Mobile Cloud System for Road Safety

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ABSTRACT
Road accidents are one of the major concerns for humanity today, since it is the source of many diseases and injuries. However, to make adequate road safety actions and policies, it is required get road accident information and analyses them. In the present work, we propose a Cloud based system for road safety called RoSa-Cloud. The system provides a cloud service offering access to road accident information from any web site and any client device (phone, tablet, laptop, etc.). We provided a prototype of RoSa-Cloud system and developed an android mobile application called RoSa App. The mobile application is very useful to police service to avoid entering precisions about accident location, since all modern smart phones supports GPS localization and by consequence the mobile application can get and record the precise GPS coordinates.

CCS Concepts
• Information systems→Information storage systems→Storage architectures→Cloud based storage. • Information systems→ Information systems applications→Spatial-temporal systems→Geographic information systems.

Keywords
Road Safety; Cloud Computing; Mobility; Web Services.

1. INTRODUCTION
With the increasing number of road accidents, the road safety is becoming a major concern for both citizens and politics. By consequence, governments are making many actions and mobilizing resources for road safety. Furthermore, from the seventeen "Sustainable Development Goals" [1] of the United Nations (UN), two of them deal with road safety. In fact, the third development goal "Health and well-being", aims to halve the number of global deaths and injuries from road traffic accidents, by 2020 (goal 3.6). Likewise, the eleventh goal "Sustainable cities and communities", requires improving road safety (Goal 11.2).

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However, to achieve these goals in terms of road safety and decrease the number of accidents, studies and researches on road accidents should be driven. However, the biggest problem with these studies is the access to road accident information. In fact, except the road accidents' statistics, the access to most accidents' information requires a heavy administrative procedure. In addition, there are many road accident's information sources.

Previous research works on road safety systems such as ROARMG (Road Accident Risk Maps Generator) [2] or GIS-RAVS (Geographic Information System and Road Accident View System) [3] can be used to analysis road accident information. However these systems are not suitable for the collaboration between the actors of road safety (police, AMT, fire-fighters, researchers, media, etc.). This collaboration become available with another work [4] providing the AVRA Bangladesh system in the form of a web site allowing the interaction between the road safety actors. However, the AVRA Bangladesh system is not suitable for mobility since it does not support the interaction with mobile devices.

The goal of this work is to provide a novel Cloud based system called "RoSa-Cloud" (**Ro**ad **Sa**fety Cloud) offering information and features for all actors of road safety. RoSa-Cloud will centralize all road accident information in a Cloud Service and this Cloud service will be requested and provided with road accident information from anywhere and anytime. RoSa-Cloud is suitable to be used through mobile devices.

In the following sections, we will present related works according to road safety system, then we will present Cloud Computing, then we will discuss the process of gathering road accident information. After that, we will present the architecture of RoSa-Cloud. Finally, a prototype of RoSa-Cloud will be presented.

2. RELATED WORKS
Liang et al. developed in [3] a prototype for reducing road accidents called "GIS-RAVS". The GIS-RAVS system allows entering and updating road accident information. The system permits also retrieving road accidents' information or performing statistical analysis. However, the main downside of GIS-RAVS is that the system is not linked to the information's sources.

In another work on road safety system [2], the system ROARMG was provided. This work permits to calculate and visualize on the accident risk for each geographical location based on road accident data. However, the main limitation of ROARMG is that the information is decentralized and the road accident information is not accessible to all road safety actors.

Chen et al. [5] proposed the Automatic Motorcycle Turn Signal (AMTS) system that utilizes gyroscope sensor of the Android phone to detect the turning direction of a motorcycle and then the system turns on the light and sound accordingly.

In a recent work, Solaiman et al. [4] presented a prototype of web based system called "AVRA Bangladesh" allowing the collection, analysis, and visualization of road accident information in Bangladesh. The system allows different kinds of analysis and road accident can be gathered from different parties (police, hospitals, etc.). However, the system AVRA Bangladesh is not suitable for mobility and interaction with other system since it was designed to be hosted in a web site and the only way to access the system is through a web browser. Thus, the system cannot interact with other systems and mobile devices.

In a more work, Sam Aleyadeh et al. [6] proposed the Smartphone Road Monitoring (SRoM) system that is capable of sensing road artifacts such as potholes and slippery roads. The information is collected through crowdsourcing and processed by base stations, to address road safety related events.

3. Cloud Computing

3.1 Definition

The American National Institute of Standards and Technology (NIST) defines the Cloud Computing in [7] as follows:

"Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction".

3.2 Essential characteristics

According to the NIST, the Cloud model is characterized by five essential characteristics: on-demand self-service, broad network access, resources pooling, rapid elasticity, and measured service [7]. Figure 1 shows these five essential characteristics of Cloud Computing.

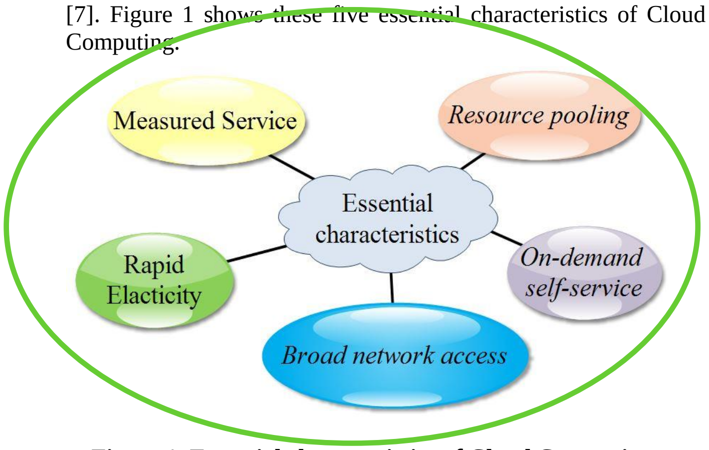

Figure 1. Essential characteristics of Cloud Computing [7].

The first characteristic "On-demand self-service" ensures that resources are provided to the user automatically without requiring human interaction. The second "Broad network access" means that resources are accessible through the network from all client platforms (thin or thick). The "Resource pooling" characteristic means that resources are pooled to serve multiple consumers using a multi-tenant model. The next characteristic "Rapid Elasticity" allows users the provision and release of resource elastically according to their needs. The fifth characteristic "Measured Service" allows the monitoring, control, and reporting of resources usage.

3.3 Service models

According to the NIST, the Cloud model provides three main categories of services: "Software as a Service", "Platform as a Service", and "Infrastructure as a Service". Software as a Service (SaaS) provides applications running on the Cloud to consumers, while Platform as a Service (PaaS) allows consumers to deploy onto the Cloud applications created using programming languages, libraries, services, and tools supported by the Cloud Service Provider (CSP). They have control on deployed applications and configuration settings. Finally, Infrastructure as a Service (IaaS) permits to consumers the provision of computing resources (processing, storage…) without managing or controlling the underlying hardware [7].

3.4 Deployment models

The Cloud Computing can be deployed according to four deployment models: Private Cloud, Community Cloud, Public Cloud, and Hybrid Cloud [7]. The Private Cloud is only used by a single organization. In the Community Cloud model, the cloud is used by a community of consumers from organizations sharing the same concerns. In the Public Cloud model the cloud is accessible for anyone. Finally, the Hybrid Cloud is the composition of two or more distinct clouds (private, community, or public).

4. ROAD ACCIDENT INFORMATION

The quality road accident information is crucial to perform analysis and make road safety policies. By consequence, the understanding of the process of collection of road accident information is required to build robust road safety system.

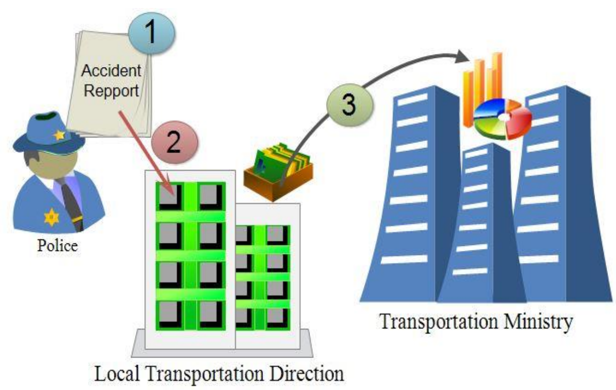

Figure 2. Road accident information

As shown in figure 2, when the accident occurs, an accident report (containing the details of the accident) is edited by the police. Later, this accident report is transferred to the Local Transportation Direction (LTD) corresponding to the location where the accident occurs. The LTDs periodically sends statistics on road accidents to the Ministry of Transportation (MT).

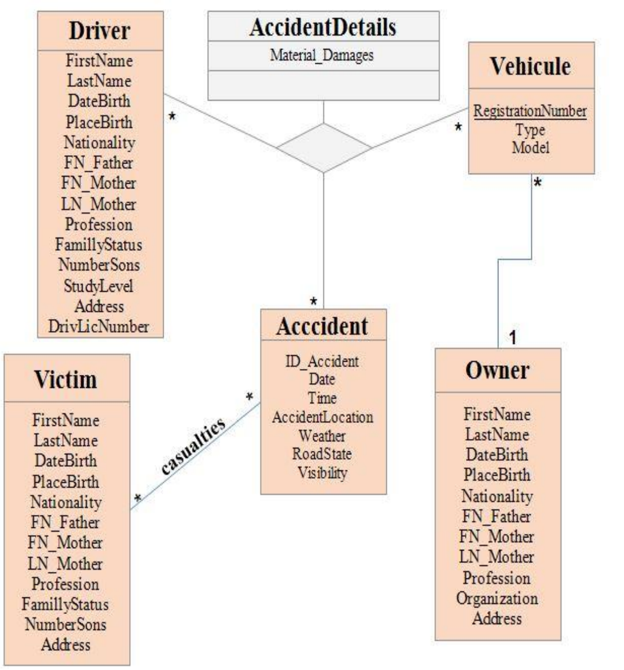

Figure 3, Class diagram of road accident information.

The accident report established by the police services contains information about the accident: type of accident (deadly accident, injury accident, or material), data and time of accident, accident location. The accident report contains also environmental information about the accident: the weather (sunny, cloudy, rainy, etc.), the visibility, and road state (slick, good, bad, etc.). The involved vehicles, their drivers, and vehicles owners should appear in the accident report (figure 3). The causalities are also mentioned in the accident report.

5. THE ROSA-CLOUD SYSTEM

5.1 The system overview

The proposed road safety system RoSa-Cloud is designed to provide a cloud service (SaaS). The web service stores the road accident information in a central database. As shown by figure 4, the web service is accessible from any device (phone, tablet, workstation, etc.) and can also be accessible from web sites also (for example the AMT's web site). Thus, the road accident information hold in the RoSa-Cloud's database is accessible by AMT's employees, the police services (from the accident location), etc.

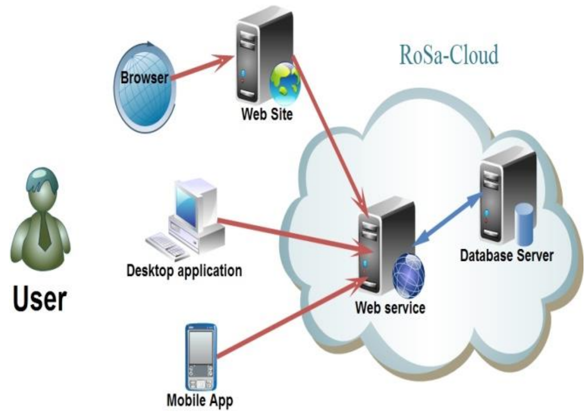

Figure 4. Architecture of the RoSa-Cloud system.

Web service offer several methods for: Authentication (***Connect*** method), uploading road accident information (***Upload*** method), updating road accident information (***update*** method), and querying road accident information (**getAccidentInformation** method). A mobile application "RoSa App" is also provided to record the road accident information from the location of the accident. It is also helpful to police services to easily indicate the precise location of the accident using the GPS (Global Positioning System) coordinates supported by all recent smart phones. Thus, using these GPS information, we avoid inserting location information such as road name, department, etc.

5.2 System implementation

We implemented a prototype of RoSa-Cloud system. The web service were developed using the programming language PHP and the "db_roadsafety" database was developed in MySQL. Both the web service and the database were deployed on a XAMPP [8] server (figure 5). The web service was developed using the PHP library NuSOAP [9].

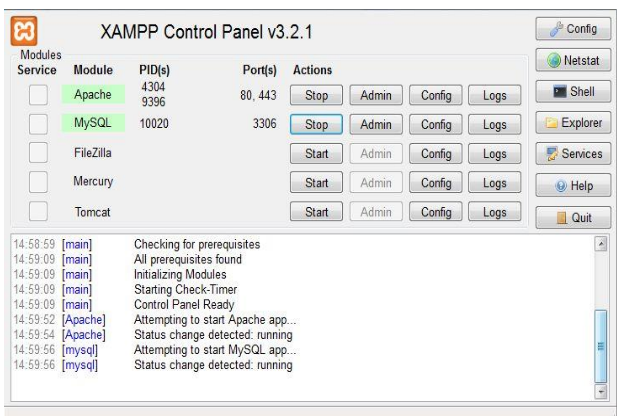

Figure 5. Control panel of XAMPP server.

The web service was implemented according to the In addition, an Android mobile application called "RoSa App" was implemented. The application can be deployed on any recent Android OS since the SDK (Software Development Kit) version was 2.3.3 (API 10). We deployed the "RoSa App" on an emulated Nexus 10 phone with 512 MB of RAM. The operating system of the emulated phone is Android 2.3.3.

5.3 Access control

The RoSa-Cloud system saves the users credentials and roles. Thus, when a user wants to connect to the system, he provide his corresponding credentials to the RoSa App and the later invokes the "Connect" method, which returns the role of the user to the application. If the credentials of the user are not correct or if the user does not exist in the database, the application will show an error message to the user (figure 6).

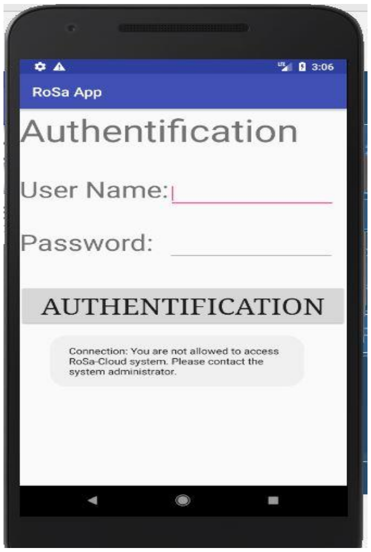

Figure 6. Connection to RoSa-Cloud using mobile application.

However, if the user exists in the database, the RoSa-Cloud system returns his role which is returned by the Connect method. We defined two basic roles: information collector (figure 7) and analyzer (figure 8). Other roles can be defined later according to future needs.

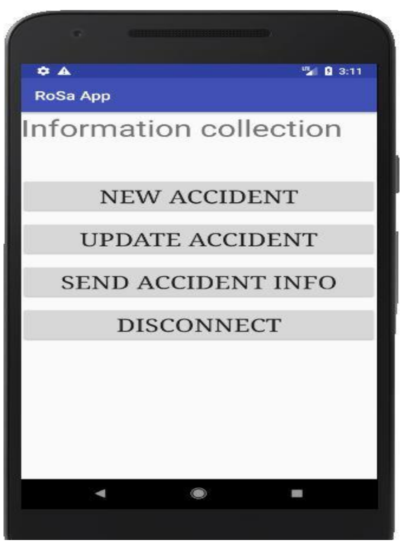

Figure 7. Information collection activity.

The information collector role (figure 7) is mainly designed to police services to enter accident information. It allows users to enter road accident information and update them. The user can validate also upload accident's information to RoSa-Cloud by invoking the web service's method "Upload".

Figure 8. Information analyzes activity.

The information analyzer role (figure 8) is designed to analyze and visualize the road accident information in form of maps and statistics. This role mainly uses the *getAccidentInformation* web service's methods.

5.4 Road accident information

When an accident occurs, the police services record information about accident such as date, time, type, and localization. With the use of RoSa App, the policeman will not enter all information about accident location (such as road name, state, etc.), but have just to enter GPS coordinates. Furthermore, if the policeman is at the accident's place, he can choose the option "Actual position" to avoid entering the GPS coordinate and get them from the mobile device (figure 9). To help investigation, the policeman should also enter weather, road state, and visibility information. All the victims and vehicles involved in the accident are recorded. For vehicles, their owners and the drivers should be entered. Once the accident information save locally, the policeman should send them to the cloud using the "Send accident Information" button which invokes the cloud service's method "Upload" with accident data.

Figure 9. Accident information gathering using RoSa App.

6. CONCLUSION AND FUTURE WORKS

In this work we provided a cloud based road safety system called "RoSa-Cloud". We also implemented a prototype of the system and developed an Android App called "RoSA App". The mobile application will help the police services to avoid inserting precise location information using the GPS coordinates. The RoSa- Cloud system will be presented to the AMT to an eventual adoption.

The "RoSa-Cloud" is designed to be used in a trusted private cloud model. As future extension for RoSa- Cloud system, we will extend the "RoSa-Cloud" to be suitable with any cloud deploy model (private, community, public, or hybrid). To achieve this, we will encrypt road accident information and use access control aware searchable encryption techniques such as xSE-ACAS [10] to encrypt and access road accident information. The use of techniques such as xSE-ACAS are required to deploy RoSa-Cloud in public cloud infrastructures since some road accident information are sensitive.

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