Communications from Inanimate Objects: Internet of Things

Sukanta Ganguly, *Research Engineer, San Jose, California 95120, USA, Email: sukanta@locomobi.com*

doi: 10.22545/2014/00050

Proliferation of networks with the connectivity that is managed in a distributed nature via the Internet has been growing in the last decade. This growth initially started with computers and large scale computing devices being the end-points for communication but now has reached out to devices that perform tasks in the electro-mechanical areas and more. The aspect of computing is attached to these existing and modified peripherals such that the interconnection of network and the reach is extended. While the "Internet of Things" has not been formally defined or a formal definition that is accepted by any standard means, it can be loosely understood as a network of things (i.e. inanimate objects) that communicates or shows and transfers its activities to the global Internet. Two main outcomes that positively impacts any vertical segment that gets applied to this principles are 1) Extended reach 2) Better real-time knowledge. One of the outcomes of these two actions would be more visible control over the components and the devices distributed geographically. The "Internet"-ing of these devices called the "things" helps increase our quest of knowledge with data coming from various systems and devices that impact peoples lives.

Keywords*:* Software, networking platform, network policies, networking systems.

1 Introduction

Internet of things has become a common phrase in networking community and this vernacular is spreading within the world of business. The spread within the wide business community has given rise to intense amount of research to help identify what more can utilize this amorphous system and how they can benefit from the utility. Given the fact that Internet of Things (IoT) is a gradually growing segment with more applications being derived in areas that could normally not participate in the networking world provides a fertile ground for researchers to address more creativity in this arena.

"Internet-working" of computing systems was invented about 40 years ago. For computing devices to talk to each other communication protocols were invented such that sender and receiver can identify themselves and speak a language that can be interpreted between the parties communicating without having share any dictionaries. As more development happened we started having more and more richness added to the communication layer. This ended creating more applications and services that can be built for communicating parties to leverage across the board, globally. The bounds of networking were limited to physical connectivity and the medium through which communications could be channelized. The expansion [4] of the medium and the establishments of various type [3] of medium has led to massive potentials for varied adoption.

Technology Component	2010 Cost*	2015 Cost**
Radio, Wi-Fi	1.50	0.80
Radio, Bluetooth	1.00	0.50
Processor (basic 8-bit microcontroller chip with embedded flash memory)	1.00	0.85
Sensor (temperature)	1.00	0.75
Sensor (vibration/accelerometer)	1.50	1.00
Camera (1.8 megapixel CMOS image sensor)	1.80	1.20
Microphone	1.20	1.00
GPS	1.25	0.70
Energy Source (inductive loop wireless power, incremental cost per unit)	2.50	2.00

*Lowest costs for simplest realistic implementation; **2015 cost assumes the same functionality as the corresponding 2010 figure
CMOS = complementary metal-oxide semiconductor

Source: Gartner (November 2011)

Figure 1: Cost reductions of the technology components used in smaller devices and Internet of Things devices [7].

2 Definition

Due to lack of an accepted standard definition of Internet of Things we would take an attempt in the paper to define what is Internet of Things (IoT). IoT are smaller entities that can be deployed anywhere with the goals of extending the reach of information source. Traditional computing devices cannot reach these areas or cannot be installed in these zones. Some of the reasons why the existing networking devices cannot be used for them are form-factor, power consumption, electro-magnetic characteristics, existing input and output interfaces, etc. Some of them are presented with physical limitations and some operational limitations. IoT challenges these assumptions and breaks the barriers to reach into zones of information gathering by innovations in all of the areas mentioned above. IoT forms a connected internet-work facilitating information flow and information gathering devices so more intelligence can be build for all types of components and operating environments ranging from health, transportation, system tracking, Oil-n-Gas, pipelines systems, long-haul carrier network, connected home appliances, energy monitoring and energy conservation, etc. The reason we see that "Things" has been emphasized in the "Internet of Things" is due to the fact that it focuses on getting inanimate objects lite up so that they send and receive data of value. They participate in building a semantic network of domain specific information flow that would help in bettering service offerings, being smart about the environment, learning more about to optimize and finding out more information.

3 Growth Factors

We start researching the key drivers that impact the positive demand from research and usage point of view for solution involving Internet of Things. Some of the important characteristics that are shown in some of the upcoming IoT devices are as follows. They are smaller in form-factor. The components smaller and they keep inventing even smaller components and complete devices, which helps the usage of these IoT components in smaller areas and places where it is impractical to have larger footprint hardware. With the miniaturization of the hardware and lesser software needs devices, which can fit inside a wristwatch, smaller controller chips inside Credit Cards, frames of eyewear, in key chains, little OBD2 dongles inside a car, active artificial heart valves used to regulate heart beats, etc. Along with miniaturization cost reduction has been another big add-on to the strong drive to create deeper penetration of IoT.

In Figure 1 shows the cost reduction from 2010 to

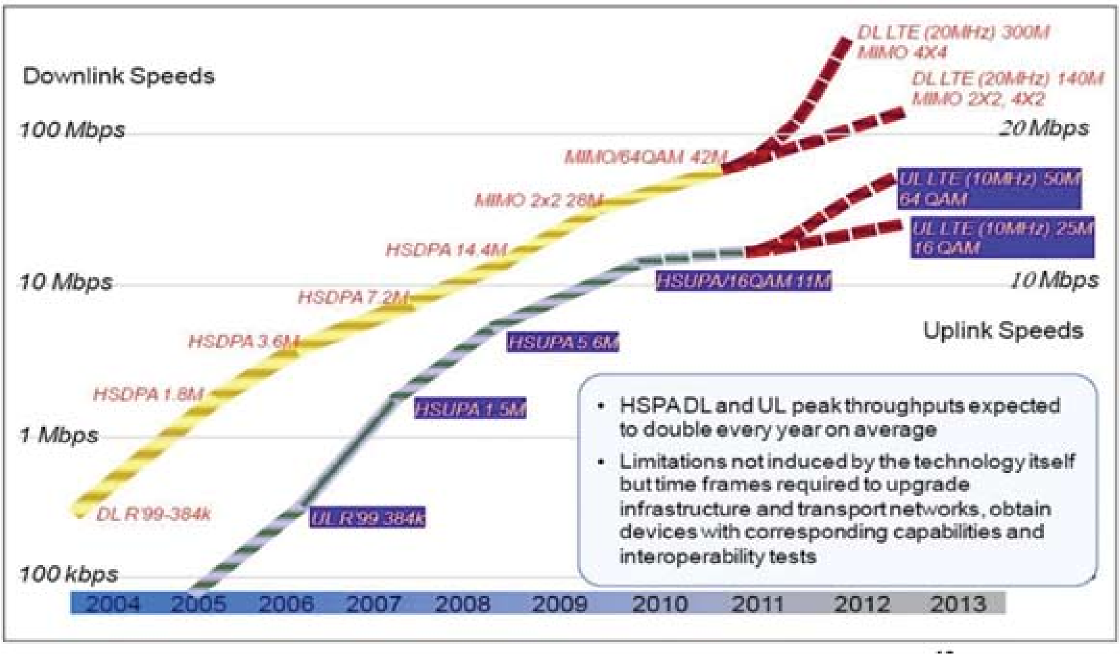

Figure 2: Download link speed increase [7].

the year 2015. The figure shows the predictions by Gartner [7] based on what has been seen in the last few years. The cost reductions are anywhere from 30% to 50% from the prices in 2010. The indicators of current pricing show that we have already achieved the cost structures in many of the areas. The impact of the cost reduction is a big encouragement and motivation for newer solutions to be invented in markets where low cost solutions are more practical.

The second very impactful drivers for IoT are the increase in the network bandwidth. Figure 2, shows the increase in the download link speed from the year 2004 till 2013. With more networking devices increasing the load of data flow within the internetwork adds more stress within the network backbone. The growth in the network bandwidth, both uplink and downlink will help in a significant way in reducing the network stress. It will reduce network congestions, which will reduce the need for network retransmission, network content buffering.

Third factor of importance for IoT is the reduction of network latency. Figure 3 documents the network latencies with the network coding systems introduced. We see that as we moved from GPRS systems to LTE the latencies in milliseconds within the network from 670ms to almost 20ms. Reduced network latencies gives rise to the options of creation smaller data packets that can be send between the sender and the receiver within the network. IoT's generally are used in applications where smaller chunks of data are transacted between multiple parties. Although these are smaller chunks of data the frequency at which these exchanges happen are quite high. Smaller network data chunks do create quite a bit of sparse traffic within the network.

There are various other drivers for the growth of IoT and many of them stem out of the elements that hold the infrastructural support.

4 Business Innovation & Impact

The business model design has become the central topic of business innovation since the rise of internet-based e-businesses. The primary challenge is the difference in interpretation between business research and engineering research. There are many different business modeling methodologies based on different classification criteria, such as the degree of innovation, degree of integration, profit making activity, relative position on the price-value continuum, degree of economic control, degree of value integration, strategy of objectives, source of value, critical success factors, core competencies, and resources /sales /profit /capital models, etc. Stakeholder Analysis is another approach for business innovation, in which the stakeholders influences, interests, and a

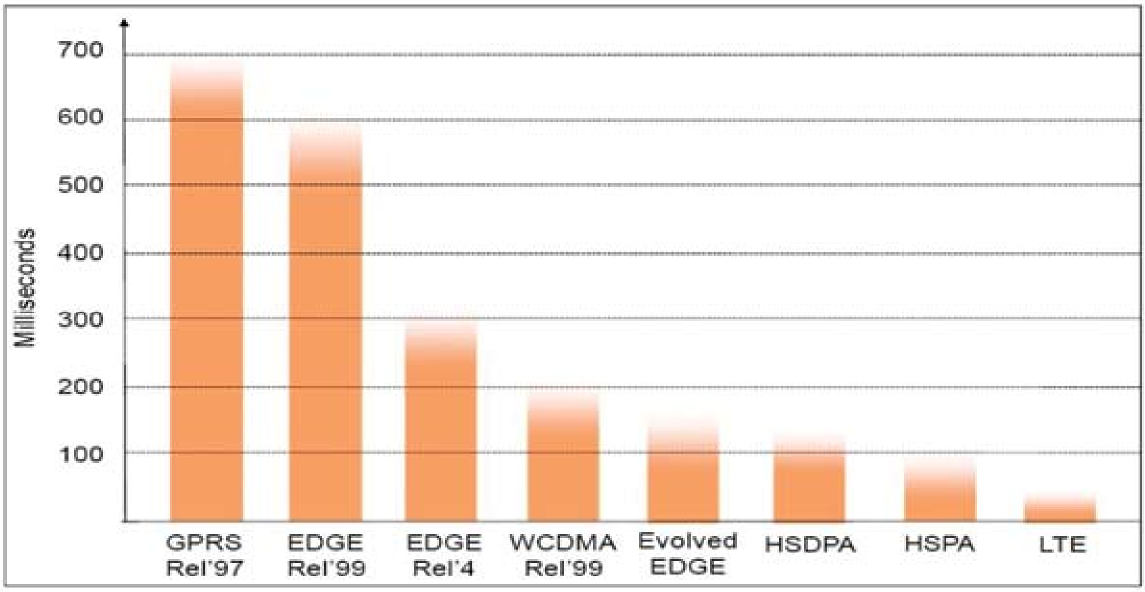

Figure 3: Download link speed increase [7].

scoring matrix quantizes satisfactions. In a value chain of IoT service, a large number of stakeholders are involved ranging from individual consumers, to enterprises and public authorities. From different stakeholders viewpoint, the main concerns and expectation are usually different. The information offered by an IoT system is the main carrier of business values. So, effective and efficient information integration is the foundation for the success of an IoT solution.

5 Componentized Architecture

The main components, which build out an IoT architecture, are as follows:

1. A Hardware element – This is the sensory part of the architecture made up of embedded computing, actuators, sensors with different types of abilities like sensing temperature, heat, light, motion detection, change in current, change in pressure, etc.

2. The data aggregator – This is the on-demand information repository which has capabilities and flexibilities of storing any type of data models at a very large scale. As mentioned earlier the scale applies to volume or repetition of the same type of data yet massive amounts of it. So scale storage, fast retrievals, faster searches and accesses to the variations, etc. are important at this level.

3. Information Presentation – This applies to the way information from the data is presented to the vertical segment that the IoT is targeting. Every element that is already connected and those that are going to be connected must be identified by their unique identification, location and functionalities. The current IPv4 may support to an extent where a group of cohabiting sensor devices can be identified geographically, but not individually. The Internet Mobility attributes in the IPV6 may alleviate some of the device identification problems; however, the heterogeneous nature of wireless nodes, variable data types, concurrent operations and confluence of data from devices exacerbates the problem further. Data centers that run on harvested energy and are centralized will ensure energy efficiency as well as reliability. The data have to be stored and used intelligently for smart monitoring and actuation. It is important to develop artificial intelligence algorithms, which could be centralized or distributed based on the need. Novel fusion algorithms need to be developed to make sense of the data collected. State-of-the-art non-linear, temporal machine learning methods based on evolutionary algorithms, genetic algorithms, neural net- works, and other

artificial intelligence techniques are necessary to achieve automated decision-making. These systems show characteristics such as interoperability, integration and adaptive communications. They also have a modular architecture both in terms of hardware system design as well as software development and are usually very well suited for IoT applications. More importantly, a centralized infrastructure to support storage and analytics is required.

The component-architecture suits the IoT systems very well due to the model in which the system builds out needs to scale. Scaling is not a re-engineering problem. It depends of systems that can be added with relative ease to extend the vector on which it operates. Scale could be applied to processing power, which albeit could small in quantum but huge in volume. It could mean scaling the information gathering layer, which although receives very small chunks of data per transaction but expects several millions of them per second. It could also mean that it deals with smaller number of data types being aggregated, filters per application and displayed but the sheer volume can cripple the local area network as well as the wide area network through which it traverses. User presentation or information display is a massive scale problem as it does not only take the challenge to summarize from a very large set, but it also summarizes on a set that is constantly changing or being added too. The motivations and technology demands on an IoT network applies creates challenge in repetitiveness and constant change.

While these challenges are being architected and many types of domain-focused applications of IoT are evolving, we do see innovations in the areas of new protocols. Some of them do cross the boundary of IoT and more into transportation of data, medium of traversal and optimizations linked to them.

6 Conclusion

IoT is evolutionary research problem. It takes into account several market drivers to build out technology to be researched in areas that were proposed impractical or non-existent. These were considered non-existent due to the fact that level of maturing in protocols, hardware architecture, communicating interfaces, and application build outs were not deriving the value-chain. Every technology vision arises from the need for consumption at some level, whether the consumption is for pure research point of view, which could be transformational or transitory. Transformational research falls into the segment of new category being created within an existing market place. IoT drives in the transformational segment. It makes possible systems and solutions that is research oriented from its value-added applications but also brings to light aspects of research that could not have been possible if the market did not reach a level of demanding more. Today we sit among a vast number of IoT applications and participate in the ecosystem, unknowingly.

Growth in this arena is going to see a massive upheaval for researchers and well as businesses. The cardinality at which this segment is going to operate is going to be quite high and that would lead to transformational changes in our lives linked to our health, food, transportation, energy consumption, resource usage alterations, public utilities, etc. We are not only learning but also participating in this today. IoT helps are learn more, be smarter about things that we do daily, things that impact us at various levels and helps us.

References

[1] Dlodlo N., Foko T., Myelase P., Mathaba S., 2012. The state of affairs in Internet of Things Research. The Electronic Journal Information Systems Evaluation, Vol. 15, Issue 3, pp. 244-258.

[2] Yun, M., Yuxin, B., 2010. Research on the architecture and key technology of Internet of Things (IoT) applied on smart grid. Advances in Energy Engineering, ICAEE, pp. 69-72.

[3] Jayavardhana G., Rajkumar B., Slaven M., Marimuthu P., 2013. Internet of Things (IoT): A vision, architectural elements, and future directions. Future Generation Computer Systems, Elsevier, Vol. 29, pp. 1645-1660.

[4] Gluhak, A., Krco, S., Natti, M., Pfisterer, D., Mitton, N., Razafindralambo, T., 2011. A survey on facilities for experiemental Internet of Things research. IEEE Communications Magazine 49, pp. 58-67.

[5] Zhibo P., Jun C., Zhi Z., Qiang C., Lirong Z., 2010. Global fresh food tracking service enabled by wide area wireless sensor network. IEEE Sensors applications Symposium (SAS-2010), pp. 6-9.

[6] Ma, N., Lu, Z., Pang, Z., Zheng, L., 2010. System-level exploration of mesh-based NoC architectures

for multimedia applications. IEEE Internation SOC Conference, pp. 99-104.

[7] Jim Tully, J., LeHon G. H. Fall cost of component will help drive the pervasiveness of the "Internet of Things," http://www.gartner.com/id=1839420, accessed: July 5, 2012.

[8] Rysavy Research. Mobile Broadband Explosion, http://www.rysavy.com/Articles/2011_09_08_Mobile_Broadband_Explosion.pdf, accessed: July 5, 2012.

About the Author

Dr. Sukanta Ganguly is a technocrat and has been an entrepreneur forming new businesses. He as taken ideas from concept to a product with go-to-market business planning and revenue modeling for several businesses. He has a Doctorate in Engineering from Texas Tech University in Transdisciplinary area with concentration in the Semantic searching, Data-mining with Context-aware information retrieval. He has an MBA in Finance and a Masters in Computer Science. He has published three books and many academic papers and has been granted several patents.

Dr. Ganguly has 20 years of industry experience. He focuses in the areas of Network & Data Security, Data/Information mining, multi-media protocols and model driven applications.