Towards the Invisible Internet of Things

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Internet of Things – Essential concepts

Internet of things can be defined as a global network that connects smart things. Most common smart things in this perspective are variety of sensors and actuators but can also be computers, storage devices, mobile devices, etc. Things in the IoT are the devices that can independently generate and use data. Things also share this data with other Things in the network.

Technologically speaking such scheme of collection, using and sharing data was possible for a long time, the reason why internet of things is gaining so much attention lately is simply due to the number of things that are connected to internet. It is estimated that currently 25 billion devices are connected to internet and this number is expected to double by 2020.

The Internet of Things is one of the most popular terms that relates to the connection of daily things to the Internet. Some of the related terms are *ubiquitous/pervasive computing, machine to machine communication, wireless sensor networks, Internet of Everything*... Definitions vary in perspective and in the variety of processes these term encompass. Nevertheless, all of them mean connecting everyday things to the Internet, which opens doors to sensing, data collection, storage and visualization as well as the data exchange between things and/or people. This was nicely illustrated by Neil Gross in 1999 –

"In the next century (21st), planet earth will don an electronic skin. It will use the Internet as a scaffold to support and transmit its sensations."

Another popular concept is Web of Things. The Web of Things can be seen as subset of the Internet of Things. The main difference lays in the fact that for IoT it is enough that the devices are connected to the Internet, while in fact in the Web of Things devices are connected to internet in the application layer, thus, information can be managed and retrieved using Web protocols, primarily HTTP. This offers significant advantages because the Web architecture is well developed and widely applied.

For a long time now there are a number of predictions about the exponential growth of IoT technologies and the number of devices. This year, the trend was apparent, and at CES, the largest consumer electronics fair, IoT has taken central stage and was the focus of the entire fair. Nearly all of the companies presented IoT devices, components or connectivity infrastructure. Thus, microprocessor producers started producing processors specifically designed for IoT, home appliance companies started manufacturing a range of devices for the smart home, big software companies started making and adapting operating systems for IoT devices, car manufacturers connected the cars to internet, data companies started collecting as much information as possible from variety of devices, and many startups started making IoT devices, such as thermostats and smoke detectors.

Hardware Maker Movement

Maker movement is the collective name for people who are making amateur level electronic and electro-mechanical devices. Makers usually use readily available components and tools to independently produce interesting and useful devices, and share instructions and the results of their work with other makers via YouTube, forums and social networks. According to Hackster.io, one of the most popular maker websites, 53% of electronics makers have direct experience creating Internet of Things technology. Even though makers create the devices on the amateur level, they are one of the main reasons why prototyping in IoT is so easy nowadays. Certain products have been made to support the maker community, among them Arduino and Raspberry PI are the most famous.

Arduino is a company, project and user community that develops open hardware and software solutions. The system is based on the Arduino

board that incorporates microcontroller, analog and digital I/O pins, and a USB programming interface. Integrated Development Environment (IDE) that allows software development in C and C ++ is used for Arduino programming. In recent years, Arduino has brought together a multitude of users because of its low cost and very easy and open access to the development. The most common beginner's projects are thermometers connected to the Internet, electrical relays for the home lighting over a Wi-Fi network, detectors for human presence in the room, etc. More advanced makers make more interesting things like robots, medical sensors, aids for the disable, etc.

Raspberry PI is very similar in principles to Arduino. It is also open-source and has a multitude of users due to the cheap and accessible circuitry. It is used in similar projects like Arduino, or on the project that require a little more powerful computing resources. The entire system is on the credit card sized board, but unlike the Arduino board has a 700 Mhz processor, HDMI output, a wide range of operating systems based on Linux kernel. Raspberry PI is as powerful as couple of years old desktop computer. Therefore, Raspberry PI is very beneficial when reading data from a camera or microphone, when complex data processing is needed or generally speaking when greater computational power is required. Often, Raspberry PI and Arduino are combined together in a single solution, so that Raspberry is used for more complex operations, and Arduino as an interface with LEDs, electric motors and other electronic equipment. The new version of Raspberry PI recently arrived, this newcomer has 900 Mhz processor with 4 cores and 1GB of RAM.

Application Domains

The range and number of domains of application of Internet of things is enormous, however couple of them are rather interesting and useful.

Many IoT devices are used to reduce energy consumption and to perform environmental monitoring, i.e., for purpose of preservation of environment. Such devices for example detect when no one is in the room and can turn off the lights and heating, they can give home owner the correct information on the power consumption, optimize production processes in industrial plants and help achieve many other savings. For environmental monitoring, most used devices are thermostats, anemometers, humidity sensors, soil composition sensors, light sensors, gas sensors, etc. For scientific research purposes, it is very useful to have devices that can be placed in inaccessible areas, like the tops of the mountains, the lakes and the sea, that work autonomously for long time and that provide useful

information. IoT devices are actually widely used by ecologists due to their mobility, connectivity and long lasting battery.

Today, there are more and more fashion accessories and devices we carry with us, that are connected to the Internet and provide their owners variety of useful features. So, smart watches can communicate with cell phones, retrieve weather forecast, send messages, measure heart rate and more. There are also bracelets specializing in fitness and activity tracking. Devices like the Jawbone UP, Fitbit Charge, Microsoft Band, Garmin Vivosmart and others can track your daily activity, running distance, calories burned, heart rate, sleep quality, and many other values.

All of these devices measure both the people's physical condition at any time and allow for drawing the necessary conclusions from the raw data. The data from these devices is automatically loaded into the applications that are used to build a health profile that can be used to locate the interdependence between the various parameters. For example, it is possible to find a correlation between quality of sleep and time spent in training on that day. So people, can possibly find that they sleep better when training in the morning. These apps also collect data on nutrition, fatigue during the day and more. When all this information is combined into a complete profile, vital health information can be extracted and ultimately users can get suggestions that will help them increase the quality of life.

Besides the fitness trackers, there are also devices for monitoring of health conditions - bracelets, plasters, necklaces and other devices that monitor the amount of sugar in blood, oxygenation of blood, heart rate, detect the fall and various other things. Such devices are especially useful for elderly people who live alone. Such devices can automatically notify a nearby doctor or relative, if some of the parameters go beyond the permitted values.

The inclusion of IoT in vehicles should also be noted. Many new car models come with cellular Internet connection. Currently Internet connection in cars is used to retrieve maps and the current traffic conditions in real time and calculate the optimal navigation route. In the case of traffic accident, the car can also send all the relevant information to the police or nearby hospital (eCall). Google and Apple are already developing operating systems for cars based on Android and iOS that provides an even wider range of functions in cars connected to the Internet.

IoT in the industry is considered as a strategic approach to linking systems to establish communication between machines, people, products and business systems. The main objectives are to create a smart company and digitized business and production processes to maximize quality,

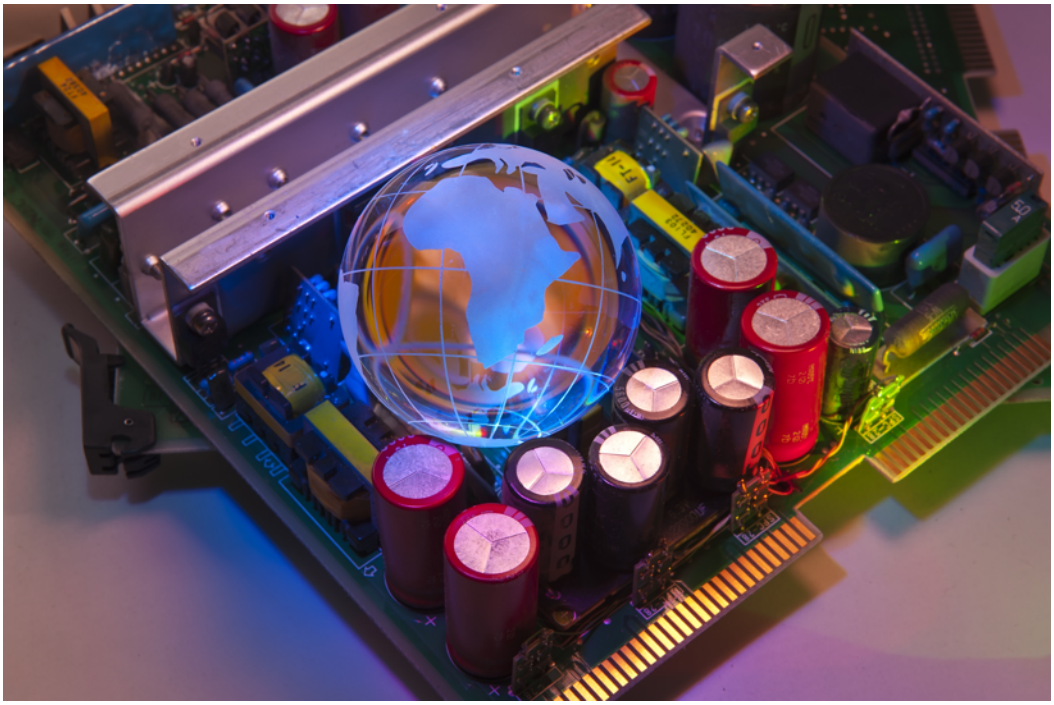
reduce production costs and operations and increase the flexibility and efficiency of production. Main aim of IoT in industry is to reduce the costs of providing services, shorten the duration of the service cycle and increase efficiency of industrial systems.

Challenges

Hardware

The development of hardware and software for IoT devices differs from the development of personal computers and even mobile devices. The devices often require integration and have stringent space constraints. In most cases the requirements are extreme, like in the case of smart watches or glucose monitoring patches, where the dimensions are so limited that they define all other parameters in the development phase.

Another major challenge in the development of IoT devices is that they must consume very little power. Such devices usually operate on batteries or harvest energy from the environment. After all, no one wants a smart watch that must be recharged every two hours or thermometer which requires battery change every week.



The third challenge is that devices must be relatively cheap.

Finally, it is necessary to network (connect) the IoT devices, and it is much harder to accomplish because of the limited size, cost and battery capacity, but also the fact that the communication should be autonomous.

These are the four interdependent issues and are difficult to solve at the same time, nevertheless, the compromises are made during the development and the technology advances relatively quickly in all four areas.

Data Privacy and Security

Various companies like Facebook and Google already have a huge amount of information about each user. The Internet of Things will significantly increase the amount and sensitivity of this information. The devices will measure and record information about your medical condition, the state of electronic devices in the apartment, the amount and type of food you have in the refrigerator and many others. These data are sensitive and can represent a real security risk so it is very important that they remain private.

The issue of privacy and data security is not yet fully resolved, and a lot of effort is invested in the security issue. The solution must be a compromise, because if the data is completely private the application loses the usefulness, yet the data must not be available to everyone.

Device Limitations

An additional aggravating circumstance is that the IoT devices have limited computational capabilities and operate completely autonomously and it is often not possible to apply the security algorithms used in personal computers.

Big Data

As the latest in a series of challenges to address is the issue of excessive amounts of data that will be generated by IoT devices. With the advent of smart phones and tablets the number of personal, internet connected devices increase. Additionally, smart watches, cars, various sensors, fitness bracelets and many other devices are being connected to the Internet, so it is clear that there will be exponential growth in the amount of generated data. The data in IoT should be saved, processed and analysed in order to draw useful information and conclusions from it. Due to this scenario, different technologies such as cloud, big data, machine learning and artificial intelligence come into play.

Invisible IoT

The basic technology for connecting to internet exists for a long time. However, internet connected devices today are much cheaper, have low power consumption, have developed communication infrastructure and have smaller size. Due to these improvements, the boarder dividing the prototypes and finished, market ready, devices are very thin and disappearing.

Cheap computers and microcontrollers such as Arduino and Raspberry PI has led to an explosion of innovation and created a lot of interesting new smart devices connected to the Internet. These devices also facilitated the development of the prototypes and the establishment of start-up companies in the IoT field. On the other hand, large companies focus on more conservative products such as connected cars, smart watches, etc. In addition, large companies also devote themselves to creation of infrastructure required for IoT ecosystem.

Before IoT technologies become ubiquitous, many challenges need to be overcome, such as reduced energy consumption and dimensions of the device and the implementation of quality and standardized system to ensure data privacy. However, judging from the current state, IoT market will continue to grow exponentially in the upcoming years.

We can say with ease that the Internet of Things will become successful once it becomes completely invisible. At the beginning of 20th Century in the United States, it was possible to buy a “house motor”. The motor would be placed at a central location in the household or restaurant and by means of various connectors it was possible to connect to it a sewing machine, meat grinder, hair dryer, etc. The motor was always in the center, and other devices were viewed as its extensions. Today, motors are so advanced that they are practically invisible. They are found in toothbrushes, hairdryers, car-windows... However, when we use these things, rarely do we realize that their functions are made possible by a motor. The same should happen with the IoT. IoT must come to such a point that for example lawn sprinklers are turned on when it doesn’t rain, and nobody thinks about a fact that the sprinkler actually connects to internet and check the weather forecast and make autonomous decision when and for how long to work.

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