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PUBLIC INFRASTRUCTURE MONITORING IN DEVELOPING COUNTRIES THROUGH A MOBILE PERSUASIVE SYSTEM

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Abstract

The research introduces a mobile persuasive system designed to address the lack of maintenance of public infrastructures in developing countries. The absence of an effective monitoring and reporting framework has deteriorated infrastructure acquired through significant fiscal investments. The proposed system employs a six-step framework for creating persuasive technologies (PTs) targeting governmental entities. It utilizes a social factor categorization method for prioritizing infrastructure issues and employs mobile crowdsourcing for data collection. The system consists of two subsystems: a mobile app for citizen reporting and a web app for administrative activities. The technology was developed using Visual Studio Code, Android Studio, Vue.Js, PHP scripting language for the backend, and MySQL for the database. Citizens can report infrastructure issues by providing details such as location, pictures, local government name, and a description. The system generates a message with map coordinates and a persuasive message based on the priority of the reported

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issue. This message is then sent to the identified contact of a local government official responsible for the identified infrastructure. The automation of reporting aims to facilitate citizen engagement in identifying and reporting poor infrastructure, while the persuasive messaging module assists local officials in prioritizing repairs that benefit the majority of citizens.

INTRODUCTION

Information communication technology (ICT) applications in monitoring and reporting have improved the data acquisition and analysis potential in many domains (Otuke, 2016; Yasin *et al*., 2021; Sakurai & Murayama, 2019; de Meira and Bello, 2020; Amosun *et al*., 2021; Oluwatayo and Ojo, 2019). ICTs in monitoring and reporting have brought timely data collection, reduction in cost, varied data collection and presentation formats, and remote information transmission (Callen *et al*., 2020). Furthermore, combining ICT with models such as machine learning, crowdsourcing, and persuasive computing has further improved the data processing and decision-making potential in many fields. An example of this application was during the covid-19 pandemic, where mobile crowdsourcing was used to obtain data from experts and non-experts alike using their mobile phones and from different locations. The data was then analyzed using machine learning to obtain patterns of disease growth, and then messages were sent using different mobile platforms to individuals to adopt a better preventive attitude toward the virus (Obabueki, 2023). One area where the application of ICT in monitoring and reporting has become very important is road infrastructure monitoring due to its strategic importance for developing countries.

Road infrastructures are strategic to the development of Nigeria's economy. Currently, over 80% of all socioeconomic activities depend on road networks for their execution (Okafor & Ezeoyili, 2020). Despite this importance, our roads have not been given the serious level of consideration it requires. Nigerian roads, like other infrastructures, have decayed mostly due to the country's inability to provide a model for monitoring its developed infrastructures (Ajakaiye, 2018). The Nigerian road network is grouped as trunk A, trunk B, and trunk C, under the control of the federal, state, and local governments respectively. Nigeria's total road network is estimated to be about 200000 kilometers, with the federal government managing 18%, the states 16% and local governments managing a total of 66% (Muhammad & Dauda, 2017). Local government areas (LGA) in Nigeria is

the level of government with the least allocation from the federation account. It is also the area, where the major means of movement of goods and services are mainly the roads. It has become expedient that a method for effective monitoring of LGA road infrastructures is developed.

Due to the rising expense of constructing new roads, the emphasis at the local council level in developed countries has changed from creating new road infrastructures to maintaining existing ones (Radopoulou et al., 2016). The maintenance has been made possible by the application of effective ICT-based infrastructure maintenance systems for use by the agencies responsible for infrastructure maintenance. In Nigeria, the LGAs use manual methods for road monitoring, which involves employed LGA staff monitoring or concerned citizen monitoring. In the first instance, the LGA staff responsible for road monitoring and maintenance routinely check on roads and report road status to the council. On the other hand, Citizens report on the status of the roads using letter petitions, which they send along with physical picture evidence to the council office either by mail or physical / walk-in visits to the LGA office. This method has not been effective in solving the problem because manual road monitoring on the part of LGA officials has been proven to be subjective, arising from corruption, favoritism, and poor attitude of government officials. Additionally, citizen monitoring using this method has been discovered to be tedious, costly, and time-consuming and citizens are not persuaded toward ownership of community infrastructure. This paper is focused on developing a citizen-centric persuasive system for road monitoring in local communities of Nigeria.

LITERATURE REVIEW

Technology that gives people access to platforms for cooperative interaction, content production, sharing, and problem-solving has been developed as a result of the expansion and widespread usage of mobile devices and internet technologies (Obabueki, 2023). Two computing fields, persuasive computing, and crowdsourcing have proved beneficial when combined with ICTs in monitoring and reporting.

Persuasive computing

Nkwo et al. (2018), describe persuasive computing "as a field of computation that combines psychology, sociology, and other disciplines to create technologies that influence the attitude of individuals toward solving societal problems". This

INTERNATIONAL JOURNAL – NSAR
VOL. 02 NO.1 OCT-2023 ISSN: 1115-8492

technology has been used to help individuals in a variety of fields, including health management, personal sustainability, and learning improve their well-being and the society as a whole (Ugah & Obabueki, 2022). When persuasion is programmed into ICT monitoring and reporting devices, these solutions have been shown to have a crucial role in assisting people and organizations in achieving their growth objectives (Shao & Oinas-Kukkonen, 2018).

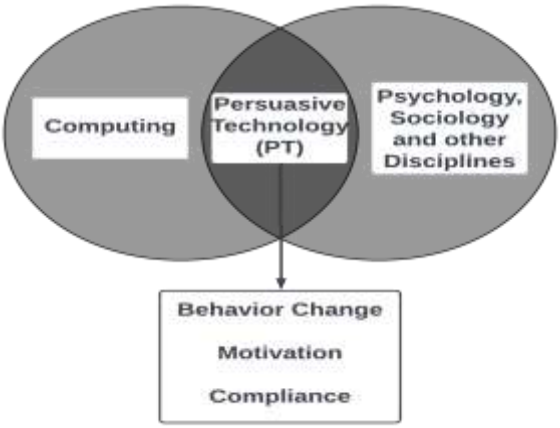

Fig 1: Persuasive computing

Additionally, there is proof from a range of disciplines that interactive platforms can be specifically created to encourage positive behaviors or to change undesirable behaviors with the help of several persuasive techniques (Orji, 2017). Techniques for designing PTs to drive changes in behavioral variables, and subsequently in the habits of subjects are called persuasive strategies (Orji, 2014). These strategies have been used to create design models, which provide guidelines on how to carry out PT design. These models have been used to create PTs that target and persuade a person to change, and both private users and institutions have applied them to build PTs that have been successfully employed on subjects Wiafe (2012). Two main models for creating PTs that target individuals are Fogg's Eight-Step Model and The Persuasive Design Model (PSD) Orji (2014). Strategies utilized in the models' construction can also be used to persuade the government (McClelland, 2009). We observe that using those models for creating PTs that will target governments will need remodeling to fit the characteristics of governments. Furthermore, research has not articulated a method that designers who want to build PTs that target the government and its agency can use for creating them. The following section describes our proposed model for creating

INTERNATIONAL JOURNAL – NSAR
VOL. 02 NO.1 OCT-2023 ISSN: 1115-8492

PTs which can be used for building persuasive systems that aim to change government behaviors.

Persuasive framework for designing PTs for monitoring and persuading the government

Information systems (IS) that target government and its agencies can also incorporate persuasive computing. Citizens can use the technology to suggest better service options and engage the government for the overall benefit of the local community. This system finds relevance today in developing countries with poor infrastructure monitoring systems where most governments seem not to notice the poor state of their infrastructures. Figure 2 illustrates the steps for creating a persuasive information system for monitoring government infrastructure which is described in the following sections.

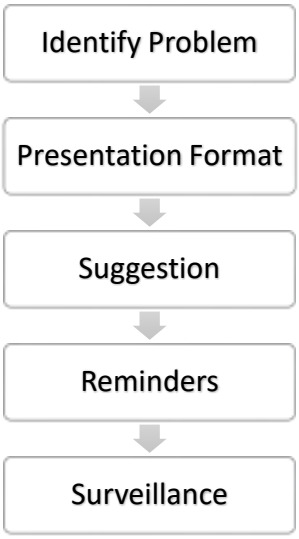

Fig 2: Steps to persuade the government

We describe how a user can use the framework above to create a persuasive system for government monitoring.

(i) Identify Problem: Understanding the issue and how it affects the entire community—rather than just an individual—is the first step towards persuading the government or a public organization. In this phase, a method of data collection that gives members of the community ability to collect and provide data on community problems should be created. Today, mobile devices can obtain data in many formats from millions of users with location-identifying components. An

example of this is to create an interface that can accept users' complaint data as pictures, text, audio, or video while attaching location coordinates to such data.

(ii) Presentation format: Monitoring systems now have many ways to present reports. This can be done electronically utilizing tools like emails, video recordings, text messages sent through apps like WhatsApp and WeChat, phone calls, SMS, and text messaging. Combining data representation types also makes it easier for receivers to understand reports and for agency staff to do so. To persuade a local authority, for instance, a reporting system for bad infrastructure can contain written descriptions in addition to data that identifies problem locations automatically available in a smartphone's mapping and photo tagging functionality. This will help to reduce the steps to verify claimed problems.

(iii) Suggestion for solution choice: A suggestion offers decision-makers options they can take. Considering the government's limited funding and the varied requirements of the communities it serves, it is essential to notify the government about potential alternative solutions to an infrastructure problem. A user can integrate a module into his system that suggests a solution based on the significance of a reported road to the majority of citizens in a community using criteria common to the community.

(iv) Reminders: A reminder is delivered to individuals or organizations to remind them of their commitment to perform certain actions or tasks. Text messages, mainly SMS texts are a common reminder tool that has been used in PTs to change a target behavior (Ugah & Obabueki, 2022). Reminder modules should be embedded in the monitoring software and set to be activated after a certain amount of time has passed with no response to the complaint.

(v) Surveillance: The use of surveillance as a persuasive tool encourages conformity. In recent years, social media has improved as a surveillance tool. The sharing of complaints by citizens on social media platforms will make the government aware that their actions are being noticed by members of the community. Another form of surveillance that can be built into persuasive IS for governments is escalation modules, which send messages to higher agency authority, and post them on a news agency's social media account when agencies ignore citizens' complaints. Links to social media platforms where individuals can view government activity can be added to the system. This can be used by system designers to inform the public of government actions and their responses to citizens' data about the community. Surveillance can also result in punishment in the form of negative comments or debates about how the government is

INTERNATIONAL JOURNAL – NSAR
VOL. 02 NO.1 OCT-2023 ISSN: 1115-8492

abandoning its responsibilities in the aftermath of complaints about concerns in the communities they neglected.

Mobile crowdsourcing (MCS)

Crowdsourcing allows a person or organization to use a group of individuals to complete a task that would normally be completed by a single person (Livescault, 2022). Figure 3 illustrates the main elements of a crowdsourcing system. The crowdsourcer is the person or institution who has a problem to be solved through the involvement of public participants. A crowd is a group of people who are interested in providing a solution to the crowdsourcer's task for monetary or other forms of rewards. The task is the well-defined problem to be solved, while the platform is where the solution takes place. Crowdsourcing platforms can be on the internet or mobile devices. Internet-based crowdsourcing occurs on the website of the task owner or on websites of organizations that carry out crowdsourcing on behalf of other organizations while crowdsourcing carried out on mobile device are called mobile crowdsourcing (MCS). Mobile crowdsourcing (MCS) activities are performed on Apps installed on smartphones or other mobile devices. Today, smartphones are widely used everywhere with built-in that can collect data in different forms, at any time, and from different locations. They are usually GPS-enabled, allowing for real-time data collecting while also expanding the scope and exposure of the crowdsourcing initiative.

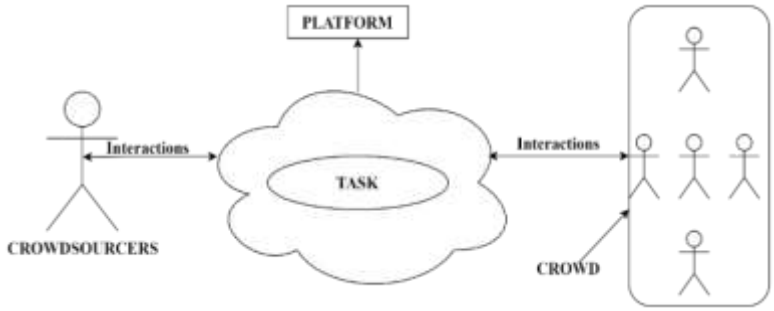

Fig 3: Crowdsourcing

Mobile crowdsourcing has become a viable substitute for traditional community monitoring methods. Governments use citizen-sourcing techniques to access the collective wisdom of citizens (Van Ransbeeck, 2015). Studies have demonstrated that successful crowdsourcing projects can lower monitoring costs, improve service effectiveness, and improve the relationship between government and

citizens (Brabham, 2015; Prpić et al., 2015: Dutil, 2015; Clark et al., 2019). Users can provide information about the state of the infrastructure in their communities using mobile crowdsourcing (MCS) software installed on their smartphones. The Apps leverage the smartphone's data-gathering capabilities to offer location-specific data utilizing the device's GPS and Map functionalities. The crowdsourcer database or agency systems are accessed over a user's local mobile network.

An MCS for reporting on road conditions using a smartphone was developed by Santani et al. (2015). To allow users to save and send reports based on network availability, the system uses delayed submission. Additionally, a user has access to MapIT, a mapping tool that uses a marker close to the user's position to identify roads in complaints. Deshmukh and Rajput (2016) created an android MCS that citizens used in making complaints about city hazards. The system sends geotagged photos together with a description of the problem that users have reported along with their complaints to the server. The complaints can be read by an administrator, who can then forward them to the proper authority.

Bamne and Shinde (2016) created an android-based MCS system for road monitoring which receives geotagged images from users and uploads them to a server. The user receives a confirmation SMS from the server along with a complaint ID, while it sends the report to the government official in charge of maintaining roads who forwards it to a contractor or local city engineer. Additionally, the MCS features a function called "On the Go" that enables users to locate and follow potholes nearby by using photographs taken by other users. Johns et al. (2019) created an MCS App for pothole mapping and route navigation that used machine learning to determine pothole picture location. Government personnel can log in to view reports of pothole incidents for necessary actions while citizens plot their travel around the city using the system pothole mapping.

METHODOLOGY

The methods investigated in the creation of public infrastructure MCS do not take into account factors that are peculiar to developing countries. Local government in Nigeria is beset by a severe lack of funding, uncooperative agency staff in charge of maintaining the roads, and apathy among the populace toward ownership of public assets, among other problems. Our approach uses the proposed framework for creating PTs that target government and its agencies with a design strategy using the object-oriented system and analysis methodology. The monitoring system combines mobile crowdsourcing and persuasive computing

INTERNATIONAL JOURNAL – NSAR
VOL. 02 NO.1 OCT-2023 ISSN: 1115-8492

using a prioritization method to determine the optimum choice for road maintenance. The system's front end was created using Visual Studio Code integrated development environment and Android studio environment with Vue.Js as the scripting language. The PHP scripting language was used to create the backend, while the MySQL database development platform was used to create the database.

Mobile persuasive system for public infrastructure monitoring

The mobile persuasive system for public infrastructure monitoring uses a mobile crowdsourcing platform for obtaining bad infrastructure data from residents. Our system uses the social factor categorization method for its prioritization algorithm (Skorokhod, 2018). The social factor categorization method is mostly used in local road maintenance systems where priority decisions are made based on the proximity of social and economic amenities used by residents to identified roads. We observed that the major social needs in LGAs are health, education, and commerce. The system was then designed to identify government landmarks of health centers, schools, and markets within the LGAs. The highest priority was assigned to hospitals, followed by schools and then markets. A persusive message is attached to users complaint depending on their location and closest social landmark. The system generated message includes details of the users complaint, map coordinates including a persuasion message that defines the importance of the landmark to citezens in the affected community. It is sent to the registered whatsapp contact of a local government official responsible for infrastructr in the community.

Architecture of the Mobile Persuasive System for road Infrastructure Monitoring

The architecture of the system is shown in figure 4. The system consists of an android-based interface and a web-based interface for citizen and admin use respectively. The android subsystem lets citizens register and create road complaints. The complaints include a picture of the issue, text description of the issues and issue area, landmark type and landmark name, and map coordinates of the issue location. A web server consisting of a PHP engine and MySQL database connected to the application manages user authentication, gets reports, and controls all device-server communications. Users must enter their phone number and a unique username when they signup for an account. To protect the privacy of the users, we made secret the phone number and other identifying data. Every

INTERNATIONAL JOURNAL – NSAR
VOL. 02 NO.1 OCT-2023 ISSN: 1115-8492

interaction between a user and the server generates a special notificationID that is tied to that interaction. Images are recorded as binary big objects, while the road metadata (location, description, etc.) is saved in a MySQL database.

A user is sent an SMS and in-app notification of the status of their complaint when they send a complaint to the system. The system then checks for landmarks in reports which it uses to send its persuasive message to the local agency via their registered WhatsApp contact number. The admin manages system activities using the website created for the Community Based Mobile Persuasive System for road Infrastructure Monitoring and Reporting. The admin adds contact for the works agency and communicates with them when there is no feedback on reported issues.

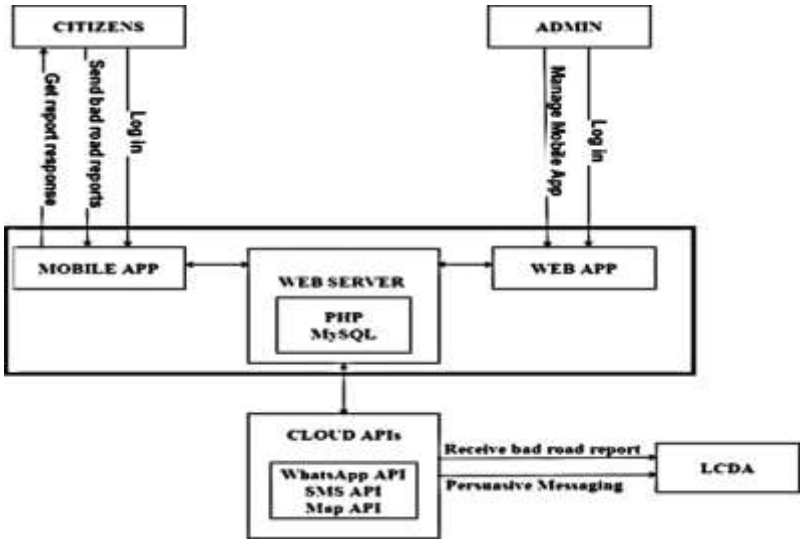

Fig 4: Architecture of the Mobile Persuasive System for road Infrastructure Monitoring and Reporting

The persuasion module

The persuasion sub-module combines the prioritization decision and the choice of persuasion message to send. It is activated when the system identifies a report with a defined landmark such as a school, hospital, or market. The prioritization mechanism involves identifying a report with any of the listed government landmarks and then computing its priority index. The system uses the status of the identified landmark on the priority index to send a persuasive message to the

INTERNATIONAL JOURNAL – NSAR
VOL. 02 NO.1 OCT-2023 ISSN: 1115-8492

WhatsApp number of the agency responsible for the local roads. The message will also include the complaint data and map information for the complaint.

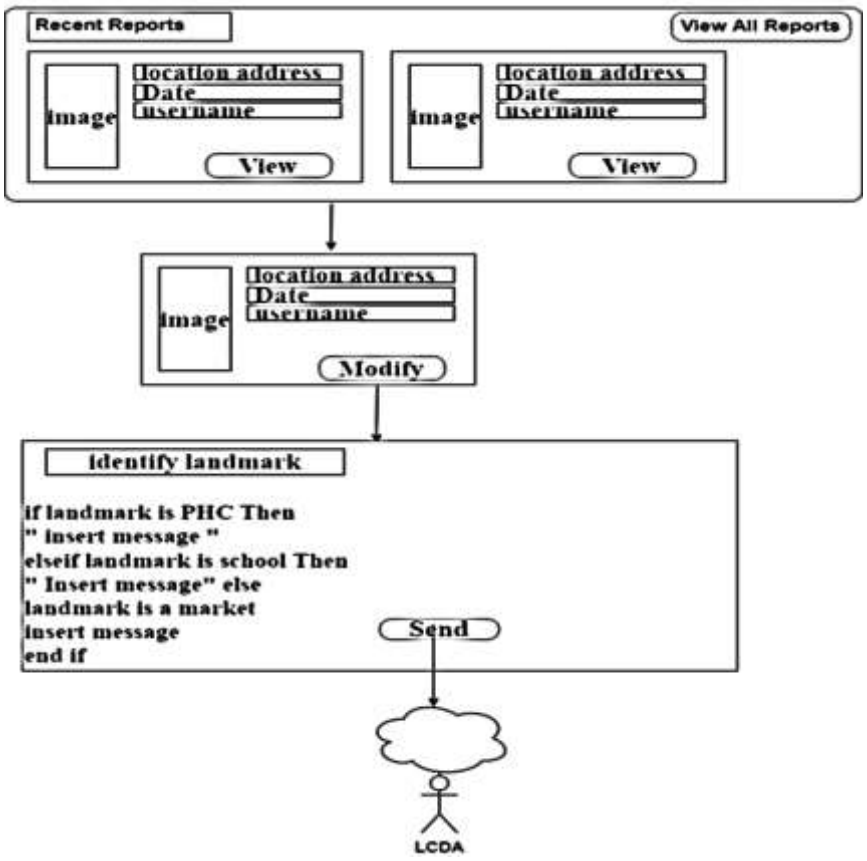

Fig 5: Persuasion module

Results and discussion

The previous literature and system have implemented community-based monitoring systems for local infrastructures but have failed to include persuasion that targets government agencies in charge of the infrastructures. Also, no prioritization scheme for maintenance management was built into the studied monitoring and reporting system. Our system was designed using a framework for creating persuasive systems for government monitoring. Furthermore, we developed a prioritization scheme that uses social landmarks to advise local agencies on maintenance. Our system added a delayed submission facility to help users who do not have data or are in an area where a network is not available to save and send the report later. We also used the WhatsApp messaging platform to send complaints from users including picture data, map data, and persuasive

INTERNATIONAL JOURNAL – NSAR
VOL. 02 NO.1 OCT-2023 ISSN: 1115-8492

messages to the agency official responsible for road management. The system was implemented and tested in Alimosho LGA of Lagos state. Screenshots from the system are displayed in this section.

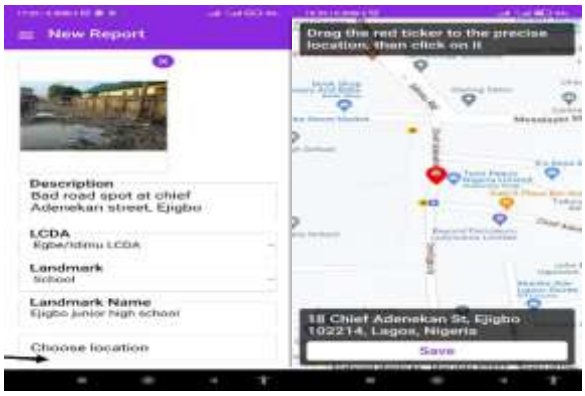

Fig 6: Complaint creation

Figure 6 shows a sample system screen for complaint creation. On this page, the user enters the road details for the identified problem. When the user saves the location the data is immediately tagged with map coordinates for the issue reported.

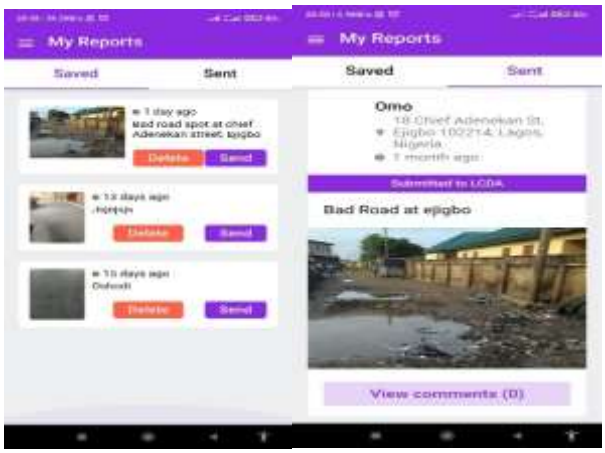

Fig 7: My reports module

Figure 7 displays my reports module. In the image, the save folder contains complaints that are stored in the system app and are to be sent later while the sent reports folder contains the reports that have been automatically sent to the LGAs.

Fig 8: Notification of sent complaints

Figure 8 shows a sample notification message sent to a user's mobile app when their message is received by the system and sent to the LGA.

Fig 9: WhatsApp message to LGA

The picture in Figure 9 is a sample system-generated persuasive message sent to the WhatsApp contact of the test LGA mobile phone.

CONCLUSION

This research developed a mobile persuasive system for public infrastructure monitoring. The reduction in the steps it takes to make a complaint through mobile monitoring helped to persuade citizens to actively participate in community monitoring. They were able to send their complaints from their smartphones while carrying out their daily activities, reducing both the stress and

cost involved in manual monitoring. The system sent reports to LGA offices in the form of WhatsApp messages. This is unlike the existing systems which send reports through emails. The familiarity and personalization of the WhatsApp messaging system encourage quick viewing by agency officials. Also, the use of texts that encourages conformity can persuade agency workers to carry out their duties. Furthermore, the systems prioritization function ensured that the maintenance decision made did not only consider the financial strength of LGA but that the choice made served the larger community. Finally, surveillance provided by the system through escalation to state-level authority and sharing of complaints via social media will further persuade managers to carry out maintenance of public assets on time.

REFERENCES

Ajakaiye, F. (2018, May 28). Fashola: Lack of Maintenance Economy Hinders Regular, Effective Management of Public Assets. *Thisday*. https://www.thisdaylive.com/

Amosun, T. S., Chu, J., Rufai, O. H., Muhideen, S., Shahani, R., & Gonlepa, M. K. (2021). Does e-government help shape citizens' engagement during the COVID-19 crisis? A study of mediational effects of how citizens perceive the government. *Online Information Review*, *ahead-of-print*(ahead-of-print). https://doi.org/10.1108/OIR-10-2020-0478

Bamne, A., & Shinde, O. (2016). Pothole Tracking System Using Android. *International Journal of Advanced Research in Computer and Communication Engineering*, *5*(6), 1–5.

Callen, M., Gulzar, S., Hasanain, A., Khan, M. Y., & Rezaee, A. (2020). Data and policy decisions: Experimental evidence from Pakistan. *Journal of Development Economics*, *146*, 102523. https://doi.org/10.1016/j.jdeveco.2020.102523

Clark, B. Y., Zingale, N., Logan, J., & Brudney, J. (2019). A Framework for Using Crowdsourcing in Government. In *Crowdsourcing* (pp. 194–214). IGI Global. https://doi.org/10.4018/978-1-5225-8362-2.ch010

de Meira, L. F., & Bello, O. (2020). *The use of technology and innovative approaches in disaster and risk management* (No. 93; STUDIES AND PERSPECTIVES).

Deshmukh, M. S., & Rajput, S. (2016). Smartphone Based Citizen Complaint System for Urban Maintenance Using GIS. *International Journal of Scientific & Engineering Research*, *7*(5), 1–9.

Dutil, P. (2015). Crowdsourcing as a new instrument in the government's arsenal: Explorations and considerations. *Canadian Public Administration*, *58*(3), 363–383. https://doi.org/10.1111/capa.12134

Ienca, M., & Vayena, E. (2020). On the responsible use of digital data to tackle the COVID-19 pandemic. *Nature Medicine*, *26*(4). https://doi.org/10.1038/s41591-020-0832-5

Johns, S., Jithin, G., Bobby, I., Babilu, C. J., & Manoj, J. (2019). Crowdsourced Pothole Mapping and Route Navigation. *International Journal of Wireless Communication and Networking Technologies*, *8*(3), 21–24. https://doi.org/10.30534/ijwent/2019/05832019

Mao, Z., Yao, H., Zou, Q., Zhang, W., & Dong, Y. (2021). Digital Contact Tracing Based on a Graph Database Algorithm for Emergency Management During the COVID-19 Epidemic: Case Study. *JMIR MHealth and UHealth*, *9*(1). https://doi.org/10.2196/26836

McClelland, A. (2009). How to persuade government with your soft and hard evidence. *Communities in Control Conference*, 1–14.

Muhammad, H., & Sebastian-Dauda, M. (2017). *The public works ministries: organisation, operation, potential studies and implementation. Annual investment budgets (last five (5) years) achievements of the past twenty (20) years, future prospects*.

Nkwo, M., Orji, R., & Ugah, J. (2018, December 3). Mobile persuasion. *Proceedings of the Second African Conference for Human Computer Interaction: Thriving Communities*. https://doi.org/10.1145/3283458.3283515

Obabueki, O.-O. (2023). *Development of A Mobile Persuasive System for Monitoring and Reporting Government Infrastructure Development and Maintenance*. Ebonyi State University.

Okafor, C. C., & Ezeoyili, N. M. (2020). Assessment Of Infrastructure Maintenance Practices Of Three Airports In Southern Nigeria. *Nigerian Journal of Technology*, *39*(3), 744–751.

Oluwatayo, I. B., & Ojo, A. O. (2019). Effect of Access to ICT on Food Insecurity Among Farming Households in Nigeria. *The Journal of Developing Areas*, *53*(2), 155–168. https://doi.org/10.1353/jda.2019.0027

Orji, R. (2014). *design for behaviour change: a model-driven approach for tailoring persuasive technologies*. university of saskatchewan.

Orji, R. (2017). *Why Are Persuasive Strategies Effective? Exploring the Strengths and Weaknesses of Socially-Oriented Persuasive Strategies*. https://doi.org/10.1007/978-3-319-55134-0_20

Otuke, J. O. (2016). *Role of information communication technologies in water management*. University of nairobi.

Prpić, J., Taeihagh, A., & Melton, J. (2015). The Fundamentals of Policy Crowdsourcing. *Policy & Internet*, *7*(3), 340–361. https://doi.org/10.1002/poi3.102

Putro, H. P. H., & Utami, N. L. P. (2017). Local Road Maintenance Prioritization Literature Review. *International Journal of System Modeling and Simulation*, *2*(4), 21. https://doi.org/10.24178/ijsms.2017.2.4.21

Radanliev, P., De Roure, D., Walton, R., Van Kleek, M., Montalvo, R. M., Santos, O., Maddox, L., & Cannady, S. (2020). COVID-19 what have we learned? The rise of social machines and connected devices in pandemic management following the concepts of predictive, preventive and personalized medicine. *EPMA Journal*, *11*(3). https://doi.org/10.1007/s13167-020-00218-x

Radopoulou, S. C., Brilakis, I., Doycheva, K., & Koch, C. (2016). A Framework for Automated Pavement Condition Monitoring. *Construction Research Congress 2016*, 770–779. https://doi.org/10.1061/9780784479827.078

Sakurai, M., & Murayama, Y. (2019). Information technologies and disaster management – Benefits and issues -. *Progress in Disaster Science*, *2*. https://doi.org/10.1016/j.pdisas.2019.100012

Santani, D., Njuguna, J., Bills, T., Bryant, A. W., Bryant, R., Ledgard, J., & Gatica-Perez, D. (2015, August 24). CommuniSense. *Proceedings of the 17th International Conference on Human-Computer Interaction with Mobile Devices and Services*. https://doi.org/10.1145/2785830.2785837

Shao, X., & Oinas-Kukkonen, H. (2018). *Thinking About Persuasive Technology from the Strategic Business Perspective: A Call for Research on Cost-Based Competitive Advantage* (pp. 3–15). https://doi.org/10.1007/978-3-319-78978-1_1

Skorokhod, K. (2018). *Priori A Prioritization Model For L Tion Model For Local Ro Ocal Roadways: A Case S: A Case Study Of Syracuse, NY*. Syracuse University.

Ugah, J. O., & Obabueki, O.-O. (2022). SMS-Based Persuasive Technology for Waste Management. *The Journal of Computer Science and Its Applications*.

Van Ransbeeck, W. (2015). *What is Citizensourcing?* Https://Www.Citizenlab.Co/Blog/Civic-Engagement/What-Is-Citizensourcing/.

Wiafe, I. (2012). *A Framework for Analysing, Designing and Evaluating Persuasive Technologies*. University of Reading.

Wirth, F. N., Johns, M., Meurers, T., & Prasser, F. (2020). Citizen-Centered Mobile Health Apps Collecting Individual-Level Spatial Data for Infectious Disease Management: Scoping Review. *JMIR MHealth and UHealth*, *8*(11). https://doi.org/10.2196/22594

Yasin, H. M., Zeebaree, S. R. M., Sadeeq, M. A. M., Ameen, S. Y., Ibrahim, I. M., Zebari, R. R., Ibrahim, R. K., & Sallow, A. B. (2021). IoT and ICT based Smart Water Management, Monitoring and Controlling System: A Review. *Asian Journal of Research in Computer Science*. https://doi.org/10.9734/ajrcos/2021/v8i230198

Ye, J. (2020). The Role of Health Technology and Informatics in a Global Public Health Emergency: Practices and Implications From the COVID-19 Pandemic. *JMIR Medical Informatics*, *8*(7). https://doi.org/10.2196/19866