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Civix: A Cloud-Native Secure Crowdsourced Civic Issue Reporting System for Intelligent City Governance

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Abstract: As urbanization accelerates, cities experience increasing civic problems in the form of potholes, waste and broken infrastructure that may not be resolved promptly, due to slow grievance mechanisms. Civix is a safe cloud-based crowdsourcing site that allows citizens to report issues using their phones or the web including photos and location information. It categorizes and ranks complaints based on AI and ML, which respond to complaints more quickly. The integration on clouds is reliable, scalable, and safe. Civix offers an open, streamlined system to bridge citizens and governments to enhance the governance of cities. Also the platform allows the citizen to get involved easily by making things simple.This means individuals can get involved in the process with ease.The platform also helps authorities make informed decisions using data.This way people can easily participate in tackling the problems in the city and manage them.

Keywords: Crowdsourced Civic Reporting, Smart City Governance, Cloud-Native Architecture, Artificial Intelligence, Machine Learning, Geotagging, Real-Time Issue Tracking, Data Security

I. INTRODUCTION

The world has experienced rapid urbanization and this has greatly contributed to the increase in the amount of the civic problems such as potholes, littering of the streets with litter, water leaks, broken street lighting, and broken infrastructures. The issues have a direct negative influence on the quality of life of urban residents and create major dilemmas to the municipal governments.

The common processes used in complaint-management are the manual registries, telephone helplines, and email-based reporting, which are not effective enough to address such concerns because of the delayed response rates, no communication, and transparency. Consequently, its citizens are being continuously frustrated and losing faith in local governance.

One of the factors contributing to the urgency to develop the interventions that are current and technology-driven is the growing popularity of digital technologies, which seems to be the reason to develop the interventions that would facilitate civic reporting of the problems and allow the enhancement of governance and active involvement of citizens. The crowdsourced reporting systems have been one potential solution and it utilizes the mobile-based application, GPS and internet connectivity to facilitate the residents to report effectively. They resort to them in cases of reporting on the issues that are more specific and prioritized because of the opportunity to post issues in real-time with pictures and geolocation information and, therefore, the authorities work quickly.

Additionally, the crowdsourced systems are also transparent, accountable, and inclusive making citizens passive spectators yet active during the process of sustaining the urban infrastructure. The said change aligns with the paradigms of smart-city, in which digital platforms can be used to distribute resources efficiently, monitor tendencies in the city and use the information to make decisions.

The proposed system, Civix, is based on this concept by offering a safe cloud-based system with user-friendly reporting, geotagging, live tracking, automated notifications, and analytical information. By integrating crowdsourcing and the latest technology, Civix will target to ensure that the civic issue reporting will be streamlined, participatory, and transparency, which ultimately will result in the increased satisfaction of the citizens and contribute to sustainable urban governance.

Civix is quite competent in processing large amount of user data since it works with native architecture. This implies that it is able to expand and process large amounts of information without difficulties. The data can also be scanned across time enabling the authorities to determine what is happening and identify the most significant issues to be undertaken. Civix relies on Artificial Intelligence to assist in this to allow it to do so automatically. Send problems to the appropriate individuals. The site also makes individuals aware of what is happening since it informs them about any occurrences. This is good in all that people trust and communicate to their authorities more. Civix is an element of transforming cities into smarter and more receptive to the community within the city which is what Civix is all about making cities better, with Civix.

II. LITERATURE REVIEW

The crowdsourced civic issue reporting systems have become a very important aspect of the handling the city issue. Binu et al. [1] proposed SmartReporter, a platform that allows citizens to submit complaints about urban infrastructure.Geotagging and photo submissions are the focus of this system to enhance the accuracy of reported problems.

Likewise, Walwadkar et al. [2] have created a Smart Civic Issue Reporting System, which combines mobile notifications and community validation to rank high-impact problems.

A related AI-assisted system was introduced in [3], and it improves civic reporting, automating complaint classification and sending them to the corresponding municipal departments.

Younis et al. [4] examined the methods of mobile self-reporting and established that mobile phone-based reporting enhances the user engagement and response rates than the conventional medium.

Lee et al. [5] studied crowdsourcing behavior, making it clear that there are issues that affect the engagement of citizens in reporting civic issues, and suggesting behavioral models that can be used to predict reporting trends.

The mobile application proposed by Shama et al. [6] is known as CitySolution, which assists in managing complaints in real-time and tracking the resolution process.

Tjandra et al. [7] used the KNN-based routing algorithms to effectively assign complaints to the municipal officers using the past resolution information.

Abdulrahman et al. [8] proposed a complex system named Fix-It which is a complaint management system that integrates location service, image verification, and status tracking to provide transparency.

According to Balakrishnan et al. [9], an image detection system was created, which is based on computer vision to recognize and classify civic infrastructure problems on the basis of photos posted by citizens.

Dhoor et al. [10] outlined the FixTheCity application, which integrates GIS mapping with reports made by people to prioritize urgent repairs.

Bhadourier et al. [11] considered the online complaints management, and to do so, they created the Dashboard, allowing administrators to track the success of ensuring issues are resolved based on real-time information provided by IoT sensors and citizen reports.UpCity, which was created by

Silva et al. [12], is a cyber-physical platform, where IoT sensors and citizen reports are used to help the administrators see what is going on in real-time, as well as how well issues are being resolved.

Huang et al. [13] also deal with the urban inconsistent prediction, where they predict what issues may arise next with the help of machine learning and the old complaints data.

Wijethilake et al. [14] established a waste monitoring framework that gathers both citizen reports and IoT devices to streamline the process of collecting waste in the UAE cities.

Finally, Sakhare et al. [15] developed Intercity Road Complaint Reporter (IRCR), the system that allows individuals to report road-related problems in various cities to facilitate the faster response to them and ensure that roads are in a better condition.

III. METHODOLOGY

The Civix system methodology is the systematic way of designing, developing, and deploying a cloud-native civic issue reporting and management platform. It concentrates on the guarantee of scalability, security, and efficient data handling and facilitating real-time communication between citizens and the municipal authorities.

The methodology will be broken down into two substantial parts:

A. System Architecture Methodology

The Civix system is based on a cloud-native, modular design to achieve high performance, flexibility, and scalability. It is built using several layers where each layer has a particular role to play, which has made it easy to communicate and maintain the architecture.

Steps involved:

1) Requirement Analysis:

- Identity to recognize stakeholders, e.g. citizens, administrators, municipal authorities.
- Bring out system functionalities such as issue reporting, tracking and resolution.
- Category civic concerns (e.g., potholes, garbage, streetlights failures).
- Choose the right platforms which includes web and mobile applications.

2) System Design:

- Develop a multi tier architecture such as:
  - Frontend (User Interface)
  - Backend (Business Logic)
  - Database (Data Storage)
- Processing and scalability of cloud services.
- Communication between layers is through the use of RESTful APIs.
- Use secure authentication systems, e.g. OAuth2 and JW
- Develop server back-end services to process data and acceptance of requests.
- Implement the system on cloud systems such as AWS or Azure.
- Combine services of notifications, analytics, and storage.

3) Implementation Phase:

- Create user friendly and responsive frontend interfaces.
- Develop server back-end services to process data and acceptance of requests.
- Implement the system on cloud systems such as AWS or Azure.
- Combine services of notifications, analytics, and storage.

4) Testing and Evaluation:

- Carry out unit testing of modules.

- Perform system component integration testing.
- Performance test system with multiple users.
- Provide data security and reliability of the system.

B. Data Handling and Processing Methodology

Civix system has a system of efficient and secure data handling mechanism that handles the information regarding civic issues. This approach will guarantee proper data collection, storage, real-time processing, and high security, thus making it possible to make accurate decisions and resolve problems more quickly.
Steps involved:

1) Data Collection:

- Through web/mobile interfaces, citizens post civic issues.
- Data includes text descriptions, images/videos, and location (GPS/geotagging).
- Timestamp and user details are automatically recorded in the system.

2) Data Validation:

- Check on user inputs to make sure they are complete and accurate.
- Format and size restriction of checking files of uploaded media.
- Identify and reject duplicate or invalid records.

3) Data Storage:

- Retrieve organized information (user data, the nature of the problem, the problem status) in a relational database.
- Store unstructured data (images/videos) in an object storage of the cloud.
- Provide consistency and availability of data.

4) Data Processing and Analysis:

- Sort the problems depending on the type and location.
- Rank problems by the level of severity or the community approval.
- Create analytical reports and dashboards to the authorities.
- Optional automatic issue detection of the pictures using AI/ML.

5) Security and Privacy:

- Encrypt data using TLS/SSL.
- Use role based access control (RBAC) to access.
- Secure confidential user information and compliance with privacy.

6) Notification and Updates:

- Send reports to local authorities about newly-reported problems.
- Give updates in real-time to users on status of issues.
- Facilitate on-going stakeholder communications.

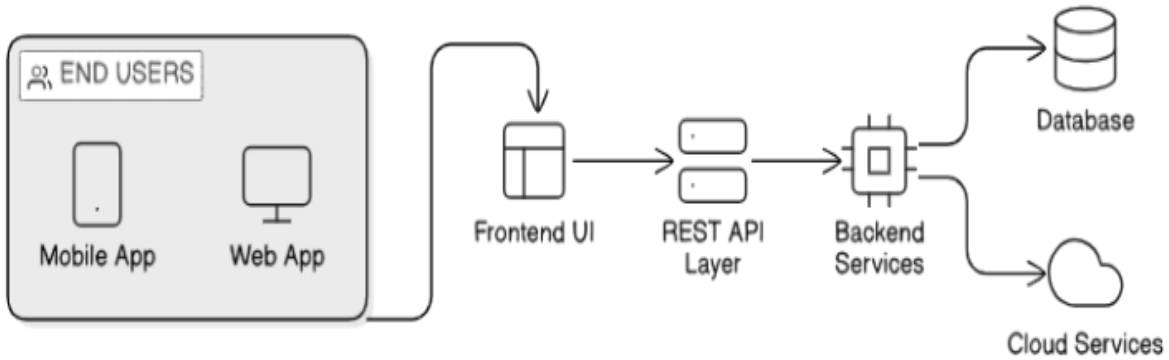


Figure 1. System Architecture of Civix.

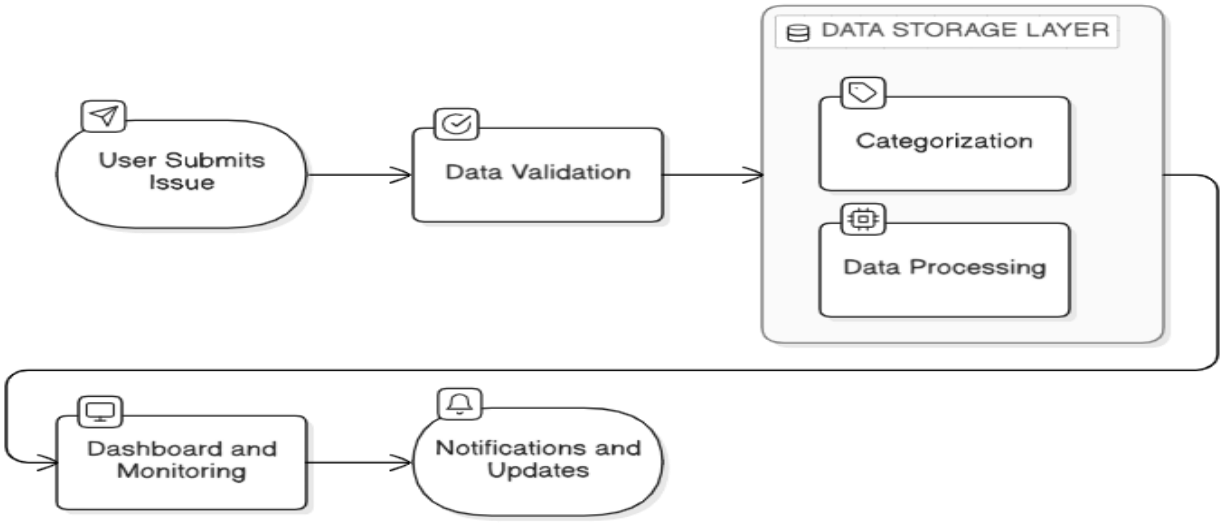


Figure 2. Data Flow Diagram of Civix System

IV. RESULT

The functionality of Civix system was tested using different loads of users in order to examine the scalability, responsiveness, and reliability of the system under real world conditions. The system was tried by using simulation of multiple users on the platform at the same time and reporting various categories of civic problems like potholes, complaints about waste management and infrastructure faults.

To provide thorough evaluation, the system was evaluated on the basis of the most important key performance parameters such as response time, system throughput, and load stability. The test conditions were simulated to represent the real time use environment where there were many users using the system at the same time.

The findings suggest that the Civix system can become stable and consistent in its performance with the increase in the number of users. Despite the slow pace of response time growth as a load increases, the system is efficient and responsive because it has a cloud-based scalable architecture. Distributed services and optimized back-end processing allow dealing with numerous requests without a system failure or a considerable delay.

In addition, the system had a high availability and reliability guaranteeing continuity of service even when its usage was at its peak. The combination of effective data processing and asynchronous processing helped to reduce delays in the processing of requests and responding to them.

A. Performance Analysis

Average time spent by the system on responding was plotted against simultaneous number of users. Table 1 is a summary of the observations.

Table I. Performance Evaluation of Civix System

Sr. No.	*Concurrent Users*	*Avg. Response Time (ms)*
1	10	110
2	50	130
3	100	165
4	250	240
5	500	390
6	750	520

As can be viewed in Table 1, there is a linear improvement in response time with an increment in the number of active users. Sensitivity to the system at lower loads (10100 users) is quick with small latency and means that the system efficiently handles requests. With the growing load, response time rises in a moderate manner as the processing demand rises with the increasing number of users.

Nevertheless, the response time is also within acceptable ranges at peak load conditions (500-750 users), which proves the effectiveness of the system in terms of scaling without any decline in its performance. The observation proves that the Civix system is capable of supporting real-world traffic.

Figure 3. Response Time API vs. Concurrent Users.

This was clearly indicated in the graph, with the number of users and response time having a positive correlation. Response time grows in a predictable and controlled manner as the number of parallel users grows.

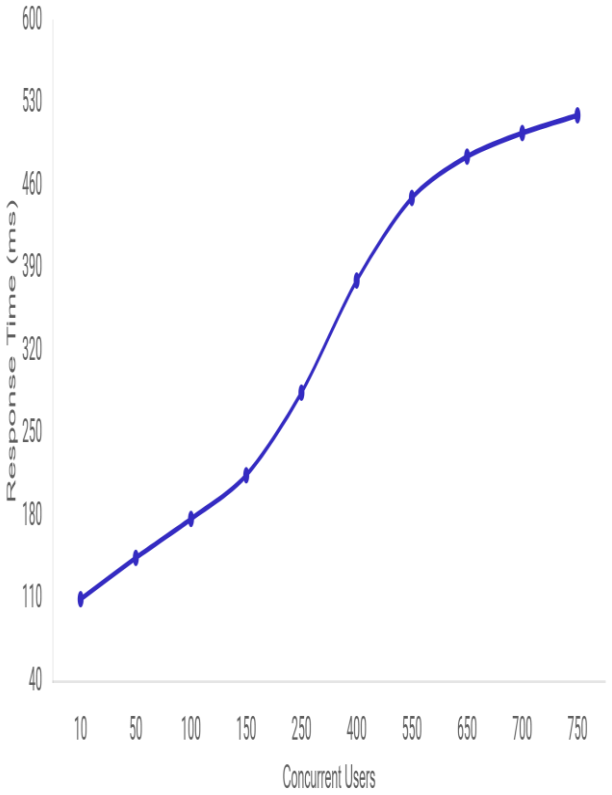
B. *Observations*

- The system works effectively with low and moderate user load.
- The response time is not sudden, but increases slowly, which implies the stability of the system.
- Cloud infrastructure allows the dynamism in resource allocation to support increased loads.
- There were no crashes or failures of any system during testing.
- The system has constant performance and therefore it has a smooth user experience.

C. *Discussion*

The results of the experiments prove the fact that Civix system can cope with the growing amount of user requirements and ensure their adequate performance. Response time is likely to grow slowly in distributed cloud systems and is a sign of adequate load control.

Scalable cloud services, efficient backend processing and optimized data handling is also used to make the system robust. Such findings prove that Civix can be implemented in smart city settings where the number of users can be very high at the same time.



V. CONCLUSION AND FUTURE WORK

A. *Conclusion*

The Civix system offers a successful online platform of reporting and handling civic matters and thus it greatly improves communication between the citizens and the municipal authorities. The platform enhances efficiency in terms of the entire service delivery, through transparency and faster response.

Civix is scalable, secure, and reliable with the use of cloud-based infrastructure, thus it can be implemented in the medium-sized cities with ease and expandability to large cities. Moreover, the system complies with the concept of smart cities because it allows the use of data in decision-making and motivates people to engage actively, which helps to enhance the governance of cities.

Moreover, the system is compatible with the goals of smart city projects because it allows making decisions basing on data and fosters active involvement of citizens. Real-time data, dashboards, and analytics allow authorities to define specific problem areas and find the best solutions to them. On the whole, Civix can help enhance the e-governance of cities by increasing responsiveness, transparency, and citizen-centricity in civic services.

B. *Future Work*

Further improvements of Civix can be made later and they can be:

- Creation of a specific mobile application on both Android and iOS to become more accessible.
- Automatic image-based issue detection with the help of AI in order to minimize the number of people classifying them.
- Reporting of issues in real time to citizens and authorities to dynamically monitor the status of issues.
- Connectivity with government systems in order to support simplified working process and automation of escalation.
- Multi-lingual assistance to ensure that the site is accommodative to varied people.
- These enhancements will transform Civix to be smarter, responsive and more user friendly which will further enhance the vision of the smart citizen-centric urban government apps (Android/iOS)

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