Vision Document
[SmartHome+: A Smart Home Platform]

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REVISION HISTORY

Date	Version	Description
06-Jul-2020	V 0.1	Initial draft
16-Jul-2020	V 0.2	Incorporated comments obtained in Requirements evaluation phase. **(Changes are highlighted in yellow.)**
30-Jul-2020	V 0.3	Incorporated comments obtained from TAs. **(Changes are highlighted in green.)**

1. Introduction

The purpose of this document is to outline a vision for SmartHome+: A smart home platform that encompasses a wide spectrum of ideas and concepts about intelligent living. The document addresses the following:

- Identify and agree on the essential needs and expectations of end users from SmartHome+.
- Mapping the identified needs to implementable features within SmartHome+.
- Analyzing the current market dynamics and researching some already existing offerings in the domain of Smart Home Automation Solution.
- Propose some new off-the-self distinctive features currently missing in general within other existing products in the market.
- Identify limitation and assumption for proposed solution.
- Identify stakeholders and users.
- Identify the user environment.

The scope of this document is limited to user needs, environment, and desired solution.

2. Positioning

2.1. Problem Statement

The problem of	● Disconnected devices and appliances ● Unmonitored In-Home environment (temperature, air, and water quality) ● Unmonitored In-House energy consumption ● Home safety against unforeseen situations. ● Decentralized media and entertainment devices. ● Mundane day to day household activities.
Affects	● The home residents: ● Adults ● Children ● Senior members ● Pets
The impact of which is	● Time and effort wastage over repetitive tasks ● Risk for home residents in the event of some exigency like flood, fire or intrusion. ● Losing more money in bills due to inefficient energy usage ● Losing out on a more comfortable lifestyle.
A successful solution would be	Offers its users an automated and intelligent

	lifestyle in terms of their daily household routine by focusing an improving over the following six dimensions: • Accessibility (an easy to use solution) • Environment Monitoring (better living conditions inside house) • Energy efficiency control (optimized energy utilization) • Enhanced security • Improved Media and entertainment experience • Automation of mundane household tasks

2.2. Product Position Statement

For	Home-Residents
Who	Are concerned about the safety, security, good health of their family, and at the same time desire to save their time effort and energy consumption by automating a variety of their daily household tasks.
The [SmartHome+]	Is a Smart Home Automation platform
That	Enables its users to: • Save both time and effort by automating daily routine tasks and enjoying more quality time with their families. • Monitor healthy and ambient living conditions within their homes. • Ensures efficient energy utilization to save costs on bills. • Provide safety and security measures for intrusion and other unforeseen emergency situations like fire and floods. • Provide meaningful recommendations towards optimizing their energy consumption • Synchronize various media and entertainment platforms and devices for a seamless and more unified experience.
Unlike	Other commercial solutions in the market that tend to support a small subset of smart devices.
Our product	Offer a more comprehensive, cost effective and an

	extensible solution that apart from supporting a bundled set of smart devices can also be customized by including smart devices manufactured by other third-party vendors.

3. Stakeholder Descriptions

3.1. Stakeholder Summary

Name	Description	Responsibilities
Smart Solutions Inc.	The owner of the project	● Provide a high-level product description ● Monitors and manages the project ● Finalizes different proposal ● Approves budget ● Provides feedback • Participate in User Acceptance Testing.
Users	Home-Residents who will be using the solution.	● Provide feedback and comments. ● Suggest new features and modifications
Developers	The team responsible for eliciting requirements and developing the product.	● Requirement elicitation and analysis to come up with a Software Requirement Specification (SRS) document. ● Designing, developing and testing the system. ● Preparing documentation and user guides. ● Post-delivery maintenance of the system.
External Smart Device Vendors	Third Party Vendors who would be manufacturing Smart devices that can easily pair with our solution	● Provide necessary device specific APIs/Interfaces that allows for a seamless device integration with SmartHome+.
Internet Service Providers	Responsible for providing and managing Internet based Wi-Fi connectivity inside the	● Internet connectivity is required by the central controller to receive commands remotely. ● Saving surveillance videos

	house.	on cloud requires internet connectivity. ● Some smart devices communication needs with the controller rely on Internet connectivity.
Interior Designers	Plan the layout and interior architecture within the house	● It is essential to plan the interiors in a way that allow for easy setup and installation of the SmartHome+ solution along with various smart devices it connects to. ● Smart devices within the home should be placed in a way that ensures maximum accessibility and comfort for the users.
Construction Workers	Involved in overall design and construction of the house itself.	● Placement of some necessary components like windows and points of entry/exit have to be taken into consideration as they are linked to some core features SmartHome+ has to offer. ● Sufficient electricity outlet points should be planned close the place where a smart device is expected to operate.

3.2. User Environment

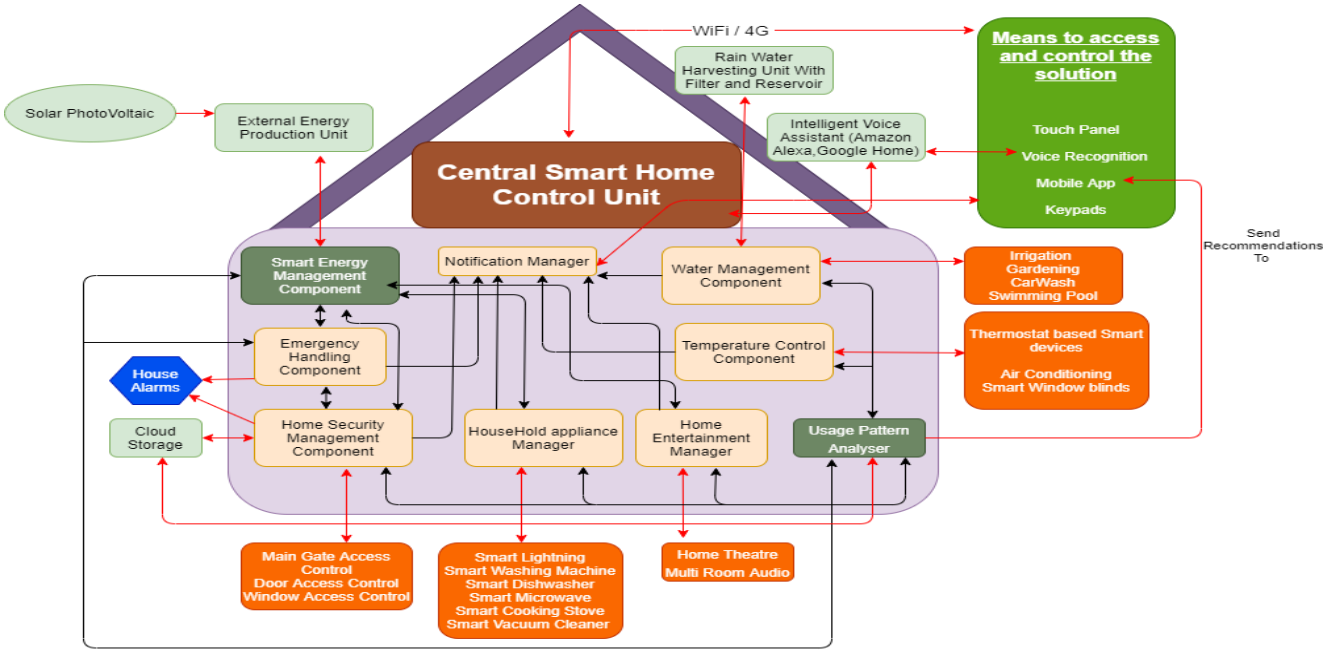
Currently there are a lot of routine tasks that are done by users like gardening, feeding pets, cleaning, laundry and so on. Some of these tasks would involve multiple people and the amount of time taken varies. The user would like to have a solution that would automate these tasks and complete them efficiently without any human intervention. They are also facing problems with multiple devices which needs manual handling in the home, this also effects the comfortability of the users. A solution that would provide them one single interface to control and manage all these devices is what the users are looking for. Our Product can allow Users to access the system both locally and remotely via interfaces like the Control Unit Touch Panel or an interactive mobile application. Local access also includes support for voice-based assistants to improve accessibility for elderly people or people with some vision related impairments. Remote access can be achieved using Mobile/Browser app. The system also supports a self-evolving mode where it would try to optimize its configurations by learning day to day household patterns of the end-users. This would improve the living condition and energy consumption based on energy

usage patterns and also some external sources like weather forecast feeds; however, user also can override the self-evolving mode and can switch to a manually controlled system at any point of time. Another most important concern for users is the security. They are looking a product which provides robust and sturdy security measures for their house. Alongside security users are also concerned about the safety of the house from unprecedented situations.

4. Product Overview

4.1. Product Perspective

The SmartHome+ is a home automation solution which integrates various IoT (Internet of Things – an internet based network of smart devices and appliances that can interact among themselves and react to inputs from their surroundings using sensors) based smart devices in a household through a central controller, to automate daily home tasks, provide home security and optimize energy utilization.



- **Central Smart Home Control Unit** comprises of various subcomponents each handling a specific dimension dedicated towards providing an overall smart living experience.
- **Smart Energy Management Subcomponent** apart from managing and optimizing energy usage also interfaces to external energy generation sources
- **Usage Pattern Analyzer** is the key component offering a Self-Evolving mode to the solution by collecting usage data from various subcomponents and trying to optimize their utility by learning patterns from the collected data. Besides it also makes meaningful lifestyle recommendations to the end users over the mobile app interface.
- **Red Colored Arrows** represent links going out from Central Control Unit to outside environment (User Interfaces, Smart Devices, Alarms, and Other Systems)
- **Black Colored Arrows** represent links internal to the Central Control Unit.

4.2. Assumptions and Dependencies

Assumptions	Dependencies
Controller and the smart devices both provide support for connectivity using Wi-Fi/Bluetooth.	Local Communication between the devices and controller happens via Wi-Fi/Bluetooth.
Controller provides support for remote connectivity using Internet.	Remote Mobile/browser apps use the Internet to communicate with the controller.
In cases where the Smart Devices is manufactured by some third party vendor, necessary Smart Device APIs are exposed for the controller to connect to it.	Controller needs to monitor and control the devices using APIs.
Environment is free from poor Wi-Fi signal strengths, interference and any other signal jamming from external devices.	Controller and devices communicate via Wi-Fi/Bluetooth.
Central Smart Home+ users are willing to give access to analyze and monitor their daily lifestyle patterns.	The usage pattern analyzer depends on data generated form home resident's daily household patterns.

4.3. Needs and Features

Need	Priority	Features	Planned Release
Modes of user access control	1	Local access to the controller using Touch panel / Keypad.	V1.0
	1	Local access to controller using Voice based assistants for elderly people or people with some visual impairment.	V1.0
	1	Remote Internet based Access through mobile/web apps.	V1.0
Security Measures	1	Surveillance Camera placement within and	V1.0

		out-side the home with due consideration to user's privacy.	
	1	Main gate access	V1.0
	1	Door Access Control	V1.0
	1	Window Access Control	V1.0
	2	Reverse the direction of windows if there are any obstacles in the path.	V1.0
	1	Centralized Home Alarming	V1.0
	1	Intrusion Detection	V1.0
Energy Management	2	Automated window blinds	V1.0
	3	Energy usage stats and analytics during different time periods in a day.	V1.0
	3	Air flow monitoring.	V1.0
	3	Managing Alternative Energy harness systems like solar and rain-water harvesting.	V1.1
Emergency Detection	1	Smoke/Gas leakage Detection.	V1.0
	1	Automated In House Roof installed Water Sprinklers.	V1.0
	1	CO (Carbon Monoxide - from appliances) level detection.	V1.0
	1	Water leakages / Water level detection.	V1.0
Household Automation	1	Automated Air Conditioning system	V1.0
	2	Smart irrigation and automated gardening.	V1.0
	2	Automated swimming pool Maintenance	V1.1

	1	Automation of the Lightning of the room	V1.0
	1	Notify customers if the window blinds in the room are not in the expected state(open/close) when turning (on/off) the lights.	V1.1
	3	Automation of cleaning activities (Like Laundry and Dishwashing)	V1.0
	3	Automation in cooking (Like a smart microwave)	v1.0
	3	Smart Home theater	V1.0
	3	Multi room audio	v1.0
Emergency Notification	1	SMS	V1.0
	1	Email	V1.0
	1	Local Controller based Monitor	V1.0
	2	Voice based assistants	V1.2
	2	Automated call to 911 in case of intrusion/break-in or other emergencies like fire / floods.	V1.1
	1	Provide the customer a predetermined amount of time to cancel the alarms if required, before making an automated call to 911.	V1.0
Mode of connectivity	1	Local Connectivity - WI-FI, Bluetooth, ZWAVE, ZIGBEE	V1.0
	1	Remote Connectivity Broadband (primary) and 4G-LTE/5G (secondary)	V1.0

	1	Remote Connectivity: Automatic switch over to secondary mode of connectivity when primary goes down.	V1.0
Mode of authorization	1	Passcode	V1.0
	1	Duress passcode	V1.0
	1	Fingerprint	V1.0
	1	Facial Recognition	V1.0
Product Operation Modes	1	User control mode	V1.0
	1	Self-Evolving mode	V1.0
	2	Customers need to authorize the changes proposed by the system in self-evolving mode	V1.2
Storage	1	Local Storage	V1.0
	1	Cloud Storage	V1.0
Routine Activities	4	Kitchen Inventory Management.	V1.2
	4	Automated feeding plan for pets.	V1.0
		Notify users about the feeding plans for pets	
	4	Medicine Inventory Management.	V1.1
Expandable Controller	1	Interface to connect devices bundled as part of the solution.	V1.0
	1	Sophisticated Interface to support third party devices.	V1.0
	1	Customers will be provided with an authorized list of third-party providers.	V1.0
User Operation Modes	1	Single user mode	V1.0
	1	Multi user mode	V1.0

User interface features	1	The current status of every installed device will be shown to the user.	V1.0
Priorities for Emergency	1	In the event of both fire and intrusion detection, fire alarm takes priority and the system switches to manual unlocking mode..	V1.0

4.4. Alternatives and Competition

- **ADT Smart homes:**

  ADT is a 145 years old company which offers some of the smartest home solutions available in the market. ADT is a customizable, pro-installed home security system with continuous monitoring. ADT has evolved beyond home monitoring into connected home automation appliances, devices and detectors, including through popular smart home assistants Amazon Alexa and Google Home.

  Pros:

  - Five Diamond Certification from TMA (The Monitoring Services) and ULC Certification for the outstanding Monitoring Services.
  - 125 years of Security Expertise.
  - 24/7 professional monitoring.
  - Temperature fluctuation protection.
  - CO Monitoring.
  - Fire Monitoring.
  - Flood protection.
  - 6-Month Money-Back Guarantee if any issues.

  Cons:

  - Complicated Security Systems.
  - ADT uses third party devices which can sometimes affect the quality of the service.
  - 36 months contract.

- **Bell Canada**:

  Known for leveraging the power of world-class wireless and fiber networks, BCE delivers a wide range of service innovations to consumers, businesses and government customers across Canada including LTE Advanced, Fiber Internet and TV, Wireless Home Internet, cloud and data hosting, IP voice and collaboration, Connected Cars, Smart Cities and Internet of Things. Bell Smart Home is for people who are already using Bell Canada for TV, Internet, and Phone who want to bundle it all together.

Pros:

- Save money by bundling.
- Affordable.

Cons:

- Complicated Security Systems.
- Poor Customer Service.

5. Other Product Requirements

5.1 Hardware requirements:

- The controller and the devices have the required hardware to enable communication using Wi-Fi/Bluetooth and ZWAVE, ZIGBEE.
- Controller has provision for SIM to enable 4G and WAN ports for Broadband connectivity.
- Controller is equipped with RAM and SD card to store local information.
- Controller can connect and run on battery backup.
- Rechargeable batteries supported by the controller.

5.2 Platform requirements:

- Controller runs on LINUX – as the Operating System and supports the JAVA – as the programing language with its runtime environment. The firmware will be implemented in Java.
- Firmware/Software upgrades will happen over Broadband (primary) or 4G (secondary).

5.3 Performance requirements:

- 24 hours battery backup in case of power failure.
- Access to 4G during broadband failure.
- Expected latency to send and receive commands to the devices is < 1 second.
- Expected latency to receiving notifications is 1-2 seconds.
- Ability to detect malfunctioning devices and power loss.
- Expected latency between cloud server and controller is < 1 second.
- Storage space will be freed up automatically by the system when available space reaches a specified threshold.
- Only few important devices will be monitored when the system is running on battery backup.

5.4 Cost requirements

Agile methodology will be used as project management process to lower the cost of product development.

5.5 Security

- All transmissions to and from the controller are encrypted to ensure privacy and data integrity.
- Authentication modes to the system include password, voice and face recognition and only authorized users can monitor and control the system.
- Default password of the installed devices will be reset once the system is paired with the controller.

5.6 Standards:

Devices and controller are compliant with CE (European Conformity) and FCC (Federal Communications Commission) standards and other required local regulatory services. Additionally, the product will be UL certified

5.7 Documentation:

User manual and installation documentation are produced which instructs on recommended and safe installation and usage of the system.

5.8 Installation:

Users will have the opportunity to install the system using a usable, self-guided interface.

5.8 Risk:

- The system will not function when there is a power failure and when the battery runs out.
- The system will not be remotely accessible in case of broadband failure and poor 4G connectivity.

Glossary:

- Controller – Central Control Unit with various sub-components for the SmartHome+ solution.
- Devices – Refers to the Smart Devices that can be connected to the SmartHome+ solution using appropriate interfaces.
- Firmware – Software dealing with low-level controls for a device's specific hardware.
- ZWAVE – Mesh Network and low-energy radio waves based wireless communication protocol to enable communication between controller and smart devices.
- ZIGBEE - A suite of high-level communication protocols used for home automation purposes. It is based on IEEE 802.15.4 specification.

APPENDIX 1 - BACKGROUND STUDY SMART HOME SYSTEM

Ubiquitous nature of communication technologies like Wi-Fi, 4G and more recently 5G, coupled with advancements in fields like IOT and Machine Learning, have garnered significant interest in Smart Home solutions. It generally refers to an interconnected network of some smart home devices installed within a home premise which can be controlled and monitored by the user.
These smart home solutions provide various benefits including but not limited to the following:

- Life safety (Ex: fire alarms, intrusion detection, duress calls etc.)
- Energy conservation, by controlling the energy usage of home appliances
- Regulate the room conditions by taking parameters like temperature, humidity, CO level etc. into consideration.
- Surveillance of the premise using cameras.
- Automation of various daily activities like switching on lights, refilling the inventory based on the content in refrigerator, controlling window blinds based on weather, feeding pets, watering plants, dish washing etc.
- Automate solar panels and rainwater harvesting based on the weather conditions.
- Dispatch security professionals in case of emergencies
- Monitor the health condition of the elderly/sick people.

In the beginning, X10 which is a protocol for power line Carrier Systems (PCS) is used for automating some of the home appliances by sending codes through power line. These legacy home automation systems used wired networks. Since it used power line to send signals it was more susceptible to interference [3].

With the advancement in technology and developments in various wireless protocols like Wi-Fi, ZWAVE [4] and ZIGBEE [5], a network of more sophisticated smart devices aka IOTs emerged. These IOTs can be integrated and controlled using a gateway/controller to provide various smart home solutions [2]. Further the advancement in accessibility methods like voice assistants and mobile apps made these intelligent solutions much more user friendly.

There is wide range of smart home solutions available in market. Starting from DIY home automation using raspberry pi to some other sophisticated solutions provided by different vendors. Most of the available solutions support only a small subset of devices and the customers are forced to use those even when better alternatives are available. Generally customers are not tech savvy enough to build their own home automation projects. Hence, we propose a product which can be tailored as per the individual's requirements. The proposed product will be compatible with most of the latest communication protocols and can learn and integrate with any new devices with minimal manual intervention.

Based on the background study we could also realize that there is no single solution that suits the needs of every home and its residents. We therefore came up with a set of questions attached below to better understand the needs of our end users. The questionnaire was prepared keeping in mind the provided project description by the solution owners, which primarily focused on 6

dimensions: **Accessibility (highly desired)**, **Environmental considerations**, **Energy Efficiency**, **Security**, **Media/Entertainment** and **Automation** of routine tasks [1].
The questionnaire was designed to be as unbiased as possible by providing some commonly accepted choice of technologies used in smart home solutions and at the same time providing end users a freedom to specify any out of the box technology of their preference. Questionnaire helped us in gaining better insights on the living lifestyle of our end users and thereby provide a solution which aligns well with their needs.

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APPENDIX 2 – QUESTIONNAIRE

Connectivity, Accessibility, and Operating Modes:

1. Considering that a general Smart-Home solution would rely heavily on establishing connectivity between various home appliances and the smart home controller. Assessing the ease of usage of some commonly used technologies with our clients within their surroundings? **Select on a scale from 1 to 5 (1 – Not using frequently or poor connectivity and 5 – Used frequently and best Connectivity)**

- **WiFi – [1 to 5] - __5__**
- **4G-LTE/5G – [1 to 5] - __4__**
- **Bluetooth – [1 to 5]- __2__**
- **Others. Please Specify.**

_____

2. Does the Smart-Home solution need to support hands-free voice-based control (using intelligent voice assistants) or the scope should only limit to other common means like app-based control? [Support for voice-based control would make the solution even more accessible for elderly people and people with visual impairments.] **Select any one and write YES next to the selected choice.**

- **With voice assistance. - ____**
- **Without voice assistance. - ____**
- **Both - _YES__**
- **Others. Please Specify. _____**

3. Modes of operation that the system needs to support. **Select only one and write YES next to the selected choice.**

- **Only User-Controlled mode – The entire system can only be controlled and configured via user-friendly mobile applications and the system would not tune itself dynamically to changing surroundings. Only driven by static configurations. - ____**
- **Both User-Controlled and Self-Evolving mode – Users can configure the system and the system as well would try to optimize its configurations by learning day to day usage patterns and lifestyle of the end-users. Here users would have the option to shut down the Self-Evolving mode if required. - ____YES**

Energy Efficiency and Environmental Considerations:

4. What daily household energy consumption processes do the SmartHome solution need to monitor and try to optimize. **Select desired options and write YES next to all selected choices.**

1. **Temperature Regulation using Thermostats.- __YES__**
2. **Water Consumption both household and irrigation purposes(say gardening).- __YES__**
3. **Lighting Systems.- ___YES_**
4. **Automated Window Blinds based on the amount of daylight.- ___YES_**
5. **Others. Please Specify.- _____Air Conditioner/heating, Time of day usage, Alternative energy, Air flow monitoring_____**

5. Integrate smart home system with other possible renewable energy resource harness systems. These features will be region-specific (like for Caribbean Solar Energy is one popular alternative source of energy). **Select desired options and write YES next to all selected choices.**

1. **Rain Water harvesting system. - __yes__**
2. **Solar panel based electricity generation. - ___yes_**
3. **Wind based electricity generation. - ____**
4. **Others. Please Specify.-**

_____

System authorization and Home Security:

6. The control and authorization modes system should support. **Select one Write YES next to the selected option and the preferred means of authorization**

a. Single User - Only one home resident responsible for managing and configuring the system.- ____

- **Voice-based authorization- ____**
- **Passcode based- ____**
- **Facial Recognition- ____**
- **Other- _____**

b. Provide both Single user and Multi-User (Distributed) as an option. Either of the two options can be selected.- ____

- **Voice-based authorization- ____**
- **Passcode based- ___yes_**
- **Facial Recognition- _yes___**
- **Other- _____Fingerprint____(whichever is more secure)_____**

***Note: In both the modes users get an option to do an emergency shutdown of the entire system in case the system starts behaving erratically.**

7. Extraordinary situations that the system should handle and preferred ways to get notified for them. **Write YES next to all applicable situations and the preferred means of notification in them [when the system is in the armed state (enabled)].**

a. Fire or Floods.- ____

- **Centralized House Alarm. - __yes__**
- **All connected Mobile Device Alarms. - ___yes_**
- **Email. - __yes__**
- **SMS. - yes____**

b. House Break-In / Intrusion- ___All_

- **Centralized House Alarm. - ____**
- **All connected Mobile Device Alarms. - ____**
- **Email. - ____**
- **SMS. - ____**

c. Water Leakage or Over-Heating in any of the rooms.- ____

- **Centralized House Alarm. - ____**
- **Mobile Device Alarm. - __yes__**
- **Email. - ____yes**
- **SMS. - _yes___**

d. System Tampering or Failure.- ____

- **Centralized House Alarm.- ____**
- **Mobile Device Alarm.- ___yes_**
- **Email. - __yes__**
- **SMS. - _yes___**

e. Others please specify.- _____

8. Visual Surveillance storage options. How do you want to store surveillance recordings? **Select only one. Write YES next to one selected option.**

.

o **Local Storage. Limited Memory has to be freed/managed by the end-user if the local storage option is full. A cheaper option in terms of budget - ___**

o **Cloud-based storage. Virtually unlimited memory. Cloud service provider costs are involved - ___**

o **Both Local and Cloud-Based (Hybrid). - __yes_**

o **Others. Please specify. - _____**

Media and Entertainment:

9. Rate some of the primary modes of entertainment for the end-users. **(1-Least used and 5-Most Used).**

· **Digital Media – Online Movies and Shows, Play-station Computer and Mobile Games, Television. [1 to 5]- __5__**

· **Family Games and other Indoor activities. [1 to 5]- __3__**

· **Outdoor activities. [1 to 5]- ___2_**

· **Others please specify.- _____**

Automation:

10. What daily household activities the end-users might consider to be the most time-consuming. **Rate on a scale of 1 to 5 (1-Least Time Consuming and 5-Most Time Consuming)**

· **Household Chores (Cleaning, Mopping, Laundry). [1 to 5]-__5__**

· **Cooking and Dishwashing (Done almost on a daily basis). [1 to 5]-__5__**

· **Buying Grocery and Taking pets out for a walk. [1 to 5]-___5_**

· **Others. Please Specify.-_____Feeding pets_____**