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DEVELOPING SMART HOME MODEL FOR APARTMENTS IN HO CHI MINH CITY BASED ON INTERNET OF THINGS (IoT) TECHNOLOGY

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Abstract

In recent years, the modernity, convenience and sophistication of apartment buildings in Ho Chi Minh city make them gradually become the new trend. They are also known as the development of society and urbanization as well. In many countries, high-rise residential apartment buildings have sprung up at a staggering rate. Keeping with that new trend, in Vietnam, apartment buildings have become the best choice of many families. One of the highlights of the apartment buildings is that residents will be living in a clean environment, less smoke, less pollution, the best space lights and natural air that bring a feeling of extreme comfort and relaxation. In particular, the interior of the apartment buildings is considered as one of the most important factors. They are invested in beautiful and modern design, optimized their functions and suitable for customer's needs and preferences.

Understanding the importance of optimizing the functions of equipment and devices in an apartment building, the article researches V-SYS application, a platform of IoT technology, to develop a Smart Home project to bring utilities for consumers. Besides, through the project, the author can also assess advantages and disadvantages of IoT technology, thereby proposing some solutions to improve products in the near future.

Keywords: *Internet of things (IoT); Smart Home*

1. Introduction

The Covid-19 pandemic has seriously caused a global economic recession. Although Ho Chi Minh City is also strongly influenced by the epidemic, the economy of Ho Chi Minh City in 2020 will still reach a growth rate, contributing over 22% of GDP and 27% of total national budget revenue as well. With the growth of Ho Chi Minh City, the demand for buying houses, especially apartments, also increased. According to the report about population and housing in 2019 of the General Statistics Office, within 10 years (from 2009 to 2019) the number of urban households living in apartments has increased by 1.5 times. Many investors still consider apartments as a key product in consumer-oriented product development in the coming years. In the third quarter of 2020, this segment recorded a 3 % growth rate of customers' interest, while other types of real estate did not grow or they decrease due to the heavy influence from Covid-19 pandemic. There are many reasons why customers and investors turn their attention to the apartment segment. One of the main reasons is that population in Ho Chi Minh City is increasing dramatically while there is not enough residential land to build houses. Besides, land prices are extremely expensive in Ho Chi Minh City. According to the Department of Housing Management and Real Estate Market (Ministry of Construction), the land price in early 2021 has increased by 15-20% comparative to 5 years ago. Owning a

house is not easy for many people. Therefore, choosing apartments to live is considered as the optimal solution in Ho Chi Minh City.

Accompanying with the people's demand for buying apartments is the selection criteria of selecting apartments at the present time. Most customers, when choosing to buy an apartment in Ho Chi Minh City, pay much more attention to the utilities and functions of the equipment and devices inside an apartment. Customers, especially young people, who are proficient in information technology always expect that convenient and easy-to-use equipment, gadgets and devices will help them save time in monitoring and controlling all electronic equipment and devices in their apartment. However, there is a big problem in application of information technology, especially application of the IoT technology in electronic equipment and devices is that it will cost a lot of money on installing and operating system for the apartment. Understanding the importance of information technology application in installation and operation of electronic equipment and devices for apartment buildings, author choose the topic "Developing Smart home model for apartments in Ho Chi Minh city based on application of Internet of things (IoT) technology" is the research topic.

2. Literature Review

2.1. Overview of Internet of Things (IoT)

There were many researches about implementing IoT technology. Kelvin Ashton, co-founder of Auto-ID Center at MIT, mentioned the concept of IoT during a conference at London in 2000. With the desire to bring RFID (Radio frequency ID), a radio frequency identification device, which took an interest from top managers of organization. Ashton called his presentation "*Internet of Things*" as a catch-up for the era: The Internet. Although Neil Gershenfeld, MIT expert, did not mention clearly about the term IoT in his 1999 book "When Things Start to Think", it also provided some clear directions on development of this platform. According to the ITU and IERC (*The International Telecommunication Union and* The *International Energy Research Centre)*, the Internet of Things (the interconnected network of things or IoT for short), is a system of interrelations between computer devices, machines, digital devices, things, animals and even people that are provided with unique identifiers (UIDs) and the ability to transfer data without depending on human – to – human or human – to – computer interactions. (Gershenfeld, 1999)

Therefore, the Internet of things is very different from the traditional internet. The traditional internet is just a network connecting computers and people that want to connect to other computers or other people. They also have to use the connection protocols of internet through a computer connected to the network (Zhu & Liu, 2022). A simple way to understand is that, IoT is all devices and equipment which can connect with each other. The connection can be made via Wi-Fi, broadband telecommunications network (3G and 4G), Bluetooth, ZigBee, infrared, etc. Devices and equipment can be smartphones, coffee makers, washing machines, earphones, hearing aids, light bulbs, and many other devices (Atzori, Iera, Morabito, & Nitti, 2012). Cisco, an American multinational technology conglomerate, predicts that in 2020, there will be about 50 billion objects connected to the Internet, even this number will be increasing significantly. The IoT will become the giant network that connects everything, including people, and there will exist the interrelations between people and people, people and devices, devices and devices. An IoT network can hold up approximately 50 to 100 trillion objects connected and this network can track the movement of each object. A person living in a city could be surrounded by 1,000 to 5,000 objects tracked.

In general, the IoT is defined as a wide network of things worldwide connected to the Internet. It is all of the devices used by people have ability to connect and interact with each other through the Internet. Therefore, people can easily collect, process and transfer information data.

There are some main fundamental characteristics of IoT mentioned below:

- Interconnectivity: With the IoT, things can be connected with each other through the information network and the overall communication infrastructure.
- "Things" – related services: IoT system is capable of providing services related to "Things", such as protecting privacy and consistency between Physical Thing and Virtual Thing. To provide this service, both hardware technology and information technology (software) will have to change. (Patel, Patel, & Scholar, 2016)
- Heterogeneity: Devices in the IoT are heterogeneous because they have separate hardware, and different networks. Devices between networks can interact with each other based on network interconnections. (Patel, Patel, & Scholar, 2016)
- Dynamic change: The status of the devices automatically changes, for example, sleeping and waking up, connected or disconnected, the device location has changed, speed has changed, etc… Furthermore, the number of devices can be changed automatically
- Enormous scale: There will be a very large number of devices that are managed and communicated with each other. This number is much larger than the number of computers connected to the Internet today. The amount of information transferred by the device will be much greater than transferred by people. (Patel, Patel, & Scholar, 2016)

IoT technology brings many benefits for life. It can be classified into 2 main types of benefit:

- Benefits for organizations:

The Internet of Things has many benefits for organizations. Some benefits are particular to certain industries, and some may apply to many different industries. Here are some common benefits of IoT for businesses:

The IoT encourages companies to rethink how they approach their business and provides them some useful tools to improve their business strategy. In general, IoT is widely used in organizations related to manufacturing, transportation, and utilities by using various sensors and IoT devices. The IoT can benefit farmers in agriculture industry by making their jobs easier. Sensors can collect data on precipitation, humidity, temperature and soil content, as well as other factors, helping to automate farming techniques. (Saheb, Cabanillas, & Higueras, 2022)

The ability to monitor infrastructure activities is also known as one factor that the IoT can help. For example, sensors can be used to track events or change in the structure of buildings, bridges and other infrastructure. This brings many benefits, such as cost saving, time saving, workflow modification for quality of life and paperless workflow. (Saheb, Cabanillas, & Higueras, 2022)

An organization in real estate industry can use the IoT to monitor and manipulate electromechanical systems in a building. For a larger scale such as smart city, it can help people reduce energy waste and energy consumption. IoT also appears in every industry such as healthcare, real estate, agriculture, finance, retail, and manufacturing, etc.

- Benefits for consumers

The IoT make the environment (home, office, and vehicles) smarter, easier to measure. Home security system makes it easy to keep track of what is happening inside and outside or to see and talk to visitors. Meanwhile, the smart air conditioner can help people heat the house before they come back, and smart light bulb can make it look like they stay at home even when we are out. Besides, sensors can help people understand how noisy or polluted our environments are. Self-driving cars and smart cities can change the way people build and manage public spaces. (Brous, Janssen, & Herder, 2020)

2.2. Overview of Smart Home:

There were some researches to develop the applications for Smart Home. According to a research of Rosslin John Robles, Smart Home refers to a house or apartment equipped with electronic devices based on application of IoT platform. Especially, these electronic devices are connected to each other to form a network system. For example, air conditioners, refrigerators, TVs, microwaves, smart lights, door locks, anti-theft security, etc... Users will monitor and control these devices remotely via smartphones or computers. These devices will be controlled automatically and synchronized very simply and easily. (Robles & Kim, 2010). In other research, Piyare and Lee proposed a Smart Home-Control and Monitoring System Using Smart Phone. This research discusses the smart home control and monitoring using micro-web server and smartphones. Micro web-server installed on Arduino used to transmit data from the sensor to smartphone user, then the user can send commands to Arduino to control electronic devices. (PIYARE & Lee, 2013)

Smart Home system brings a lot of convenience for people. There are some main features of a Smart Home system as follows:

- Function 1: Smart Home system can help control smart lighting system. With a light touch through the phone screen or iPad, homeowners can easily turn on or turn off the lights as well as control the system of electric devices in their house. In addition, the smart home also has the function to set up scenes. For example, when the person opens the door, the light is on. Wherever the person goes, the light will light up and will turn off when the person leaves. (Kadam, Mahamuni, & Parikh, 2015)
- Function 2: Control electronic devices using remote. In addition to the lighting system, the smart home also has the function of controlling electronic devices in the house that use remote such as air-conditioner, fan, television, entertainment system, etc. the owner can control television, air-conditioner, speaker, player, hot and cold water tank at the same time.
- Function 3: Smart home can control the curtain system. Smart home allows homeowners to control the curtain system remotely on their cellphone or tablet. Besides, they can also set up system based on the following contexts: welcoming guests, watching movies, going to sleep and controlling many curtains at the same time. (Kadam, Mahamuni, & Parikh, 2015)
- Function 4: Turn on / Turn off air conditioner or water heater remotely. Smart home is to be able to set up the air conditioning system or the water heater system. They will automatically work depending on the time frame homeowners preset or adjust modes suitable for the health of whole family. With this function, homeowners will no longer have to worry about forgetting to turn off the air conditioner or water heater. (Kadam, Mahamuni, & Parikh, 2015)
- Function 5: Smart home can control the environment, temperature, and humidity inside the house. Smart home is equipped with an environment control system with sensor devices for measuring temperature, oxygen saturation in the house, and humidity. The parameters are calculated by the central controller and sent to homeowners' phone. When the homeowners feel the indoor temperature seem to be inappropriate, the central controller will immediately command to the air conditioner, dehumidifier, ventilation fan to adjust settings and help the space maintain clean and fresh air. (Davidovic & Labus, 2015)
- Function 6: Control smart garden system. Smart home has function is to automatically water the plants in the garden every day at a predetermined time or by switching on and off remotely through cellphone. (Malche & Maheshwary, 2017)
- Function 7: Ensure absolute security for homeowners' house. Smart home has integrated closed-circuit television system and anti-theft device which protect the house 24/7. Therefore, when strangers break

in, the sensor system will detect the intrusion and the system will immediately send an alert on the smartphone screen, open siren alarm, open curtains, electric lights turn on. It will help homeowners not to worry even though they stay at home as well as go away. The house will be extremely secure with two protective levels including door/window sensor and motion detector. (Davidovic & Labus, 2015)

- Function 8: Control smart home by voice. Smart home also has a very special function that is to obey the voice of the owner. This is a very special function which many people are interested in. They allow homeowners to control all electronic devices in the house by their own voice. With this solution, people can control everything in their home no matter where they are, whether on business trip, vacation, ... Especially, people also can know exactly which electronic devices in the house are turn on or off. (Malche & Maheshwary, 2017)

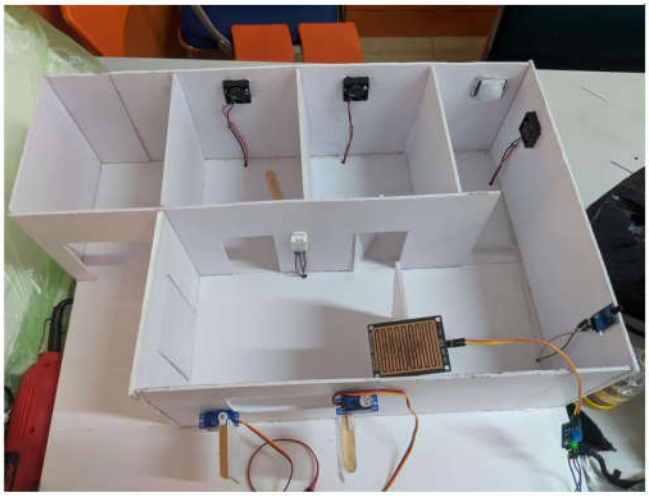
3. Results And Analysis

3.1. The main idea of the Smart Home for apartment project based on V-SYS technology:

Based on the IoT technology platform, the author will build a healthcare system for each family member living in an apartment by using identification technique for each member through fingerprints, heat, the level or heart rate. From there, the smart home will automatically adjust the lighting, bedroom temperature to be suitable for the physical condition of children and for adults as well. When an alarm clock sounds in the morning, all sensors simultaneously activate electronic devices in the morning such as turning on hot water, making coffee, forecasting and reporting the weather. Moreover, it will create an application on the homeowner's phone, tablet or smart watch to control all household items. Depending on the settings chosen by the homeowner (for example: "Going to Work", "Going Home", "Going to Bed", "Entertainment" or "Party"), household items such as air conditioner, TVs, sound system, devices in kitchen, window system, curtain system, fan, electricity, heating, security camera, fire warning system, garage, etc... will automatically cooperate with each other. In addition, when the user creates a new operating mode, the system remembers and stores these parameters and automatically serves them in next time.

This project applies advanced technology of V-SYS for smart home apartment building. It is at the formation stage of project and has a sample product:

Figure 1. Sample product of Smart Home project for apartments based on V-SYS application



(Source: Author)

There are many benefits which this project brings for people living in an apartment.

Firstly, it helps customers lock door or unlock door automatically. It can integrate high-speed and high-resolution camera system, door sensor system, and motion sensor. It helps to send the warning message to homeowners' phone about strangers' breaking no matter where customers are. When customers leave the house, exit or enter the garage, the door system will help the customers open and close door automatically. By integrating technology of Smart Home system and high-speed camera, customers can be assured of convenience and safety brought by a smart home (Ramlee, Othman, Leong, Ismail, & Ranjit, 2013). It also helps customers control lighting, electrical devices, and air conditioners everywhere in the apartment with just a few simple steps on the Smart Phone or iPad via Internet connection.

Secondly, it helps customers save money from electricity bills. Smart Home helps customers to control electronic devices in the apartment from anywhere. It will turn off the air conditioner when homeowner forgets to turn it off, open the curtains automatically when it is morning and turn off the lights when not needed. All utilities help customers use everything in the best ways. When people try to work and save money, they expect to buy a beautiful and fully-equipped apartment. Along with a reasonable price, the smart home project will help customers' dream come true (Lutolf, 1992). The apartments will become more attractive, more beautiful, luxurious and convenient. People have more opportunity to experience a customer's apartment through smart home technology

Thirdly, it makes a comfortable and clean living environment. Smart Home systems will gather information, analyze information, and calculate data about the temperature, humidity, and light of the environment and provide context suitable for the apartment. It makes customers and members feel at ease in their own apartment (Yamazaki, 2016). It also helps homeowners take time to enjoy life because all electronic devices in apartment have been programmed and self-implemented the modes without owners' control. Besides, it helps to keep good connection with family. When customers go to the office, go on business overseas, or their children have to study abroad, the add-ons of Smart Home system will allow customers to connect with their families they have phone or tablet.

3.2. Research method

This research uses V-SYS technology which is one application of IoT. V-SYS was established in 2010 in Ho Chi Minh City. It tries to bring added value to society by creating new and comprehensive solutions in the fields of automation, information and software. Starting from V-tools, a successful company in the mechanical manufacturing industry, V-SYS has started its business by providing machining programs, ERP software for mechanical factories, automatic tool feeders, automation solutions, etc. It was applied for a wide range of customers from mechanical factories to seafood factories. Because of the success from major customers, V-SYS has developed and diversified its activities in many fields especially for manufacturing vending machines and the development of mobile applications or Internet. Since 2011, V-SYS has focused on researching and implementing the idea of "Internet of things" in Vietnam. Starting from single devices applied in many different fields such as smart homes, irrigation, lighting and anti-theft systems for farms, black boxes of CNC machines, vending machines, etc. It developed the idea of "Internet of things" into "*Controlling everything over the Internet*". To install a Smart Home system, project should prepare all following materials.

Table 1. Materials for Smart Home project applying V-SYS technology

No.	Material	Quantity
1.	ESP8266 (NodeMCU)	01
2.	Arduino R3	01
3.	Air sensor	01
4.	Temperature sensor	01
5.	Soil moisture sensor	02
6.	Set of 8 relays	02
7.	Set of central controller IO	01
8.	Peripherals with 16 outputs	01

(Source: Author)

Smart Home model can collect parameters such as: room temperature, humidity, light, heart rate of members living in apartment, body temperature of members, etc...

Smart Home can control of electronic devices such as electric fans, air conditioners, electric lights, kitchen equipment, etc.

Smart Home enable to give automatic warning when there are dangers such as gas warning, fire warning, intruder detection, etc.

Smart Home has ability to manage electronic devices remotely via the internet such as monitoring and controlling TVs, refrigerators, air conditioners, electric fans, etc... and operate in preset modes

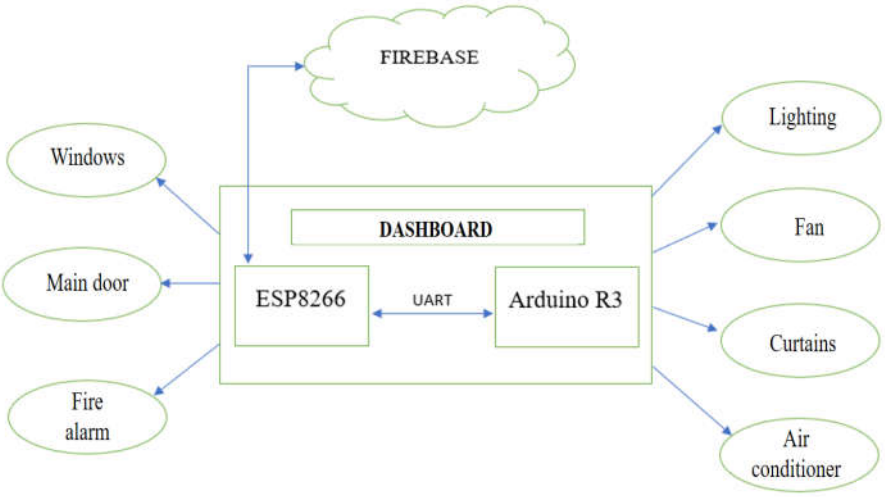
3.3. The operating principles of the model:

Sensors collect parameters of temperature, humidity, air, etc... from the environment and then send signals to the central processor.

The central processor receives data from the sensor system. After that, depending on the requirements set by each condition, the devices are controlled for specific purposes.

In manual control mode, the central processor will receive the user's direct control via Web browser, application of Android phone or computer.

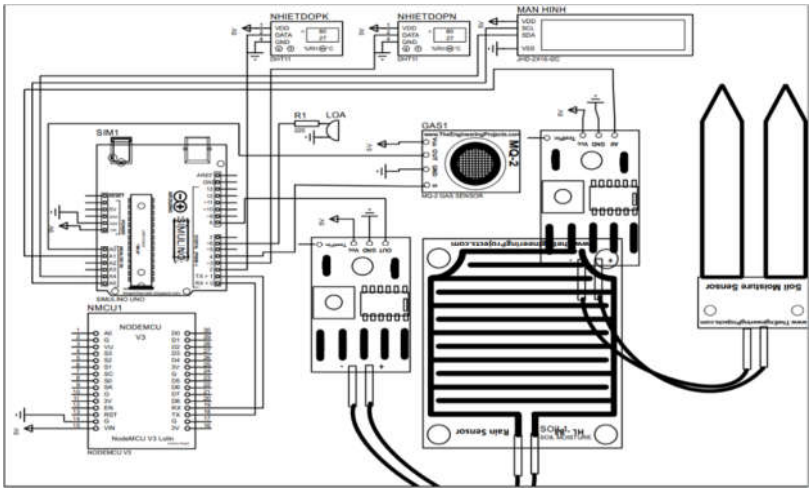
Figure 2. The operating diagram of Smart Home project for apartment based on V-SYS



(Source: Author)

A diagram for V.SYS application of IoT technology for room temperature in a certain apartment:

Figure 3. The particular operating diagram for temperate function and rain function



(Source: Author)

3.4. Advantages of the project

The project uses IoT technology, especially V-SYS advanced programming technology, which makes software application much simpler than other software tools, thereby providing the most suitable price for customers.

The project applies AI technology to increase accuracy and intelligence for Smart Home

The project has ability to inherit and develop to other fields such as Smart Office, Smart Farm, Smart Car, Smart Building, Smart City more easily.

The price of product is competitive on the market and suitable for users

3.5. SWOT analysis for project

Table 2. SWOT analysis for Smart Home project for apartment in Ho Chi Minh City

Strengths	Weaknesses	Opportunities	Threats
S1. Enthusiastic, young and professional staff. S2. The product's price is reasonable. S3. There are many customer services to support them. S4. Applying AI technology to increase the accuracy and intelligence of Smart Home project.	W1. Not much experience. W2. The product is not well known in the market. W3. Not much capital W4. Marketing activities are not enough to help customers identify the brand in a short time W5. The ability to inherit and develop to other fields such as: Smart Office, Smart Farm, Smart Car, Smart Building, Smart City is very easy.	O1. The smart home market is developing and drawing more attention O2. Vietnam's population has increased over the years O3. Demand for owning a modern apartment is growing strongly Government policies in the real estate industry	T1. The price is not affordable to all people T2. Concerned about the complexity of installation and use T3. The market has many competitors with a lot of experience T4. Marketing must be good to bring the services to the customer T5. The user's knowledge about smart home is still limited

(Source: Author)

After analyzing SWOT, author propose some recommendations for the project:

When developing smart home products, project needs to focus on researching and exploiting V-SYS application of AI technology as a competitive advantage to compete with other competitors in the same industry. Investing more in V-SYS application will help project inherit and develop to other fields such as Smart Office, Smart Farm, Smart Car, Smart Building, Smart City. At the first phase, project should focus on developing Smart Home model for apartment buildings. When brand is known well, it should be expanded to private houses and villas as well.

Cheap price is also an advantage of the project. Project should take advantage of this strength to promote products to customers. It will be supply sensors and hardware by themselves. A basic set of equipment for a Smart Home product includes: ESP8266 (NodeMCU), Arduino R3, air sensor, temperature sensor, soil moisture sensor, set of 8 relays, set of central controller IO, peripheral with 16 outputs. Expenses for purchasing materials and equipment which are calculated are not too much expensive compared to the others products. Because the equipment cost is low, project should consider carefully to choose the high-qualified equipment to ensure safety when operating and using in practice.

To develop the protect as expected, it is necessary for establishing a company. Setting up a company should be considered carefully and needs to comply with government law. Especially, company should pay more attention to marketing plan. The company is a star-up organization. Customers really do not know about the company and products. That the reason why company needs to promote the image of the business and products more to increase brand awareness through Internet or website. Besides, company needs to focus on recruit high-qualified employees. Employees of company should be young and enthusiastic. Programs should be designed to improve knowledge and skills for employees.

4. Recommendations And Conclusion

4.1. Threats and opportunities for developing the project

4.1.1. Opportunities for the project

According to the statistics of the Department of Planning and Architecture of Ho Chi Minh City, within 2 decades, the population of Ho Chi Minh City has doubled, from 4 million people in 1990 to 8 million people in 2016. To 2019, the population of Ho Chi Minh City was approximately 9 million people, but actually more than 13 million people are living, studying and working here. The permission of about 200,000 people immigrating to Ho Chi Minh City per year to live has set high requirements on the development of technical and social infrastructure, especially the need for people's residence. The growth in population of Ho Chi Minh City that leads to a sharp increase in housing demand for people. In addition, an issue that was presented in the previous section is that residential land for housing construction is insufficient, even scarce. In general, the demand for housing has still increased but the residential land for housing construction is not sufficient, which is considered as an opportunity for real estate market development, especially in the apartment building segment for customers.

Based on the information mentioned above, it shows that the apartment building market has great potential for growth in the near future. The apartment market of Ho Chi Minh City in the third quarter of 2020 shows gradual increase as the number of apartments for sale have risen significantly compared to the second quarter. According to research data released by CBRE Vietnam, in the third quarter of 2020, 3,964 apartments of 4 apartment building projects were offered to sell in market. Among them, there were about 3,552 apartments sold out, reaching 89.6%. From the beginning of 2020 up to now, the total number of apartments for sale in the third quarter of 2020 increased approximately twice as compared to the second quarter and also slightly increased than that of first quarter. According to Ministry of Planning and

Investment, with the formation of new city in the east of Ho Chi Minh City including Thu Duc District, District 2 and District 9, will create a wave of attracting investors to develop apartment building projects and costumers as well. Accordingly, the cumulative supply in the East area of Ho Chi Minh City is forecasted to account for 44% of the total supply by 2025, corresponding to 198,000 apartments. Meanwhile, based on the forecast of CBRE Vietnam, the apartment building market in Ho Chi Minh City next year 2021 will increase relative to 2020, but not much, both supply and sales are forecasted to not exceed 20,000 units

4.1.2. Risk and Issue Management Plan for the project

It is considered as a start-up company, the company is trying to achieve its goals. Besides the opportunities available such as potential apartment building market or the growth of technology, company also faces many potential risks.

Risk 1: Many customers still concern about the complexity of installation and use of smart home. Some user's knowledge about smart home is still limited. Therefore, to avoid this risk, when promoting products on media channels, company must describe extremely clearly the functions, uses and benefits that smart home brings. It should be compared to an apartment without a smart home. In addition, it is necessary to design training course to improve communication skills for salespersons and technical staff when consulting on Smart home installation for customers.

Risk 2: The market has many competitors with a lot of experience. It is not easy to compete with them. To avoid this, company needs to focus on developing new feature which competitors do not have at the present, especially, company should consider AI technology as a competitive advantage.

Risk 3: In the process of developing product sample, company will encounter problems such as defective samples, not creating smart home as expected, incomplete functionality, etc. It can affect the overall progress of project. To avoid the possible risk, company should adjust the plan more appropriate

4.2. Assess the feasibility of the project

At *Vietnam International Construction* & Building Exhibition (VICB *2015*) held from September 1 to 5 at the SECC Exhibition Center (District 7 - Ho Chi Minh City) with hundreds of companies, the most prominent are Smart home companies applied IoT. Most of the Smart home companies believe that the development and technology trends make owning a smart apartment easier in big cities of Vietnam such as Ho Chi Minh City, Hanoi, Da Nang, Can Tho, etc. Furthermore, according to the report of General Statistics Office in 2020, population of Viet Nam is over 90 million people, and about 67% of which are under 36 years old. The middle class in society is increasing and living standards of people have also risen. People especially demand on the utility of household items. For example, the remote security monitoring system that automatically alerts the homeowners email or phone when it detects something unusual and then help people improve quality of life. Using voice or gesture control technology, as well as saving power through a smart light system that can automatically turn on and off can help people save time and enjoy their lives. Besides, the price of product is not too expensive relative to the other products. In the first phase, project has plan to develop 2 main product lines including Customized application and Simple application to manage data. Depending on the size of each apartment and the number of electronic devices equipped inside the apartment, the prices of products will vary. It is considered to be suitable for young people who have incomes ranging from 15-20 million and choose to buy regular apartments.

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