėtra, apžvelgiami pirmaujantys regionai: Kinija, Jungtinės Amerikos Valstijos ir Europos Sąjunga. Trečioji darbo dalis apima daiktų interneto ekspertų empirinio tyrimo, siekiančio nustatyti daiktų interneto verslo plėtros kokybinius sėkmės kriterijus, analizę. Atlikus teorinę daiktų interneto reiškinio analizę ir empirinio tyrimo rezultatų analizę, ketvirtoje darbo dalyje pasiūlytas daiktų interneto verslo plėtros kokybinių sėkmės kriterijų taikymo modelis.

LIST OF ANNEXES

Annex 1. The survey questionnaire

Dear Sir or Madam,

I am a graduate Electronic Business Management programme student from Mykolas Romeris University, Lithuania. Currently, I am conducting a master's thesis research 'Development of the Internet of Things business: worldwide analysis'.

In order to explore the phenomenon of the IoT business development, I am asking industry experts to share their experience and opinions. The aim of the survey is to identify critical success factors in successful Internet of Things business development cases and to figure out crucial criteria and conditions that, according to industry experts, could encourage and facilitate development of new IoT businesses.

The survey is confidential, respondents' identity will not be disclosed to public. Thank you in advance for your time and answers.

I) What is your current job position?

_____

_____

_____

II) How long you have been working in the Internet of Things industry?

_____

_____

_____

III) Your current country of residence?

_____

_____

_____

IV) Has your company benefited from a cooperation with other institutions, for example, business incubators, workshops, R&D or data sharing with universities, alliances with other companies? Could you describe general outcomes and experience?

V) What were the main obstacles that your company has encountered in the Internet of Things business development and how they were solved?

VI) Could you suggest ways how government bodies could encourage and facilitate the development of IoT businesses?

VII) Which recent IoT ecosystem changes have positively impacted the IoT business development? Could you name next steps that could facilitate the development even further?

VIII) From your experience, which criteria could be defined as critical success factors in a process of new Internet of Things business development?

Annex 2. Job positions of IoT experts

Management / Strategic positions	**Business Development / Sales**	**Other**
Leading Technical Product manager for IoT business	Sales and Business Development	Freelance IoT Senior Consultant
Chief of IoT Academy	Sales Director IoT Services	
Director for Mobility and IOT	Sales Manager	
Head of IoT Business Europe	SVP of Sales	
CEO		
Director		
Head of IoT Solutions		
Iot Global Service Architect in IoT		