



Internet Of Things at Home

Abstract

The Internet of Things is emerging as the third wave in the development of the internet. Internet of things (IoT) is expected to have a massive impact on consumer products, business and wider culture, but these are still early days. Given its potential for very wide applicability to almost all verticals and aspects of business, industries, manufacturing, consumer goods, supply chains, etc.. IOT as a whole is very broad area. This paper focuses specifically to its adoption to our Homes. Examines current leading companies in the market and technologies driving the same. Importantly based on analysis of current consumer sentiment about the new smart devices, carves out the potential opportunities to bring down the barriers the Internet of Things is facing on its way to mainstream adoption and who has potential to win in this segment.

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1. Introduction: Main Hypothesis and Topic

The internet has played a fundamental role in our lives by allowing people to connect across continents and has brought us closer as a race. The first internet wave made it possible to connect 1 billion users via personal computers in the 1900s. This was followed by the mobile internet wave which resulted in more than 2 billion additional connected users since early 2000. The next wave, which has already begun, will connect up to 50 billion “things” to the internet by 2020 up from the 10 billion which are already connected today. We are at the cusp of realizing the full potential of the information collected through these internet of things (IoT).

Up until the dawn of this decade (2010s), the devices connected to the internet have predominantly been homogenous (PCs or smartphones) and used primarily for communication purposes. The next wave of “things” ranging from the wearables such as smart watches and glasses to smart refrigerators and door locks are going to be heterogeneous. To some degree currently each smart product functions on its own but doesn’t connect to other things as people in day to day expect, to create value things need to talk to other things and need to go beyond just providing remote control functionality. So, in order for a smart home containing this heterogeneous set of things to operate with little or no human intervention a management system will be needed. As shown in Figure 1, the lack of such a management system along with the cost of the current devices has been a major factor in preventing customer from embracing the connected devices in their homes.

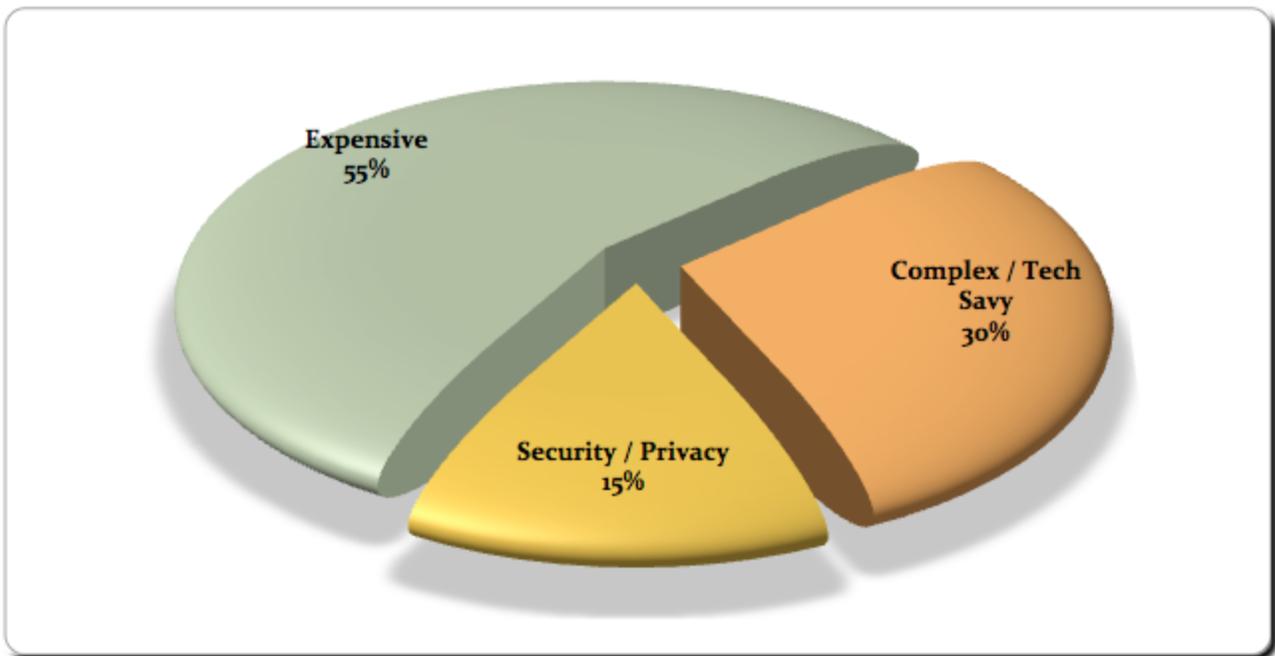


Figure 1 Reasons preventing consumers from embracing Internet of Things

Given the current trends and the customer psychology (based on the market research), we expect the following trends to unfold in the near future:

1. The scale and production economics will lead to a significant reduction in the cost of the connected devices (things) that can provide us useful information and controls related to our home
2. The abundance of devices will lead to large amounts of data generated related to consumer behaviors
3. A management system will emerge from one of the primary players (Apple, Google, Samsung etc.) that will collate and process this information to enrich consumers lives

2. Market Trends

The Internet of Things is a phenomenon where tiny machines have the ability to sense, respond, compute, and connect to the Internet, providing unprecedented access to control things and the environment around us. While it is still in its infancy, the time is ripe now with all the key ingredients in place – low price points for the devices, explosion of smartphones, tablets, PCs which are essential for providing the ability to manage and control the devices, broadband access to the Internet in homes, consumer demand, and manufacturers providing the capabilities to differentiate their products - for an explosive growth over the next decade.

Home automation with the proliferation of IoT is becoming a reality now, and a variety of players like, Apple, Amazon, Google, Samsung, are all converging into this space to provide the platform and solutions for smart homes. Homes account for more than 30% of electricity usage, have natural overlap with consumer-oriented devices (e.g., smartphones), and ample room to digitize. While the concept of “smart homes” has existed since the 1960s, the house remains one of the few elements in our lives still governed by physical / analog solutions. Digitization within the home is going to increase, specifically in home energy efficiency, home comfort, and security as initial key areas of focus.

Connected-home device shipments will grow at a compound annual rate of 67% over the next five years, much faster than smartphone or tablet device growth, and hit 1.8 billion units shipped in 2019, according to BI Intelligence estimates. Connected-home devices include all smart appliances (washers, dryers, refrigerators, etc.), safety and security systems (internet-connected sensors, monitors, cameras, and alarm systems), and energy efficient equipment like smart thermostats and smart lighting, healthcare for remote monitoring, diagnostics and services. Some of these areas like healthcare are in the stages of infancy, whereas, security and energy efficient equipment are in the early growth phase.

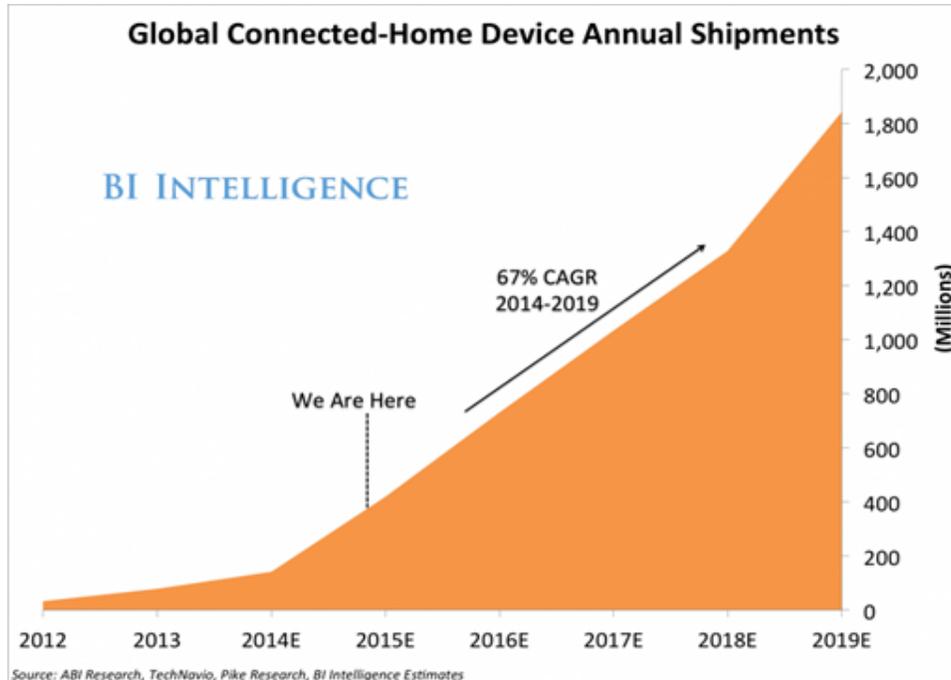


Figure 2 Projected Global Annual Shipments of Connected-Home Devices

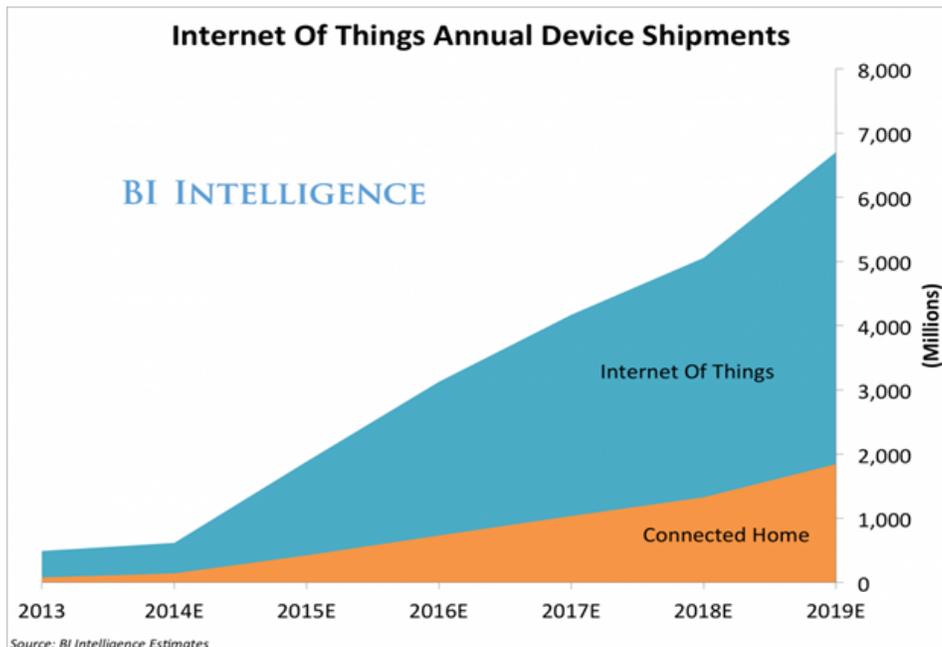


Figure 3 Projected Global Annual Shipments of overall Internet of Things

The connected-home category will make up about roughly 27% of shipments within the broader Internet of Things category by 2019 based on BI Intelligence forecast, as growth in other IoT areas picks up. The economic implications are huge, as it is projected to add a massive \$1.7 Trillion value in the form of hardware, software, installation, management services and value added from the efficiencies.

3. Home IoT Landscape

In Home IoT arena, current players are transformed traditional players from service sectors providing modernized Smart security/surveillance services, internet/TV/media services and Smart power utility services and new players are from emerging IOT device & gateway device manufacturers, health care related services providers and integrated management function providers.

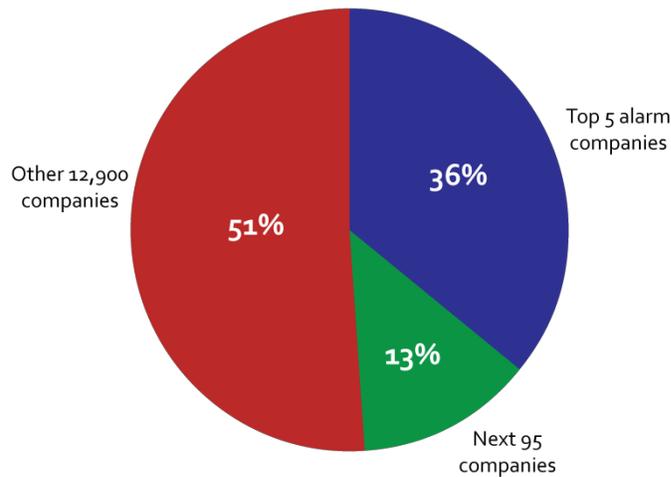


Figure 4 Diverse landscape of companies providing security solutions

ADT dominates \$13B Home security and automation providers market by taking around 25% of market with \$3.3B revenues in 2013 with seven million customers. The ADT Corporation (ADT) is a leading provider of electronic security, interactive home and business automation and monitoring services for residences and small businesses in the United States and Canada. ADT's broad and pioneering set of products and services, including ADT Pulse® interactive home and business solutions, and health services, meet a range of customer needs for today's active and increasingly mobile lifestyles. Three biggest players behind ADT are Protection 1, Monitronics and Vivint commanding only 9 percent of the market. There are many other smaller players sharing the rest of the pie.²²



Figure 5 Revenue Growth for professionally monitored security domain

Cable behemoth Comcast with its new home monitoring service and telecom giant AT&T with its new Digital Home service are expected to make big strides into home security markets constituting a trend to move more into IP based security with significantly higher growth rates (>10%) than the traditional security services (<2% current to negative).

Smart Power sector took off starting in 2007 by the roll out of Smart Meter at homes by traditional utility companies reaching installation of 46 million homes by mid 2013. PG&E in west coast spearheaded this move in 2011 in this government-regulated market making revenues in the tune of \$14B in 2013 aided by the highest installation by any utility company in the order of 5.1million homes. Top smart meter vendors include large companies Lutron , Siemens and a startup Silver Spring networks.²³

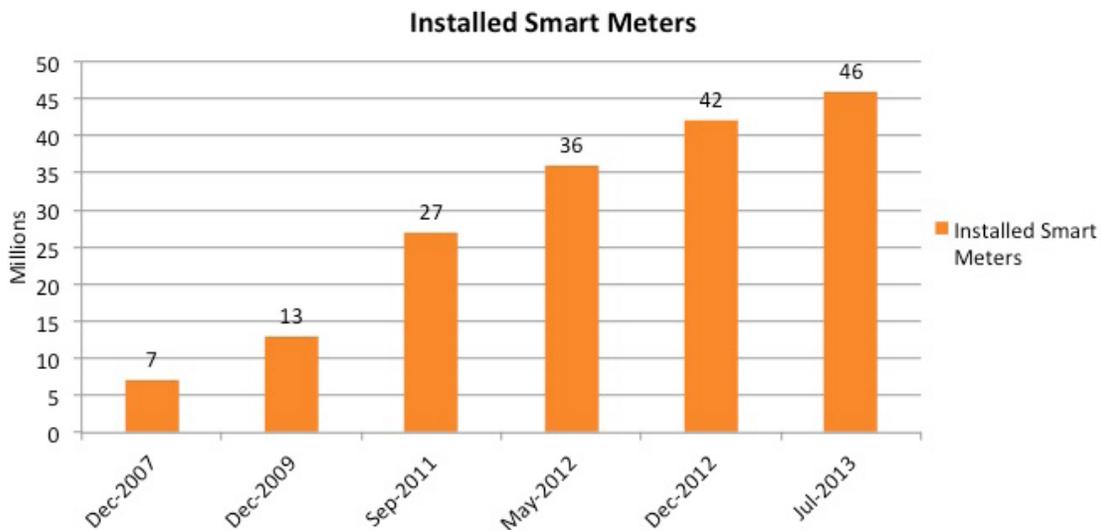


Figure 6 Historical adoption of Smart meters

Other two power related emergent technologies are smart thermostats and lighting. Honeywell is an incumbent in smart thermostat field with 39% of \$3.1B market and Johnson Controls with 6.5% of market share. Google quickly acquired a new entrant Nest that entered the market with an auto programmable thermostat, for \$3.2B, showing the potential and the hype, causing big players to get a foothold in 'Connected Home' market. Traditional lighting manufacturers Philips and GE dominate the smart lighting market.

Home IOT technology also created a niche for health & medical devices and a market for health services connecting data to the health care providers. This sector attracted hundreds of million of dollars in investments into smaller companies including AdhereTech and Fitbit. Qualcomm with a revenue of \$25B in wireless technologies made an early entry into home health service market by creating a subsidiary Qualcomm Life, that is defining and connecting the wireless health network to improve lives and advance the capabilities of medical devices. Qualcomm Life is focused on medical device connectivity and data management and empowers medical device manufacturers to deliver wireless medical data quickly and easily to those who need it.

With Connected-home devices annual growth projection of 67%, other large players Samsung made an entry by acquiring SmartThings, a fast growing home automation startup for around \$200 million. Apple with its interest to connect all the consumer devices to the home gateway, made a move by defining a common communication platform with its HomeKit. HomeKit is a framework in IOS for communicating with and controlling connected accessories in a user's home. One can enable users to discover HomeKit accessories in their home and configure them, or can create actions to control those devices. Users can group actions together and trigger them using Siri, IOS voice operating tool.

Apple, Google & Samsung entry into home IOT market is the likely catalyst in next 3 to 5 years for the home IOT device vendors move towards common communication platforms and integrate with a consolidated management. IOS and Android are the likely mobile platforms center of access to highly automated homes.

4. Current Barriers

Many studies show that the adoption of IOT devices at home are going to be quite high in mid to long term, main barrier for a faster growth is that 'not many people heard of Internet of things'. Among those aware of these devices are concerned about the perceived value of these devices, price, fear of new technologies, security and privacy (Figure 1).

Consumers are more willing to pay higher prices for safety devices like smart alarms and smart smoke detectors. Better consumer education about benefits of these devices will help in early adoption of these devices by many households. Consumers are also willing to purchase smart devices like smart thermostats if these are offered instead of standard devices in the stores.

4.1. Regulations

The Federal Trade Commission is examining the emerging role of connected technology and the ramifications for user privacy and data security. FTC recently handed down 20-year Consent Order²⁵ to TRENDnet over the company's "secure" webcams which were due to faulty software. FTC is taking a serious look at what kind of regulatory steps or oversight are necessary for personal and home devices that collect unique user data and transmit it over the Internet.²⁶

FDA also has developed guidance document to assist industry and FDA staff in identifying and appropriately addressing specific considerations related to the incorporation and integration of radio frequency (RF) wireless technology in medical devices. This guidance highlights and discusses RF wireless technology considerations that can have an effect on the safe and effective use of medical devices. These considerations include the selection of wireless technology, quality of service, coexistence, security, and electromagnetic compatibility (EMC). Consideration of these areas can help provide reasonable assurance of safety and effectiveness for medical devices that incorporate RF wireless technology, and are supplementary to other device-specific guidelines.²⁷

4.2. Societal impact

Societal impact of auto-data collection by sheer number of IoT devices, likely in 100s of billions, is huge as this data could be used in ways that change how humans and devices, humans and humans, and, data owners and service providers interact. Medical data collected by medical IoT devices help patients remotely treated by doctors transforming the current model of visiting doctors office or hospital for any kind of illness. Smart power devices may help control the power consumption to an extent that makes local governments & power utility companies self sufficient in energy that lessen the need to search for alternate and more greener energies. Increased privacy concerns that arise out of huge data management and data usage likely to increase governmental regulations in the wireless communications and user data access. Societal impact is hard to predict as it is hard to predict the adoption of variety of IoT devices.

5. Technology Enablers

IoT is wide and complex technical area as reflected from above diversity. Number of significant technologies coming together is enabling the rise of IoT, as it cannot be achieved by just one or two. Below we provide a glimpse of high impact technologies that have emerged tremendously. New advancements and overwhelming innovative products in each individual category in recent years are making IoT technically feasible and evolving it from just being a science fiction. Some other ecosystem enablers to facilitate connected homes are drop in prices of sensors and cost of bandwidth, extremely high growth in smart-phones, ubiquitous wireless coverage.

5.1. Communication

Zigbee or Thread like suite of high-level communication protocols to create personal area networks, designed specifically for the home. Mesh network designed to securely and reliably connect hundreds of products around the home – without blowing through battery life. Designed

to support a wide variety of products for the home: appliances, access control, climate control, energy management, lighting, safety, and security. Designed to have extremely low power consumption. Devices efficiently will communicate to deliver a great user experience; yet will run for years on the smallest of batteries.

5.2. BackBone

IPv6 or 6LoWPAN, the newest version of the Internet Protocol (IP) standard that is intended to replace IPv4. IPv4 supports 32-bit addresses, which translates to about 4.3 billion addresses – a number that has become largely exhausted by all the connected devices globally. In contrast, IPv6 can support 128-bit addresses, translating to approximately 3.4×10^{38} addresses – an almost limitless number that can amply handle all conceivable IoT devices. 6LoWPAN is an acronym of IPv6 over Low power Wireless Personal Area Networks. The 6LoWPAN group has defined encapsulation and header compression mechanisms that allow IPv6 packets to be sent to and received from over IEEE 802.15.4 based networks.

5.3. Embedded OS for IoT devices

Software designed to require as little battery power and memory as possible. It is based on a microkernel and designed for energy efficiency, hardware independent development, a high degree of modularity. Supporting 6LoWPAN, IPv6, RPL, TCP, and UDP.

5.4. Cloud Computing

Cloud is secret weapon in internet of things and IoT is the next big market for cloud. Cloud computing in nutshell is computing in which large groups of remote servers are networked to allow the centralized data storage, and online access to computer services or resources. They are classified as public, private or hybrid. Smart objects will be endowed with sensors that will feed data back to cloud platforms for analysis. With so much data flowing in from potentially millions of different nodes, the diversity and precision of the knowledge we have about the world will explode. The cloud is the only technology suitable for filtering, analyzing, storing, and accessing that information in useful ways. Cloud computing will be driving Internet of things in every step of the way forward.

5.5. Big Data and Analytics

Big data analytics is the process of examining large amounts of different data types, or big data, in an effort to uncover hidden patterns, unknown correlations and other useful information. As the IoT will by definition generate voluminous amounts of data, the availability of big data analytics is a key enabler. Currently also Google nest uses this to carve out usage patterns of user and make auto adjustments to the temperature after learning the user behavior and preferences. So, this technology in general will enable importantly interconnecting the data from different devices from home, drawing more intelligence collectively and allowing various innovative applications emerging based on the same.

6. Summary and Opportunity Prediction

Internet of things has been predicted to happen since the late 90's. However, the lack of a complete eco-system has prevented a major forward movement. With the significant reduction in the cost of sensors, processing (cloud) and bandwidth the main obstacles have been eliminated paving the way for Internet of Things to grow in all areas.

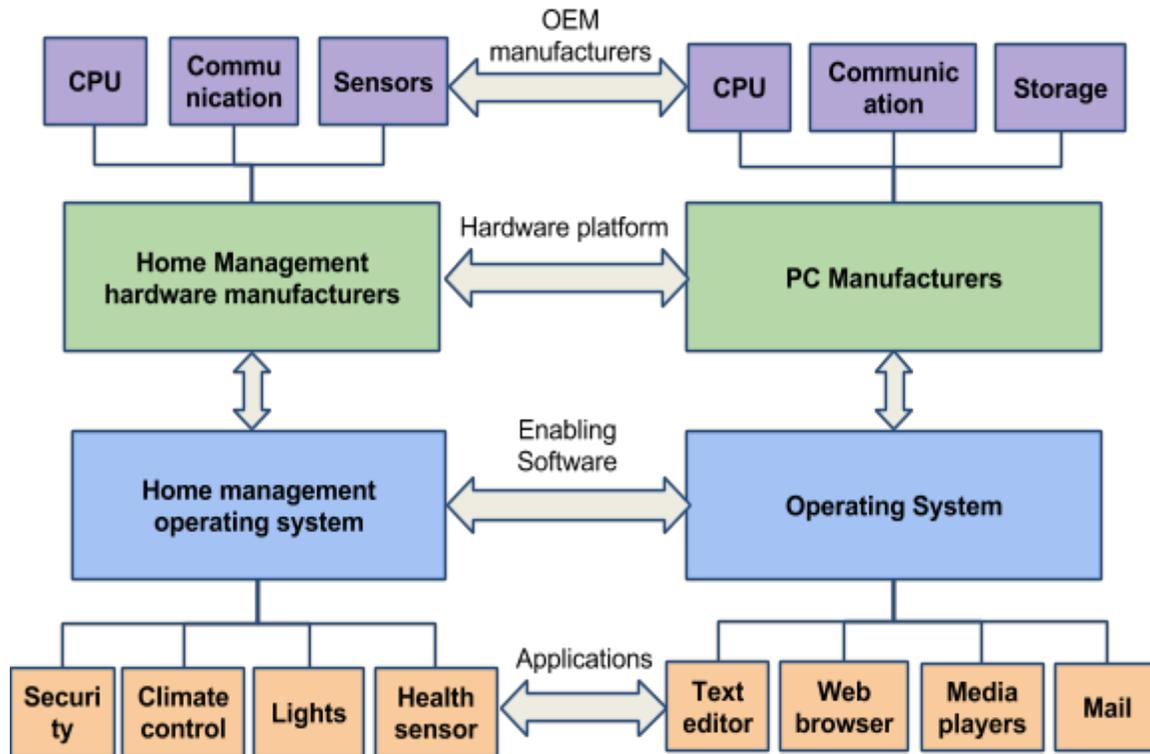


Figure 7 Parallels between different horizontal layers for IoT and PC

We see a number of parallels between the IoTs and how the PC revolution unfolded in the past. Figure 7 shows that significant business opportunity lies at all levels starting from the hardware OEM manufacturers to different solutions (application) developers. We see that there will be a strong demand for the sensors, communication and processing hardware. This will be similar to the growth seen by the processor, memory and disk industry during the PC boom. There will be a set of integrators that will integrate the hardware into a system. To enable the heterogeneous devices to share data and operate based on the shared information a management software provider will be required. We envision a large software company to lead this area. This will alleviate another impediment to the adoption of Internet of Things at Home related to the complexity in the management of these devices. With the massive proliferation of Mobile devices and the unification in the platforms (iOS, Android) this problem is likely to be solved in the near future (example: HomeKit). Finally, a number of different applications will plug into the management infrastructure and will allow for further business opportunities.

In summary, our prediction is that Internet of Things at Home will see significant growth in the next 3-5 years with Apple and Google being direct beneficiaries along with many small players which will develop individual applications that will plug-in to the central system.

7. References

1. <http://qz.com/269840/the-internet-of-things-explained-making-sense-of-the-next-mega-trend/>
2. <http://fortune.com/2014/10/04/the-7-most-useful-smart-home-devices/>
3. <http://www.informationweek.com/strategic-cio/digital-business/forget-things---its-the-internet-of-business-models/a/d-id/1297515>
4. <http://radar.oreilly.com/2014/04/business-models-that-make-the-internet-of-things-feasible.html>
5. <http://www.iot-i.eu/public/news/the-internet-of-things-by-internet-of-things-experts>
6. <http://www.iot-i.eu/public/news/internet-of-things-europe-the-movie-imagine-everything-was-linked...-1>
7. <https://www.youtube.com/watch?v=Yd98Naz8jvQ>
8. <http://www.cio.com/article/2686197/business-analytics/internet-of-things-as-a-service-taas-hype-vs-reality.html>
9. <http://cloudtweaks.com/2014/08/business-models-internet-things/>
10. <http://mobile.itbusinessedge.com/slideshows/ten-cool-companies-that-are-monetizing-iot-and-how-you-can-too.html>
11. <http://www.zdnet.com/googles-physical-web-project-looks-to-inject-internet-of-things-with-more-search-7000034320/>
12. <http://www.fool.com/investing/general/2014/10/03/is-invensenses-internet-of-things-opportunity-bein.aspx>
13. <http://news.yahoo.com/city-ready-join-internet-things-op-ed-205004939.html>
14. <http://www.cnet.com/news/internet-of-things-promote-thread-protocol-at-google/>
15. http://www.slideshare.net/claropartners/claro-meetup-28oct2013jv?next_slideshow=1
16. http://go.gigaom.com/rs/gigaom/images/gigaomresearch_the_internet_of_things_report.pdf
17. <http://www.slideshare.net/claropartners/claro-io-tw1329oct2013>
18. <https://thethings.io/>
19. <https://www.youtube.com/watch?v=Jrg5IIHNEIU>
20. <https://www.abiresearch.com/market-research/service/home-automation-and-smart-buildings>
21. <http://wallstcheatsheet.com/technology/can-google-apple-or-samsung-lead-the-internet-of-things.html/?a=viwall>
22. <http://www.fiercetable.com/special-reports/comcast-leads-cables-push-cut-13b-home-security-and-automation-market-0>
23. http://www.edisonfoundation.net/iee/Documents/IEE_SmartMeterUpdate_0813.pdf
24. <https://developer.apple.com/homekit/>
25. <http://www.google.com/url?q=http%3A%2F%2Fwww.ftc.gov%2Fos%2Fcaselist%2F1223090%2F130903tr%2Fendnetorder.pdf&sa=D&sntz=1&usq=AFQjCNGgn4E0kR5v8MyGzW0q5wSVMr5wwQ>
26. <http://www.forbes.com/sites/amadoudiallo/2013/11/23/ftc-regulation-internet-of-things/>
27. <http://www.fda.gov/downloads/MedicalDevices/DeviceRegulationandGuidance/GuidanceDocuments/ucm077272.pdf>



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