Challenges and Opportunity in Internet of Things (IoT)

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Abstract— The Internet of Things continues to develop, further potential is estimated by a combination with related technology approaches and concepts. Such as Cloud computing, Future Internet, Big Data, robotics and Semantic technologies. The idea is of course not new as such but becomes now evident as those related concepts have started to reveal synergies by combining them. However, the Internet of Things is still maturing, in particular due to a Number of factors, which limit the full exploitation of the IoT Overcoming those hurdles would result in a better exploitation of the Internet of Things potential by a stronger cross-domain interactivity, increased Real-world awareness and utilization of an infinite problem-solving space. Here the subsequent chapters of this will present further approaches and solutions to those questions.

Key words: Cloud Computing, IoT

I. INTRODUCTION

The internet of things (IoT) is expected to be the next revolution following the World Wide Web. It will provide new bridges between real life and the virtual world. The internet will no longer be merely a network of "human brain ", but will integrate real life objects, sensors and physical activities. The internet of things is defined by ITU and IERC as a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where the physical and virtual "things" have identities ,physical attributes and virtual personalities ,use intelligent interfaces and are seamlessly integrated into the information network. Over the last year, IoT has moved from being a futuristic vision –with sometimes a certain degree of hype-to an increasing market reality. The EU has already for some time invested in supporting research and innovation in the field of IoT, notably in the areas of embedded systems and cyber-physical systems, network technologies, semantic interoperability, operating platforms and security, and genetic enablers.

"Innovation accelerates and compounds. Each point in front of you is bigger than anything that ever happened."

Marc Andreessen.

II. IOT VISION

The vision of the IoT is to fuse the physical and digital worlds by bringing different concepts and technical components together. It aims to create a seamless network of billions of wireless identifiable objects that communicate with one another. This vision promises to create a new ecosystem in which smart devices would be able direct their transport, adapt to their respective environments, self-configure, self-maintain, self-repair and eventually even play an active role in their own disposal. They would be able to harvest the energy needed for their sustenance, adapt to changes in the environment and deal with unforeseen circumstances. The IoT promises to raise the quality of human life to a whole new level. Internet of Things is a new revolution of the Internet. Objects make themselves recognizable and they obtain intelligence by making or enabling Context related decisions thanks to the fact that they can communicate Information about themselves. They can access information that has been aggregated by other things, or they can be components of complex services. This transformation is concomitant with the emergence of cloud computing Capabilities and the transition of the Internet towards IPv6 with an almost unlimited addressing capacity .New types of applications can involve the electric vehicle and the smart House, in which appliances and services that provide notifications, security, Energy-saving, automation, Tele-communication, computers and entertainment are integrated into a single ecosystem with a shared user interface. Obviously, not everything will be in place straight away.

Fig. 1: IoT Vision

A. IOT Strategic Research and Innovation Directions

The development of enabling technologies such as Nano electronics, communications, Sensors, smart phones, embedded systems, cloud networking, network.

Virtualization and software will be essential to provide to things the capability to be connected all the time everywhere. This will also support important Future IoT product innovations affecting many different industrial sectors. Some of these technologies such as embedded or cyber-physical systems form the edges of the “Internet of Things” bridging the gap between cyber spaces.

The physical world of real “things”, and are crucial in enabling the “Internet of Things” to deliver on its vision and become part of bigger systems is world of “systems of systems”.

The final report of the Key Enabling Technologies (KET), of the High-Level Expert Group [9] identified the enabling technologies, crucial to many of the existing and future value chains of the European economy:

- Nanotechnologies
- Micro and Nano electronics
- Photonics
- Bio Technology
- Advanced Materials
- Advanced Manufacturing Systems.

As such, IoT creates intelligent applications that are based on the supporting KETs identified, as IoT applications address smart environments either Physical or at cyber-space level, and in real time. Mobile data traffic is projected to double each year between now and 2015 and mobile operators will find it increasingly difficult to provide the bandwidth Requested by customers. In many countries there is no additional spectrum that can be assigned and the spectral efficiency of mobile networks is reaching its Physical limits. Proposed solutions are the seamless integration of existing Wi-Fi networks into the mobile ecosystem. This will have a direct impact on Internet of Things ecosystems.

The chips designed to accomplish this integration are known as “Multicom” Chips. Wi-Fi and baseband communications are expected to converge in three Steps:

- 3G - the applications running on the mobile device decide which Data are handled via 3G network and which are routed over the Wi-Fi network.
- LTE release eight - calls for seamless movement of all IP traffic between 3G and Wi-Fi connections.
- LTE release ten - traffic is supposed to be routed simultaneously over 3G and Wi-Fi networks

B. What is a Connected Object?

In computing, the IoT, also known as the Internet of Objects, refers to the networked interconnection of everyday objects. It is described as a self-configuring wireless network of sensors whose purpose would be to interconnect all things.2 In the IoT, an object is connected to other objects over the Internet either as a source of information or as a consumer. Some objects are also equipped with small computers and can process the information they receive.

The IoT aims to create bridges between the ‘Internet world’ and the ‘real world’: When an object is connected to the Internet, the object creates a bridge between these two worlds.

C. Enablers of the Internet of Things

The below section briefly highlights some of the factors that enable the IoT.

- Human beings- They can act both as consumers and producers of data.
- Smart devices- Technological advances and reduction in the cost of manufacturing has enabled the widespread use of smart devices.
- Communication networks -, for example, Wi-Fi, GPRS, 3G, Wireless HART, ZigBee, Bluetooth, etc., are the key denominator as they make a lot more options available to the IoT.
- Cloud computing- Cloud computing is able to scale rapidly to meet the growing demand resulting from the IoT in terms of storage and computing power.

III. OPPORTUNITIES

Any technology evolution has an impact on industry and that remains true for the IoT as well. It brings a whole new paradigm for companies and industries to take advantage of.

A. IT’S Opportunities in Integration Solutions

1) Data Collection and Brokerage

Connected objects would generate an incredible amount of data to be transferred, processed and stored. If historical data also needs to be stored, this problem is multiplied many-fold. Data centres would need to scale accordingly to handle this. This presents a great opportunity in the field of data collection and brokerage.

With technological advances in the field of cloud computing, it may be a viable solution to the data storage and processing problem. With the huge amount of data generated, the brokerage platform also needs to be able to provide expiration of data. It should be possible to configure timelines for the data to expire and for the data to be archived.

The real-time nature of the IoT places a huge demand on the processing capabilities of a data broker. Quantum computing4 can play a major role in addressing this issue. According to physicist David Deutsch, the parallelism associated with quantum computing allows a quantum computer to work on a million computations compared to just one in a conventional computer. A 30-qubit quantum computer would equal the processing power of a conventional computer that could run at 10 teraflops. Quantum Computing is a relatively recent development, but quite a few successful experiments have been carried out.

A concrete example for data collection and brokerage, today, is the Pachube community. Pachube is a small start-up which has created a community of people sharing their entire sensor data. All data published on Pachube is publicly available.

B. IT'S Opportunities in Various Sectors

The IoT will impact most of an organization's existing customers. IoT innovation will bring a new dimension to the existing business models across all sectors. Opportunities exist in many sectors, some of which are illustrated below. Although this doesn't cover all sectors, it provides an overview of how users of today's Internet will move into the IoT.6

1) Smart Cities

Smart Cities aim to make public service infrastructures and business processes significantly smarter (i.e. more intelligent, more efficient, more sustainable) through tighter integration with Internet networking and computing capabilities. Sensors deployed throughout the city gather information about goods consumed, facilities used and other information pertaining to the life of the community. This information is given to the city council to take appropriate steps to improve the quality of life in the city.

2) Aviation Sector

In the aviation sector, the IoT can provide system status monitoring for aircrafts via sensors that measure various conditions, such as pressure, vibration, temperature, etc. This data then provides access to trends, maintenance planning and condition-based maintenance. RFID tags could be used for aircraft parts helping to prevent counterfeiting. At least 28 accidents or incidents in the United States have been caused by counterfeits. There is important ongoing research about intelligent materials especially for aviation. These materials can detect and communicate with the maintenance team when the structure is damaged.

3) Automotive Industry

Some limited connecting capabilities have been seen appearing in high-end cars in the past years, for instance, real-time traffic information. Expanding these capabilities to make the car a truly connected object will allow it to contact the manufacturer to diagnose a malfunction in real-time, or even better, anticipate it; be informed of road hazards; negotiate charging prices with power stations7; and book maintenance operations. Vehicle-to-vehicle (V2V) communication will open the road to collaborative driving, addressing traffic issues from a global, rather than an individual standpoint, and will help find optimal solutions, relieving congestion and also averting collisions, leading to a decrease of road casualties. Google is developing self-piloted cars that are able to run 1,000 miles without human aid and about 14,000 miles with minimum human intervention.

4) Energy Sector

In the energy sector, the IoT will help manage and monitor energy consumption. Smart appliances will be able to operate optimally, conserving energy and at the same time satisfying the end user's need. Smart meters will send signals to customers to regulate their power consumption. This would result in lower power consumption and also lessen the burden on existing sources of energy. Sensors placed at strategic nodes in a gas pipeline would send signals to the control centre informing the controller about the pressure and volume of gas flowing through at the node at a given time.

5) Manufacturing

A lot of manufacturing companies are making use of RFID for tracking and tracing. Managing inventory is improved and easier. Tagging a device also helps to avoid counterfeiting. Sensors attached to products can give information about their health allowing the user to decide when that device should be recycled. The Ford factory in Cologne, Germany, currently uses bar codes tagged to the hood of a car to help determine the make of the car during production. The robots on the assembly line read the information on the bar code and then determine which parts are needed for that particular car. The parts are then sourced from the inventory. This allows Ford to use the same assembly line to manufacture different cars. Today, connected objects are still in their early stages and there are still many challenges to be overcome before the benefits of connected objects can be fully realized.

6) Addressing and Tagging

The IoT should be able to tag or address about 50 to 100 trillion objects. To achieve this, the current IPv4 protocol will be insufficient. A key challenge is to agree on a common way of addressing and identifying objects.

It is also important to have unique UIDs (user-ids), even for mass- produced objects (i.e. all objects coming out of a factory will have their own unique UID, not a common one). The relationship between objects, such as raw material (one UID) becoming refined material (another UID) or parts (each with their own UID) that are then assembled as a car (again a different UID) also needs to be considered to enable us to follow these relationships and thus maintain traceability.

There are two major areas of standardization for the IoT:

- Semantic: This will describe how to communicate with objects and what to expect from them. As there could be many different kinds of objects, which are possibly (and hopefully) long-lasting, then the semantic must be time-proof.
- Communication Protocols: As pointed out by Elgar Fleisch, a global standard protocol, identification and addressing scheme for bridging the last mile from the Internet to the smart object would be required. For the IoT to be adopted widely, a standard needs to be established which serves as guidelines for individual implementations and interactions between them

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The price and availability of the required hardware is today the key challenge preventing companies and end users from having more ‘connected objects’. Today the limitations on the hardware are:

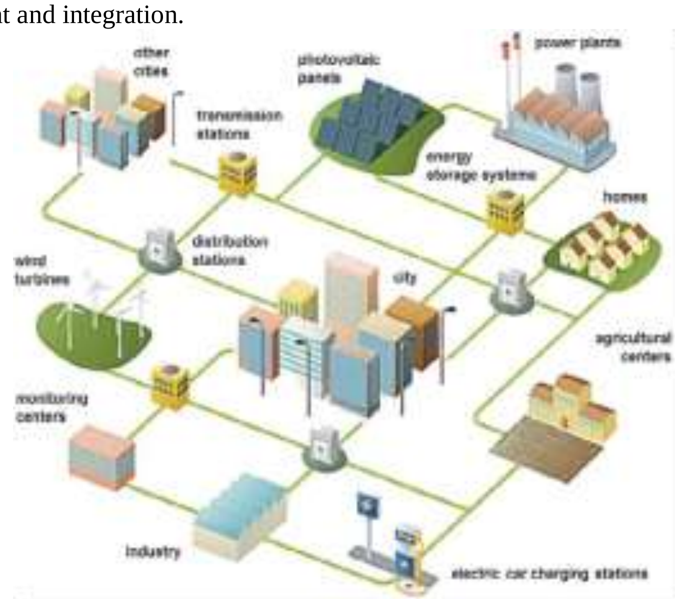
- Battery Life: Having connected objects can ease everyday life, but if one has To ‘thinkof recharging all everyday objects, it will become too much work compared to the benefit’.
- Hardware size: The new connected objects should not be much bigger than their non-connected counterparts.
- Radio connectivity: This element is of course crucial. If a user is using RFID, which is becoming quite cheap and may not require batteries, then they will have to install extra equipment to ‘discuss’ with objects

7) IoT Applications

It is impossible to envisage all potential IoT applications having in mind the development of technology and the diverse needs of potential users. In the following sections, we present several applications, which are important. These applications are described, and the research challenges are identified. The IoT applications are addressing the societal needs and the advancements to enabling technologies such as Nano electronics and cyber-physical systems continue to be challenged by a variety of technical (i.e., scientific and engineering), Institutional, and economical issues.

In this context there are numerous important research challenges for smart city IoT applications:

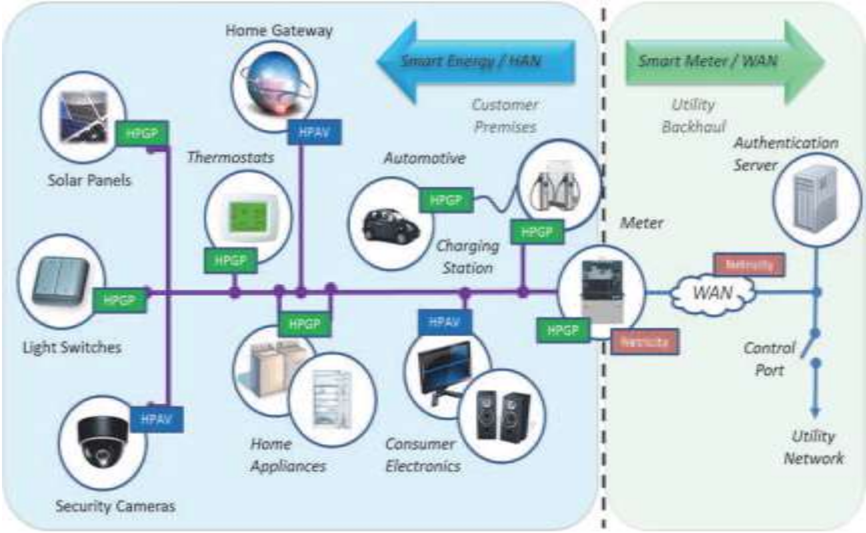
- Overcoming traditional silo based organization of the cities, with each utility responsible for their own closed world. Although not technological, this is one of the main barriers.
- Creating algorithms and schemes to describe information created by sensors in different applications to enable useful exchange of information between different city services.
- Mechanisms for cost efficient deployment and even more important maintenance of such installations, including energy scavenging.
- Ensuring reliable readings from a plethora of sensors and efficient calibration of a large number of sensors deployed everywhere from lamp-posts to waste bins
- Low energy protocols and algorithms
- Algorithms for analysis and processing of data in the city and making “sense” out of it.
- IoT large scale deployment and integration.



Sophisticated and flexible data filtering, data mining and processing procedures and systems will become necessary in order to handle the high amount of raw data provided by billions of data sources. System and data models need to support the design of flexible systems which guarantee a reliable and secure real-time operation. Some research challenges:

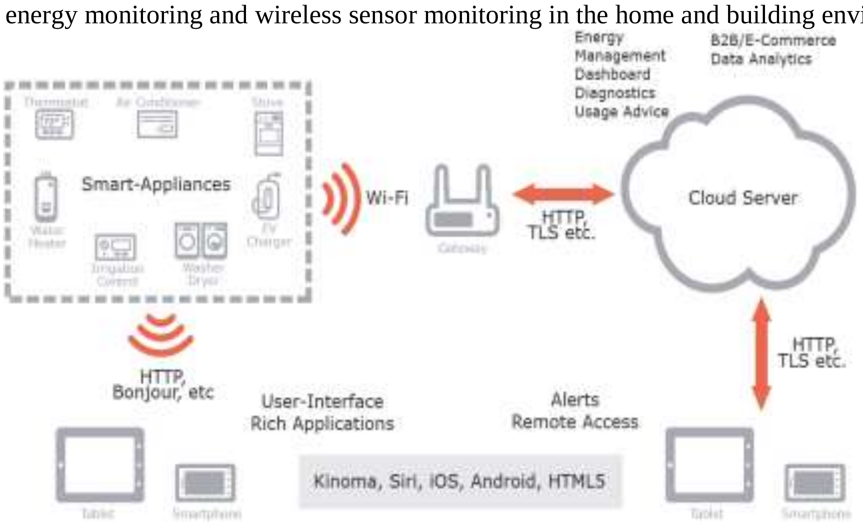
- Absolutely safe and secure communication with elements at the network edge
- Addressing scalability and standards interoperability
- Energy saving robust and reliable smart sensors/actuators
- Technologies for data anonymity addressing privacy concerns
- Dealing with critical latencies, e.g. in control loops
- System partitioning (local/cloud based intelligence)
- Mass data processing, filtering and mining; avoid flooding of communication network

- Real-time Models and design methods describing reliable interworking of heterogeneous systems (e.g. technical/ economical/ social/ environmental systems). Identifying and monitoring critical system elements. Detecting critical overall system states in due time
- System concepts which support self-healing and containment of damage; strategies for failure contingency management
- Scalability of security functions
- Power grids have to be able to react correctly and quickly to fluctuations in the supply of electricity from renewable energy sources such as wind and solar facilities.



C. Smart Home, Smart Buildings and Infrastructure

The rise of Wi-Fi's role in home automation has primarily come about due to the networked nature of deployed electronics where electronic devices (TVs and AV receivers, mobile devices, etc.) Have started becoming part of the home IP network and due the increasing rate of adoption of mobile computing devices (Smart Phones, tablets, etc.), see Figure 2.23. The networking aspects are bringing online streaming services or network playback, while becoming a mean to control of the device functionality over the network. At the same time mobile devices ensure that consumers have access to a portable 'controller' for. The electronics connected to the network. Both types of devices can be used as gateways for IoT applications. In this context many companies are considering building platforms that integrate the building automation with entertainment, healthcare monitoring, energy monitoring and wireless sensor monitoring in the home and building environments.



D. Smart Health

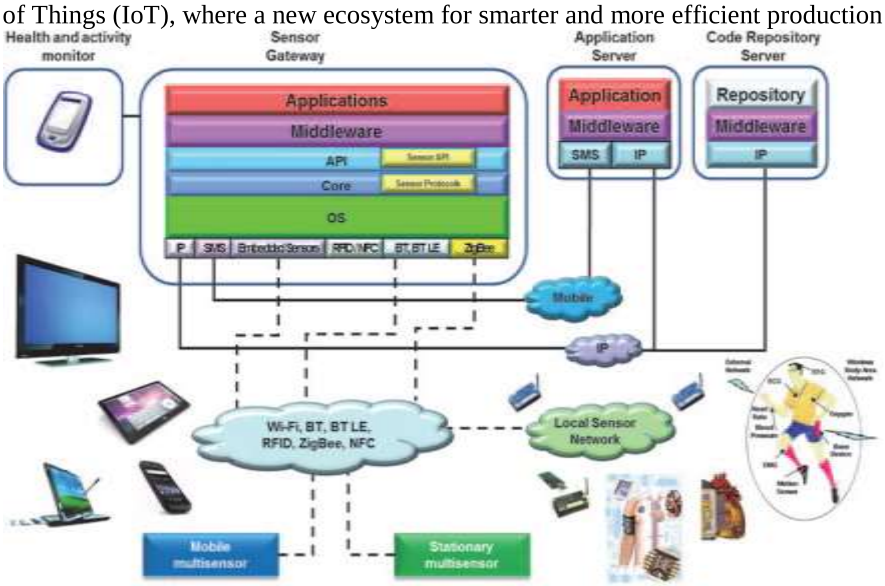
The market for health monitoring devices is currently characterised by application-specific solutions that are mutually non-interoperable and are made up of diverse architectures. While individual products are designed to cost targets, the long-term goal of achieving lower technology costs across current and future sectors will inevitably be very challenging unless a more coherent approach is used

The links between the many applications in health monitoring are

- Applications require the gathering of data from sensors
- Applications must support user interfaces and displays
- Applications require network connectivity for access to infrastructural services
- Applications have in-use requirements such as low power, robustness, Durability, accuracy and reliability.

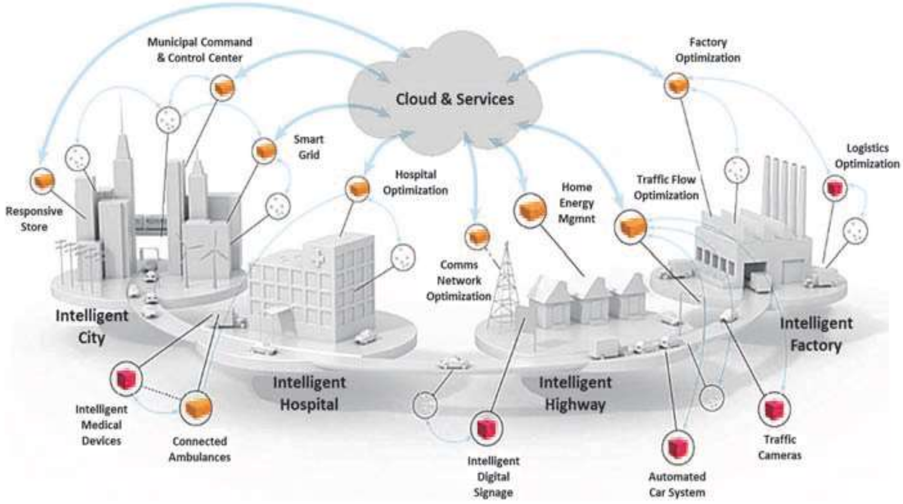
E. Smart Factory and Smart Manufacturing

The role of the Internet of Things is becoming more prominent in enabling access to devices and machines, which in manufacturing systems, were hidden in well-designed silos. This evolution will allow the IT to penetrate further the digitized manufacturing systems. The IoT will connect the factory to a whole new range of applications, which run around the production. This could range from connecting the factory to the smart grid, sharing the production facility as a service or allowing more agility and flexibility within the production systems themselves. In this sense, the production system could be considered one of the many Internets of Things (IoT), where a new ecosystem for smarter and more efficient production could be defined.



F. Participatory Sensing

People live in communities and rely on each other in everyday activities. Re -commendations for a good restaurant, car mechanic, movie, and phone plan Etc. were and still are some of the things where community knowledge helps us in determining our actions. While in the past this community wisdom was difficult to access and often based on inputs from a handful of people, with the proliferation of the web and More recently social networks, the community knowledge has become readily available— just a click away. Today, the community wisdom is based on conscious input from people, primarily based on opinions of individuals. With the development of IoT technology and ICT in general, it is becoming interesting to expand the concept of community knowledge to automated observation of events in the real-world.



Participatory sensing applications come with a number of challenges that need to be solved:

- Design of algorithms for normalization of observations taking into account the conditions under which the observations were taken. For example temperature measurements will be different if taken
- By a mobile phone in a pocket or a mobile phone lying on a table;
- Design of robust mechanisms for analysis and processing of collected observations in real time (complex event processing) and generation of "community wisdom" that can be reliably used as an
- Input to decision taking;
- Reliability and trustworthiness of observed data, i.e. design of mechanisms that will ensure that observations were not tampered with and/or detection of such unreliable measurements and Consequent exclusion from further processing. In this context, the proper identification and authentication of the data sources is an important function;

- Ensuring privacy of individuals providing observations;
- Efficient mechanisms for sharing and distribution of "community wisdom";
- Addressing scalability and large scale deployments.

G. Internet Technologies

- Cloud Computing: Since the publication of the 2011 SRA, cloud computing has been established as one of the major building blocks of the Future Internet. New technology enablers have progressively fostered virtualisation at different levels and have allowed the various paradigms known as "Applications as a Service", "Platforms as a Service" and "Infrastructure and Networks as a Service.
- Self-adaptation: In the very dynamic context of the IoT, from the physical to the application layer, self-adaptation is an essential property that allows the communicating Nodes, as well as services using them, to react in a timely manner to the continuously changing context in accordance with, for instance, business policies or Performance objectives that are defined by humans
- Self-organization: In IoT systems and especially in WS & ANs it is very common to have nodes that join and leave the network spontaneously. The network should
- Therefore be able to re-organize itself against this evolving topology
- Self-optimisation: Optimal usage of the constrained resources (such as memory, bandwidth, processor, most importantly, power) of IoT devices is necessary for sustainable and long-living IoT deployments.
- Self-protection: Due to its wireless and ubiquitous nature, IoT will be vulnerable to numerous malicious attacks. As IoT is closely related to the physical world, the attacks will for instance aim at controlling the physical environments or obtaining private data.
- Self-healing: IoT systems should monitor continuously the state of its different nodes and detect whenever they behave differently than expected. It can then perform actions to fix the problems encountered. Encounters could include re-configuration parameters or installing a software update.
- Self-description: Things and resources (sensors and actuators) should be able to describe their characteristics and capabilities in an expressive manner in order to allow other communicating objects to interact with them.
- Self-discovery: Together with the self-description, the self-discovery feature plays an essential Role for successful IoT deployments (Topology-wise).

May have its origin in different aspects, depending on the application type. There is no value but "values" each contributing to the total benefit such as:

- Value from visibility identification, location tracking
- Value form IoT-supported safety in hard industrial environments
- Value from right information providing or collecting
- Value form improved industrial operation and flows in industry
- Value from reduced production losses
- Value from reduced energy consumption
- Value from new type of processes made possible by IoT applications
- Value form new type of maintenance and lifetime approaches
- Value enabled by smart objects, connected aspects
- Value from sustainability.

H. Internet of Things (IoT) Application

- Participatory sensing;
- Cheap, configurable IoT devices;
- IoT device with strong processing And analytics capabilities;
- Ad-hoc deployable and configurable Networks for industrial use;
- IoT in food/water production and tracing;
- IoT in manufacturing industry;
- IoT in industrial lifelong service and Maintenance;
- IoT device with strong processing and Analytics capabilities;
- Application capable of handling heterogeneous; High capability data collection And processing infrastructures
- IoT information open market (Continued).

IV. CONCLUSION

The Internet of Things breaks the basic norm for communication today, which focuses on human entered data. Technologies like RFID, Wi-Fi, real-time localization and sensor networks empower computers to perceive the world for themselves. In the sequel of open issues for technical and semantic interoperability in the IoT domain a set of open issues in the form of actions to do are listed in the form of bullets and could be considered in the scope of the early requirements in the evolution of IoT.

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