EVOTION

727521 – EVOTION

DELIVERABLE No: D8.4

First Market Analysis and Exploitation Report

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Dissemination level	
PU	PU Public

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727521.

Project acronym and grant agreement number	EVOTION- 727521
Project full title	Evidenced based management of hearing impairments: Public health policy making based on fusing big data analytics and simulation
Project type	RIA
Start date – end date	1 November 2016 – 31 October 2019
Website	www.h2020evotion.eu
Deliverable type	Report (R)
Delivery date	M12 (31 OCT 2017)
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To be cited as	Laplante-Lévesque A, Dimakopoulos N, Papagrigoriou P, Gutenberg J, Brdarić D, Sifniadis P. (EMP). (2017). First Market Analysis and Exploitation Report, Deliverable D.8.4 to the EVOTION-727521 Project funded by the European Union, Oticon A/S, Denmark.
Subject and keywords	Market analysis; exploitation plan; value network analysis; hearing devices; healthcare; health technology; big data analytics; security systems
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List of Abbreviations and Acronyms

BAN	Body Area Networks
BASN	Body Area Sensor Networks
BDVA	Big Data Value Association
CAGR	Compound Annual Growth Rate
DWaaS	Data warehouse as a service
e.g.	exempli gratia: “for example”
EIS	Enterprise information systems
etc.	Et Cetera
i.e	id est: “that is”
IDC	International Data Corporation
IEEE	Institute of Electrical and Electronics Engineers
IoT	Internet of Things
IT	Information technology
OtC	Over-the-counter
PaaS	Platform as a service
PSAP	Personal sound amplification product
RPM	Remote patient monitoring
USD	US Dollar
VAR	Value Added Retailers
WAN	Wide area network
WHO	World Health Organization
WSN	Wireless Sensor Networks

1. Executive Summary

EVOTION is a research project funded by the European Commission that collects and analyses large datasets to transform public policies regarding hearing health. This public report targets the commercial exploitation of outcomes that EVOTION will generate. An obvious EVOTION outcome is a public health policy decision-making tool. Such an outcome would combine several features, products, and services in a new commercial landscape. Therefore as a first step we felt necessary to divide the commercial landscape into three areas of relevance for EVOTION. This document analyses the commercial landscape for three outcomes that relate to EVOTION: 1) hearing devices and hearables (i.e., ear-level device with wireless link, for audio augmentation and/or remote control of audio augmentation), 2) big data analysis platforms, and 3) security systems for body area sensor networks. For each commercial outcome, we present an analysis of the market and of the competitive environment (customers, value proposition, market size, market growth rate, and industry cost).

More specifically, this report uses two widely trialled and tested methods to describe the three markets and the potential positioning of EVOTION's commercial outcomes within their respective competitive landscapes. Firstly, we describe each of the three markets according to the eight dimensions of a market analysis as defined by Aaker and McLoughlin (2010). Secondly, we describe each of the three markets from a systems perspective according to the stakeholder value network as defined by Peppard and Rylander (2006). This first evaluation of the potential market impact of EVOTION points to four main conclusions:

1. Growth is expected in the markets relevant to the three commercial outcomes: 1) hearing devices and hearables, 2) big data analysis platforms, and 3) security systems for body area sensor networks. The market for hearing devices is more mature but disruption could occur within hearables and new service delivery models. The markets of big data analysis platforms and security systems for body area sensor networks are more recent and expect stronger growth.
2. Whilst several medical applications were noted, some applications outside of the medical domain were also identified, e.g. industry for hearables and banking and business intelligence for big data analysis platforms.
3. The three commercial outcomes are related: together, the three commercial outcomes could lead to decision making tools and decision support for public health policy and hearing care as well as better performing hearing devices. The three commercial outcomes could form a very interesting combination of wearable device, secure data transfer and storage, and big data analysis to inform health prevention, early diagnosis, and monitoring.

4. For all commercial outcomes, stakeholders include patients, hospitals, and third-party payers such as Ministries of Health. Therefore, public finances and public policies will have an impact on future market size.

We will continue this public reporting twice, at yearly intervals. The subsequent market analysis and exploitation reports will cover the convergence of the three markets. Furthermore, they will analyse any additional commercial outcomes, if deemed relevant based on the new market information available. The work leading to this report also collects insights to be included in the confidential Intellectual property rights plan for EVOTION (Deliverable 8.7, due October 2019). This supports an agile mind-set that positions EVOTION's maturing commercial outcomes in the best competitive position in response to ongoing market changes.

2. Introduction

2.1 Overview

EVOTION is a research project funded by the European Commission that collects and analyses large datasets to transform public policies regarding hearing health. You can find more information about the project on the EVOTION website: http://h2020evotion.eu EVOTION wishes to reach optimal impact and to real-world changes. Therefore, dissemination to professional and lay audiences as well as plans for commercial exploitation are part of EVOTION's activities. This public report focuses on the commercial exploitation of the EVOTION results, components, and overall computer systems. An obvious EVOTION outcome is a public health policy decision making tool. Such an outcome would combine several features, products, and services in a new commercial landscape. Therefore as a first step we felt necessary to divide the commercial landscape into three areas of relevance for EVOTION. More specifically, this report summarises the market potential, the target end-users, and the potential competitors for three commercial outcomes that EVOTION could lead to: 1) hearing devices and hearables, 2) big data analysis platforms, and 3) security systems for body area sensor networks. This is the first of three reports targeting commercial exploitation of EVOTION outcomes. The two other reports will be published at yearly intervals (October 2018 and October 2019).

2.2 Purpose and Scope of Market Analysis and Exploitation Report

This public report aims to support the launch of commercial exploitation activities resulting from the research project EVOTION. The report's main target group is the EVOTION consortium partners. By describing the current market forces, it aims to position EVOTION's outcomes in growth submarkets to secure commercial success. This report focuses on three commercial outcomes: 1) hearing devices and hearables, 2) big data analysis platforms, and 3) security systems for body area sensor networks (BASNs). These three outcomes are related: multiple sensors connected securely through BASNs would collect the accurate data required for big data analyses that can inform decision support systems and hearing devices that lead to greater user benefits. This report presents a separate market analysis and value network analysis for each of the three commercial outcomes. We see **EVOTION as a combination of these three commercial outcomes**. We are aware that future interesting **commercial solutions arising from EVOTION could be a combination of two or three of the commercial outcomes**. We are also aware that specific tools and components of these three commercial outcomes could be exploited independently. Figure 2-1 depicts as a Venn diagram the three commercial outcomes and their overlapping application areas. The subsequent market analysis and exploitation reports will shed a light on the overlapping application areas and will analyse the relative attractiveness of their markets.

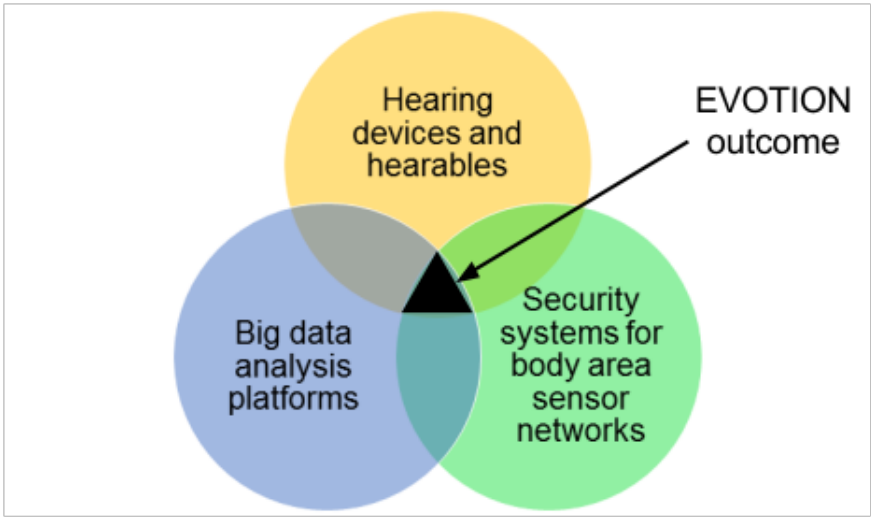

Figure 2-1 The three EVOTION commercial outcomes for which this report presents a market analysis and value network analysis.

These three outcomes were chosen as they are outputs of the EVOTION project, but also because they are close to the current activities of the three industrial partners in the project, respectively: 1) Oticon, a hearing device manufacturer, part of William Demant Holding, 2) Athens Technology Centre, an information technology and software development small and medium-sized enterprise, and 3) Empelor, an information technology and software development small and medium-sized enterprise. These three industrial partners led the analytic work that this report presents. Table 2-1 summarises the links between the industrial partners' current commercial activities, the EVOTION commercial outcome, and added value to current activities.

Industrial partner and country of incorporation	**Type of partner**	**Sector of partner's current commercial activities**	**EVOTION commercial outcome**	**Added value of EVOTION commercial outcome to current activities**
Oticon, Denmark	Industry with 13,000 employees, founded in 1904	Manufacturing and retail of hearing devices and related products and services	Hearing devices and hearables	Personalised hearing devices and hearables through big data and monitoring of hearing and hearing device performance over time in the user's environment

Athens Technology Centre, Greece	Small and medium-sized enterprise with 70 employees, founded in 1987	Information technology and software development with focus on research and development	Big data analysis platforms	System solution for collection, storage, and analysis of data for decision support within health and public policies
Empelor, Switzerland	Small and medium-sized enterprise with 9 employees, founded in 2011	Information technology and software development with focus on safe mobile communication devices	Security systems for body area sensor networks	Privacy-preserving communication protocols between body area sensor networks and Internet of Things (IoT) devices that support medical care

Table 2-1 Summary of links between the industrial partners' current commercial activities, the EVOTION commercial outcome, and added value to current activities.

2.3 Structure of this Document

This report starts with a description of the two methods used: Aaker and McLoughlin's market analysis and its eight dimensions as well as Peppard and Rylander's value network analysis and its four steps. We chose these two methods for two reasons. Firstly, they have been commonly used to describe potential markets in the past. Secondly, they provided a useful structure that we could follow for all three commercial outcomes, making the results of the market analysis more easily comparable across commercial outcomes.

We performed these analyses for three commercial outcomes that EVOTION could lead to: 1) hearing devices and hearables, 2) big data analysis platforms, and 3) security systems for body area sensor networks. Whenever possible, we provide references to both scientific literature and grey literature. Finally, this report concludes with pointers for future work.

3. Introduction to Market and Value Network Analyses

3.1 Introduction to Aaker and McLoughlin's Market Analysis

An analysis of a market describes its submarkets and its dynamics. A market analysis helps determine the relative attractiveness of a specific market, now and in the future. Determining the likelihood of a market to generate profit in the future is central to investment decisions. By understanding the dynamics at play, a market analysis also helps actors adopt favourable positions compared to competitors. Most markets are constantly undergoing change and therefore each product or service supplier must constantly defend their brand relevance. Therefore, market analyses present a market as it is today, but also relevant trends and forecasts for the future state of the market. Aaker and McLoughlin (2010) describe eight dimensions to a market analysis: We depict those in Figure 3-1 and we describe them below.

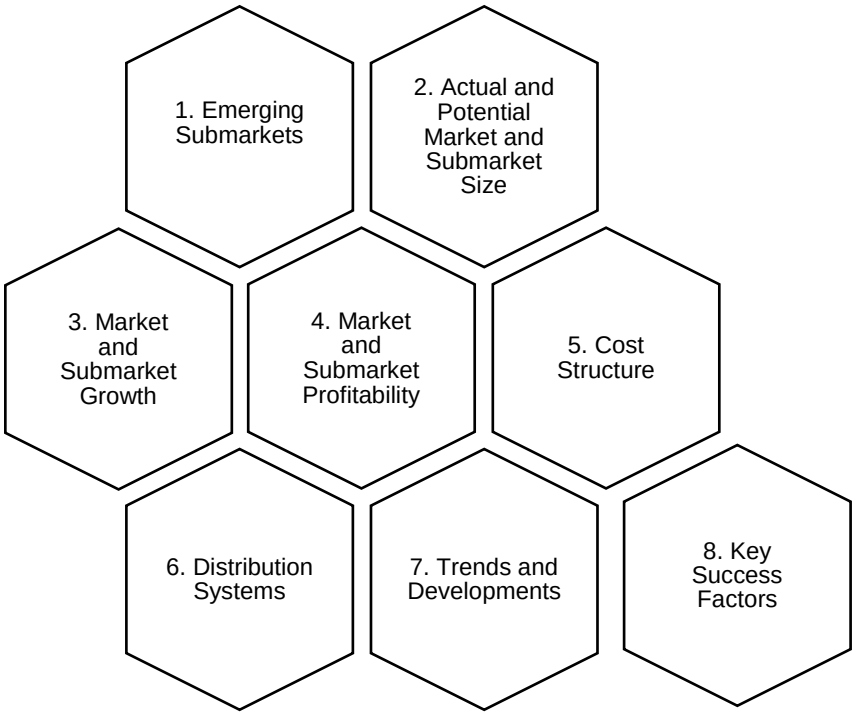

Figure 3-1 The eight dimensions of a market analysis according to Aaker and McLoughlin.

The eight market analysis dimensions after Aaker and McLoughlin (2010):

1. **Emerging Submarkets:** This involves detecting and understanding parts of the market that are attractive. Submarkets that are emerging usually have one or many of the following characteristics: they provide a lower price point (e.g. budget grocery stores), serve people who were previously non-users (e.g. bike rental schemes in cities), integrate components to provide systems solutions (e.g home cinema systems), serve previously unmet needs (e.g. website that aggregates air ticket costs), respond to a customer trend (e.g. customised running shoes), and leverage a new technology (e.g. smartphones with touchscreen).
2. **Actual and Potential Market and Submarket Size:** This involves the size of total sales, both now and in the future. Sources for this information include financial analyses from competitors, trade associations, and investors as well as government data.
3. **Market and Submarket Growth:** This involves describing the expected size over time of the different submarkets, and the speed at which they will expand or contract. Companies need to understand the driving forces behind sales trends to derive the expected growth.
4. **Market and Submarket Profitability:** This involves considering the likelihood to generate revenue (the difference between sales price and production costs) in the different submarkets. Awareness of competitors, including threats from incumbents but also potential entrants and substitute products and services, is central. The relative bargaining power of suppliers and customers also affects profitability.
5. **Cost Structure:** This involves knowing the different production costs (including labour costs) and depreciation costs expected to formulate strategies that develop a competitive advantage.
6. **Distribution Systems:** This involves the current distribution channels used to market the products and services as well as alternative distribution channels and how they are developing.
7. **Trends and Developments:** This involves being aware of trends relevant to the market and how they impact the market. Trends can be technological advances (e.g. batteries making the range of electric cars much more interesting to customers and therefore opening a new submarket), consumer trends (e.g. skincare products now designed for women as well as men), and government and economic trends (e.g. change in regulation or jurisdiction that affects a submarket such as over-the-counter pharmaceuticals).
8. **Key Success Factors:** This involves knowing the key success factors, assets, and competencies required to succeed over the competition in the market. This also involves knowing how they will interplay in the future, and which strategies should be deployed to neutralise the assets and competencies of competitors.

This deliverable follows Aaker and McLoughlin (2010)'s eight dimensions of a market analysis as it provides a useful and holistic view of the market both in the present and in the future. It calls for verifiable facts whenever possible, to avoid bias. However, Aaker and McLoughlin's descriptive method takes a rather fragmented approach to a market and its actors. Therefore, we have supplemented our market analysis with Peppard and Rylander (2006)'s value network analysis, which is an interesting alternative to value chain analysis as it visualises stakeholders and their interactions within competitive ecosystems.

3.2 Introduction to Peppard and Rylander's Value Network Analysis

As a complement to the market analysis, the value network analysis visualises the stakeholders and the tangible and intangible value exchanges between them (Peppard and Rylander, 2006). Feng and colleagues (2010) propose four steps to the Value Network Analysis, which we depict in Figure 3-2 (Feng et al, 2010) and summarise below.

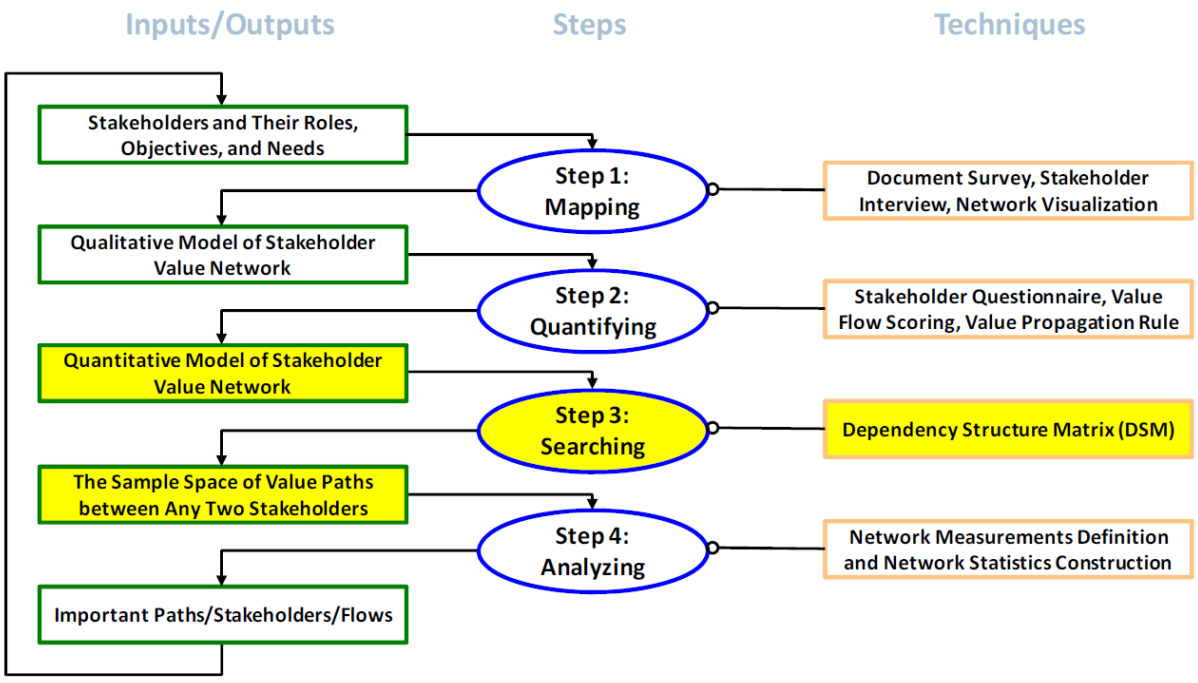

Figure 3-2 The four steps of a Value Network Analysis.

The four steps of a Value Network Analysis after Feng et al. (2010):

1. **Mapping:** This involves identifying stakeholders and their roles, objectives, and needs from documents/interviews. This also maps each stakeholder according to their specific needs as value flows (e.g. directed value exchanges).
2. **Quantifying:** This involves scoring value flows with the perceived utility of the recipient stakeholder and define the value propagation rule.
3. **Searching:** This involves building a quantitative model of the Stakeholder Value Network, to search for all value paths between any two stakeholders.
4. **Analysing:** This involves defining network measurements and construct network statistics. Focus on the value paths beginning from and ending with the same stakeholder as the sample space to study the implications for that stakeholder.

This deliverable focuses on Step 1 of the Value Network Analysis and maps the stakeholders and their roles, objectives, and needs. We could not complete Steps 2-4 of the Value Network Analysis in this deliverable as there was a lack of reliable data regarding the value flow between stakeholders to support the quantification/scoring required for Steps 2-4. We will attempt those in the subsequent market analysis and exploitation reports of this work package. If a lack of data is still preventing us from completing Steps 2-4 at that stage, we will propose an alternative method to describe value exchanges between stakeholders.

The next section describes the market and value network analyses for the commercial outcome *Hearing devices and hearables*.

4. Hearing Devices and Hearables

4.1 Introduction to the Market

Hearing impairment is very prevalent: 360 million people have a disabling hearing impairment, which represents over 5 percent (%) of the world's population (WHO, 2012). Of those, 32 million are children. However, hearing impairment is especially prevalent in older adults: approximately one-third of people over 65 years of age have a disabling hearing impairment (WHO, 2017). Amongst adults, the main causes of hearing impairment include ageing, exposure to excessive noise, and use of particular drugs. In the majority of cases, surgery or drugs cannot cure hearing impairment. The main treatment for permanent hearing impairment is the use of hearing devices such as hearing aids and cochlear implants (Laplante-Lévesque et al, 2010). From large trumpets in the beginning of the 19th century to small, Internet of Things devices (IoT) that connect wirelessly to other internet-enabled devices, hearing devices have been at the forefront of miniaturisation and digitalisation (Mills, 2011). Still today, the design, engineering, and innovation of hearing devices frequently receive recognition such as CES awards, Red Dot awards, Edison awards, and European Inventor awards (Hearing Industries Association, 2017). The following section describes the market of hearing devices and hearables. The EVOTION deliverable 2.1 *EVOTION stakeholders, scenarios and requirements* completed earlier this year (2017) summarised the state-of-the-art in hearing aid technologies with an overview of hearing aid signal processing, eHealth, IoT, and hearables (i.e., ear-level device with wireless link, for audio augmentation and/or remote control of audio augmentation: Hunn, 2016). The following section is complimentary as it outlines the market consequences of these trends within hearing aid and hearable technologies.

The multi-billion Euro hearing device market in Europe has the following three characteristics:

1. **Limited use of hearing devices:** Most people who could benefit from hearing devices do not use them. Hearing aids have low market penetration, with only 3-15% of people with hearing impairment who could benefit from hearing aids owning them (Godinho, 2015). Barriers to adoption include lack of awareness of own hearing difficulties, poor access to care, and suboptimal quality of care (Laplante-Lévesque et al., 2011). Furthermore, social stigma turns people away from hearing devices. Whilst hearing impairment is invisible, hearing devices make the condition visible - and hearing impairment is a stigmatising condition (Wallhagen, 2009). Not all Europeans have access to free or subsidised hearing devices. Yet in Europe, subsidy for hearing devices does not explain all variance from country to country in hearing aid adoption rates (Godinho, 2015).
2. **Demographic changes:** The market is set to increase in size due to demographic trends. Life expectancy is increasing rapidly (WHO, 2015) and approximately one-third of people over 65 years

of age have a disabling hearing impairment (WHO, 2017). These demographic trends result in an increasing prevalence of people with hearing impairment, both in Europe and worldwide. This increase in the prevalence of hearing impairment is especially noticeable in low- and middle-income countries, such as in South Asia, in the Asia Pacific region, and in sub-Saharan Africa, where the prevalence of hearing impairment in higher than in other world regions (WHO, 2017).

3. **Evolving distribution channels:** Historically, hearing devices have been medical devices that trained hearing care professionals prescribed and dispensed. In Europe, third parties such as governments and insurers typically contribute to the cost of most hearing devices, in either full or in part (EHIMA, 2010). However, deregulation, competition, and ubiquity of consumer electronics are seeing new models of service delivery emerge. The new modes of service delivery propose to provide hearing devices directly to the consumer. This trend is especially prevalent in North America and in Australia but is also influencing the European market. Table 4-1 compares the main characteristics of traditional hearing aids, over-the-counter (OtC) hearing aids, personal sound amplification products (PSAPs), and apps that provide amplification (Manchaiah et al., 2017). Recently, several researchers have attempted comparisons of the benefits of hearing aids versus alternative hearing devices. For example, a study found hearing aids superior to PSPAs for speech intelligibility and sound quality (Rønne and Rossing, 2016), whilst another study found that many PSAPs provided similar improvements to those of hearing aids (Reed et al., 2017). Hearing aids were recently shown to be efficacious both when delivered through a qualified hearing professional and when delivered over the counter (Humes et al., 2017). Experts have also described apps that provide amplification as a good temporary/starter solution for people with hearing impairment before they adopt hearing aids (Amlani et al., 2014).

	Traditional hearing aids	OTC hearing aids/ direct-mail hearing aids	PSAPs	Smartphone-based amplification apps
Regulated under FDA	Yes	Yes	No	No
Professional consultation needed	Yes	No	No	No
Average price range per device (in US $)	1,000–5,000	200–500	20–400	0–10
Intended target group	PHL	PHL	PNH	PNH
Intended user	PHL	PHL	PNH	PHL and PNH
Typical consumer image	Stigmatizing	Stigmatizing	Stigmatizing to mass appeal	Mass appeal

Abbreviations: OTC, over-the-counter; PSAPs, personal sound amplification products; FDA, US Food and Drug Administration; PHL, person with hearing loss; PNH, person with normal hearing.

Table 4-1 Comparisons of hearing aids, over-the-counter (OtC) hearing aids, personal sound amplification products (PSAPs), and apps that provide amplification.

4.2 Overview of Competitor Products and Services

Mergers and acquisitions in the market have led to six companies dominating with 98% the hearing aid sector worldwide. Smaller competitors share the other 2%. Figure 4-1 presents the six hearing aid manufacturers according to the size of their 2012 global market share (taken from a report from the research company Bernstein), together with their country of incorporation and some of their hearing device brands, where relevant.

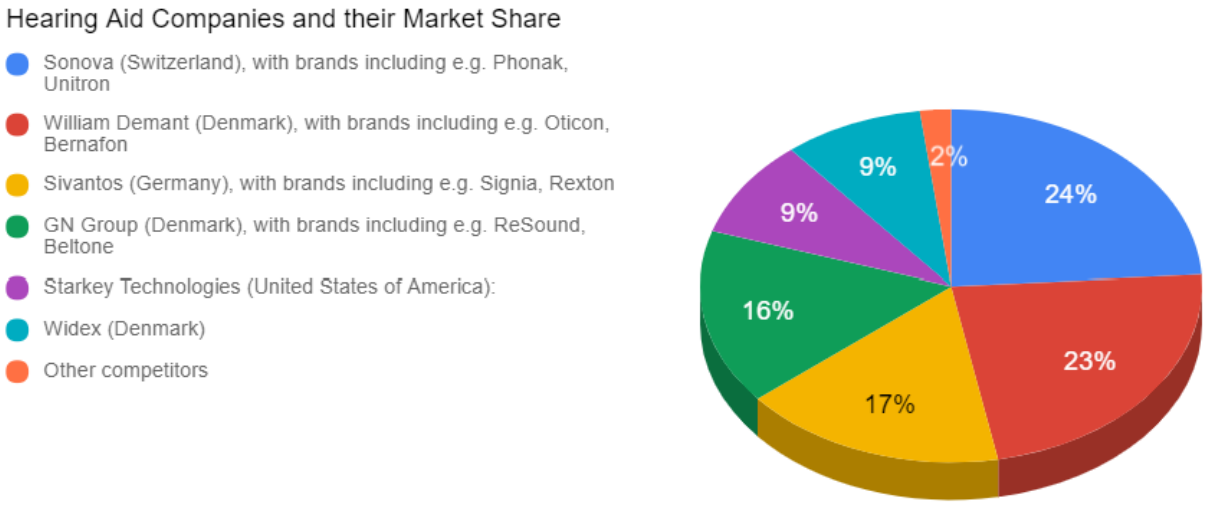

Figure 4-1 Six largest hearing aid manufacturers and their respective market share.

These six hearing aid manufacturers have expanded into the hearing aid retail area, buying independent hearing clinics as well as hearing clinic chains worldwide, including in Europe. The last years have seen considerable consolidation within retail. Figure 4-2 depicts the six largest hearing aid manufacturers and their associated brands and flagship retail chains (Hearing Tracker, 2017).

Figure 4-2 Six largest hearing aid manufacturers and their associated brands and retail activities.

Beyond hearing aids, other devices such as hearing implants (medical device partly or completely implanted in the auditory system of the person with hearing impairment) and hearables (ear-level consumer electronics with wireless link) are promising to take an increasing part of the market of wearable technologies for people with hearing impairment.

4.3 Emerging Submarkets

Some parts of the hearing device industry show promise to grow rapidly: these include hearing implants and hearables. Hearing implants, which started in the 1970s as a niche product for people with a profound hearing impairment who could not benefit from hearing devices, are increasingly performant. Therefore, they are increasingly recommended to both children and adults with less profound degrees of hearing impairment than before (Vickers, De Raeve and Graham, 2016). Four competitive players dominate the hearing implant market: Cochlear, Advanced Bionics (part of Sonova), MED EL, and Oticon Medical (part of William Demant Holding). This includes implants that stimulate the auditory system directly through both vibrations or electric impulses.

Emerging functionalities in the form of the wearable device allow their users to collect, track over time, visualise, and export data such as their pulse, their sleep, their physical activity, etc. Through a Bluetooth connection, wearables communicate wirelessly with other devices such as mobile phones and computers.

Hearables are ear-level wearables. Hargrave, (2017) showcased in the Guardian the likely features of hearables which, beyond improving hearing, include tracking health and fitness around the clock through biometric sensors, translating languages and supporting voice-activated personal assistants. The ear is an interesting location for sensing physiological parameters (Da He et al., 2010). Bragi (in collaboration with Stakey), Doppler Labs, Jabra (in collaboration with GN Group), Waverly Labs are only a few of the companies bringing hearables to the market. Larger companies such as Intel, Oakley, Samsung, and Sony have recently added hearables to their product portfolio. Figure 4-3 presents the features that hearables can support (Hunn, 2016). Beyond the amplification that hearing devices provide, hearables can support for example protection against noise-induced hearing loss, monitoring of vital signs through ear-level sensors for health, sports, and wellness, and voice control of IoT devices through automated speech recognition at the level of the ear.

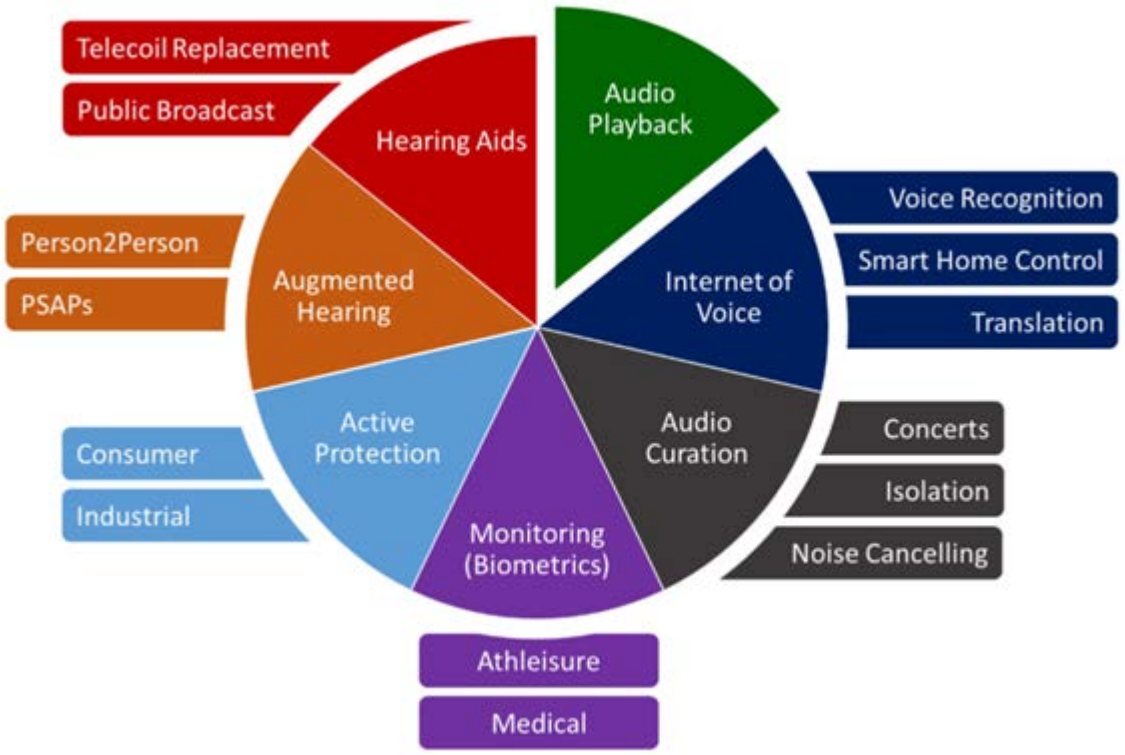

Figure 4-3 Market segments for hearables based on features.

Beyond hardware, some companies are proposing apps that provide personalised sound amplification. This includes EarMachine, Jacoti (collaboration with MED EL), and Listen. Whilst some of these apps offer sophisticated hearing tests and customisation of the amplification, they currently require its user to wear a standard headset to send the amplified sound to the ear. This is a limitation if an app is to be used in

conversations in social situations, as it is socially awkward to wear standard headsets during social interactions. The latency measured in less intrusive Bluetooth headsets such as the Apple AirPods make them currently unsuitable for live listening in conversations (Einhorn, 2017).

4.4 Actual and Potential Market and Submarket Size

Approximately 3 million hearing aids are sold globally every year. Hearing aids represent a 4 billion USD market value in 2015, whilst the cochlear implant market was valued at 1.4 billion USD in the same year (William Demant Holding, 2016). Another source valued the global hearing device market at 4.5 billion USD and the global cochlear implant market at USD 1.1 billion in 2015 (Grand View Research, 2017). Most hearing aids are sold in high-income countries: 41% of hearing aids are sold in Europe and 29% are sold in North America (William Demant Holding, 2013).

According to a report from ABI Research (2017), 600,000 hearables were sold globally in 2017. Hearables have an average retail price of 125-275 euros (Hunn, 2016).

4.5 Market and Submarket Growth

Table 4-2 shows how growth is expected in the market of hearing devices and hearables.

	Market size (wholesale value) as of 2015	Expected market growth (compound annual growth rate)
Hearing aids	4 billion USD	1-3%
Cochlear implants	1.4 billion USD	10-12%
Bone-anchored hearing implants	170 million USD	10-15%
Hearables	Unknown	10-100%

Table 4-2 Expected in the market of hearing devices and hearables.

Also, it displays the market size and expected market growth for hearing devices, cochlear implants, and middle ear implants (period 2015-2020) as well as hearables (period varies by the source but within 2016-2023) (William Demant Holding, 2016; International Data Corporation, 2017; MarketsandMarkets, 2016).

The compound annual growth rate is expected to be around 1-3% in the period 2015-2020; another source forecasted a compound annual growth rate of 5.1% during the period 2017-2023 (Research and Markets,

2017), whilst a third source forecasted a compound annual growth rate of 4.3% over the period 2016-2024 (Grand View Research, 2014). These figures seem in line with measured growth in the market, with for example sales data from the British and Irish Hearing Instrument Manufacturers Association showing a 4% increase in unit sales in Q1 2016 over the previous year (Audiology Worldnews, 2016). Growth in cochlear implants is expected to be more pronounced, with a compound annual growth rate of 10.5% over the period 2014-2025 (Grand View Research, 2017). These similar numbers confirm that the growth estimates are most likely realistic.

However, the growth in the hearable market is open to debate and speculation. According to ABI Research, the hearable segment for industrial purposes will grow at a compound annual growth rate of more than 100% in the period 2016-2021. Some estimates are more conservative, with for example an expected compound annual growth rate of 43% in the period 2016-2021 (International Data Corporation, 2017). Another report predicts a compound annual growth rate of 9.98% in the period 2017-2023 (MarketsandMarkets, 2016). Despite the expected growth ranging from 10 to 75%, what is common to all these estimates is high expectations for growth in the coming years.

4.6 Market and Submarket Profitability

Within the hearing aid market, component suppliers, hearing device manufacturers, and retailers share profits. Suppliers have a profit margin of 5%, manufacturers have a profit margin of 25% and retailers, a profit margin of 70% (William Demant Holding, 2016). Figure 4-4 taken from another source (Powers, 2014), corroborates these estimates.

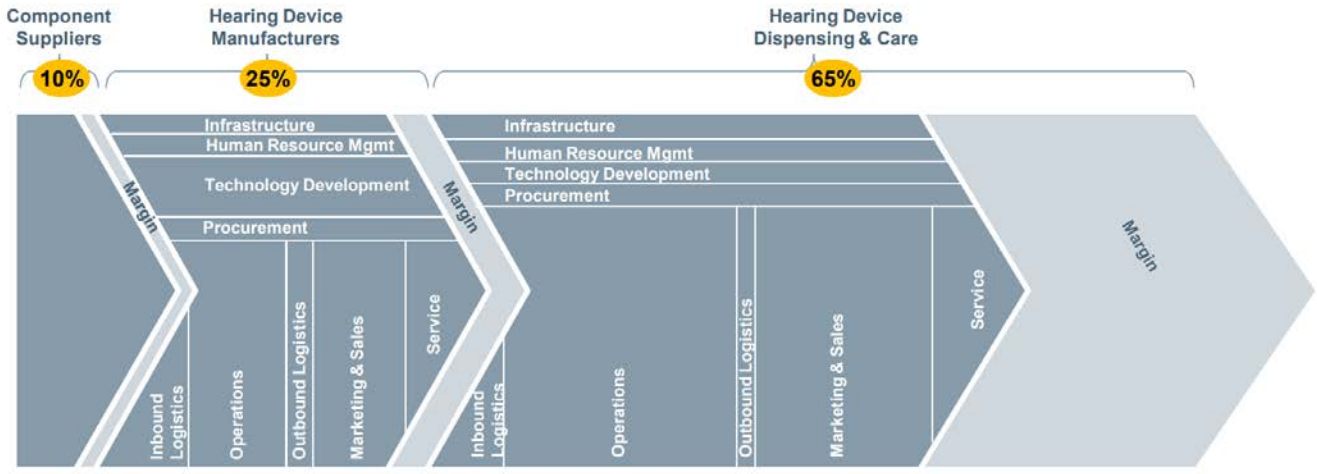

Figure 4-4 Value chain for hearing devices: Share of profitability for component suppliers, hearing device manufacturers, and retailers.

The profit margins of the different actors within the market of hearables are unknown, but combined revenues are expected to exceed 33 billion euros in 2020 (Hunn, 2016).

4.7 Cost Structure

Hearing devices are sophisticated electronic devices that are costly at the point of sale as the cost of the device is bundled with other fees. The cost structure of hearing aid devices includes production costs for the manufacturing companies, mainly for raw materials, consumables, and production staff. It also includes costs such as the preparation, extension, and maintenance of property and inventory, as well as intangible assets used in the production process (William Demant, 2016). Hearing aid manufacturers also invest in research and development, and costs incurred for sales and marketing and general administration.

The costs of hearing aid device retailers include rent, salaries, training, licenses, diagnostics, marketing, and services to provide ongoing services to patients (Gandel, 2017). In one example, the 3000 USD cost of a hearing aid at the point of sale was broken down into the following costs: 250 USD (8%) for production, 75 USD (3%) for research and development, 250 USD (8%) for marketing, 425 USD (14%) for general and administrative expenses, and 2000 USD (67%) for retail and service after sale (Audicus, 2014).

4.8 Distribution Systems

Trained hearing care professionals prescribe and dispense hearing aids after a hearing assessment at either in a public or private hearing clinic. Hearing aids are provided in Europe through several distribution models: 1) private retail chains and clinics (69% of global unit sales in 2012), 2) public healthcare systems through public procurement (22% of global unit sales in 2012), and 3) directly to patients through retail sale (9% of global unit sales in 2012; all figures from William Demant Holding, 2014). The latter refers to vertical integration where the same company expands its activities from development to production to retail.

In Europe, some countries cover the cost of hearing aids and related services (e.g. United Kingdom, Denmark), whilst others do not (e.g. France, Italy). The former has been termed “State Organised Mixed Model” and the latter has been termed “Free Market Model” (AEA, EFHOH & EHIMA, 2016).

In most countries, several distribution channels cohabit. For example, sales data from the British and Irish Hearing Instrument Manufacturers Association show that in Q1 2016, of the 386,386 hearing aids sold in the UK, 81% were to audiology departments whilst 19% were to private retail chains and clinics (Audiology Worldnews, 2016). This pattern of distribution in public versus private channels is opposite in other countries, with for example 79% of hearing aids distributed privately in the USA (Staab, 2015).

As mentioned above, the distribution of hearing devices has been historically dependent on hearing care professionals. However, new distribution systems are seeking, through over-the-counter and online sales, to reach the person with hearing impairment directly. Figure 4-5 depicts distribution channels for hearing devices together with examples (William Demant Holding, 2016). It shows the level of specialisation from very specialised professionals to complementary businesses distributing hearing devices. Further, it displays relevant players and how the market is split between them together with examples (William Demant Holding, 2016).

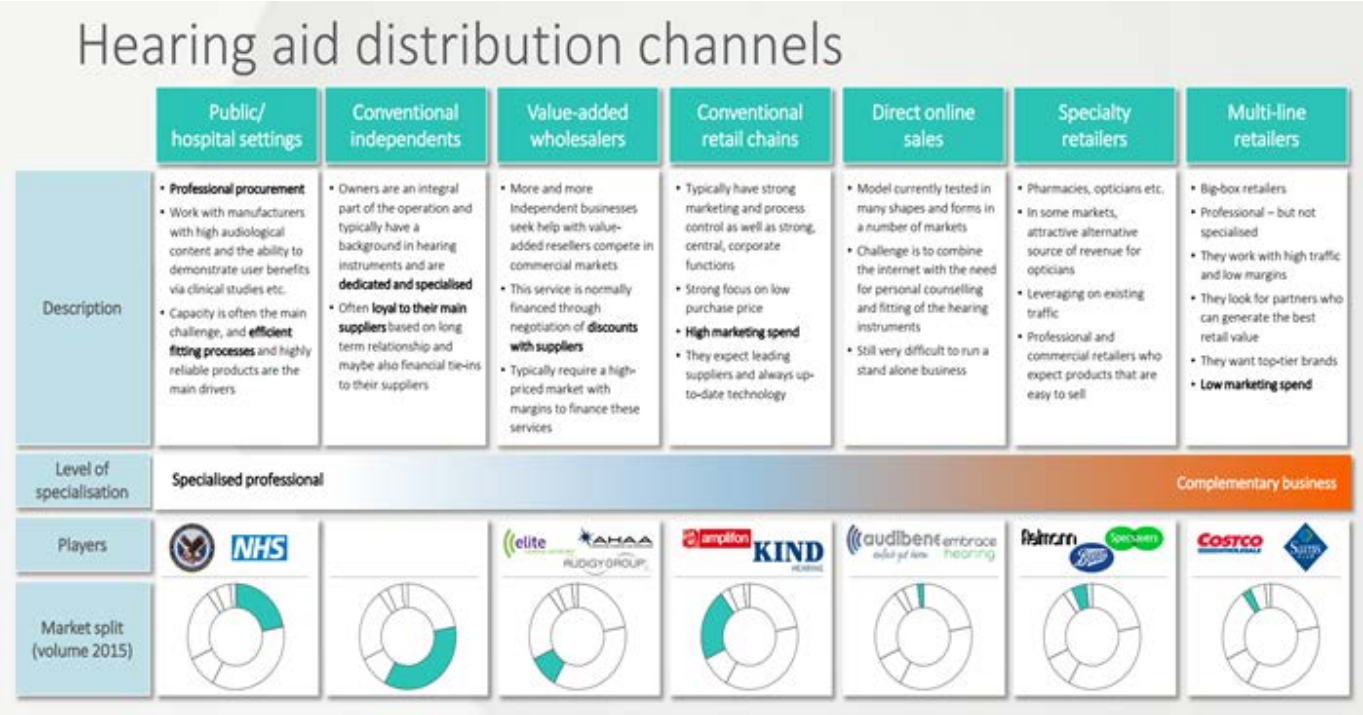

Figure 4-5 Distribution channels for hearing aids.

The following section explores trends, including the emergence of new distribution systems that target the person with hearing impairment directly.

4.9 Trends and Developments

Three global trends are impacting the future of hearing devices and hearing healthcare.

1. **Technology to improve end-user benefit and support self-management:** Hearing aids are now IoT devices and future developments will capitalise on related opportunities. Moore's law, which predicts that the number of components per integrated circuit doubles every year, has held since the mid-1960s. The hearing device chip performance is constantly increasing, leading to new possibilities for sound signal processing. These possibilities include using machine learning and artificial intelligence, and more specifically deep learning. For example, deep neural networks can be trained to identify and enhance a specific person's voice. This artificial separation of one voice from other sounds can lead to significant end-user benefit in noisy situations when many people are talking at the same time.

   Furthermore, hearing aids can now send and receive data wireless and are now one of several wearables that can enhance one's functioning. People are increasingly eager to receive eHealth-enabled hearing healthcare, such as the possibility for the hearing care professional to remotely adjust hearing aids. For example, Unitron's Patient Insight has a Log It All functionality that displays to the hearing professional both objective and self-reported data about hearing aid performance, to help the hearing professional monitor hearing aid outcomes and, if necessary, propose changes. Similarly, Signia's Telecare and ReSound's Assist provide a mobile-based communication function between the hearing care professional and the hearing aid user. It also allows the professional to push new hearing aid settings at a distance, without the user needing to visit the clinic to have their hearing devices adjusted. In the future, hearing devices will also rely on more advanced input to personalise their signal processing to every individual and every situation. Whilst hearing devices today rely on their microphones and on user interaction (through a control on the hearing device or through an app), hearing aids of the future can benefit from body signals to infer intention, fatigue, etc. of its user. Through biofeedback, hearing aids will become more performant in all situations. Furthermore, hearables to become platforms for sensors that monitor vital signs such as blood pressure and body temperature.

   People are increasingly interested in being empowered, in self-management of their own condition, of being an active agent in their health and healthcare, and in taking an approach that focus on prevention and early detection of health conditions (Sullivan, 2017). This includes at-home validated tests, with results that can be compared over time, and early treatment of hearing

impairment so that co-morbid conditions such as isolation and cognitive decline can be avoided. Self-management, training of one's abilities, and monitoring of progress over time give a lifelong perspective to healthcare. Hearing devices can become a gateway to a suite of health monitoring services that maintain health and wellbeing. This trend will drive a growth in the market from the provision of products to services. For example, software that supports self-management, including ongoing monitoring of hearing function, could become business opportunities.

2. **Market forcing the average selling price down:** Universal health care coverage can include the provision of hearing devices. Public coverage of hearing devices increases penetration and reduces profitability, as large public buyers buy hearing devices at low unit costs through competitive procurement tenders. The average selling price of hearing devices is falling worldwide (William Demant Holding, 2016). As overall health care costs are exploding worldwide, some public healthcare systems, such as the National Health Service in the UK, are cutting down on the provision of hearing devices (Campbell, 2015). A lowering in public reimbursement recently took place in The Netherlands, in Denmark, and in Switzerland (William Demant Holding, 2016). This trend will drive a reduction in the profitability of the market.
3. **New distribution channels:** New models of service delivery are being trialed to open the market to people with hearing impairment who currently are excluded from it. There is a global shortage of hearing health professionals, with for example one audiologist per 800,000 inhabitants in sub-Saharan Africa (Mulwafu et al., 2017). Sadly, the access to audiologists is decreasing as populations in low- and middle-income countries are growing rapidly seeing (Mulwafu et al., 2017). Self-fitting hearing aids propose to address the hearing needs of currently underserved communities (Convery and Keidser, 2016). These hearing aids allow their user to perform hearing tests and, based on test results, personalise device settings without the need for professional support or access to dedicated equipment (Convery and Keidser, 2016). Quality instructional materials tailored to the knowledge and skills of the user are important for successful usage of these hearing aids (Convery et al., 2017). In support of deregulation, the US President Donald Trump signed into law in August 2017 the Food and Drug Administration (FDA) Reauthorization Act of 2017. This legislation includes the *Over the Counter Hearing Aid Act,* which aims to provide greater public accessibility and affordability through over-the-counter hearing aids. The *Act* wishes to enable adults with a mild-to-moderate hearing loss to access over-the-counter hearing aids without being seen by a hearing care professional. The FDA will create and regulate a new category of over-the-counter hearing aids that meet the same high standards for safety, consumer labeling, and manufacturing protection as other medical devices. Deregulation in the USA might also transform the European market towards lower cost devices that are provided directly to consumers (Blustein and Weinstein, 2016). However, key

stakeholders, such as the European Association of Hearing Aid Professionals, the European Union of Hearing Aid Acousticians, the European Federation of Hard of Hearing People, and the European Hearing Instrument Manufacturers Association, have jointly disapproved of this possibility (Audiology Worldnews, 2017).

4.10 Key Success Factors

Thriving medical device manufacturers have a sustainable management with a clear vision, a culture of innovation, and fair and healthy working conditions with low employee turnover (Russell and Tippett, 2008). Proactive innovation management in changing times is central to the success of hearing device manufacturers such as William Demant (Stranne, Maier and Strebel, 2014). Competitors that thrive in tomorrow's hearing device market have quality products, have product offerings that go beyond promoting hearing health to also maintaining the overall health of its users, and may offer direct sales to people with hearing impairment. Current hearing aid manufacturers develop high-quality hardware with state-of-the-art digital signal processing algorithms for optimal sound quality. In the future, winners in this market will go beyond regular hearing aid functionality. They will partner with others, either through mergers or through open source platforms/application programming interfaces that enable third parties to create software applications for hearing devices and therefore provide enhanced value for its users. Modular sensors and accessories will further enhance the value for the hearing device users. Therefore, winners have an innovative mindset and the ability to position hearing care on the market within a broader context of health monitoring.

Furthermore, as mentioned earlier, most people with hearing impairment do not own hearing aids. Hearing device manufacturers with a competitive edge position their brand, products, and services to increase penetration rate, to reduce the stigma typically associated with hearing devices, and to offer options that better meet the needs of people with hearing impairment. These manufacturers leverage trends of user choices to offer products and services that go beyond technology to offer personalised services.

4.11 Value Network Analysis within Hearing Devices and Hearables

Stakeholders within hearing devices and hearables include: manufacturers, hearing care professionals, users, and third-party payers.

Figure 4-6 describes the stakeholders and their current tangible and intangible relations interaction through the three distribution channels described in section 4.8. Brackets indicate value exchanges that are not relevant for all distribution channels.

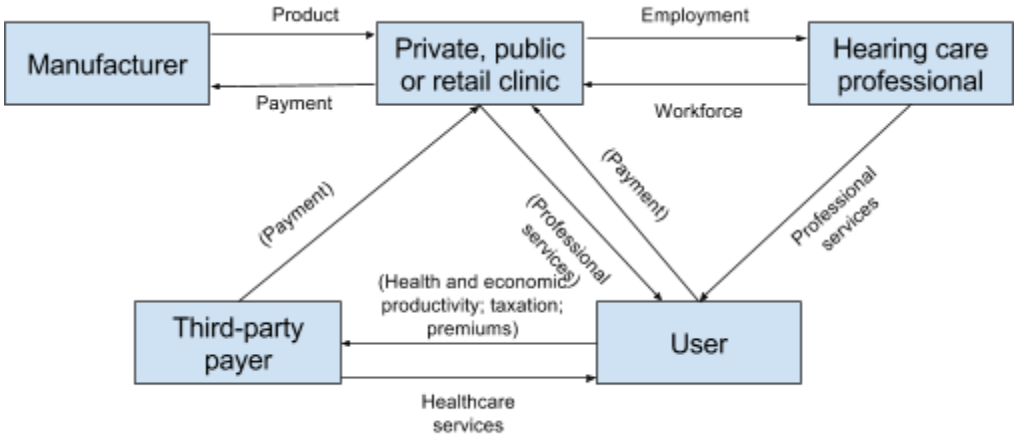

Figure 4-6 Stakeholder map for hearing devices.

The main stakeholders are manufacturers, retail/public clinics, third-party payers, hearing care professionals, and users. Manufacturers sell their products to retail/public clinics in exchange for payment. Clinics employ hearing care professionals to provide professional services to users. Third-party payers such as Ministries of Health and private health insurances receive financing either directly from the users, for example through insurance premiums, or indirectly, for example through economic productivity and therefore taxation in the case of public hearing healthcare.

4.12 Summary of Market Analysis and Value Network Analysis for Hearing Devices and Hearables

In summary, the market of hearing devices and hearables is in the expansion of new distribution channels for the greater availability of consumer electronics as the market changes in the coming years. Hearing devices that offer a greater level of personalisation to better address the needs of people with hearing impairment will increase the currently low market penetration of hearing devices. Furthermore, hearables, with their functionalities that are interesting for all people regardless of their hearing status, could widen dramatically the target group for ear-level devices.

The next section describes the market and value network analyses for the commercial outcome *Big data analysis platforms*.

5. Big Data Analysis Platforms

5.1 Introduction to the Market

Big data is a term for data sets that are so large or complex that traditional data processing application software is inadequate to deal with them. An focusing on its relevant market it is well known that there is a dramatic increase of this market during the last years and large prospects for further increase in upcoming years. An International Data Corporation (IDC) forecast sees worldwide big data technology and services market growing to 48.6 billion USD in 2019, driven by wide adoption across industries (Press Release, IDC 2015). According to the same reference, the big data market continues to exhibit strong momentum as businesses accelerate their transformation into data-driven companies. This momentum is driving strong growth in big data-related infrastructure, software, and services. Subset of the Big data market is the Big data analysis platforms market which follows the prospects and the trends of the Big data market and which we are going to focus on and analyse in the following sections.

Big data platforms have predominantly focused on the volume aspects of large-scale data management. The growing pervasiveness of IoT applications, along with their associated ability to continuously collect data from physical and virtual sensors, highlights the importance of managing the velocity dimension of big data (Simmhan and Perera, 2016). Many companies recognise that data is the key to increasing their success and gaining data-driven advantages in competitive market spaces. A few early pioneers, such as Datameer began to work on big data analytic platforms that allowed businesses to compile, crunch, and analyse their data more quickly and thereby deliver on their service-level agreement more readily. These big data solutions aimed to reduce the burden on businesses and IT departments while also increasing the depth and accuracy of the big data analyses themselves. In order to maximise effectiveness, the best big data platforms consider the needs and desires of both the business side and the IT side, allowing for deep, complete analysis while reducing the risk of bottlenecks (Schloss, 2016).

5.2 Overview of Competitor Products and Services

There are several big data platforms available with different characteristics and choosing the right platform requires an in-depth knowledge of the capabilities of all these platforms (Agneeswaran et al., 2013). There are many vendors selling products classified as big data analytics software. However, it is challenging to differentiate these products based on functionality alone, as many of the tools share similar features and capabilities. Additionally, some of the tools exhibit extremely subtle differences. There are multiple facets of the scope of the data to be analysed, including the issue of structured versus unstructured information as well as access to conventional on-premises databases and data warehouses, cloud-based data sources,

and data managed in big data platforms such as Hadoop. However, there are varying degrees of support for data managed within less-conventional data lakes (either managed within Hadoop, or in other NoSQL data management systems intended to provide horizontal scaling) (Loshin, 2015). Apache Hadoop, a nine-year-old open-source data-processing platform first used by Internet giants including Yahoo and Facebook, leads the big-data revolution. Cloudera introduced commercial support for enterprises in 2008, and MapR and Hortonworks piled on in 2009 and 2011, respectively. Among data-management incumbents, IBM and EMC-spinout Pivotal each has introduced its own Hadoop distribution. Microsoft and Teradata offer complementary software and first-line support for Hortonworks' platform. Oracle resells and supports Cloudera, while HP, SAP, and others act more like Switzerland, working with multiple Hadoop software providers (Henschen, 2014).

5.3 Emerging Submarkets

Amid the proliferation of real-time data from sources such as mobile devices, web, social media, sensors, log files, and transactional applications, big data has found a host of vertical market applications, ranging from fraud detection to scientific research and development. According to 'The Big Data Market: 2016 - 2030 - Opportunities, Challenges, Strategies, Industry Verticals & Forecasts' (prnewswire, 2017), the big data ecosystem has five emerging submarket that are: i) Banking, ii) Discrete Manufacturing, ii) Process Manufacturing, iv) Professional Services and v) Retails which are part of Big Data market and can be also included to the following segmentation into horizontal submarkets and vertical markets:

- Horizontal submarkets

    1. Storage and compute infrastructure
    2. Networking infrastructure
    3. Hadoop and infrastructure software
    4. SQL
    5. NoSQL
    6. Analytic platforms and applications
    7. Cloud platforms
    8. **Professional services**

- Vertical submarkets

    1. Automotive, aerospace, and transportation
    2. **Banking** and securities

3. Defence and intelligence
4. Education
5. Healthcare and pharmaceutical
6. Smart cities and intelligent buildings
7. Insurance
8. **Manufacturing and natural resources**
9. Web, media, and entertainment
10. Public safety and homeland security
11. Public services
12. **Retail, wholesale, and hospitality**
13. Telecommunications
14. Utilities and energy

5.4 Actual and Potential Market and Submarket Size

According to IDC (Framingham, 2017)., big data and business analytics Western European revenues forecast to reach 34.1 billion USD in 2017, led by banking and manufacturing investments. The adoption of big data solutions lags that of other third platform technologies such as social media, public cloud, and mobility, so the opportunity for accelerated investment is great across all industries. Big data analysis technology investments will be led by IT and business services, which together will account for half of all big data and business analytics revenue in 2017 and throughout the forecast. Software investments will grow to more than 17 billion USD in 2020, led by purchases of the end-user query, reporting, and analysis tools as well as data warehouse management tools.

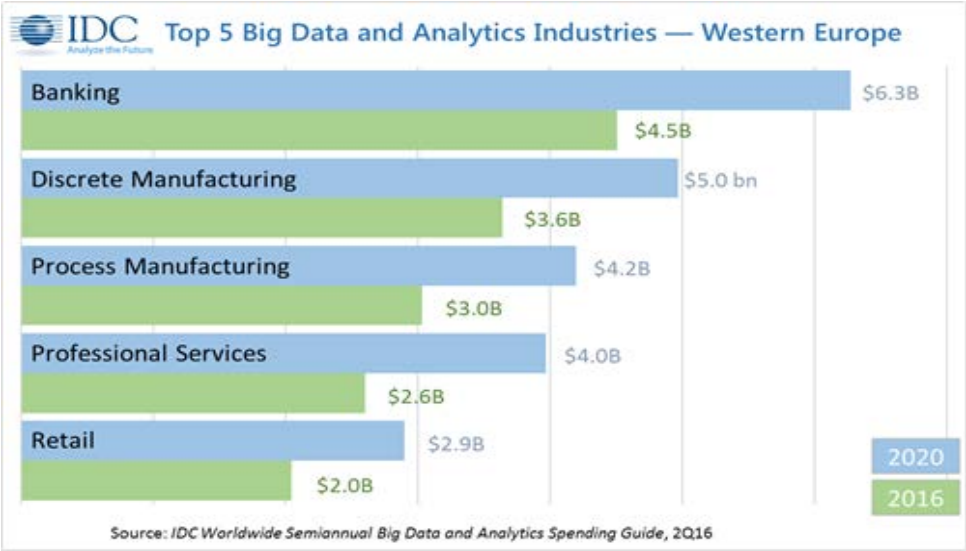

Figure 5-1 Current size (2016) and expected future size (2020) for big data submarkets.

5.5 Market and Submarket Growth

IDC[2] sees the big data technology and services market growing at a compound annual growth rate (CAGR) of 23.1% over the 2014-2019 forecast period with annual spending reaching 48.6 billion USD in 2019. Businesses transformation to data-driven companies will create 4.4 million information technology (IT) jobs globally according to a Gartner press release. Furthermore, according to IDC's report (Framingham, 2017), the worldwide revenues for big data and business analytics will grow from 130.1 billion USD in 2016 to more than 203 billion USD in 2020, at a compound annual growth rate (CAGR) of 11.7%. Despite the challenges relating to privacy concerns and organisational resistance, big data investments continue to gain momentum throughout the globe. SNS Research[3] estimates that big data investments will account for over 46 billion USD in 2016 alone. These investments are further expected to grow at a CAGR of 12% over the next four years. In addition to being the industry with the largest investment in big data and business analytics solutions (nearly 17 billion USD in 2016), banking will see the fastest spending growth.

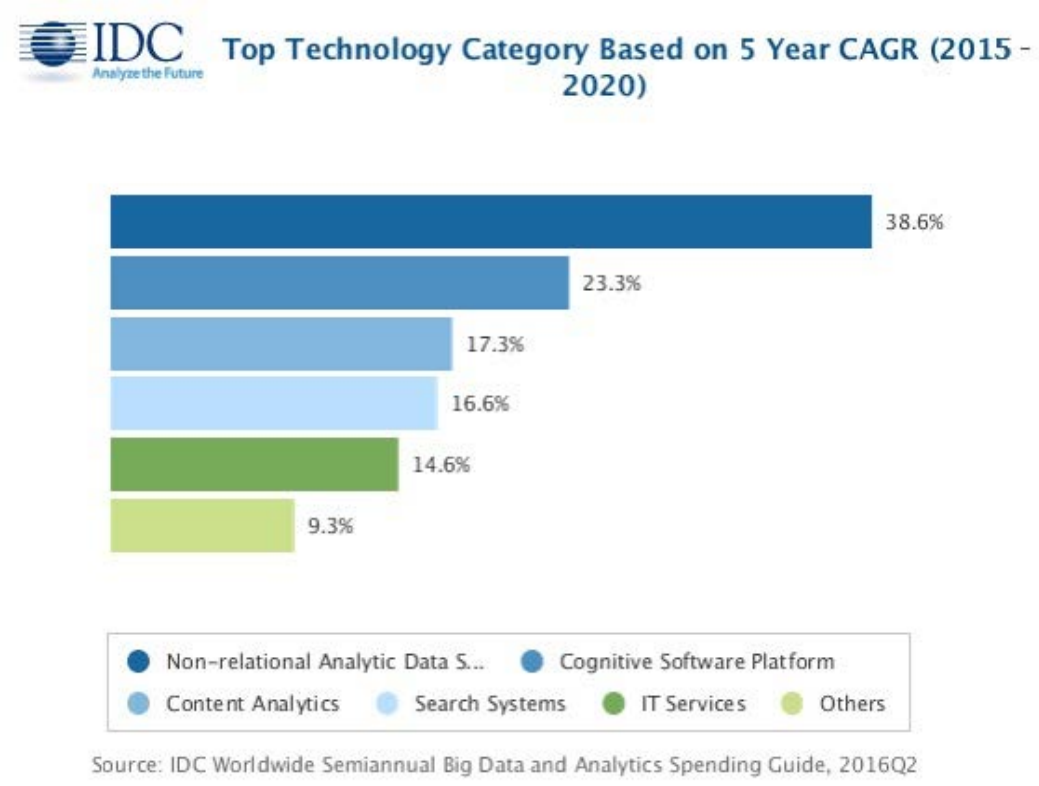

Figure 5-2 Expected growth in big data, according to technology category, for the period 2015-2020.

[2] https://www.idc.com/
[3] http://www.snsintel.com

Global revenue in the business intelligence (BI) and analytics market reached 16.9 billion USD in 2016, an increase of 5.2% from 2015. Gartner predicts that the BI and analytics market is in the final stages of a multiyear shift from IT-led, system-of-record reporting to business-led, self-service analytics (Gartner, 2016). Big data and business analytics worldwide revenues will grow from nearly 122 billion USD in 2015 to more than 187 billion USD in 2019, an increase of more than 50% over the five-year forecast period. The industries that present the largest revenue opportunities are Discrete Manufacturing ($22.8B in 2019), Banking (22.1 billion USD), and Process Manufacturing (16.4 billion USD) (Shirer and Goepfert, 2016). The global big data market will grow from 18.3 billion USD in 2014 to 92.2 billion USD by 2026, representing a compound annual growth rate of 14.4 percent. Wikibon predicts significant growth in all four sub-segments of big data software through 2026. Data management (14% CAGR), core technologies such as Hadoop, Spark and streaming analytics (24% CAGR), databases (18% CAGR) and big data applications, analytics and tools (23% CAGR) are the four fastest-growing sub-segments (Wheatley, 2016).

5.6 Market and Submarket Profitability

For the calendar year 2014, the big data market – as measured by revenue associated with the sale of big data-related hardware, software, and professional services – reached 27.36 billion USD, up from 19.6 billion USD in 2013. While growing significantly faster than other enterprise IT markets, the big data market's overall growth rate slowed year-over-year from 60% in 2013 to 40% in 2014. This is to be expected in an emerging but quickly maturing market such as big data. According to Wikibon's[4] market forecast for big data through 2026 from 2017 it is expected that the big data market will be 84 billion USD in 2026, which represents a 17% compound annual growth rate over the 15 year period beginning in 2011 (see Figure 5-3).

[4] https://wikibon.com

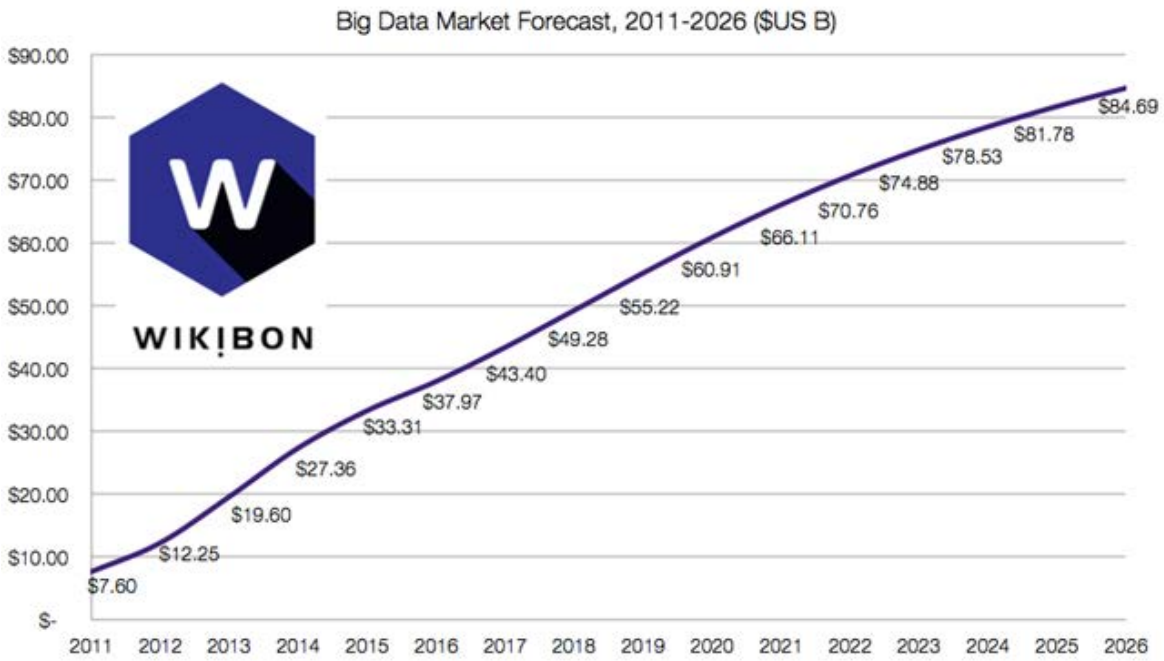

Figure 5-3 Forecast growth in big data market from 2011 to 2026

5.7 Cost Structure

Together with the complementary technology forces of social, mobile, the cloud, and unified communications, big data brings the potential for disruption and realignment. Organizations that work with big data analysis platforms are facing potential hidden costs and complexity that may present barriers, which should be avoided. In order to provide a better vision on the Big Data analysis platform market, we have to provide the frame of the cost structure which is distinguished and presented below in five main categories of costs.

The first category of the aforementioned costs is the i) ***Human Resources*** cost which includes costs for staff like engineers, researchers, project managers, administration, supporters (customer support & trainers), marketing and sale people. Another category of the cost is the ii) ***Data Infrastructure*** (Data Center, physical or cloud infrastructure) and the accompanying costs like data communication and infrastructure's maintenance. iii) ***Licensing costs*** for development kits, third-party frameworks and supporting tools could be also necessary to develop Big Data Analysis platforms and support platform for a stable presence in the market. Furthermore, one major category of costs are the iv) ***Marketing and Sales costs*** which are associated with the delivery of the platform to customers. Such expenses for promoting, selling and expanding organization's market for a Big Data Analysis platform via physical/online/digital channels are the creation of marketing material, the advertisement to media, public relations, etc. Last but not least, are the v) ***Administrative & Overheads costs*** that should be considered as a major category of the cost structure

that includes expense such as accounting and legal fees, front office salaries, rent, repairs, supplies, taxes, telephone bills, and utilities.

5.8 Distribution Systems

They are at least two types of distribution systems/models that could be used for the Big Data Analysis Platforms. The first one is the ***Platform as a service (PaaS)*** model which is a cloud computing model in where the provider delivers hardware and platform to users over the internet. And the second one is the ***Software license*** model which is a legal instrument governing the use or redistribution of the platform.

With the PaaS model, the Big Data Analysis Platforms provider hosts the hardware and software on its own infrastructure. The principal benefit of PaaS is simplicity and convenience for users where the PaaS provider supplies much of the infrastructure and other IT services and users can access it via a web browser. Through PaaS providers' sales team and their affiliates the provider's charges for accessing the platform on a per-use basis or charges a flat monthly fee.

With the Software license distribution model, there is a legal agreement between the Big Data Analysis Platform provider with a customer to install and use at his premises & infrastructure the software. This legal agreement is established by either the providers' sales team or Value added Retailers (VAR) & Affiliates.

5.9 Trends and Developments

Big data analytics is moving beyond the realm of intellectual curiosity and is beginning to tangibly affect business operations, offerings, and outlooks. No longer merely hype or a buzzword, big data analytics will soon become a central tenet for every sort of business enterprise. Meanwhile, real-time analytics has become a hot requirement. For example, factories require the use of real-time data such as sensor data to detect abnormalities in plant and machinery (Raj and Vanga, 2015).

Cloud-based data analytics has been growing rapidly in an effort to reap all the benefits of the cloud paradigm. Raj and Vanga (2015) presented a list of potential key benefits of moving to the cloud:

- Agility and affordability: No capital investment of a large-scale IT infrastructure is needed. Just use and pay.
- Big and fast data platforms: Deploying and using any kind of big data platforms (generic or specific, open or commercial-grade) for analytics are quick and easy.

- End-to-end Hadoop platforms: Data virtualisation, ingestion, processing, mining, analytics, and information visualisation tasks are being performed by these platforms.
- Data management systems: Parallel, clustered, distributed SQL databases, NoSQL, and NewSQL databases are made available in clouds.
- Data warehouse systems: Recently, data warehouse as a service (DWaaS) capabilities are being realised.
- Social sites, mobile application stores, and similar apps: Popular social media and network applications are being run on public clouds.
- Wide area network (WAN) optimisation technologies: WAN optimisation products and platforms for efficiently transmitting data over the Internet infrastructure have emerged.
- Business applications in clouds: With enterprise information systems (EIS), business-critical packaged applications such as electronic patient records, content management systems, supply chain management, Knowledge Management, are also being deployed in clouds.
- Cloud integrators, brokers, and orchestrators: Assists with the migration and setup of cloud applications by using products and platforms for seamless interoperability among different and distributed systems, services, and data are available.
- Operational, transactional, and analytical systems are being modernised, migrated, and hosted in clouds.
- Devices, sensors, and other machines are being integrated with cloud-native applications, as well as enabled applications, services, and data.

5.10 Key Success Factors

With more and more systems talking to each other (the Internet of Things) and deployment of mobile strategy, it can be assumed that data are set to grow by 15 to 20 percent every year. As applications gradually move to the cloud, monitoring the applications is also set to become a complex task due to dynamic provisioning and deprovisioning of IT resources to meet applications' demands. Enterprises need to adopt analytical solutions that can analyze the terabytes of big data from IT operations and provide relevant insights that can be acted upon immediately.

Several key success factors of Big Data Analysis platforms can be identified which are presented below as the major platform's KPIs:

- To provide both flow management and streaming analytics capabilities for building end to end data-in-motion use cases
    - Flow management provides an easy, secure, and reliable way to get the data you need from anywhere (edge, cloud, data center) to any downstream system with intelligence (routing, transformation, filtering, bi-directional communication).
    - Streaming analytics provides immediate and continuous insights using aggregations over windows, pattern matching, predictive and prescriptive analytics, and so on. Streaming analytics is part of a superset of capabilities provided by stream processing.
    - Advanced analytics capabilities as businesses move toward predictive analytics
- Easy of building streaming analytics
    - Building stream analytics platforms with no specialized skill sets needed by its users
    - Stream analytics with no low-level programming, testing, and tuning to bring to production.
    - Minimizing the time to design, develop, test, and deploy into production.
    - Key streaming basics such as joining/splitting streams, aggregations over windows of time, and pattern matching are difficult to implement.
- Scale-out architectures & Scalable capacity where big data analytics solution can accommodate huge quantities of data, but it also can grow organically with data volumes. A modern analytics solution introduces very little downtime if any at all. Capacity and computer expansion happens in the background

5.11 Value Network Analysis within Big Data Analysis Platforms

The main stakeholders within Big data analysis platforms are Public bodies (international, national, and regulators), Industry associations like Big Data Value Association (BDVA), standardisation bodies like The Institute of Electrical and Electronics Engineers (IEEE), researchers and academics, Investors, entrepreneurs, incubators, technology providers, data suppliers like hospitals and the group of end-users which includes policy makers, clinicians and patients. Below at figure 5-4 is presented some of the main the connections between the stakeholders and visualizes business activities and sets of relationships from a dynamic whole system perspective. With the Value Network Analysis, we aim to help our understanding and consider how well we could exploit EVOTION assets. The connections between the stakeholders are extremely important in identifying strong stakeholders as well as finding a stakeholder's potential risks. For example, if a network

member (stakeholder) has a large influence, the loss of that member could devastate the entire group. This is an example of intrinsic value analysis because there is value, but it is hard to place a price on.

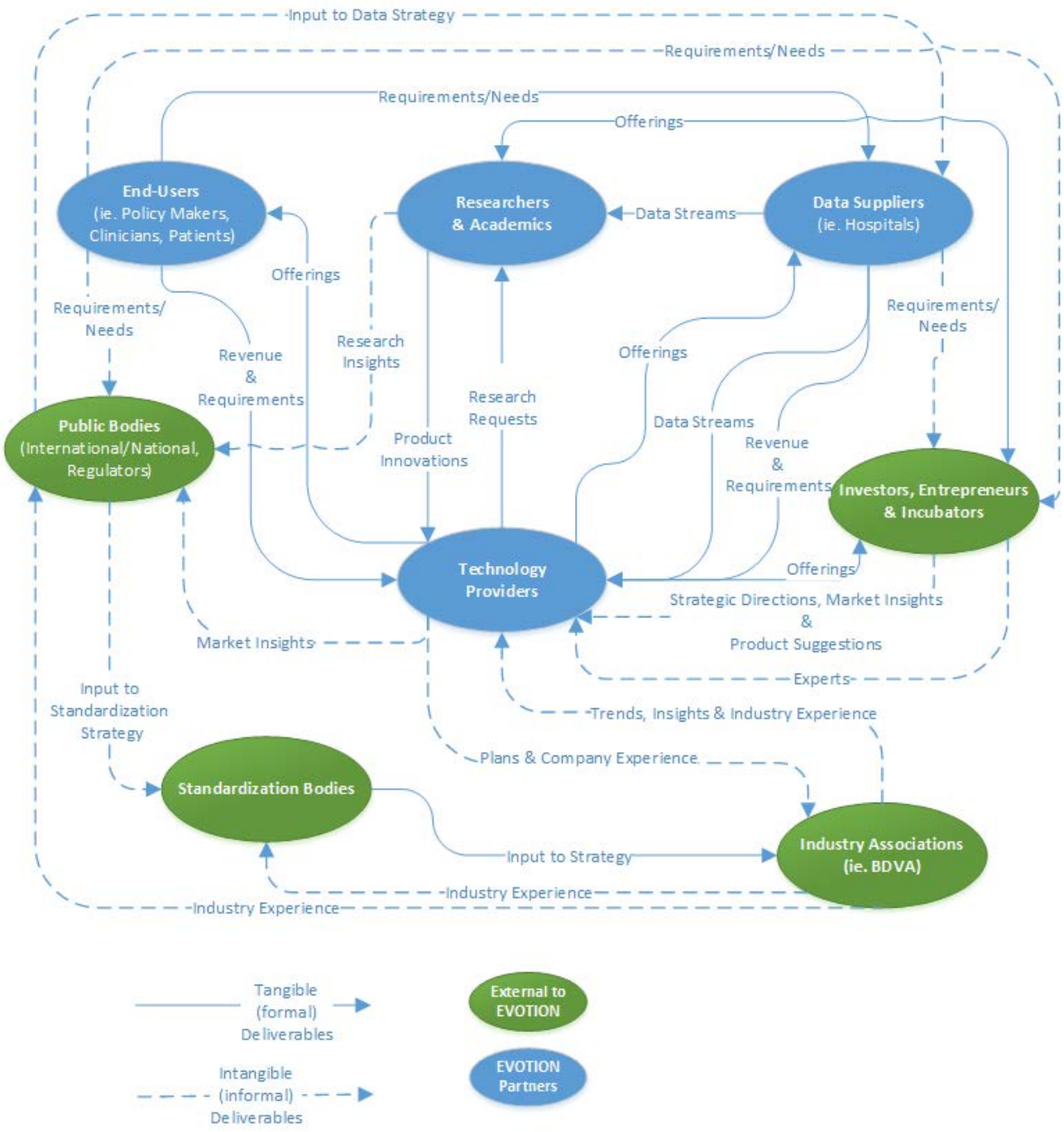

Figure 5-4 Value Network Analysis of stakeholders relevant to big data analysis platforms.

5.12 Summary of Market Analysis and Value Network Analysis for Big Data Analysis Platforms

In summary, there is large expected growth in big data in the future. The market is rapidly becoming an emerging area of focus across numerous end-use industries. The technology adds up substantial value by providing useful information; enabling organizations to manage large chunks of data efficiently. Organizations with the help of these solutions obtain both efficiency and quality in managing a large volume of raw information, ultimately resulting in significant cost reduction. Analysis platforms is a major segment of Big Data and are expected to witness bullish growth over the coming years, and is majorly on account of increasing awareness, need, and adoption of big data analytics among several small and large enterprises. Organizations are increasingly adopting these solutions owing to the growing need to make fact-based strategic business decisions in an attempt to reduce the risk of failure and excel in this highly competitive environment.

The next section describes the market and value network analyses for the commercial outcome *Security systems for body area sensor networks*.

6. Security Systems for Body Area Sensor Networks

6.1 Introduction to the Market

Future healthcare systems will integrate medical IoT for real-time monitoring, networking, and information technologies on the client site, cloud computing, and big data techniques to collect, analyse, and communicate to other systems the patient's vital parameter signal and safety monitoring information. The EVOTION platform is an example of such healthcare systems. In recent years, a significant development of medical IoT relates to Body Area Sensor Networks (BASNs) and Body Area Networks (BANs) and their special subclass of Wireless Sensor Networks (WSN). These networks have enabled the rapid development of telemedicine systems, which provide remote monitoring of patients and their vital parameters. The systems that incorporate BASNs, BANs, and WSNs embed security technologies to ensure data privacy, confidentiality, and integrity whilst transferring medical data from the various sensors to their final or intermediate destinations. This section reviews gateways that implement various interfaces, networking, and communication techniques to collect and transmit securely medical data to intelligent terminals for safety monitoring or databases, protect privacy, and enhance transmission reliability and efficiency.

The vast majority of medical and health sensors are wireless in nature due to the rapid growth in physiological sensors, low-power integrated circuits, and wireless communications. BASN nodes must be extremely non-invasive. Smaller nodes imply smaller batteries, creating strict trade-offs between the energy consumed by processing, storage, and communication resources and the fidelity, throughput, and latency required by applications. Packaging and placement are also essential design considerations since BASN nodes can be neither prominent nor uncomfortable.

Common medical applications include but are not limited to heart rate, blood pressure, and glucose monitoring. More specialised applications, including endoscopic capsules, are gaining momentum. In such applications, security and privacy issues are major areas of concern. This is because the loss of trust on the security of the data that medical devices transfer may restrict people from taking advantage of the full benefits of technology. Malicious or not, manipulation of the data that are transferred from the sensor to the final endpoint (e.g. by hackers) will raise concerns that medical devices are not fit and safe for daily use. There may also be the possibility of serious social unrest due to the fear that government agencies or other private organisations may use such devices for monitoring and tracking individuals or personal information. Therefore, security and privacy issues are in focus for EVOTION. These will be discussed and analysed in the next section.

An exception to this market analysis are smartphones operating as gateways for medical data. Smartphones are becoming capable of doing more and more every day. However, various entities collect data from smartphones. Service providers, criminals, advertisers, and - in some cases - the government love to collect and to get their hands on the data stored in smartphones. We need to be aware of using the smartphone for storing and transmitting private data. As long as sensors are not able to transfer their data encrypted and authentically secure to smartphones, these devices are not considered suitable for handling private data and therefore are not considered in this analysis.

6.2 Overview of Competitor Products and Services

Devices that collect and process medical data range from cheap evaluation kits and hobby electronics boards that have large dimensions with a single microcontroller and a wireless interface to special medical gateways with security embedded features in hardware. Medical applications can be of two different types:

1. Monitoring/recording: Monitoring devices can only monitor or sample a medical characteristic. Such devices include heart rate, blood pressure or temperature monitoring.

2. Controlling: Controlling devices have the capability to administer certain commands to an active device that can directly affect human health (e.g. pacemaker, implantable insulin pump). A malicious attacker could modify programming commands to the implanted device, which could result in rapid battery depletion and/or administration of inappropriate commands (e.g. a shock in a pacemaker).

The current analysis will be focusing on “monitoring/recording” types of medical applications, as certain medical certifications are necessary for the second type. So in order to conclude, single-board microcontroller boards with sufficient wireless communication interfaces could be potential competitor products provided that the size and battery characteristics allow this kind of use.

6.3 Emerging Submarkets

Apart from the main market of secure gateways for medical sensors this kind of technology will also cause relevant submarkets to emerge. Three possible submarkets are described below:

1. **Development of software applications:** As the number of medical sensors monitoring the human body will increase, the amount of medical information that has to be analysed will increase proportionally. This will lead to software applications that are able to monitor in real time health, activity, mobility, and mental status, both indoors and outdoors. Based on their information, the

applications will provide suggestions when pre-specified conditions are met, e.g. when peak mental condition is reached, when peak physical condition is reached, or when the person is dehydrated. Furthermore, it will provide early warnings to avoid health problems.

2. **Fitness and entertainment:** The same technologies and architecture that capture body motion or heart rate for medical assessment can be equally used for capturing body motion in a video game or measuring stress levels at a sports event.
3. **Continuous health monitoring:** Private insurance companies can have a new business model that will allow them to monitor the vital signs of healthy individuals and act proactively when they receive an early warning (e.g. abnormal heart rate).

New sensors will only increase the range of potential applications and market opportunities and propel this technology into applications formerly depicted only in science fiction.

6.4 Actual and Potential Market and Submarket Size

To determine actual and potential size for this market and its submarkets, it is important to understand the factors that determine the request for this kind of technology. Life expectancy has been increasing worldwide due to significant improvements in healthcare, and medicine, as well as due to growing consciousness about personal and environmental hygiene. According to the World Health Organization (WHO), by 2017, the elderly population over 65 years or older are expected to outnumber the children less than 5 years of age (WHO.int., 2012). Therefore, it is an utmost necessity to develop and implement new strategies, technologies, and products that provide better healthcare and remote monitoring of patients and their vital parameters. Both individuals and governments will drive the request for the market of medical sensor node related security systems.

“Healthcare and technology have always been connected, but that relationship due to the rapid growth of the Internet of Things (IoT) and the popularity of wearable devices has been significantly transformed in recent years. This leads to personalised healthcare, increasing healthcare access and customisation the likes of which we have never seen. These advancements, while exciting, should be adopted carefully, as there are still legitimate concerns related to consistency, safety, cost-effectiveness, and more. Many changes need to take place to make this technology viable in the medical field. Most importantly, hardware and software need to be engineered to work together to address novel IoT technologies and their role in the healthcare field. This special issue addressed all important aspects of IoT eHealth technology including smart healthcare wearable sensors, body area sensors, advanced pervasive healthcare systems, and Big Data analytics to provide eHealth services to individuals for healthier lifestyles”. This is the conclusion of

the article “Internet-of-Things and big data for smarter healthcare: From device to architecture, applications, and analytics” (Firouzi et al., 2017). IoT in healthcare covering the markets of medical devices, systems, software, and services is expected to grow to a market size of 300 billion USD by 2022 according to the market analyst, Grand View Research, as shown in Figure 6-1. Government initiatives are also likely to promote this demand for that personalised e-healthcare. These applications include wearable and body sensors, advanced pervasive healthcare systems, and the big data analytics required to inform these devices.

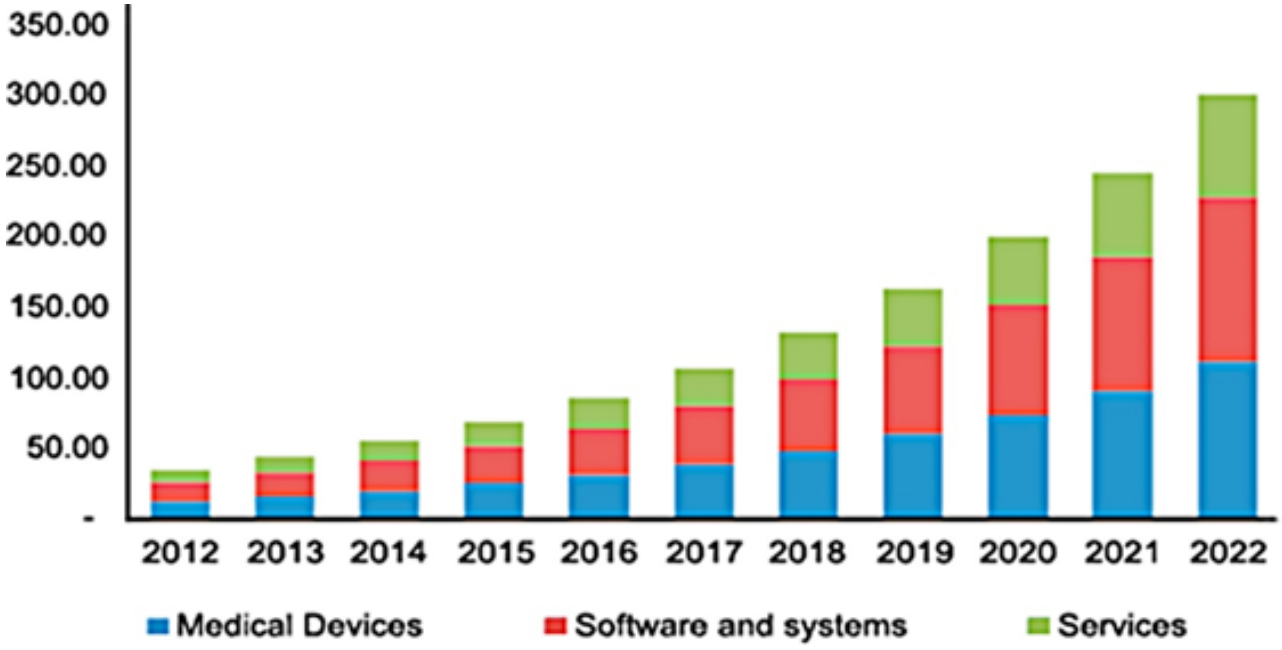

Figure 6-1 Market Growth of Internet of Things (IoT) in Healthcare in the USA, by Component, 2012–2022, in billion USD.

6.5 Market and Submarket Growth

IoT is expected to surpass mobile phones as the largest category of connected devices in 2018 (Ericsson, 2016). The IoT healthcare market is projected to grow from 41.22 billion USD in 2017 to 158.07 billion USD by 2022, at a Compound Annual Growth Rate (CAGR) of 30.8% from 2017 to 2022. Major growth drivers of the IoT healthcare market are an evolution of artificial intelligence technology, the rise in investments for the implementation of IoT healthcare solutions, and increasing penetration of connected devices in healthcare (MARKETSandMARKETS, 2017).

The market size for IoT in healthcare based on another research from Allied Market Research is estimated to reach net worth 136 billion USD by 2021. IoT, comprising of intermediary components, such as devices, network connectivity, electronics system, and software, is basically the networking of smart electronic devices to transmit data signals between them in the absence of human intervention. In the healthcare

segment, this technology can be implemented to manage and scrutinise available patient data as well as resources with great ease (Allied Market Research, 2016)

According to Allied Market Research, the global remote patient monitoring market size was 703 million USD in 2015 and is expected to grow at a CAGR of 17.0% to reach 2.130 million USD by 2022. Remote patient monitoring (RPM) is a technology used to collect medical and health-related data from individuals at one location and electronically transmit it to a healthcare provider at another location. RPM is used to remotely monitor and analyse physiological parameters such as blood oxygen levels, vital signs, blood pressure, heart rate, and blood sugar, which improves the quality of care, quality of life, and allows early prediction of aggravations and exacerbations (Allied Market Research, 2016).

The base year considered in the report by MARKETS and MARKETS (2017) IoT security market is 2016, and the market is expected to grow from 6.62 billion USD in 2017 to 29.02 billion USD by 2022, at a compound annual growth rate (CAGR) of 34.4% from 2017-2022.

Future Market Insights (2017) forecasts revenue from the global IoT security product market to increase from 12 billion USD in 2017 to about 48 billion USD by 2027, representing a CAGR of 14.9% from 2017 to 2027. This increasing revenue growth is attributed to the continuous launching of IoT security offerings and the emergence of niche players in the market. Moreover, an increasing number of service providers is also supporting revenue growth of this market.

6.6 Market and Submarket Profitability

Market and submarket profitability depends upon the adoption of medical sensor node related security systems. As mentioned above, this is a new market where no definite studies have been conducted. However, the special characteristics (gateway functionality, privacy conformity and secure transmission, multiple node capability, network/communication protocols technology) of this market and the close connection with telemedicine are enough to guarantee both market and submarket profitability.

6.7 Cost Structure

It is extremely difficult to establish a direct cost structure for the market of medical sensor node related security systems. Apart from the fact that this is a new market where no studies have been conducted, the cost of a gateway device depends on several factors including but not limited to the size, battery capacity, level of integration, number and kind of wireless interfaces, etc.

6.8 Distribution Systems

To describe the various distribution channels used to supply medical sensor node security systems, some preliminary information is necessary. Medical sensor node security systems come in various form factors and capabilities. Simple medical sensors along with gateways and evaluation kits can be purchased in various online electronics stores. Normally these sensors and gateways are used for experimentation and prototyping and not for patient health status monitoring. More advanced non-invasive and unobtrusive wearable sensors that can help general practitioners and medical personnel to monitor important physiological signs and activities of hospitalised and non-hospitalised patients in real time according to standard medical protocols, are normally provided directly by the national health insurance. Finally, even more, specialized sensors or especially expensive equipment are provided directly by the manufacturers and their distributors. In special cases the devices could be distributed through national insurance.

6.9 Trends and Developments

As mentioned in previous sections, the market of medical sensor node security systems is in an early development stage, increasing the difficulty to foresee the market trends and developments. However, four points have a stronger potential:

1. Both medical sensors and secure medical gateways are based on electronics and wireless communications. Due to the rapid growth in low-power integrated circuits and new developments in communications technologies, the devices are expected to shrink in size, acquire more processing power, and have less battery consumption.
2. As the processing power of both the medical sensors and secure medical gateways will be increasing, devices will be integrating more advanced algorithms for encryption/decryption and message integrity in order to provide increased security as far as the user data are concerned.
3. The greater processing capabilities in combination with power efficient communication techniques and along with the elevated security and privacy levels will lead to devices receiving considerable information and data from several medical sensors and combining them in real time.
4. Complex and advanced algorithms will be developed to monitor the overall health status of humans not only in hospitalised patients but also in the general population, leading to early warning systems before health issues arise.

6.10 Key Success Factors

Several factors determine the success of medical sensor node related security systems in the market. Due to the sensitivity of medical information, the most important parameters are the security and the privacy characteristics that these devices offer to the end user. They will be entrusted with extremely sensitive information about people and resource-aware encryption mechanisms will be necessary to increase security and protect user privacy. Another significant factor is the capability to connect with several sensors from different manufacturers. Interoperability will be the key so that connection to sensors, other networks, and even with electronic health record systems, is possible. The amount of medical information that these devices can store in combination with the processing capabilities of medical data is another key success factor. Those characteristics will enable the device to monitor the health status of an individual with great accuracy and provide early health warnings should any problems arise, thus contributing to the protection of the overall health of the person. Additional characteristics like the enhancement of the device through application programming, on the condition that privacy issues will be dealt with, will provide even more functionality to the device.

6.11 Value Network Analysis within Security Systems for Body Area Sensor Networks

The first step in the value network analysis to understand the impacts of both direct and indirect relationships between stakeholders on the success and adoption of secure BASNs is to identify the stakeholders. Many different categories can benefit from the market of secure BASNs. Figure 6-2 presents the potential stakeholders.

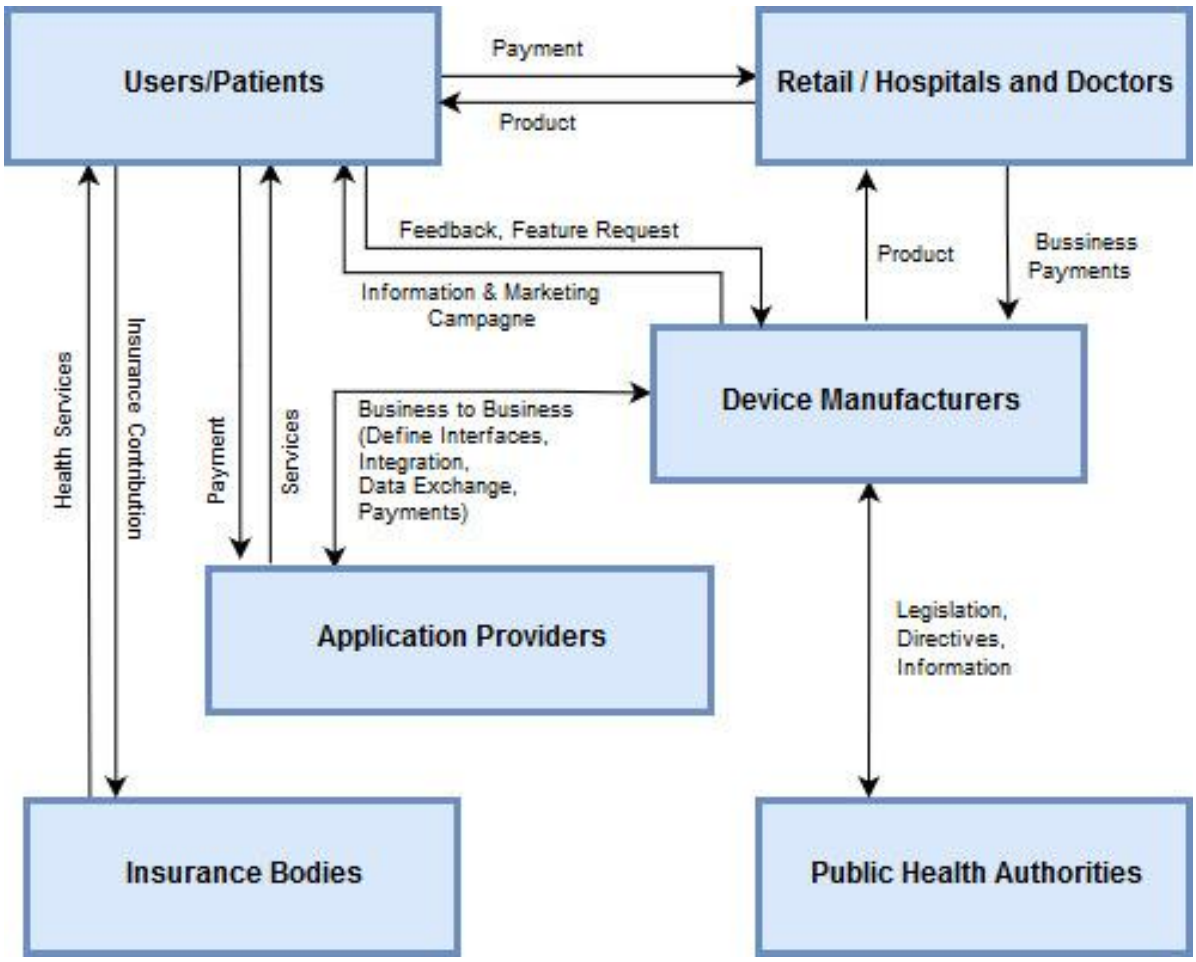

Figure 6-2 Potential stakeholders for security systems for body area sensor networks.

Figure 6-2 also shows the main interactions between stakeholders. It must be noted that only the primary and direct interactions are shown. Secondary interactions that are unimportant have been omitted. The users/patients have a direct relationship with all the stakeholders apart from the public health authorities. They purchase products from retailers and services from application providers, contribute to the insurance bodies, provide feedback to the device manufacturers about the products and accept services both from application providers and insurance bodies. Device manufacturers, apart from providing products that adhere to policies and legislation, also interact with users/patients and application providers. The interaction between application providers and device manufacturers is both financial and technical in nature. A similar two-way collaboration is true for device manufacturers and public health authorities, where information is exchanged regarding regulation on hospital guidelines, legal and technical aspects.

6.12 Summary of Market Analysis and Value Network Analysis for Security Systems for Body Area Sensor Networks

The market of medical sensor node related security systems is in an early development stage but is expected to grow at a fast pace due to both the technological advances in electronics and the benefits that can it can bring not only in healthcare but also the in the protection of general population health. These devices have the capability to cooperate with several medical sensors and store sensitive medical information and data. Due to the sensitive nature of the information in combination with the health risks associated with malicious attacks against the devices, the concepts of privacy and security are of prime importance to this kind of devices. The general public should be made aware of the benefits and implications in order to be better prepared for the new technology.

This section concludes the market and value network analyses for the three commercial outcomes. The following section summarises the analyses and proposes pointers for future work.

7. Conclusions

7.1 Summary

This report presented a market and value network analysis for three commercial outcomes. This section summarises the main learnings:

1. **Hearing devices and hearables**: This analysis showed that this market is in general mature with several submarkets with good market potential for growth, especially the implant and hearable submarkets. Its target end-users are people with hearing impairment, but increasingly also people without hearing impairment who wishes to benefit from the potential of in-ear ongoing monitoring and support. Competitors include the incumbent manufacturers of hearing devices, but also larger consumer electronics manufacturers.
2. **Big data analysis platforms:** This analysis showed that this is a market with significant growth in multiple sectors, with banking the predicted most profitable sector for big data analysis platforms. Its target end-users are many, including patients and clinicians for health applications and data suppliers and investors who wish to access data-informed business intelligence. Competitors, including open-source platforms, provide similar features and capabilities.
3. **Security systems for body area sensor networks:** This analysis showed that, like big data analysis platforms, this is a market with significant growth. It target end-users includes patients and clinicians, but also medical device and application providers, public health authorities, and insurance bodies. Competitors are not well defined.

Based on the information provided above, this preliminary evaluation of the potential market impact of EVOTION points to four main conclusions:

1. Growth is expected in the markets relevant to the three commercial outcomes: 1) hearing devices and hearables, 2) big data analysis platforms, and 3) security systems for body area sensor networks. The market for hearing devices is more mature but disruption could occur within hearables and new service delivery models. The markets of big data analysis platforms and security systems for body area sensor networks are more recent and expect stronger growth.
2. Whilst several medical applications were noted, some applications outside of the medical domain were also identified, e.g. industry for hearables and banking and business intelligence for big data analysis platforms.

3. The three commercial outcomes are related: together, the three commercial outcomes could lead to decision making tools and decision support for public health policy and hearing care as well as better performing hearing devices. The three commercial outcomes could form a very interesting combination of wearable device, secure data transfer and storage, and big data analysis to inform health prevention, early diagnosis, and monitoring. Subsequent market analysis and exploitation reports will cover the convergence of the three markets we analysed in this document.
4. For all commercial outcomes, stakeholders include patients, hospitals, and third-party payers such as Ministries of Health. Therefore, public finances and public policies will have an impact on future market size.

The target stakeholders for these three commercial outcomes overlap partly with the groups that EVOTION's dissemination activities target. Figure 7-1 is taken from the First EVOTION Dissemination Report (Sliwinska-Kowalska, 2017) and it depicts the target groups for EVOTION's dissemination activities.

Figure 7-1 EVOTION Target Groups

7.2 Future Work

Whilst the EVOTION deliverable 8.1 focuses on public dissemination, this deliverable focuses on commercial exploitation. This deliverable also collects insights of non-public nature that will be fed into the confidential *Intellectual property rights plan* for EVOTION (deliverable 8.7, due October 2019). This supports an agile mindset that positions EVOTION's maturing commercial outcomes in the best competitive position in response to ongoing market changes.

This report focused on three tangible commercial outcomes that are a natural extension to the current activities of the three EVOTION industrial partners. The following reports will readjust the scope to new submarkets of potential, including intangible outcomes such as services if relevant.

We are aware that specific tools and components of the three commercial outcomes we covered in this report could be independently exploited: the following Deliverable reports (D8.5 and D8.6) will investigate whether any specific submarket should be in focus. This could for example be a mobile application for a specific component of EVOTION.

Furthermore, the three commercial outcomes are related and could form a very interesting combination of wearable device, secure data transfer and storage, and big data analysis to inform health prevention, early diagnosis, and monitoring. This will also be considered in the following reports.

The following reports will also seek to mature the value network analyses. If this is not possible due to a lack of quantitative data available, an alternative method will be suggested. For example, the five forces analysis of business competition (Porter, 1979) might be relevant to use.

More specifically, we expect the Second Market Analysis and Exploitation Report (EVOTION Deliverable 8.5, to be available in October 2018) to include:

1. Updates to the market analysis of the three commercial outcomes presented in this report, based on ongoing market changes. The most relevant scope of each of the three commercial outcomes will be reassessed in the light of the latest market information. If necessary, the scope of any of the three commercial outcomes could be expanded or reduced to focus on the most attractive market areas.
2. Analysis of the overlapping areas between the commercial outcomes: See overlapping areas of the Venn diagram presented in Figure 2-1. This could for example be the market potential for a commercial outcome that includes all three commercial outcomes (EVOTION solution) or any other

combination of the EVOTION commercial outcomes to target submarkets of growth. This also includes more information on whether/how the combination of wearable device, secure data transfer and storage, and big data analysis could be an interesting market to inform health prevention, early diagnosis, and monitoring.

3. Market analysis of new commercial outcomes, if relevant. These could, for example be intangible outcomes such as services and programs within consulting, training, etc.

Stay tuned for the Second EVOTION Market Analysis and Exploitation Report (Deliverable 8.5) to be available in October 2018!

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