The Application of Smart Home Concept into Existing Typical Malaysian Single-storey Terrace Houses: Device Installation

Nasrul Arif Ahmad Mahmud¹, Nurul Nabilah Mohamad Yusof¹, Izuddinshah Abd Wahab¹ and Nur Amalina Hanapi¹

¹ Department of Architecture, Faculty of Civil and Environmental Engineering, University Tun Hussein Onn Malaysia (UTHM), 86400 Parit Raja, Johor.
*Corresponding author: nasrularif@uthm.edu.my

Abstract. A Smart Home Concept is often referred to the application of smart system technology into residential typology of building. It is a system in which provide home automation that used by the home owner in order to adjust the condition of the house either they are home or away from home. In Malaysia, typical single-storey terrace houses builds according the specifications through a conventional construction complied with Universal Building By-Laws 1985 that help occupants to live in safe and comfort. However, with the introduction of new concept and new technology of Smart Home, Malaysian residential building is upgraded. Thus, aim of this study is to identify the aspects of Smart Home Concept that will inform its usage and application into existing typical Malaysian single-storey terrace houses in terms of device installation. Three major Smart Home system providers were interviewed in order to gain information for the analysis. The analysis is basically to test the applicability of the system in terms of its ideal positioning and installation construction. At the end of this paper, the objective of the study is achieved, in which, smart home concept requires proper planning of home furnishing for them to work effectively. In terms of installation construction, there is no needs to do major renovation or hacking of the existing houses.

1. Introduction
In this recent years, Smart Home Concept is famously promoted as one image of futuristic living in residential sector where house can be controlled by a network, that allows a real-time exchange of information from and to the buildings and users by connecting and coordinating all the technology devices installed in the system. The Smart Home Concept is very closely related to energy efficiency and security in buildings. Fabi et al. [1] refer Smart Home Concept as a technology that provide a home energy management system to manage energy consumption within homes. Energy efficiency in smart home is controlled through smart devices integration designed as part of the house built. The increasing emphasis of energy savings and reduction of greenhouse gases brings to increasing of importance of energy control. Therefore, together with promoting energy efficiency, designers and environment engineers come up with advancing another way to reduce consumption and improving energy efficiency. According to Lazakidou, Siassiakos and Loannou [2] in their chapter, smart home concept for security includes a technology that provides notifications mechanism that allow immediate action in case of burglary and thefts.

It is understandable that Smart Home Concept is a concept for new residential typology by embedding the automation devices in order to help house owner to have full control of their house when they are in and away from it. Currently, this new concept of smart home is applied mainly for new
development of houses because smart home needs planning that plays a very crucial role in order for the integration to works well. The Smart Home Concept is usually planned in developing a new residential as one of the requirement in the design stage [3]. As it is usually integrated in design phases, the existed typical houses might not be able to adapt the Smart Home concept and applications. Otherwise, major alteration might be needed. In fact, increasing system efficiency is the only approach available to the many existing building [1]. This can be very challenging as the existed single-storey house were built without any fulfilment towards the smart home concept requirements.

Improving energy efficiency through smart devices require a central control of energy related to components to ensure that the whole system works together [4]. Communication networks is also very important in order to collect data from all devices and appliances for homeowner to come up with appropriate strategy of device installation for energy efficiency and cost sustainability. With right installation and placement of the technology, Smart Home Concept will be able to be applied into existing Typical Single-storey Houses in Malaysia. Thus, this paper is investigating the methods can be used in order to install the devices and to test whether hacking methods should be done.

2. Literature Review.

2.1. Smart Home System.
Smart Home System offers advantages in whole areas including limiting environmental impact, energy efficiency, improve cost savings and advancing building security and safety. The system not only regulate housing functions, but as well transform data collected for home owner to evaluate and determine ways to improve housing systems [5]. The system enables home owner to modulate the energy used depending the strategy planned through analysis of data collected. Information and feedbacks form the system should be considered as to test whether it functions in experiencing the changes of indoor and outdoor environment.

This system is an integration of housing automation and services through home networking for a better quality of living. Recently, there are so many technologies related to Smart Home Concept has emerged which help occupants to be more connected and more control towards their own home. The term ‘Smart’ and ‘Intelligent’ is related to home control that often referred to home energy management system (HEMS) which is used by the adaptation of Smart Home System [6]. Robbles and Kim [7] define Smart Home as a term whereas home owner that using home controller to integrate themselves with various home automation systems. The home automation system allows home owner to communicate with their house through home controller, thereby enabling single button and voice control of the various home system simultaneously in pre-programed operating modules.

Smart Home System encompasses network in communications, entertainment, security, convenience and information. The system is using to send coded signals along home existing electric wiring to program switches and outlets [5]. The coded signals convey commands the correspond to location of receiver or specific devices that control how or when those devices to operate. This system is called Powerline Carrier system (PCS), in which, it can send signals along home wiring and receiver plugged into any electrical outlet or appliances in the house that could receive the signals and operate. This operation involves short radio frequency (RF) bursts that represent digital information, enable communication between transmitter and receiver [7].

2.2. Smart Home Technology.
Smart houses technology usually connects sensors, devices and appliances over a network of communications to monitor, access and control the living environment remotely. In addition, this smart home system also provides services that meet the needs of users. Using web services is the most open and interoperable way to provide remote service access or allow applications to communicate with each other. Internet Of Thing (IOT) is classified as a system that can be used as connectors such as internet television, sensors and movers to the internet to any device intelligently linked to forming a new communication among users [1]. Smart Home Technology application can be either wired or wireless. There are few components in wireless systems, which are, Bluetoot system, Infrared, Radio Frequency, Wireless Figuration System (WiFi), and Global System for Mobile communication (GSM)
Bluetooth system is usually available on portable computers, tablets and mobile phones. Bluetooth system are usually help in connecting various nearby devices to work and collecting data. But, Bluetooth system can only be used in the existing of their own networks. By the emerging of Wireless Figuration system (WiFi), bluetooth is no longer reliable as WiFi can be used in a personal computer-based web browser (PC) which connected to home-based devices [9]. Wifi are more reliable because it has central networks that can integrate multiple devices in one time even though the devices are apart away from one and another. Wifi system are most globally and famously used as it is the most connected systems.

In terms of security, Global system technology network systems for mobile communications (GSM), Short Message Service (SMS), and web cameras are used to detect home infiltration via the internet and at the same time warn sounds [10]. The normally used parameters in home security are 24 hours monitoring of any intruders, easy in use, high reliability, high efficiency, and precise notification in the systems. The system is using web camera, install in the house premises and operated by software installed in a personal device that connected to the wifi. This system has its own interface and it will usually respond to alarm incidents by monitoring everything in moving cameras. In short, any intrusion will be detected by the camera and short message will be sent quickly to notify the home owner so that they can take an action instantly.

In terms of energy management, the components in smart homes are able communicate with each other wirelessly by sending data to users which facilitate long distance communication in order to reduce energy consumption [11]. The strategy is to calculate all actions by the home owner including switching commands and any other parameters that are executed by the home automation system. There are few sample of system regarding energy management through smart home system. One of them is thermostat control which programmed to combine all board tables where the user sets various time points with different temperature setting up by reducing heating and cooling load at unnecessary time. Moisture data, occupants, light levels and outdoor weather are available in this thermostat application. The energy management can also be applied in smart devices which involve the use of energy through a portal application in a smart phone. So, if there is a correction the appliances or home owner wanted to know the condition of the equipment, they can change and view through smart phone as a remote control.

2.3. House Floor Plan Sample.

Typical Single-storey houses are the most similar housing typology that is used for Smart Home Concept. Thus, it is taken into consideration as part to test the device and system installation methods whether hacking or any major alternation should be done. Few single-storey housing is compared in order to get ideal spatial planning of the house. Typical single-storey houses are usually minimum size of 650 to 700 square feet with three bedrooms, two bathrooms, a kitchen, an area for drying clothes and tiles floors [12]. This standard is highlighted as it is typically used in two highly-developed cities which are Kuala Lumpur and Penang. The Rationale of referring the standard of single storey house in high development cities is because the potential of Smart Home Concept application itself. Thus, this standard is used in the test of installation of the devices.

Due to the increasing value of land in urban area, terraced housing is in high demand as compared to other types of compact housing such as high-rise apartment as it allows room for modification [5]. Malaysian Terrace Houses is design to accommodate single family unit which includes spaces such as bedrooms, a living room, a kitchen and bathrooms. This basic spaces are the requirements in order for terrace house to be occupied. Typical single-storey terrace house is usually having adequate size range between 1000 sqft to 1500 sqft. Thus, as sample to smart home concept, the size and spatial arrangement is chosen as shown in Figure 1.
3. Data Collection and Analysis.
This complete this paper, a study on the criteria of the smart home system should be done where it is to determine any relevant reference materials, the requirements, features and functions of smart home installations. Its criterion is based on the interaction between home appliance and devices connection such as microcontroller, hub and smart phone. Then, criterion on the suitability of sensor position, home area factor, the number of smart devices are needed for particular house. On top of that, the interaction between smart home devices and homeowners shall be done as well. Three companies have been interviewed and they are Google companies, Vyrox International Sdn Bhd and Shield Technologies Sdn Bhd.

3.1. Smart Home Devices
Today, there are lots of devices that has been invented which relates to smart home concept. Personal gadgets and home appliances are the most commonly used. Technically, there are possibly no appliances in the house that are not available with some degree of automation [7]. In designing a smart home, every components and devices should be identified in order to have a good planning and most ideal arrangement of devices. The design can be possibly started as very small as simple single connection to a complex network. It is very ideal to carefully position the devices and the programmes as smart home devices might require rewiring or renovations.

From the interviews with three different companies, data is collected and put in a table (Table 1). All types of devices are classified by its usage in terms of safety, entertainment, information, management of energy resources, landscape and communication. This classification is purposely done to identify the product information and its installation methods including ideal position of smart home devices.
Table 1. The classification of smart home devices according to its function and its installation requirements.

| Function         | Company                        | Product          | Technology                                           | Installation of the system. |
|------------------|--------------------------------|------------------|-----------------------------------------------------|----------------------------|
| Safety           | Smart Door Lock                | CCTV             | Apps that have been installed to the smart phone for the user to see the occupant that enter the house. | i. Finger print of the occupant of the house.  
|                  | Shield Technologies Sdn Bhd    |                  | i. Place at corridor of the house.                   | ii. Inside the house       |
|                  |                                | Camera           | Apps that have been installed to the smart phone for the user to see the image.                      | i. Place at entrance door of the house |
|                  | Vyrox International Sdn Bhd    | Smoke Detector   | i. Place at the corner of the room.                  | ii. If a room has a high ceiling mount, the unit near the ceiling is the highest point, installation should be done between 4 to 12 inches (10 to 30.5 centimetres) away from the peak |
|                  |                                | Glass Broken     | i. Place distance from 4.5m if at bottom.            | Sensor                    |


**Table 1.** The classification of smart home devices according to its function and its installation requirements *(Cont.)*

| Function                      | Company                          | Product          | Technology              | Installation of the system.                                      |
|-------------------------------|----------------------------------|------------------|-------------------------|------------------------------------------------------------------|
| **Entertainment**             | Google                           | Voice Control    | Google home apps        | i. 10-meter distance for receive command.                        |
|                               |                                  |                  |                         | ii. 6 voice of the user.                                         |
|                               |                                  |                  |                         | iii. Google account to set up the setting.                        |
|                               |                                  |                  |                         | iv. Language that user have to use is English only.               |
|                               | Shield Technologies Sdn Bhd      | Music            | Smart phone to setting  | i. Bluetooth or insert the SD card to store the list of the music |
| Information                   | Google                           | Google Information System | Google home apps      | i. 10-meter distance for receive command                         |
|                               |                                  |                  |                         | ii. 6 voice of the user                                          |
|                               |                                  |                  |                         | iii. Google account to set up the setting                         |
|                               |                                  |                  |                         | iv. Language that user have to use is English only                |
| Management of energy resources| Google                           | Voice Assistant  | Google home apps        | i. 10-meter distance for receive command                         |
|                               | Vyrox International Sdn Bhd      | Touch Screen     | Touch Screen            | i. Replace the existing lamp plug                                |
|                               | Shield Technologies Sdn Bhd      | Mechanical Switch Lamp | Dimmer Control          | i. Replace the existing lamp plug                                |
| Landscape                     | Shield Technologies Sdn Bhd      | Mini garden to control the water flow and lighting | Smart Phone Application | i. Landscape area                                                 |
| Communication                 | i. Google                        | All smart device | Wireless Figuration     | i. Can control anytime and anywhere                              |
|                               | ii. Vyrox International Sdn Bhd  |                  | Smart Home Application  |                                                                 |
|                               | iii. Shield Technologies Sdn Bhd |                  |                         |                                                                  |
3.2. Device Installation.
In this section, smart home devices are analysed according to its requirements of installation. It aims to come up with synthesis and best strategy in installation the device. This section will also identify any needs of rewiring or renovation to install the devices.

3.2.1. Voice Assistant.
Voice Assistant is a device that help home owner to giving out instruction through voice, sound wave or echoes as medium of communication. In order for the device to works, it will receive voice commands from home owner and home occupants as instruction in order to operate home appliances, for example, switching on home general lighting. It is like home owner is owning a virtual butler. Voice assistant device will act as helper in the functions of entertainment, information and management of energy resources. According to Google Malaysia, the ideal distance of the device is within the radius of 10 meters and it can identify up to six types of voices (Figure 2). The devices need to be set up by home owner by recording the voice recognition and instruction through Google Home Application in the smart phone. The application can be downloaded without any payment through Google Play Store. However, the systems and programmes can only recognize the instruction in English as default language.

![Diagram of a typical existing Malaysian single-storey terrace house](image)

**Figure 2.** The ideal position for a voice assistant in which the device can receive voice commands from the occupants and provide information according to the voice instructions given such as switching on home appliances.

Voice Assistant device is very small and compact and it is easily fits in any space in the house. As the main form of communication is through voice recognition, houses with more complex compartment or spatial planning will need one for every spaces. Voice Assistant can be a hub of voice instruction for all home appliances, but, the installation will require a holistic home rewiring.

3.2.2. Motion Sensor.
The main purpose of motion sensor in smart home concept is to detect any sudden movement around the house that might be a threat. Terrace houses are most easily exposed to crime which includes burglary [13]. However, the invention is extended into more function, such as, to switching on the indoor home appliances when home owner goes pass through motion sensor. In terms of security, motion sensor will stand guard and ready to react to any theft situation. The purpose of installation including to alert the house owner on burglary, to trigger the doorbell when visitor approaching the house, and to save energy in unoccupied spaces.

Motion sensor has angle observation of 110° and ideally to be placed at the corner of the house and near to the available access to prevent any intrusions (Figure 3). There are few types of motion sensor including passive infrared (PIR), microwave (MW), and Dual Technology Motion Sensor. To avoid any
false alarm, Dual Technology Motion Sensor are most likely to be used. This system integrating both infrared as passive detector and microwave as active detector.

The different between infrared and microwave system is that infrared is function to detect heat and movement. Once it is turned on, it will create protective grid. However, with too many moving object that blocks the infrared in motion sensor, it will create a false alarm. In microwave system, the system will send pulse toward any object in the house. This pulse will measure the reflection off a moving object. With large areas of coverage, the system will be very vulnerable towards electrical appliances that create heat that might disturbs the pulse. Thus, the combination of both systems produced most effective motion sensors that detects any movement depending on the passive and active situations.

![Figure 3. The ideal position of the motion sensor.](image)

3.2.3. Home Monitoring

Home monitoring in smart home concept includes Close Circuit Television (CCTV) camera and Home Energy Management System (HEMS). Both devices are used for visual monitoring and energy consumption respectively. Security and energy management are two of the most crucial aspect as priority for home owner. It is to ensure home owner is always safe from any intrusion and at the same time always aware of minimizing the carbon footprint.

The wireless closed circuit camera is not only having all the traditional camera functions but also supported by smart home system where home owners can monitor the home situation anywhere and anytime. This camera can record 360 angle views with pictures taken can be seen through mobile phones. This closed circuit camera will quickly notify the home owner if any suspicious movement happens when it is integrated with the motion sensor devices [8]. However, the placement of CCTV camera plays a big role in minimizing blind spot (Figure 4). Thus, the ideal position for the device is depending on range of camera views visibility. For the purpose of recorded data storage, this closed circuit camera can be installed SD memory card.

The implementation of HEMS aims to monitor energy consumption based on the indoor thermal condition of the smart home. According to Nacer, Marhic, and Delahoche [8] HEMS includes five components monitoring includes smart electrical meters, smart parameters detection, smart home appliances connection, smart networks and home management. The integration of all five components creates an independent control of home appliances and devices in order for smart home to work efficiently. On top of that, with the world can possibly be controlled on a tip of a finger, it is very possible to make a connection with smart home, in which, home owner has the ability to control home condition from outside house area.
3.2.4. Smoke Detector.
According to Fire Safety Department Malaysia, every single home must have at least a fire extinguisher. Universal Building By-Law 1985 stated that fire protection is one of the main concerns in developing architectural house design. Fire extinguisher will work more efficient with the installation of smoke detector. For smart home systems to warn residents, smoke detectors are installed in order to trigger alarms when an emergency occurs. The alarm will ring to indicate the fire is happening. This smoke detector is not recommended to be placed close to the stove to prevent an alarm issuing an inaccurate warning. The ideal distance of smoke detector is 2/3 distance from kitchen door and front doors as kitchen are having higher risks of fire emergency (Figure 5).

3.2.5. Central Control System.
Central Control System acts as brain to the whole system of smart home concept. It centralised the systems of all smart home devices and appliances in order to ensure the integration of all devices works efficiently. This central control system is put in a control box where it is connected to home owner smart phones or computers through wireless figuration (WiFi) [8]. This control hub simplifies the workflows and giving effortless methods of control for home owner. This intelligent system will send notification regarding any extreme measurement produce by any smart home devices.
Installation of central control system does not need major hacking to the house. However, it might need a complex rewiring in order to connect physical smart home devices. Central control system is usually set up near to home main electrical power switch so that easier to locate in case of emergency (Figure 6). It is also recommended to put the control box near to any architectural opening of the house. This is because complex wiring has bigger risk towards short circuits and fire.

![Figure 6. Possible areas to install control box.](image)

4. Discussion and Conclusion.

The Smart Home Concept system requires devices to be installed in particular position around the existing terrace houses. Even though in recent practice requires a proper planning for the installation to be done from the beginning of design and development, Smart Home system can also be installed in existing single-storey houses. The devices only require it to be install with correct position an ideal distance without having any needs of major hacking. With the advancement in technology, home owner nowadays can have total control of their house anywhere and anytime. By having a smart phone, home owner can even monitor house condition and security while working or even in holidays.

Nevertheless, the only hacking should be done is to seal the wiring connection between the devices and central control systems. Even that particular process can be minimized by having wireless figuration devices. This paper proves that Smart Home Concept can be applied majorly in Malaysian typical existing single-storey houses as part of energy efficiency and security control. Data collected by the devices can also be used as persuasive technology to educate home owner in cost savings in using electricity. In short, Smart Home system are one of evidence and way of moving to a better future by having total control to the house and the systems. The only problem now is the feasibility of the devices as to have total control, various devices install might have added up to short terms costing.

5. References

[1] Fabi V, Spigiantini G and Corgnati S P 2017 Insights on Smart Home Concept and Occupants’ Interaction with Building Controls. *Energy Procedia*, 111 pp759–769

[2] Lazakidou, Siassiakos and Loannou 2011 *Wireless Technologies for Ambient Assisted Living and Healthcare: System and Application* (New York, USA: Medical Information Science Reference) pp 170-191

[3] Zabalza Bribián I, Aranda Usón A and Scarpellini S 2009 Life Cycle Assessment in Buildings: State-of-the-art and Simplified LCA Methodology as a Complement for Building Certification *Building and Environment* 44(12) pp2510–2520

[4] Tirado-Herraro S 2017 *Smart Home Control Device. Summary and Assessment of Energy and Lifestyle Marketing Claims* Center for Urban Reasearch (Australia:Royal Melbourne Institute of Technology) pp 1-20.
Acknowledgement
This research is supported by Department of Architecture, Faculty of Civil and Environmental Engineering, University Tun Hussein Onn Malaysia (UTHM). Special thanks to Google Malaysia, Shield Technologies Sdn Bhd, and Vyrox International Sdn Bhd on the very great opportunity and cooperation in giving information regarding smart home devices and technology. Last but not least, colleague and family who has been the biggest moral support in completing this research.