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DEVELOPING A SMART CAMPUS SAFETY AND SECURITY FRAMEWORK USING INTERNET OF THINGS (IOT): A CASE STUDY

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ABSTRACT
Tertiary institutions around the world have embraced the development of smart campuses as a means of monitoring students' activities on campus in recent years. Smart campus, adaptation of smart city, use of campus environment as the foundation for project development. Smart learning, smart libraries and smart sports complexes are examples of smart campus applications, smart healthcare, smart water and waste management, smart energy consumption, smart security and safety management and so on. These procedures make it easier to work together on campuses. This paper focuses on smart campus design on security and safety framework with an emphasis on intrusion on critical facilities that require access permission. When an intruder is detected, the application uses embedded system cameras, which are cameras designed for microcontrollers to receive notification with a new photo and/or sensor data. Intruders are detected using passive infrared (PIR) motion sensors, and the information is sent to the premise owner via telegram bot (Telegram App). The owners can also request general conditions of things from a remote location, whether within the premises or outside the continent, through bi-directional communication. The technology was validated in real-world scenarios and the feedback data was analyzed for potential intruder. The results showed that the model have the capacity of detecting intruder into the defined area and relate information and location of the intruder to the owner of the premises in real-time anywhere in the continent for prompt action. Conclusively, the developed smart campus safety and security framework using IoT has improved the campus security and safety system.

1. INTRODUCTION
The majority of Nigeria's higher institutions are currently dealing with security and safety issues. Recent increase in kidnapping in Nigerian institutions has become worrisome and the safety on the Nigerian institution campuses became a growing concern to stakeholders among the campus community and the across the country. A serious security breach occurred sometime ago at the National Institute of Construction Technology and Management's campus, putting lives and the institution's properties in danger. This was made easy due to the school's campus's location on the outskirts of the city. To protect lives and property, the school has hired

private security guards. However, due to the high cost of maintaining this approach, it has recently been discovered that it is no longer sustainable. Hence, new ways that is sustainable to secure lives and properties in the Institute is highly required. As a result of the useful information learned about creating smart cities, many researchers have recently focused on the concept of a smart campus. A tertiary institution campus is essentially a mini-city that provides a variety of services to a wide range of customers. The Smart Campus research area at Urban, Internet of Things (IoT) is critical. As a result, the application of IoT on smart campuses provides useful insight into the application of urban IoT (Alghamdi and Shetty, 2016). The idea is to create a campus that makes the best use of its resources, provides high-quality services to the campus community, and has significantly lower operating costs.

The Internet of Things (IoT) is now an unavoidable component of the smart campus in the industrialized world. IoT is a communication medium that have gained capacity overtime for varieties of objects to the internet. The ability of the Internet of Things to connect a variety of everyday devices to the internet is what ensures its survival as a communication paradigm. The objects are but limited to: Sensors, robotics, security locks, alarms, drones, appliances, smart grid systems, office supplies, and other items are examples, but they are not limited to them. Despite the fact that the Internet of Things is still in its early stages, numerous applications and standards have been developed for it in a variety of fields, including home automation, smart grids, water and waste management, traffic control, autonomous vehicles, healthcare assistance, industrial automation, and security, which is the focus of this current research work. The smartness of campus can have diverse applications depending on the services that is been conveyed and received in the campus. The campus can be divided into four (Abdullah, et al. 2019) areas: intelligent buildings, campus smart grid, learning environment and other applications. Figure 1 shows the Impacts and applications of smart campus concept (Alghamdi and Shetty, 2016).

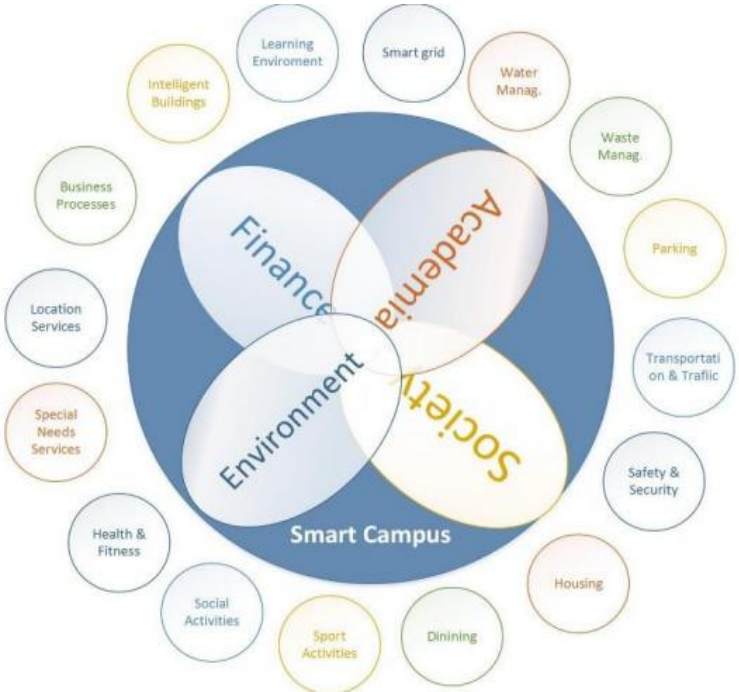

Figure 1. Impacts and Applications of Smart Campus Concept

Campus security is critical; there are sensor systems or video observation frameworks that generate data about any event of the 24 hours of the day. The capability of this framework enables the use of their information for variety of tasks, such as pattern recognition or

identifying the population's unique needs (Villegas-Ch et al., 2019). The checking limit that was added to the investigation cycle enables campus administrations to self-regulate and carry out identification. Campus security is inextricably linked to human tracing data because it focuses on individual activities and social gatherings. The occurrence of social events, unusual groupings of people, individual misbehaviour, the movement of criminals and the missing, and human behaviours in disasters can all be inferred from mined data (Pan, et al., 2013). Based on the data collected about the crowd and human behaviour, campus security could be improved in a variety of ways, including: i) identifying individual misbehaviour from aberrant traces that may indicate probable individual misbehaviour; and ii) searching for and monitoring important individuals. People who went missing or were involved in a disaster could be found. Traces of alleged criminals could point to real criminals, gangs, or dangerous neighbourhoods.

This current research is an off-shoot of the comprehensive smart campus project that is currently being developed. The study proposes an IoT-based safety and security architecture that would improve safety on the NICTM campus in Uromi. This study describes the proposed "Smart Campus" concept and architecture in order to define the underlying criteria for its construction and provide a strategic framework for its components.

2. LITERATURE REVIEW

Every person on the planet is still looking for safety. The greatest fear of any person is that his/her surroundings is safe and if not, it will no longer be safe for him/her and that his/her life will no longer be safe. Furthermore, the security conditions of Nigeria as a country has inevitably seep into the tertiary institutions. Campuses cannot be safe in a setting where Nigerian residents are not safe.

The majority of the students on campuses are between the ages of sixteen and thirty-five. The young are at a stage in their lives when they have an insatiable desire for adventure. As a result, people begin to engage in anti-social behaviours such as drinking, smoking, drug use and joining cults. Youth can be equally beneficial at this point in their lives if they choose to be useful to themselves. Majority of our students are so active, our schools' security needs to be tightened to limit and reduced youth exuberate. Most institutions now employ private security, which can be costly to maintain and this has increase cost of running institutions in the country. The concept of an intelligent system for campus security and safety has recently gained popularity in the industrialized world, but adoption in this country has been extremely slow. The need for a smart campus is driven by the variety of services offered to various user groups on campuses, who expect lower costs while receiving high-quality services (Alghamdi and Shetty, 2016). The effects of campus services extend beyond the academic community into the environmental, financial and social spheres. Internet of Things (IoT) will unavoidably be used on smart campuses to bring variety of services needed in the campus. A smart campus typically includes, among other things, a smart grid, water and waste management, intelligent buildings, learning environments, parking, traffic, transportation, business processes, location services, safety and security, housing and dining, social and sporting events, health and fitness programmes and services for people with special needs (Alghamdi and Shetty, 2016). Also, Abdullah et al. (2019) proposed a smart campus framework for safety and security system in the University campus using IoT technologies which was tailored to fit any University campus that would act as an instantaneous responder to incidents that may happen on campus. He summarized the challenges into technical, financial and political and their work highlight future area of improvement.

As a result of modern and evolving technologies, people's living standards and overall quality of life have improved. However, a good education is an important component in the development of society because it shapes future generations and influences their thought processes. It appears that there is a current need to incorporate new technological developments into existing educational institutions to meet required need of services. Furthermore, combining educational institutions with new technology is one solution to the on-going issue of using sustainable resources. Smart campuses, like smart cities in general, can only serve as a catalyst for changing how educational institutions are currently organized (Harrison et al., 2010). How people experience and navigate data challenges in their daily lives is becoming increasingly important as communication networks expand due to digitalization, connective devices, and the Internet of Things (IoT), with higher education serving as a significant data frontier (Van Dijck, 2014 and Beer, 2019).

Villegas et al. (2019) uses the concept of smart cities to define smart campuses as the integration of three key axes, including big data management and analysis, data centralization, and IoT-based data collection. As a result of the integration of axes, traditional campuses can effectively manage the information generated on their own.

The report by CenturyLink (2018) recommends implementing IoT in three areas to improve campus safety and security: asset protection, facility access control, and interactive signage and kiosks. The use of track-able beacons on high-value resources can help millions of organizations secure their investments. To avoid disaster, IoT provides campuses with control over their buildings, including who can enter and when, as well as a log of entry and exit. IoT can be used in an emergency to display critical information on interactive signage and kiosks. So, it's safe to say that using IoT to improve safety and security is a good idea, and it's also a critical component of creating a smart campus. This study proposes an IoT-based safety and security architecture that would improve safety on the NICTM campus in Uromi using passive infrared (PIR) motion sensors. The information collected is sent to the premise owner via Telegram bot (Telegram App) through bi-directional communication for him/her to take prompt action.

3. CONCEPTUAL FRAMEWORK OF THE SMART SECURITY AND SAFETY CAMPUS PROJECT

The entire project is a comprehensive smart campus proposal that covers the following as shown in the Figure 2. However, the current research focuses on the safety and security aspect of the proposed comprehensive smart campus project. The design and implementation of the security system architecture is described below.

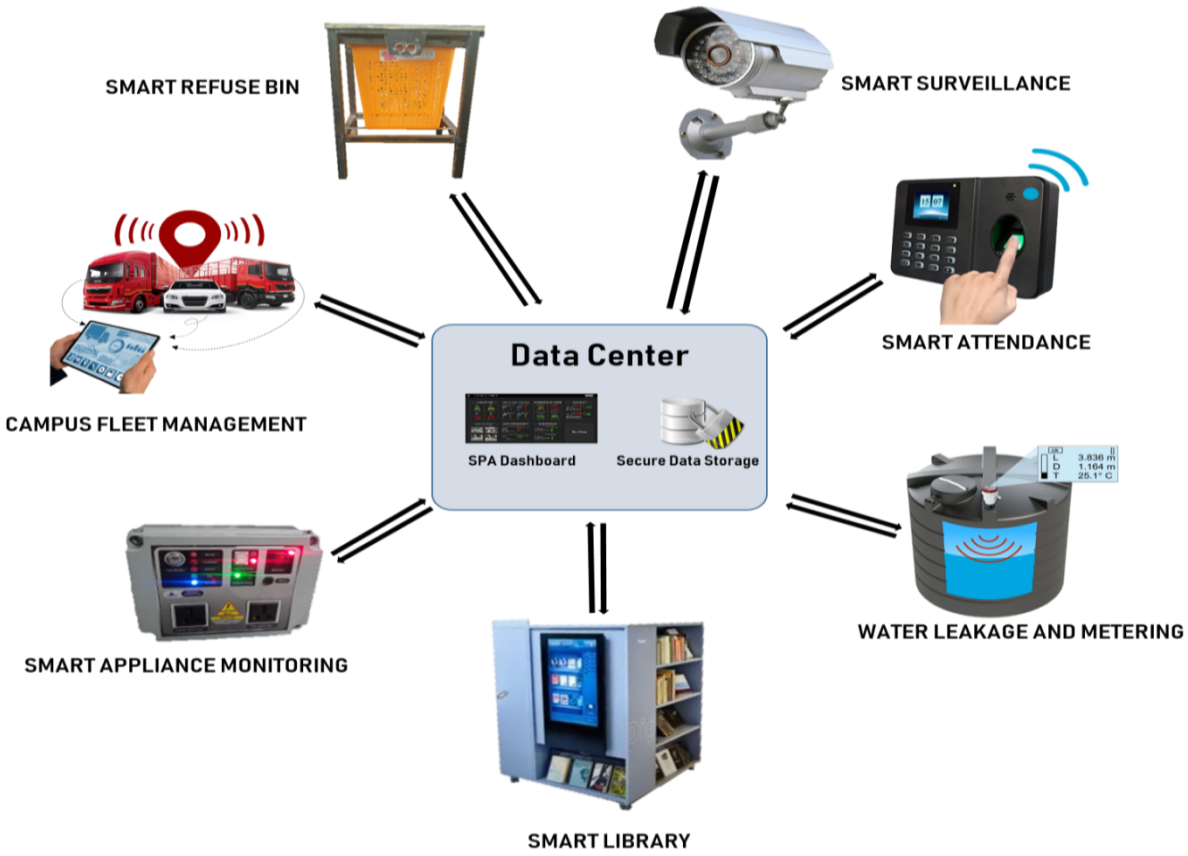

Figure 2. Dashboard that integrates all the Components of the Framework

The entire architecture involves creating a Telegram bot to control the surveillance system, so that the system can monitor the premise from anywhere (as long as you have internet access on your smartphone). The system works by detecting unauthorized intruders, using proximity sensors to detect movements, and take the photo of the event and send the picture to the premise owner through the Telegram app. It was designed in such a way to ask the system to send information by command. The proposed smart security campus works based on two communication systems. These are:

1. Bi-directional communication (User-smart cam-user Interaction): The communication is imitated from the user's interaction and it queries the setup for proceedings at the other end. If any intrusion is detected in an authorize location, it send photo signal back to the user for prompt action.

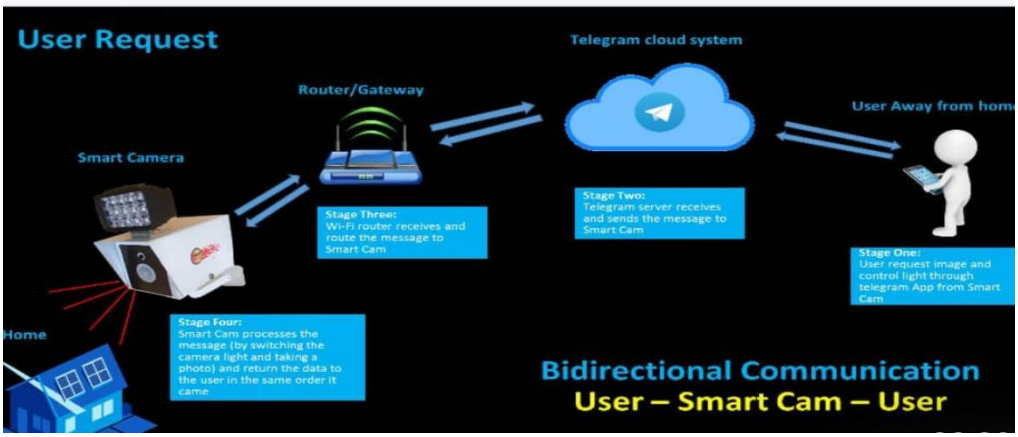

Figure 3. Bidirectional Communication Architecture of the Smart Security

2. One-Way communication (Smart Cam-User) communication. The communication is imitated from the user's interaction and it queries the setup for proceedings at the other end. If any intrusion is detected in an authorize location, it send photo signal back to the user for prompt action.

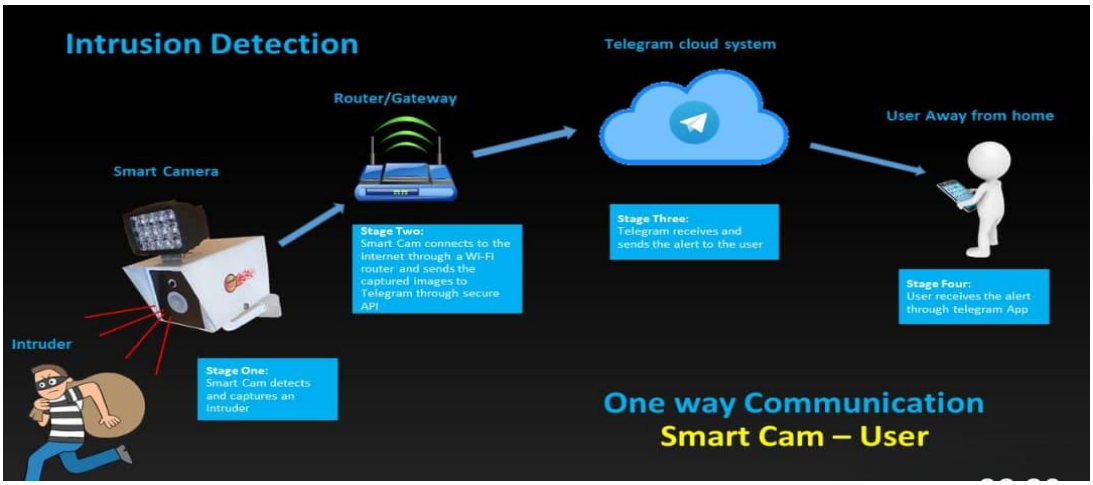

Figure 3. One-Way Communication Architecture of the Smart Security

The design of the system enclosure was constructed in such a way to prevent harsh weather acting on it. A printed circuit board (PCB) was designed for the work. Readings were initiated using the requests for the latest sensor readings that were attached to the system's unit, like temperature, etc. The C++ programming language was used to implement the design of the smart campus. The system was validated in the next phase of the study.

4. TESTING AND VALIDATION

The system was validated using real life data for the evaluation. The process was initiated from the extreme ends of the school to test the efficiency of the data sent to the bot telegram system. The following commands were used to interact with the system as shown in the Figures 5 and 6 below:

Start: sends a welcome message containing the valid camera control commands.

Photo: takes a new picture and sends it to your Telegram account.

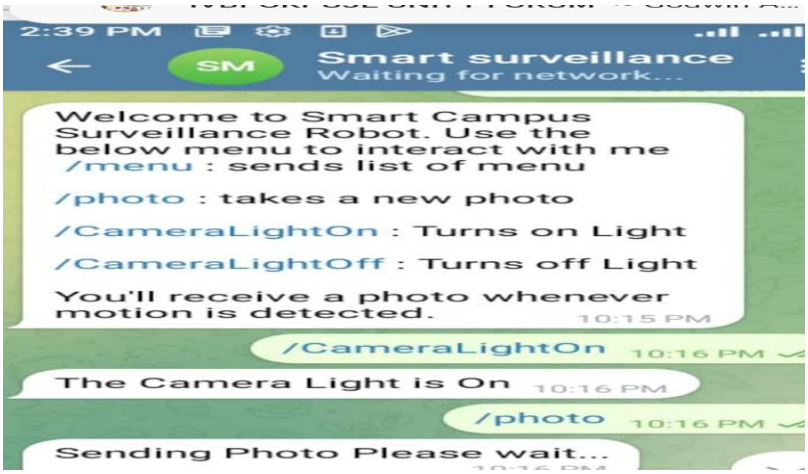

Figure 5. Sends a welcome message containing the valid camera control commands

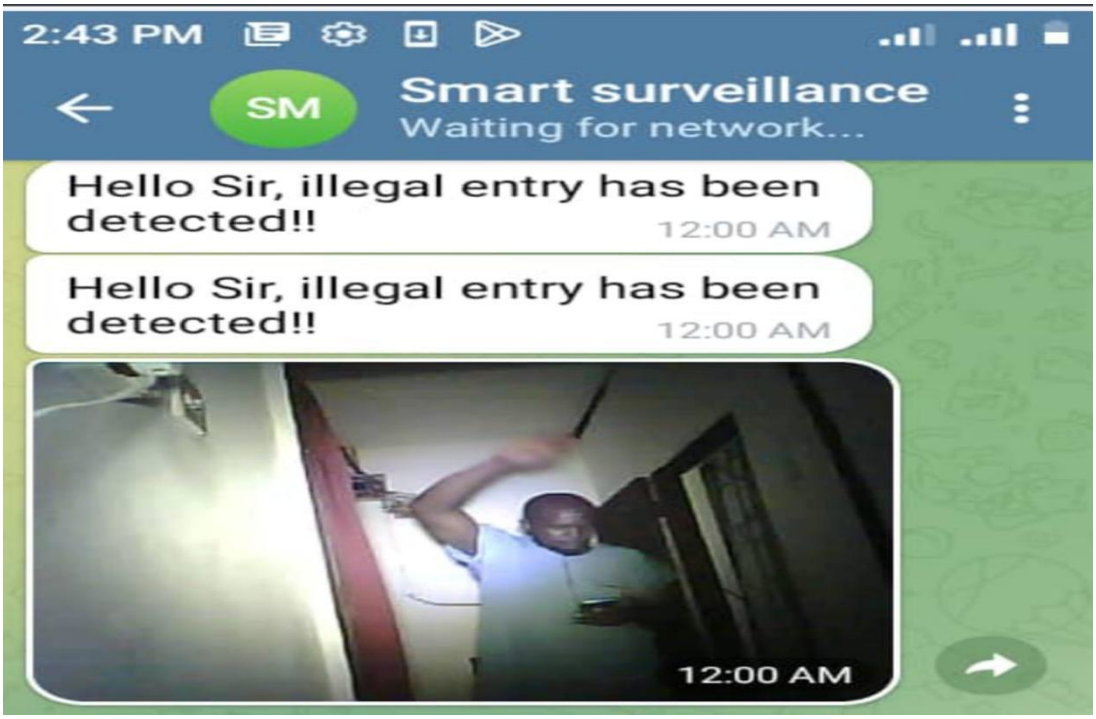

Figure 6. Takes a new picture and sends it to your Telegram account

It was observed that once an authorized entry was detected, the information was relayed to the user almost immediately. This was the case in the six locations that were tested for the smart security and its efficiency in the day was determined. The result displayed shows a good quality display of the photos taken in real time. However, the reverse was the case when we try to initiate the unauthorized entry into the key areas of the institution at night. The result showed a poor quality feedback of the photos taken. This aspect was later corrected by introducing the light-on command when conditions are not favorable to get good quality photos in real time. Several tests were conducted and result displayed showed prompt response in terms of the light on command and the quality feedback of the photos taken in real time at the various spot was very clear due to the light on command introduced to the system.

5. CHALLENGES AND FUTURE WORK

The challenges encountered in the course of the project work were poor internet connectivity across the campus premises. Furthermore, there were issues that arose from the delay in feedback photo from the point of camera to the bot telegram in a remote location as a result of poor internet connectivity.

6. CONCLUSION AND RECOMMENDATION

The study developed and validated a smart security and safety framework for the NICTM's campus and it relevance was shown in the system since the campus is situated in the outskirt of the Amedokhian town with bushes on both side of the campus. Hence, it development is a critical asset to the security outfit of the campus. Basically, it is recommended in future work that the camera should be design in such a way that is not clearly visible to the would be offender or intruder. It should be such a way that nobody will suspects or anticipate that there is a camera placed in that location. Finally, we intend to expand the current project by providing a big data base for video recording of the sessions and uploading the information collected to crowd directing.

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Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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