

## Crime Mapping System for Papua New Guinea University of Technology Campus, Lae

<sup>1</sup> Camilla Yanabis, <sup>2</sup> Lewi Kari, <sup>3</sup> Alois Napitalai

Department of Surveying and Land Studies, The Papua New Guinea University of Technology,  
Lae, Papua New Guinea

<sup>1</sup>camilla.yanabis@pnguot.ac.pg, <sup>2</sup>lewi.kari@pnguot.ac.pg, <sup>3</sup>alois.napitalai@pnguot.ac.pg

Received: 26 October 2021 | Accepted: 08 January, 2022

### Abstract

*Technological advancement has seen a dramatic surge in web mapping applications especially crime mapping applications. These online crime mapping applications are important, useful, and cheaper means of collecting with people and analyzing crime data to assist in curbing crime occurrences. The developed countries had recognized the usefulness and importance of crime mapping applications and are now collecting and displaying crime data online using crime mapping applications. The aim of this study is to develop an interactive crime mapping application for Papua New Guinea University of Technology Campus residents to display, view and report crime occurrences on an online web application using their smartphones, desktop computers or laptops.*

**Keywords:** *Crime, Crime Mapping, Interactive Crime Mapping, Online Application, Papua New Guinea University of Technology*

### 1. Introduction

The evolution of Web GIS and Web Based Mapping application has created new channels for users to create and contribute to viewing spatial data online. Viewers are now not only able to view but can also contribute their own new data or edit existing data. Interactive maps, on the other hand, are powerful maps that allow a user to interact with the map. This can mean selecting different map data layers to view or zoom into a particular part of the map that is of interest to the user. This is possible while the user interacts with the web page and a map image is repeatedly updated (Mitchell, 2005). The adoption of Interactive Web Mapping could yield beneficial result in the field of Crime Mapping. A well-developed online crime application has the potential to increase user contributed data and can also be helpful in keeping the community well aware of crime activities in their surrounding by disseminating helpful crime information back to them (Cotter, 2013), a recent study found that the average person's thoughts on crime activity were "heavily influenced by media depictions, demographic qualities, and personal experience" (Witzell, 2017).

Interactive web-based crime mapping was recently developed and adapted by developed countries to assist them in capturing and analyzing crime data also known as *ePolicing* or *electronic policing*. For instance, the Chicago Police Crime Portal ([data.cityofchicago.org/Public-Safety/Crimes-Map](http://data.cityofchicago.org/Public-Safety/Crimes-Map)), Queensland Police Service Online Crime

Map (<https://qps-ocm.s3-ap-southeast-2.amazonaws.com>), and the London Police (UK) online crime map (<https://www.police.uk/city-of-london/cp/crime/>). Crime analysis is advanced with those automated crime maps where Police can identify crime hotspots, monitor crime impacts, and aid in decision making and resource allocation (Akpan, 2018) /

Crime or an offence is an unlawful act harmful to a person as an individual, to a society or to a nation as a whole and is punishable by law (Martin, 2003). A criminal offence is defined by the criminal law of each country, which the government (state) sets up. If one committed an offence that breaches a law, that person may be guilty of a crime and prosecuted in court. There are many diverse types of crime, but crimes may be divided into four main categories (Shoener, 2016). A personal crime is a crime committed against a person who offends them either physically or psychologically. Examples of Personal crimes are assault, battery, homicide (murder, manslaughter, and vehicular homicide), rape, sexual assault, kidnapping and false imprisonment). Property crimes are offences committed against property.

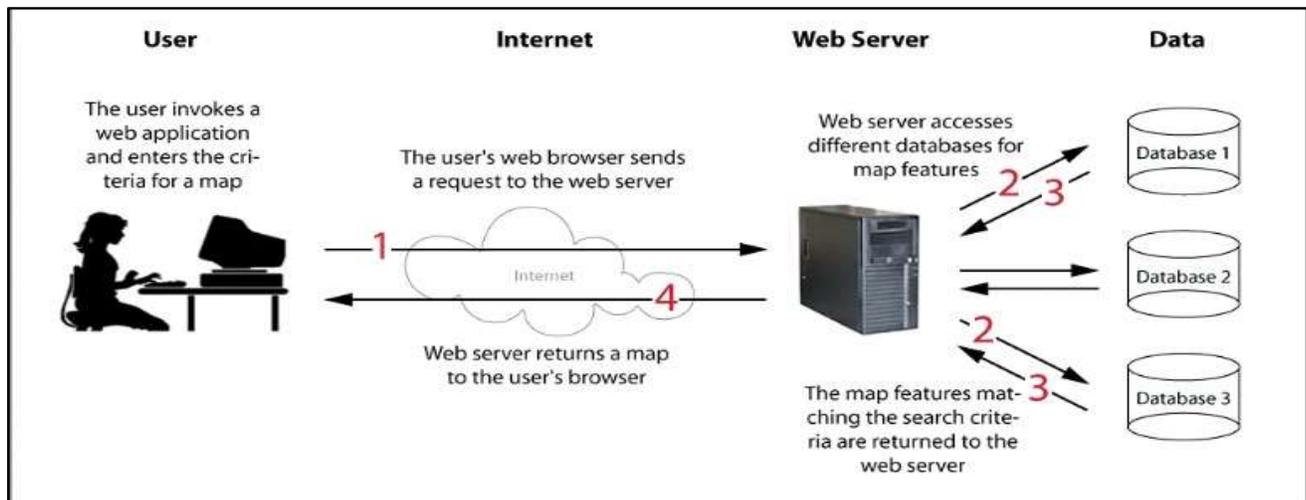
Ownership of a property is a person's right. Interfering or preventing someone from enjoying their property is a crime. Examples are theft, robbery (theft by force), burglary, arson, embezzlement, forgery, false pretenses, fraud, etc. Inchoate crimes are crimes committed to fulfill other crimes. These required a person to take substantive steps to complete a crime and not just by 'intent.' Examples are solicitation, conspiracy, bribery, etc. Statutory crimes, as it sounds, are crimes committed against the government as well as the laws passed by its legislative body (Shoener, 2016). Insider trading, statutory rape, drug trafficking, and drunk driving by people, are classified as statutory crimes.

Crimes may be further classified according to their level of severity (ISFMA, 2018). Infractions are referred to as petty offences that are often committed on the university campus, breaching of university administrations' regulations. Examples are cheating in examinations by students, illegal harboring of non-campus residents, driving without university or statutory permits, etc. Misdemeanors are more serious compared with infractions. They are punishable by incarceration at a local county jail or through fines. Deception, theft, stalking, gross indecency, and aggravated assaults are common criminal offenses in this category. Felony is the most severe criminal offense. Felonies include arson, rape, robbery, terrorism, treason, and kidnapping. These types of crimes are always referred to as criminal cases and are reported directly to the police. Offenders are usually arrested and handed over to the police regardless of whether they be staffs or students.

'Crime mapping is the process of using a geographic information system to conduct spatial analysis of crime problems and other police-related issues' (Boba, 2007). It is a subsidiary of crime analysis and performs three functions: displays visual and statistical analysis of geography relating to crime, allows link to other geographic data sources and provides maps to communicate crime analysis results. Some crime mapping techniques as described by Williamson & Goldsmith (1997) and used previously are overlaying crime data on census data, geocoding and heads up digitizing. Advances in technology have now simplified the processes and techniques in crime mapping and studies show that many Police forces in the developed countries are relying on computerized and online crime mapping to assist them to analyze crime (Bowers & Johnson, 2014).

According to the Environmental Research Institute (ESRI, 2007), an interactive map 'is a map in digital form that allows one to manipulate the map display and query the map to get the information needed using a set of tools provided with the map. Interactive maps are created using GIS software, and then distributed to users, usually over a computer network.' An interactive

map does not contain the data associated with the map, but points to the data stored elsewhere, such as on the user's local computer, on a server on a local network, or on a server on the Internet. That allows the underlying data to be updated independently of the map, so the map is always current. Since the user can display the map in diverse ways and can query the map for various kinds of information, a single interactive map can communicate the same information that would otherwise require several static maps. Figure 1 shows a general diagram of an Interactive web mapping application. A user sends a request of the map through the Internet to the map server; the web server retrieves the data from the database and passes it back to the user. An example of a static online crime mapping application is the crime mapping system of Namibia showing crime occurrences and a tool that was used by Namibia Police to predict crime occurrences (Mukumbira, 2012). Also, in a paper titled 'Web GIS tools for Crime Mapping in Toronto,' Lockyer (2013) developed two interactive online mapping applications for Toronto Police and the public to publish crime data through the web for their citizens to view and anonymously report incidences of crime and graffiti gang activities in their neighborhood. The Crime Portal allows a citizen to access the application on their phones, tablets, and PDAs through a URL and make a report anonymously.



**Figure 1:** General Interactive Web Mapping Structure (Source: Duggan, 2015)

About five years ago, the Papua New Guinea University of Technology Campus was a victim of students' unrest and violence. Several buildings were burnt down, a student was murdered, and others suffered injuries (Kisselpar, 2016). Spread of crime on the campus ranges from moderate crimes including theft, disorderly conduct, drug abuse, illegal gambling, vandalism, alcohol consumption disorder and harassment. Serious crimes include fighting, domestic violence, sexual/physical assault, murder/attempted murder, kidnapping and burglary. Igo (2017) identified several types of most occurring crimes (Figure 2) on the campus by interviewing selected participants from students, staff and dependents. Recent PNG Unitech crime statistics (Nomenda, 2019) also supported her research showing that, crimes such as drunken disorder, domestic violence, theft, physical assault, and burglary (break and enter, hold ups, etc.) were seen as the most committed crimes (Figure 3). Frequency of crime occurrences ranged from 20-25 occurrences per month, and they increase during the annual peak periods (Christmas, New Year & Special Holidays)

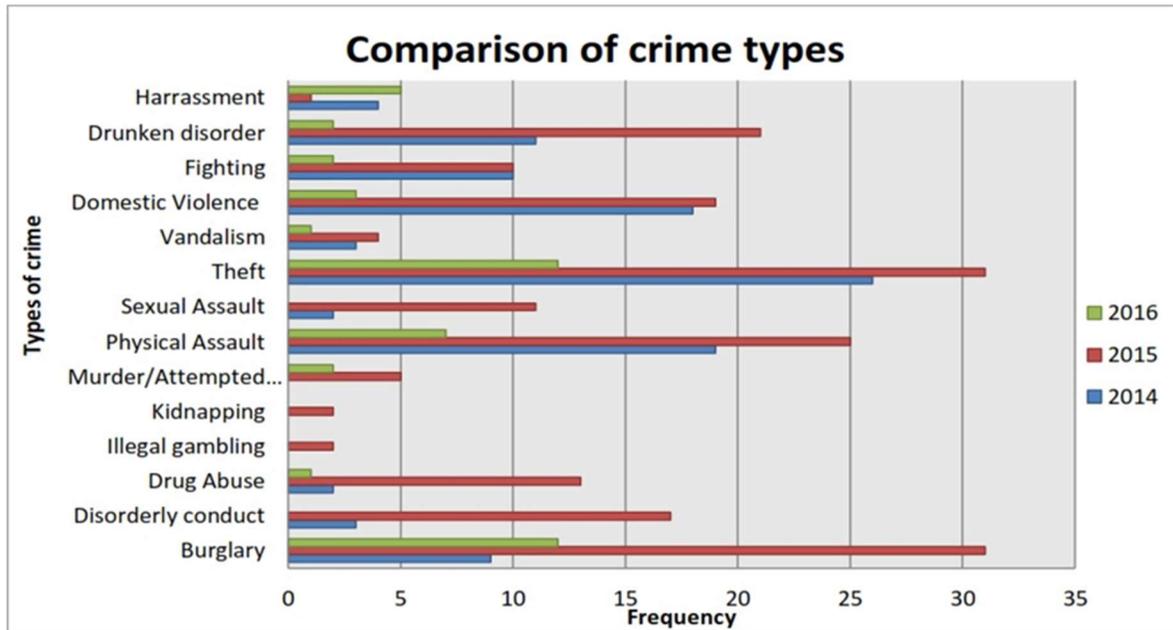


Figure 2: Crime Types on Unitech Campus from 2014-2016 (Source: Igo, 2018)

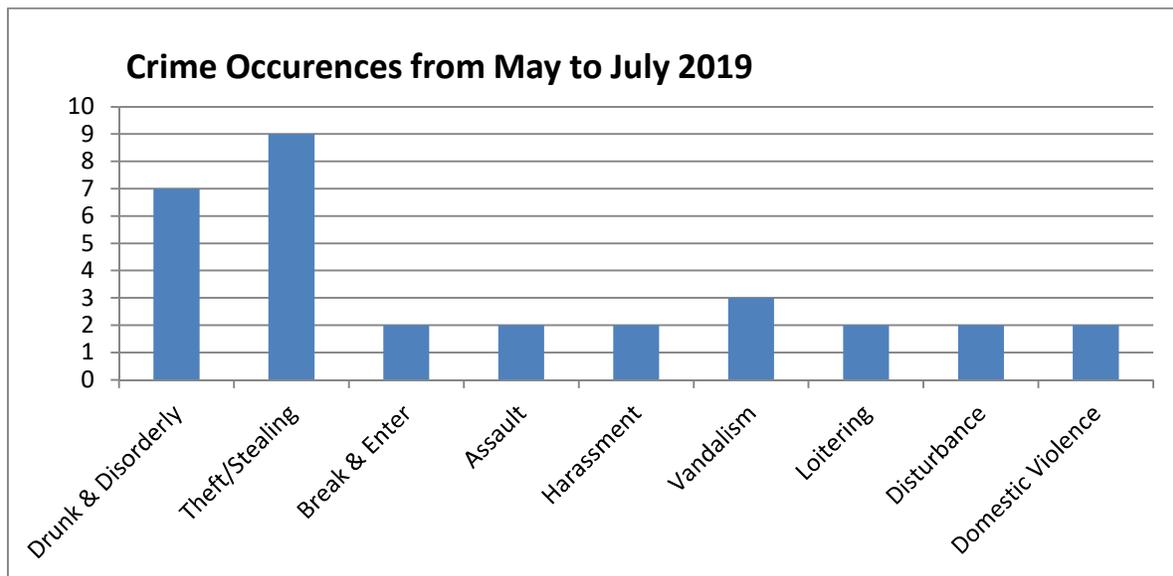


Figure 3: Crime Type’s Frequency for a 3-month Period (Source: Nomenda, 2019)

On the Unitech campus, the reports are just records compiled by whoever the security officer is at the time of crime occurrence. For example, in one instance one officer might record a particular crime as stealing, and another might record the same type of crime as theft. Also, the records did not always specify which officer reported it or who recorded it. Mostly it was just a general description of the crime/offence itself. During a verbal discussion with the campus Chief Security Officer, it was found out that “the category from the Police is not a standard crime

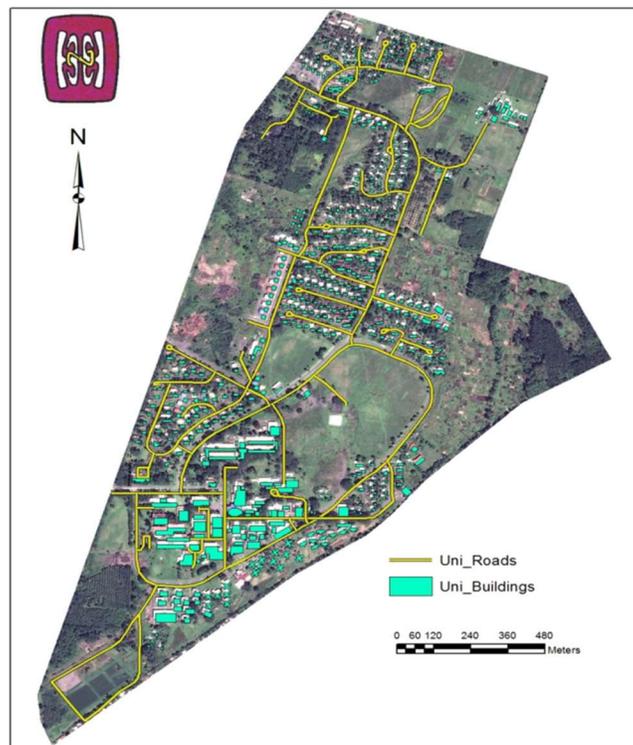
recording format and does not really capture all the crime occurrences and they were trying to develop a standard category that could encompass all crime occurrences on the campus.”

The Royal Papua New Guinea Police Constabulary does not have any established database for storing/recording crime data. Also, there is no standard or specific category that crime or offences may be captured under. All reports are structured anyhow by the officer who recorded the crime. Former PNG Police Commissioner (2015-2019) Gary Baki reportedly admitted that “current data on crime and arrest trends in the Royal Papua New Guinea Constabulary (RPNGC) has been suffering from under reporting” (The Post Courier, 2019). He further added that the ‘constabulary is still trying to develop a reporting system to properly capture crime data’ and blamed ‘limited training facilities’ and ‘lack of funding’ as the main factors causing crime under reporting.’

## 2. Materials and methodology

### 2.1 Study area

PNG University of Technology campus is in Taraka, a suburb on the outskirts of Lae City, Capital of Morobe Province in Papua New Guinea (Figure 4). The campus site covers approximately 226 hectares of land, is home to a rainforest habitat, agriculture plantations and farms, thirteen academic departments, students’ facilities and services, grounds and estates services that look after campus cleanliness, Information and Communications Technology services which provide Wi-Fi and Internet services for staff and students, students’ dormitories, and staff houses. Residents living on the campus are mainly: i) Staff & Dependents and ii) Students.

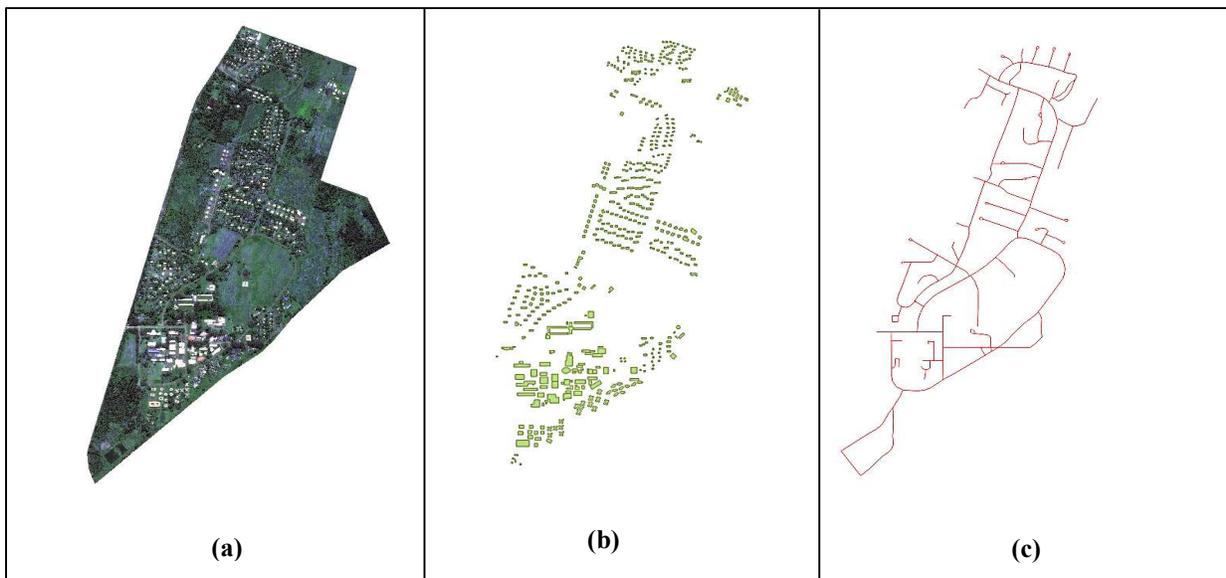


**Figure 4:** PNG University of Technology Campus

Staff are mostly Expatriates and Nationals. Expatriate staff make up a third of the staff population and they hold academic positions (Professors, Associate Professors, & Lecturers). Campus security outfit is managed by the Chief Security Officer, his assistant, senior patrol men who patrol the campus on foot and in vehicles, and static guards who man specific areas within the campus. The Security team has approximately one hundred security personnel at the moment that are divided into four shifts in an eight-hour rotation. That means approximately twenty-five personnel per shift to guard and patrol the whole campus. Currently they only have two vehicles which they use for patrol. They have a landline and a mobile number which one can call to report any crimes. All the calls go through to the main campus security office, which the officer on duty records and calls for patrol guards stationed near the location of an incident for help using their hand-held radio.

## 2.2 Background Data

Two layers (Uni\_roads & Uni\_buildings) were digitized recently from a satellite Image of the campus under the projection Lat/Long WGS84. Google Maps were used to provide the background to the application. The layers are indicated in Figure 5.



**Figure 5:** a) Google earth image, b) digitized buildings layer and c) digitized road layer

## 2.3 Crime Data

The Campus Security Team usually provides crime data. The reports of crime occurrences on the campus are then recorded into an observation book (OB) whenever it is reported. The data collected and used in this study were collected between January 2018 and June 2019. Out of all the records collected, not all are classified as crimes. Some are complaints, negligence or accidents/incidences. Examples are building door left open after office hours, speeding vehicle, tree branch felling, etc. Of the crime occurrences recorded, only 100 incidents were chosen to

form the sample used in this application. They are recorded and assigned the attributes as shown in Table 1 below.

**Table 1:** Crime Attributes on Unitech Campus (2018 – 2019)

Crime Attribute	Description
Crime ID	A unique number given to each crime reported
Crime Type	Type of Crime
Crime Category	Category of crime (Personal, Property, Inchoate, etc.)
Crime Severity	How serious the crime is (Infractions, Misdemeanor, Felony)
Location	The street and/or building where the crime occurred in
Date	The date the crime occurred
Time	The time the crime occurred
Action taken	If the crime was resolved by Campus Security

*Source: Authors 2019*

After organizing the crime records into the table, the records were geocoded in MapInfo and ArcGIS to create crime points. The points were then converted to GeoJSON format and uploaded onto PostgreSQL/PostGIS database.

## 2.4 Database

Post GIS extension of PostgreSQL enables spatial data to be stored in the database. The data type that PostgreSQL supports is usually shapefile. The two methods used to upload data onto PostgreSQL are using the Ubuntu Terminal: shp2pgsql-which loads ESRI shapefile into SQL and loads them into Post GIS database or using Import options on PgAdmin interface. The three files Uni\_roads, Uni\_buildings and crime points are connected through the topology layer which defines their geometry and the spatial ref\_system layer, which is the layer that identifies the projection system, which they are projected under as Lat/Long WGS 84 (EPSG 4326). Figure 6 is the schema of the datasets in PostgreSQL/PostGIS database.

## 2.5 The Application Architecture

Different free and open-source software (FOSS) and operating systems are integrated to develop the application. A Restful Web Architecture is the architectural style used to develop the application. Figure 7 shows the various components of the application, how they are connected and interact with each other. On the client side, users using any device, laptop, computer or mobile will access the application on any browser by entering the application link on the URL. This will invoke the mapping library Leaflet to render maps, display and allow user to interact with the data on the application interface. On the server side, the Restful API is created using Node.js, an open-source, cross-platform, runtime environment that allows developers to create all kinds of server-side tools and applications in JavaScript. Express.js is a web application framework for Node.js and acts a server at the backend of the application.

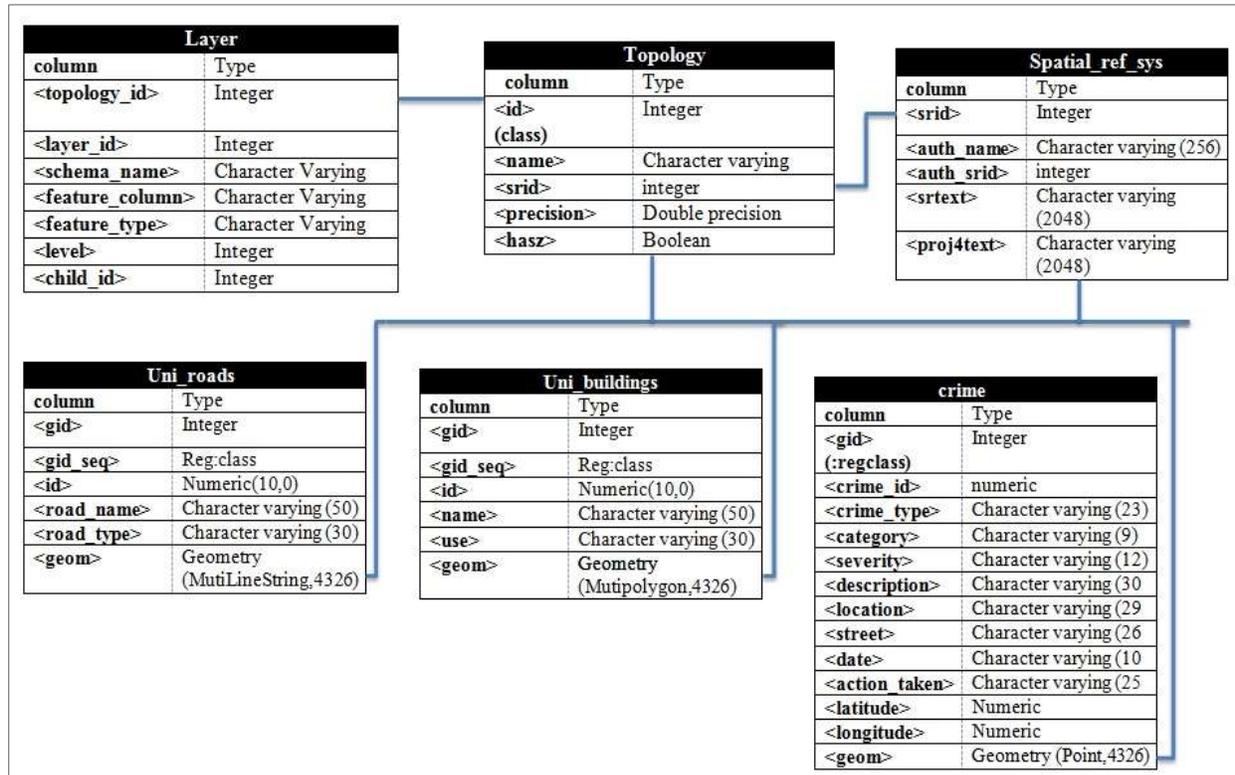


Figure 6: Database Schema of the Datasets in Post GIS

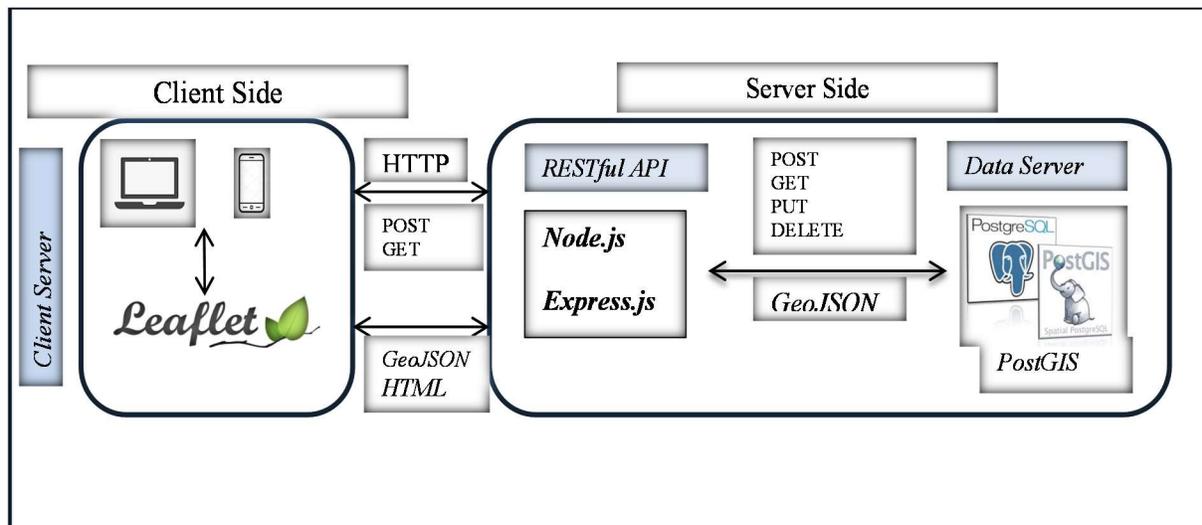


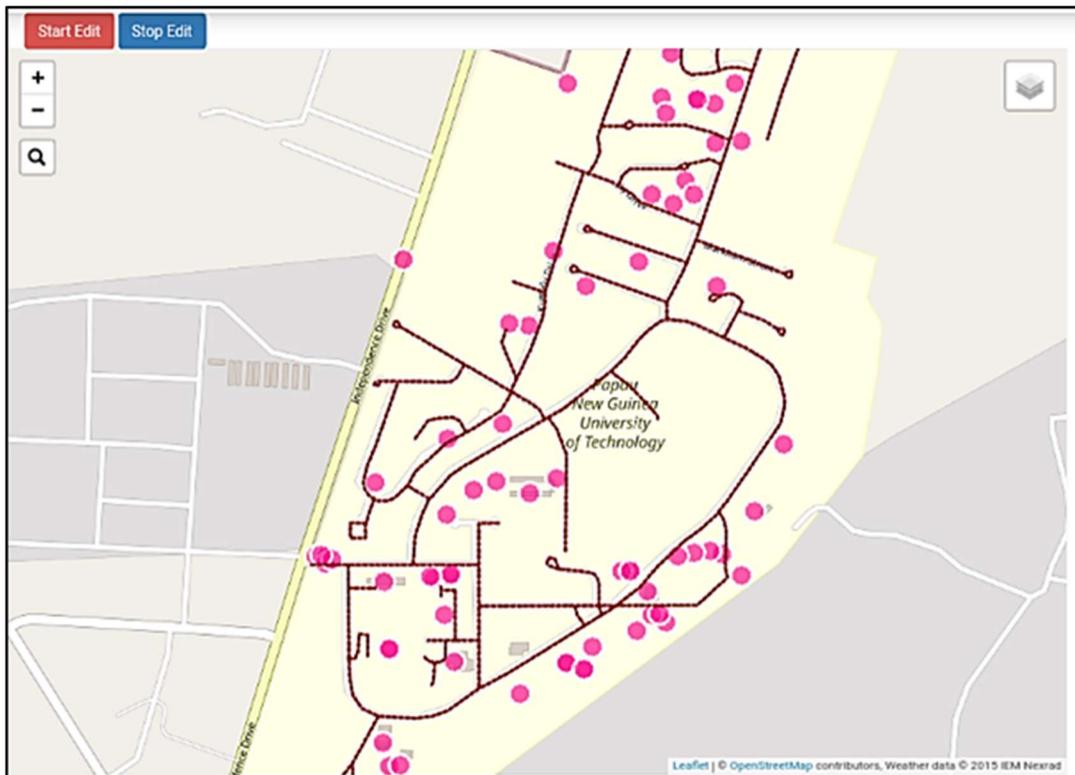
Figure 7: The Unicrime Application Architecture

An Express App (Express.js) is created as a server that has access route to the endpoints, GET (to view the data), PUT (to create a new resource) or DELETE (delete the resource). It listens to HTTP request from clients, defines a routing table which performs the different actions based on HTTP Method and URL and allows it to dynamically render HTML Pages. Routing

refers to determining how an application responds to a client request to a particular endpoint, which is a URI (or path) and a specific HTTP request method (GET, POST). To allow GET, POST, PUT, and DELETE operations on the API which will run the corresponding database commands, a route for the shapefiles endpoint (database) is set up with a function to correspond to query. Now since the data sets stored in the database are in shapefiles format, they are converted to GeoJSON format by the API Service Handler in order to be displayed on Leaflet.

### 3. Results and discussion

The Unicrime Application Interface in Figure 8 was tested under the Surveying Department domain and run on the Local Area Network of the campus. The user interface for this application is designed in such a way that a user can be able to toggle between satellite imagery and the actual campus map on the interface, perform zooming, panning, and be able to see building and street names. Maps of the campus were generated to allow the user to select features such as buildings on the interface. The crime points are displayed as pink points (Figures 8, 9 and 10). The other cartographic animations applied on this application are 'click on' and 'mouse over.' When the points are 'clicked over,' the crime description (crime type) will appear (Figure 9). The application interface shows the crime points overlaid on the campus map. The interface also allows zoom options, search by crime type and different background image options provided by Google Maps (Figures 9 and 10).



**Figure 8:** The Unicrime application interface



**Figure 9:** Crime Points on Campus (left) and Crime Description when point is ‘moused over’ (right)



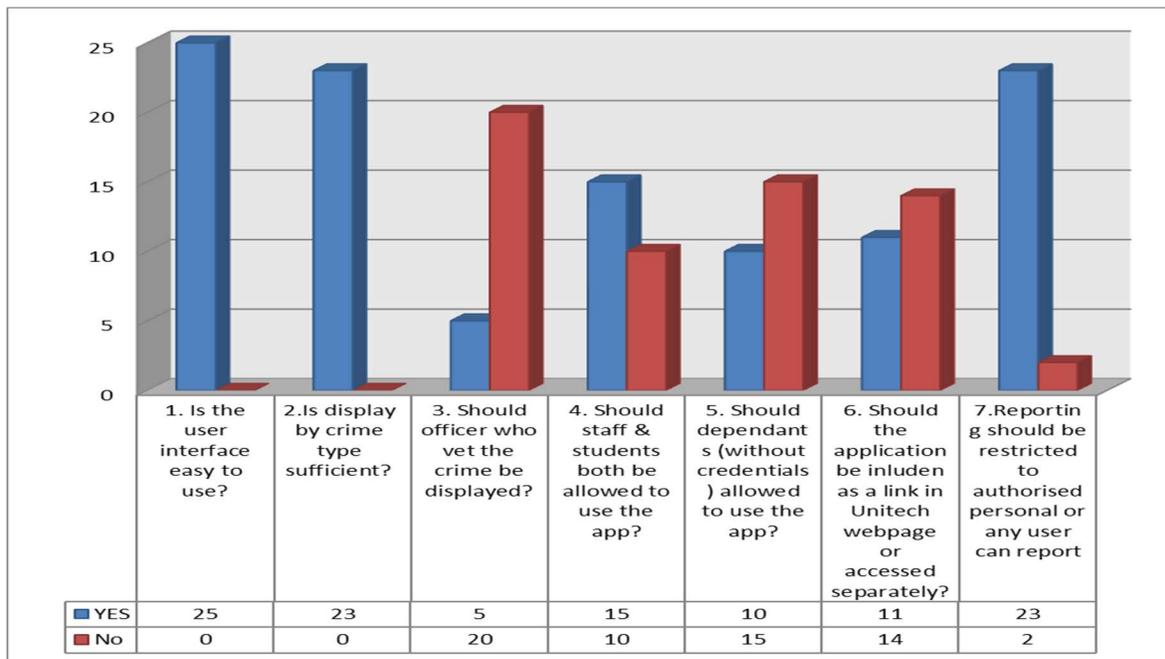
**Figure 10:** Road layer (left) & building layer highlighted, and description given when clicked (right)

The building layer (Figure 9) is made transparent so it will not clutter the interface of the application; however, when a building is selected on the image, or ‘moused over,’ the attribute (building name) will pop up (Figure 10). The road layer is visible now when a stretch of road is selected or ‘moused over,’ the road name/street name will pop-up and the stretch of road highlighted (Figure 10).

A lot of time and effort during this study was spent on the actual development of the application. Due to unavailability of software, limited skills in programming language, the focus was on researching and developing techniques for creating the application based on FOSS. The application is a prototype at this stage and is not yet fully developed. There are still potential of improving the interface and database that are yet to be discovered. There are some issues encountered during the development stage of the application especially after collection of crime data. When resolved, application can then be fully developed to achieve its full potential. The

issues were crime reports on the campus, and they are sensitive and carefully scrutinized by University Management to preempt unnecessary reporting.

The University management keeps records of all crime reports especially when a staff is concerned. Some crimes committed by staff are very sensitive, which the management likes to keep private. Reporting such crimes on the application interface means it will be displayed for all users to view and may cause inconvenience to the staff and the University as well. Also, staff or students with malicious intent might use the application as a tool to defame or tarnish another person’s reputation through unnecessary reporting. The other issue is the data displayed on the interface is the ‘crime type’ attributes which is a general description of the offence or crime itself. It is not a standard category of crime. The crime data can also be displayed using its other attributes: crime description, crime severity, or crime category. It can also display two or three attributes at the same time. More attributes can also be added to the crime data. For example, the name of the officer who vetted the crime report, the month and the year the crime occurred. A questionnaire was circulated to get users’ feedback on the application after it was tested. The results are shown in the bar chart graph in Figure 11.



**Figure 11: Users’ feedback on the application**

The application can also be utilized as an instrument for crime data capture. Other crime attributes such as the date the crime occurred, the time it occurred, the month and year it occurred can be added in the database and the interface for reporting as well. Based on this crime statistics data, filtering and querying options can also be added on the interface to allow filtering of crime occurrences according to the date, month or year it occurred. Graphs and hotspots can also be displayed on the application. Other crime statistics like the age group and ethnicity of the offender may also be added and recorded in the database, which will be very helpful to law enforcement officers in the country. The application can also be utilised to capture evidence of a crime. Interface and database can also be configured to capture media like pictures, videos, and voice recordings.

#### 4. Conclusion and recommendations

Although online crime mapping applications are utilized fully by developed countries, Papua New Guinea is yet to develop a proper Crime database for the Police Force and to develop such application to be accessed by the public. Developing an application like this is a breakthrough for the country and that application has immense potential in assisting the Police as well as other security agencies. Applications of GIS in web mapping are under-researched in the country. Yet this study found that a combination of crime mapping and interactive web mapping developed from Free and Open-Source software has the potential of creating an application that can assist the campus security, keep the community aware of crime occurrences, and can also be used as a tool for crime data collection. The focus of this study was to create the application based on FOSS and how crime data is processed and displayed on the application. The function of the application and its potential are yet to be researched and fully developed. A fully functional crime mapping application is going to assist the Police, securities, communities and other stakeholders. Even though the application is developed, a lot of effort and time was spent on researching the FOSS, their codes and converting the data to the required format to display on the application.

Having regard to the above, several recommendations have been identified to assist in addressing some issues that arose during the research. Due to funding issues facing Papua Guinea, buying vendor-based GIS software from overseas dealers to create such applications is expensive. Only mining companies, private firms and some government organizations can afford it. Therefore, universities in the country must encourage research into FOSS and how it can be utilized to develop such an application for crime management or other purposes. Web mapping is a field that is under-studied and under-researched in relation to GIS field of study. It has enormous potential not only in crime prevention but also in mapping other themes and features, which can be used as a tool in most firms and organizations to assist in decision making. A GIS expert does not solely create such applications. To create such applications, a good background knowledge of programming is essential and required. Universities teaching GIS in the country must introduce programming to the students at an early stage during their course so that they can utilize that skill in developing projects instead of relying solely on vendor-based software. Once the potential of this application is recognized, it must be applied at a bigger scale involving the Police and security firms in an urban or metropolitan area, e.g., Lae City and Port Moresby in PNG. When the application becomes fully functional, stakeholders (Security Personnel) must be trained to fully utilize the application and use it to capture crime data. They must be trained in how to collect and record crime data consistently and accurately to enhance system sustainability.

#### References

1. Akpan, A., (2018), Crime Mapping Solution. International Journal of Computing and Technology. Volume 5, Issue 9, September 2018. 2348-6090
2. Boba, R., (2007), Crime Analysis and Crime Mapping. Sage Publications; 1 edition (July 8, 2005) Arizona, USA.
3. Bowers, K.J., Johnson, S.D., (2014), Crime mapping as a tool for security and crime prevention. In: Gill M (ed) The handbook of security, 2nd edn. Palgrave, New York, pp 566–587

4. Categories of Crime under criminal Law., (2018), *ISFMA*. Retrieved From: <https://www.isfma.com/law-and-order/categories-of-crime-under-criminal-law>
5. Creating Interactive Maps., (2007), *ESRI Press Release*. August 15<sup>th</sup>, 2007. Viewed on March 13, 2018. Retrieved from: <http://webhelp.esri.com/arcgisdesktop/9.2/body.cfm?tocVisible=1&ID=422&TopicName=creating%20interactive%20maps>
6. Crime and Arrest Trend under reported., (2019), *The Post courier*. March 12, 2019. Viewed on: Monday 4<sup>th</sup> November 2019. <https://postcourier.com.pg/crime-arrest-trend-reported/>
7. Igo, C., (2017), Application of GIS and Remote Sensing Technology to Identify Crime Hotspot & using Crime Prevention through Environmental Design: A Study of the Papua New Guinea University of Technology, Lae. *PNG University of Technology*, Nov. 2017.
8. Kisselpar, J., (2016), Student killed, buildings torched at PNG University of Technology, Lae. *Australian Broadcasting Corporation*. Posted 26<sup>th</sup> June 2016. Viewed 12 November 2017.
9. Lockyer Cotter, J., (2013), 'Web GIS Tools for Crime Mapping in Toronto'. Waterloo, Ontario, Canada.
10. Martin, E., (2003), 'Crime'. Oxford Dictionary of Law (7 Ed.). Oxford: Oxford University Press. ISBN 0198607563.
11. Mitchell, T., (2005), *Web Mapping Illustrated*. Sebastopol, CA, USA: O'Reilly & Associates Inc
12. Mukumbira, S., (2012), 'Development of a crime mapping, analysis and prediction tools for Windhoek'. Polytechnic of Namibia, November 2012.
13. Shoener, N., (2016), 'What are the different types of Crimes?' *Legal Match*, 2018-06-26 04:24:41. Retrieved from: <https://www.legalmatch.com/law-library/article/what-are-the-different-types-of-crimes.html>
14. Williamson & Goldsmith, V., (1997), 'An Example from the City University of New York (CUNY) -Solving the Problems of Overlaying NYPD Crime Data with New York Police Department (NYPD)
15. Witzell, K., (2017), How Crime Mapping Is Making Communities Safer. Retrieved from: <https://www.madhattertech.ca/chatter/how-crime-mapping-making-communities-safer>

### Author Biographies

**Camilla Yanabis** is a Principal Technical Officer in the Department of Surveying & Land Studies at the Papua New Guinea University of Technology and has a Master of Philosophy degree in Geomatics from the same University.

**Lewi Kari** is a Lecturer and Deputy Head of the Department of Surveying & Lands Studies at the PNG University of Technology, Lae, Morobe Province. He graduated with a Degree in Cartography from the Papua New Guinea University of Technology and has a Master's Degree in Spatial Science and Technology from the University of Southern Queensland, Australia.

**Alois Napitalai** is a Senior Technical Officer in the Department of Surveying & Land Studies at the Papua New Guinea University of Technology. He graduated from the Papua New Guinea University of Technology in 2004 with a Diploma in Electrical Engineering, majoring in communications.