

CLOUD COMPUTING IN SMARTER HOMES: ENABLEMENT OF INTERNET OF THINGS

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ABSTRACT

Cloud Computing is acting as a backbone of IT by fulfilling the needs not only for infrastructure but also for applications for the organizations. Cloud Computing enables Smart Homes services that allow consumers to monitor and control their homes. This research provides details of contributions in facilitating the readiness of the concept "Internet of Things" in Smart Homes. In this paper, we have studied roles of cloud computing in supporting Smart Home, scope and components of Smarter Homes' technologies required for Smarter Homes.

Keywords: Cloud Computing, Internet of Things, Smarter Homes, Platform as a Service.

INTRODUCTION

When away from home, stress related to the security of the home is typical. Doubts such as did I switch off lights occur. Did I enable the security alarm or CCTV? What are children doing? With Home Automation (Kamarudin & Yusof, 2013), One can get away with these qualms with a single application configured in one's smartphone or tablet. One can not only view the status of integrated devices at home but also can control these devices. Samsung Electronics has assured that 90% of overall devices such as televisions, microwaves, etc., it manufactured, will have sensors so that these can be the internet enabled by 2017. All devices will be interconnected and can be accessed using remote application connected via a network (internet or intranet) (Pulvirent, 2015).

The presence of WIFI (ElShafee & Hamed, 2012) and the internet at home are smoothing the process of implementing Smart Home technologies. Users of Smart Home are required to access the devices or appliances using the internet. Instead of building an infrastructure to support the implementation of Smarter Home, Cloud Computing diminishes the need for installing and managing the infrastructure. Cloud computing (Mell & Grance, 2011) minimizes the implementation time and also provides other benefits of Green Computing (Karp, 2008). Cloud Computing, Platform as a Service (Lawton, 2008), plays a very crucial role to provide the secure and private platform. Smart Home technologies are looming fast as it is based on Internet of Things (Xia et al., 2012) that enables the usage of Sensors and access the devices remotely either through intranet or WIFI.

Cloud Computing not only can host the applications but also can be used to store the data (McKinsey report, 2009). Kirkham et al. (2014) proposed in their research by describing how Cloud service management principles of risk and contextualization for virtual machines can make solutions available to address rising challenges related to Smart Devices.

The objective of the paper is to showcase the architecture to be followed for Smart home while cloud computing in consideration. Multiple parameters are indicated to use Cloud computing instead of using on-premise servers accessed using public internet making the security and privacy vulnerable.

HOW CLOUD COMPUTING IS FULFILLING SMART HOME TECHNOLOGIES REQUIREMENTS

Developed applications shall be hosted on the servers that can be available to users via Cloud Computing. Cloud Computing (Eugene Gorelik, 2013) offers multiple models such as SaaS, IaaS or PaaS and has been widely used by organizations. It provides applications or infrastructure as service accessible from computers/laptop/smartphones/tablets using the internet. Cloud computing is enabling information processing as a service and is the backbone of the upcoming Internet. Servers or applications are hosted in data centers with the flexibility to increase or decrease the resources as per user's needs. Cloud is available in three deployment models: Public, Private, and Hybrid. Some of the vendors who provide cloud services are IBM, Amazon, Google, Microsoft. To build the smart home, Cloud Computing can offer the services that can be used in OPEX model resulting in saving in upfront capital investments.

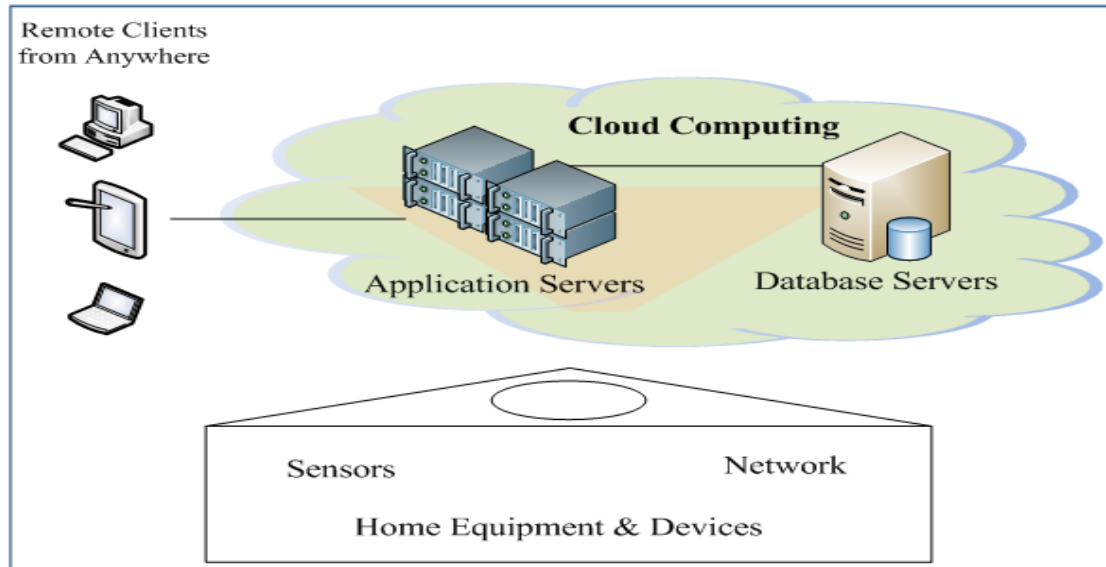


Figure 1. Smart Home using Cloud

COMPONENTS OF SMART HOME

There are multiple components of Smart Homes that are connected with the internet of things. They are given below:

- **Lights** - Generally lights are controlled using switches installed at homes. Smart Homes gives the concept of controlling the light of the home using smart panels or computing devices like smartphones or tablets. Smartphones use internet connection to connect to the servers on the cloud and applications. It sends or receives the data from lighting devices either to monitor or to turn on/off the lighting devices. This technology can also help homeowners to save money as these can be monitored and controlled.
- **Heating and Air** - Homes are equipped with centralized air conditioning or air purifying devices. These HVAC devices are using sensors to identify the temperature or air purity. Through the smart home technology, users can control from remote location to increase or decrease the temperature, for example, homeowner is away from the home for some time, and HVAC devices are off but on the way back to home, HVAC devices can be turned on so that the homeowner can get the environment as per his needs.
- **Automated Appliances** - There are options for controlling the devices using multiple commands like voice control, control panel or mobile applications. Such devices are entertainment systems, lawn sprinklers, lighting equipment (Lights, Fans). These automated devices presence can ease the task for the person, especially senior citizens. Multiple command ready devices provide the flexibility to program it for Smart.

- **Entertainment** - Smart home has entertainment devices like audio or video. Smart home users can control these devices from the remote control. These tools are easy to program from one central application either installed on smartphones or tablets.
- **Safety** - Safety is one of the most important components of Smart home. Smart homes have sensors that can detect gas leakage or water leakages. Smoke and Fire Alarms can also be triggered using sensors under irregular situations. At the time of detecting a problem, an alarm is raised, and appropriate action can be taken either automatically or by the user from the remote location.
- **Security System** - When a homeowner is away from the home, he always is worried about the security of the home. Smartphone owners can check the security of his home from the remote location by checking the online feed generated using multiple sensors and interconnected to the centralized server deployed using cloud computing. Doors or windows are coming which can also be controlled from the remote location. Keeping a property safe from burglars is an important task of the homeowner. Installation of IP surveillance cameras, smoke & fire detectors, motion sensors or some scanners is preferable for smart homeowners. Smart homeowners can check or connect to the devices to see the live status and can thus avoid any harm to his home. This kind of system is expensive but an important component of Smart Homes

ADVANTAGES OF CLOUD COMPUTING FOR SMART HOMES

Cloud Computing is offering multiple benefits to the Smart homeowners (Dargha, 2009). As there is an increase in a number of consumers of Smartphones or tablets, it is easy for these users to connect to server deployed on Cloud using the internet. Some of the benefits of using cloud computing are as follows:

- High Availability - Cloud offers high availability that can provide flexibility to the users to connect almost all the time. Almost all the cloud service providers are offering SLA (NetmagicSolutions, SimpliCompute: SLA)
- Reduction in Upfront Investments - Instead of having own servers, cloud computing provides services to use the servers or applications thus reducing the upfront investments.
- Safety of Data - Data gets accumulated at a central location, so safety is ensured. Apart from one central location, users can also opt for Disaster Recovery options
- Analytics - Users can opt for keeping the data for the longer duration and can get the analytics done using the data to know the trends.
- Flexible in Pricing - Cloud computing provides flexibility in payment & pricing as it offers "Pay as one use" model (Edlund, 2009).
- Faster implementation time - There are multiple cloud providers available. One has to choose the right vendor and can access the infrastructure to support the applications in very little time.
- Future Scale Up - Cloud computing is supported by the vast pool of resources which provides the ability to manage future scale up needs. One can also scale down the requirement up to minimum level.

LIMITATION OF CLOUD COMPUTING FOR SMART HOMES

In case of using cloud computing services from the cloud service provider, customers will be billed on a monthly basis. If a customer is looking for long-term services, then cost (Rosenberg, 2009) of maintaining own servers will be lesser in comparison to using cloud services. Cloud service provider shall charge based on the utilization of resources but in on-premise server shall have lower maintenance cost as compared to the server placed in Cloud. On-premise, server can be shut down based on the needs of the customer but cloud server will always be running and shall be charged accordingly.

Privacy (Bisong & Rahman, 2011) is one of the major concerns of using cloud computing. As all the data generated using, Smart Home Sensors are accumulated in the server deployed in the cloud so cloud service providers can access the data unless it is in encrypted form. Service Providers can then sell the data to third parties like electricity departments, electronics companies, etc. Smart homeowners' behavior can be monitored and analyzed for various research without his permission.

Security threat (Bisong & Rahman, 2011) is also an important point. Think of a scenario if personal data goes into wrong hands, multiple crimes can also take place as each and every step can be monitored making users' lives more vulnerable. People can be harmed financially or physically. Some of the most significant security and privacy concerns are given below:

- Some of the sensors work on electromagnetic technology to communicate the data. Hackers can attack the data without the consent of the user and can use the data to track the patterns to keep an eye on the user's behavior.
- Hacker can change or update the data on the server and can trick the security systems so that smart homeowner does not pay attention to the potential threat.
- There are cases where hacker instead of changing the information makes other's believed that data is from some other user's smart home thus arranging falsified data to the servers.
- Hackers can also destroy the data generated and stored on the server. Data loss is very crucial as without the history of the data no analytics will be performed.
- Hackers might also block the system usage by changing the password or by pushing load on the server thus jamming the server

ARCHITECTURE OF SMART HOME USING CLOUD COMPUTING

Building the Smart home using Cloud computing is a critical activity. Specialized architectural skills are required to prepare the whole architecture that can fulfill all the aspects of Smart home. Below is the diagram displaying multiple essential components of Smart Home design.

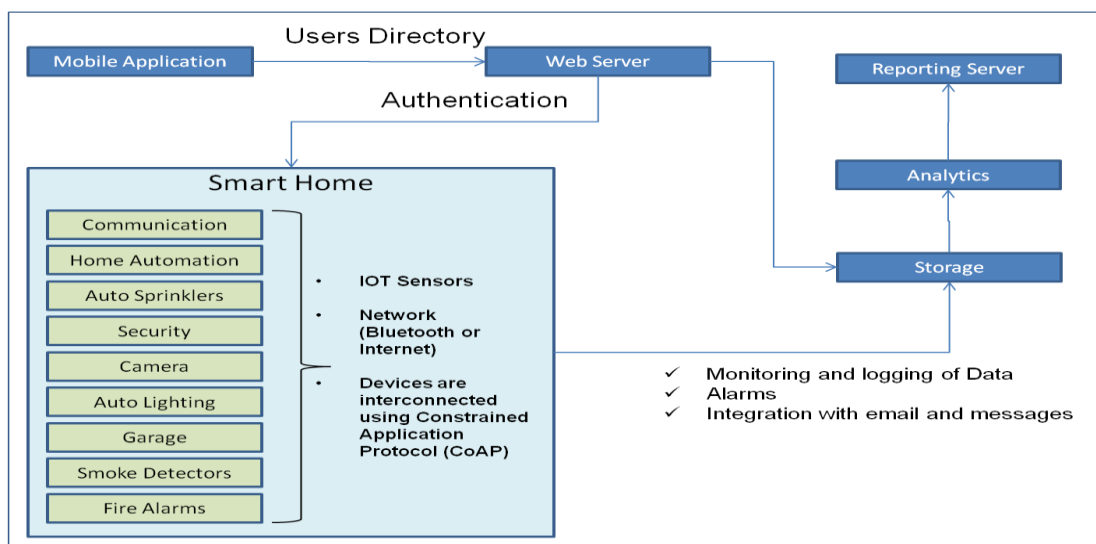


Figure 2: Architecture Diagram

- **Mobile Application** - An Application which connects with the devices at home and then control these devices is required to be installed in Smartphone or tablet.

- **Web Server** - A Server is required either to hosted on premise or cloud. This server not only communicates to mobile application to facilitate the data but also interacts with Smart home devices using IP protocol.
- **DB/Storage** - A database or storage is required to accumulate the data pushed by the sensors of the devices. The user can maintain the data as long as one wishes.
- **Analytics** - One can analyze the data stored in the database to know the patterns of the users.
- **Reporting Server** - This server generates the reports as per user format. Users can access the server and can download the reports.
- **CoAP** - Wireless protocols are required to enable interaction between devices. Multiple wireless protocols are available for example IEEE 802.11 Series, 802.15 Series, Zigbee, etc. Internet Engineering Task Force (IETF) has also come up with the protocol known as Constrained Application Protocol (CoAP) which is light weight. CoAP has been gaining grounds and has become the replacement of HTTP for IOT (<http://coap.technology/>).
- **Network** - Availability of network connectivity at home is the primary driver for Smart Home. Multiple networks such as broadband, Fiber at Home or 3G/4G networks and then usage of IP enables connectivity.
- **Sensors** - Electronics manufacturing organizations are working towards getting the devices allowed through sensors that can be used to generate the data and moreover multiple functions of these devices can also be controlled from the remote location. These sensors (Eriksson, 2011) are linked with IP that can be accessed and monitored. Currently, there are two technologies for IP, i.e., IPv4 and IPv6. IPv4. IPv4 is used for managing data traffic on the internet although addresses are getting exhausted. With IPv6, we can utilize the same technology for these kinds of devices which can be used in the smart home.
- **Alarms and Messages** - There are other service lines raising alarms in case of any issues. Alarms can then result in sending emails or messages to the users.

CONCLUSION

In this paper, we provide the details of using Smart home and usage of cloud computing in building Smart home. As internet usage has been increased, and almost all the smartphone users are online but users are sacrificing privacy for the operational ease. Applications of Cloud computing are accessed using smartphones making it easy for users to access the data, connect to friends, access to emails. The majority of applications are free of charges apart from some specific applications of particular use. Some of the gaming applications are chargeable. Organizations are surviving either through funding or through other services like advertising or providing data to third parties for the use. Smart home users are far more concerned about security and privacy that can be achieved using cloud computing instead of deploying servers on premise.

More & more Smart Homes are being adopted, so users, servers, and services are increasing thus attracting hackers to intrude the systems and access the data. Smart home users require robust security solutions for their home. A public home-based server can attract intruders and can compromise the privacy of the users. Cloud computing uses the best of technology thus providing a better option for the users to use it for Smart home although cost might be a challenge that is to be addressed over a period of time.

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