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Developing the Earthquake Early Warning and Evacuation Systems (EEWES) for Schools in Ranau District

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Abstract. This article presents the main development components Early Earthquake Warning and Evacuation System (EEWES) for the Ranau District of Sabah. Many early earthquake warning systems have been developed since the last major earthquake in Ranau in 2015, but none has appropriately investigated the school children evacuation processes/exercises. The system was developed not just to expedite the evacuation process at these schools but also to help evacuate the school children and to get in touch with the children's parents who are outstation. Those parents will be updated on the evacuation initiative that is taking place on a real-time basis. The system may also transfer the evacuation details to the local and federal emergency services and other agencies concerned with the evacuation exercises. The system mainly utilised the APIs released by regional disaster centres, which may deliver speedy transmission alerts. The future research direction is to incorporate the local tremor sensor details into the system.

1. Introduction

Back in 2015, tremors with a substantial magnitude of 6.0 were experienced throughout the State of Sabah, including Federal Territory of Labuan, Beaufort, Beluran, Keningau, Kota Belud, Kota Kinabalu, Kota Marudu, Kudat, Kunak, Penampang, Putatan, Sandakan, Tambunan, Tuaran, Lawas, Limbang, Miri and Brunei. The substantial magnitude has caused eighteen fatalities on Mount Kinabalu (i.e., nine Singaporeans, six Malaysians, and three miscellaneous nationals). In addition, 140 climbers stranded on the mountain were rescued [1]. As a result, townships near the epic centre, such as Ranau, have experienced many changes in exposure to earthquakes [2-4]. For instance, many attempts were established to develop Earthquake Emergency Warning and Evacuation Systems (EEWES). These warning systems development initiatives were nonetheless focused solely on the detection perspective. Another predicament with the existing EEWES development initiatives is the lack of focus upon school children emergency evacuation [5] & [6]. As a result, those alerts have not been thoroughly combined with the other apps that can accommodate the needs of school children. There are also non-integration system weaknesses of the existing local seismic accelerometers like short-time windows alert, false event declarations, expensive maintenance, etc.

2. Significance of the studies

Ranau and other towns close to the epic centre, such as Kota Belud, are now highly susceptible to major natural disasters such as earthquakes, flooding and landslides. Given the high probability that these disasters might reoccur, and no thorough effort thus far was initiated to develop a proper Earthquake Emergency Warning and Evacuation Systems (EEWES) which involved the school children, their parents and teachers, this article outlines the initial EEWES development initiative, which was constructed for schools in Sabah.

3. Review of the literature

In an earthquake incident, an EEWES conceivably represents a source of alarms for assisting school emergency coordinators in their duties, allowing them to start the emergency plans. The teacher appointed as the emergency supervisor will consider the evacuation procedure by activating warning signals (e.g., siren and social media). They may warn other teachers responsible for evacuations and coordinate all the needed operations. In addition, the teacher must constantly be in contact with the parents [7].

EEWES for schools can be described as systems that seismic networks produce prompt alert messages to users (e.g., school children, teachers, and parents) within seconds of the beginning of an earthquake. Therefore, the system can be a viable means for implementing protective measures to lessen the number of schools facing earthquakes. For instance, the EEWES has benefitted the OKI Factory in Japan [8]. As a result, the system has been able to offer a significant reduction of losses. The critical parameter of the system is the lead time for taking rapid actions once an earthquake has been promptly detected [7]. However, lead times depend upon the distance between the earthquake source and the targets (school children, teachers, and parents) to be protected. Therefore, the time required to implement protective measures may vary from no warning to greater distance.

A review of the EEWES concepts and methodologies have been discussed by [9-11]. These articles highlight how challenging it can be for the school emergency coordinator to make the precise steps during an earthquake, often when the tremor has already been felt. Without proper EEWES for schools, children and their teachers will not be ready for an earthquake prompt evacuation. The evacuation exercise cannot thus occur as they were not within reach of the tremor information they were supposed to have. An integrated EEWES for schools will aid the school children and their teachers to evacuate rapidly and encourage the teachers (acting as evacuation supervisors) to effectively communicate with the parents on the present state of their children. These parents will be updated on the evacuation initiative that is taking place on a real-time basis. The system may also send the evacuation details to the emergency services and other agencies involved in the evacuation exercise. There is thus a need to intensify the state governments' readiness by developing an integrated EEWES for schools.

4. Research methodology

The problem with the existing EEWES development initiative is its lack of focus upon school children emergency evacuation. Most of the initiatives thus far only focus on the detection perspective since the last major earthquake event in Ranau. The system development methodologies were classified into four main parts: 1) Developing a control centre web-based app 2) Developing a school children evacuation emergency Android-based app, 4) Setting the earthquake alert APIs from Pacific Disaster Center (www.pdc.org) and the United States Geological Survey (USGS), and 4) Implementing and integrating all the development initiatives involved.

The development methodologies employed were fundamentally agile-based (i.e., Extreme Programming). Extreme Programming (XP) was adopted as the overall development methodology for the proposed warning system to help circumvent development delay. Furthermore, as an agile development methodology, it advocates regular "releases" in short development cycles and introduces checkpoints to promote requirement loops. Other XP elements combine code simplicity, user requirements, and frequent communication with the end-users. In addition, the proposed warning system can be designed not just for scalability but also for cost. Finally, XP is a team approach development methodology that enhances software quality and responsiveness to changing customer needs.

4.1. Developing a control centre web-based app
The Windows-based monitoring centre app will send alert messages to the mobile apps. The aims are to encapsulate some regional early warning systems centres such as PDC and USGS data and determine its magnitude. The lead times from these stations are essential as they will determine how quick the school children will be alerted about an earthquake event. The app is designed to cope with a target site like Ranau, close to a seismogenic area.

4.2. Developing a school children evacuation emergency Android-based app
The Android-based school-children app will capture the messages from the external disaster and local monitoring centres and release the alerts to the end-users (Figure 1).

4.3. Setting the on-site API earthquake alert from Pacific Disaster Center (www.pdc.org) and the United States Geological Survey (USGS)
This stage will focus on building the alert to detect the earthquake. In this instance, the API earthquake alerts from United States Geological Survey (USGS) and Pacific-Disaster Centre will be streamed to both the control centre and school children apps. While an event occurs, both apps can promptly perform event detection and provide location and magnitude estimates.

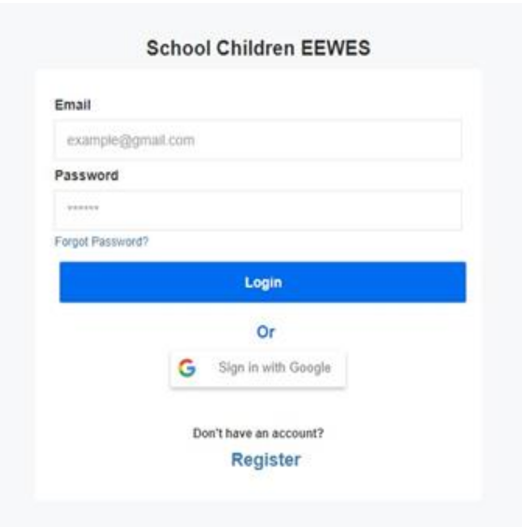

Figure 1. System log-in page.

4.4. Setting the on-site API earthquake alert from Pacific Disaster Center (www.pdc.org) and the United States Geological Survey (USGS)
The fourth stage is the system integration methodology. This involves a few rounds of field tests to ensure that the application is working well (providing evolutionary alerts like bell alarms and earthquake emergency evacuation 'To Do List'), embodied in its components, their relationships to each other, and the principles governing its design. This stage ensures that the application developed is operational and used, ensuring that the information system meets the quality standard.

5. System description and discussions
The critical components of the systems are divided into two parts (Figure 2). The Windows-based monitoring app primary function was to assure that the school children Android-based app was up-to-date. This was done through consecutive examinations of the Android-based apps. The Android-based school children apps were the core component of the entire school children EEWES. It does have log-

ins for the school emergency supervisors and parents or guardians of the school children. However, its primary function is two-fold: 1) for the emergency supervisor to refresh the present state of the children and 2) for the parents of the children to be updated with the present state of their children. This function is crucial as not all the parents of these children are within the school's neighbourhood when an earthquake occurs.

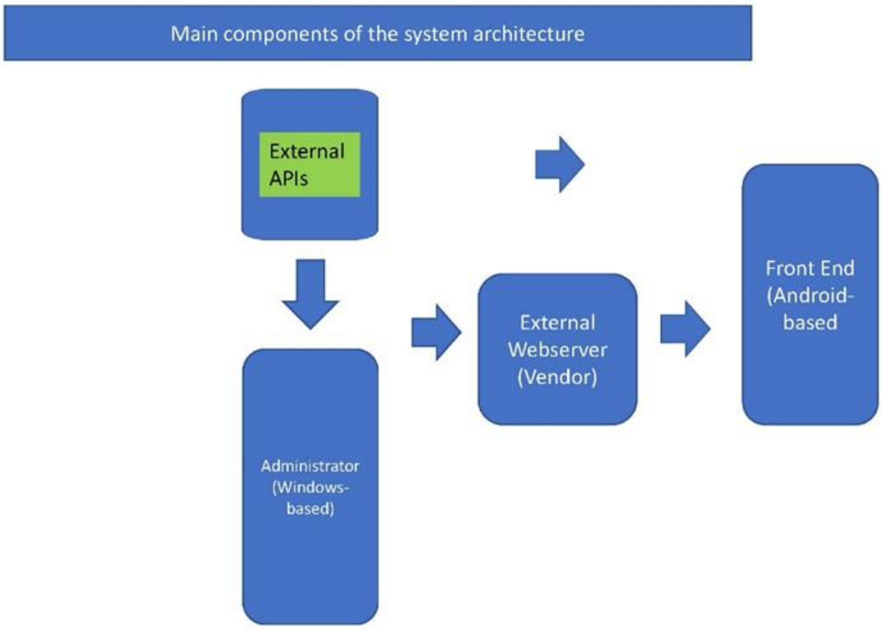

Figure 2: Main components of the system architecture.

The school children EEWES integrates Windows-based control centre app, Android-based school children app and alerts from disaster centres throughout the globe such as Pacific Disaster Centre and the United States Geological Survey APIs to accommodate rapid alert messages to school children. These parents need up-to-the-minute alerts and information. The shared earthquake APIs from these disaster centres have enabled the school children EEWES to be developed (Figure 3).

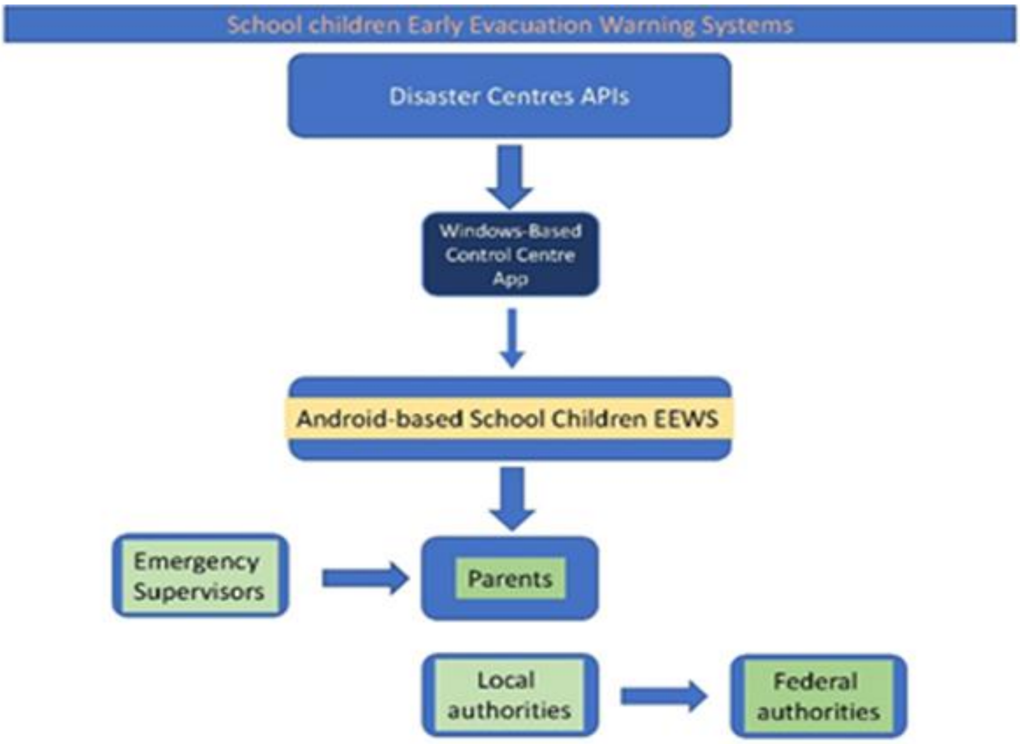

Figure 3: Information flow of the EEWES.

An early alert from the regional disaster centres will indeed allow the emergency supervisors of the schools in Ranau to rapidly react to the situations by ensuring the safety of the students and calm the parents down. In addition, the supervisors may also alert the local authorities for further evacuation initiatives. The development initiative is evolutionary. The alerts that were extracted from the disaster centres are 3-5 minutes late. Although the reading is lagging, it is worthwhile for the emergency supervisors in Ranau to initiate the evacuation plan.

6. Conclusions
Many EEWES have been developed since the last earthquake in Ranau [12]. Nonetheless, these systems have excluded the need for school children to be evacuated. The component-based development approach has allowed all the main components of the school children to be rapidly developed. The originality mainly lies in systems development, integration, and implementation methodologies, bringing together on-site sensor and disaster centre alerts, monitoring centres and school children apps. This integration work moves forward the existing focus of EEWES, which solely focusing upon the on-site sensor alert perfection studies. In addition, the proposed prototype usage may also be extended to other kinds of natural disasters such as tsunami.

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