Secure and Reliable IoT Adoption: "I think I can, I think I can"

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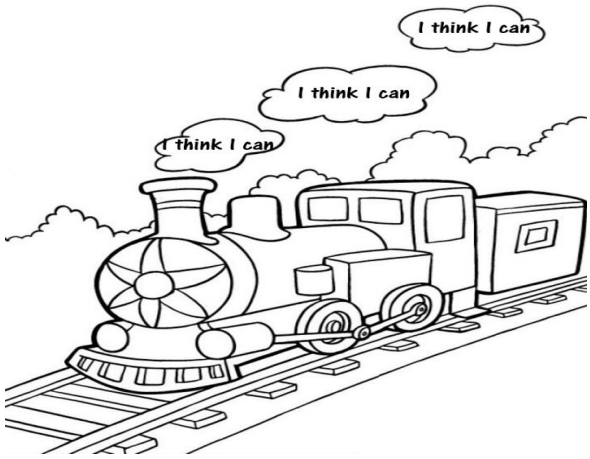

IoT is much like the "little engine that could" given the current challenges and barriers hindering forward progress, but succeeds through persistence and a "can do" attitude.

Abstract - Internet of Things (IoT) has emerged as one of the most promising technologies of the 21st century. However, despite noticeable progress in advancement of its enabler technologies, adopting secure and reliable IoT on a global scale has decelerated due to security, privacy, and interoperability issues in IoT's wireless ecosystem. Therefore, its fundamental building blocks require revisiting to ensure security and reliability in the IoT systems.

Keywords - Internet of Things, IoT Security

The technology evolution and telecommunication paradigm shift from "Telecommunications" to "Internet and Data Service Provider" is moving at a rapid pace taking on characteristics similar to a revolution. This paradigm shift is being driven out of necessity in an effort to reduce operating costs, increase marketability, and enrich the consumer quality of life as the cost of doing business continues to increase and the cost of internet connectivity decreases. There are several variables that impact the cost of doing business such as Infrastructure operating costs, costs associated with technology, cost of resources, and cost of utilities, but it is paramount that these rising costs are kept transparent to the end consumers. Achieving a higher levels of efficiency and effectiveness become key stepping stones in this technology evolution.

The technology evolution stepping stones with regards to telecommunications really began with mobility and has progressed through Cloud, Big Data and has now left us on the doorstep of IoT. IoT is a very broad term with numerous definitions. Forbes [1] defines IoT as "the concept of basically connecting any device with an on and off switch to the Internet (and/or to each other)". Accenture [2] provides another view of IoT as "everyday devices connecting to the Internet through tiny embedded sensors and computing power". Examples of these devices could be home appliances, smart phones, and computers. Each of the telecommunications evolutionary stepping stones has a strong dependency on the previous stepping stones and has built on top further enhancing their capabilities, technologies, and use of those technologies.

The IoT stepping stones are now maturing at a pace far quicker than consumer realization, manufacturer adoption, and industry standardization resulting in the proverbial "Chicken and Egg" scenario. Consumers, both general and enterprise, are reluctant to adopt this technology concerned with privacy and security of their information and reliability of the systems/services. From the other side, manufacturers are reluctant to take that bold step forward in any non-proprietary way concerned about their ability to differentiate their products, increased time to market, and increased manufacturing costs. Moreover, interoperability [5] in the IoT domain is absent and lacks any mature level of industry standardization with regards to technology, communication protocols, and reference architectures resulting in a direct dependency on any one device manufacturer and/or service provider. Therefore, the fundamental operational limits besides the reluctance of both consumers and manufacturers to adopt IoT due to associated risks of IoT maturation decelerates secure and reliable IoT adoption on a global scale.

1. IoT Adoption

The current state of consumer IoT adoption is slow thereby impacting manufacturer and vendor adoption. A 2015 study was conducted by Accenture [2] looking at consumer adoption of personal and home appliance-based IoT. The study was based on more than 2000 consumer surveys across the United States. The study results in Figure 1 identifies a slow adoption rate, but expects a much higher level of adoption at the five year mark and beyond.

A study was conducted by Business Insider Malaysia [3] surveying top technology executives across Malaysia during the fourth quarter of 2014 identifying the top five barriers to company IoT adoption depicted in Figure 2.

The number one barrier with a 39% concurrence was about the privacy and security aspects of IoT. The remaining barriers were associated with the cost and utility of IoT.

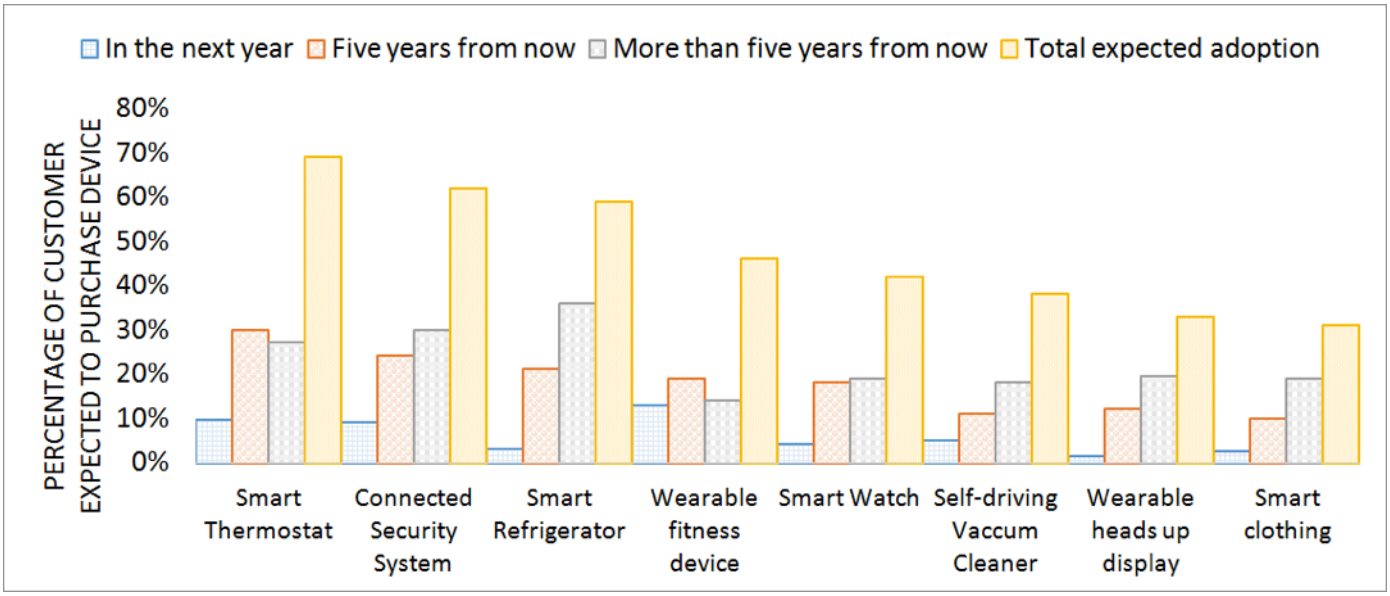

Figure 1 *- Consumer adoption of IoT: Majority of the customers are purchasing IoT devices once they are fully adopted while there are only a fraction of subscribers who are willing to spend on IoT within the next year.*

2. A Secure and Reliable IoT Model

The successful adoption of secure and reliable IoT systems and services has a strong dependency on some fundamental building blocks. The suggested IoT model comprised of actors and building blocks identified in Figure 3 are deemed to play a key role in shaping the future of IoT. Successful deployment of these building blocks will also help resolve the "Chicken and Egg" scenario by addressing key challenges and barriers impacting both consumers and manufacturers. The core building blocks and perimeter building blocks described below are considered to be essential to widespread adoption of secure and reliable services on a global scale.

1. Core building blocks – The key functions or enablers that will drive a higher adoption of IoT are considered core building blocks that can enhance security and reliability in IoT.

- **Reference architecture** - A standardized and industry accepted reference architecture will be critical for the development of reliable systems and services that are widely adopted by both manufacturers and vendors. The reference architecture will become one of the core elements necessary for manufacturers to better manage time to market, manufacturing costs and still enable product differentiation from competition. An example of a reference architecture model would include an IoT enabled device containing Software on Chip (SoC). The device would connect and register to a home base station (e.g., a wireless hub) passing a data package containing information about the device, instructions on how to interface with the device, and a function library. This model would eliminate the need for a home base station to require a library of millions of device types and their associated information. Further, this would help manufacturers maintain their autonomy when developing their products.
- **Mobility** – Mobility in wireless ecosystems of IoT necessitate a high degree of seamlessness. The predominant 4G technology that is quickly being deployed across the globe is Long-Term Evolution (LTE). LTE adoption with regards to mobility is a core building block that will play a significant role in reliability for those IoT systems and service that are typically not based on fixed locations. Major telecommunication operators around the world are actively deploying 4G services to fulfill ever increasing connectivity and bandwidth requirements of the users in varied domains particularly IoT. Those operators that were providing services prior to 4G likely have 2G, 3G and data networks carrying with it a significant Total Cost of Ownership (TCO). The 4G networks when fully implemented are usually fully converged flat IP address-based networks having significantly lower TCO and higher reliability. Such costs encourage telecommunications operators to sunset their non-4G networks over the next 5-7 years. The 4G technology (LTE) is also maturing at a rapid pace with new capabilities planned for subsequent releases such as Cat 0 and Cat 1. Both Cat 0 and Cat 1 are special LTE air interface capabilities that are specifically designed for the mobility of IoT systems and other systems with low bandwidth requirements.

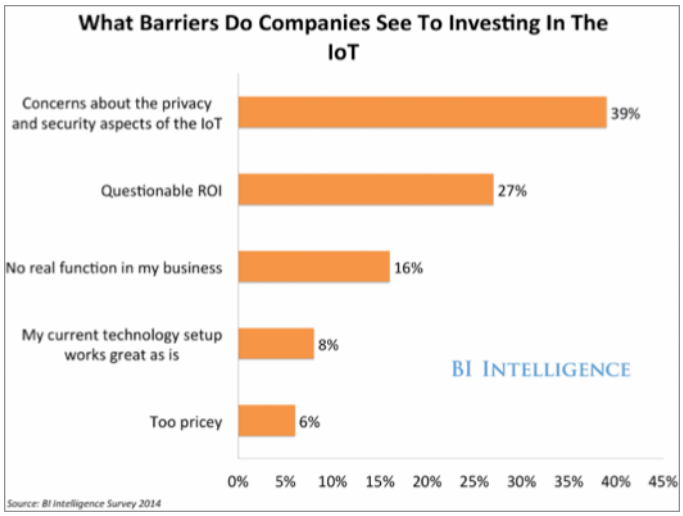

Figure 2 *- Company barriers to IoT adoption identify over 60% of the surveyed technology executives are reluctant to adopt because of privacy and security or skepticism around Return On Investment (ROI)*

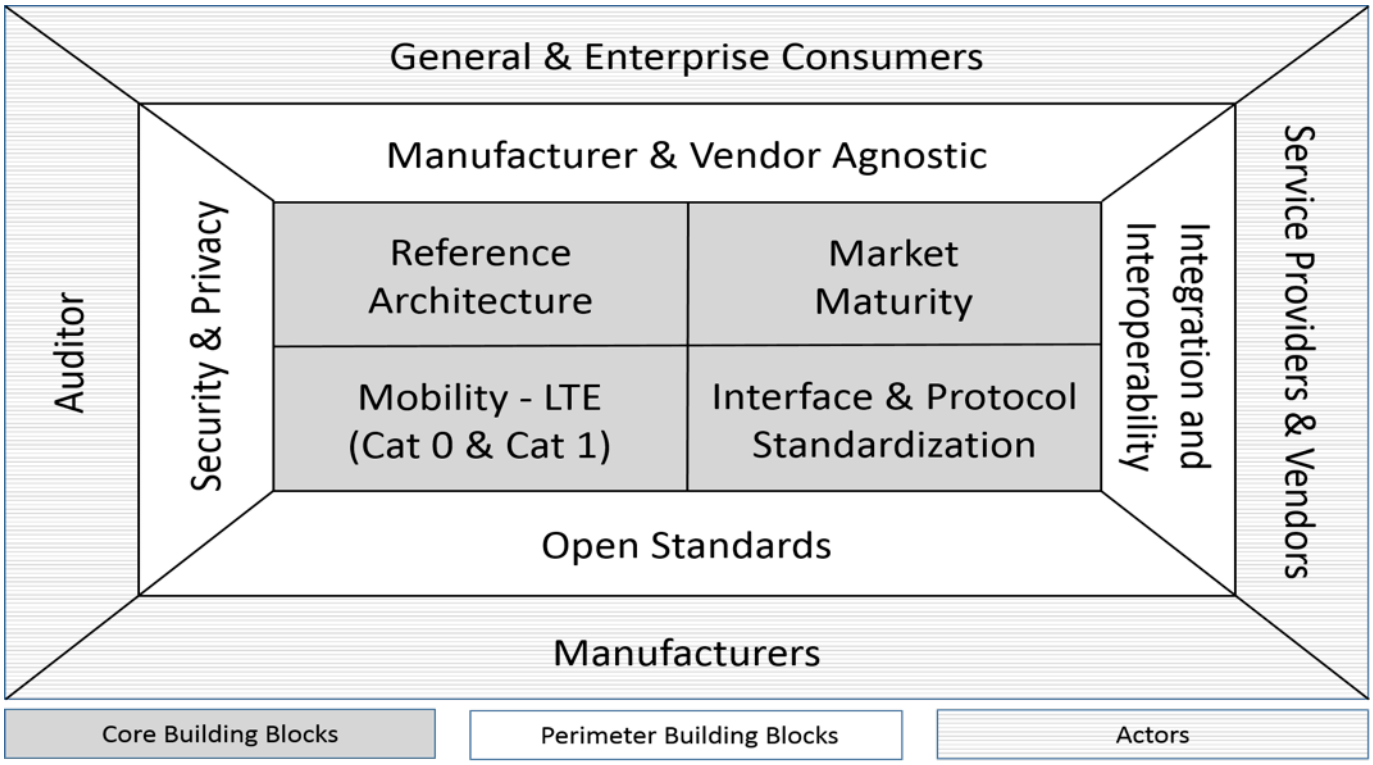

Figure 3 *- IoT model: Successful deployment of the building blocks in collaboration with the actors will lessen the security, privacy, and interoperability issues expediting IoT adoption.*

- **Interface and protocol standardization** - Ensure seamless integration and interoperability between systems, services and connectivity devices both directly through a telecommunications service provider and home base station. The interface and protocol standardization will also protect consumers from proprietary solutions by supporting a vendor, manufacturer and service provider agnostic approach to IoT.
- **Market maturity** - The consumer market demographics today is comprised of varying degrees of knowledge regarding technology and more specifically IoT. A study by EDUCASE and North Carolina State University [4] showed that today's college students have grown up with technology with 20% or more using computers by the ages of 16-18 and a much higher percentage for children. Further the study showed that 96% of today's children between the ages of 8-18 have gone on line. The technology savvy younger generation is more likely to understand IoT and more quickly adopt. Conversely, the elder generations commonly referred to as the "Baby Boomers" and "Gen X" had far less exposure to technology and are less likely to understand IoT resulting in a slower adoption rate. During the period of time when the "Baby Boomers" and "Gen X" would have gone to University, the personal computer had not been released yet or was still in its maturation infancy. Market maturity also requires available and reliable connectivity whether it be solely within the home, to the internet or cloud.

2. Perimeter building blocks: The perimeter building blocks represent some key characteristics yielded by the core building blocks and that will pave the way for a higher and more rapid adoption rate. These characteristics will help address those IoT challenges and concerns of manufacturers, vendors, and consumers alike.

- **Manufacturer and vendor agnostic systems** and services is a key characteristic necessary for driving more reliable IoT systems and services. Consumers will be apprehensive about spending any money on a particular product or service if it will only work with other products and services from the same manufacturer or vendor.
- **Integration and interoperability** will increase consumer confidence and adoption ensuring that the best of any products or services can function with each other whether from the same or varied vendor(s). Manufacturer or vendor concerns about losing share of wallet through this level of Interoperability should be safeguarded through differentiation of their products and services which is considered in proposing the core building blocks.
- **Open standards** will foster a higher level of entrepreneurialism. This is a critical characteristic that significantly contributes to innovation and the advancement of technology. Embracing open standards also minimizes proprietary solutions driving higher costs to the consumer.
- **Security** is a key characteristic given the international focus on data privacy and ever increasing risks with cyber threats. Each of the core building blocks will contribute to an overall increase in security for all products and services regardless of the manufacturer or vendor creating a win-win situation for all.

3. Actors: Successful IoT adoption requires close collaboration and support of actors, including manufacturers, consumers (general and enterprise), service providers and vendors, and auditors. Service providers are mostly mobile network operators and software as a service providers. Auditors take into account international laws and domestic regulations in each region to devise guidelines toward secure IoT deployment. Finally, the consumers are either general end-users who utilize

the IoT services and products or enterprise companies that incorporate the IoT into their products.
In the next section, an exemplary scenario demonstrates how the successful deployment of IoT and its building blocks can improve quality of human life and increase the confidence level of patients.

3. Scenario Background

It is the year 2020 and IoT has wide spread adoption. Manufacturers are producing devices that are based on an open standard reference architecture inclusive of standardized interfaces and communication protocols. Full integration and interoperability exists with LTE-enabled smart phones leveraging the widely deployed LTE technology, specifically taking advantage of the Cat 0 interface. The tremendous heterogeneity yielded by market maturity drives manufacturer and vendor agnostic solutions creating a high level of interoperability. Collectively, the IoT building blocks result in secure end-to-end communications thereby safeguarding the consumer and their sensitive data. Further, IoT systems and services become significantly more reliable addressing more critical consumer needs.

The highly reliable and secure IoT systems and services are used in industries such as healthcare, insurance, automotive, security, and agriculture along with many others. The healthcare industry has significant time sensitivities and leverages IoT systems and services to expedite actions that would otherwise take much longer and exceed the "Golden hour" reducing the odds of recovery.

- **Scenario Narrative**

John Smith is a retired senior citizen who has had a successful accounting career for over 40 years. He spent a significant amount of his work hours in a chair behind a desk not getting much cardio exercise. His work was high stress and time consuming not leaving much room for personal activities. John visited his doctor for a physical and was informed that he has a serious heart condition and has been placed on medication and a strict cardio exercise routine. Further, the doctor has recommended that a small IoT enabled chip be implanted in his neck that would communicate with an application on his smart phone. This chip would identify when medication is needed, advise to slow current pace down, send information to the doctor, advise to seek medical attention and call an ambulance sending current location. He happily follows the doctor's recommendation and has a minor outpatient activity performed to implant the chip.

Months go by with John following his cardio routine and enjoying the extra level of confidence provided by the implanted chip. One early morning he is in the middle of his morning walk and begins to feel his left arm go numb. He becomes dizzy and nauseous making it impossible for him to operate his smart phone. The chip detects the heart incident and automatically calls an ambulance and sends his current location. An ambulance arrives within 5 minutes and 10 minutes later John is in the emergency room with a full accommodation of doctors. Shortly after arriving to the emergency room, his regular doctor arrives and has all the information from the incident that was sent via the implanted chip. John is given some medicine and spends a day in the hospital for observations. He is also informed that if he did not have the chip, the time lost due to no information and no location could have cost him his life. John continues to lead a normal life, but lives with a much higher level of confidence in being able to manage his illness.

The security provisions in the design and implementation of the building blocks, ensure that the encrypted sensitive data of John is securely transmitted over the seamless LTE medium to the Things in his emergency case. Moreover, the vendor-agnostic features of the solution allowed the implanted chip to interoperate with varied Things including the ambulance, doctor and emergency department's monitoring systems with no worries of his private medical data being compromised.

The industry implementation and acceptance of the building blocks will incrementally remove the challenges and barriers responsible for the slow IoT adoption. Manufacturers will begin investing in the development of new products and devices that support IoT having more confidence in the longevity and sustainability of IoT. Consumers will begin to more widely adopt IoT having a higher level of confidence in the security and reliability of those products, devices, and services.

4. Conclusions

IoT has tremendous value to add to the consumer, manufacturer and vendor, but its lack of maturity in reliability, security, as well as other traits that are hampering a more rapid adoption. A structured and more aggressive approach that puts the IoT building blocks in place will accelerate the maturity of reliability and security fast tracking adoption. Like the "Little engine that could", positive thinking, a clear understanding of what is required, and persistence from consumers, manufacturers, and vendors will result in IoT success.

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