E-PreS: Evaluation of Building Evacuation Drills

A Smart Tool to Help Building Evacuation Drill Designers to Find the Optimal Evacuation Pattern

Michail Chatzidakis*
Pervasive Computing Lab,
Department of Informatics, National and Kapodistrian University of Athens
Athens, Greece
mhatzi@di.uoa.gr

Michael Loukeris†
Pervasive Computing Lab,
Department of Informatics, National and Kapodistrian University of Athens
Athens, Greece
michael.loukeris@icloud.com

Stathes Hatjiefthymiades‡
Pervasive Computing Lab,
Department of Informatics, National and Kapodistrian University of Athens
Athens, Greece
shadj@di.uoa.gr

ABSTRACT

E-PreS is an EU funded program, which lasted from February, 2015 through December, 2016. It's goal is to provide the building drill evacuation designer with a useful tool, to evaluate specific evacuation scenarios and monitor them in real-time, increase community awareness against natural hazards and build up evacuation confidence while minimizing side effects. It's main target group is the school communities, primarily focusing on earthquake, flood or volcanic eruption drills, but it turned out to be a useful tool for generic use in all types of building evacuation drills. It is compact, user friendly, doesn't require internet connection and it can even function autonomously, without even the need for external electric power presence.

CCS CONCEPTS

• **Computer systems organization → Embedded systems**; *Redundancy*; Robotics; • **Networks** → Network reliability;

KEYWORDS

evacuation, drill, RFID monitoring, flood, volcanic eruption, earthquake, school

ACM Reference Format:
Michail Chatzidakis, Michael Loukeris, and Stathes Hatjiefthymiades. 2017. E-PreS: Evaluation of Building Evacuation Drills: A Smart Tool to Help Building Evacuation Drill Designers to Find the Optimal Evacuation Pattern. In *Proceedings of PCI 2017*. ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3139367.3139369

*Research Associate
†Researcher
‡Associate Professor

PCI 2017, September 28–30, 2017, Larissa, Greece

ACM ISBN 978-1-4503-5355-7/17/09…$15.00
https://doi.org/10.1145/3139367.3139369

1 INTRODUCTION

Building emergency evacuations are quite common and drills are organized to ensure that the evacuation, when and if needed, will be fast, secure and effective. There are general rules that apply, mostly based on guidelines from disaster prevention organizations, but designing a building evacuation pattern is still a challenging job, leaving to the evacuation organizer room for improvising and fine tuning so that an effective evacuation plan is created.

E-PreS [1] is the outcome of the collaboration of diverse organizations and institutes[1], leaded by the National and Kapodistrian University of Athens[2]

2 MOTIVATION

The evacuation of a building after a natural disaster can be a quite challenging task. The evacuation pattern depends on the type of the disaster, to begin with, the actual structure of the building which can be quite complex, the existence of places (e.g. staircases) which act as bottlenecks should also be taken into account, as well as the emotional state of the evacuees which may prohibit them from following the evacuation instructions precisely. Handicapped or injured evacuees add to the complexity of the drill evacuation scenario.

E-PreS goal is duo fold. It aims to help the drill designer watch his scenario in action, locate its weak points and take remedy actions where appropriate, and, on the other hand, build up a feeling of security to the evacuees by repeating an evacuation drill while they know that they are being "watched".

3 THE E-PRES SET UP

A complete E-PreS system consists of a number of checkpoints, each monitored by a couple of RFID antennas connected to an RFID reader which, in turn, is connected to a board computer. The evacuees are equipped with wearable RFID tags preferably placed on their shoes to avoid signal absorption and false readings from interfering bodies.

The RFID readers are connected to a board computer, which transmits the RFID tag readings along with the antenna id and the corresponding time stamps, through a number of Wi-Fi repeaters, to a back-end server which runs the web services and the databases needed for the system to operate.

[1]EPPO, NHMC-UoC, INGV, CEI, INCD "URBAN INCERC"
[2]http://en.uoa.gr

4 THE E-PRES ARCHITECTURE

From a high-level point of view, E-PreS system consists of five components:

- Sensor network.
- Data stream components.
- Data processing components.
- Service components.
- Web application components.

We adopted a *modified lambda architecture*, to meet the need for scalability and fault-tolerant processing in a distributed environment, as well as unexpected popularity. The architecture is adjusted to the resources' constraints and limitations, of a sensor network controlled from a mobile server.

Lambda architecture defines three layers of data processing maintained and prepared for queries from external components, namely:

- Batch layer.
- Serving layer.
- Speed layer.

4.1 Batch layer

The incoming data stream is equally distributed to *batch layer* and *speed layer*. The batch layer stores the data to a database, for persistence and consistency. It acts as a backup and failsafe environment for incoming data. We implement batch layer as a *data-lake* system that can handle massive amounts of data streams storing them efficiently.

4.2 Serving layer

The *serving layer* is essentially a specialized database, that loads the batch views. When a new batch view is complete and available, the serving layer takes over and automatically updates the outdated views so that up-to-date results are always available.

4.3 Speed layer

The *speed layer* acts identically to the batch layer, in the sense that it is processing the data received and creates views. However, data in speed layer is stored in a specialized memory module. It is used to compensate for the latency of the batch layer and acts as a real time storage and an analytical component filtering and processing the streams of fast incoming data.

Speed layer utilizes cutting-edge technology, implementing a storm server and bolt architecture, to achieve real-time views of the ongoing drill. Highly specialized interconnected pieces of software (bolts), provide a variety of functionalities, by transmitting messages from one to another and thus enabling the materialization of different functionalities, completing the location analytics picture. An example of flux real time calculation utilizing bolt architecture follows:

Storm topology receives a data stream of sensor readings through an MQTT message queue, as shown in Fig. 1. An implementation of a Storm IRichSpoutn is in charge of receiving and feeding the rest of the Storm topology, which delivers them to a Storm bolt designed to unmarshall the JSON format of the messages and transmit them, based on the message field of their respective tag id, to another bolt which is tasked to remove possible false readings. Finally, the bolt

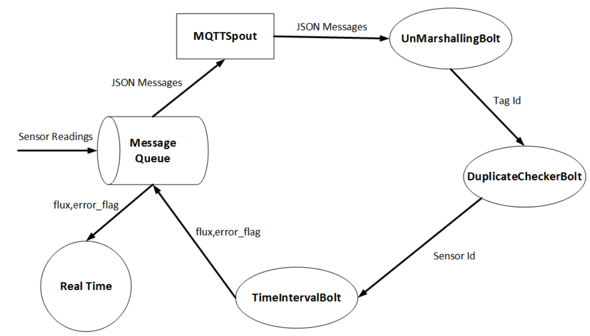

Figure 1: Flux Calculation Workflow

which calculates how crowded a specific point of interest is at any time, receives the messages based on the field of their respective antenna id and for repeated time intervals is measuring the possibility of congestion. This final Storm bolt, called TimeIntervalBolt, pushes the error messages to a dedicated MQTT topic for real-time consumption and also stores the calculated results for each antenna to a specific table in the database. Thus the real time flux is computed and the drill organizer has the most up-to-date information at his/her disposal.

5 PLATFORM TESTING - RESULTS

Seven official field trials have been conducted in all kind of environments and type of potential hazards. Specifically EPPO conducted two earthquake evacuation drills (on November 10th, 2016 and on November 23rd, 2016), NHMC also conducted two earthquake evacuation drills (on November 22nd, 2016 and on November 25th, 2016), INCD conducted one earthquake evacuation drill on November 24th, 2016, CEI conducted two flood evacuation drills (on October 21st, 2016 and on October 25th, 2016) and INGV conducted two volcanic eruption evacuation drills (on November 7th, 2016 and on November 30th, 2016)

The feedback of the evacuees and the personnel that used the equipment was more than satisfying. It proved that E-PreS is a robust, mature system which greatly improves the design and testing of every evacuation procedure. Its ability to be deployed in all kinds of environments even without electric power and accurately pinpoint scenario weaknesses, makes it a valuable tool in evacuation procedure planning.

E-PreS was presented in the 2016 Euroinvent and was awarded the Gold Medal.

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