

INTERNET OF THINGS/M2M FOR SMART HOME



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**DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING.
SONARGAON UNIVERSITY, DHAKA, BANGLADESH.
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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
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ABSTRACT

The Internet of Things (IoT) is the next step in the evolution of wireless networks, Big data, and connected devices, as sensors shrink in size and migrate from our smartphones to other everyday objects. Analysts predict the IoT will double in size to nearly 50 billion things by 2020, comprising a \$1.7 trillion market.¹ Some of these smart things already monitor the performance of power plants, factories, and jet engines; others collect our vital signs from bracelets and watches. In each of these cases, the IoT is both saving lives and transforming industries and societies.

One of the greatest opportunities still lies ahead in the form of the "smart home." Smart homes typically evoke visions of *The Jetsons'* robot maid or refrigerators ordering milk from Amazon, but they also offer possibilities for energy and cost savings, greater home efficiency through automation, as well as improved home security. Smart homes have the potential to provide for consumers' growing expectations of convenience, sustainable living, safety, and security.

The world has seen tremendous growth in telecom technology during the last decade. As a result of this, a multitude of new applications of the Information & Communication Technologies have emerged and changed the way we live, work, play, interact and even think. This has created a lot of momentum in many spheres that impact our lives. Latest trend is Machine-to-Machine (M2M) communication / Internet of Things (IoT) which has led to a new world of possibilities and opportunities. Smart Home is one of the focus areas in this initiative as is evident from the large number of IoT / M2M enabled nodes being created for this sector.

While 'Smart' inherently means 'connected' in IoT world, Smart Homes could have multiple meanings for different people and even different situations. A Smart Home is a user's private space and each user may have different needs. The users spend a significant amount of time at their homes and may have different expectations depending on their background, taste, affordability and availability of common services.

A Smart Home is an aggregation of all the needs of its occupants while they are inside and also when they are not. Remote control, Security, surveillance, remote monitoring of premises including monitoring those who are sick, young, elderly, etc are all requirements of users. In order to meet these requirements, an integration at the Application level and scalability at the cloud level are needed.

With this kind of diverse backgrounds of users and their requirements and tastes, defining a common platform for a Smart Home is a rather challenging task. What could perhaps be possible is to create a generic platform that accepts multiple technologies as its inputs and somehow combines these inputs at the Home Gateway level and sends the information about various sensors from all the vendors on a single high speed communication link.

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1 Introduction

A smart home is one that incorporates advanced sensing and automation systems to provide the inhabitants with monitoring and control regardless of whether they are inside or outside the home. For example, a smart home may have controls for lighting, temperature, multi-media, security, window and door operations, as well as many other functions.

A Smart home, then, may be defined as a residence or a building with equipment which can be remotely controlled and operated from any location in the world by means of Smart Devices or through a smartphone. Smart Homes comprise of Devices that provide comfort, security, convenience, energy efficiency and enhance intelligent living. The Devices communicate and interact with each other and form a connected ecosystem. Smart Home is usually understood as automated home but the actual capabilities are beyond automation. Smart Home ecosystem comprises of a set of connected gadgets with Intelligence that help them in executing the task and take necessary decisions.

The first step towards making a home smart is automation as shown in Figure 1. The automation could be related to the individual appliances or nodes being intelligent enough to take local decisions. A simple



Figure 1 : Automated Individual Components, [14]

example could be a standalone porch light that turns on only when there is movement detected or wirelessly operated curtains / blinds. Another example could be a camera that records the movements
Asolar roof top system that charges a battery and acts as an inverter for the requirement of the individual home is also an example of an automated home system.

We may have another scenario where these elements are connected to each other controlled by a gadget placed inside the home (that may be called as in-home display). This connectivity could enable us to take

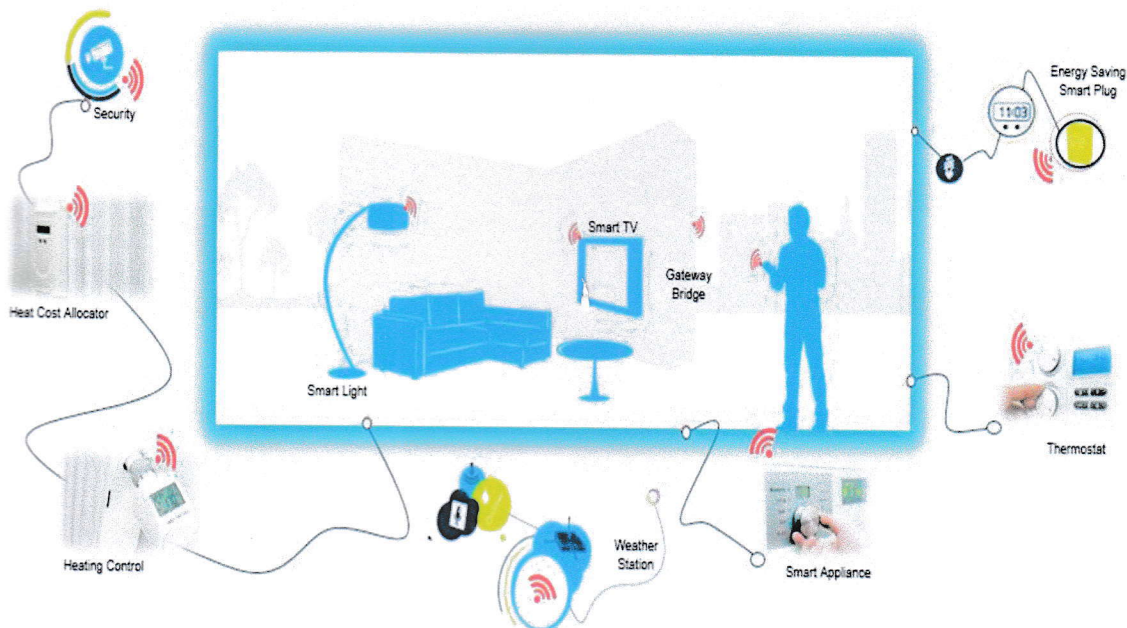


Figure 2 : Standalone Automated Home, [14]

Centralized decisions and monitoring, and would make the home autonomous. These systems, even if individually smart, do not make a complete smart home. This scenario has been projected in Figure 2.

Home buildings in Bangladesh scenario are difficult to be classified into a few categories, largely due to the economic disparity and the place of living. On one hand there is a large population that has barely access to essential requirements of water, electricity and food; and on the other hand Bangladesh has a small percentage of population with income levels similar to those of developed countries. The expectations of comfort, automation, security and services by this population are same as those of the developed countries.

Smart Homes present some very exciting opportunities to change the way we live and work, and to reduce energy consumption at the same time. The owners of smart homes are empowered with conveniences like: being able to check messages, open windows, operate lights and curtains and monitor how much

Money the house has made or saved from the renewable energy system or smart energy management system, through their respective smart phones, from anywhere in the world.

Further a Smart Home is a common and unifying gateway to the world for its occupants, various sensors and automating elements inside it. In fact it may be commented here that many other functions of connectivity may be considered as embedded within a Smart Home. As an example, remote patient

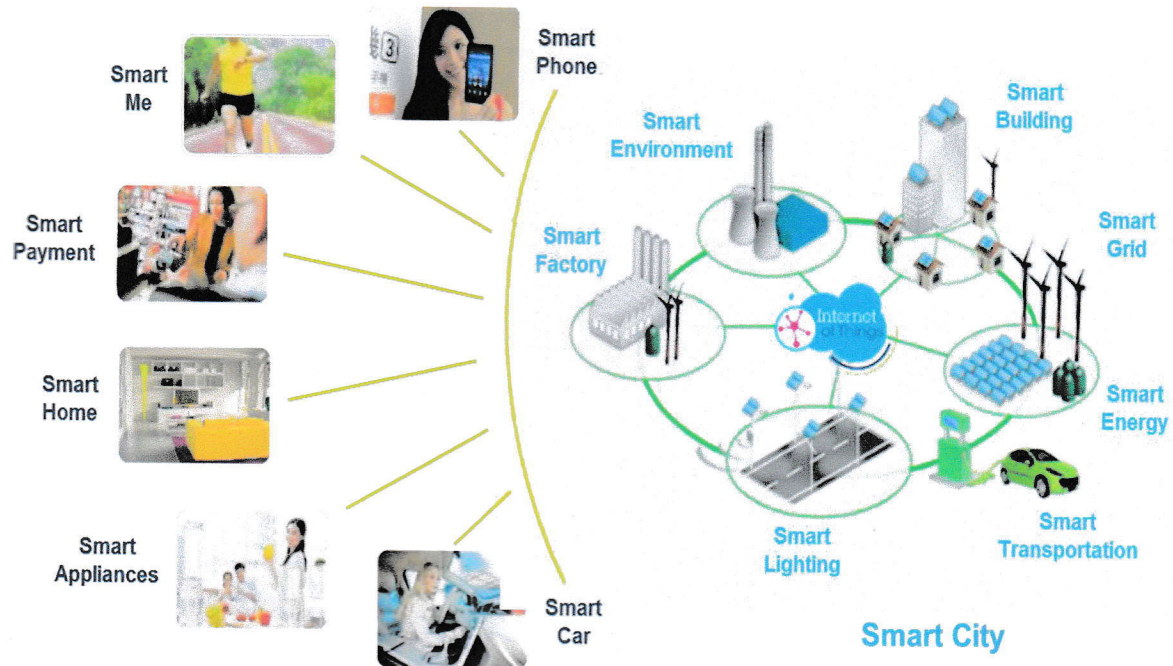


Figure 3 : A connected Home: Reference Smart Home as part of a Smart City, [14]

monitoring, vehicle charging, solar rooftops, metering, home appliances, electric and aircon controls, entertainment, health and fitness equipment and a host of other connected devices are part of a home and a Smart Home system is expected to provide a unified view of all these services. Smart home concept as described has been illustrated in Figure 3 in the context of Smart Home itself being a unit of Smart City.

Extending this concept further likewise, a Smart Home in itself may be a part of a large building complex and in a much broader sense of a Smart City. This presents opportunities and challenges for connectivity and interoperability. A large number of smart devices are now available and their numbers are increasing. At present most of the devices and gateways are working on proprietary standards. However for the fast development of the sector and to have economies of scale, devices, gateways, network and the applications are required to be developed on open standards with interoperability.

1 What is M2M Communication / IoT?

1.1 M2M Communication

It refers to the technologies that allow wired / wireless system to communicate with the devices of same ability. M2M uses a device (sensor, meter etc.) to capture an 'event' (motion, meter reading, temperature

etc.), which is relayed through a network (wireless, wired or hybrid) to an application (software program), that translates the captured event into meaningful information. A conceptual picture is shown in Figure 4.

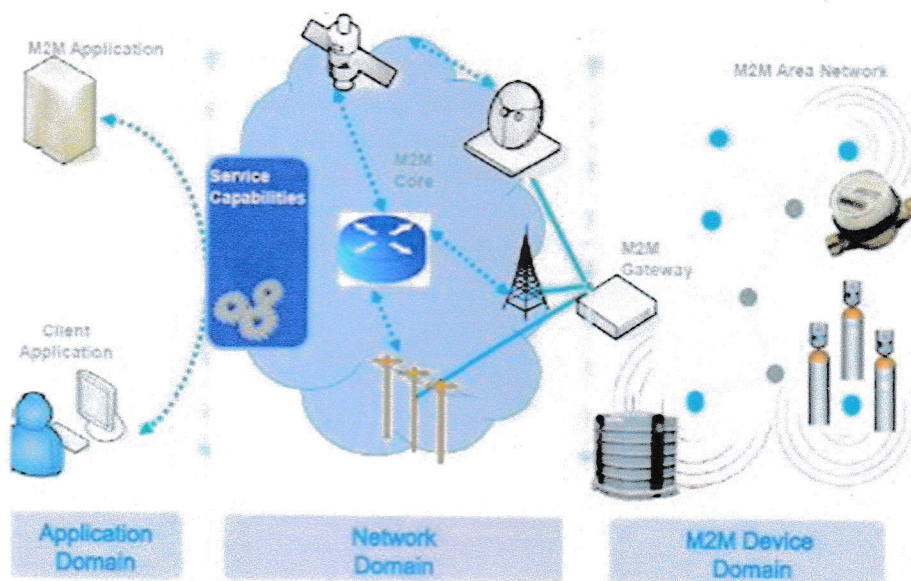


Figure 4 : M2 M Concept, [1]

The enabling technologies for M2M are sensor networks, RFID, mobile Internet, wired & wireless communication network, IPv4 / IPv6, etc. In Home area network (HAN) / Local area network (LAN), low power wireless communication technologies such as Wi-Fi, ZigBee, 6LoWPAN, Bluetooth Low Energy (BLE), Z-wave etc. may be used to connect the devices with the M2M gateway. GSM 3G/4G or fixed line broadband / FTTH may be used for connecting M2M gateway to the server. Low Power wide area network (LPWAN) technologies such as LoRa and Sigfox are being used for transmitting very small data. Based on 3GPP release 13 and 14, NBIoT technology is expected in near future on LTE network.

IPv4 addresses are going to exhaust. Standardization and adoption of IPv6 in telecom and ICT organizations will provide an opportunity of having billions of devices which can be IP enabled and seamlessly addressable through mobile or wired broadband connections.

1.2 Internet of Things

The Internet of Things (IoT) will revolutionize and change the way all businesses, governments, and consumers interact with the physical world. This level of disruption will have a significant impact on the world in improving the quality of life. IoT ecosystem may have M2M devices, Gateways, M2M Communication technologies, big data and process management, IoT platform, User interface (web, Mobile, HMI) and end to end security.

ITU-T in its Recommendation ITU-T Y.2060 (06/2012) has defined Internet of Things (IoT), as a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies.

ITU-T has also created a Study Group (SG)-20 in 2015 to study IoT and its applications in Smart cities and communities.

IoT will be having a heterogeneous network, having IP and non IP devices connected through IP Gateways. Gateways will be connected to IoT Platform. A huge amount of data will be generated by the sensors. Big data analytics may be used to create intelligence, which may be further used for various operational and planning activities. A typical network having various communication technologies and Gateways have been shown in Figure 5.

Connecting Things in M2M/ IoT

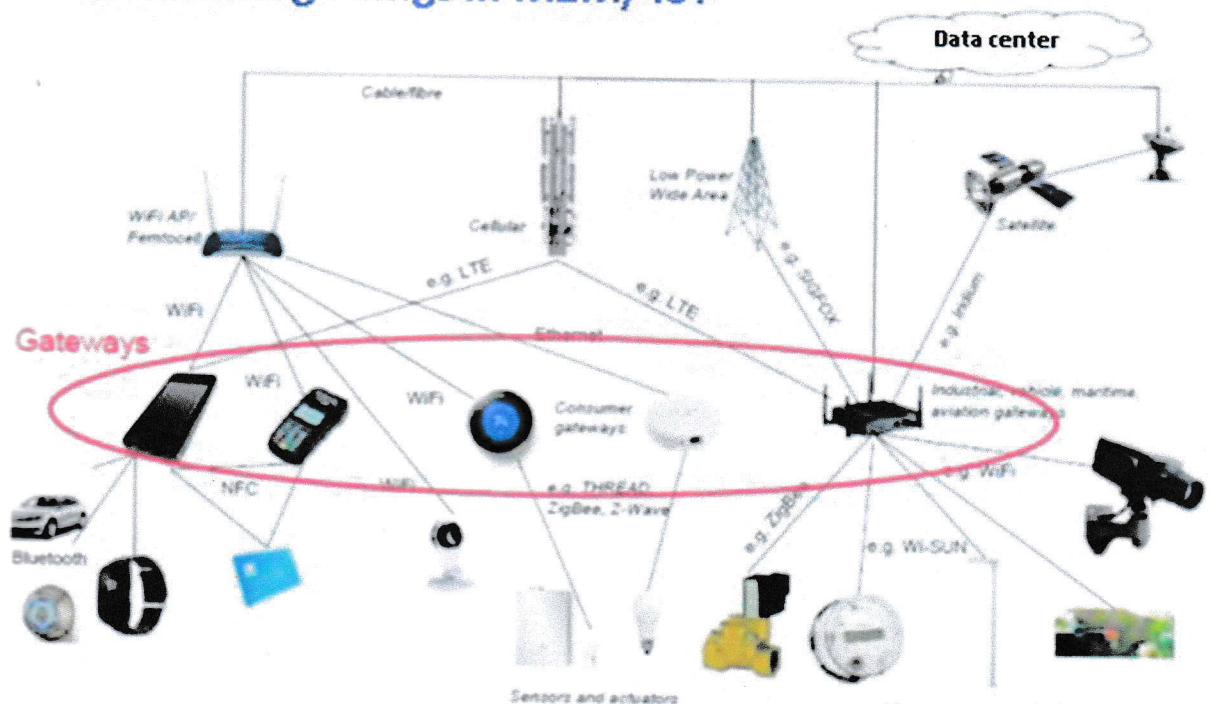


Figure 5 : A typical IoT / M2M Connectivity Network, [KeysightTechnologies]

Various verticals such as Power sector, Intelligent Transport system, Remote Health management, Safety & Surveillance systems, Village & Agriculture, Homes, and Industries etc. may be transformed to become smart by using M2M / IoT technologies. This will improve the efficiency and in turn the quality of life.

2 Smart-Home Background Analysis

As per the projections made by CISCO / ERICSSON / ITU, there may be around 50 billion connected devices globally by 2020 [2]. As per another study by CISCO in 2015, share of computers (including PCs, tablets,

and smart phones) will be around 17 percent of all Internet connections; the other 83 percent will result from devices to be used in various verticals of IoT domain [3]. Bangladesh is expected to have around 2.6 billion connected devices by 2020. The home automation market in Bangladesh is expected to reach INR 8800 Crores (US \$ 1.3 B) by 2017 and is growing at a rate of 30% CAGR (Source: RedSeerconsulting).

By 2022, a typical family home will contain 500 smart devices (Source: Gartner).

The idea of Smart Home was originated long back before the advent of IoT. The world has seen a tremendous change due to the invention of various devices to automate household activities during 1901-

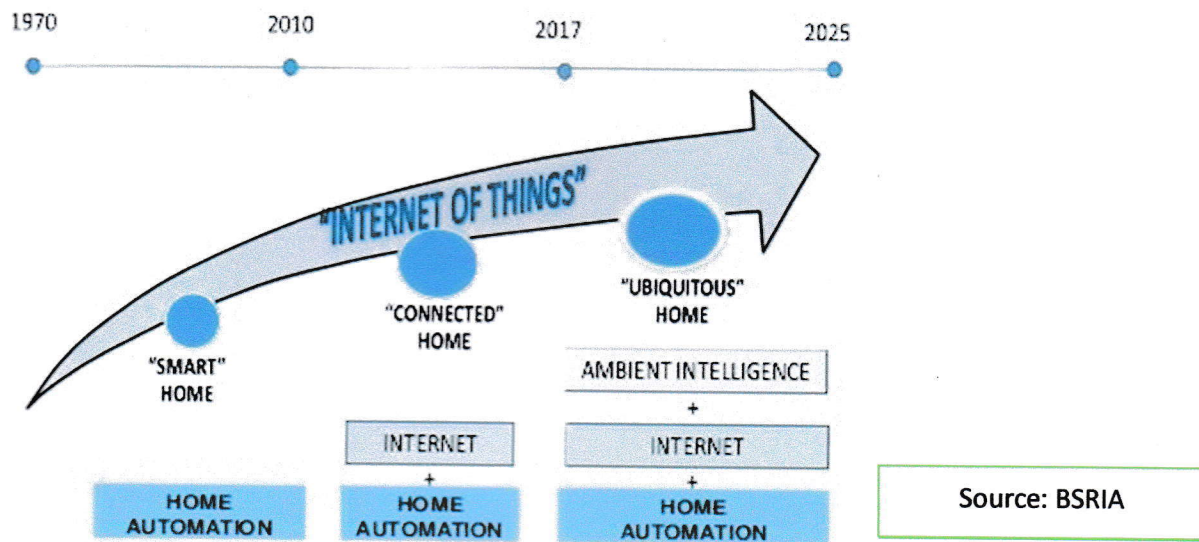


Figure 6 : Evolution of Smart Homes

1920. Among the few inventions of early twentieth century were first engine powered vacuum cleaner in 1901 followed by first generation of refrigerators, washing machines etc. In 1966, ECHO IV (Westing house) was the first smart device invented but was not sold in the commercial market. The device helped in automation of home appliances, controlling the room temperature and also assisted in preparing shopping list. This was followed by the invention of H316 Kitchen computer by Honeywell Corporation that could store recipes but was not commercially available. X10, the first commercial home automation technology was developed in the year 1975 and it used electrical power transmission wire lines for signaling and communication. Bill Gates's smart home which was built in 1995 attracted many people because of its features like temperature control, heated floors, customized preference for room lighting and climate control, monitoring his favorite Maple tree with sensors and computer to provide watering and better gardening. The major trend has started from 1990 where home automation was the basic functionality. With the growth of smart-phones and other smart devices, the smart home penetration has

increased in the world. The remote control is now embedded in smart phones in form of application to control.

Smart Homes are the integral part of Smart Cities. Connected things relevant to Smart Homes are forecasted to grow from 294 million to more than 1 billion; more than tripling in just three years, as shown in Table 1, [4]. Smart things inside the Smart Home are representing the biggest portion of the connected devices as per this report. Evolution of Smart Homes with IoT is shown in Figure 6.

Table 1 : Connected Things Installed Base within Smart Cities (in Millions)

Smart City Subcategory	2015	2016	2017
Healthcare	9.7	15.0	23.4
Public Services	97.8	126.4	159.5
Smart Commercial Buildings	206.2	354.6	648.1
Smart Homes	294.2	586.1	1,067.0
Transport	237.2	298.9	371.0
Utilities	252.0	304.9	371.1
Others	10.2	18.4	33.9
Total	1,107.3	1,704.2	2,674.0

Source: Gartner (March 2015)

Smart homes and smart commercial buildings represented 45 percent of total connected things in use in 2015. Due to investment and service opportunity, Gartner estimates that this will rise to 81 percent by 2020. Homes will move from being interconnected to becoming information- and smart-enabled, with an integrated services environment that not only provides value to the home, but also creates individual-

driven ambience. The home will become the personal space that provides assistance or personal concierge experiences to the individual as per Gartner report [4].

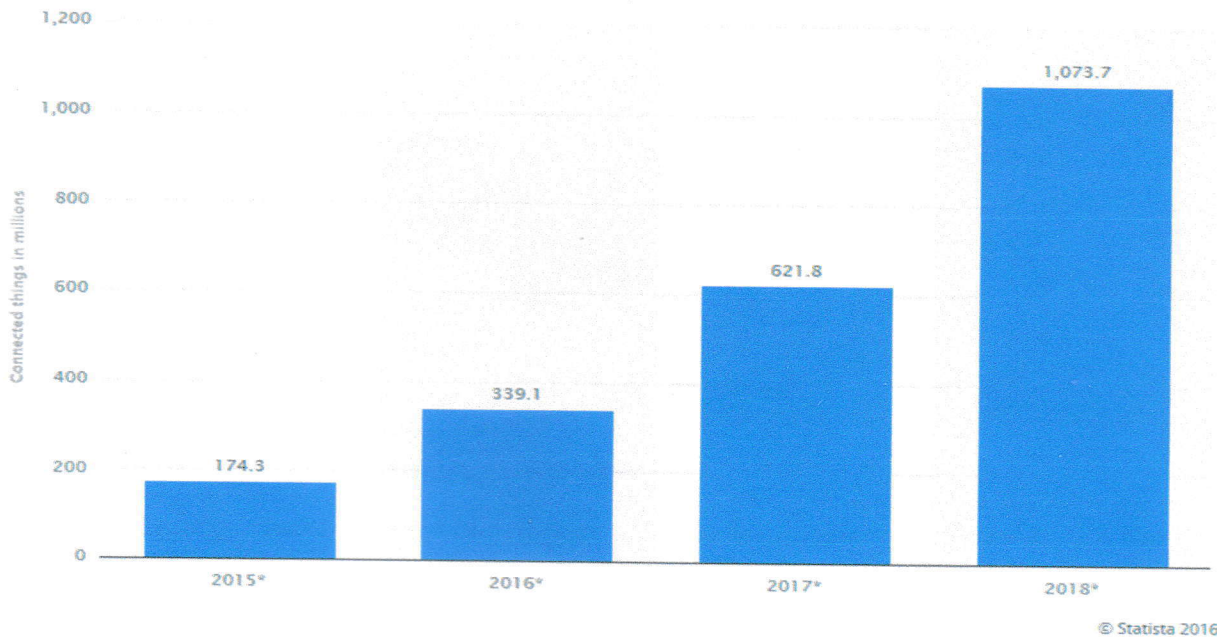


Figure 7 : Smart homes installed base of connected devices within smart cities from 2015 to 2018 (in millions)

In a similar analysis by Statista [5], the growth of installed connected devices in smart homes within smart cities from 2015 to 2018 is shown in Figure 7.

2.1 Current Market Scenario

According to a report [6] published in 2015, the major drivers for Smart Homes are Security, Convenience and Energy Efficiency. The awareness of Smart Homes is very high among customers from upper income segment and urban areas. Low entry barriers like open source technologies are encouraging more number of players to look for innovation and to provide better value proposition for their customers.

The Home automation market is broadly classified into Application based and Technology based. From Application perspective, the market may be segmented into Lighting, Safety and Security, Entertainment and Energy Management Systems, etc. Whereas based on various technologies used, it may be classified into Wired and Wireless technologies that may be further classified into X10, ZigBee, Bluetooth, Wi-Fi, Wi-SUN, Thread, PLC, Z-Wave etc. Presently the market is more concentrated towards luxury deployments based on specific or proprietary technologies and solutions, however there is a trend where more and more users and startups are creating Home automation platforms and systems that are cutting across the technology domains in many cases.

Region	Revenue in mUSD (2016)
Asia	2496.6
Australia	143.8
Europe	2803.8
Latin America	168.7
North America	9912

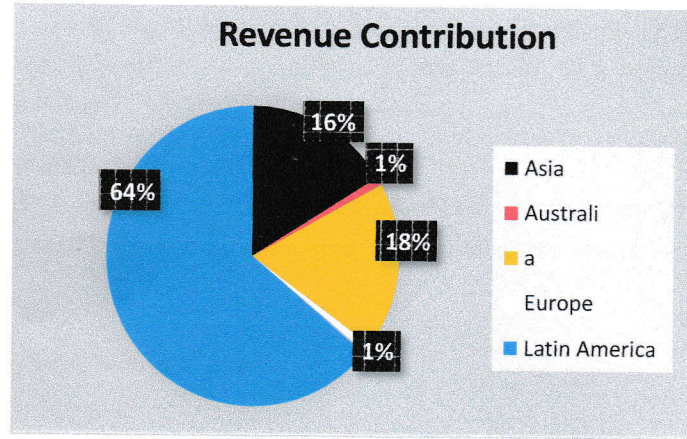


Figure 8 : Market Revenue, Source Statista

Presently the market revenue from Smart Homes is estimated as shown in Figure 8. The chart clearly shows that North American market is dominating in the revenues. This growth is driven by various Industries spread across the region. This leads to concern among the population about safety, security and creates a need of increased product offerings. European market and Asian market also show a growing trend.

2.2 Smart Homes Market Landscape

Smart home trend is gaining momentum day by day. Many international conferences and exhibitions are being held in various parts of the world, emphasizing the need, offerings, security issues and aspects of smart homes for a future connected home.

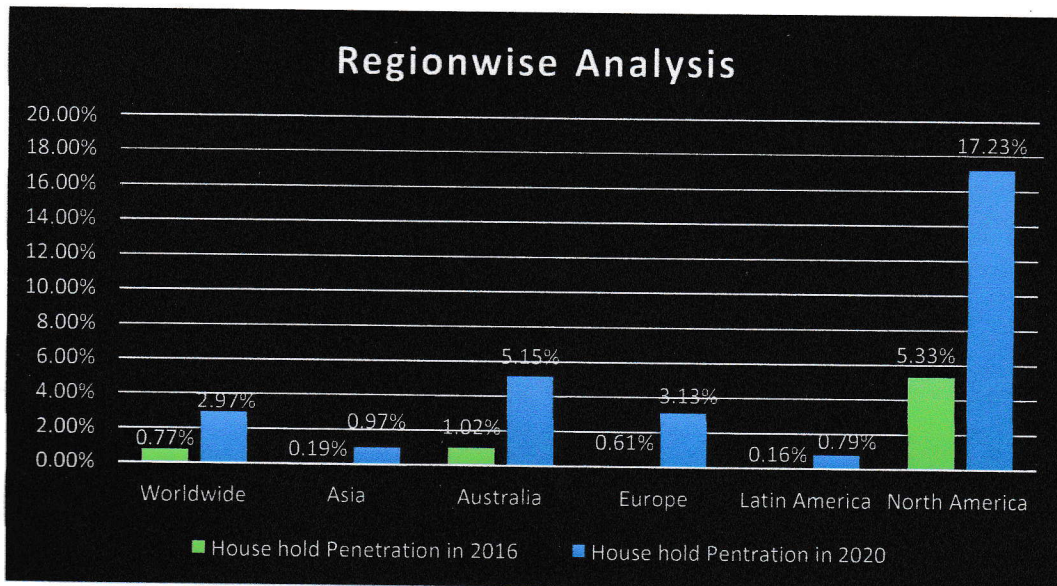


Figure 9 : Region wise Smart Home Market

In Asia, Smart homes and building market is one of the fastest growing market at a CAGR of 37.7 percent. Bangladesh is one of the fastest growing Smart Homes markets in Asia Pacific. The home automation market in Bangladesh is expected to reach INR 8800 crores by 2017.

2.2.1 Smart Homes Market Landscape-Global Perspective

The chart in Figure 9 shows the house hold penetration of Smart Homes across the world. The trend shows an increase in household penetration for North America which is dominated by US market.

2.3 Major Characteristics of Global Smart Home Market

2.3.1 US leads in Smart Homes Penetration

The US market is dominated by all the major value chain players and they focus on serving the US customers that are rich, willing to pay for comfort, luxury and convenience. This is resulting into increased innovations also originating from US.

2.3.2 Smart Homes is a requirement, not a luxury

There has been a myth that Smart Home is a luxury item. While this has been true previously, the modern day needs have moved Smart Homes from a luxury to required category. This has happened mainly on account of Smart Devices penetration at more affordable prices and integration into the IoT ecosystem. The low entry barriers, especially with Do It Yourself (DIY) kits are further aiding this.

2.3.3 Market Penetration is less and needs to be increased

The idea of Smart Homes is presently limited to Home automation and this need to be updated in customers' mind.

2.3.4 Fragmented Market & estimation of Return on Investment

Due to the lack of standardization, many players are competing in the market, some with their proprietary technologies. Return on investment is difficult to estimate because of many players and availability of devices based on standard and proprietary technologies. There is a need of interoperability at device, network and application levels in order to provide unified solutions and economies of scale. This will help all the players and finally the consumers.

2.4 Major Trends in Global Smart Home Market

Figure 10 shows the concept of Smart Home in another manner in an immersive experience to the user. Various trends in the global market are explained below.

2.4.1 Global IoT segments are growing- Smart Home is becoming a trend

M2M/IoT technologies are proliferating and Smart Homes vertical is witnessing a major action. Variety of sensors that can be easily connected to the cloud at affordable prices are resulting into this proliferation.

2.4.2 Investment Research & Development

The connectivity technologies for home are the ones that are applicable in other sectors as well. This helps every sector to enjoy the benefit of the technological advancements. Smart Home sector is getting attention of major players. Players like Google, Apple, Nest Labs, Amazon (Echo), AT & T (Digital Life), Xiaomi, Xfinity (Comcast) etc are already having their offerings in this sector.

2.4.3 Trend in Smart Wearable Devices with Smart homes

Smart Gadgets with Augmented reality and Virtual reality platforms are now interacting with customers in day to day life. As these wearable gadgets are closely associated with the users, the Smart Home value chain players are targeting these smart gadgets for integrating their smart appliances.



Figure 10 : Smart living in a Smart Home, [2]

2.4.4 Convergence of Consumer and Enterprise Technology.

Mobile consumer and enterprise technologies are converging in most industries. Smart Home will be equipped with features similar to that of an enterprise. Analytics, Smart TV, Gadgets will be a part of this ecosystem. A parallel to this can be drawn with the fact that earlier, automation or surveillance was part of only commercial buildings earlier but it has started to become a requirement in an ordinary home today.

2.4.5 Smart Homes and Automobile market

Smart home scope is getting extended to automobiles too. Many automobile manufacturers like Ford, Toyota are working to synchronize their automobile with smart home gadgets. Most

of them have invested in their R&D to establish a fool proof system. A Smart Home will provide not only charging to the automobile in case of Electric Vehicles, but may also be powered by it in certain situations. An automobile roof may provide solar power to home or for net-metering in future.

2.5 Major Technology Trends

2.5.1 Décor- Friendly Gadgets

The gadgets are aesthetically more appealing than normal gadgets. This helps to make a fashion statement as good looking sensors / nodes placed at various locations in the house are considered as desirable elements. The small size further adds to this feeling.

2.5.2 Programmable Devices

The smart gadgets can be programmed and customized according to the user preference. For example, programmable thermostats that can be controlled using the smart gadgets and can be used to control the temperature based on occupancy. The programming capability also adds to personalization.

2.5.3 Wireless controls

More and more devices are now connected through wireless. This makes the installation simple. A further element of wireless is portability as devices or nodes can be moved easily to another location in the house or to another house.

2.5.4 Advanced Security Systems

The Smart Home gadgets provide a better home automation with enhanced security. These gadgets can track the activity of human beings especially monitoring children and elderly people and activate the security systems in case of an emergency. Security systems and remote monitoring can be further thought to aid remote patient care also.

2.5.5 Automated door locks

The automated door locks are configured in such a way that these doors unlock based on the user and his access criteria. These smart locks can be configured with wearable gadgets also. These are considered to be aiding to safety also as depending on the category of the visitor, one may unlock the lock for different time durations and auto lock when needed. The remote door locks are expected to create several different use cases and at present these are in various stages of experimentation even if deployment has already started.

2.5.6 Smart Appliances

Currently, household appliances are responsible for about two thirds of the energy consumed by buildings. Industrial appliances are also major energy users. In the future, such appliances will no longer be stand-alone items. By communicating between themselves and with energy

control systems, the impact of these devices on the environment can be managed and optimized. Smart appliances will include white goods, heating, ventilation and air conditioning systems and storage systems [7].

2.5.7 Solar Roof tops

It is pertinent to mention that roof-top solar, net metering and electric vehicles would play a huge role in the Smart Home, thereby creating a micro grid. Electric vehicles would not only provide a clean and efficient means of transport, but would act as virtual power plants which could supply power to the grid in case of an outage [8].

2.5.8 Wearable Devices

Furthermore, with the proliferation of wearable devices for improved healthcare, the quality of life of citizens will substantially enhance [9].

2.6 Customer Expectation from Smart Homes

The customer expectations from a Smart Home are depicted in Figure 11.



Figure 11: Customer Expectations of a Smart Home

2.6.1 Security

Security of the home is of paramount importance. This applies to both the situations when the

occupants are inside or away. Increasingly people are required to monitor their homes for intrusions from outside or to have a look at the well-being of their children or elderly relative staying at home.

2.6.2 Hassle Free system

The system should not be too complex to operate or understand. The home owner or user expectation is a bug free and threat free system. Overall expectation is that automation must result into more comfort, more personalization of the space and lesser hassles.

2.6.3 Cost Effective

Majority of the customers are always price sensitive. They need solutions which are value for money. Smart Home adoption and penetration will increase if the price are reduced.

2.6.4 Convenience

With the growth of technology products a customer expects to solve his problem within short period of time and without much human intervention. In general, a customer prefers an automated environment that improves the quality of life for him.

2.6.5 Pro-active technology

A customer expects a better quality of life, convenience, and smart automation in accordance with the preferences selected. A personalized Home with an intelligent system that understands the occupants' requirements and perhaps moods should not be considered as a distant dream with virtual reality making its inroads everywhere.

2.6.6 Smart Energy Saver

Energy cost is one of the major costs in most countries. Customers are hence cautious about the Energy consumption. They need to control and customize their energy consumption and patterns.

2.6.7 Safeguard Privacy

While connectivity and automation are required, no one would like to compromise privacy and security. With most smart devices being able to communicate with each other either locally or through cloud, the information leakage is required to be blocked at every level. Customers are worried about security threats, vulnerabilities that may jeopardize their privacy. Privacy includes safeguarding and protecting the user information from unauthorized access. Key challenges related with the technology have been described in Section 12 of this report.

3 Value Chain Players

Various players in the value chain of M2M / IoT domain are depicted in Figure 12.

M2M/ IoT Value Chain

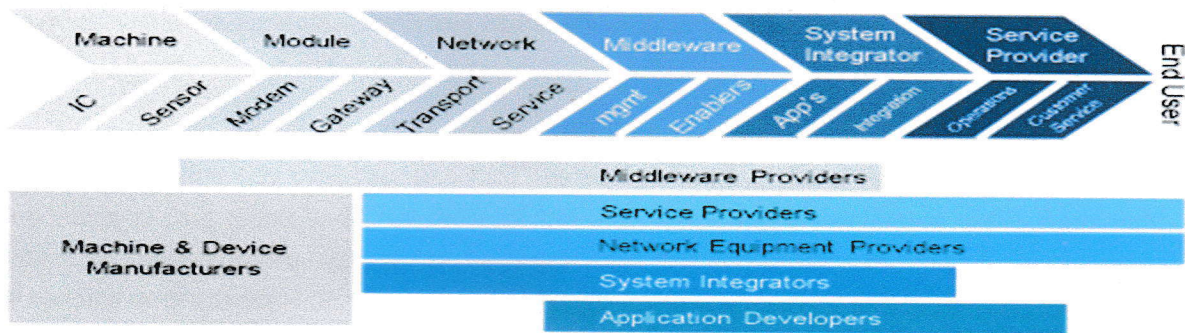


Figure 12 : M2M / IoT Value Chain

3.1.1 Chip/ Module Makers

The Chip/Module Designer includes the main vendors who design semiconductors and modules (chipset for the appliances / gateways) for automation systems. They design the components and help to integrate software applications in the end products as proof of concepts. These reference designs demonstrate the data gathering and sharing concepts.

3.1.2 Device/Appliance Manufacturer

They comprise of the appliance manufacturers that help to provide the useable systems to the customers. Usually they may start with one of the reference designs available from Chip / Module makers and bring in the necessary user experience, form factor, casing and other requirements to embed in the products.

3.1.3 Mobile/ Telecom Service Providers

Telecom Service providers (TSPs) play an important role in connecting the devices / Gateways on wired (fixed line BB / FTTH) / wireless (3G/ 4G) networks to the M2M service providers. High speed and reliable internet services are required at Home Gateway and also at the Smart phones for connecting the home remotely.

3.1.4 Cloud service provider

Cloud service providers enable accessing data from anywhere in the world. Cloud helps in maintaining and managing data remotely. The cloud provider helps by offering shared pool of resources and services like Platform and Software. They provide features of accessibility and recovery.

3.1.5 Application Provider

They help to deliver the web application or mobile based application providing interaction with consumer and appliances. These applications help to access the device and control them remotely.

4 Smart Home Offerings and System Components

The various system components of a Smart Home are depicted in Figure 16 and described below:

4.1 Lighting

This comprises of smart lighting solutions that controls the lights of smart homes. These solutions include controlling the intensity, dimming the light, changing the schema of light in a room depending on the mood and preference of the user. Using motion detection sensors and light detecting sensors, more options can be customized like auto switch on and off, of the lights depending on proximity.

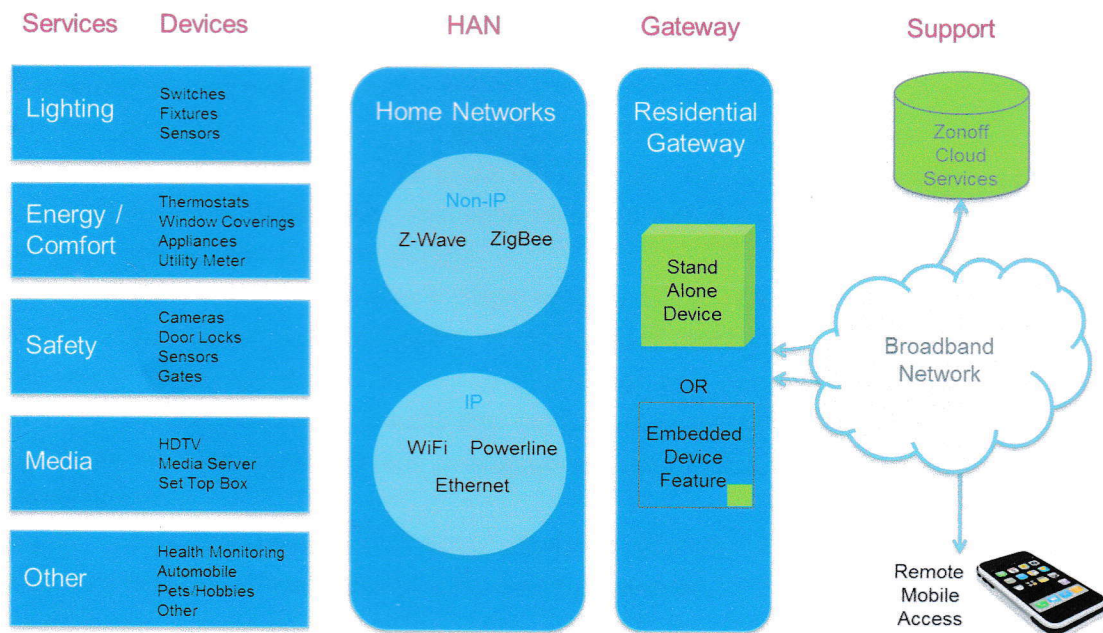


Figure 16 : Smart Home Offerings and System Components

4.2 Energy/ Comfort

These solutions include gadgets to monitor, control and use energy efficiently. Smart meters act as the fulcrum for monitoring and controlling the energy usage. Smart meters can also act as important elements in demand response, wherein, the consumption pattern of consumers is envisaged to vary as per the needs of the utility. Smart thermostats can be used to control the temperature being a critical tool for energy efficiency. Smart curtains, window coverings etc. provide a better comfort level.

4.3 Security & Safety

This is one of the crucial segment that needs to be catered. Security cameras for surveillance, smart locks that locks and opens based on preference, Smart sensors that monitor elderly people and children to estimate the activity level, are some of the offerings.

4.4 Media and Entertainment

Smart TVs are already available in market and the penetration is increasing day by day at an affordable price. These devices help to interact with the external world through IP or Wi-Fi technology and enhance the quality of living. Now YouTube and Skype can be enjoyed using a smartTV.

4.5 Hybrid Broadcast Broadband Television, [11]

Hybrid broadcast broadband TV ('HbbTV') is a global initiative aimed at harmonizing the delivery of broadcast TV and broadband TV to the home through connected TVs (smart TVs), set-top boxes and multiscreen devices.

The Hybrid broadcast broadband TV specification improves the video user experience by enabling interactive services such as catch-up TV, video on demand, interactive advertising, personalization, voting, games and social networking, as well as program-related services such as digital text and electronic program guides.

Hybrid broadcast broadband TV uses a single user interface. This creates an open platform as an alternative to proprietary technologies, which increases user choice.

Hybrid broadcast broadband TV is easy to implement and compatible with other hybrid TV technologies such as MHEG-5. Products and services using the Hybrid broadcast broadband TV standard can operate over different broadcasting technologies, such as satellite, cable and terrestrial networks.

Hybrid broadcast broadband TV is being deployed globally. A broad set of Internet and broadcast services have already been tested and implemented.

4.6 Miscellaneous Services

These services include features like E-health, Tele-medicine etc. These services help focusing individual health and allied services. With these services, the patient's health report can be sent to a doctor at regular time intervals, who can suggest meaningful proper medication which makes

the statement "Prevention is better than Cure" much more clearer. Also these can be used for life critical services like whenever the patient is down or severely ill, these gadgets can be used to gather attention or send SOS mails to the configured number and help save life.

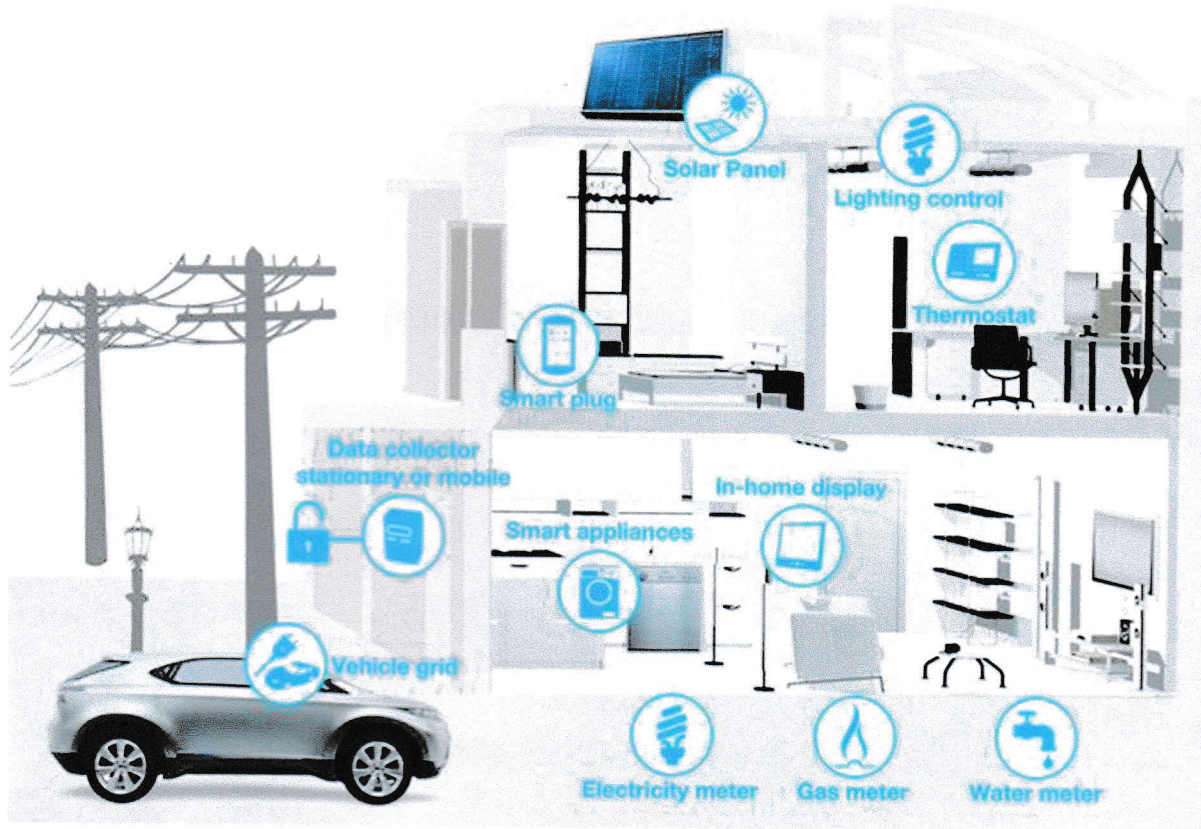


Figure 17 : Smart Home with Power Line and Solar and Vehicle Charging, [14]

4.7 Smart Home Components and Concepts

There is a lot of thrust on green energy and clean energy and smart systems to measure the energy consumption. Figure 17 shows a typical smart home that has electricity coming from Solar Panel connected to the grid. The lights are smart and can be controlled by Smartphone/tablet. Utilities such as gas meter, water meter and energy meter are connected to central database of the area and we have charging stations for electric vehicle coming from dedicated line. Bluetooth low energy can be used to control Smart appliances and Power Line Modem can be used for the communication within the home.

4.8 In-home Display and Control

Figure 18 shows the concept of in-home display which acts as a concentrator unit for the home. The display may consists of multiple wired and wireless technologies as per Smart home

requirement such as Bluetooth Low Energy, Power Line Modem and Wi-Fi. The display gives all the information regarding the energy consumption and different energy related information. The display can give information

Regarding the ambient temperature, weather, online news, in-home camera. The user can also control the appliances from the display supporting touch control.

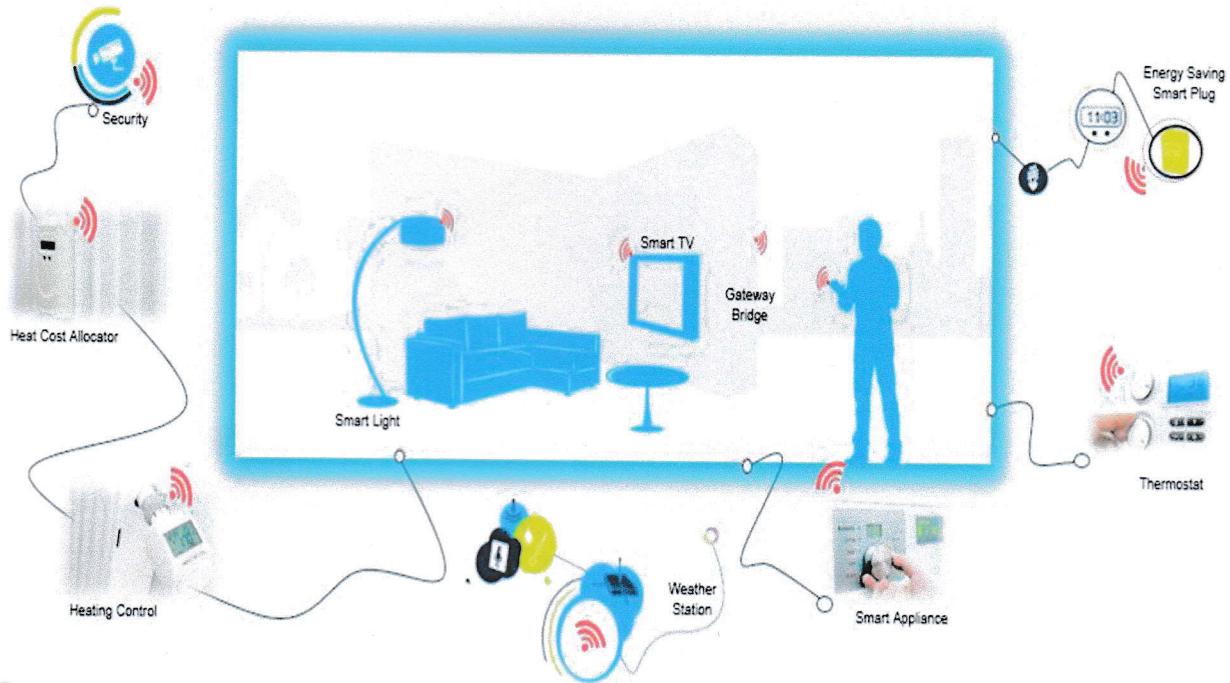


Figure 18 : Smart Automated Home with In-Home Display, [14]

4.9 Cloud Connected Home

Figure 19 shows an extended use case of Figure 18. There is an in-home display with Wi-Fi connectivity. The in-home display acts as data concentrator for each home and is also connected to Wi-Fi router. The concentrator unit sends the sensors data to the Cloud Application so that user can view information of their home on internet. There will be provision to actuate sensors (switch on/off air conditioner etc.) in the home using the Cloud Application.

5 Automation Platform

Home automation devices is a network of multiple devices which can serve different purpose and are offered by different vendors. Hence they are heterogeneous in nature and there is a need to have

/invest multiple gateways to communicate and transform the data and push the data to cloud.

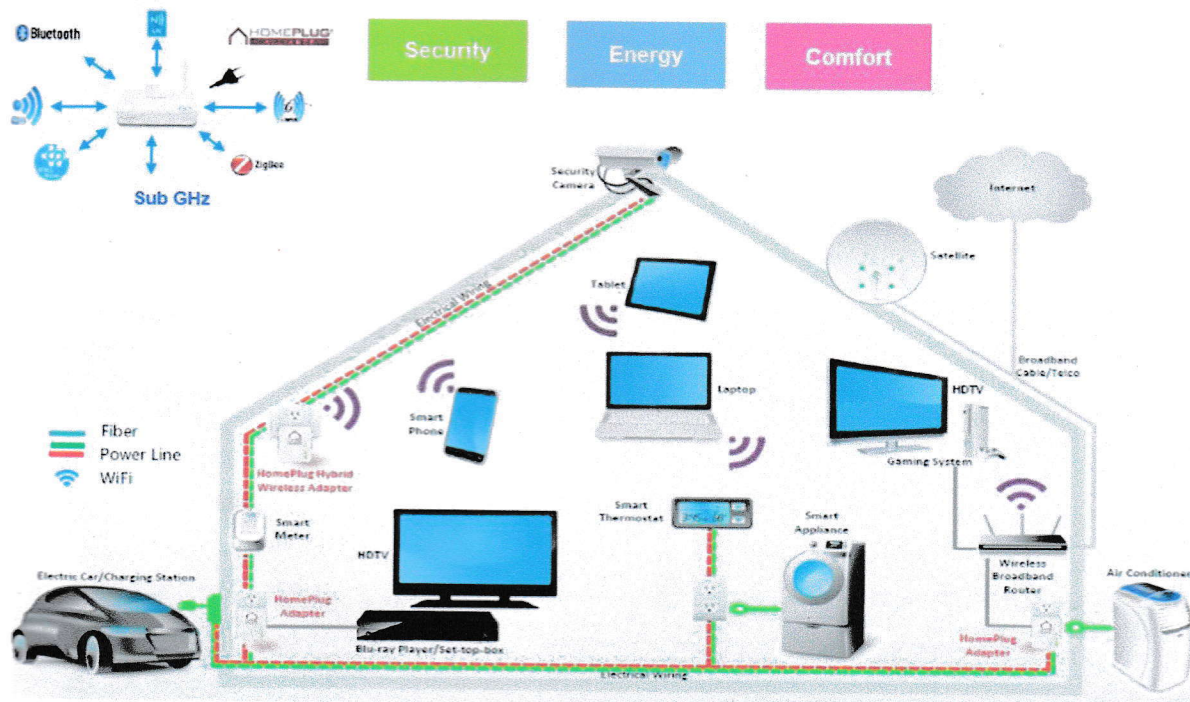


Figure 19 : A Concentrator / IHD / Gateway for a Smart Home, [14]

If there is centralized middleware it will ease communication, monitoring, maintenance and support and upgrades to the standards.

5.1 Architecture and Protocols

The home automation network will contain IP based embedded devices which can be wired or wireless following standard protocols. Each device can communicate with the other or with server over COAP based application protocol. COAP is lightweight protocol which can be used on embedded devices with limited processing power and memory. It uses which itself is very lightweight and supports things like multiplexing. It also uses *get*, *post* and *observe* like *http* and hence used to support *REST* based service. Each device can be embedded with a middleware stack on its own which can convert the data to be consumed by the consuming server(COAP or MQTT) hosted in cloud. Each middleware should have a persistent database to store the data still it gets pushed to

the hosted consumer. If a device does not have embedded middleware, a separate gateway will be used which can convert the protocols to generic oBix protocol and transfer the data to the cloud server.

The data transfer to and fro between devices and server can be done by pull and push mechanism over http/rest/soap in xml or JSON supported by the vendor of the devices.

Distributed nodes by the cloud could be identified by a framework using URLs. The cloud vendor should have a platform which comes with standard APIs or services for all sorts of devices, protocols and data format. Support for additional features such as security, automation, device controls, monitoring and alerting can be built on top of them. An indicative picture of protocols is shown in Figure 20.

5.1.4 Pros:

- Data is centralized
- Multiple protocol support and uniformity in data format
- Ease of setup
- Reduces the cost for customers

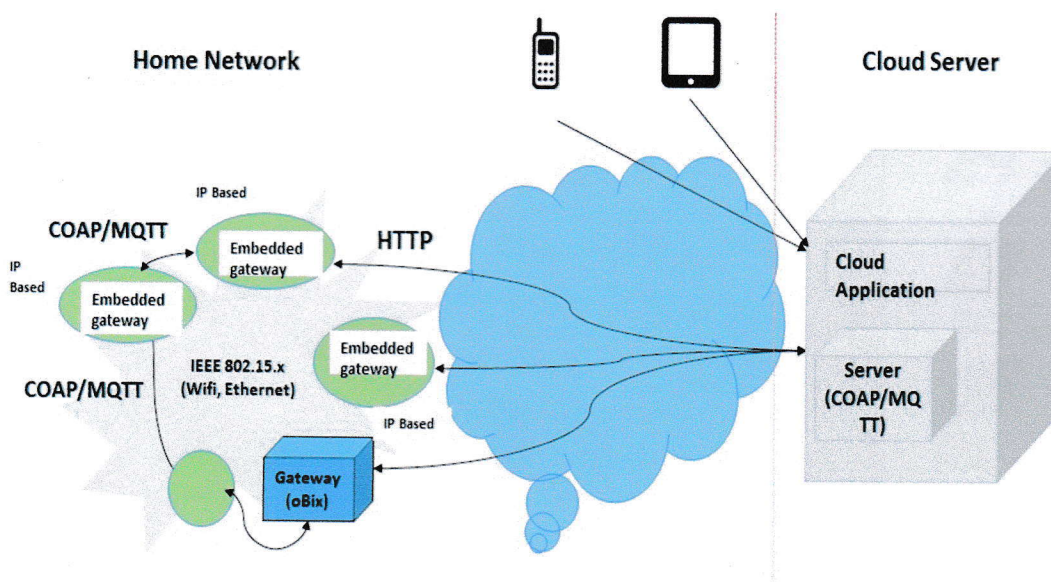


Figure 20 : A Smart Home Platform Architecture and Protocols

- Reduces the number of gateways to be used.
- Data lost is reduced and no need to manage locally
- Private or public cloud can be set up
- Reduces overhead of maintenance.

5.1.5 Cons:

- Since data is over the cloud, there is a need to be cautious about middle man attack / use by third parties for sale / Use by third parties for behavioural analysis or finding out routines in a home.

5.2 Components to build a Smart Home Gateway

5.2.4 Components of Gateway unit:

The Gateway unit which also known as concentrator unit consists of many other components apart from the wired and wireless technology as shown in Figure 21. They are:

- **Power Management Unit:** The Power management unit is one of the important components of Gateway or concentrator unit. There would be provision of different kind of power inputs to the Gateway making it a portable unit
- **MCU / MPU:** The micro-controller unit or micro-processor unit is the brain of the concentrator unit that controls the in-home display unit. The controller / processor will talk with other supporting devices using various board level protocols.

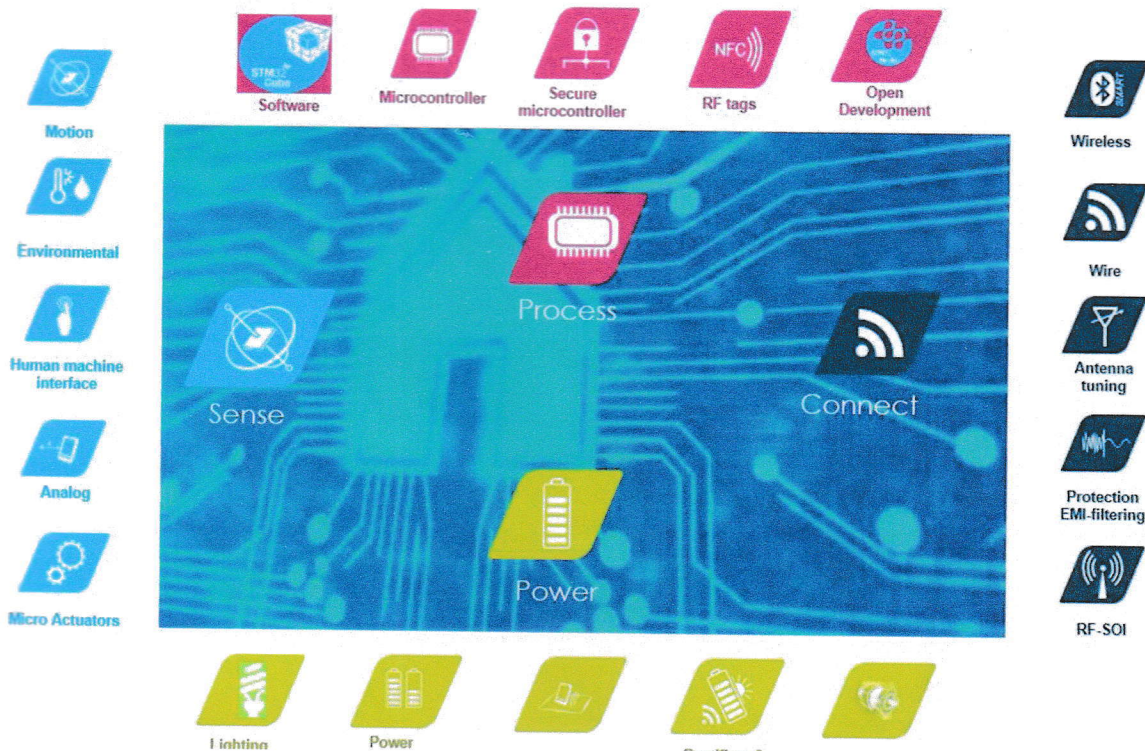


Figure 21 : Smart Home Gateway Components, [14]

- Touch Display (Human machine Interface): Human machine interface is essential element for the Human Machine Interface system as user will be able control different appliances and see different logs / dumps on the concentrator side. The user will be able to make changes in the settings

5.2.4.1 Security: Security of the system is one of the important requirement for the Smart Home Solution. As all the devices are connected to internet, Security of the System from any external attack becomes important. There are different mechanism to prevent external attack and hacking of data. There can be different method of providing security to our system. Some of them are :

5.2.4.1.1 Secure booting

5.2.4.1.2 Access Control

5.2.4.1.3 Firewalling and IPS

5.2.4.2 Software / Apps: Human Machine Interface (HMI) at the Gateway makes the usage of the system easy for the end user. There can be provision of Mobile Apps which can simulate the functionality of HMI system on the Gateway using the wireless connectivity available on the Gateway

5.2.4.3 Firmware / Libraries : are the software running on the MCU / MPU that gives functionality to the Gateway

5.2.4.4 Sensors : Motion and Environmental sensors available on the Gateway gives environmental information of the Gateway

Protection: is the usage of the protection mechanism on the DCU from sudden surge in current and voltage that may damage the board.

A Smart Home Platform is illustrated in Annexure 2.

6 Smart Home Vertical use-cases

6.1 Safety

Under this category the residents are provided with the following functionality with smart home systems.

- a) Single touch panic alarm to alert monitoring station and family members during medical, fire or any other emergency situation
- b) Motion detection in secured area while family is asleep or away
- c) Detection of hazardous LPG/CO (Carbon monoxide)gas leakage
- d) Early detection of fire using smoke detectors to ensure timely response

6.2 Security

- a) Intrusion detection through Door/Window
- b) Remote locking and unlocking of the doors
- c) Access to the visitor/family based on face detection (very advanced function)
- d) Multiple Indoor & outdoor IP cameras to keep an eye on home.
- e) View live video from anywhere on any smart phone/ tablet /Laptop /PC to monitor activities inside the house
- f) View who is outside the main door on touch screen or smartphone
- g) Scenario based and event driven recording of video clips with ease of configuration of alerts for each event.
- h) Ability to archive video locally or on the cloud with tagging making retrieval archived video easy
- i) Access to all home videos, including live streams and recordings as well as the ability to organize, save, search, tag, and share them

6.3 Automation

- a) Switch on/off lights using smartphones/tablets
- b) Configure and save mood lighting settings best suited for occasion. Activate mood lighting as required with touch of a button.
Control appliances like storage boiler, ACs, curtains, garage doors, etc. using smartphones/tablets
- c) On/off control of water pump based on the water levels in OH/UG tanks
- d) Automatic illumination while entering a dark hallway
- e) Schedule periodic triggers to switch on /off lights when away from home, set them to replicate normal usage pattern when on holiday or out of town so it looks like home is occupied
- f) Configure and program sprinkler system

6.4 Energy Management

- a) Remote reading of the energy consumption using the Smart energy meter(by the utility)
- b) Monitor and analyze energy consumption patterns per device per day / week / month with trend reports.
- c) Remote connection/disconnection of the energy supply to the customer premises via smart meter
- d) Smart net metering using solar arrays which enables customer to obtain incentive from utility
- e) Adjust luminous intensity as per ambient conditions for optimal energy usage
- f) Adjust room temperature and configure preset temperature parameters as per comfort.
- g) Automatically turn off lights when rooms are unoccupied using occupancy sensors

6.5 Entertainment & Personal Lifestyle

- a) Personalized support with the help of smart Gadgets and wearable devices.
- b) Smart Curtains
- c) Smart TVs and other Gadgets
- d) Streaming, IP support on smart gadgets and music players.

6.6 Common Customer interaction

6.6.4 Home Management

- a) One touch 'AWAY' button to switch off lights/audio/video systems while moving out of house
- b) Interactive touch screen with user friendly interface to check status of home.
- c) Video playback , searching of recorded video from any device
- d) User shall have flexibility to create scenes, scheduled events, get alerts and notifications to meet their needs

6.6.5 Mobile management

1. Real time two –way communication with a Gateway connected home allowing user access her security features from her smart phone
2. Remote appliance control like turn the air conditioning or boiler on before arrive home
3. View live video and control pan , tilt and zoom features of camera from smart phone
4. Manage all connected devices

6.6.6 Remote Assistance

1. Receive Real time continuous video and or video clips on smartphones
2. Remote arming and disarming of alarm system
3. All registered users of family to remotely access and share home data anywhere from any device

4.Web and Mobile control of home

6.6.7 Monitoring, Alerts and Notifications

1. Central monitoring station for 24*7 alarm monitoring and verification
 2. Programmable Notifications of events (like their children coming home from school) via text message, e-mail, instant message on multiple cellphones & email accounts as registered
 3. Co-ordinated third party emergency response - Medical, Fire, Police
 4. In case an alarm goes off, an alert to authorities with message to user cell phone
 5. Wrong passcode alert
 6. Duress alert
 7. Pet alert
 8. Device health update alerts like low battery, tamper, fault, etc
- Access Control
1. RFID based access control system
 2. Automatic Gate & Door Opener
 3. Smart Locks

7.Conclusions:-

Looking at various aspects dealt in this report, it is clear that there are positive elements present that are supporting and encouraging the adoption of M2M in the context of Smart Homes and also there are bottlenecks as pointed .

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Abbreviations

6LoWPAN	IPv6 over Low power Wireless Personal Area Networks
CAGR	Compound Annual Growth Rate
CDMA	Code Division Multiple Access
CoAP	Constrained application protocol
DECT	Digital Enhanced Cordless Telecommunication
DLNA	Digital Living Network Alliance
FTTH	Fibre to the Home
GHz	Giga Hertz
HAN	Home area network
HGI	Home Gateway Initiative
HMI	Home Machine interface
HPNA / HomePNA	Home Phone line Networking Alliance
HTTP	Hyper Text Transfer Protocol
HVAC	Heating, Ventilation and Air Conditioning
ICT	Information and Communication Technology
IoT	Internet of Things
IP	Internet Protocol
ISM	Industrial, Scientific and Medical
KNX	OSI-based Network Communications protocol for building automation
LAN	Local area network
LPWAN	Low Power Wide Area Network
LoRa	Long Range
M2M	Machine to Machine Communication
M-Bus	Meter Bus
MoCA	Multimedia over Coax Alliance
MQTT	Message Queuing Telemetry Transport
OSI	Open Systems Interconnection
wM-Bus	Wireless M-Bus
NFC	Near Field Communication
REST	Representational State Transfer
RoI	Return on Investment
SH	Smart Home
SOAP	Simple Object Access Protocol
WG	Work Group
XML	Extensible Mark-up Language