ISSN 2278-3091
Volume 9, No.1.2, 2020
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse3391.22020.pdf
https://doi.org/10.30534/ijatcse/2020/3391.22020

Analysis and System Architecture Design for Road Traffic Incidents

Maria Charmy A. Arispe[1], Rosemarie T. Bigueras[2], Jocelyn O. Torio[3], Daniel E. Maligat, Jr.[4]
[1]Bicol University Polangui Campus, Polangui, Albay, Philippines, cham.arispe@gmail.com
[2]Camarines Norte State College, Daet, Camarines Norte, Philippines, rosemariebigueras@gmail.com
[3] Camarines Norte State College, Daet, Camarines Norte, Philippines, jocelynt77@gmail.com
[4] Camarines Norte State College, Daet, Camarines Norte, Philippines, dmj234@gmail.com

ABSTRACT
This study determines and analyze the traffic accident profile of Legazpi City under reckless imprudence resulting to homicide, reckless imprudence resulting to physical injury, and reckless imprudence resulting to damage to property. Thus, system architecture design was developed with activity diagrams to propose an emergency response system to improve the communication and coordination process of emergency response units and to increase community awareness of the factors leading to traffic incidents. It integrates the applications of spatial analysis to specifically identify the area of the accident location and applicable to a user-friendly mobile application that can submit traffic accident data. The user may send a report of the incidents and send a notification of the location of the incident to the nearby response units. Further, the researchers used the Architecture Tradeoff Analysis Method (ATAM) to evaluate the proposed system architecture design for traffic incident emergency response system and obtained a total weighted mean of 4.07 which is interpreted as moderately potential.

Key words : emergency response, road incidents, system architecture, traffic incidents.

1. INTRODUCTION

Road traffic accidents are events that are unknown and unpredictable [1]. These accidents often result in people around the world being killed, injured or damaged [2]. It is a global tragedy with the ever-rising trend which distracts the normal trajectory of moving vehicles. It is very common in big cities as there are many modes of transport and roads are narrow and overcrowded. Almost every day, news about accidents was on the television, radio and internet. Most people continue to be negligent and ignore the danger involved in their driving and so, these accidents happen [3].

Similarly, the components required for an effective transport system cannot be underestimated, because the transportation industry is one of the largest growth areas for electronics and implanted computers [4]. Road traffic accidents are increasingly recognized as a growing major issue. They bring significant losses to society and the economy [5]. It is understandable that traffic congestions and accidents are now very popular and there are high risks for every road user. Efforts are needed to improve infrastructure and vehicles, conduct traffic enforcement and educational activities, prevent pre-occurrence accidents, and present the important role of medical emergency to save life after accident [6]. It has become a development issue of being a significant reason for fatalities, injuries and property damages. Emergency communication needs to be sustained, flexible, and clear. Decisions and communications need to be recorded. The emergency planner can help this process by ensuring that the technological means of communication are present and are robust in the face of potential failure, the protocols for sending messages are established, and the priorities for communication are known to participants [7].

With the incredible demographic explosion that have witnessed in the last few decades, management of transport is of paramount importance [8]. Technological development is important in traffic management system as it can provide benefits to the environment and society [9]. New systems need to be established, allowing different rescue units to work together in any critical situation. A well-defined centralized infrastructure for the discovery and information exchange is one of the main challenges. These systems are also closely linked to the implementation of Spatial Data Infrastructure (SDI) at all levels (local, regional, national and international) [10]. In addition, accident-prone locations using Geographic Information System (GIS) can be identified along with the road traffic and vehicle accidents by analyzing spatial characteristics about identified locations as well as the underlying factors that cause accidents [11]. Using GIS, the emergency response units can be picked and redirected at fixed locations for emergency response. There is more to GIS than just applications. Individuals and methods are combined with geospatial software and tools to enable spatial analysis, manage large datasets, and display map or graphical information. Once the location is known through GIS, the nearest emergency response units can be selected, routed and dispatched to an emergency [12].

In this context, the researchers identify the study's objectives based on the defined problems and user requirements: (1) to determine and analyze the profile of road traffic incidents; (2) to design a system architecture applicable for road traffic incidents mobile application emergency response system; and (3) to evaluate the potential rate of the proposed model that would enhance the communication and coordination process of emergency response units.

2. METHODOLOGY AND RELATED WORKS

The researchers used quantitative data analysis [13, 14] to determine and analyze the profile of traffic accidents in Albay province, particularly in Legazpi City. Figure 1 describes the study's conceptual paradigm in which the primary data sources were gathered from the Albay Provincial Police Office (Albay PPO). The interview method was conducted to obtain first-hand information and meet with the Albay PPO Police Superintendent and other Provincial Investigation Detective Management Branch (PIDMB) Officers. The researchers efficiently collected accurate and relevant data about traffic incidents. The profile of traffic incidents in Legazpi City was categorized under Reckless Imprudence Resulting to Homicide (RIR-Homicide); Reckless Imprudence Resulting to Physical Injury (RIR-PI); and Reckless Imprudence Resulting to Damage to Property (RIR-DP).

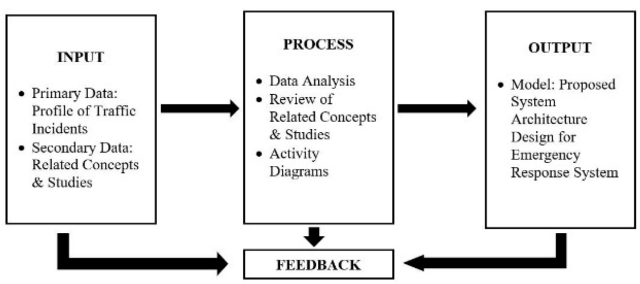

Figure 1: Conceptual Paradigm of the Study

The data collected was translated into the technical design to determine and analyze the user requirements and specification of the study's various features. Then, the researchers developed the system architecture design for the proposed emergency response system to enhance the communication and coordination process of emergency response units and increase community awareness of factors leading to road traffic and vehicle accidents. Activity diagrams were also created to enhance the PIDMB officers' response system ability, reduce the number of accidents and improve overall road safety.

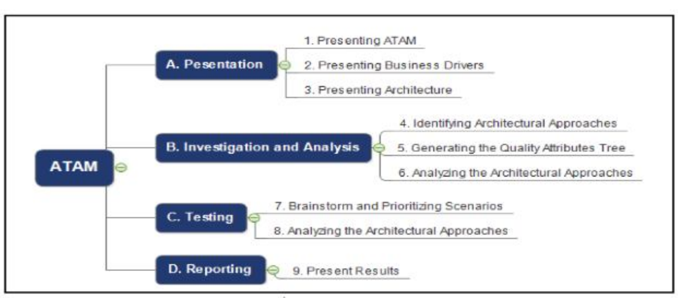

Figure 2: Architecture Tradeoff Analysis Method (ATAM)

Through analyzing the traffic incidents profile, this paper made several choices through prioritizing the system performance attributes needs by designing an emergency response system architecture model using the Architecture Tradeoff Analysis Method (ATAM) [15, 16] method, as shown in Figure 2 [17]. The researchers used ATAM because the approach is well known and its utility has already been demonstrated in other studies [18] helping to extend the knowledge of researchers in improving the system architecture design and using ATAM to evaluate the proposed traffic incident emergency response system.

Thus, the Healthcare Information System (HIS) used ATAM to validate the research. The paper shows the applicability and usefulness of HIS architectural assessment. The ATAM analysis showed the generation of utility tree quality attributes, priorities, scenarios, sensitivity points, risks involved and their benefits to the healthcare system. Evaluating the system showed the need migrate the database system from a hierarchical structure to relational one. The evaluation is implicitly useful for improving quality in the earlier stages of HIS development, which presupposes an indirect impact on patient care [19].

In addition, the method of architectural analysis approach based on the ATAM scenario was used to analyze the behavior exhibited of the DC system. By following the ATAM steps, they gain a better understanding of the alternatives to the architectural model, because their characteristics can be broken down into specific quality attributes that become targets and evaluated as risk/non-risk to architectural decision-making by stakeholders. It is also proved from the course taken that the method can be flexible to implement, that it can be applied early before any system development occurs [17].

3. RESULTS AND DISCUSSIONS

3.1 Process Flow of Emergency Response

In Legazpi City Police Station Central Office and Albay PPO, the recording of the raw information on road traffic incidents is still done manually. Collecting data on road traffic incidents in Legazpi City is the responsibility of the nearest Police Community Precint. The incidents recorded must be reported and submitted to Legazpi City Police Central Office and Albay PPO within 24 hours. It is recorded in accordance with the Standard Operating Procedure (SOP) No. 2012-001 of the Philippine National Police (PNP) [20, 21] where the road traffic reports and vehicle accidents are treated as an event or activity. The PNP maintains a handwritten document called the Police Blotter which documents all aspects of organizational and administrative operations using the basic report writing criteria.

A record entry in the police blotter is not to be made directly to the police blotter book with respect to incident reporting. In the Incident Record Form (IRF) [22] the details and data of a blotter entry must first be registered. In order to report incident reporting mechanisms, concerned citizens need to contact the local or cell phone numbers of the nearest police community precint within the area or other response units, such as hospital or fire station in order to address the incidents. The dissemination of information between police stations and external fields can be achieved by using cell phones to enable police officers to know where the various emergency incidents are currently located. Police officers investigate the incident on the road traffic and vehicle incidents scene, collect data and make a decision on the fault of the scene.

3.2 Profile of Traffic Incidents

The road traffic and vehicle accident profile illustrate the traffic incident condition over the past three (3) years. At present, vehicles traveling to Legazpi City in Albay province have grown dramatically compared to the past few years. In 2015, Albay PPO recorded 3,604 vehicle accident cases; 3,577 in 2016; 3,109 in 2017; 2,682 in 2018; and 634 accidents in January to March 2019. The highest number of road accidents recorded in Albay was between 7:00a.m. to 8:00a.m. and from 4:30p.m. to 7:00p.m., considered to be the day's rush hours. It was also noted that the Legazpi City area has the highest number of vehicle accidents recorded by Albay PPO. As shown in Figure 3, the number of road and vehicle accidents recorded in Legazpi City was 1,060 in 2014; 1,237 in 2015; 1,386 in 2016; 1,475 in 2017; and 1,522 in 2018.

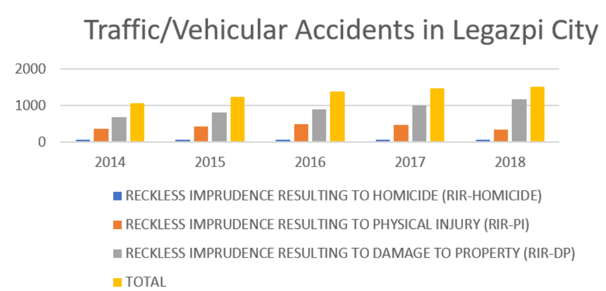

Figure 3: 2014-2018 Traffic Incidents in Legazpi City

With regard to the time delay in reporting traffic incidents, it was categorized under (a) less than five minutes; (b) five to 30 minutes; (c) 30 minutes to one hour; (d) one to five hours; and (e) five to 12 hours. RIR-Homicide records from 2016 to 2018 were slightly higher under one to five hours. In 2016, 4 out of 13 reports were received; in 2017, received 5 out of 11 reports; and in 2018, 5 out of 9 reports were received.

For RIR-PI, the road traffic and vehicle accidents emergency reports are constant and delay under five to 30 minutes interval. The data compiled in 2016 were 179 of 485, 154 of 467 in 2017 and 120 of 348 in 2018. The year 2016 to 2018 remains relatively constant for RIR-DP and is also delayed by five to 30 minutes. The reports collected in 2016 were 354 out of 888, 372 out of 997 in 2017, and 453 out of 1,165 in 2018. It only shows that it takes several minutes to report incidents before it is reported to police stations. It implies that the accidents reporting must be addressed immediately and should not be delayed on longer hours.

3.3. Proposed System Architecture

Figure 4 presents the proposed system architecture design of an emergency response system. The proposed system architecture design model is applicable to a user-friendly mobile application that can submit traffic accident data. The user or concerned community may send a report of the incidents and send a notification of the location of the incident to the nearby response unit or police precint station concerned. It would try to improve the ability of the response system so that the police and traffic officers reach the site easily. The various details provided in the proposed model would be useful in providing a database of accidental data, and the Geographic Information System (GIS) spatial analysis may be useful in making decisions and analyzing incidents where police stations can provide assistance for accident prevention. It would also limit the time needed to report an accident and more accurately determine its location.

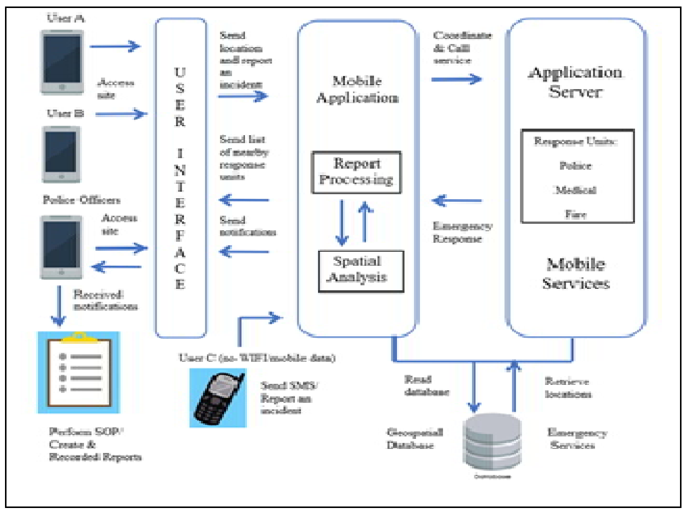

Figure 4: Proposed System Architecture Design

Also included was the activity diagram of the entities involved in the system to further understand the sequential workflow for each entity to complete the activity. These diagrams are the graphical representations of the functional operations that have been done. This also describes the parallel and conditional operations of the proposed emergency response system architecture. As shown in Figures 5, to report an incident after successful access, the user may report an incident, determine the location of the incident on the map and take photos of the incident. An additional feature to see the traffic condition in the accident was also included.

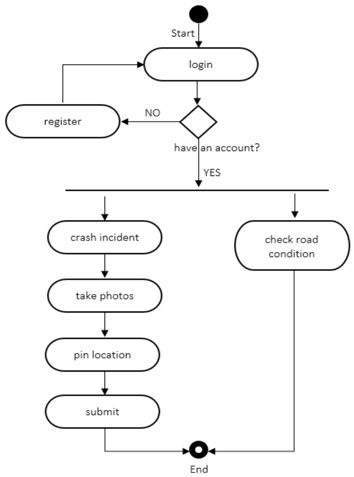

Figure 5: Activity Diagram for User (Community)

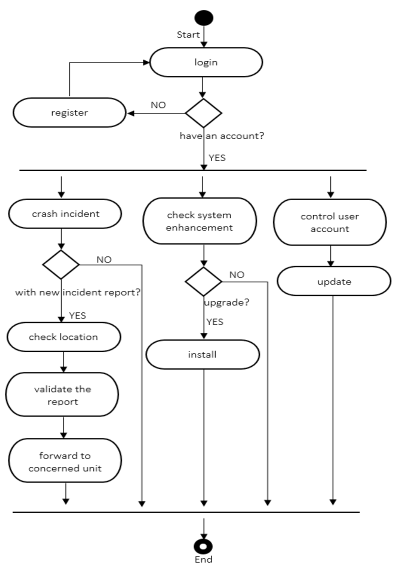

Figure 6: Activity Diagram for User (Albay PPO)

There are three main actions that might possibly be done by the personnel from the Albay PPO after successfully accessing the account as shown in Figure 6. Upon receiving report coming from the concerned community, the office would be alerted and the personnel in-charge should check and validate the report along with the photos and location submitted by the user and immediately forward to the respective unit/s that may have a concern with the incident. Aside from that, the personnel can check also if a system enhancement is available and install the upgrade as well as updating and controlling the access level of the users. Moreover, the response team consisting of police officers, medical staff and/or fire station personnel must have access to their respective accounts with the concerned community and Albay PPO. After accessing the account, the respective units will be able to check and return to the incident report that the Albay PPO has reviewed and verified for the incident reported. And finally, for proper documentation, submit the created report.

3.4 Evaluation of the Proposed Architecture

The evaluation was carried out through a plenary presentation using the Architecture Tradeoff Analysis Method (ATAM) to assess the potential level of the proposed system architecture design for emergency response. The evaluation is based on metrics five-point Likert scale of 4.51-5.00: highly potential; 3.51-4.50: moderately potential; 2.51-3.50: potential; 1.51-2.50: less potential; 1.50-Below: non-potential. The evaluation of ATAM for the proposed system architecture design of emergency response to traffic incidents was carried out shown in Table 1. A total weighted mean of 4.07 was obtained, which is interpreted as moderately potential.

Table 1: Evaluation of Proposed System Architecture Design using ATAM.

Group	Activities	Mean	Interpre-tation
(A) Presentation	Presenting ATAM. Presenting business drivers. Presenting architecture	3.50	Potential
(B) Investigation and Analysis	Identifying architectural approaches. Generating the quality attributes. Analyzing the architectural approaches	4.30	Moderately Potential
(C) Testing	Brainstorm and prioritizing scenarios. Analyzing the architectural approaches	4.40	Moderately Potential
(D) Reporting	Present Results	4.10	Moderately Potential
	Total Weighted Mean	4.07	Moderately Potential

ATAM has nine phases that are grouped into four categories [23], such as (A) Presentation, including tasks such as presenting ATAM, presenting business drivers and design presentations. The system architecture design of the proposed system was introduced and discussed with the selected evaluators, five (5) PIDMB officers, seven (7) Albay PPO personnel and eight (8) randomly selected members of the community. (B) Investigation and Analysis, includes tasks such as identification of architectural approaches, the generation of value attributes and the analysis of architectural approaches. The researchers present the design in this activity and discuss the advantages of using a mobile application with spatial analysis integration in emergency response. (C) Testing, activity involves the prioritization of scenarios and the analysis of architectural approaches. Evaluators mapped the possible emergency response scenarios in the proposed system architecture for this activity. In developing the emergency response system, they provide and mention emergency response situations that express their concerns. (D) Reporting, requires the findings presented. Positive questions were asked by the evaluators to assess whether the proposed model meets the requirements and their effect on other emergency response scenarios. Comments and feedback have been properly documented.

5. CONCLUSION

The data collected from Legazpi City Central Police Office and Albay PPO was classified under RIR-Homicide, RIR-PI and RIR-DP. In this regard, system architecture design was proposed to improve the communication and coordination process of emergency response units and to increase awareness on the factors leading to road traffic incidents in the community of Albay, particularly in Legazpi City. The proposed design has an integration of GIS spatial analysis and is applicable to mobile applications emergency response system. Activity diagrams were also used to determine the structure of the emergency response process and to further explain the systematic procedure for each individual to complete the task. It also aimed at enhancing the PIDMB officers' response system ability, reducing the number of incidents and improving overall road safety. Furthermore, evaluation of the proposed model was performed to assess its relevance and define the number of potential thresholds for the improvement of the study. It obtained or perceived as moderately potential 4.07 total weighted mean. Nonetheless, the traffic incident situation should be recognized as an urgent matter and action should to be taken to reduce the number of incidents and improve overall road safety.

ACKNOWLEDGMENT

The researchers would like to express their gratitude to Albay PPO's PIDMB Officers, particularly to Police Superintendent C, PIDMB Honesto A. Garon, who led on where to collect the tangible data needed for the study. They also provided the necessary inputs to help the researchers fully understand Albay's road traffic and vehicle accident profile, particularly in Legazpi City area. The researchers would also like to thank their Doctor in Information Technology (DIT) fellow colleagues for their input, cooperation and most importantly friendship.

REFERENCES

1. S. Kumar and D. Toshniwal. **A data mining framework to analyze road accident data**. *Journal of Big Data*, 26, 2015. Available Online at https://journalofbigdata.springeropen.com/articles/10.1186/s40537-015-0035-y
2. G. Shafabakhsh, A. Famili, and M. Bahadori. **GIS-based spatial analysis of urban traffic accidents: case study in Mashhad, Iran**. *Journal of Traffic and Transportation Engineering*, 4(3), 290-299, June 2017. doi:https://doi.org/10.1016/j.jtte.2017.05.005
3. W. S. Gayo, J. D. Urrutia, L. A. Bautista, and E. B. Baccay. **Mathematical modeling of road accidents in Metro Manila**. *UNP Research Journal*, Vol. XXIII, January – December 2014.
4. W. N. Hussein, L. M. Kamarudin, H. N. Hussain, M. R. Hamzah and K. J. Jadaa. **Technology elements that influence the implementation success for big data analytics and IoT-oriented transportation system**. *International Journal of Advanced Trends in Computer Science and Engineering*, Volume 8, No.5, September - October 2019. Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse74852019.pdf, https://doi.org/10.30534/ijatcse/2019/74852019
5. WHO. **World Health Organization, global status report on road safety: supporting a decade of action**. 2015. Available Online at https://www.who.int/news-room/fact-sheets/detail/road-safety-supporting-a-decade-of-action
6. S. Miller. **Traffic congestion: why it's increasing and how to reduce it**. July 7, 2015. Available Online at https://www.livablestreets.info/traffic_congestion_why_its_increasing_and_how_to_reduce_it
7. D. Alexander. **Disaster and emergency planning for preparedness**. *In Oxford Research Encyclopedia, Natural Hazard Science. USA: Oxford University Press USA. September, 2019.* doi:10.1093/acrefore/9780199389407.013.12
8. S. El Mendili, Y. El Bouzekri El Idrissi and N. Hmina. **Big data processing platform on intelligent transportation systems**. *International Journal of Advanced Trends in Computer Science and Engineering*, Volume 8, No.4, July – August 2019. Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse16842019.pdf, https://doi.org/10.30534/ijatcse/2019/16842019
9. A. D. M. Africa, F. X. Asuncion, J. L. Tiberio and R. M. F. A. Munchua. **Sensor-based traffic control network with neural network-based control system**. *International Journal of Advanced Trends in Computer Science and Engineering*, Volume 8, No.4, July – August 2019. Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse01842019.pdf, https://doi.org/10.30534/ijatcse/2019/01842019
10. H. Vardhan. **Spatial Data Infrastructure**. December 19, 2017. Available Online at https://www.geospatialworld.net/entity/spatial-data-infrastructure/
11. M. Keymanesh, H. Ziari, S. Roudini and A.N. Ahangar. **Identification and prioritization of black spots without using accident information, modelling and simulation in engineering**. doi:10.1155/2017/1832654,

Available Online at https://www.hindawi.com/journals/mse/ 2017/1832654/

12. M. Milenkovic, and D. Kekic. **Using GIS in emergency management**. *Sinteza 2016 - International Scientific Conference on ICT and E-Business Related Research*. April 2016, pp. 202-207, doi:10.15308/Sinteza-2016-202-207
13. A. Bhat. **Data analysis in research: why data, types of data, data analysis in qualitative and quantitative research**. Available Online at https://www.questionpro.com/blog/data-analysis-in-research/
14. Research Methodology. **Data Analysis**. Retrieved from https://research-methodology.net/research-methods/data-analysis
15. P. Clements, R. Kazman and M. Klein. **Evaluating software architectures: methods and case studies**, *Addison Wesley Publishing Comp., 2016*. Available Online at https://www.amazon.com/Evaluating-Software-Architectures-Methods-Studies/dp/020170482X
16. B. Venckeleer. **ATAM: Architecture Trade-off Analysis Method with case study**. Available Online at http://lore.ua.ac.be/Teaching/CapitaMaster/ATAMmethod.pdf
17. I.M. Putrama, K.T. Dermawan, G.R. Dantes and Y.E. Aryanto. **Architectural evaluation of data center system using architecture tradeoff analysis method (ATAM): A case study.** *2017 International Conference on Advanced Informatics, Concepts, Theory, and Applications (ICAICTA), 2017*. Available Online at https://www.researchgate.net/publication/320832148_Architectural_evaluation_of_data_center_system_using_architecture_tradeoff_analysis_method_ATAM_A_case_study https://doi.org/10.1109/ICAICTA.2017.8090982
18. Carnegie Mellon University, Software Engineering Institute. **Architecture Tradeoff Analysis Method Collection**. Available Online at https://resources.sei.cmu.edu/library/asset-view.cfm?assetid=513908
19. A. Gambo, A. Soriyan and R. Ikono. **Health information systems architectural evaluation with architecture trade-off analysis method (ATAM): a case study in Nigeria**. Journal of Health Informatics in Developing Countries, Vol. 9 No. 1, 2015. Available Online at http://docplayer.net/40824627-Health-information-systems-architectural-evaluation-with-architecture-trade-off-analysis-method-atam-a-case-study-in-nigeria.html
20. Philippine National Police. **PNP SOP No. 2012-001**. *Directorate for Investigation and Detective Management.* Available Online at https://didm.pnp.gov.ph/Standard%20Operating%20Procedures/SOP%20ON%20INCIDENT%20RECORDING%20SYSTEM.pdf.
21. Philippine National Police. **Reports & Forms**. *Directorate for Investigation and Detective Management*. Available Online at https://didm.pnp.gov.ph/index.php/report-forms/basic-investigation-reports
22. Philippine National Police. **SOP Forms. Incident Record Forms**. *Directorate for Investigation and Detective Management*. Available Online at https://didm.pnp.gov.ph/Incident%20Record%20Forms/Revised%20Incident%20Record%20Form.pdf
23. B. Venckeleer. **ATAM: Architecture Trade-off Analysis Method with case study**. Available Online at http://lore.ua.ac.be/Teaching/CapitaMaster/ATAMmethod.pdf