Real-Time Microservices Based Environmental Sensors System for Hazmat Transportation Networks Monitoring

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Abstract

The transportation of dangerous goods represents one of the most critical risks particularly in urban areas. For example, every day large quantities of hazardous substances are transported by roads or railways inside areas with high density of population. Thus, to ensure urban and public safety the first challenge that we tackle is to find an environmental information system, which is able to provide risk management and monitoring. Moreover, it can capture urban transportation dynamics and offer specific services, visualization, analyses and evaluation of the hazmat risk in various high-risk zones. In addition, due to wireless technologies and real time intelligent sensors, the risk of dangerous goods can be carried out in real time. In this work, we adopt a microservices based architecture to have a real-time environmental sensors system that have highly scalable applications on cloud environment. By definition, this architecture consists of a set of loosely coupled and independently deployable services. In addition, the proposed system is conducted with a smart data collector, visualization abilities and a variety of distributed sensors in order to enhance the hazmat transportation network monitoring. Finally, we show how to integrate efficiently into the system prototype the hazmat routing container embedded microservice, and illustrate the orchestration with other microservices to improve this system with hazmat routing capabilities using various routing algorithms particularly bi-directional A* algorithm. This work constitutes the first step to build the Hazmat planning aid system that provides valuable data and knowledge to urban planner and decision makers.

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1. Introduction

Accidents represent an event caused by the damage to a chemical plant, transport vehicle, and storage of hazardous substances. Hazardous materials or dangerous goods include explosives, gasses, flammable liquids and solids, oxidizing substances, poisonous and infectious substances, radioactive materials, corrosive substances, and hazardous...
wastes. Accidents involving the transportation of hazmat can result from different causes and lead to severe consequences characterized by fatalities, injuries, evacuation, property damage, environmental degradation and traffic disruption. Therefore, it is relevant, important and necessary to work towards identifying, predicting and minimizing the risk of incidents in the transportation of dangerous goods and their potential consequences. The transportation of dangerous goods currently confronts a large number of problems. Such as: i) Lack knowledge of the position, the nature and characteristics of the goods transported, and the risks associated with them; ii) No systematic data on incidents involving the transport of dangerous goods; iii) Late and incorrect information, concerning the application and control of rules and regulations of hazardous transportation; iv) No Continuous regulatory monitoring. All these facts emphasize the necessity to specify and prototype a real-time environmental system for hazmat transportation, which can track in real time hazmat vehicles and provides information, knowledge and services that helps decisions makers and urban planners to supervise hazmat transportation and to better reduce the risk of moving hazardous materials. This work focuses on providing as single system various cooperating services such as real-time hazmat monitoring, risk-knowledge, hazmat routing, and transportation document, in order to provide more effective and reliable transport problem solutions aimed at monitoring dangerous goods transportation in Mohammedia City. The global system is designed as a microservice based architecture as defined in (Daya, 2016). It is an architecture style, in which large complex software applications are composed of one or more services. Microservice can be deployed independently of one another and are loosely coupled. Each of these microservices focuses on completing one task only and does that one task really well. Moreover, this type of architecture can allow building a large-scale system capable of evolving and adopting new standards and services. The rest of the paper is organized as follows: in Section 2, we begin with highlights related work specifically within the context of hazmat transportation management and microservice-based architectures. Section 3 presents an overview of microservice architectures before describing in detail the proposed system in section 4. Sections 5 gives the main technical part of the paper and describes the architecture implementation of the prototype, in addition to the performance evaluations. We conclude the paper in Section 6 and address areas of future work.

2. Related works

The transportation of dangerous goods is one of the most complex and most safety requiring transportation technologies. Many researchers have studied transportation monitoring, tracking and vehicle routing problems. In (Boulmakoul, 1999) the authors give general specifications for a monitoring system for the transportation of hazardous materials. The paper (Planas, 2008) presents a monitoring and intervention system for the transportation of dangerous goods based on systems used in air traffic control. This system aims to provide civil security centers with real-time knowledge of the position and contents of dangerous vehicles. An open architecture for real time GPS data collection in addition to its performance and scalability tests is explained in (Laarabi, 2012). (Erkut E. T., 2007) . The authors of (Yılmaz, 2016) give a literature survey about the hazmat transportation articles classified according to risk, routing and scheduling, emergency response, network design and accident analysis.

As microservice is relatively a new concept, there are a few works in the field of microservices-based architecture. Basic information about the microservice approach is provided in (Newman, 2015). With lots of examples and practical advice, this book takes a holistic view of the topics that system architects and administrators must consider when building, managing, and evolving microservice architectures. In (Familiar B. , 2015), Familiar provides a working definition of microservices and contrasts this approach with traditional monolithic layered architecture. Daya in (Daya, 2016) gives a broad understanding of this increasingly popular architectural style, and provides some examples of the way to develop applications using the microservices approach.

3. Microservices-based Architecture

In general, the objective of environmental information systems is to facilitate the collection, organization, storage, analysis, and publication of information related to an interesting phenomenon (the hazmat transportation in our case). These types of systems deal with geospatial information and services. They allow the user to store, query and process environmental information and visualize it in maps, diagrams and reports. From the point of view of system theory, environmental information systems are autonomous components, which provides different functionalities in a cooperating way. The proposed system, as an environmental information system, can be viewed as a collection of
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