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DiversIoT

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http://its-wiki.no/wiki/DiversIoT:Home

Title:

D5.0 Dissemination and Exploitation Plan and Report

Editor(s):	Approved by:
Arnor Solberg	Project Technical Manager: Franck Fleury
	Classification: Public version

Abstract / Executive summary:

This deliverable provides an overview of the dissemination and exploitation related activities and results for the Phase one of the DiversIoT and outline the first dissemination and exploitation plan for the DiversIoT consortium. In particular we report on:

- DiversIoT web site
- Currents Publications and submissions
- Collaboration activities and events
- DiversIoT reference group/Advisory Board
- Establishment of the IoT Geminicentre with SINTEF, UiO and NTNU
- Initial publication plan
- Initial exploitation fleet number infrastructure
- Open Source proof of concept case study

We also report on a market analysis on IoT more in general and presents the individual exploitations plans for all partners.

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Version	Description	Date	Who
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1.0	Final version reviewed (internal review)		Franck Fleurey, Arnor Solberg

1 Introduction

This deliverable includes a report on performed dissemination and exploitation activities and results during Phase 1. The main objective of these has been to prepare and ensure high scientific and industrial impact of the DiversIoT project. This deliverable also includes an initial dissemination and exploitation plan, that will be evolved throughout the project lifetime. DiversIoT has established a reference group/Advisory Board, composed of industries and academics in Norway and abroad to ensure the interest and relevance of the project across academia and industry. We also report on an intial market analysis of IoT more in general as baseline for exploitation activities.

2 Dissemination and exploitation activities performed in phase 1

2.1 DiversIoT web site

We have created a website and a wiki both for internal and external communication and collaboration. The website can be explored at http://its-wiki.no/wiki/DiversIoT:Home. Here you will find some general information of the project as well as information of conducted meetings and activities and you get access to the publications related to the project

2.2 Press release

We have made the following initial press release for DiversIoT

SINTEF tell.u UiO : University of Oslo

Press release

Next generation IoT secured by DiversIoT technology

The newly started project **DiversIoT: Diversification for Resilient and Trustworthy IoT-systems** has the bold vision to make the IoT ecosystems resilient and trustworthy by diversifying IoT service implementations, enabling companies, public authorities and people to exploit and use IoT services, with low risk for privacy and security breaches and significantly reduced impact in case of cyberattacks.

Diversification to immunize IoT against cyberattacks

DiversIoT is a result of social, regulatory, and market pressures, and seeks to test, validate and propose new and innovative software development solutions for secure IoT based on the simple concept of **diversification**. In nature, diversity has been a key mechanism for resilience for all forms of life, by enabling them to evolve immunity to external threats. Resilience is the ability to be resistant (i.e., hard to harm) and the ability to recover quickly and with limited damage in case of infringes.

Enabling Industry's IoT services while protecting critical infrastructure from these

Gartner predicts that by 2020 more than 25% of the cyberattacks against enterprises will originate from the IoT. IoT vulnerabilities transform IoT devices into originators of enormous numbers of requests to targeted services. The infamous Mirai botnet was one example of attacks enabled by IoT on Internet (DNS) infrastructure around the world. Securing IoT is simply too costly for the current market.

DiversIoT software techniques will boost security and privacy compliance endeavours for existing IoT companies with little demands on their development costs because of the focus on usability and automation for the proposed techniques.

The founding partners, SINTEF, UiO, and TellU IOT, will be joined in this IoT software revolution by national and international collaborators, both prestigious academic institutions like Ecole Politechnique, KTH, or INRIA, as well as heavy industrial players in IoT like Telenor or NCE Smart Innovation Norway.

Additional information

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Figure 1 Initial Press release

2.3 Currents Publications and paper submissions

The following four papers has been accepted during the first phase of DiversIoT, Publication no 2 is an outcome of the DiversIoT survey on Diversification mechanisms:

1. **Confidentiality of Interactions in Concurrent Object-Oriented Systems.** By Olaf Owe, Toktam Ramezani. In proceedings of 12th International Workshop on Data Privacy Management (DPM 2017) Lecture Notes in Computer Science 10436, pages 19--34, Springer, 2017. Link to Authors Draft

2. **Code Diversification Mechanisms for Securing the Internet of Things.** By Shukun Tokas, Olaf Owe and Christian Johansen, to be presented in the 29th Nordic Workshop on Programming Theory (NWPT'17) on 1-3 November 2017 in Turku, Finland.
3. **Hoare-style Reasoning from Multiple Contracts.** By Olaf Owe, Toktam Ramezani, Elahe Fazeldehkordi. Accepted to 13th International Conference on Integrated Formal Methods (iFM'17) Torino, Italy, September. To appear in Lecture Notes in Computer Science 10510, pages 263--278, Springer, 2017 Link to Authors Draft
4. **Offline Trusted Device and Proxy Architecture based on a new TLS Switching technique.** By Denis Migdal, Christian Johansen and Audun Josang. Accepted to Workshop on Secure Internet of Things (SIoT 2017) held in conjunction with the European Symposium on Research in Computer Security (ESORICS 2017). To appear in IEEE (10 pages) Link to Authors Draft
5. **A High-Level Language for Active Objects with Future-Free Support of Futures**, by Toktam Ramezanifarkhani, Farzane Karami, and Olaf Owe, to be presented in the 29th Nordic Workshop on Programming Theory (NWPT'17) on 1-3 November 2017 in Turku, Finland. Link to Authors Draft
6. **Survey of Code Diversification Mechanisms for Securing the Internet of Things (long version)**, by Shukun Tokas, Olaf Owe and Christian Johansen, Technical report nr. 473, ISBN 978-82-7368-438-7, University of Oslo. Link to Authors Draft

The following papers are submitted and under review:

1. **A Modular Reasoning System Using Uninterpreted Predicates for Code Reuse.** By Crystal Chang Din, Einar Broch Johnsen, Olaf Owe, and Ingrid Chieh Yu. Under second review for Elsevier's Journal of Logical and Algebraic Methods in Programming (Norwegian level 2). (37 pages)
2. **Dynamic Structural Operational Semantics.** By Christian Johansen, Olaf Owe. Under first review for Elsevier's Journal of Logical and Algebraic Methods in Programming (Norwegian level 2). (32 pages) Link to Authors Draft
3. **Assumption-Commitment Type System for Resource Management in Virtually Timed Ambients**. By Einar Broch Johnsen and Martin Steffen and Johanna Beate Stumpf. Submitted to European Joint Conferences on Theory and Practice of Software ETAPS'18 (Norwegian level 1 Springer LNCS). (15 pages) Link to Authors Draft
4. **An Operational Semantics for a Weak Memory Model with Channel Synchronization**. By Daniel Fava and Martin Steffen and Volker Stolz and Stian Valle. Submitted to European Joint Conferences on Theory and Practice of Software ETAPS'18 (Norwegian level 1 Springer LNCS). (15 pages) Link to Authors Draft

2.4 Networking and Collaboration activities and events

We have spent significant effort and resources during the Phase one of the DiversIoT project to disseminate the project ideas and create an external network to ensure rewarding collaboration with external experts both within academia and industry and prepare for high scientific and industrial impact. The main results of this effort is presented in the following.

2.4.1 Geminicentre on IoT

As part of preparing the DiversIoT phase 1 and improve the potential impact of DiversIoT the partners from SINTEF and UiO agreed to apply for a Gemini centre on IoT. This attempt turned

out to create a lot of positive response and we were successfully awarded a Gemini centre on IoT April 26 2017 (see award in the picture below). The centre includes all the main IoT experts from the respective Gemini institutions SINTEF, UiO and NTNU. About 50 experts are associated to the centre, and we organised a kick off meeting August 28 2017 with about 30 participants.

The centre is lead by Arnor Solberg (the project leader of DiversIoT), with the following persons in the operational management team:

o Research manager Arnor Solberg, SINTEF (leader of the centre)

o Research Director Bengt Holter, SINTEF

o Prof Josef Noll, UiO/ITS

o Prof Olaf Owe, UiO/IFI

o Prodekan Forskning IE, Professor Bjarne E. Helvik (NTNU)

o Assoc. Professor Frank Alexander Kraemer (NTNU/IIK)

Figure 2 Gemini centre award diploma

In the context of DiversIoT we will exploit this Gemini centre to disseminate results, collaborate with other IoT experts and get comments and feedback on our achivements.

2.4.2 Workshops and events

To build network and disseminate the DiversIoT project ideas and initial results we have organized a set of meetings and events:

- During the ETAPS conference 22-29 April 2017 at Upsala in Sweden we organized a DiversIoT meeting with Uli Fahrenberg (Ecole Politechnique Paris, France) and Gerardo Schneider (Chalmers, Sweden), where DiversIoT was presented and discussed.
- We organised a DiverseIoT open workshop on IoT May 8 at UiO with 9 participants
- SINTEF did a one week visit to one of the most recognized research team on diversification of Software, the Diverse Team at INRIA, Rennes France (dates) to dicuss DiversIoT ideas.
- We organized a set of meetings to discuss relevant DiversIoT papers and talks that was conducted at conferences that we attended. In particular the The ACM SIGCHI 2017 Conference on Designing Interactive Systems (in Edinburgh, UK), 7th oCPS PhD school on Cyber-Physical Systems (2017 in Lucca, Italy), and The UX of IoT: Unpacking the Internet of Things.

2.4.3 DiversIoT reference group/Advisory Board

We have created a DiversIoT Advisory Board with people coming from both academia and industry. The following assignment has been agreed by the set of persons in the Advisory Board:

I hereby confirm that <person, affiliation/company> has accepted to take part in the IKTPluss DiversIoT project Advisory Board. I will follow the project in terms of their activities and achievement and will provide feedback to these, in particular by participation in invited DiversIoT Advisory Board meetings.

The DiversIoT Advisory Board consists of the following:

1. **Prof. Olivier Barais,** Université de Rennes 1 (France). Leading the DiverSE group (Diversity-centric software engineering) at INRIA (100+ pubs)**.**
2. **Prof. Dieter Gollmann,** Technische Universität Hamburg-Harburg, Germany and Nanyang Technological University, Singapore. International expert in Computer Security (120+ pubs.).
3. **Prof. Benoit Baudry,** Wallenberg Autonomous Systems and Software Program at Royal Institute of Technology (KTH) (150+ pubs)
4. **M.Sc. Amund Lundegaard,** Senior Advisor eHealth at Telenor Norway
5. **Dr. Judith Rossebø,** Cyber Security Specialist, ABB Chemical, Oil & Gas,
6. **Prof Sven Schewe,** University of Liverpool, reactive systems and development of safety-critical systems (80+ pubs)
7. **Ass.Prof. Frank A. Kramer,** coordinator of the NTNU Internet of Things Lab, working in the interdisciplinary research group for Autonomous and Adaptive Sensing (70+ pubs)
8. **Dr. Heidi Tuiskula,** Coordinator of Research & Innovation in Smart Innovation Norway, a large Cluster of Expertise with high focus on applications of IoT (services and business).

2.4.4 Open Source

The DiversIoT results will to a large extent be validated through open source implementations of both tools and demonstrators. The proof of concept case study developed in the phase 1 of the project is available as open source (https://github.com/SINTEF-9012/diversiot-poc)

During phase1 we have also developed a research experiment workbench that provides a set of services and features to support setting up DiversIoT Diversification experiments. This workbench is based on the ThingML open source project (https://github.com/TelluIoT/ThingML).

3 Impact, Dissemination and exploitation plan

3.1 Intial Dissemination plan, scientific impact

The project will interact with IoT end-users, in particular through interactions with the Advisory Board as well as public authorities like Forbrukerrådet and Datatilsynet. The goal is to raise the awareness of a large audience and public authorities on the potential security and privacy flaws of the current IoT, and inform about solutions being developed to address these issues. New courses at UiO (Master student level) will be provided, transferring knowledge the IoT security and privacy challenges as well as means to address them.

The technical results developed in this project will be released as open-source on GitHub, and we will leverage the social network support from GitHub to disseminate the results among international development communities. Furthermore, we will directly publish the software libraries and tools as built packages, images or applications on mainstream repositories such as Maven Central, the Docker Hub, easily available for developers. Beyond the source code, a set of tutorials and getting-started guides will also be elaborated to rapidly get external users started with the technologies.

The project will also arrange annual seminars with the Advisory Board and others, and publish articles targeting large audiences like Teknisk Ukeblad and Gemini, in addition to publishing in reputed scientific journals. The project members will attend technical and scientific conferences and disseminate the project by presentations and posters. At least 27 papers will be published including at least 9 scientific journals papers.

The following venues will be targeted:

ETAPS Joint Conferences, ICSE, MODELS, SEFM, HotSPOT, CCS and AsiaCCS, IEEE S&P and EuroS&P, CSF, USENIX, NDSS. Our top results will target journals s.a.: SoSyM, ACM-TOSEM, IEEE Trans. Softw. Eng., IEEE Software, JLAMP, Elsevier SCP. We will continue to attend and contribute to cross-disciplinary conferences, workshops and seminars, in order to reinforce the ethnographic aspect of DiversIoT, such as: ACM-DIS, UX for IoT, ACM-MobileHCI.

3.2 Initial exploitation plan, Industrial impact

IoT represents a great opportunity but also a threat for the Norwegian industry, which will be accountable for the protection of personal data collected from IoT systems. The project will interact closely with the Norwegian industry to raise the awareness about security and privacy issues related to the IoT, for example through regular interactions with industry partners in the DiversIoT Advisory Board and in projects that we are collaborating with (e.g., IoTSec)

In general, succeeding with DiversIoT concept has the potential to accelerate the adoption of the IoT domain, by improving IoT resilience and trustworthiness and lowering the risks of massive-scale IoT-driven cyber attacks infringes. This again will enable the full potential of IoT systems in the future digitalised society. In particular DiversIoT we plan to:

- Approach some selected application domains where security is of main concern and where we believe DiversIoT can have significant impact. In particular we will first approach the eHealth domain with the DiversIoT partner TellU, where the TellUCloud eHealth platform will be applied to validate the DiversIoT results. The eHealth domain has particularly stringent requirements in terms of safety, privacy and security, which

makes it proper for the DiversIoT validation. We also plan to approach the Industry4.0 domain coupled to the EU Excel project Productive4.0 where both SINTEF and TellU are partners. In general DiversIoT has potentially great impact on a wide range of other industry sectors as well such as SmartGrid and ITS for which security and privacy are major concerns. This will be measured by assessing the applicability and importance of proposed solutions by members in the Advisory Board representing various domains.

- Provide mechanisms and tools that have wide applicability across different existing and upcoming IoT hardware and software platforms, by leveraging abstraction and platform independent programming models. This will be measured by applying the solutions to a large number of heterogeneous IoT platforms and devices.
- Be compatible with software best practices ensuring agility, short time to market and cost efficiency. This will be validated by measuring the impact related to such key properties when introducing diversification in modern software engineering practices, and by evaluating the resource consumption of the run time monitoring and forensics analysis.

3.3 Individual exploitation plans

THIS SECTION IS PARTLY REMOVED AS IT INCLUDES CONFIDENTIAL INFORMATION

3.3.1 SINTEF

SINTEF as a large independent research organisation in Europe it is significant to be recognised for excellent research and for delivering validations of its research, for example, in terms of reference implementations and open source projects as well as building communities, and contribute to standardization. SINTEF will exploit the achievements of DiversIoT to increase its reputation on research for safe and secure IoT systems and provide validation in terms of reference implementations and open source software. Through this SINTEF will seek to Acquiring new R&D projects in competitive R&D project calls both in Norway and in EU. Moreover, SINTEF will provide new and improved lectures and courses conducted by SINTEF employees at Universities based on advances in the SoTA developed in DiversIoT as well as transfer of knowledge, tools and training to companies interested in adopting the DiversIoT technologies. SINTEF will also seek to build and reaching open source communities around the DiversIoT results.

3.3.2 UiO

University of Oslo (UiO) leads the largest national research initiative in security for the Internet of Things, IoTSec.no. Together with industry we are building the National Smart Grid Security Centre, where we transfer the security- and privacy-research on IoT into solutions for industry. This application-oriented approach has provided UiO with a broad network of industrial partners. These partners contribute already today with 5 industrial PhD positions. We expect that DiversIoT will extend the national activities into international importance, and thus contribute to higher impact of UiO research. UiO has a series of courses on security for industrial systems and IoT-systems, which is the basis for Master- and PhD-education. Through DiversIoT we expect to become even more attractive to the best researchers. Our medium-term perspective is to transfer the collaborative research into a Centre for Research-based Innovation (SFI). Such an SFI will generate national funding and bring a substantial increase of the number of scientific positions in the area of measurable security to UiO.

3.3.3 TellU

THIS SUB-SECTION IS ENTIRELY REMOVED IN THE PUBLIC VERSION OF THIS DELIVERABLE

4 Market analysis

To analyse the opportunities for exploitation of DiversIoT technologies and methodology we have investigated and provided an initial market analysis of the IoT market in general. The market analysis is partly based on a market analysis performed in the EU FP7 HEADS project where SINTEF was a coordinator. Software AG was a main contributor to the market analysis.

With the digitalisation of the society and new laws and regulations such as the GDPR, we believe security, privacy and trustworthiness will be main diffentiating factors in general in the IoT market. Thus, we believe that DiversIoT have exploitation opportunities in the general IoT market in the years to come and when this market matures and becomes an integrated part of the societies digital infrastructures

The IoT market is an extremly fast growing market with respect to number of devices and size of data. Market research expects the Worldwide revenue generated by 2020 to exceed $1 trillion where more than half will be earned through managed, about 40% through Network Services and Management and about 5% through hardware enablement (cf. Figure 1 below).

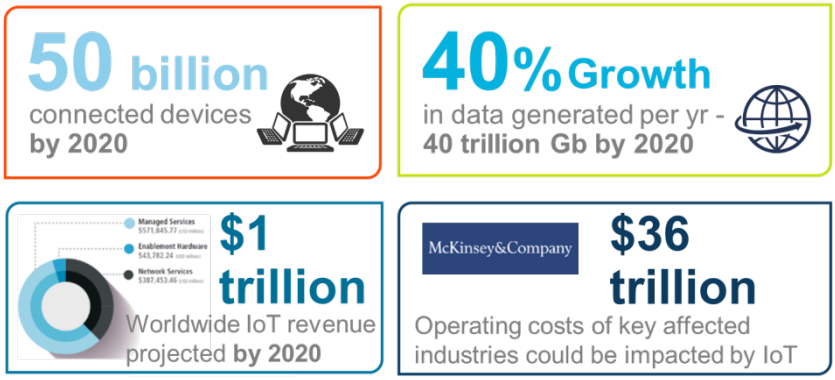

Figure 3 Facts about Worldwide IoT Market

When looking on a regional breakdown of this figure it becomes apparent that revenues will steadily increase. The Asian-Japan market will experience the largest growth exceeding €670 billion by 2025 followed by EMEA (Europe, the Middle East and Africa) and the North American market. Germany will lead the EMEA market with €65 billion throughout 2025 followed by UK and France.

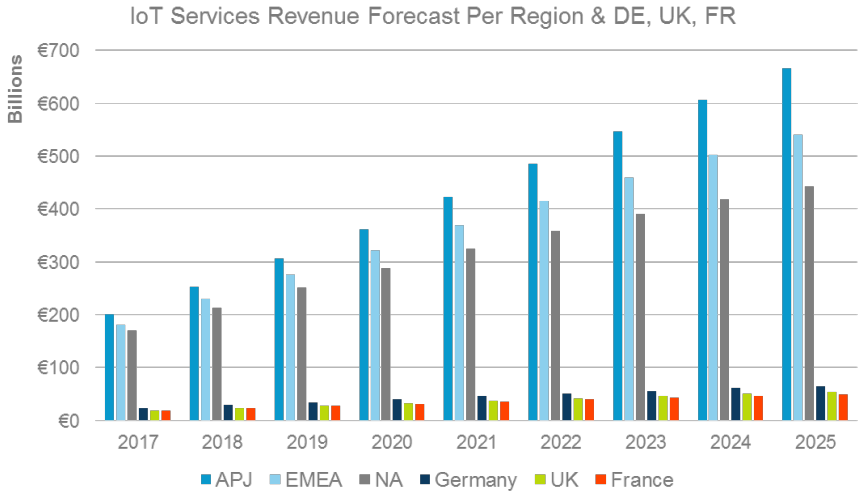

Figure 4: Market Analysis -- Regional Breakdown [Gartner, BCG, IDC, Project Work 2025, 2017]

From customer's perspective services around IoT, IoT applications and Analytics will capture around 60% of IoT spending. Fields are clearly dominated by IoT services, IoT Applications and Connected Things – all within focus of the DiversIoT.

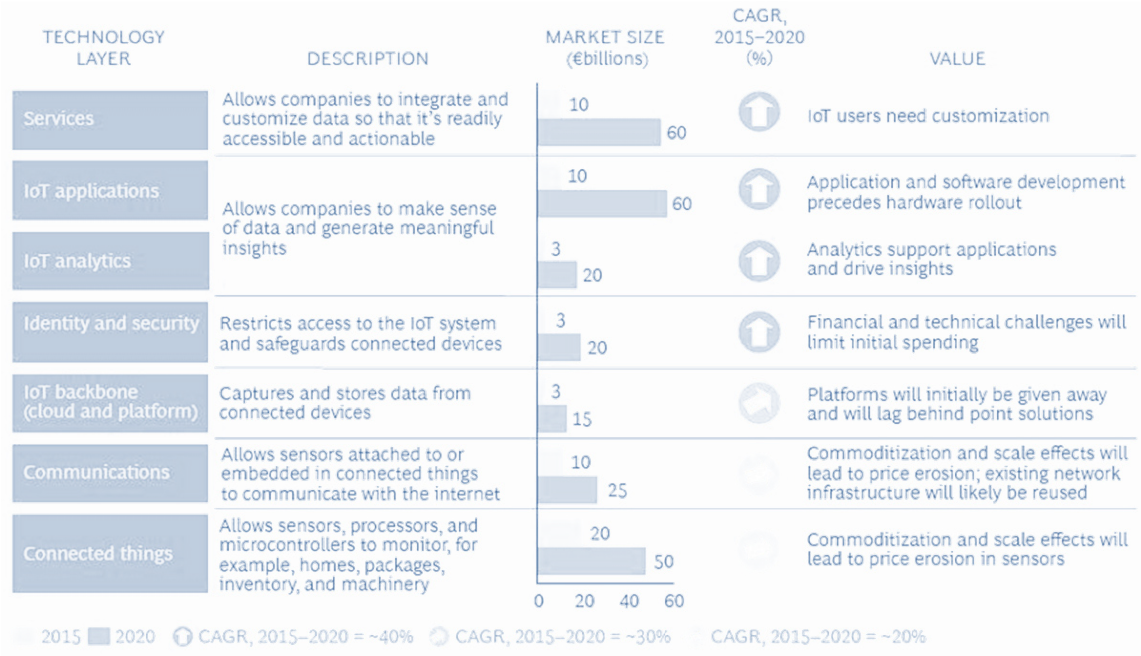

Figure 5 Distribution of Spending among Services and IoT Applications and Analytics[1]

[1] IDC, Gartner, ABI Research, BCG Internet of Things buyer survey, expert Interview, BCG analysis, 2017

The IoT platform market boomed in 2013 driving business opportunities for potentially 25 billion things connected to the Internet in less than five years from today as stated in Gartner's research report [IoT-Analytics 2016].[2] This section aims to provide an overview of this vibrant fast-paced market. The analysis considers the currently most extensive IoT database, a collection of more than 360 IoT platform providers. The topic Complex Event Processing (CEP) evolved to Streaming Analytics, which is often used when larger volumes of data are analysed. For this reason, only the term Streaming Analytics is used in the following text parts and subchapters. The market for Streaming Analytics will be also analysed in this section. The analysis highlights similarities and differences among countries, companies, technologies, and industrial sectors.[3] Subsection 2.1.1 Competitive Rivalry is organized as follow:

- The evolution of the IoT platform market and Streaming Analytics
- Regional markers of IoT market and Streaming Analytics
- Segments in the IoT market and Streaming Analytics
- Technologies alongside IoT platforms and Streaming Analytics
- Magic Quadrant for IoT platform providers and Streaming Analytics

The following graphic will show the evolution of the IoT platform market. It describes the number of IoT platforms launched per year.

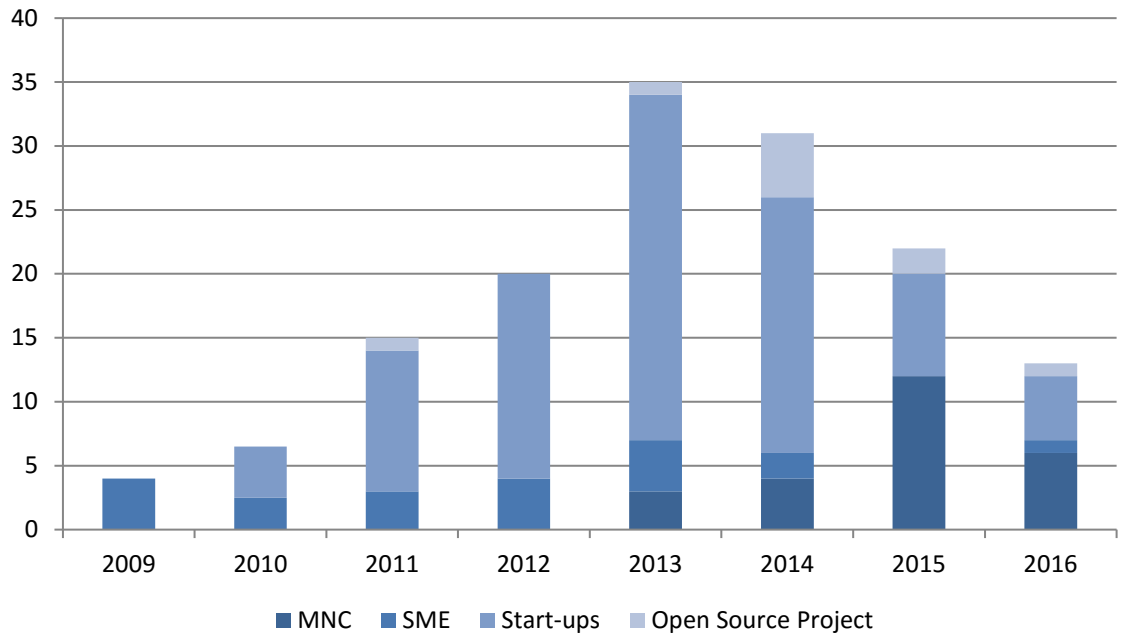

Figure 6 Worldwide focus on the number of IoT platforms launched on the market per year [Source IoT Analytics]

Figure 4 is divided into four categories of companies and examines the demographic market segmentation. The categories are MNC (Multinational Corporation), SME (Small and Medium-

[2] http://www.gartner.com/newsroom/id/3165317.

[3] D03_01_WP02_H2020_UNIFY-IoT_Final.pdf P.19 ff.

sized Enterprises), Start-ups and Open Source Project. The IoT market evolved and advanced over the last ten years and will continue to expand in the years to come. Figure 4 provides insights into the evolution of the IoT platform market. Information related to launching IoT platforms tells us that a small number of IoT platforms have been emerging since late 2000 and that this market experienced a significant boost during the last few years. While in 2009 the most relevant companies in the IoT platform markets were SMEs, the percentage in the following years decreased until 2013 when IoT began to face a higher level of industrial interest. In fact 70% of platforms in the worldwide scenario are operating only since 2013.[4]

Figure 5 visualizes the market size and market growth of Streaming Analytics in percent (0-100%). The figure is split into five regions. The regions are North America, Asia Pacific, Europe, Middle East Africa and Latin America. Furthermore the chart describes the percentage distribution between 2013 and 2018.

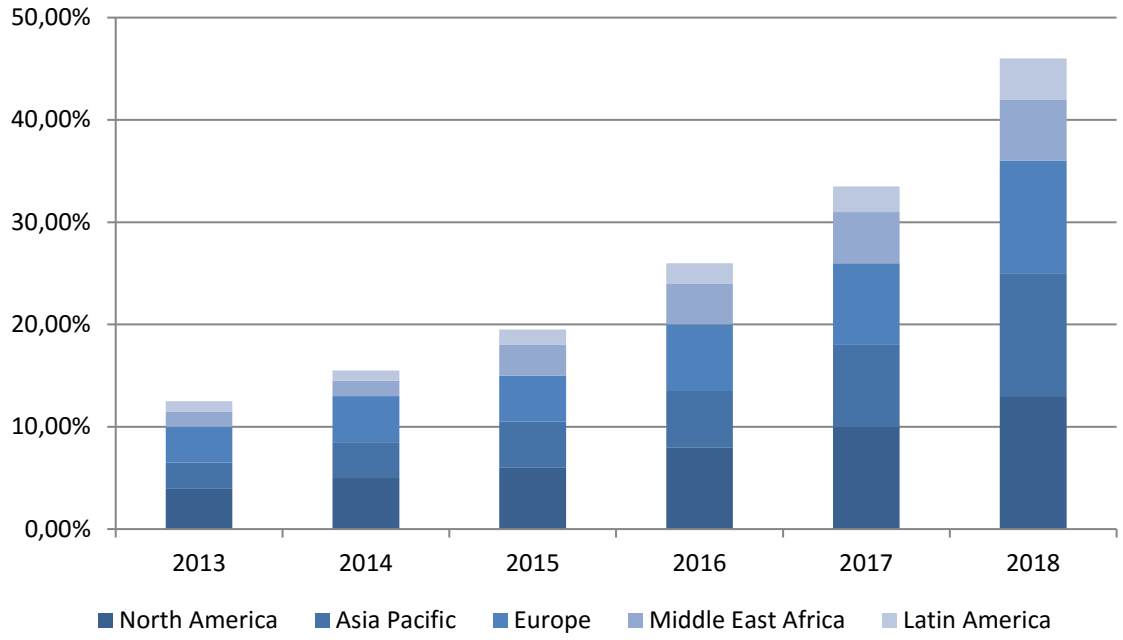

Figure 7 Streaming Analytics: Market size and market growth [Source MarketsandMarkets Analysis]

Figure 5 displays the market growth of Streaming Analytics between 2013 and 2018. There is a consistent growth in all regions. The market size for Europe in million $ starts 2013 with 224.1, 2014 with 277.0, 2015 with 344.7, 2016 with 436.2, 2017 with 562.2 and 2018 with 734.9.[5] For more information about market size in other regions please find Table 1 below this text.

[4] D03_01_WP02_H2020_UNIFY-IoT_Final.pdf P.19 ff.

[5] WP_CEP-Market-Forecast-and-Analysis-2013-2018_2014-05-12.pdf P. 36 f.

Streaming Analytics market	2013	2014	2015	2016	2017	2018	CAGR (2013-2018)
North America	268.3	339.6	432.5	558.4	730.9	977.7	29.5%
Asia Pacific	134.9	191.3	273.4	395.5	581.3	871.3	45.2%
Europe	224.1	277.0	344.7	436.2	562.2	734.9	26.8%
Middle East and Africa	91.5	123.6	169.9	237.9	337.0	492.1	40.0%
Latin America	45.7	62.4	85.5	119.8	170.4	246.1	40.0%
Total Value	**764.5**	**994.0**	**1,306.0**	**1,747.9**	**2,382.0**	**3,322.0**	**34.2%**

Table 1 Streaming Analytics market size [Source MarketsandMarkets Analysis]

Figure 6 visualizes the current distribution of the different types of companies all over the world. This graphic describes how the market is shaped and how innovation can be supported by comparing these areas. The different colours describe the company type. Inside Figure 6 are five company types included which are Non-profit (red), Open Source Project (blue), MNC (pink), SME (green) and Start-up (yellow). The size of each circle determines the Number of IoT platforms. As the volume increases, the Number of Records increases.

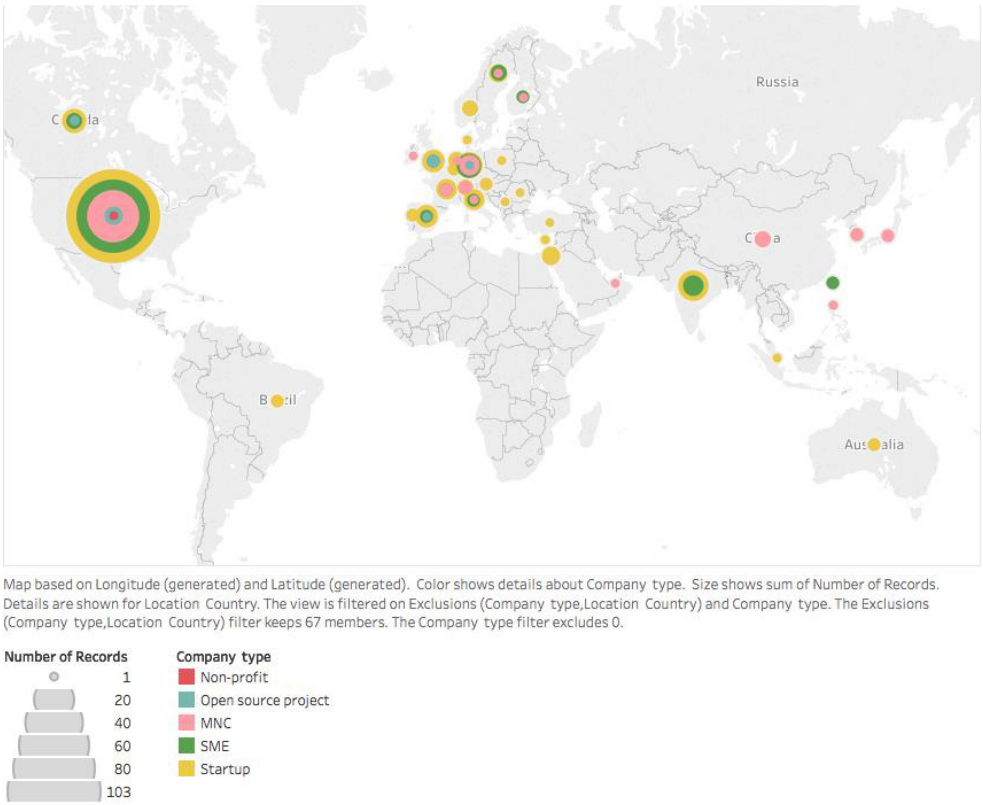

Figure 8 Global distribution of different type of companies [Source D03_01_WP02_H2020_UNIFY-IoT_Final.pdf P.21].

Figure 6 highlights that US and European markets have the most diverse ecosystem in terms of different company types. Other regions such as Australia, Brazil, Canada, India, Israel, Korea, Philippines, Singapore, Taiwan, and United Arab Emirates, are increasingly taking part in the IoT market. "However, differently from these countries, China, Korea, Japan, Philippines, and United Arab Emirates IoT market are dominated by multinational companies, which include more than 10 thousand employees and/or are publicly listed ones."[6]

The third part of this subchapter contains the segments in the IoT and Streaming Analytics market. First, the IoT market will be analysed. Figure 7 describes the existing segments split into two high level groups, Business to Business (B2B) and Business to Consumer (B2C). "The B2C products include segments such as Health, Home, Lifestyle, and Mobility; the B2B products include a larger variety of segments such as Energy, Health, Mobility, Manufacturing/Industrial, Public sector and services, Retail, Smart City, and Supply Chain."[7] Figure 7 visualizes the worldwide focus on the IoT segments covered in the current IoT Industry. The proportion IoT platform targeting B2B and generally all segments on the market is considerable higher than the proportion of the B2C segments that include applications for consumers related to health, lifestyle, and mobility. The chart below this text describes an increased focus on B2B applications with predominance for Manufacture and industry,

[6] D03_01_WP02_H2020_UNIFY-IoT_Final.pdf P.21 f.

[7] D03_01_WP02_H2020_UNIFY-IoT_Final.pdf P.23 ff.

Mobility, and Smart cities. "Other similarities among the global and the European market include the Business-to-Consumer sectors with particular regard to the Smart Home."[8]

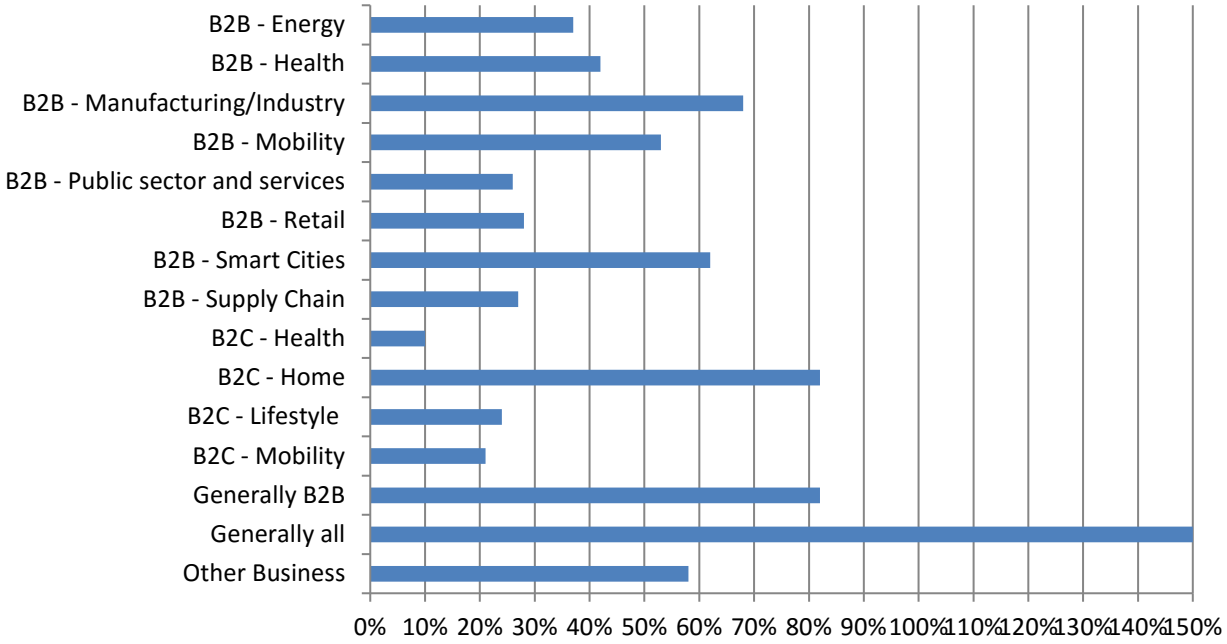

Figure 9 Global description of number of IoT platform for the different segment – each platform can cover different segments, with the exclusion of generally all. [Source D03_01_WP02_H2020_UNIFY-IoT_Final.pdf P.24]

The market segmentation for Streaming Analytics is organized by types, verticals, professional services and regions. Market size and growth have already been described earlier in this chapter. This section deals with the verticals and which parts they include. Figure 8 visualizes the verticals in form of an organigram.

[8] D03_01_WP02_H2020_UNIFY-IoT_Final.pdf P.24.

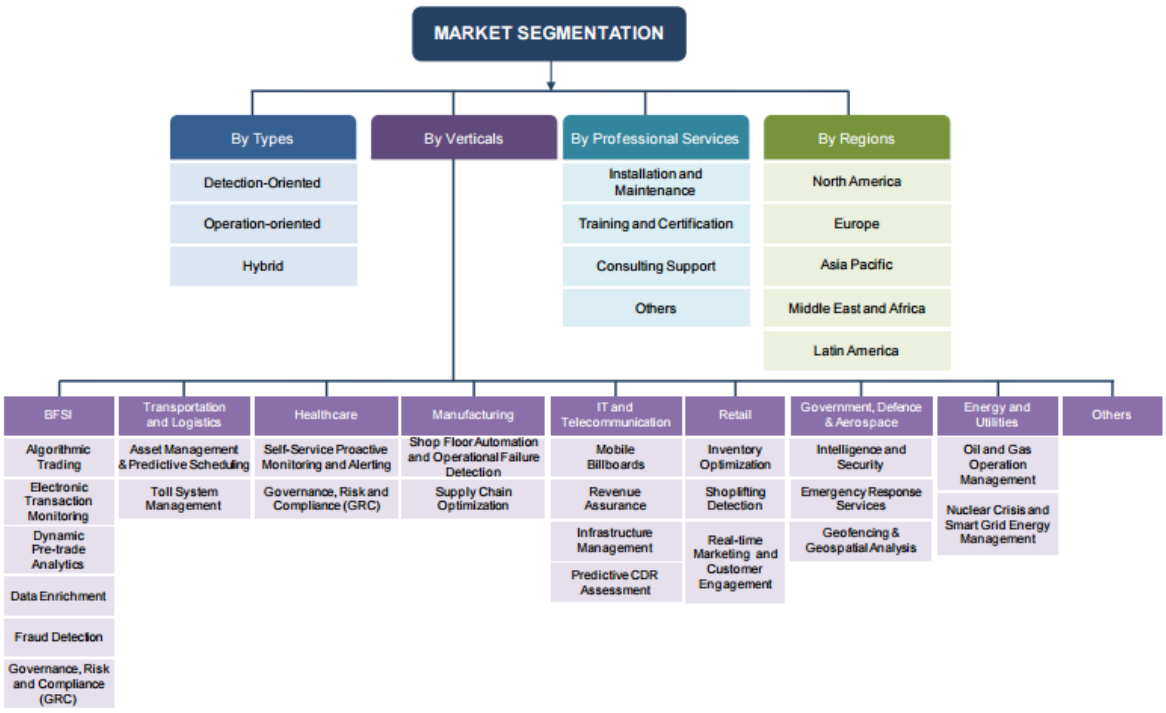

Figure 10 IoT Streaming Analytics: Market segmentation [Source MarketsandMarkets Analysis]

The following section describes which kind of additional technologies the IoT platform is currently focusing on and which professional services inside Streaming Analytics exist. The IoT market can be separated into ten supporting technologies. These ten supporting technologies are Analytics, Communication hardware, Communication protocols, complete device, Database, Developer tools, Operating systems, other hardware, other technology focus, Processors and semiconductors, and Sensors. The supporting technologies will be visualized in Figure 9 with their worldwide percentage distribution.

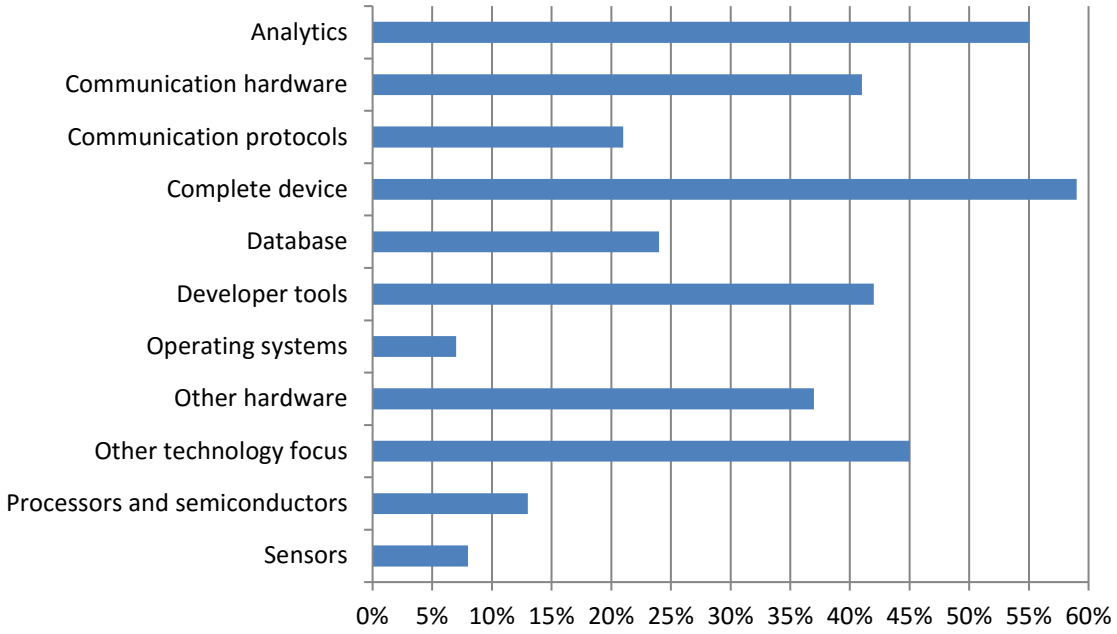

Figure 11: Global description of technologies that complete and enhance the production of IoT platforms. [Source D03_01_WP02_H2020_UNIFY-IoT_Final.pdf P.26]

45% of the companies active in the IoT market are focusing only in developing IoT platforms. However the remaining 55% offer alongside their IoT platforms other related IoT technologies.[9]

The next section of this subchapter is analysing the market size of the professional services which the Streaming Analytics market vendors provide. The part of professional services contains four services. These four services are installation and maintenance, training and certification, consulting services and other professional services. Table 2 highlights the market proportion across various services in million $.

Services	2013	2014	2015	2016	2017	2018	CAGR (2013-2018)
Installation and Maintenance	34.5	44.2	57.3	75.5	101.2	138.9	32.1%
Training and Certification	15.1	20.0	26.5	35.7	49.3	69.4	35.6%

[9] D03_01_WP02_H2020_UNIFY-IoT_Final.pdf P.25 f.

Services	2013	2014	2015	2016	2017	2018	CAGR (2013-2018)
Consulting Services	22.7	30.5	41.5	57.5	81.0	116.9	38.8%
Others	11.8	14.6	18.4	23.5	30.5	40.2	27.8%
Total	84.1	109.3	143.7	192.3	262.0	365.4	34.2%

Table 2 Streaming Analytics: Services, market size [Source MarketsandMarkets Analysis]

The services market is expected to grow from $84.1 million in 2013 to $365.4 million in 2018.[10]

The last part of this subchapter is focusing the vendors at the IoT and Streaming Analytics market. Figure 10 shows the distribution of the benchmarked IoT platform providers. Figure 11 describes the distribution of the Streaming Analytics market.

[10] WP_CEP-Market-Forecast-and-Analysis-2013-2018_2014-05-12.pdf P. 63.

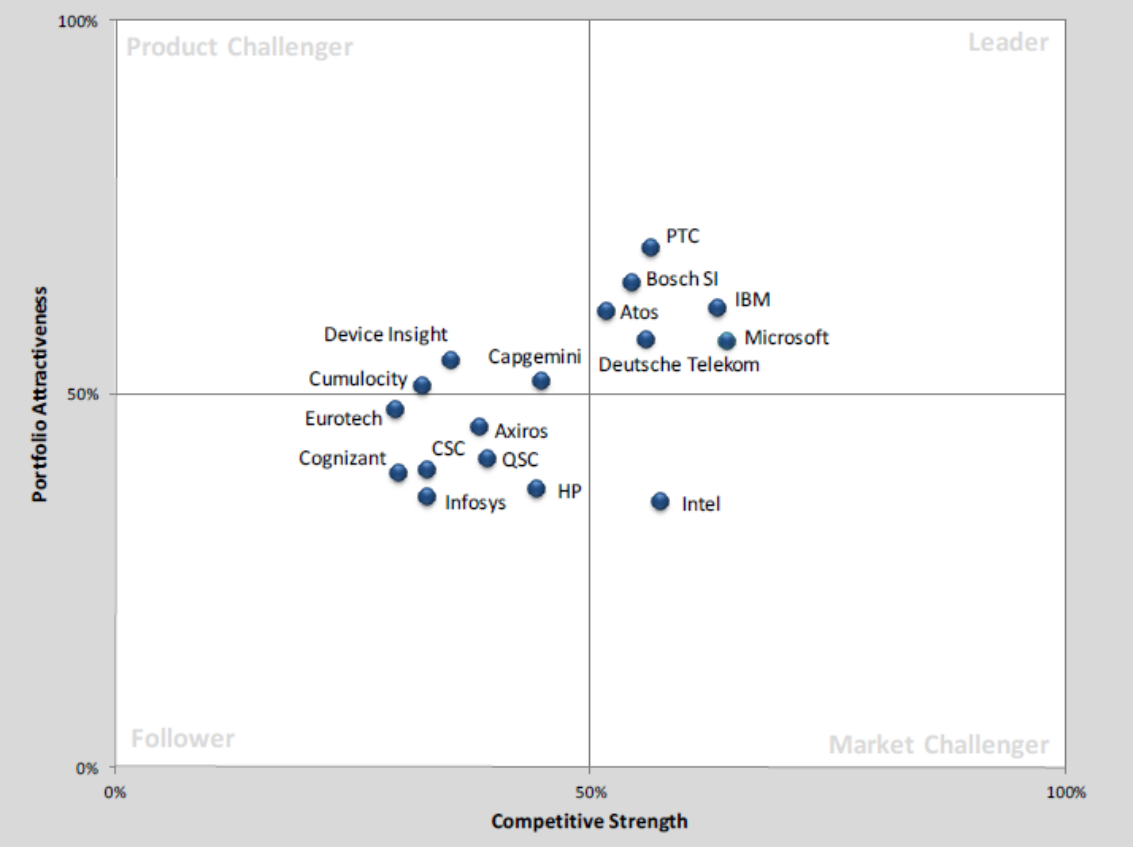

Figure 12 Magic Quadrant for Benchmarked IoT platform providers [Source Experton Group 2015]

The following six IoT platform providers were able to reach the Leader quadrant: Atos, Bosch SI, Deutsche Telekom, IBM, Microsoft and PTC.[11] Atos' "Connected Living Enabler" IoT platform is a very advanced platform with huge potential. The provider has realized rather early that a specific IoT/I4.0 business unit is required and that it is also important to invest into the development of dedicated IoT business models. The Bosch IoT Suite is based on a combination of acquisitions and in-house developments of Bosch Software Innovations. Bosch wants to position itself as IoT/I4.0 "lead user" and, with the Bosch SI business unit, also as IoT/I4.0 "lead provider" in the market. Deutsche Telekom's "Connected Industry / DT IoT Platform" is a highly performant, modular end-to-end solution. IoT platforms are a topic where Deutsche Telekom can leverage its very own local strengths under performance, security and connectivity considerations, whereas thought leadership and ecosystem for their own IoT platform can still be improved. IBM is another strong player in this market segment and can add various strengths to its "IoT Foundation" IoT platform, such as its excellent analytics/big data expertise and application development in the Blue Mix IoT Zone. Microsoft's great strength, besides the actual platform, is the vendor's ecosystem. No other vendor can provide such a strong developer and ISV ecosystem as Microsoft on its Azure Cloud. Under portfolio aspects, PTC with its

[11] WP_Experton-Group_IoT-Vendor-Benchmark_EN.pdf P. 17.

Thingworx IoT platform can be regarded as the leader in this market segment who has secured a strong starting position through the acquisition of Thingworx in 2013 and Axeda in 2014.[12]

Figure 11 visualizes the Forrester Wave of Streaming Analytics market. The graphic is from Q1 2016 and describes the strengths and weaknesses of the market participants. The strategy is analysed on the horizontal axis and the current offering is displayed on the vertical axis. Moreover the diagram is separated into four market types. The four types are Challengers, Contenders, Strong Performers and Leaders. The Forrester Wave includes 15 platform providers with different market presentence.

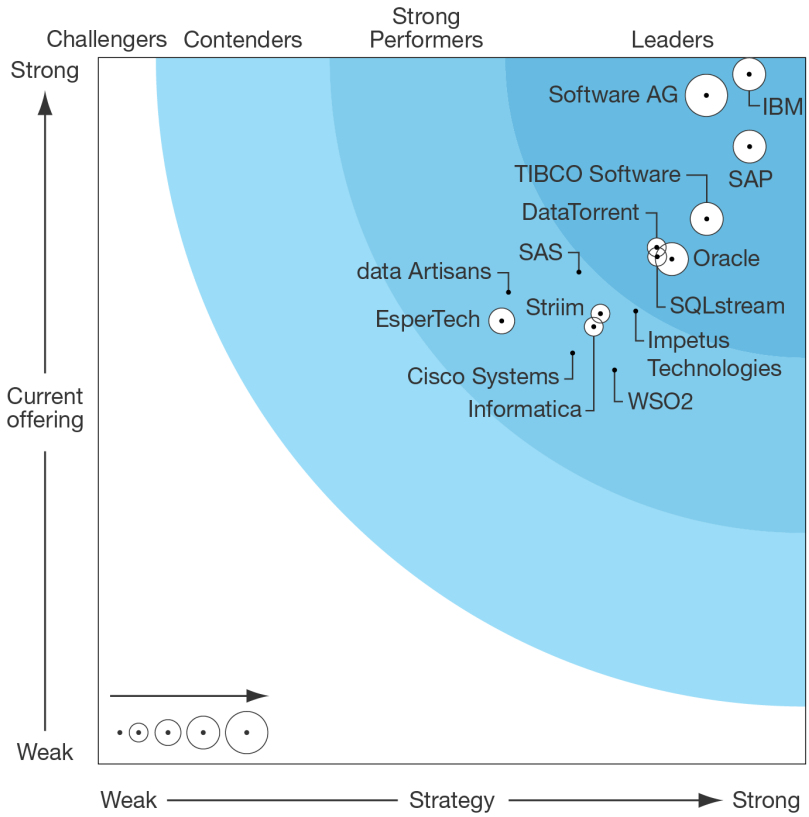

Figure 13 Forrester Wave for Big Data Streaming Analytics market [Source The Forrester Wave™]

As you can see in Figure 11, Software AG is positioned as a Leader with a strong market presentence. The Software AG product used at Streaming Analytics market is APAMA. Apama Streaming Analytics is a market-leading platform for companies to continuously analyse data streams to derive intelligent, automated actions.

Figure 12 visualizes the distribution of vendors at the Streaming Analytics market of the year 2016. The graphic below is divided into the three groups Champions, Challengers and Innovators. Furthermore Figure 12 is organized by different colours which describe the type of the streaming Analytics vendor. There exist five types Stream Processing Enterprise (green), Stream Processing Pure play vendor (blue), In memory database plus streaming (red), In

[12] WP_Experton-Group_IoT-Vendor-Benchmark_EN.pdf P. 17 ff.

memory data grid plus streaming (orange) and Cloud streaming Analytics (purple). Software AG is positioned as a Champion of Streaming Processing Enterprise.

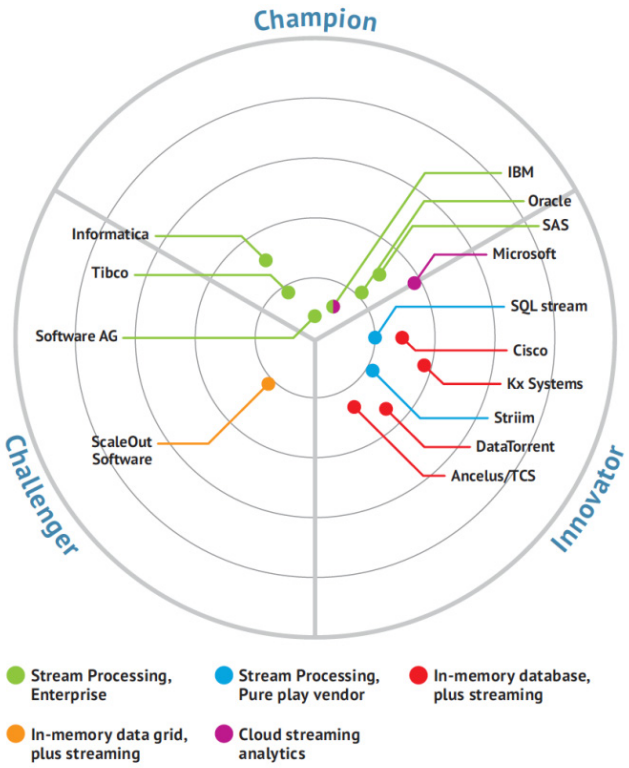

Figure 14 Vendor Landscape for Streaming Analytics market [Source Streaming Analytics 2016]

4.1.1 Threat of Substitutes

This subchapter examines the substitute products which threaten the industrial product. The analysis of IoT platforms and streaming analytics is presented below. On the IoT platform market there is a moderate threat due to the relatively high number of IoT platform providers, as can be seen in Figure 10 above.

Threats of substitutes existing within the IoT market include: High cost of licenses, maintenance and support. In addition, threats may be due to poor quality and performance of the IoT platform.

4.1.2 Threat of new entrants and entry barriers

The Threat of new entrants and entry barriers analyses if it costs little in time or money to enter the market and compete effectively, if there are few economies of scale in place, or which entry barriers exist, in order to looks at the power of the consumer to affect pricing and quality.

At first the IoT platform market will be analysed. By 2013, there was a strong growth up to 35% in introducing new IoT platforms worldwide. However, this trend is declining and is estimated to be slightly above 10% in 2016 as in subchapter Competitive rivalry Figure 4 described. In Europe, growth looks similar. As in the rest of the world, the percentage value of launched IoT platforms will grow rapidly by 2013. 2016, however, the trend is losing enthusiasm and falls to just under 7%. A reduction in new IoT platforms can be expected.

4.2 IoT Market Analysis on Long-Run

When looking on the on the upcoming years, figures confirm experience made through the market analysis done in the previous section. Also interviews assessed with decision makers confirm this trend.

On the question "Which of the following areas has been identified as a significant driver for organisations' Internet of Things (IoT) initiatives over the next 24 month" they report that operation costs are currently too expensive (38%). More than 35% claim that better customer service and support is essential to further drive their business and expansion policies (cf. Figure 15 below). In addition one quarter of European Enterprises will be adopting their IoT technology foundation in the near term.

Figure 15 Significant drivers for company's IoT initiatives for the next 12 to 24 month[13]

I turned out that the majority of IoT investments are made by enterprises at more than 85% of forecasted spending (vs. customer). When looking at worldwide application areas however IoT is not limited to enterprises but also partially enters home and end-consumer markets. Here use cases which are expected to obtain the largest spending growth are Smart Home (not limited to home automation), Connected Vehicles, environmental monitoring, smart buildings and remote health monitoring (c.f. Tellu Use Case) with 17.6%.

[13] IDC 2016 Vertical IT & Communications Survey, IDC, May 2016

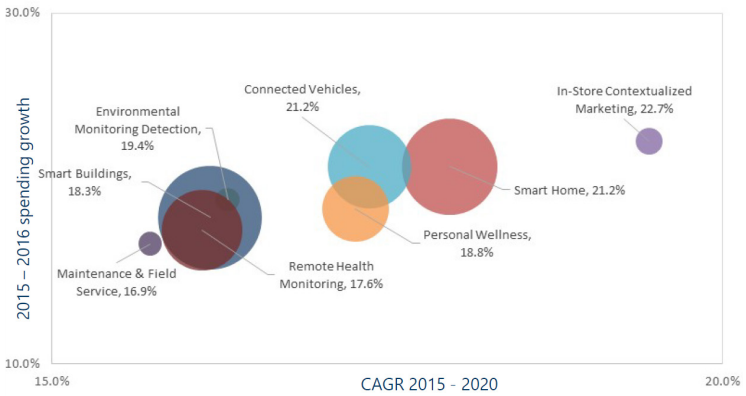

Figure 16: Worldwide Top Ten Fastest growing Application Areas for IoT[14]

According to [22] IoT technology investments will reach %1.29 trillion in 2020 and is distributed as follows:

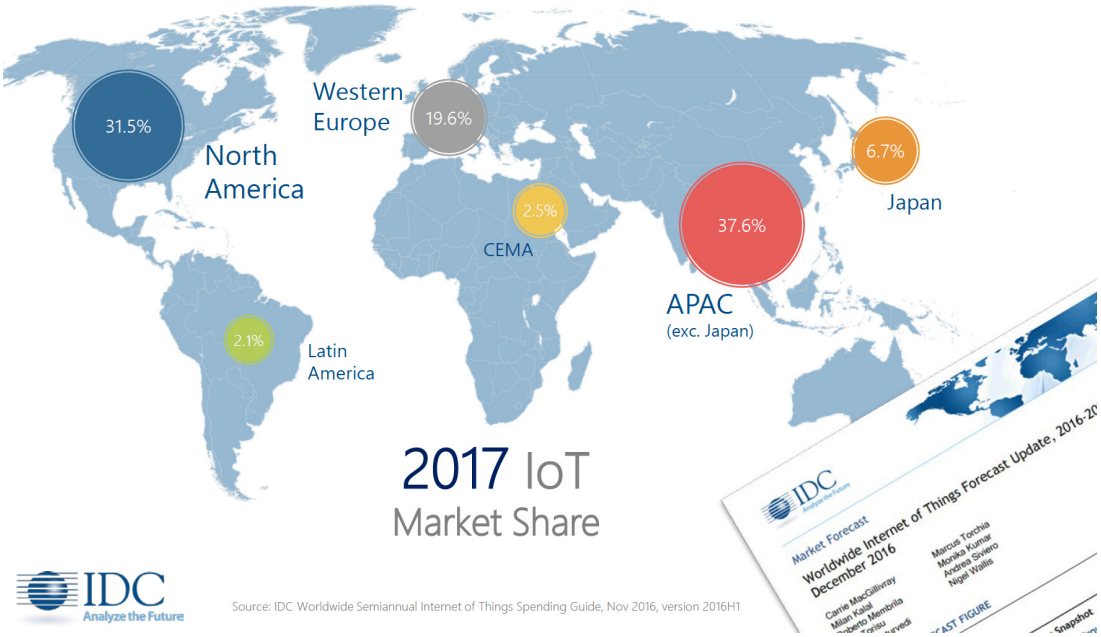

Figure 17 2017 IoT Market Shares[15]

When considering the EMEA (Europe, the Middle East and Africa) market is expected to exceed for Western Europe 19.6% of worldwide spending and CEMA around 2.5%. The study reports, that the following four use cases have been identified as drivers for future spending

[14] IDC 2016 Vertical IT & Communications Survey, IDC, May 2016

[15] IDC 2016 Vertical IT & Communications Survey, IDC, May 2016

- Freight Monitoring represents the leading UC for spending in EMEA
- Manufacturing Operations follows, fueled by Germany's Industrie 4.0 scenario
- Smart Grid in Utilities, driven by a widespread smart meters deployment, is under the spotlight
- Legislation driving Smart Buildings and Connected Vehicles investments in the near future