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Smart City and Smart Building Startups: state of the art and role inside the market

Thesis Supervisor: Prof. Angela Tumino

Co-supervisor: Dr. Roberta Vadruccio

Master's degree thesis by:

Salvatore Di Frisco 952804

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Abstract

Internet of Things (IoT) technologies have been revolutionizing the business world since the early years of the last decade. The expression IoT has grown from its first meaning, when Kevin Ashton invented it in 1999 to refer to RFId technologies, until today's concept of network of smart devices. The field of IoT has evolved over the past years due to the convergence of a variety of technologies like Cellular Networks, Low Power Wide Area, NFC, and multiple others. The range of applications these technologies enable is so wide and various that it can go from people's home to manufacturing plants, transforming the nature of everything it enters in contact with. Two of the many fields of application are Smart City and Smart Building. It is undeniable that the technology industry is known for being a fast-paced changing environment that is always evolving. At the same time, in today's world is hard to talk about innovation without having to deal with startups. This duo of Startups and Smart City & Smart Building is exactly the focus of this thesis. The objective of the research is to depict the current state of art of Startups within these two sectors and the role this type of companies plays within it. This is possible thanks to the realization of a census of startups from which quantitative and qualitative data was gather. Several case studies are presented along the work, in the form of datasheets, aiming to better understand late trends and technologies common to the market. Finally, a framework created ad hoc for the analysis is proposed with the intention of qualify the different startup's approaches to the industry.

Executive Summary

Introduction

The market of the Internet of Things technologies has been exponentially growing since 2017, and according to Finch Capital, IoT Analytics and Statista Estimates it is expected to be almost 16 times bigger by 2025.

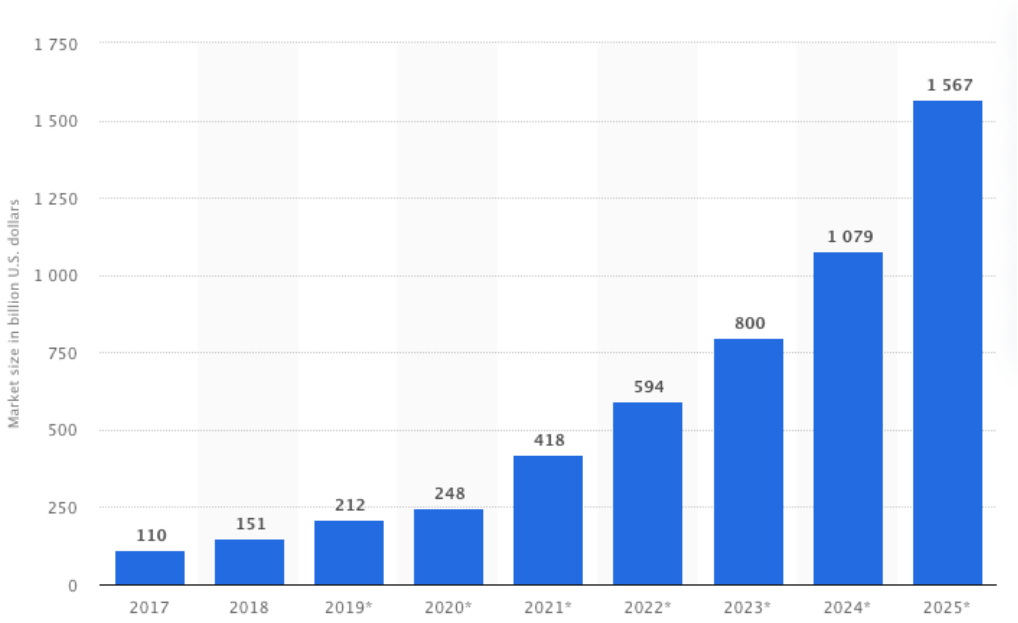

Figure 1: Market Value of the IoT industry by Statista Estimates

Not even the worldwide pandemic managed to stop the growth of the sector, on the contrary it gave a boost to the developing of the industry in certain areas, like for example Health, Home and Retail among the others. All industries where the implementation of modern technologies came in handful to fight the pandemic. One of the many applications fields IoT technologies enable is the one of Smart City and, consequently, Smart Building. The latest might be consider a subcategory of the former, but the context of application is so wide that it can be study as an application field itself.

The urban population growth is one of the multiple reasons behind the strong interest on the city's development. According to the United Nations by the year 2050 the urban population is expected to account for almost 70% of the global population.

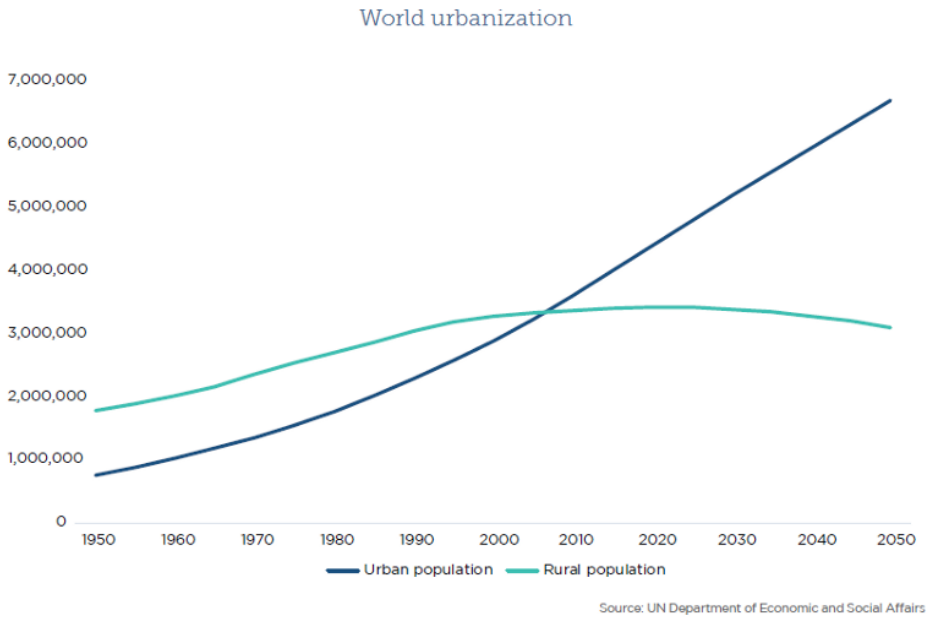

Figure 2: World Urbanization Data by the UN

Therefore, the need to create environments characterized by a high quality of life for citizens arise. In this context, IoT technologies plays a fundamental role. In fact, throughout its implementation is possible to kick off the transformation of cities in smart habitats, allowing public administrators but also private actors to put in action solutions to ensure the creation of these sustainable, efficient, and innovative environments. The different functionalities where IoT is implemented within the cities are shown in the figure below:

Figure 3: Smart City functionalities

In this new and modern environment where innovation and technology are deal with on a daily basis, startups find a perfect fertile ground to operate. Within this environment a vicious circle is created, where Smart Cities & Smart Buildings offer tremendous potential and opportunities from which entrepreneurs and especially high-tech startups can benefit. At the same time, the multiple innovation and solutions introduced by these startups increase the value of the city. The result is a system where both parties feed from each other, continuously improving and evolving.

Objective & Methodologies

Having pointed out the relevance of the IoT market, with special focus on the Smart City and Smart Building's application and how the Startups can impact in the industry, the objectives of this thesis have been set out in the form of two research questions:

- *What is the state of art of the Smart City & Smart Building Startups at a global level?*

To understand the Smart City & Smart Building's Startup scenario is first and foremost essential to study the state of art of the industry, with a focus on the current offer and the evolution undertaken by the sector in the last years. To achieve this goal a census of startups is going to be made, gathering quantitative and qualitative data of Startups operating all over the world, creating in this way a database of companies to be analyzed.

- *What role are Startups playing on the technological transformation of Cities and Buildings?*

Cities and Buildings aren't born "Smart". Instead, it is a process of transformation they go through when implementing new technologies on their daily operations. How startups are participating to this change is the goal of this second question. To classify and understand the different roles startups can have an ad hoc framework is going to be created and subsequently applied to the database of startups collected.

To achieve these two objectives two main methodologies have been applied:

- *Analysis of secondary sources*: Data, reports, articles, and analysis from reliable sources were used during this research in two main phases. The first one was to carry out the census of startups, the main scope was to build a database of companies relevant enough to perform

multiple analysis. The main source of information for this phase was the website Crunchbase. The second step was to use the information collected as support to better understand and validate the trends and reasons behind the results highlighted by the previous analysis. This last step is match with the deepening of severe interesting startups, aiming to highlight its characteristics.

- *Creation and use of a qualitative framework:* To better understand and qualify the current scenario of startups in the Smart City & Smart Building, a framework has been created. Two main variables were identified and explore in order to frame the different startups according to their approach and business offer within the market.

Smart City & Smart Building Startup Analysis

The census of Startups was performed gathering data form second sources, once it was completed the results were frame in a database, as shown on the figure below.

Nome azienda	FONTE NEWS - link diretto	Sito web	Descrizione	Data Nascita Startup
Important	https://www.crunchbase.com/organization/important	https://www.important.com	Pedoni, ciclisti, e-scooter, motociclisti possono ora connettersi con i conducenti per avvisarli della loro presenza (e, presto, attiveranno automaticamente i sistemi di frenata). Per le aziende e le smart city che desiderano connettere i propri veicoli, IoT e infrastrutture ai nostri sistemi di sicurezza, contattaci per maggiori informazioni.	2019
75F	https://www.crunchbase.com/organization/75-fahrenheit#/entity	https://www.75f.io	75F offre un sistema in grado di gestire i sistemi di HVAC e le luci degli edifici commerciali, in modo da ottimizzarne i consumi economici ed energetici e massimizzare il comfort.	2012
ADASKY	https://www.crunchbase.com/organization/adasky	https://www.adasky.com	ADASKY è una startup israeliana che costruisce sensori a infrarossi lontani e tecnologie di rilevamento termico intelligenti per veicoli elettrici autonomi.	2016
Agrow Analytics	https://www.crunchbase.com/organization/agrow-analytics	https://www.agrowanalytics.com	Agrow è una soluzione ibrida e all-in-one per migliorare l'efficienza idrica nell'agricoltura e nelle città intelligenti.	2021
AI Shading	https://www.crunchbase.com/organization/ai-shading	www.AIShading.com	AI Shading sviluppa tecnologie abilitate per AI e IoT per ridurre l'impatto ambientale di case ed edifici	2021
Aircare	https://www.crunchbase.com/organization/aircare-srl	https://www.aircare.it	Aircare aiuta le aziende a gestire il benessere indoor e ad aumentare la loro produttività. Aircare srl è uno spin-off di Harpaitalia srl, azienda con 35 anni di esperienza nello sviluppo di software, soluzioni IT e IoT.	2019
Airly	https://www.crunchbase.com/organization/airly-ddd4	https://airly.eu/en/	Airly costruisce reti di sensori di qualità dell'aria che possono essere distribuiti in intere città o contee. La tecnologia consente il monitoraggio in tempo reale della qualità dell'aria tramite una mappa online. La missione dell'azienda è costruire una fitta rete di sensori che aumenti la consapevolezza delle persone su ciò che respiriamo ogni giorno. Aiuterà anche a identificare le fonti di problemi e le loro posizioni esatte.	2016
AlertMedia	https://www.crunchbase.com/organization/alert-media	http://www.alertmedia.com/	La piattaforma AlertMedia collega i dati dei sensori aziendali, i dati di sistema, i dati sulla posizione e i dispositivi intelligenti dei dipendenti per creare un'unica piattaforma di comunicazione in caso di emergenza. AlertMedia aiuta i suoi clienti a confrontarsi con una varietà di situazioni di emergenza, come maltempo, minacce alla sicurezza, incendi e interruzioni di corrente.	2013
Alfa Centauri Technology		http://alfacentauri.tech	La startup ha sviluppato un software di analisi del traffico in real-time che, attraverso un dispositivo installato sui regolatori semaforici e una serie di webcam, riesce a suggerire agli autisti i percorsi ottimali;	2017
Anagog	https://www.crunchbase.com/organization/anagog#section-overview	www.anagog.com	Anagog sfrutta l'intelligenza Artificiale per offrire soluzioni che permettono alle case automobilistiche e alle aziende che forniscono servizi auto di conoscere meglio le abitudini dei conducenti e offrire così soluzioni che incontrano i bisogni del cliente. Le soluzioni offerte vanno dal supporto offerto per la gestione delle soste a pagamento alla personalizzazione dell'ambiente di guida.	2010
Antariksh Waste Ventures Pvt ltd	https://www.crunchbase.com/organization/antariksh-waste-ventures-pvt-ltd	https://antariksh.io/	La società Antariksh Waste Ventures offre la gestione dei rifiuti per le Smart Cities tramite cassonetti intelligenti e applicazioni.	2017
AppyParking	https://www.crunchbase.com/organization/appyparking#/entity	http://www.appyparking.com/	appParking accede a informazioni su parcheggi privati e pubblici per abilitare gli utenti a trovare aree di parcheggio controllate, vialetti registrati e fornisce indicazioni per arrivarci attraverso navigazione satellitare.	2013
Apsiyon	https://www.crunchbase.com/organization/apsiyon#section-overview	http://www.apsiyon.com/	Apsiyon è una piattaforma online basata su Cloud che agisce da assistente digitale per i gestori di immobili al servizio di edifici residenziali e commerciali, comunità recintate e sviluppi a uso misto.	2012
Aqualtas	https://www.crunchbase.com/organization/aqualtas-9be3	https://www.aqualtas.tech	AQUALITAS sviluppa un sistema modulare per il monitoraggio continuo, economico ea bassa manutenzione della qualità dell'acqua fornito come servizio. Il sistema consente al cliente di scegliere quali parametri fisico-chimici monitorare, mentre la sua piattaforma dinamica esegue l'autodiagnosi e altre azioni in base alle particolari capacità di rilevamento, riducendo i requisiti di manutenzione del sistema di monitoraggio in modo realmente automatizzato	2020
Aquanta	https://www.crunchbase.com/organization/sunnovations#/entity	https://aquanta.io	Il controller scaldabagno di Aquanta porta lo scaldabagno elettrico o a gas fuori dal seminterrato e nel palmo della mano per riscaldare l'acqua solo quando se ne ha bisogno.	2008
Argentum	https://www.crunchbase.com/organization/argentum-electronics	https://www.argentum.ai	Rendiamo gli edifici commerciali più intelligenti e più efficienti dal punto di vista energetico attraverso una micro-grid DC plug-and-play abilitata per IoT. La nostra piattaforma potenzia i sistemi antiquati di automazione degli edifici e di distribuzione dell'energia, per migliorare notevolmente le prestazioni energetiche	2015
Arkoid Automation	https://www.crunchbase.com/organization/arkoid-automation	https://arkoid.com	Arkoid propone una soluzione autonoma basata su cloud che ottimizza in modo continuo e preciso le impostazioni HVAC in base alle condizioni interne ed esterne. Creiamo un gemello digitale dell'edificio e stabiliamo indici di comfort o restrizioni termiche in ogni zona dell'edificio. Eseguiamo milioni di cicli di simulazione tenendo conto di possibili scenari. Il nostro obiettivo è trovare le migliori politiche	2019

Figure 4: Database of Smart City & Smart Building Startups

The creation of the database was the first step in order to perform the analysis. The information collected was frame under different column clusters that report different type of information about

the startups. The main categories of the cluster are: General Information, Financial Information and Business Offer Information.

The first part of the analysis focus on describing the main intrinsic characteristic of the startups. The main features identified are reported on Figure 5, for each one of these categories it is study the distribution of the Startups. This analysis allowed to have a clear picture of the current state of the industry.

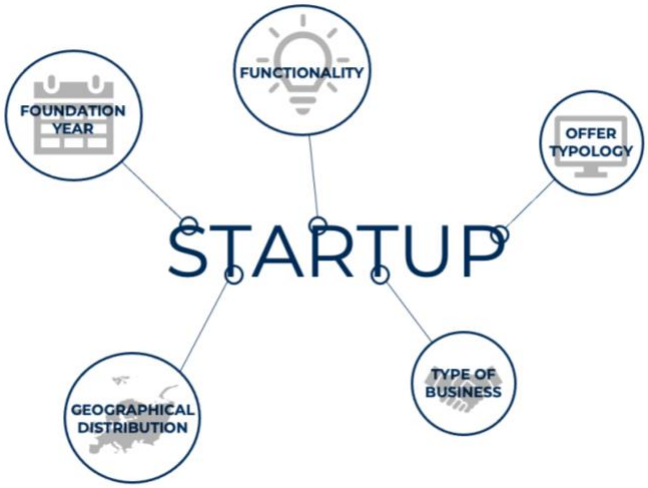

Figure 5: Main Startup's characteristic

For example, the geographic distribution of the startups by continent is shown in Figure 6. As it was expected the most part of the headquarters, more then 80%, are located between the North America and Europe. In a more in deep analysis is possible to identify the countries distribution of the startups, in this case are the United States of America leading the chart, followed by European countries like Italy and Germany.

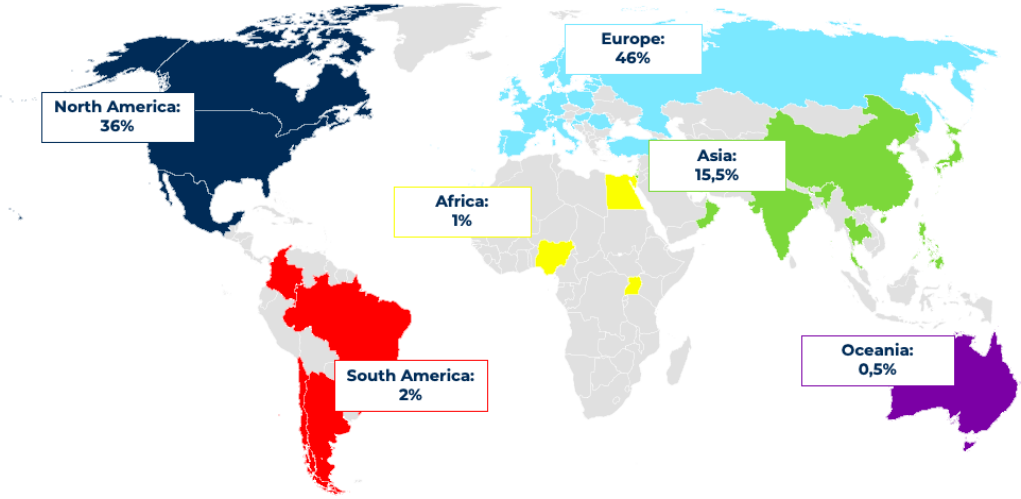

Figure 6: Geographic distribution of the startups by continent

The next step of the research is the trend analysis and its evolution over the last period, focusing in particular on the last 3 years. The mix of quantitative and qualitative data collected is put in action, highlighting the direction in which the industry has been moving, linking causes and effects that different external factors have on the sector. For the quantitative ones, information about the amount of money startups manage to collect is studied. In Figure 7 the total amount collected each year is shown. This type of distribution is analyzed using information from secondary sources to understand possible causes. In this case the drawback hit in 2020 can be easily associated to the Covid 19 pandemic effects, while the one of 2021 is due to the fact that the data collected for that period is missing the last quarter of the year.

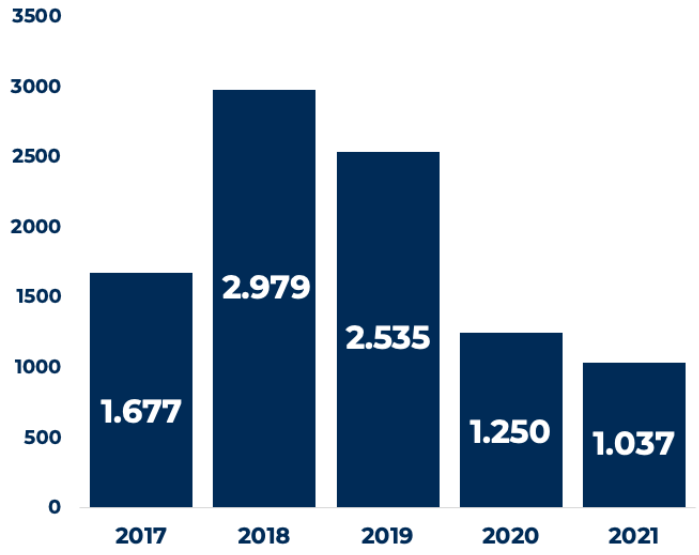

Figure 7: Total Financing received by the startups by year (millions of euros)

Moving to more qualitative information is possible to analyze how external factor impact on startups nature, for example how the environmental concern that is affecting the world affect the orientation Startups have been taken. Green mobility, environmental control and pollution reduction are some of the main objectives the companies pursue with their innovative solutions. This is proven by an increase on the diffusion of this functionalities in the last 3 years.

To provide a complete picture of the current scenario, along the whole analysis datasheets of case studies are presented, aiming to provide concrete examples of the topics discussed.

Qualitative Framework: Startup Role Matrix

The qualitative framework created ad hoc for the analysis focus on the role startups play in the transformation process cities and building undertake in order to become “Smart”. The framework is a matrix distributed along 2 main dimensions, as shown in Figure 8.

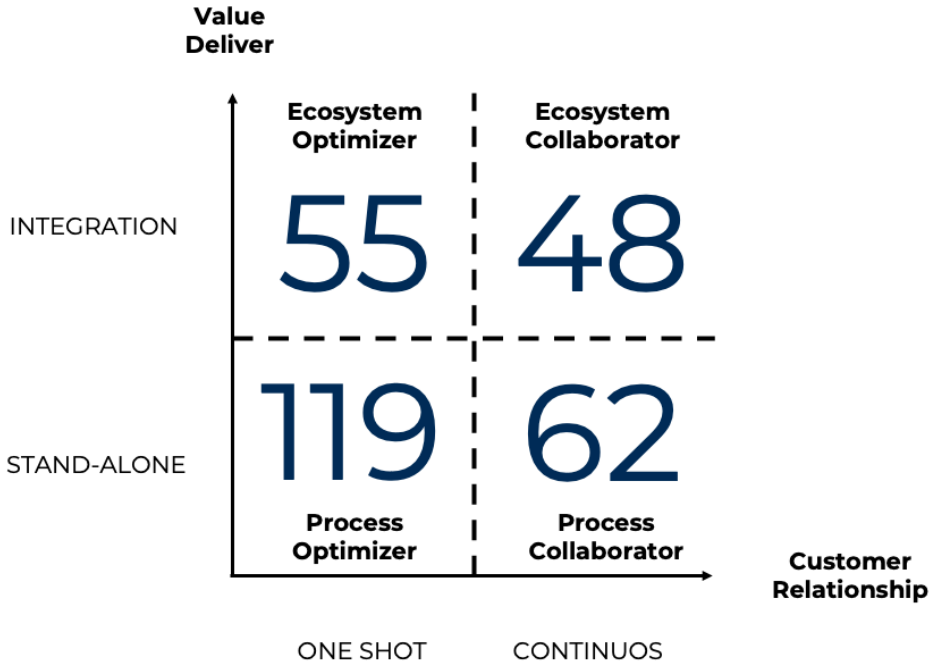

Figure 8: Database Classification according to the Startup Role Matrix

For the vertical axis the focus of study is “What are Startups offering to the market?”, in particular, how the solutions available on the market manage to create value for users. Two main approaches were identified, according to certain characteristic of the solutions. The final distinction relies on the fact if the solution has a Stand-Alone value, or if it is only exploited in the right way when integrated with a system of objects. For the horizontal axis the dimension chose is “Customer Relationship”. It came up during the analysis that Startups had two complete opposites methods to deliver solutions. On one hand the One-Shot approach, where companies deal only with the transaction that allow the customer to possess the solution. On the other hand, the Continuous Relationship is characterized by an engaged commitment, where Startups often tend to play an active role during the implementation of the solution. An important remark to make is that this second dimension doesn’t measure the frequency of interaction between parties, but there are other factors to be consider during the evaluation of companies’ business offer.

The combination of the two dimensions chosen allowed to create a matrix composed by 4 main quadrants. Each quadrant represents a typology of startup role played in the market and at the same time it identifies startup's nature and characteristics. Moving along the vertical axis, is possible to find on one side Startups characterized by their strong focus on process, while on the other extreme there are the ones that put an effort on the creation of ecosystems, providing solutions that manage to exploit synergies thanks to the integration with existing environments. A parallel comment can be made for the Customer Relationship axis, where startups go from being pure Optimizers, meaning that their solutions aim at optimize the operation carried out by the user, like for example the research for a Parking Spot, ending up with the concept of Collaborators, where companies became real collaborators playing active roles in the Smart transformations, often as consultants or analyst, like in the case of Traffic Management where the data analysis and management allow the public administrations to put in action plans to improve the fluidity of the traffic within the cities.

Each quadrant has its own characteristics and is important to remark that each one of them represent different roles, new and already existing Startups, can decide to play to be part of the IoT revolution.

The final step of the analysis consists of classifying the startups of the database according to the matrix. The results are shown on Figure 8, where the majority of the companies evaluated fell into the Process Optimizer quadrant. The number of the startups diminish as the complexity along the matrix increase, in fact putting in action integrate solutions combine with active collaboration represent bigger efforts for the companies.

Conclusion

This work established has its main goals to answer two research questions, which are "What is the state of art of the Smart City & Smart Building Startups at a global level?" and "What role are Startups playing on the technological transformation of Cities and Buildings?". For the first question analysis of secondary sources, like Crunchbase, allow the completion of a census of startups, were quantitative and qualitative information was gathered, creating in this way a database of companies to be analyzed. Using the database as starting point the current state of art of the industry was depicted, studying the main characteristics of the startups as geographical distribution, foundation

year, functionalities provided and many others. This allowed to understand the physical constitution of the sector. Moving on a trend analysis was performed, the information collected mixed with other sources as reports and articles consent to portray the direction in which the sector was moving. In particular, linking cause and effects to external factor that had an impact on the industry, like for example the COVID 19 pandemic or the environmental crisis that the world has been dealing with in the recent years. Along the whole analysis, in order to provide a more concrete sight of the current scenario, many case studies were present in the form of datasheet, in this way the analysis was validated, providing solid proof of the trends identify.

Once the state of the art of the industry was completed, an ad hoc framework was created to better qualify the startups' role within the smart transformation Cities and Building are facing. Two main dimensions were identified, and according to its many combinations possible, 4 main quadrants were established inside the matrix. Each quadrant represents a typology of role startups might play, enclosing within it different companies with similar characteristics.

This research work might be useful for different actors of the industry. On one side, current and future startups might use it to support their business decisions and understanding which role they intend to play and consequently how to move inside the market, defining in this way their business offer and approach. On the other side, investor might grasp relevant insights about the sector trends and future direction, allowing in this way to have a tool to better support their financial decisions.

1. Introduction

This introductory chapter has as main purpose to provide some useful information about the Internet of Things' (IoT) industry and the multiple subcategories that delineate it. A particular focus will be made on Smart City and Smart Building, which are the subject of this thesis. The two areas will be explored and contextualize within the IoT scenario, highlighting its features and characteristics. Finally, the chapter will explain the role that the Startups plays in the industry and how they will be use as compass to understand the direction of innovation the Smart City & Smart Building market is taking.

1.1. Internet of Things

The term Internet of Things (IoT) is used to refer to the output of a new technology wave that has been striking the world during the last decade. This new wave is deeply changing the way products are made and services are delivered. Moreover, it is affecting their role during the final consumption and use, in some cases, it is even redefining the purpose of an object or service itself. For example, a traffic light doesn't just control traffic anymore, but it can become source of relevant data that enables further services. These new improved products have three core elements: physical components, "smart" components, and connectivity components. Smart components amplify the capabilities and value of the physical components, while connectivity amplifies the capabilities and value of the smart components and enables some of them to exist outside the physical product itself[1]. These are referred to as "Smart, Connected Products" (SCP). This environment of SCP is what IoT refers to, a networked interconnection of everyday objects which are often equipped with ubiquitous intelligence[2].

Depending on how and with which purpose this new technology is used, multiple application areas regarding the IoT can be identify[3]:

[1] How Smart, Connected Products Are Transforming Competition by Michael E. Porter and James E. Heppelmann

[2] Editorial Internet of Things Feng Xia, Laurence T. Yang, Lizhe Wang and Alexey Vinel

[3] Osservatorio Internet of Things Politecnico di Milano, Internet of Things: connessi o estinti!

- ***Smart City***: monitoring and management of the element of a city (for example the means for public transport, public lighting, parking spots) to improve livability, sustainability, and competitiveness;
- ***Smart Environment***: monitoring and management of surrounding environment (for example rivers, forest, mountains) to improve livability, sustainability, and competitiveness;
- ***Smart Metering & Smart Grid***: smart meters for the measurement of consumption (electricity, gas, water, heating), their correct billing and remote management; smart electric grid for the optimization of the distribution, managing the distributed production and electric mobility;
- ***Smart Home***: solutions for the automatic and/or remotely management of the systems and the objects connected to the house, with the objective to reduce electric consumption and improve the comfort, the safety of the home and of the people on the inside;
- ***Smart Building***: automatic management of the building's installations and systems (for example lighting and air conditioning) for energy saving, comfort, and building security of the people on the inside;
- ***Health***: remotely real time monitoring of vital parameter, reducing the appeal to hospitalization, with diagnosis and cure purposes; locations of patients in order to ensure their safety;
- ***Smart Car***: communication between vehicles or between vehicles and surrounding infrastructures for the prevention and detection of accidents, new insurance business models and/or georeferenced information on traffic;
- ***Smart Logistic***: traceability of the supply chain, brand protection and monitoring of the cold chain, safety on complex logistic centers and fleet management;
- ***Smart Asset Management***: remotely management of valuable asset with breakdowns and malfunctions detection purposes, location, tracking and inventory management;
- ***Smart Factory***: Cyber Physical Systems adoption, connection between machinery, operators and product in order to enable new logics of production management, supply chain planning and life cycle product management;
- ***Smart Lifecycle***: improvement of the development of new product processes, for example using data gather from older versions of connected products;

- ***Smart Agriculture***: monitoring of micro-climatic parameters in order to support the agriculture and improve the product's quality, reduction of resources use and environmental impact;
- ***Smart Retail***: monitoring of customer behaviors inside the shops, with the purpose of improve the customer experience and boost sales. Solutions that enable a higher visibility during the supplying operations to optimize the resource's management and reduce stock out's probabilities.

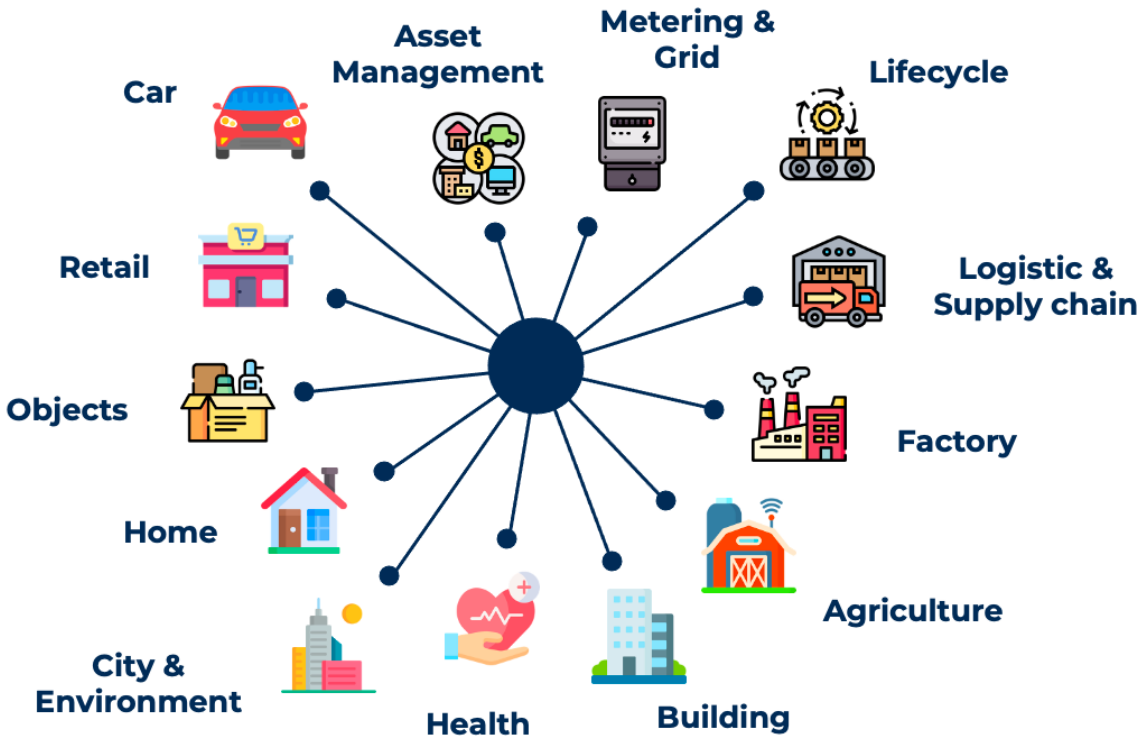

Figure 9: IoT application fields

1.2. Smart City

1.2.1. The concept of Smart City

As mentioned before, the Smart City is one of the many areas where IoT finds largely space to be employed. In fact, the Smart City was born thanks to the digital transformation and application of IoT technologies in the various spheres of the Public Administration: public transport and mobility; energy management and distribution; public lighting; urban security; environmental management and monitoring; waste management; maintenance and optimization of public buildings (schools,

hospitals, museums), communication and information systems and other public utility services[4]. Nevertheless, it is important to remark that the concept of Smart City is not to be associated only to the Public Administration, instead, it is open to any private player. Furthermore, the relationship between these two players is fundamental to the development of the sector and its actual implementation within the cities.

The strong interest on cities development come from an important shifting in the global habitat scenario, as the UN reports by the year 2050 the urban population is expected to account for almost 70% of the global population. This trend brings a spotlight to the cities and its management.

The main and final goal is to create a sustainable, efficient, and innovative place where citizens can achieve a greater quality of life. This is only possible throughout a correct and effective integration between modern IoT technologies, sensors, big data management, and existing structures in the area.

1.2.2. Main features and characteristics

Even though an official definition that qualifies a city as "smart" doesn't exist, it is still possible to identify certain aspects and pillars that characterize and make a Smart City.

- ***Shared Commitment*:** information and communication are fundamental to a Smart City, a continuous dialogue between citizens and Public Administration should exist. In order to enable this conversation cities must be able to rely on a computer system that allows anyone to send a report on a problem or request in real time.
- ***Energy Efficiency and Environmental Sustainability***: A Smart City must promote the implementation of sustainable and renewable energy sources and to intelligent waste management systems, all this in a circular economy perspective. At the same time the management of green areas within the urban boundaries is a motive of concern when talking about optimization and improvement of the environmental capital.
- ***Integrated Security***: Security means less criminality and more attention to the critical areas of the city. This is possible thanks to IoT and interconnected security systems. One of the most common ways to implement these technologies is through the so call "control rooms",

[4] Smart city: cos'è, come funziona, caratteristiche ed esempi in Italia by Laura Baronchelli

these are structures that are capable of processing large amounts of data and information centrally and in real time.

- ***Transport and urban mobility***: streamline the traffic within the city and reduce the environmental pollution is one of the main objectives of a Smart City. This can be achieved through e-mobility and sharing solutions. Another aspect of the urban mobility that must be considered are parking spots and their management.
- ***Smart Building***: buildings are of course a key part of the Smart City. New and retrained constructions must answer to specific standards of energy efficiency and smartness. Nevertheless, the technologies implemented, and the main objectives can be studied, within the application of IoT, as an area of interest to itself.

As mentioned for the IoT industry, also within the Smart City different application areas can be identify. This is done focusing on the final benefit and function the product/service provides. These areas will also be address and better deepen in the following chapters, when describing the database used for the analysis, and will be refer to as "Functionalities" of the Smart City Startups.

- Environmental Monitoring
- Infotainment & Tourist Services
- Parking Management
- Public and Private Transport
- Security
- Smart Building
- Smart Lighting
- Traffic Management
- Waste Management

1.3. Smart Building

1.3.1. The concept of Smart Building

Buildings are a fundamental part of the Smart Cities, accordingly the optimization and improvement of citizen's quality of life must pass by the upgrading of the spaces where they spent most of their

working and private life. According to the Energy & Strategy Group of the Politecnico di Milano, Smart Buildings are buildings whose systems are managed in an intelligent and automated manner, through a supervision and control infrastructure, to optimize energy consumption, comfort, and safety of the occupants, ensuring their integration with the electrical system.

1.3.2. Main features and characteristics

The elements and main characteristic that identify a building as "smart" are[5]:

- ***Building Device and Solution***: the systems and technologies that ensure the safety of the occupants, such as those for energy generation and energy efficiency and those relating to the safety & security theme
- ***Automation Technology*****:** the sensors connected to the systems, aimed at data collection, and the actuators that give the systems the commands processed by the control and management platforms
- ***Control and management platforms***: the set of software systems aimed at collecting, processing, and analyzing the data acquired by the sensors installed on the systems
- ***Connectivity***: the set of communication protocols, wireless or wired, which allow communication between sensors, actuators and the control and management platform.

1.4. Startups

The advent of the new technology wave not only modified and affected the products and services final scope, but at the same time it impacted their whole nature and life cycle, starting from their creation. In this new and modern environment, startups find a perfect fertile ground to operate. In fact, some of the characteristics that belongs to this type of companies perfectly match with the concept of Smart City & Building and IoT technologies. For example:

- ***Innovation and Tech-Oriented:*** Startups are involved with innovation, new ideas and using technology to create something that address a problem. They are typically disrupting existing markets and creating new value networks. Therefore, the access to new tools, like

[5] Smart Building: cosa sono, applicazioni ed esempi di edifici intelligenti by Gianluigi Torchiani

IoT, to solve obstacles and the contact with countless quantity of data that it provides enables Startup's tremendous growth.

- ***Build Engage Communities***[6]**:** The most successful startups think beyond customer acquisition and work toward community building. Unable to rely on decades of brand loyalty, like their established counterparts, they roll-up their sleeves and engage their target markets. This entirely lines up with the principle of Inclusion and Shared Commitment Smart Cities have.

In this environment a vicious circle is created, where Smart Cities & Buildings offer tremendous potential and opportunities from which entrepreneurs and especially high-tech startups can benefit. At the same time, the multiple innovation and solutions introduced by these startups increase the value of the city. The result is a system where both parties feed from each other, continuously improving and evolving.

In this scenario startups become an important indicator of the course of industry. Therefore, they can be used to better understand its late trends and releases. With this purpose in mind, a census of startups will be made to capture the current situation and state of art of the sector, highlighting through the deepening of some startups relevant technology applications and business models.

[6] The 7 Characteristics Successful Startups Share by RocketSpace

2. Objectives & Methodologies

This chapter has as main goal to illustrate the purpose of the study, and the issues to which the research intents to give an answer to. Also, the methodologies and procedures followed for the analysis will be explain and defined.

2.1. Objectives

The IoT technologies are changing the world impacting on the way it operates, even though it has been happening for a few years, the industry hasn't reached the maturity phase yet, in fact, it's potential of growth is still very high, making the sector object of interest. Being a field where innovation and technology goes hand in hand, a relevant matter of study are the Startups operating in this field. In this context the objectives of the research, which have been set out in the form of two research questions, are presented below.

- *What is the state of art of the Smart City & Smart Building Startups at a global level?*

To really understand the state of art of the industry, is important to have a clear picture about its characteristics and features. For this purpose, a census of startups is fundamental since this procedure will allow to gather both quantitative and qualitative data. For example, for the first one data about the financing the multiple startups received over the course of the years will be collected. For the last one, information about the functionalities developed and the business model operations are going to be the focus. Therefore, a database of Startups operating both in City and Building fields at a worldwide level, will be created. Subsequently, studying the database, trends and practices will be identify, also underlying how they have changed over the course of the last years.

- *What role are Startups playing on the technological transformation of Cities and Buildings?*

As discussed in the previous chapter, Smart Cities and Smart Buildings aren't just the result of innovative ways to reduce costs. Instead, they are the outcome of the application of a new technology that has as its main characteristic communication and connection. Specially for Smart Cities, and then consequently for Smart Buildings, IoT represent the creation of new environments.

This is possible through the improvement of the already existing ones thanks to its enlargement and enrichment, and at the same time through the creation of new spheres that weren't consider in the past. These new environments impact on users' life in a broad way, involving the many aspects that define it. How exactly are Startups participating and what role are they playing on this transformation is the object of research of this second question. To address this topic an ad hoc framework will be created trying to identify the multiple approaches Startups can have within these two IoT application areas.

2.2. Methodologies

In order to achieve the objectives set, and provide an answer to the research questions, two main methodologies were implemented:

- *Analysis of secondary sources*: Data, reports, articles, and analysis from reliable sources were used during this research in two main phases. The first one was to carry out the census of startups, the main scope was to build a database of companies relevant enough to perform multiple analysis. The main source of information for this phase was the website Crunchbase. The second step was to use the information collected as support to better understand and validate the trends and reasons behind the results highlighted by the previous analysis. This last step is match with the deepening of severe interesting startups, aiming to highlight its characteristics.

- *Creation and use of a qualitative framework:* To better understand and qualify the current scenario of startups in the Smart City & Smart Building, a framework has been created. Two main variables were identified and explore in order to frame the different startups according to their approach and business offer within the market.

3. Smart City & Smart Building Startup Analysis

In this chapter is presented a macro analysis of the database of Smart City & Smart Building startups currently operating on the market, the aim is to use this to get a clear picture of the ongoing state of art of the industry. The first part of the chapter will describe the database structure, presenting the characteristic of the companies in it. The second part will illustrate and comment the main trends identified during the analysis. Along the work several relevant cases will be proposed to highlight significant tendencies present on the market.

3.1. Database Structure

The database construction was the starting point of the whole analysis. A census of startups was made starting from an already existing database, establishing for each company if it met the parameters to be considers in the final database. Afterward, more Startups were added searching from secondary sources, as for example Crunchbase. The result is 284 Startups operating in the Smart City or Smart Building sector.

In this section is provided a detailed description of the header items and all the information that was decided to be traced for each one of the startups mapped.

The database is divided into column clusters that store information about different aspects of the solution.

1) The first cluster provides general information:

Company Name

Description

A brief description about the startup is provided. Usually are presented information about their business model and value proposition. This allows to have clear picture about the service and products provided by the startup.

Foundation Date

It indicates the year in which the Startup was founded.

Headquarters Continent

Continent where the headquarters of the company are based. The macro-area considered are Europe, North America, South America, Asia, Africa, Oceania

Headquarters Nation

It expresses the country where the headquarters of the company are based.

IoT Application Area

It identifies in which IoT Application Area the startup operates. For each startup up to 3 levels were consider. For the final analysis, obviously, were only consider startups that had Smart City or Smart Building in one of these levels.

Functionalities

It is possible to deepen the IoT Application Area (Smart City/Smart Building) identifying a classification, based on the final aim of the offer and which type of functionalities it provides. These functionalities are:

- *Air Conditioning/Heating*: intelligent devices to control heating and cooling systems, usually associated to HVAC technology. The main scope is to reduce energy consumption bills or to learn from users' habits and automatically set the temperature in the room.
- *Energy Consumption Management*: products and systems that aim to identify the main sources of energy consumption and waste, often proposing optimization plans or technologies to reduce costs.
- *Environmental Monitoring*: sensors measuring air parameters such as air quality, temperature, humidity, and carbon levels, to ensure better living conditions
- *Infotainment & Tourist Services*: these products and services have as main target tourist and visitors; the goal is to provide solutions to better explore the city and promote tourism.
- *Parking Management*: implementing IoT, and in some cases even Artificial Intelligent, these type of solutions aims to facilitate the research and management of public and private parking spots.

- *Private Transport*: solutions to facilitate the movement of citizens within the city, often these solutions allow the reduction of CO2 and other pollutants. Furthermore, the use of these means enables data collection useful for other purposes.
- *Public Transport*: the concept is like the one of Private Transport, the main difference is the fact that the service is provided to the public and not to the individual.
- *Reporting City Problems*: these types of services allow citizens to better communicate and initiate a dialogue with the Public Administration, signaling and reporting any kind of problem they come up against. The aim is to create a connected community, pilar of the smart cities.
- *Scenario Management*: solutions that allow the integration and management of multiple products in just one interface at the time, facilitating the control and administrations of spaces and objects.
- *Security*: products and services that ensure the public safety within the city and private safety within buildings. (e.g., sensors to detect access or to provide smart routing to first aid workers)
- *Smart Lighting*: intelligent lighting systems to reduce energy consumption and waste and to increase comfort, in some cases even to learn from user's habit and automatically set lighting standards.
- *Software Infrastructure*: software solutions, as Cloud services and SaaS, to enable the correct implementation of smart applications and technologies.
- *Territory Monitoring*: sensors and technologies to detect and control multiple aspects regarding the territory. (e.g., processing of images produced by satellites for the urban planning sector)
- *Traffic Management*: these types of solution allow data collection and processing. The main purpose is to provide insights and suggest actions to the relevant authorities and private drivers. (e.g., real-time analysis of the situation of a road intersection)
- *Waste Management*: solutions that provide optimization plans and technologies to improve the administration and control of waste within the city. (e.g., sensors that optimizes collections, avoids overflowing bins and allows you to save on collection costs)

- *Water Consumption Monitoring*: products and services to better keep track of the water consumption within buildings to optimize cost and ensure safety of possible water damage.

2) The second cluster deal with the financial information of the Startups:

Total Funding Received

This is the total amount of money the startup received since its foundation.

Year

For each column is shown how much money a startup received in the indicated year.

Last 3 Years Funding

It indicates the amount of money received in the last 3 year.

Typology Last Financing Round

It expresses the nature of the last financing round received by the startup.

Main Investor

The names of the main investors are reported in this column.

3) The third and final cluster provide information about how the final offer is deliver:

Business Relationship

The nature of the relationship startups establish with its clients is reported in this column.

Type of Offer

This indicates the typology of the offer provided by the company. The main categories are Hardware (HW), Software (SW), Services, Infrastructure & Networks and the possible combination of the first three.

3.2. Reference Database

This paragraph aims to provide a detailed description of the database that has been used as reference for the analysis performed.

The total number of Startups considerer is 284. As previously stated, the analysis performed intents to depicture the current state of art of the Smart City & Smart Building Startups, therefore companies founded in the last 15 years were selected, trying to combine late developments with already establish business models. Nevertheless, since the "age" is a critical factor when talking about startups, the majority of the companies evaluated were founded in the last 6 years and 76% in the last 7, as it is shown in Figure 10. Moreover, the 85% of the startups was either founded in the last 3 years or received at least one financing round in the same period.

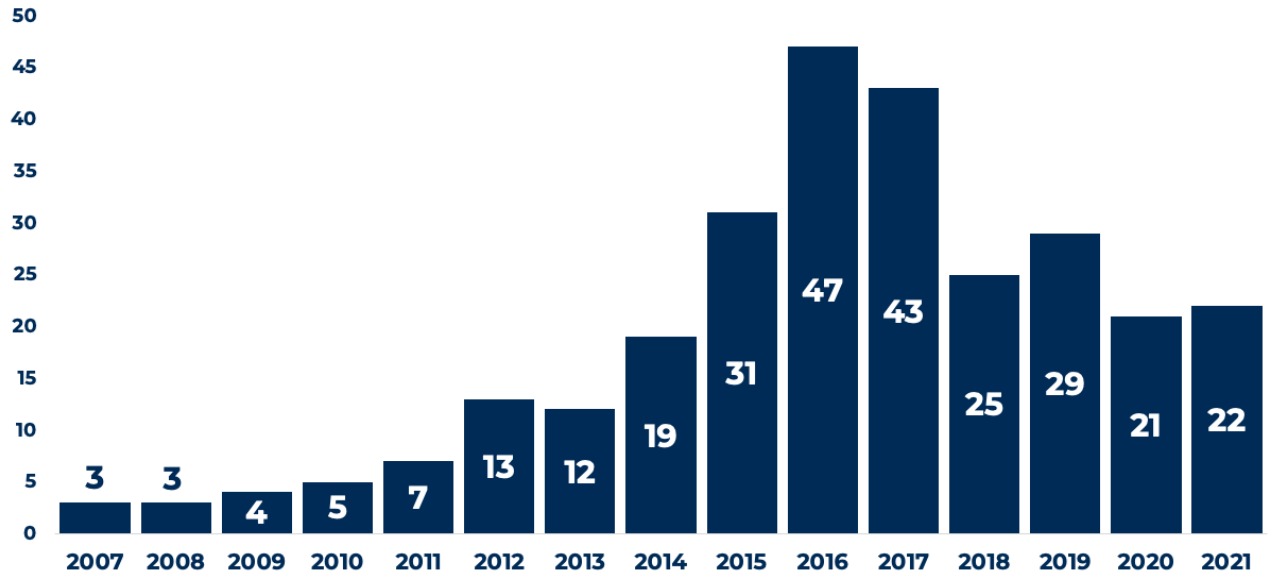

Figure 10: Distribution of the Startups by year of foundation

Another important dimension to account for is the geographic distribution of the startups. Figure 11 allows to have a first glance at the different headquarters' dispersion. As it is shown, the analysis involved startups located all over the world. Nevertheless, as might be expected, Europe and North America account for the 82% of the startups, with the former who alone gives home to almost half of the grand total.

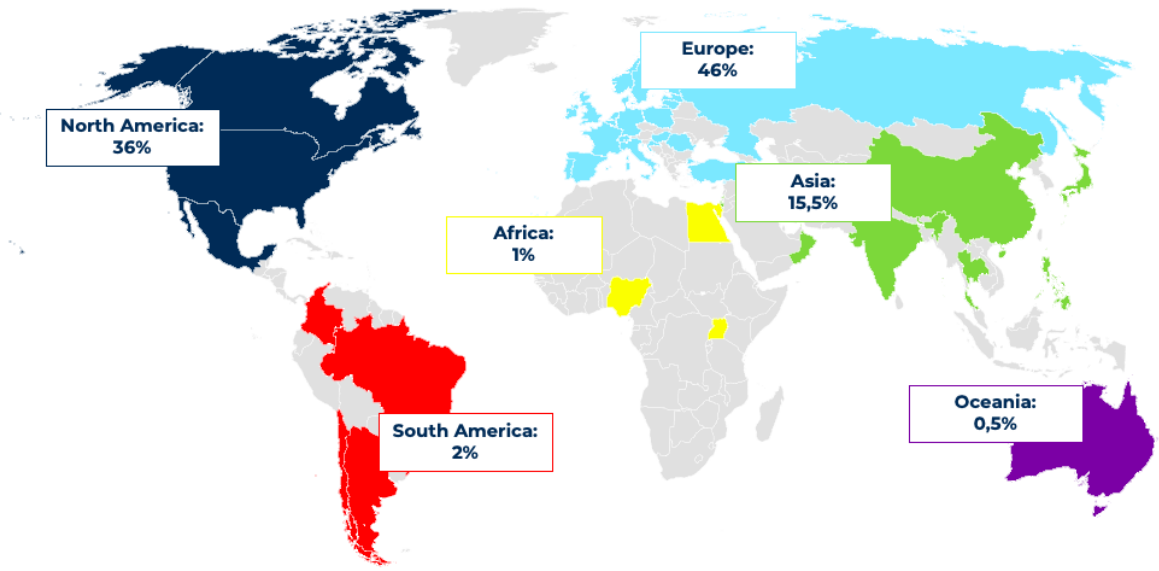

Figure 11: Geographic distribution of the startups by continent

In Figure 12 a deeper look at the geographical distribution of the headquarters is shown. More specifically, the countries with the biggest concentration of startups mapped are reported.

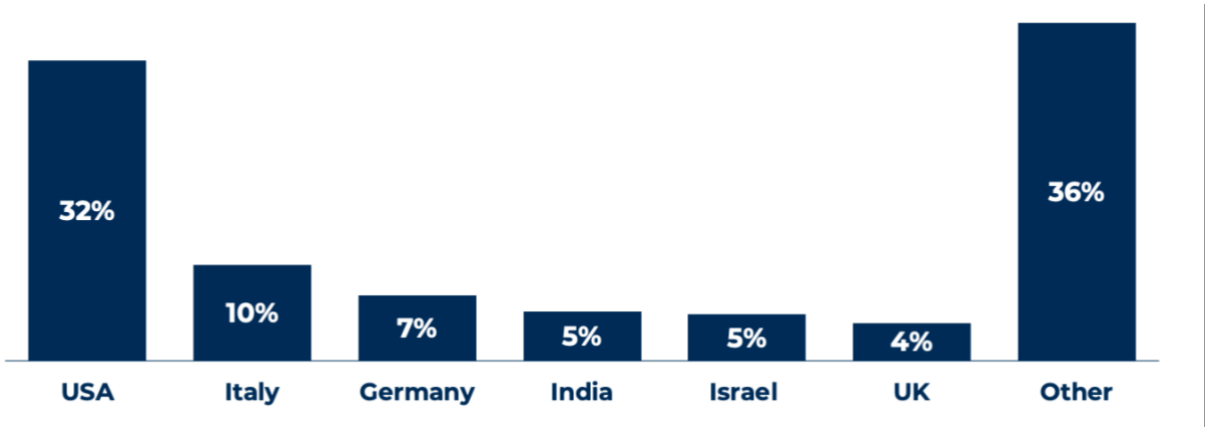

Figure 12: Geographic distribution of the startups by country

The country leading the category are the United States, this can be explained by the common practice of startups to move their headquarters to this country in order to continue with their growth path. In fact, is no secret similar markets and industries tend to become concentrated in a particular area, and there is no better place for a tech-startup, that implements modern technologies as IoT, Machine Learning or Artificial Intelligence, than the Silicon Valley. An area where established business infrastructure, talented resource pool, and a flourishing marketplace provides a clear head start compared to other locations. An example of this trend is represented by the American Startup Hayden AI.

Hayden AI

Foundation Year: 2019

Headquarters: Oakland, United State of America

Geographic scope of the offer: North America

Concept Description: HaydenAI developed the world's first autonomous traffic management platform, simultaneously serving citizens and governments to help cities become safer and more sustainable.

Use Case/ Application Area: Smart City

Web site: https://www.hayden.ai

1. Founder

Chris Carson: Co-Founder & CEO (Chief Executive Officer); background: Scientific/Managerial

Michael Byrne: Co-Founder & VP Product; background: Scientific/Technical

2. Financing

Total Amount Received: 30.300.000 $

Last Financing Amount Received: 20.000.000 $

Date of the Last Financing Received: 19 August 2021

Type of the Last Financing Received: Series A

3. Business Model

Value Proposition: Hayden AI was founded on the belief that by combining mobile sensors with artificial intelligence, is possible to help governments bridge the innovation gap by making traffic flow more efficient and less dangerous, the world's first traffic management platform was developed. autonomous traffic to the world to help cities become safer and more sustainable. The fully integrated platform combines sensor data with Digital Twin technology to simulate different scenarios and generate actionable information, helping city agencies with traffic, fire, health, and law enforcement agencies to operate more efficiently.

Target Client: B2B, Public Administration

Revenues Model: Software solution and service sale

4. Use Case

Use Case: Conduent, a huge global company with multiple technology offerings, is partnering with Hayden AI to propose a new solution to help local government keep bus lanes clear. The solution will use Hayden's technology - cameras mounted on the buses, plus software to analyze that video - with Conduent's systems for managing pavements, including the ability to issue quotes. Then there is the possibility of expanding the external buses. Video analytics is flexible; they don't necessarily have to come from a particular type of camera, so Hayden and Conduent's technology could be applied to cameras mounted on other municipal vehicles or fixed cameras such as those mounted at intersections to capture drivers crossing red lights.

Main clients: Public Administration

Geographical scope of the offer: United State of America

The presence of a significant number of startups with headquarters in Italy is due to the strong focus kept on our country during the analysis. In fact, gathering data and conducting more exhaustive analysis is easier for companies based on the Italian territory. A successful case of Italian Startup is the Milan based company ISAAC.

ISAAC

Foundation Year: 2018

Headquarters: Milan, Italy

Geographic scope of the offer: Europe

Concept Description: ISAAC is a company specializing in the development of intelligent solutions for seismic protection and structural monitoring.

Use Case/ Application Area: Smart Building

Web site: https://isaacantisismica.com

1. Founder

Alberto Bussini: Founder & CEO (Chief Executive Officer); background: Scientific/Technical

Anna Impedovo: Co-Founder & COO (Chief Operating Officer); background: Scientific/Technical

2. Financing

Total Amount Received: 2.200.000 $

Last Financing Amount Received: 1.800.000 $

Date of the Last Financing Received: 15 April 2021

Type of the Last Financing Received: Seed Round

3. Business Model

Value Proposition: ISAAC offers intelligent seismic protection technology for existing buildings. A disruptive technology has been developed for the earthquake protection of structures, the I-Pro 1; once installed on the top floor of the building to be protected, it minimizes the risk of damage during earthquakes, ensuring both the safety and comfort of residents, being completely non-invasive.

Target Client: B2B

Revenues Model: Product and service sale

4. Use Case

Use Case: I-Pro 1 is simply installed on the roof to be able to identify the building structure (through a series of algorithms) and protect it in case of shocks. A highly technological, safe and effective tool, accessible to all. It can be installed easily and quickly and being a non-invasive system, it does not create any inconvenience to residents. The Pro 1 works through a series of sensors that monitor the building all day, to immediately identify any anomalies and activate in case of necessary maintenance.

The movement of each building is recorded in real time: the sensors are also able to calculate the number of forces that the system must emanate to dampen the oscillatory effects of an earthquake.
To limit the damage and avoid collapse. Based on the needs of the house, it can be adapted by installing a greater or lesser number of devices, to ensure maximum seismic protection. It is ideal for buildings from 1 to 10 floors, made of reinforced concrete or steel. The ISAAC Protection 1 system works and is effective, as demonstrated by a recent test conducted on two 3-storey buildings with a total height of 8.84 meters, at the Eucentre European Center for Training and Research in Seismic Engineering in Pavia. One structure mounted the system, the other did not. The laboratory tests that took place at the beginning of March 2021 showed how existing buildings can be protected in the event of an earthquake by installing I-Pro 1 on the roof.

Main clients: Final Consumers

Geographical scope of the offer: Italy

The other relevant countries within the European region that host most of the startups are Germany (7%) and the UK (4%).

As mentioned before, a deepening of the IoT Application Areas Smart City & Smart Building is possible, identifying and classifying multiple "Functionalities" that vary according to the startups' final offer nature. As Figure 13 shows the most popular category is "Scenario Management", this is the result of the companies, public actors, and citizen's need to better manage the many situations and tools at their disposal. Often these many instruments are the result of the variety of applications IoT technologies enable. The final output is a complex environment, hard to administrate. DABBEL is a Switzerland startup that operates in this particular field.

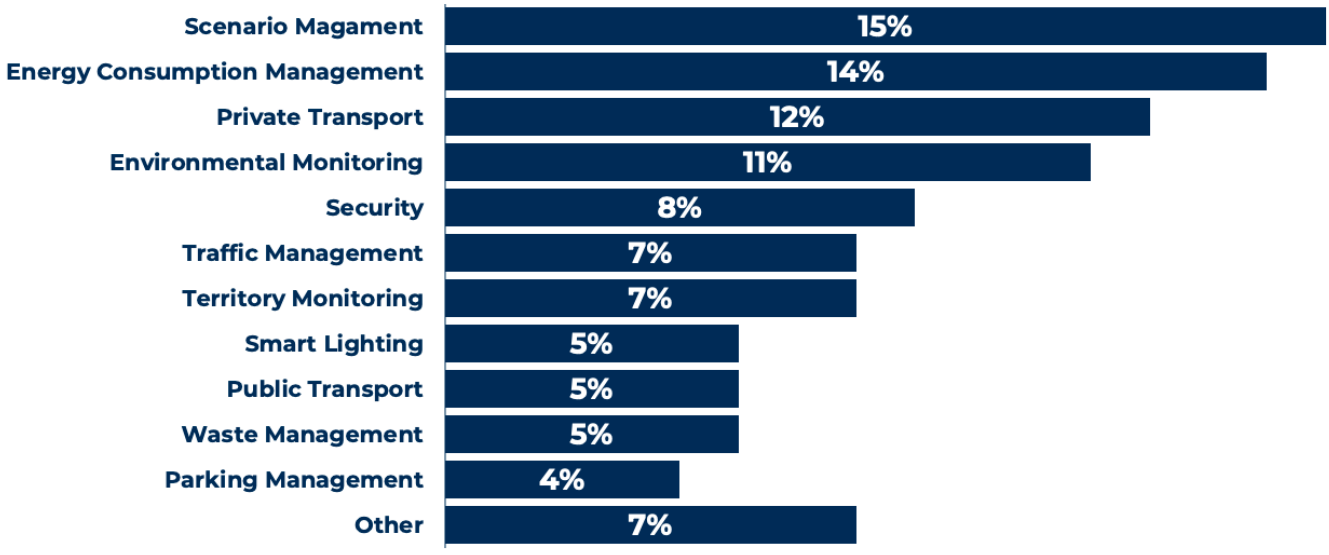

Figure 13: Distribution of the startups according to the functionalities offered

Dabbel

Foundation Year: 2018

Headquarters: Dusseldorf, Germany

Geographic scope of the offer: Worldwide

Concept Description: DABBEL is an AI building management system (Ai-BMS) with the ability to self-manage building control systems.

Use Case/ Application Area: Smart Building

Web site: https://www.dabbel.eu

1. Founder

Abel Samaniego: Founder & CEO (Chief Executive Officer); background: Scientific/Technical

Javier Ferre: Co-Founder & CTO (Chief Technology Officer); background: Scientific/Technical

Pablo Stahl: Co-Founder & CDO (Chief Digital Officer); background: Scientific/Technical

2. Financing

Total Amount Received: 4.400.000 $

Last Financing Amount Received: 3.600.000 $

Date of the Last Financing Received: 2021

Type of the Last Financing Received: Series A

3. Business Model

Value Proposition: DABBEL is the AI-Autonomous Building Management System (AI-BMS). The next generation of Building Management Systems based on a new core, a predictive control based on an artificial intelligence model capable of autonomously adapting to each building and replacing the human brain of the Technical Facility Manager responsible for HVAC and energy systems in commercial buildings. . DABBEL AI saves up to 40% of HVAC energy consumption and CO_2 emissions in commercial buildings.

Target Client: B2B

Revenues Model: Product sale

4. Use Case

Use Case: The application of DABBEL through a joint project with Zurzach Care AG at the Reha Bad Zurzach Clinic was voted one of the TOP 10 digital real estate projects in Switzerland. The numbers obtained from the application of the DABBEL system are: 20% of energy saved, 136.557Kw saved and 245t of CO2 avoided, among the main benefits we highlight energy and cost savings, reduced carbon footprint, improvement of the internal environment, comfort and streamlined FM activities. Feedback from Stefan Rutimann Head of corporate facility at Zurzach Care AG: “In order to increase the well-being of our patients and at the same time reduce the energy consumption in our buildings, we became aware of the DABBEL company. Thanks to the dynamic control of our energy systems, we were able to reduce consumption by up to 20% after only one month. This not only saves us money, but also makes an important step towards sustainability”.

Main clients: Commercial Buildings

Geographical scope of the offer: Switzerland

Following closely the first category, is possible to find “Energy Consumption Management”, “Private Transport” and “Environmental Monitoring”, at a first glance these 3 categories might seem completely unrelated between them, but taking in consideration their final goal, is possible to understand why their positioning and high relevance. All three functionalities aim, in a way or another, to preserve the environment, critical topic of recent years. Starting from the “Energy Consumption Management” that offer solutions to better manage energy resources of course saving costs, passing through the “Private Transport” that often put at disposal of citizens green mobility solutions as ride sharing or electric mobility, arriving to “Environmental Monitoring” that are proper products and services to keep track of environmental parameter for its protection and at the same time to improve citizen’s quality of life. Therefore, even when is not the main goal and objective of the functionality, the environment conservation remains relevant part of these categories.

The analysis of the database continues exploring the nature of the relationship startups establish with their clients and what type of business they carry on. As Figure 14 shows around the 60% of startups dedicate to B2B transactions, meaning that their final client are often other companies or public administrations and not the final consumers.

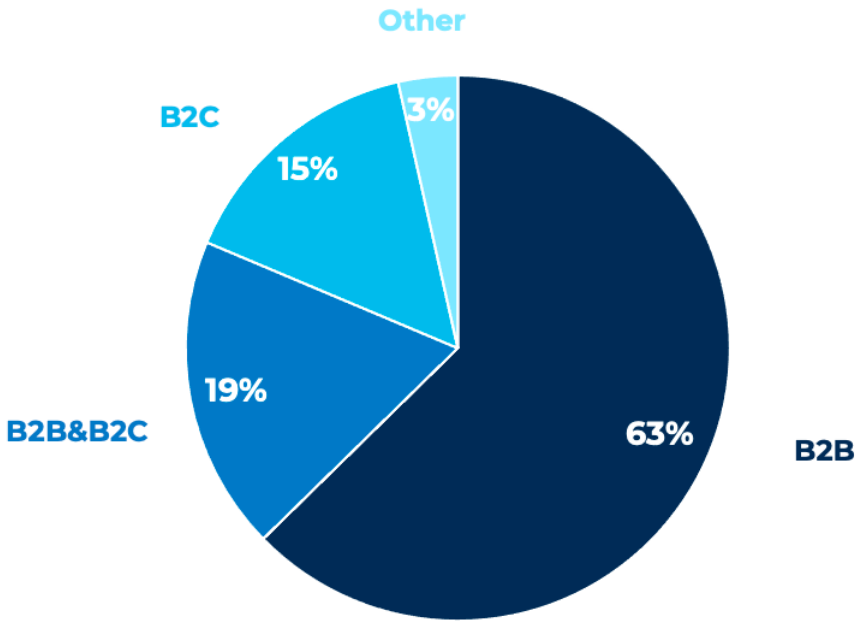

Figure 14: Distribution of the startups according to the typology of Business

This can be explained by looking at the database nature, most of the startups provide services or products that will impact on users and citizens' life, nevertheless, the offer is rarely directly sell to them. For example, when talking about Traffic Management, the systems and sensors that gather data are operated by public administration or private companies, once the information at their disposal is analyzed, they provide to generate a suggestion or an action, such as display alerts on road signs, aiming to modify the current traffic situation. Automotus for example is a startup that collaborate with Public Administrations ensuring citizen safety throughout the implementation of modern technologies.

Automotus

Foundation Year: 2017

Headquarters: Los Angeles, United State of America

Geographic scope of the offer: United State of America

Concept Description: Automotus automates roadside operations for everything related to mobility, from passenger vehicles and scooters to Ubers and delivery trucks.

Use Case/ Application Area: Smart City

Web site: https://www.automotus.co

1. Founder

Jordan Justus: Co-Founder & CEO (Chief Executive Officer); background: Managerial

Harris Lummis: Co-Founder & CTO (Chief Technology Officer); background: Scientific/Technical

Prajwal Kotamraju: Co-Founder & Head of computer vision; background: Scientific/Technical

2. Financing

Total Amount Received: 1.700.000 $

Last Financing Amount Received: 1.200.000 $

Date of the Last Financing Received: 1 February 2021

Type of the Last Financing Received: Seed Round

3. Business Model

Value Proposition: Roadside management solutions help cities, airports, fleets, and businesses increase revenue while creating more sustainable and less congested roads. It offers comprehensive analysis and real-time access to roadside activity of freight vehicles, passengers, buses, electric scooters, bicycles and pedestrians, and automatically alerts police officers of violations in real time as well as sending citations directly to vehicle owners, finally check parking availability via a mobile app or integrate this data via an open API into any guidance system for freight or food delivery vehicles.

Target Client: B2B, Public Administration

Revenues Model: Software solution and service sale.

4. Use Case

Use Case 1: Using proprietary video analytics technology, Automotus will work with the City of Santa Monica and LACI to monitor, analyze and automate all forms of road activity in a one square mile area that includes priority access for emission-free delivery vehicles. zero. The applied technology will collect anonymous data to assess the impacts on the area in terms of delivery efficiency, safety, congestion, and emissions, and will make real-time parking availability data available to all drivers in the zero-emission delivery area. We will also be able to alert law enforcement in real time when unauthorized vehicles are using the area. The technology used will not only have the potential to reduce air pollution, greenhouse gas emissions and traffic congestion, it will also support more efficient operations for fleets and offer greater economic opportunities for small businesses.

Main Client: Public Administration

Geographical Scope of the offer: United State of America

The result is that drivers can easily adapt their behavior or route, benefiting from the whole system. Therefore, is easy to understand how despite being the final beneficiary, consumers are not the main clients of these startups. This doesn't mean final consumers are never the main client, in fact 34% of the startups are pure B2C or B2B&B2C businesses. The category "Other" includes the less popular relationships like B2D and B2B&B2D.

Finally, a relevant data to consider is the typology of the offer these startups place on the market. The main categories are Hardware, Software, Services, and Infrastructure & Networks. The results are presented on Figure 15.

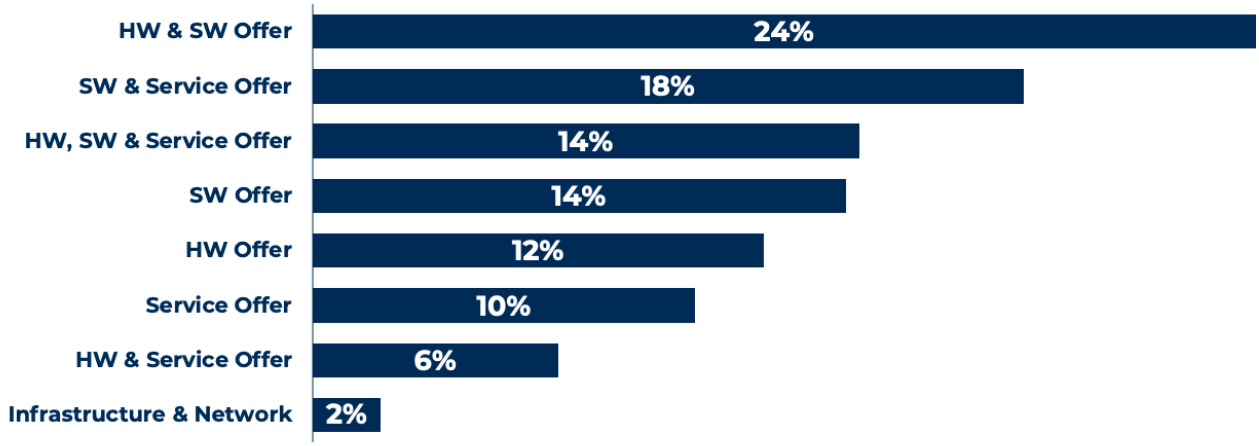

Figure 15: Distribution of the startups according to the typology of offer

The most common deliver offer is HW & SW, in fact a very typical feature of Smart, Connected Products is that physical components are match with software that allow their management. For example, startups that deal with Environmental Monitoring usually create sensors to detect, gather and analyze data regarding the air quality. This type of offer is rarely limited to the physical sensor, online dashboards and programs to visualize data and manage the information collected are typically offer as well. The outcome, as mentioned before, is a combination of HW & SW that together allow to better exploit the technologies' potential. Another important remark that can be done, is that companies often restraint themselves to offer just one component, but, as it is shown by the Figure 15, the most common practice is to propose complete solutions that allow the final costumer total control over the different scenarios. KIDO Dynamics for example offers a combination of services and software to its customer allowing them to understand people's mobility patterns.

KIDO Dynamics

Foundation Year: 2018

Headquarters: Lausanne, Switzerland

Geographic scope of the offer: Worldwide

Concept Description: Kido Dynamics uses machine learning and quantum physics techniques to analyze and predict human mobility.

Use Case/ Application Area: Smart City

Web site: https://www.kidodynamics.com

1. Founder

Ignacio Barrios: Co-Founder & CEO (Chief Executive Officer); background: Scientific/Technical

Alberto Hernando: Co-Founder & CTO (Chief Technology Officer); background: Scientific/Technical

2. Financing

Total Amount Received: 4.370.000 $

Last Financing Amount Received: 930.000 $

Date of the Last Financing Received: 12 October 2021

Type of the Last Financing Received: Seed Round

3. Business Model

Value Proposition: Kido Dynamics provides tools for companies to fully understand people's mobility models. The technology used provides comprehensive and contextual analyzes for people's mobility patterns. The demand for such tools is very broad across the globe, including segments such as transportation, away-from-home marketing, tourism, events, and smart cities. KidoDynamics technology (inspired by computational physics) was created specifically to analyze mobility data and extract the maximum of useful information, reducing costs, implementation times and months of development and investment in data scientists.

Target Client: B2B, Public Administration

Revenues Model: Software solution and service sale.

4. Use Case

Use Case 1: After the eruption of the volcano on the Spanish island of Las Palmas, through the geolocation of the telephones combined with the information of KIDO, it was possible to carry out the evacuation, the exit of the tourists and the movements in the area of the volcano of La Palma. About 4,000 residents have left. Most, as explained by Alberto Hernando de Castro, co-founder of KIDO, have moved to other areas of La Palma. Many evacuees stay with relatives, in second homes or in makeshift shelters, such as the El Fuerte barracks.

Main Client: Public Administration

Geographical Scope of the offer: Spain

This is also the consequence of new business strategies and trends where companies try to not just to sell products but have as main goal the creation of ecosystems. This new scenario allows companies to propose solutions with even more potential, since to the stand-alone value of products and services they can add synergy advantages created by the wide range of the offer.

3.3. Industry Trends

In the previous section the main features and characteristic of the startups that are part of the database have been explore, this section aims to continue the analysis highlighting late trends in the industry, with a focus on the financing received by the startups, and how this money has been distributed over the last 3 years.

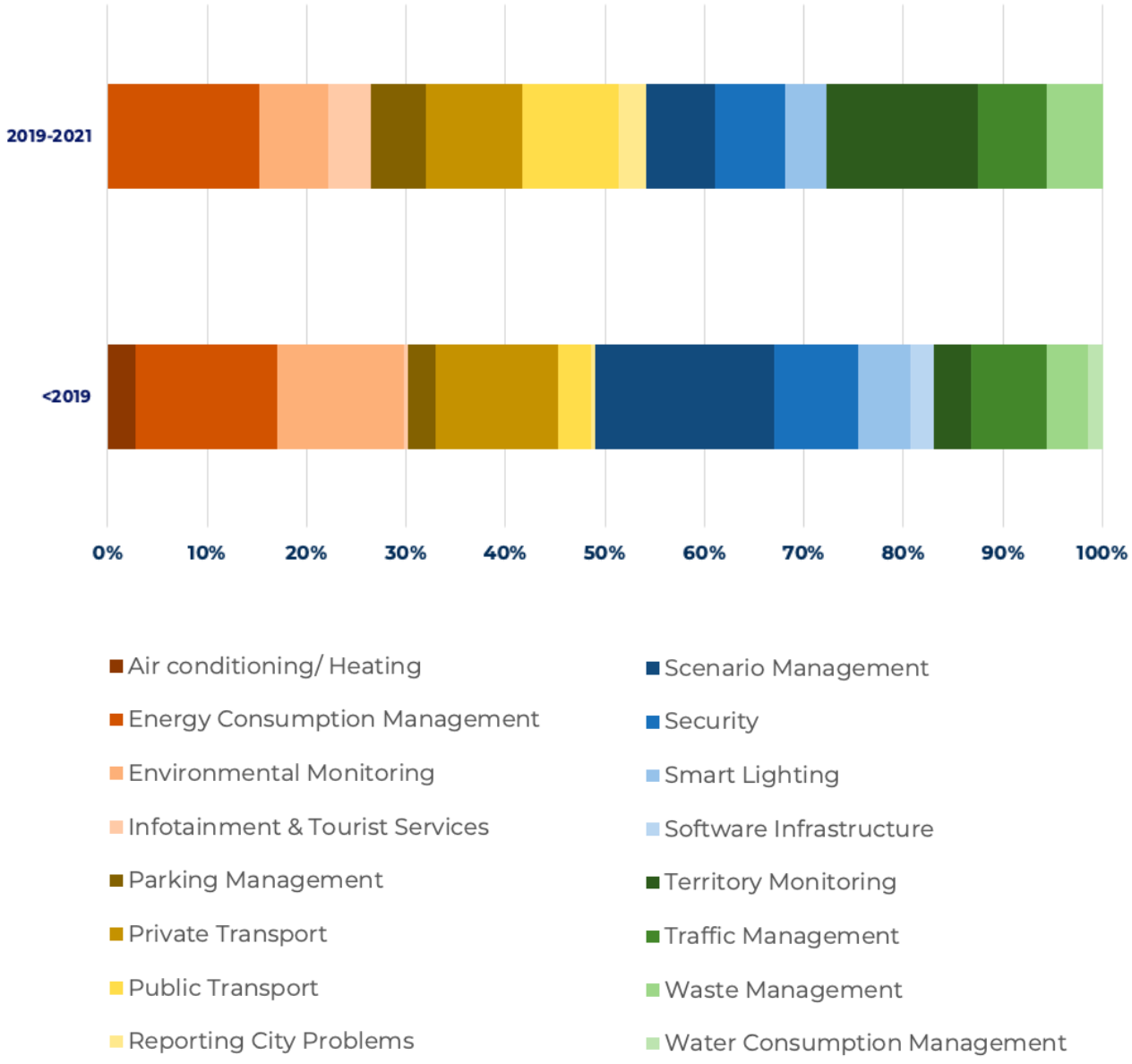

Figure 16: Diffusion over time of the Smart City & Smart Building functionalities

The first thing that can be done to understand how the industry has been changing, over the course of the last 3 years, is to look at how the diffusion of the different functionalities has been shifting. It

catches the eye how the Environmental Monitoring has decrease in percentage with respect to the past years. This might seem in contradiction with the late trends of environmental care that has been concerning the world in the past decades. Nevertheless, is important to remind what is behind the functionalities, sensors and data gathering are just a part of the environmental actions that can be done in this fight. In fact, the "green" trend is confirmed by the increase on percentage of areas like Parking Management and Public Transport, since both categories have within their many goals the reduction of the circulation of fuel vehicles. For example, the first one providing fastest ways to park spending less time polluting with proprietary cars, the late one implementing electric mobility solutions for citizens. Of course, these are just two examples, the range of application on these field doesn't just limit to pollution reduction. GetHenry is an example of innovative solution in the mobility sector.

GetHenry

Foundation Year: 2018

Headquarters: Berlin, Germany

Geographic scope of the offer: Europe

Concept Description: GetHenry is a fully equipped mobility solution for last kilometer deliveries and couriers. It offers a bespoke mobility service that allows customers to subscribe to electric vehicles, including regular maintenance and software.

Use Case/ Application Area: Smart City

Web site: https://gethenry.co/en

1. Founder

Luis Orsini-Rosenberg: Co-Founder & CEO (Chief Executive Officer); background: Social/Economic

Nikodemus Seilern: Co-Founder & CPO (Chief People Officer); background: Social/Economic

2. Financing

Total Amount Received: 1.000.000 $

Last Financing Amount Received: n.d

Date of the Last Financing Received: 25 August 2021

Type of the Last Financing Received: Seed Round

3. Business Model

Value Proposition: GetHenry aims to change the business model of last-mile delivery and thus shape the future of electric mobility along with reducing CO2 emissions related to long-distance traffic. The mission is to ensure that thousands of bicycle couriers have a smooth, fast and safe delivery experience every day. What we do is offer a complete subscription-based mobility service for the main delivery services. This includes providing customers with e-bikes, weekly maintenance by local service teams, and digital solutions for a user-friendly experience.

Target Client: B2B

Revenues Model: Service and software solution sale. Product rental.

4. Use Case

Use Case 1: A new study finds that transport and delivery bikes offer service that is 60% faster than that of vans and reduce carbon emissions by 90% compared to diesel vehicles. GetHenry's E-Bikes have a higher average speed in urban centers and allow you to deliver around 10 packages per hour, compared to 6 for vans. As home deliveries soared during the pandemic, making online shopping the new norm, e-bikes will be the future if you not only want cities to stay clean and greenhouse gas emissions to decrease, but also for packages arrive on time.

Main Client: SME and Big companies

Geographical Scope of the offer: Europe

Infotainment & Tourist Services is one of the categories that exhibit an increase, this could be explain due the effects of the pandemic COVID-19, it is reasonable to presume that public administration and private actors put a significant effort in trying to boost and recover the commercial life within cities. Another considerable shift is the one about Scenario Management, it might seem in conflict with the fact that most of the startups mapped deal with this functionality. The reason behind this stands not so much on a decline of the sector but in a rise of the other ones. Is important to keep in mind that the IoT market has still potential to growth, as figure 17 shows, furthermore, considering future projections the industry might still be considered at its early stages.

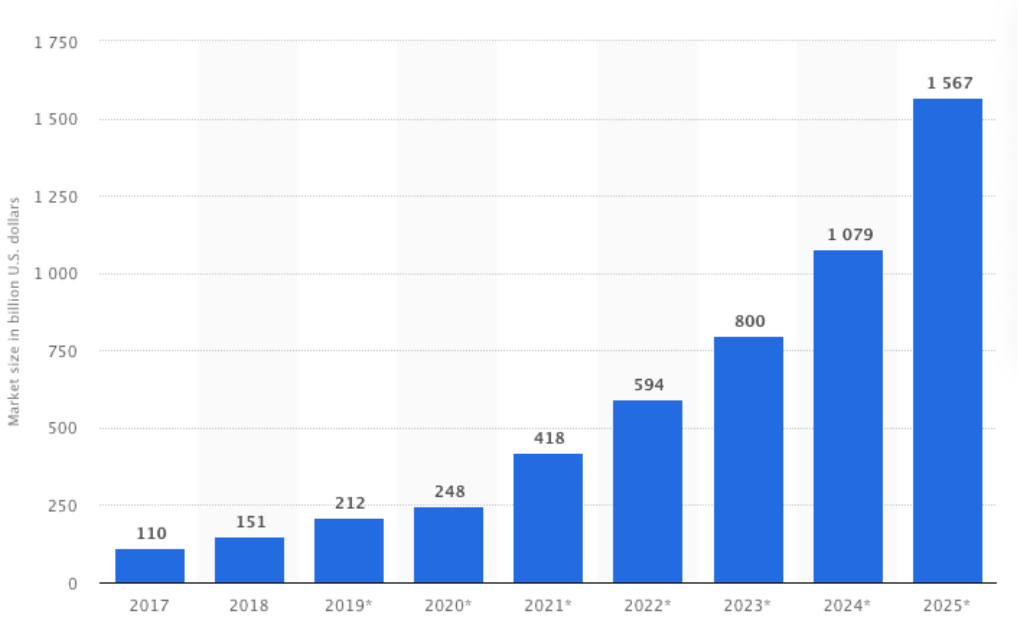

Figure 17: Market Value of the IoT industry by Statista estimates

So, it is reasonable to expect, has figure 16 have shown, an increase and expansion on new functionalities as time goes on. Another important consideration to make, about the IoT industry growth, is that this type of technology feeds from itself, meaning that the more it is implemented the more potential and space for further development is created. Scenario Management is a clear example of this phenomena, where the application of multiple IoT solutions led to the need of a new specific application area that could deal with the complexity of the environment.

A similar analysis made for the functionalities can be conducted for the typology of offer deliver by the startups, in this case comparing between the trend of the last 3 years and the overall state of the industry, figure 18 shows the distribution of the offers.

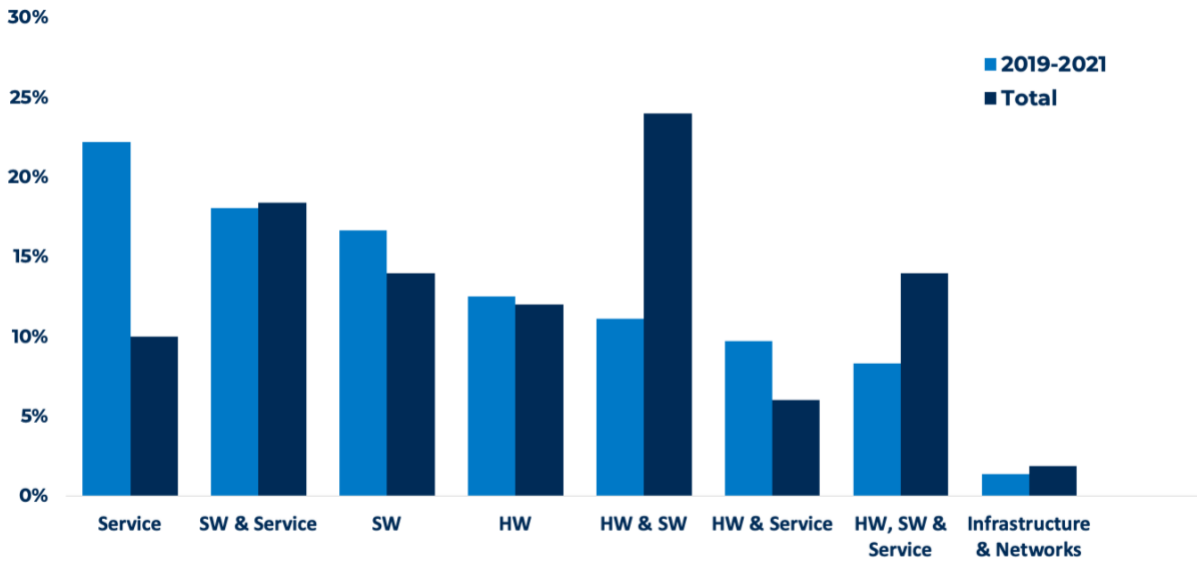

Figure 18: Diffusion overt time of the typology of offer

The first and most relevant result is how Service took the lead in the last 3 years, even when the percentage is not so high, like in the case of HW & Service, is possible to notice a considerable increase with respect to the total value. This trend can be explained by a process of digital transformation and servitization companies are going through. The main concept behind is service and product integration to form a new value solution for customers. In this context, the adoption of new technologies, such as IoT, artificial intelligence, big data analytics and blockchain can certainly favor the transformation process. This is the case of Smart City and Smart Building who relies on IoT technologies. For example, Luys System a startup that offers IoT devices for the smart building and lighting market.

Luys System

Foundation Year: 2020

Headquarters: San Jose, United State of America

Geographic scope of the offer: Worldwide

Concept Description: Luys Systems develops IoT devices and end-to-end systems for the smart building and lighting market.

Use Case/ Application Area: Smart Building

Web site: https://www.luys-systems.com

1. Founder

Daniel Castellano Co-Founder & CEO (Chief Executive Officer); background: Scientific/Technical

Gagik Haruty: Co-Founder & CTO (Chief Technology Officer); background: Scientific/Technical

Thomas Chanian: Co- Founder; background: Scientific/Managerial

2. Financing

Total Amount Received: n.d

Last Financing Amount Received: n.d

Date of the Last Financing Received: n.d

Type of the Last Financing Received: n.d

3. Business Model

Value Proposition: LUYS as a company is focused on "Smart Building" technology with the idea of interconnecting data mining and analysis services with proprietary hardware: an "intelligent" lighting device equipped with a myriad of interactive solid-state sensors coupled with sophisticated software of artificial intelligence. LUYS Systems' initial end-to-end solution is the bathroom industry's first and only "smart" product with advanced solid state integrated sensors to continuously display, monitor and record bathroom occupancy intervals, air cleanliness, temperature, humidity, floor hygiene, plus many optional sensing devices for future use. The cloud application software design includes advanced, unique and patented algorithms which, in addition to providing real-time data to facility / maintenance management, also gather rich and valuable data for extraction and analysis.

Target Client: B2B

Revenues Model: Product and Service sale.

4. Use Case

Use Case: Have you ever walked into a public restroom and are unsure which toilets were available? We believe this common and uncomfortable experience has been encountered far too often (think airports).
We have found that while solutions exist, they are expensive, difficult to install and, in our opinion, not very attractive. Due to these limitations, none have wide adoption, although some are in places like stadiums or airports. Our goal was to address all the weaknesses by making our solution practical to implement in any bathroom regardless of the size of the venue.

Main clients: Commercial Buildings

Geographical scope of the offer: United State of America

Together with the rise of services, it can be notice, an increase on Software (SW) solutions and, in parallel, a decline of the Hardware (HW) ones. Nevertheless, looking at the whole picture, as mentioned before, HW & SW solutions stay on the first place of the chart, being product solutions and software for its management and implementation the most diffuse category.

Going back to some more monetary data about the industry, in Figure 19 the Total Financing received by the startups mapped, in the last 5 years, are shown.

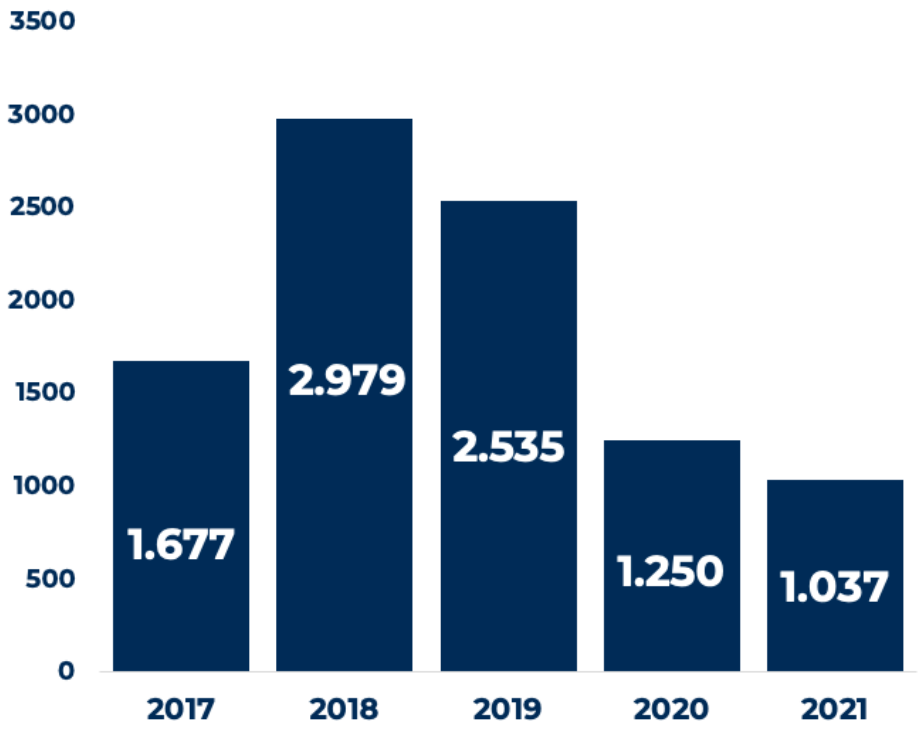

Figure 19: Total Financing received by the startups by year (millions of euros)

To explain the trend present it is possible to rely on figure 20. The late graph represents the evolution of the Global Venture Deal Volumes over the last 10 years. As it is possible to notice for the 4 years in common (from 2017 to 2020) both graphs follow the same movement. Starting from the 2017, the lowest level reach pre- pandemic, it moves to the "boom" of 2018 where the increase, in terms of deals made, was characterize by a bigger leap with respect to the mean of the last years. In fact, it might seem to hit a slump in 2019, with a reduction of almost 15%, but again looking at the trend that was distinguishing the years from 2015 to 2017 the reality is that it just returned to its "normal" growth rate.

Finally, hitting year 2020, an obvious decrease is notable both in terms of total funding and total deal volume, this is easily explained by the effects of the pandemic on the global economy.

For the year 2021 it might seem to have hit another drawback, but it is important to remark that the data for this year doesn't take in consideration the last quarter of the year.

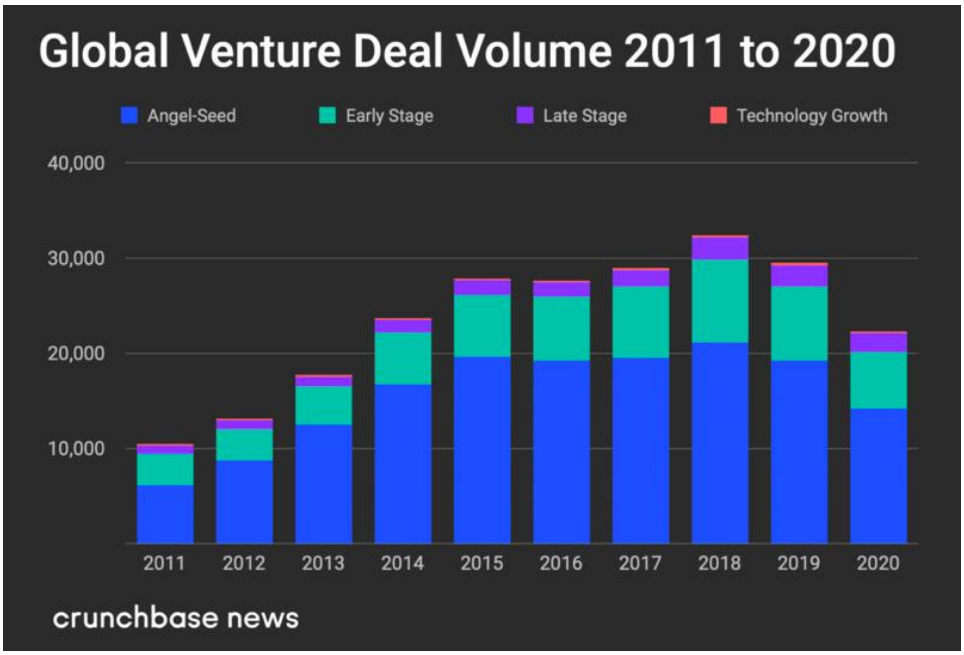

Figure 20: Global Venture Deal Volume 2011 to 2020 by Crunchbase

Going more in-depth in the money distribution analysis, figure 21 is presented, it shows the total funding startups received distributed by continent. Leading the chart there is the North America with almost 8 billion of euros collected, with the United States of America accounting for almost 93% of this grand total.

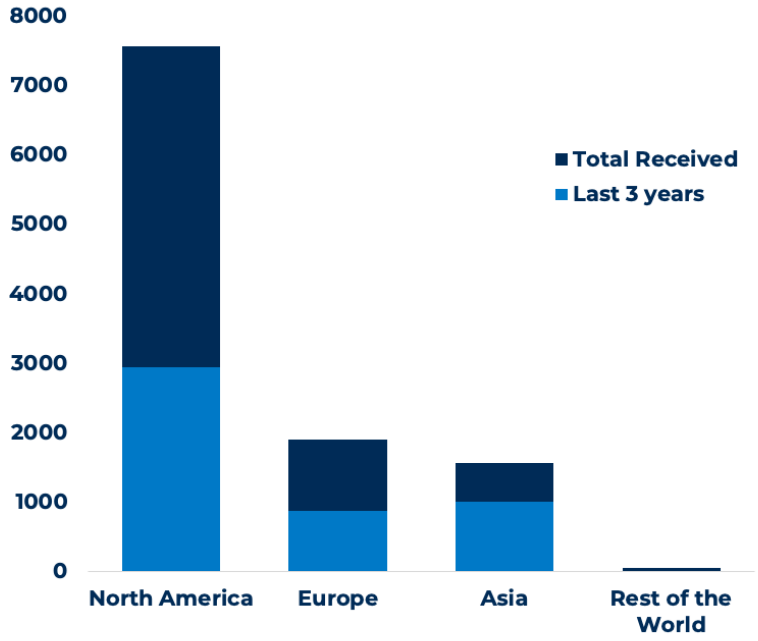

Figure 21: Total Funding received by continent (millions of euros)

Europe and Asia stand at second and third place respectively, what is interesting to remark is that despite Europe having collected the most total funding between the two, it is Asia that place at 2nd considering only the last 3 years. This is the result of mega trends that are transforming the IoT market in the APAC region, in fact according to industry analyst firm Frost & Sullivan "On a macro level, increasing government focus on smart cities and Industry 4.0 initiatives is driving demand for digital IoT solutions in the region, such as e-government, public transportation, smart traffic management systems and smart power grids,". Furthermore, ICT research analyst Hemangi Patel said that the APAC region accounts for about 40 per cent of global Low Power Wide Area (LPWA) connections[7]. The Asian based startup Sensgreen, for example, manage to collect 120.00$ in its last financing round in 2021.

Sensgreen

Foundation Year: 2018

Headquarters: Singapore, Singapore

Geographic scope of the offer: Worldwide

Concept Description: Sensgreen improves indoor environmental conditions in commercial real estate with its AI-based models and plug and play sensors.

Use Case/ Application Area: Smart Building

Web site: https://www.sensgreen.com

1. Founder

Hasan Basri Tosun: Co-Founder & CEO (Chief Executive Officer); background: Scientific/Technical

Ahmet Kazanç: Co-Founder; background: Scientific/Technical

Aykut Yildirim: Co-Founder & CSO (Chief Security Officer); background: Scientific/Technical

Yigitcan Yesilata: Co-Founder & CTO (Chief Technology Officer); background: Scientific/Technical

2. Financing

Total Amount Received: 361.000 $

Last Financing Amount Received: 120.000 $

Date of the Last Financing Received: 27 January 2021

Type of the Last Financing Received: Pre Seed Round

[7] Opportunities emerge as Asia Pacific IoT market gets set to top $437B by Leon Spencer

3. Business Model

Value Proposition: Analysis and forecasting technology is built with reinforced learning algorithms and years of experience in building science. In addition, it can develop advanced wireless sensors to collect data in real time to constantly improve our models. Finally, the existence of the mobile App, adaptable and user-friendly customized by each user, allows an overview of their environment in a few seconds, which makes Sensgreen unique in the commercial built environment.

Target Client: B2B

Revenues Model: Product and service sale.

4. Use Case

Use Case: Singapore-based IoT solutions company Sensgreen has successfully installed the first indoor air quality monitoring sensors - IAQ in Dubai on the premises of Kids First Group's Redwood Montessori Nursery on the Palm. Using Sensgreen's IAQ monitoring solutions, Redwood Montessori Nursery has taken a concrete step to create a safe and healthy indoor educational environment for children.

Nursery management uses Sensgreen's IAQ system to monitor nursery air quality, receive instant notifications of critical readings, and take data-driven action to keep the air clean inside the nursery while fostering a productive environment for children's development.

Main clients: Final Consumer

Geographical scope of the offer: Dubai, United Arab Emirates

Moving forward with the analysis is possible to switch from a geographic point of view to a more operational one. Analyzing which are the functionalities that manage to gather the biggest quantity of funding. As Figure 22 shows, two main categories catch almost 75% of the total funding. The first one is “Private Transport” with almost 6 billion of euros collected.

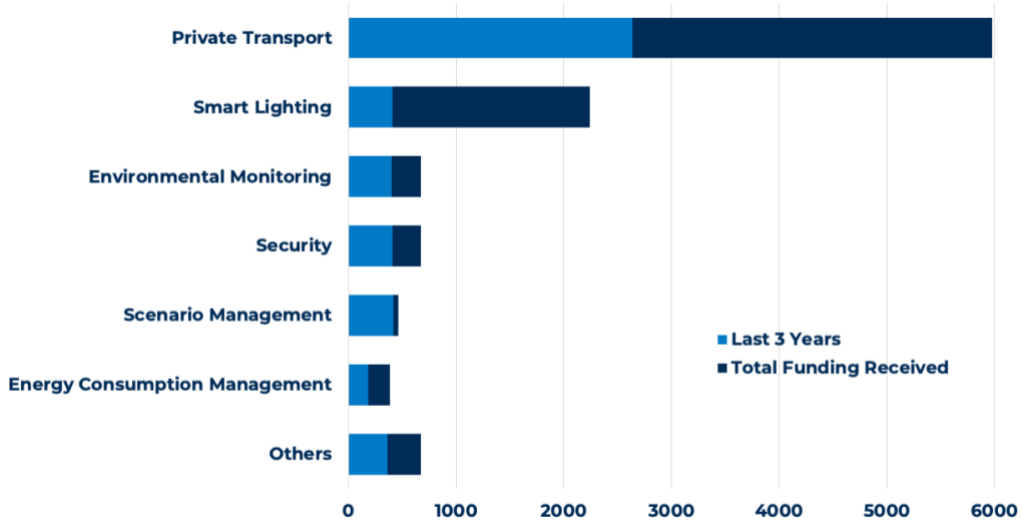

Figure 22: Total Funding received by Functionalities (millions of euros)

This result come as no surprise since the propagation of innovative urban mobility solutions have been taken place since the start of the last decade. Companies like Uber, Enjoy, Share Now, are among the multiple players that offer alternative solution to the common transport by car, and are all consider as establish companies in the market. Nevertheless, the private transport sector doesn't just stop at the car sharing frontier, new mobility opportunities are being explore by startups, electrical scooters and bike sharing are just examples of how the urban mobility industry is evolving. Furthermore, the innovation in this sector doesn't come just in the form of new vehicles but also in the implementation of modern technologies, as for example Blockchain, Big Data Analytics and Cloud solutions, that are allowing the industry to expand beyond what were consider its common boundaries. Volvero for example is an Italian based startups that is exploring the use of Blockchain in the mobility industry.

Volvero

Foundation Year: 2018

Headquarters: Milan, Italy

Geographic scope of the offer: Italy

Concept Description: Volvero is an app that allows vehicle owners to earn money by sharing them overnight by leveraging a secure DLT system and Big Data technologies for vehicle tracking and user awareness.

Use Case/ Application Area: Smart City

Web site: https://volvero.com

1. Founder

Marco Filippi: Founder & CEO (Chief Executive Officer); background: Scientific/Economic

2. Financing

Total Amount Received: 220.000 $

Last Financing Amount Received: 60.000 $

Date of the Last Financing Received: 6 November 2021

Type of the Last Financing Received: Seed Round

3. Business Model

Value Proposition: Application of blockchain technology to create a simple, reliable and sustainable service that connects vehicle owners with drivers looking for a new solution for their needs.

A comprehensive insurance methodology and bespoke protection has also been developed to ensure the peace and safety of drivers and owners who join our community.

Target Client: B2C

Revenues Model: App service

4. Use Case

Use Case: In the Volvero app, you can find a wide range of vehicles which vary not only in size, functionality or age of the vehicle, but also in price. It is also possible to find cheap vehicles suitable for those who want to spend little to get around, or the latest super-equipped models for those who want to enjoy as much comfort as possible. There is no safe and secure journey without insurance. Using Volvero, an instant policy is created upon sharing and is suitable for any specific situation. Volvero makes use of the best European experts in the field of Insurtech: Neosurance, an innovative platform capable of connecting insurance companies with a digital community of users in order to activate instant and appropriate policies for every driver's need, developed in collaboration with Europe Assistance.

Main clients: Final Consumer

Geographical scope of the offer: Italy

Smart Lighting can be found at the second place in the graph, with a total funding of around 2.2 billion of euros, it is important to signal that this remarkable result is bias by the presence of just one company that accounts for almost 95% of this total sum.

Following the same approach of the previous graph, Figure 23 is presented. In this case, the total funding received by the startups are distributed by typology of business. At first place with almost 5 billion of euro collected there is the B2C category. This result might seem in contrast with Figure 14, where it was shown how B2B account for almost 62% of the startups.

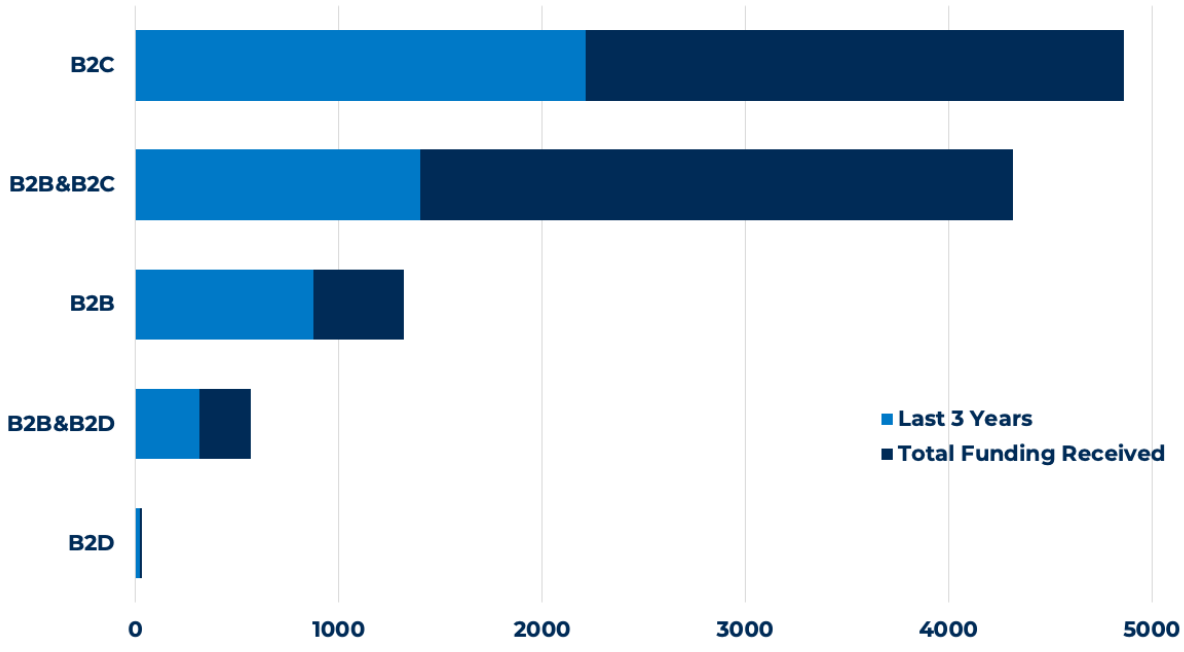

Figure 23: Total Funding received by typology of business (millions of euros)

To explain this result Figure 24 is exhibited, showing a breakdown of how the multiple functionalities are distributed within the B2C category. In this way is possible to understand the high placement of the B2C, since it is mainly composed by Private Transport, the functionality with the highest funding. At the same time is possible to perform the reverse analysis and find out that 55% of the Private Transport startups operate in the B2C market. An example of B2C Private Transport Startup is Switch.

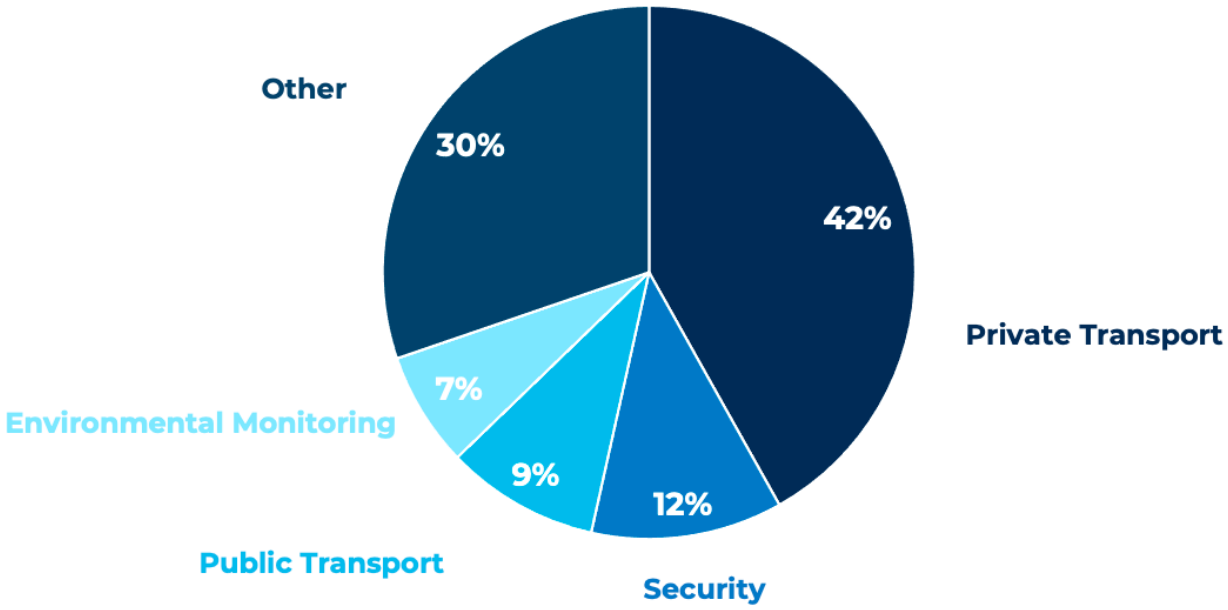

Figure 24: Distribution of the functionalities within the B2C category

Switch

Foundation Year: 2019

Headquarters: Italy

Geographic scope of the offer: Europe

Concept Description: SWITCH intelligently connects those who drive a car in car sharing with those who are currently looking for a car.

Use Case/ Application Area: Smart City

Web site: https://getswitch.io

1. Founder

Matteo Forte: Founder & CEO (Chief Executive Officer); background: Scientific/Technical

2. Financing

Total Amount Received: n.d

Last Financing Amount Received: n.d

Date of the Last Financing Received: n.d

Type of the Last Financing Received: n.d

3. Business Model

Value Proposition: As a Car Sharing user, you spend more time searching for parking than it actually takes to get to your destination. SWITCH intelligently connects those who drive a car in Car Sharing with those who are currently looking for a car, optimizing costs and saving precious time for those who would otherwise be forced to waste it in the search for parking or available cars. SWITCH also connects those who drive with those who need a ride, building a world where you can immediately find a car, drive it and share the cost of the trip.

Target Client: B2C

Revenues Model: App service

4. Use Case

Use Case: The number of cars in circulation has now reached exponential levels, as has the resulting pollution. And the contradictions are many. An example? 90% of motorists travel alone in a vehicle that could hold five people! Just think of a one-kilometer-long motorway lane occupied by about forty vehicles, containing less than 50 people. And here comes one of Switch's missions! Why not share your journey with someone who goes the same way as you? The challenge is to change the habits of Italians, working with all our commitment to guarantee an intelligent, intuitive and above all useful service. Switch is aware of the problem and strongly believes that car sharing could be one of the solutions, not only of efficiency but also of environmental sustainability.

Main clients: Final Consumer

Geographical scope of the offer: Italy

4. Qualitative Framework: Startups Role Matrix

This chapter has as main goal to present the Startups Role Matrix created ad hoc for this analysis. The objective of the framework is to provide a tool to better qualify Startup's operations and role within the Smart City and Smart Building industry.
The first part of the chapter will introduce the model and the axis of the matrix, later the different quadrants will be explained, and examples will be provided, finally the startups of the database will be classified within the matrix.

The concept of "Smart" isn't something cities and buildings are born with. Instead, it is a process of transformation that happens gradually, throughout the implementation and adoption of modern technologies in day-to-day operations. The framework aims to identify the role startups play within this procedure of renewal.

As shown by the multiple examples provided until now, the range of possibilities IoT technologies enable, within the two application areas object of study of this research, are countless. Even within the same application area, like for example Smart City, the variety of functionalities is so wide that it makes hard to allocate Startup's under a same framework. For this reason, specific characteristic and features regarding the functionality applications will be set aside, and the focus will be place on a macro level, exploring the more operational aspects of the solutions proposed by the startups.

The two main aspects that will be consider with this tool are "What are Startups offering to the market?" and "How are Startups delivering their business offer?". More in detail for the first question the focus will be the way in which the solution delivers its value, while for the second one the focus will be in the different customer relationship startups establish throughout their current business offer. Combining the two variables different possible approaches for Startups comes out.

4.1. The framework

Keeping in mind the different essence of the startups, the main scope of the framework is to be able to classify their multiple business approaches according to, of course, the nature of their business offers. The framework created is a Matrix placed on two perpendicular axes, as shown in Figure 25.

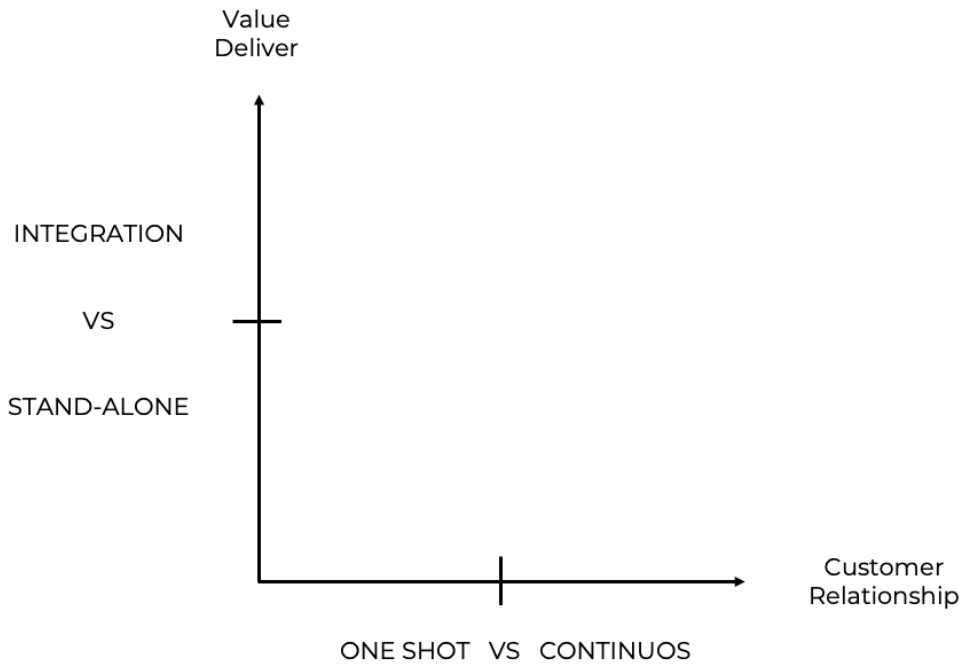

Figure 25: Startup Role Framework

The two variables selected for the classification are “Value Deliver” and “Customer Relationship”. The choice of these variables was made in order to be able to approach the startup’s heterogeneity, enclosing them under the same criteria regardless of the application area to which they belong to. The matrix focuses on two main aspects of the solutions proposed and allows to understand what these companies are offering to the market in terms of pure business solution and from a business relationship point of view.

4.1.1. Value Deliver

The “Value Deliver” dimension takes in consideration the way in which the solution proposed by a startup manage to create value for the user. Even though the concept of IoT already implies communication and connection, this doesn’t mean they always happen between different systems of the same environment. In this context is possible to identify two main procedures: Stand Alone vs Integration. Focusing on the first one is safe to say that some companies limit themselves to the creation of products and services, throughout the implementation of IoT technology, that had a stand-alone value, meaning that their use isn’t linked or depends on already existing systems. An example of this is the company Parkble Inc, the New York based startup offer to its users a mobile app, based on peer-to-peer community, that helps drivers share, find and exchange street parking spots. The app is used only during the process of research of parking spots, without further application for the users or at least without interacting with other actors. In fact, the whole operation happens in a close environment, where the only actors participating are the ones that belong to the Parkble Inc habitat.

Parkble Inc.

Foundation Year: 2019

Headquarters: New York, United Stated of America

Geographic scope of the offer: North America

Concept Description: Parkble is a peer-to-peer community-based mobile app that helps drivers share, find and swap street parking.

Use Case/ Application Area: Smart City

Web site: https://parkble.com

1. Founder

Djurabek Ismatov: Founder & CEO (Chief Executive Officer); background: Managerial

2. Financing

Total Amount Received: 300.000 $

Last Financing Amount Received: 300.000 $

Date of the Last Financing Received: 24 July 2021

Type of the Last Financing Received: Seed Round

3. Business Model

Value Proposition: Parkble rewards you points when you share your street parking with other drivers, invite a friend to download and use Parkble when you register by email. Points are redeemable for gift cards. Browse through the car parks available in the area where you plan to arrive and ask for the place you prefer. Select the exact location, where you want your parking to be reserved at a specific time, and we'll match you with someone who shares their spot in the area.

4. Use Case

Use Case: How many times have you had to stressfully wander around the area in search of parking and then have to park your car 4-5 blocks from your destination? How many times have you forgotten where you parked your car and felt confused and lost? Think about how many times you have received parking violation fines due to street cleaning rules. Parkble offers a solution to alleviate all the problems mentioned above. Drivers share their street parking spaces by indicating their location and departure time in the future, so that other drivers arriving at their destination at corresponding times can search for shared parking spaces available on the street by others and take their parking spaces instantly. In our system we call these two parts - "Giver" and "Receiver" of the parking lot. Parkble provides a community-based online platform that brings these two parties together, saving them time, nerve, fuel in the street parking process and also reducing traffic congestion, pollution, conflicts and dangerous parking situations.

Main clients: Final Consumer

Geographical scope of the offer: United State of America

On the other hand, is possible to find startups that design solutions that have a real value only if integrated with other systems present on the environment. This is happening for example in the case of solutions that benefit from the aggregation of data coming from multiple sources. A case of this phenomena is present in the field of energy consumption management, where startups provide products and services that aggregate the information gather from the different energy sources, in this way the solution can create a big picture of the current energy situation within the city/building. Summing up this variable aims to qualify if the solution proposed benefit or exploit the integration with other existing elements, capitalizing in this way on the synergies create between this exchange of information. Even though the variable is purely qualitative, is possible to identify some factors that impact on the final classification of the solution along this dimension.

- ***Environment compatibility***

  Whatever type of product or service are proposed by the startups, is unavoidable that it is going to end up being implemented within an already functioning system of objects. The distinction to do relies on if the solution depends on the communication with these other parts of the systems to perform at his maximum.

- ***Systems management***

  Nowadays when talking about smart solutions it is reasonable to consider two main components that characterized them. On one side the physical part that perform required tasks, on the other the intangible part regarding the data collected and the information produce. As mentioned in the previous chapters, this current composition of today's smart solutions generates complex environments. The fact that there is or there isn't the need to integrate the solution at management level, allows to differentiate between Stand Alone and Integration value deliver approach.

- ***Customization***

  As well as startups, also customers tend to have multiple characteristics that makes them different from each other. To ensure the correct function of the solution proposed startups need to make sure that the fit within the environment of utilization is possible, therefore a higher need of customization might indicate an Integration value deliver approach.

4.1.2. Customer Relationship

The "Customer Relationship" dimension deals with the relationship the startup establish and propose to its customer throughout their business offers, especially during the implementation phase of the solution offered. The two extremes of the spectrum are One Shot and Continuous. Some of the features that allow to distinguish between the two cases are:

- ***Product/Service Management***

  Smart City and Smart Building fields, unlike other IoT application areas, doesn't require particular infrastructures or complex systems to be manage. Nevertheless, especially when Public Administration is involved, the management and manutention of the parts enabling the smart functionalities are required, this might fall within the field of competence of startups or not.

- ***Front Office and Back Office***

  The multiple solutions startups offer vary on type and characteristics. According to those the involvement of startups during the dispensing of the product or service change. Continuous interactions with clients require certain competences and skills, like for example the presence of a strong front office or in the case of apps a clear user interface. Analyzing the structures of these two aspects is possible to understand the customer approach the startups intend to offer to the market.

- ***Customer Care***

  The transition to become Smart City or Building, doesn't just stop at the possession of Smart features, as it will be illustrated in the example of AirCare, it is not enough to possess air sensors, the real transformation happens when the quality of air is improved by their implementation. In this sense it is not said that customers possess the right qualifications to perform these improvements. To have an active role during this process is up to the startups business decisions and might mean a Continuous relationship approach.

An example of a Startup that implements a Continuous Customer Relationship approach is given by the case of the Italian Startup AirCare

Aircare

Foundation Year: 2019

Headquarters: Rome, Italy

Geographic scope of the offer: Europe

Concept Description: AIRCARE tracks and manages indoor air quality by monitoring 3 internal parameters: air quality, environmental comfort, and electro smog.

Use Case/ Application Area: Smart Building

Web site: https://www.aircare.it

1. Founder

Lorenzo Facello: Founder; background: Scientific/Technical

1. Financing

Total Amount Received: n.d

Last Financing Amount Received: n.d

Date of the Last Financing Received: n.d

Type of the Last Financing Received: n.d

2. Business Model

Value Proposition: Aircare® is an Italian project that redesigns the indoor wellbeing paradigm, its direct focus on air quality and comfort control is exclusively dedicated to people's wellbeing. In addition to the HW components, Aircare offers a platform dedicated to the control and management of your devices, which analyzes the data collected and allows access to information of interest. Finally, Aircare supports you in obtaining more credits related to indoor air quality requirements with the aim of obtaining environmental certifications.

Target Client: B2B

Revenues Model: Product and Service sale.

4. Use Case

Use Case: Aircare is a small smart device, with a smooth and white surface, with reduced dimensions and a simple and linear design. The small slits on all sides allow continuous ventilation for effective air quality measurement. Given the cubic shape, it can be positioned without the need for supports, for example on shelves and tables. If necessary, wall mounting is made available from the appropriate slot or from the display that can be branded with your company logo. The AirCare device can connect to the collection server (in the cloud or on an intranet) via WiFi or NB-IoT connectivity. On request it can support LTE-4G, LTE-M, LoRa, LoRa-WAN wireless connectivity. Finally, Aircare has indicator lights on the top of the case. Based on the frequency of illumination and color, they allow you to understand the activity in progress and the general health of the device. Acoustic indicators signal the switching on and off the device.

Main clients: Final Consumer, SME and big companies

Geographical scope of the offer: Europe

The Italian startup offer solutions to track and manage the quality of internal air, in particular monitoring parameters like air quality, environmental comfort, and electro smog. The startup has a wide offer of products and services common for the market standard, but what really set this startup a part is the active role they play during the transformation of the building environment into “Smart”. In fact, what characterized the business offer of the company is that it doesn’t provide just the tools for the improvement of the environment, but among the services provided there is an engaged and continuous commitment, helping and supporting the customers in achieve air quality

certifications. This concept might be extended to many fields of the Smart City and Smart Building, for example in the Traffic Management field, where the most important operations doesn't rely on just data gathering, but as before the actual benefit is drawn when from the data an action is decided, like closing a road or activating alternative routes, here is where startups might have an active role or not supporting this type of decisions. This is exactly what this variable tries to capture, the level of engagement startups offers to its customers. Is important to remark that this dimension is not just about the frequency of interactions between customer and startup, of course it remains an important factor, but the focus is on the nature of the business offer and if it foresees the possibility to establish a shared commitment, pilar of the Smart Cities.

4.2. The matrix classification

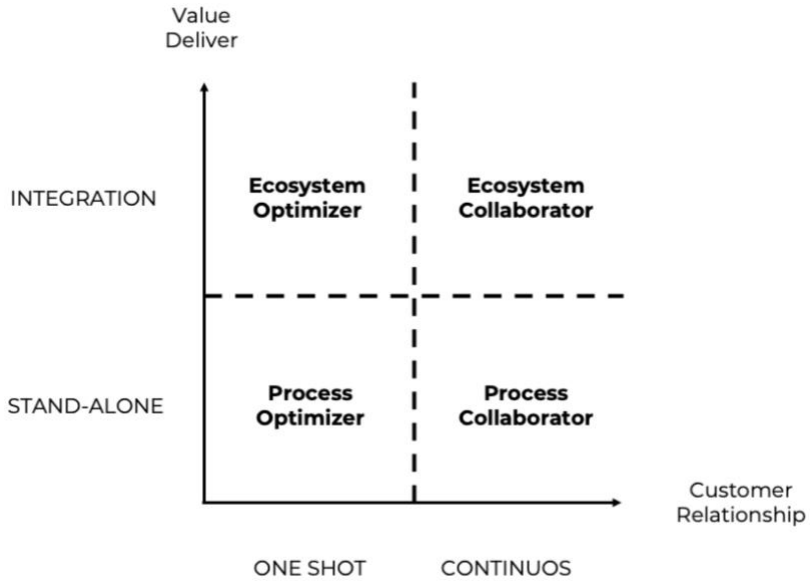

Figure 26: Startup Role Matrix

According to the positioning along the "Customer Relationship "(X axis) and the "Value Deliver "(Y axis) is possible to identify 4 quadrants, in which is possible to allocate the multiple startups, each one of the quadrants identify a profile under which startups with the same characteristics can be frame.

4.2.1. Ecosystem Optimizer

The first quadrant is identified by an Integration + One Shot approach. In this quadrant are present the startups that managed to create a solution that rely and benefit from the integration with other actors, meaning that the product or service can communicate and exchange information with other parts of the system, extracting in this way value for the user. Startups in this category deliver their business solution in a One-Shot way, meaning that their involvement in the application of the smart functionalities provided is low, leaving to the customers, both private and public administrations, the job of implementing the solution. Therefore, Startups limit their operations to the selling phase. An example of this approach is the Italian Startup Nextome.

Nextome

Foundation Year: 2014

Headquarters: Conversano, Italy

Geographic scope of the offer: Italy

Concept Description: Nextome is a leader in indoor positioning. Locate, guide and track users and resources with an easy-to-deploy, ready-to-use interface

Use Case/ Application Area: Smart Building

Web site: https://www.nextome.net

1. Founder

Vincenzo Dentamaro: Founder, President BoD and CTO (Chief Technology Officer); background: Scientific/Technical

Domenico Colucci: Founder & COO (Chief Operating Officer); background: Scientific/Technical

Giangiuseppe Tateo: Founder & Product and platform leader; background: Scientific/Technical

Marco Bicocchi Pichi: Founder & Strategy & Business Development; background: Managerial/Economic

2. Financing

Total Amount Received: 637.000 $

Last Financing Amount Received: 115.000 $

Date of the Last Financing Received: 22 May 2018

Type of the Last Financing Received: Grant

3. Business Model

Value Proposition: The patented technology uses smartphone sensors and low-signal Bluetooth beacons exploited by a physical model and by A.I. algorithms. to achieve remarkable results. In a highly competitive market, the solution stands out for its high accuracy (1-2 meters), great value and a simple installation approach (no fingerprint) that makes the system ready for use almost immediately. In addition to the internal positioning, navigation and asset tracking system, Nextome provides tools to manage the infrastructure and analyze data in real time.

Target Client: B2B

Revenues Model: Product and Service sale

4. Use Case

Use Case: The company is currently testing the system - developed thanks to the co-financing of the European Space Agency - ESA - using the mobile App and the bracelet with doctors and patients within the ASLBari ecosystem and within the COVID unit of the "Ospedali Riuniti" University Hospital of Foggia. In the meantime, data collection is underway for epidemiological and predictive analyzes that will be performed by the IRCCS National Institute for Infectious Diseases "L. Spallanzani ".

Main clients: Final Consumer

Geographical scope of the offer: Italy

4.2.2. Ecosystem Collaborator

Moving forward there is the Ecosystem Collaborator, it is characterized by an Integration approach of the solution and at the same time a Continuous relationship. Unlike its predecessor, these startups are characterized by an active role during the employment of the solution offered establishing strong relationships that carry on during time with customers and users. Often startups play the part of consultant or analysist, in the case of data management, linking multiple parts of complex environments to provide a final solution. The most relevant aspect of this category is the relationship establish with customers, only a continuous interaction guarantees the achievement of the desire result, as shown by the case of Metrikus.

Metrikus

Foundation Year: 2019

Headquarters: London, UK

Geographic scope of the offer: Worldwide

Concept Description: Metrikus is a smart building platform that integrates sensors to create more sustainable, healthy, and productive places to live and work.

Use Case/ Application Area: Smart Building

Web site: https://www.metrikus.io

1. Founder

Juan Quintas: Co-Founder; background: Scientific/Technical

Michael Grant: Co-Founder & COO (Chief Operating Officer); background: Scientific/Technical

2. Financing

Total Amount Received: n.d

Last Financing Amount Received: n.d

Date of the Last Financing Received: 26 November 2020

Type of the Last Financing Received: Series A

3. Business Model

Value Proposition: Metrikus is a single digital platform that connects an entire built environment. The unique software platform that helps users understand and optimize the environment, maintenance, use and health of their buildings. Metrikus connects the building's assets and sensors into a single digital platform and provides real-time information 24/7 on all aspects of the heritage that are relevant. Metrikus helps clients obtain useful information on three key areas, the maintenance of critical assets, the use of space and the health of a building's physical environment as it impacts the people who work there.

Target Client: B2B

Revenues Model: Service sale

4. Use Case

Use Case: By displaying occupancy data in real time, the platform allows you to understand and control how your space is being used. You can highlight how many people there are on each floor or in certain areas, and you can even see which specific desks are occupied or vacant. This can be used to direct employees to underutilize floors or empty desks, ensuring compliance with social distancing regulations. The company has partnered with a major UK bank to optimize the use of their workplace. Based on the number of employees and an estimated maximum occupancy of 71% of the floors, they were asked by HR and FM to sign a new lease worth £ 500,000 to cater to the expanding population of employees. The proposed solution was implemented within a week and real-time capacity monitoring immediately provided an accurate and detailed view of usage within their space. The average usage during the first 10 days of monitoring was only 33%. And even after the stress load with additional employees, the average utilization remained below 44%. Volume control and floor staffing went ahead with real-time alerts to ensure any increases did not violate building regulations. After the monitoring period, it was recommended that employment levels remain between 80-90%, allowing for a 34% increase in staff allocation.

Main clients: Big companies

Geographical scope of the offer: UK

4.2.3. Process Optimizer

Moving back to a Stand-Alone value approach there is the quadrant of the Process Optimizers. These startups offer solutions with a punctual purpose. The implementation of the IoT technologies aim to simplify and optimize current activities performed by the customers, without including other spheres outside the one of competence. From a relationship point of view the interactions between startup and customer are rare, often a final version of the product is the one dealing with the customer needs. In case of apps, startups limit to the management of the platform without interacting with final users. Kairos IoT is an example of this type of startup.

Kairos IoT

Foundation Year: 2017

Headquarters: Atlanta, United States of America

Geographic scope of the offer: United States of America

Concept Description: Kairos has created a patented system of wireless technology for detecting leaks and measuring water inside buildings, designed for the protection of resources and saving water.

Use Case/ Application Area: Smart Building

Web site: https://www.kairoswater.io

1. Founder

Dean Fung-A-Wing: Co-Founder & CEO (Chief Executive Officer); background: Scientifico/Tecnico

Seth Taylor Co-Founder & CTO (Chief Technology Officer); background: Scientifico/Tecnico/Manageriale

2. Financing

Total Amount Received: 3.100.000 $

Last Financing Amount Received: 2.300.000 $

Date of the Last Financing Received: 1 November 2020

Type of the Last Financing Received: Seed Round

3. Business Model

Value Proposition: Manufacture of cloud-connected water meters and smart sensors that produce critical data to help commercial and residential property owners prevent billions of damages from water leaks. The system created also allows for better conservation and management of water in general. By analyzing connected meters and sensors, machine learning can be used to better guide customers in how they use water on a daily basis. The technology used is wireless and wireless with the ability to process critical data even without an Internet connection.

Target Client: B2C & B2B

Revenues Model: Product sale

4. Use Case

Use Case: Through the application of these smart technologies, property and asset managers are able to achieve new levels of value through an increase in the Net Operating Income (NOI) due to the protection provided by smart water systems. Traditionally, accidents related to water loss and damage have been a huge threat to the US of properties. Now with Kairos' multifunctional leak sensor, the Gateway in partnership with LoRa leak sensors at the heart of these systems, managers can realize the threat long before accidents can wreak havoc on a property's value, this application will allow Multi-family property managers to increase the US of the property.

Main clients: Final Consumer

Geographical scope of the offer: United State of America

4.2.4. Process Collaborator

The final quadrant is the one of the Process Collaborator, these types of Startups offer solutions that have a Stand-Alone value. Nevertheless, they manage to establish a collaborative and continuous relationship with customer, offering additional products or service that increment the value of the final offer. For example, The Littery is an European startup in the Waste Management field, the company offer an innovative approach to waste collection involving not only smart technologies but its own effort trying to involve people to achieve its final goal.

The Littery

Foundation Year: 2019

Headquarters: Riga, Latvia

Geographic scope of the offer: Europe

Concept Description: The Lottery is an environmental services company that recycles plastic pollution into electronic lottery tickets.

Use Case/ Application Area: Smart City

Web site: https://www.thelittery.com

1. Founder

Michael Manniche: Founder & CEO (Chief Executive Officer); background: Managerial

2. Financing

Total Amount Received: 140.000 $

Last Financing Amount Received: 140.000 $

Date of the Last Financing Received: 16 April 2019

Type of the Last Financing Received: Pre Seed Round

3. Business Model

Value Proposition: The Littery offers cities a unique and disruptive solution to fight waste, plastic pollution and CO2 emissions with smart solar powered bins and a cash prize lottery concept that incentivizes citizens to keep their cities clean on their own using a business model that does not require any CAPEX from the cities themselves as it is provided as a waste removal service by tapping into the existing Opex spent on the multibillion dollar industry for waste removal. Today's Opex is spent on services that clean up the areas used by citizens, or treat "symptoms", while with the new business model, Opex will finance the technology and the concept of The Littery, motivating citizens to keep clean their city alone, curing "the disease". The solution uses only technology, but uses humans, reformulating waste and recyclable materials as "electronic lottery tickets" causing an instant change in behavior by tapping into the innate bias of human optimism.

Target Client: Public Administration

Revenues Model: App service

4. Use Case

Use Case: The technology was tested in a relevant environment (TRL 6) and a strong consortium was formed to carry out pilot projects in the city of Bristol (UK) and 4 French cities, Paris, Issy-les-Moulineaux, Romainville and Boissy-Saint -Léger. The aim of the pilot projects is to complete the product and demonstrate that the concept can actually revolutionize the global waste removal industry. As soon as the test results of the pilot projects have been validated, implementation plans will be launched according to agreements with the pilot cities and from there, together with strategic partners and investors, SUEZ, ENVAC and CITEO, the collaboration to design tenders will continue. future in order to present them in a highly competitive environment to cities in the EU and around the world. In 5 years, it aims to reach 50 cities and 25 million end users, reduce CO2 emissions by 2 million tons, reduce waste by> 90% and reduce waste removal costs by 25-35%. Achieving these KPIs will result in 1,600 new hires and € 1 billion in turnover.

Main clients: Final Consumer, Public Administration

Geographical scope of the offer: Europe

4.3. Database Classification

The final step, after the framework was created, is to classify the multiple startups present on the database according to the two dimensions and to position them inside the matrix. The results are shown on Figure 27.

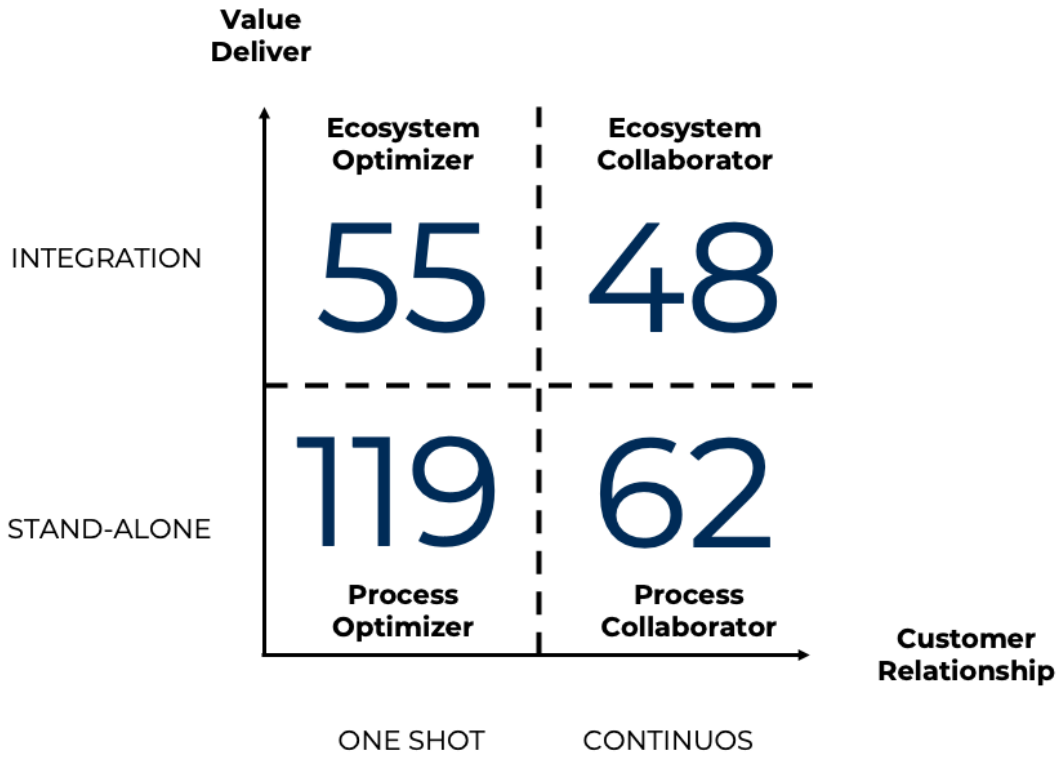

Figure 27: Database Classification according to the Startup Role Matrix

The Startup present a strong tendency to operate as Process Optimizers. More than 40% of the companies mapped can be allocated in this quadrant. As explain until now and as proven by the examples provided, this type of solution is the most common on the market, it is the typically approach of startups that sell product and services that aim to collect data for insights, like in the case of energy consumption management or environmental monitoring. Following closely there are the quadrants of Ecosystem Optimizer and Process Collaborator with respectively 19% and 22% of the total population of the database. These types of solution require more effort to be put in action, and for each case the focus shift from the product to the customer. Consequently, different features will characterize the different startups, like for example stronger front office in the case of Process Collaborator since the relationship and the interactions with customer are higher. Finally at the last place with just 16% of the population there is the Ecosystem Collaborator quadrant. Undoubtedly,

the most complex of the solution where a mix of strong focus on product and customer is employed. This last consideration is also the reason behind the distribution of the startups along the quadrants. In Figure 28 the direction of the solution's complexity is shown.

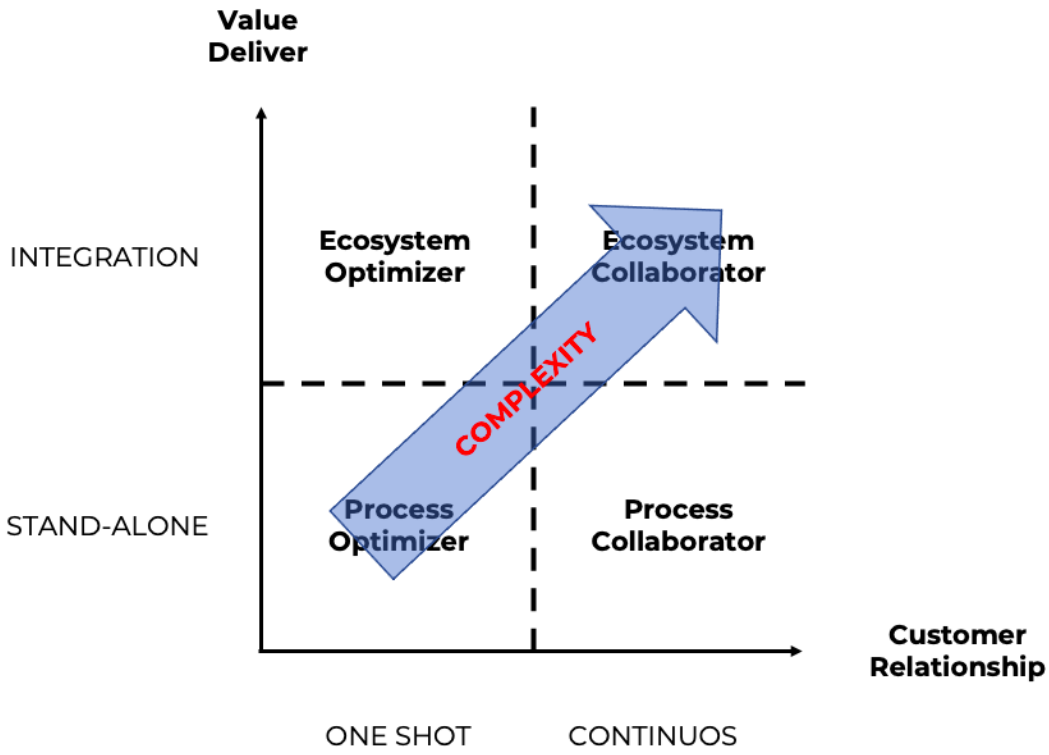

Figure 28: Solution's complexity direction inside the Matrix

Starting from the Process Optimizer and ending up in Ecosystem Collaborator, the solution's complexity tends to increase, as the factors in play became more and more. The efforts required to the startups grows as they are called to answer to more complex environments due to, in the case of the product, the dealing with external players, and, in the case of the customer, the more attention and communication required. Each solution aims and deal problems in different ways, it is true that in some cases the two approaches might overlap, and one could be considered an evolution of the other, like in the case of movement along the same dimensions of the matrix, for example from Process Optimizer to Process Collaborator. Nevertheless, is hard to say than one methodology is better than the other and the final decision on how to operate remains up to the startups busines strategy.

5. Conclusion

This final chapter concludes the thesis work retracing the main steps that allow to give an answer to the two research questions. Key findings are highlighted, and the main results obtain with the framework application are presented.

The initial purpose of this research was to depict the current state of art of Startups within the fields of Smart City and Smart Building, and at the same time to frame their role inside the smart transformation process enabled by IoT technologies implementation. The starting point of the study was the census of startups carry out through secondary sources analysis. Different startups at a worldwide level where reviewed, establishing from each one of them if they met the parameters and requirements to be part of the work. Quantitative and qualitative data regarding financing received and business operations was collected and frame under different clusters of information, creating in this way the final database that stood at the foundation of the analysis. 284 startups were the final number of companies that took part in the research.

Among the many results obtained some might appear more interesting and noteworthy than others, one of this is the strong effort APAC countries are putting in the development of Smart Cities and Smart Buildings. In fact, even though the number of startups mapped in this region are by far lower than the ones in the European continent, it came up that in the last 3 years is the Asian Continent the one placed at second by Total Financing Received behind the North America. Clearly this last one area was monopolized by the United State of America, the country managed to host the greatest number of companies and at the same time to collect the major amount of funding as expected. The research work doesn't stop just at numeric findings, but it managed to capture multiple trends inside the industry that were the result of external factors. Among the most relevant there are the effects of the COVID 19 pandemic and the environmental crisis the world has been dealing with in the recent years. These two important phenomena radically impact the nature of startups, especially their value proposition and main purposes. As proven by the increase in Infotainment & Tourist Services solution as response of public administrators and private actors against the hard hit the pandemic took on urban economies. In parallel action to fight environmental crisis is seen in the evolution of the Mobility sectors, both in terms of Private and Public Transport but at the same time in Traffic and Parking management. Innovative solutions as green mobility and

riding sharing took the lead aiming to reduce the total number of fuel vehicles circulating in the cities. For Smart Building the most remarkable result was the strong presence of Scenario Management solutions, this is the consequence of the birth of complex environments that need to be managed due to the multiple technologies employed. Energy Consumption Management remains relevant in this field, startups are offering more and more efficient products and services aiming at cost reduction within building expenses.

Two interesting results related to the more internal and operational side of startups are: on one hand the predominant B2B approach, startups offer solutions aimed to create sustainable, efficient, and innovative environment for users and citizens. Nevertheless, these are often not directly delivered to final customers, instead benefits are harvest only thanks to the implementation by public administrations and private actors of the smart solutions. On the other hand, the offer proposed by startups are characterized by combination of multiple parts, that can be hardware, software, or service. This being the result of common practices of late companies to provide complete packages of solution to its customers.

The framework created for the research aimed at classifying Startups, that strongly differ in characteristic and features, under common criteria. For this reason, the framework operates at a macro level focusing on Startups' business offer in terms of value deliver and customer relationship. For the first dimension, the distinction made is between Stand Alone and Integration, the main goal is to understand how solutions manage to deliver value for the final users, either by working alone or by being part of existing systems of objects. The customer relationship variable aims at understanding at how startups relate to its customers, either by One Shot processes that stop for example at the selling phase leaving the user alone for the implementation or by Continuous Relationship where companies help users along the smart transformation path.

The possible combination of the approaches, identify by the two dimensions, leads to the creation of a matrix with 4 quadrants, where is possible to allocate the different startups according to its features. The result is the grouping of startups with common characteristic, identifying in this way the possible roles that can be played within the industry, being the four possibilities: Process Optimizer, Process Collaborator, Ecosystem Optimizer and Ecosystem Collaborator. An important characteristic of the matrix is that the complexity of the solutions proposed increased moving along the main diagonal of the matrix, explaining in this way why the greatest number of companies is positioned in the lower left quadrant, the one of the Process Optimizer.

In conclusion this research paper can be useful for different actors of the industry. On one side to future or already existing startups, that are trying to understand how to enter the industry and which role can they play, comprehending which are the main characteristics they need to have in order to perform in a certain sector. Furthermore, thanks to the multiple case studies proposed startups can grasp a first insight on what are the common technologies and approaches in their operating field, establishing what could be for them market qualifiers. On the other side, investor can understand which are the most profitable sectors of the industry and possess a tool to better evaluate the startup of their interest.

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