

# Proactive Disaster Notification: Utilizing Smart Home Networks for Emergency Response

J. Kountouri<sup>a\*</sup>, M. Tzouvaras<sup>a</sup>, C.F. Panagiotou<sup>a</sup>, M. Prodromou<sup>a</sup>, E. Evagorou<sup>a</sup>, C. Mettas<sup>a</sup>, C. Panayiotou<sup>b</sup>, A. Chrysaphis<sup>b</sup>, P. Panayiotou<sup>b</sup>, D. Hadjimitsis<sup>a,c</sup>

<sup>a</sup> ERATOSTHENES Centre of Excellence, 82 Franklin Roosevelt, 3012, Lemesos

<sup>b</sup> C.P.P. Intelligent Systems Solutions Ltd., 3A Stavrou Stylianidi, Lakatamia, Lefkosia 2320

<sup>c</sup> Cyprus University of Technology, 30 Arch. Kyprianos Str.  
3036 Limassol

## ABSTRACT

The increasing intensity and occurrence of natural disasters such as fires, earthquakes, and floods, necessitate the design of more effective emergency notification systems. Conventional alarm systems, such as sirens, and SMS alarms, are often insufficient to address issues such as slow response times and the provision of warnings of limited accuracy. By providing near real-time, localized notifications, a more proactive strategy that makes use of smart home technologies could improve disaster preparedness. This study focuses on the contribution of smart home environments to emergency alerting systems with Cyprus used as the pilot study. Cyprus is vulnerable to natural hazards, highlighting the need to develop more reliable and efficient warning technologies. Compared with traditional systems, the potential to develop a distributed alert system that increases the precision and promptness of warnings by utilizing sensors that are frequently present in smart homes, such as temperature, smoke, and flood monitoring, will be explored. Data will be collected from several households and used to evaluate the ability of the proposed concept to reduce false alarms while guaranteeing pertinent notifications. The feasibility of this approach is also discussed in terms of key design principles, challenges, and installation issues. The integration of this approach with existing emergency response frameworks, scalability, and user adoption is also considered since this is a crucial factor for the success of such systems. The outcomes of this analysis provide a foundation for further research and practical evaluation, contributing to broader discussion on how smart technologies can be leveraged for enhanced disaster resilience and public safety.

**Keywords:** Smart Homes, Emergency Notifications, Disaster Preparedness, Early Warning Systems.

## 1. INTRODUCTION

Over recent decades, there has been a significant rise in the occurrence, severity, and unpredictability of natural disasters impacting societies worldwide. Factors such as climate change, urban expansion and environmental deterioration have increased our vulnerability, especially in the Mediterranean region, with Cyprus being particularly affected<sup>1</sup>. This rising vulnerability is reflected in regional patterns and the reported impacts of extremes on Mediterranean communities, such as interruptions in infrastructural services, economic losses, and threats to public health<sup>2</sup>. Cyprus faces particular risks from wildfires during extended dry periods<sup>3</sup>, intense rainfall resulting in flash floods<sup>4</sup>, and moderate seismic activity<sup>5</sup>. These challenges highlight the necessity for a contemporary approach to disaster preparedness and response.

Traditional emergency alert systems, including centralized siren networks and SMS broadcast notifications remain prevalent but exhibit significant shortcomings. Recent civil defense evaluations underscore the difficulties in implementing contemporary, precise alerts across countries in all word, including Cyprus<sup>6,7</sup>. These systems frequently have poor flexibility to change, confined conditions, limited geographic targeting, and delays. Additionally, they fail to make use of the fast-emerging smart home technologies in residential locations.

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\* Josefina.Kountouri@eratosthenes.org.cy

Consistent with the United Nations “Early Warnings for All” effort, there is a growing recognition in the international community of the force to enhance accessible, inclusive, and proactive disaster warning systems<sup>8</sup>. In this context, the implementation of early warning systems on existing digital infrastructures especially in smart homes and buildings is feasible in order to enhance the resilience of society. This paper examines both the technical and strategic factors that would lead to the use of smart home networks and raw sensor data to produce a more distributed and real-time alternative to traditional centralized hazard warning systems. In this context, the system will deploy sensors for flooding and fire, and earthquakes provide the capability for early warnings and proactive action against a range of hazards.

## 2. RELATED WORK AND BACKGROUND

Current early warning systems (EWS) are commonly based on the government infrastructure and the centralized sensor network. Existing systems such as EU-ALERT, ShakeAlert (USA) and realization of siren-based alerts in Cyprus provide valuable coverage, but they do not feature portability, easy scalability and many of them lack support for multi-platform customization. Previous efforts such as the DISARM and RiskMed projects underlined the regional interest in EWS, but had been shown to have limited sustainability, partly due to scale and interoperability barriers<sup>6,7</sup>.

Nowadays, with the recent developments in advanced Internet of Things (IoT), cloud computing, and mobile technologies, there emerges a new paradigm of distributed EWS. Sensors for fire, flooding, and seismic events can in smart homes be used for automation and security as well as for real-time sensing of marine-applied agents. Yet, relatively few studies have successfully combined the heterogeneous smart home data into a harmonized system of disaster notification. This, in doing so, exploits the available Z-wave infrastructure and open-source cloud environment to create a timely, user-centric alert system.

## 3.METHODOLOGY

The methodology presented in Figure 1 describes a conceptual framework along with a technical plan, which has been assessed primarily in controlled settings and has not yet been implemented in real-world situations. The system collect real-time data from home gateways and performs validation for the data by analyzing them and comparing with neighboring homes’ gateways to ensure data accuracy. After successful verification of the accuracy of the data and if the pre-set conditions are met then a trigger function enable different scenarios such as mobile push notifications, SMS, web-hooks, or restless APIs.

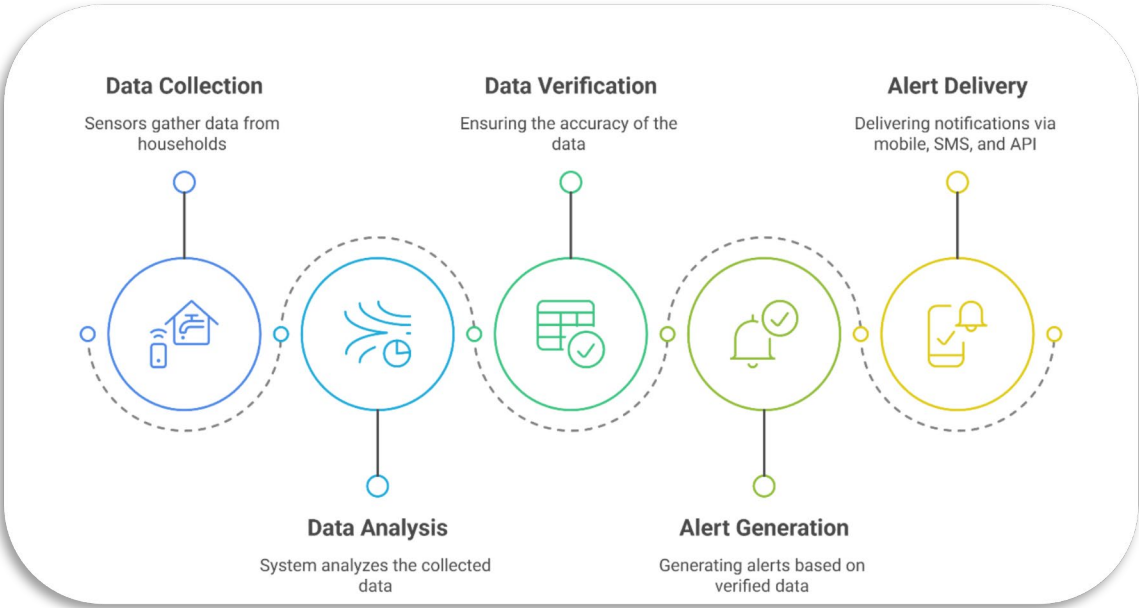


Figure 1: Overview of the current methodology

Regarding the system design consists of a three-tier architecture as presented in Figure 2, which is composed of end-user devices, front-end applications and well-developed backend infrastructure. The purpose of the system is to assist real-time data collection and alert sending messages that can be applied in homes<sup>9</sup>.

At home, some smart sensors are implemented at the edge, such as temperature detectors and water or gas detectors, seismic sensors to detect environmental hazards. These devices use the A Z-Wave protocol, as well-known standard for smart home communication<sup>10</sup>, is used to transmit data from these sensors to a central API Gateway, which collects the data and sends it to the backend system. Seismic sensors send Modified Mercalli Intensity (MMI) readings<sup>11</sup>, while heat and flood sensors spot fires and water leaks.

Users geolocation on the Internet in real-time Me On the user side there is a monitoring application for Android and iOS platform under revision which offers real time notifications, event history and geospatial visualization. Every alert comes with details regarding the observed event, the time of observation and the distance from the user. In this way users can assess risk both in space and time.

The backend is implemented using the Things Board open source IoT platform providing device management, telemetry visualization, event rule engine execution. The basis upon which alerts are raised uses a logic system to confirm multiple sensors reading across nodes<sup>12</sup>. For instance, a warning of flood or fire is given only if at least two spatially different sensors trigger the event. In the same manner, an earthquake alarm is raised if the MMI value is above a threshold value. Push Notifications are sent with One Signal and Firebase provides authentication for users<sup>13</sup>.

In addition, the mobile applications do a poll (from a background task) of the telemetry database for changes to improve reliability. When an event update is recognized (by the timestamp differences), it is appended into the event history and gets aligned.

End-users are also no longer aware of JSON data structures although they are used in the background. The backend architecture is scalable; new upgrade features can easily be incorporated. Such add-ons would comprise rain sensors in order to utilize the precipitation for flooding and rainfall flooding triggers, wind sensor for storm characterization, and a weather model to get better predictions<sup>9</sup>.

This pattern is based on distributed systems and edge computing principles to guarantee decentralization, responsiveness, and fault-tolerance. Real-time data validation across sensor clusters helps to eliminate false positives and ensures strong confidence in alerting even within high-density urban environments.

#### **4. PRELIMINARY RESULT AND DISCUSSION**

While not yet fielded, lab simulations and initial demonstrations yielded several insights. First, it significantly decreased false alarms via cross-node comparison in the validation of sensor data. Second, the delay in dispatching an alert, from the time of event detection, was acceptable. Third, the mobile app effectively sent notifications to Android/iOS devices, with the outcomes constituting a system wide affirmation.

The systems also indicate good responses and accuracy. These tests validated that the system could adjust for simulated disaster-related effects in a timely and accurate manner, clothing it with operational viability for real-time operation. But there were some bumps in the road in the beginning. These difficulties include protecting privacy and being compliant with laws while collecting data in private homes. Privacy and emerged as a key legal and ethical issue. In addition, user engagement and interoperability in heterogeneous devices still posed quite challenging design and implementation issues.

#### **5. CONCLUSION**

This paper is an presents a conceptual framework for leveraging smart home sensor networks as a basis for decentralized early warning systems. By incorporating IoT-enabled sensors, distributed logic, and user-focused mobile applications, the framework provides a fresh perspective on real-time hazard monitoring at the household level. While initial simulations conducted in laboratory conditions have shown encouraging results concerning latency and data

validation, the system has yet to be implemented in real-world scenarios. Therefore, this research highlights the theoretical and architectural viability of the concept rather than offering practical implementation outcomes.

The simulation results prove the technical feasibility of the system, especially in terms of filtering false alarm and preserving low-delay communication and its robustness to diverse event types. And the findings reinforce that smart home infrastructure has the potential to play a strong role in preemptive warning efforts. Conclusion Overall, the system described in this paper is a useful addition to the disaster risk reduction toolbox elevating situational awareness, public preparedness, and rapid response amidst the ever-increasing proliferation of complex environmental threats.

## ACKNOWLEDGEMENTS

Acknowledgments: The authors acknowledge “The Proactive Emergency Notification System based on Household Data “NotifyMesh”. The “NotifyMesh” project has received funding from the Research and Innovation Foundation (RIF) of Cyprus.

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