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A Novel VOBE Framework for Road Safety Management

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Abstract

Virtual Organization Breeding Environments (VOBE) represents a framework of organizations, institutions and individuals that cohere to long term base co-operations and infrastructures, mainly towards ensuring the ability of rapid configurations of temporary alliances working in potential Virtual Organizations. In order to produce positive road safety outcomes, strong management in all aspects of road safety is required. Integrating road safety management technologies with VOBE will provide a unique resource sharing capability that will improve road safety .In this paper, we propose a framework based on the VOBE concept to model the functional structures and processes between diverse interdisciplinary entities (e.g. police stations, health institutes, intelligent systems etc.).Unified Modeling Language (UML) is used as a standard way to visualize the design of the new framework. We demonstrate the applicability of the proposed framework by applying it to two case studies representing major problems on the road. The evaluation of the framework shows that it is both applicable for resource sharing in road safety management scenarios. The framework is designed in a conceptual way without committing to any specific programming or technical aspects of implementation which make it very scalable

Keywords: *Virtual Organization, Virtual Breeding Environment, Road safety management, conceptual design, UML*

1. Introduction

Automobile technologies have made it possible for people to travel from a location to another in a short time, but this has put great amounts of pressure on the roads and often causes many problems such as traffic jams and accidents. In Spain traffic accidents kill more than 3000 per year [1], in the United Kingdom there were 1,754 traffic accident fatalities and 23,039 serious casualties in 2012 [2], and in the United States there were 33,808 traffic accident fatalities in 2009 [3]. Researchers in all areas concerned with road management have been trying to come up with solutions capable of improving road safety; the concept of vehicle to vehicle (V2V) communication is considered as one such solution. As the medium for V2V communication, Vehicle Ad Hoc Network (VANET) is used which is a wireless network formed dynamically between a collections of cars. VANET has been researched widely to provide road safety services such as accident warning and weather notification as well as some none safety services such as multimedia and gaming. The concept is in its infancy and can only be used for limited resource sharing and there are some unsolved challenges yet to be addressed in VANET such as how to involve other resource providers outside the boundary of vehicles such as police, hospital and fire brigades in cases such as accident. [4] Claims that the data sources held by police and hospital for example have limited values on their own and they should be combined and shared to produce a comprehensive view of an accident.

In this paper we use the concept of Virtual Breeding Environments (VBE) and Virtual Organizations (VO) in combination with VANET to propose a novel resource sharing management framework to improve road safety. A VBE provides the environment in which VOs can be born and live for the duration of their task according to some predefined collaboration criteria. VO can be thought of as a dynamic ensemble of communicating and collaborating entities (vehicles in our case) that come together to share resources to accomplish a shared goal. Our proposed framework is particularly important for rural roads because accidents happening in rural roads in USA for example “account for 54% of all traffic fatalities” and one of the reasons for this number of fatalities put forward by [5] is not being able to alert emergency services on time. In an even of accident a VO can be set up to alert all relevant parties in a timely manner and bring together required resource to deal with the accident quickly. According to [6] 50% of all traffic accident deaths in the UK occur at the site and [1] claims that quick and efficient emergency service provision in an accident is critical to reduce the number of fatalities. Two other researchers [7] and [8] also found that having an automatic notification mechanism to notify emergency services in an event of accident reduces fatalities substantially. Our conceptual framework can be realized

to manage communication and resource sharing between relevant parties that can deal with arising situations effectively and in result improve road safety. To show the applicability of the framework we develop and model two nontrivial road safety case studies and visualize the proposed solution using derivatives of UML diagrams suggested by [9] .The paper is organized as follows; the subsequent section demonstrates the related research, the research methodology is described in section 3, while section 4 illustrates the framework design and modeling. Section 5 discusses the analysis and the evaluation of the framework and finally section 6 concludes the work.

2. Related Research

VO is accepted by both industry and academic communities as one of the mechanisms to tackle the challenge of information sharing and collaboration, because VO can bring together all resources and create one face that stakeholders can interact with [10] . The concept of virtual resource sharing has been researched in diverse areas such as road management, archaeology, science labs and health care. For example a VGrid is suggested by [11] and [12] where grid computing technology is combined with VANET to tackle traffic related challenges such as lane merging, VANET-Cloud is suggested by [13] where the cloud computing infrastructure is extended with VANET to share resources between vehicles. [14] Suggests a Virtual Research Environment (VRE) where researchers across disciplines can come together and share knowledge and skills to carry out research over time and space. VRE is described as "a set of online tools, systems and processes; interoperating to facilitate and enhance the research process within and without institutional boundaries" [15]. A VO framework to manage archaeological excavation is presented by [16] where they show how the concept of virtual organization can enhance the management process of an excavation. ArchaeoGRID is suggested by [17] and the purpose is to establish a GRID-network between many communities of archaeologist to unify the knowledge, data and resources present in these communities. [18] Has developed a framework from software engineers' point of view, for collaboration in healthcare sector during service provision. A patient centric system for virtual medical teams delivering health care to patients at their homes is developed by [19], the system aims to support "dynamic creation, management and coordination" of the virtual teams.[20] present an outline of a virtual lab for engineering students, and the purpose is to provide students with the tool to participate in various experiments in control engineering across several universities via the internet.

However all the researches relating to road safety concentrate on resource sharing between vehicles and ignore resources outside vehicles which are very important for road safety. The researchers also fall short in providing a clear picture as to how resources are managed which is the core issue in virtual collaboration. [21] Stresses the importance of having a clear mechanism to manage the resource sharing between resource providers and consumers. In this paper we propose a conceptual framework for V2V and other road safety stakeholders to collaborate and share resources in virtual organization settings.

3. Research Method

The research methodology of this paper is through case study development and evaluation as explained in [22]. A case study investigates real life phenomenon which in a sense is an empirical inquiry that relies on multiple sources of evidence and according [23] a case study is investigated to provide understanding about an issue or to "redraw generalization". To achieve this we carry out the following steps:

1) Survey available literature in the field of road safety management and resource sharing
2) Investigate the concept of VBE and VO and put together the novel framework that aims to manage the communication and resource sharing between interdisciplinary entities concerned with road safety
3) Develop simple nontrivial road safety related case studies
4) Classify the main actors and resources in the case studies according to the framework
5) Visualize the frameworks for each case study using graphical notation proposed in[9]
6) Evaluate the framework and identify the strength and the shortage of the design.

4. Framework Design and Modeling

Our research is built upon some assumptions that are clarified in Section 4.1. The framework is designed and set up to include long-term road safety management facilities using the concept of Virtual Breeding Environment. Generally speaking VBE provide the required infrastructure on a long term base for the creation and management of dynamic resource sharing ensembles called VO. VBE also can ensures and develop trust between the entities willing to share resource on a temporarily base by providing a near permanent environment with the necessary infrastructure for the creation and management of VOs. The main aim of a VBE is to increase "chances and preparedness towards collaboration in potential virtual organizations" [24]. The infrastructural components of a VBE may include precise processes for the formation of VOs, IT infrastructures, catalogues of participants, service level agreements (SLA), etc. VOs are temporary ensembles that can rapidly come to existence based on a timely collaboration request for resource sharing and a VO should provide the following:

1) Participants collaboration medium
2) Resource allocations mechanism

3) Resource access policies
4) Service level agreements that regulates participations

The need for creating a new VO typically follows from the emergence of a set of collective opportunities, goals, or interests; once a VO is formed it manages the collaboration between all participants to achieve the required goal. Our VBE framework named **Vec-VBE** is explained in section 4.2 and two scenarios are considered in the framework to demonstrate the use of the framework in two major problems faced on the road (i.e. accidents and traffic jams). These scenarios are designed and set up using the Virtual Organization concept and we call them **EmergencyM** and **TrafficM** which are explained in Section 4.3.

4.1 Research Assumptions

Our research assumes that police stations, health institutes and insurance companies can be online and connected to the internet through any web based interface. The Vehicles connected in VANET and the drivers are equipped with existing mobile applications or in the near future, smart cars (i.e. Internet based vehicles or Internet of Vehicles) to be able to use the services of our new framework. Any free or paid software/hardware tools (i.e. traffic analyzer software, intelligent decision support systems, Dynamic Google Map, Cloud services, CCTV etc.) can be a part of the framework.

4.2 The Design and Setup of Vec-VBE

VBE models according to [9] may include the following list of actors: resources, partners, customers, externals and associates. The main difference between partners, associates and externals is the time that they act in the framework. Partners are permanent actors and should be defined from the beginning in the VBE model while, associates and externals act (provide services) for a limited duration of time and usually participate in the VO rather than the VBE. Externals have shorter acting time as compared with associates. Our VBE, Vec-VBE, makes use of the following actors as represented in the table below:

Table 1 Actors in Vec-VBE

Resources	Partners	Customers
Internet Resources	System Administrator	Driver
Intelligent Cloud Services	Finance	-

Figure 1 illustrates the scenario of the Vec-VBE framework which is modeled using UML notations. The task of the finance partner is to provide required funding to support the VBE administration. Funding can be from government, road safety agencies, regional interest groups or insurance companies, the "finance" partner shown in figure 1 can represent any of these funding parties. The System Administrator has full control and access to the resources. The driver can use the paid Intelligent Cloud Services and freely access the Internet resources (i.e. free weather forecast, Google maps etc.). The use of both resources is operated by a task called Infotainment.

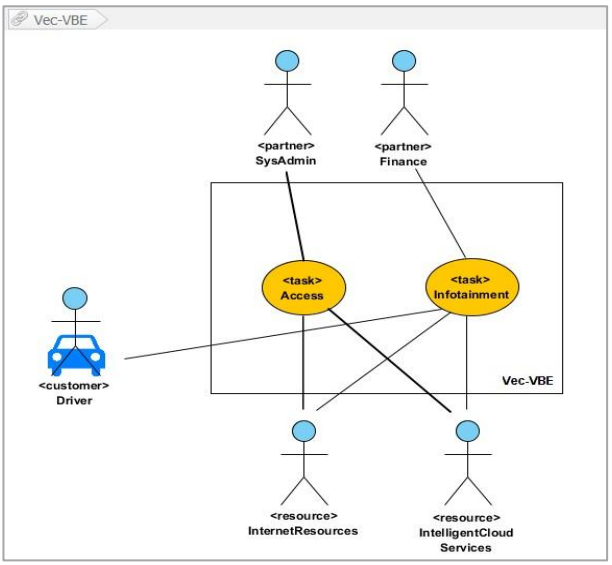

Fig.1 Use case diagram of Vec-VBE

Figure 2 shows the behavior of the infotainment task while handling the payment function. The Orchestrator (OR) controls the payment transactions between the Driver (DV) and the Finance (FN) to allow the use of the Intelligent Cloud Services (ICS). The Internet resources however can be accessed without the need of the OR as no payment is required. The technology used in the OR is out of this paper's scope and it may involve the use of web interfaces, network connections, software and hardware.

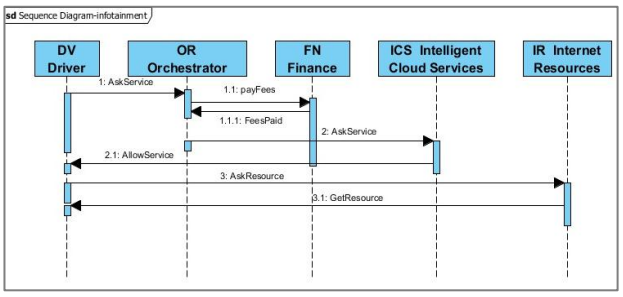

Fig.2 Sequence diagram of the Infotainment task

4.3 The Design and Setup of VO

The VO framework supports the timely services and communication between relevant parties in terms of road safety management, for instance in the case of vehicular accidents and traffic jams. Case one and two illustrates the accident, and traffic jam scenarios respectively.

Case 1: Accident Scenario (EmergencyM VO)

We consider the following scenario for our first case study:

Two vehicles on the road involve in an accident, the drivers and passengers in the vehicles are injured. The driver of the first vehicle manages to use the facilities in his vehicle which is connected to the internet to request the VBE (Vec-VBE described in Section 4.2) to organize an emergency rescue task where the nearest health institutes and police stations are located and alerted to send assistance to the site of the accident. CCTV footage of the accident may also be required by the police to report the incident.

The following services should be supported:

1) finding the nearest health institute (e.g. hospitals, clinics)
2) finding the nearest police station
3) contacting the insurance companies (e.g. car insurance, health insurance)
4) In this case, the hardware/software services are also supported using the technology provided by Mobile applications or the internet based vehicles in case the driver is unable to use the interface when the vehicle is in (abnormal) situations.
5) sending warning signals to the upcoming traffic (supported by VANET) and suggesting an alternative traffic plan

The Emergency M VO shown in Figure 3 is linked to the actors of Vec-VBE i.e. Driver, Finance and the resources. The other actors linked to the Emergency VO are:

1) A customer, Initiator (i.e. driver's vehicle, other vehicles, bystanders) who sends the distress signal
2) Three associates, Health Institute, Insurance Company, and Police Station
3) An external member, CCTV which provides temporary services for the investigation of the accident

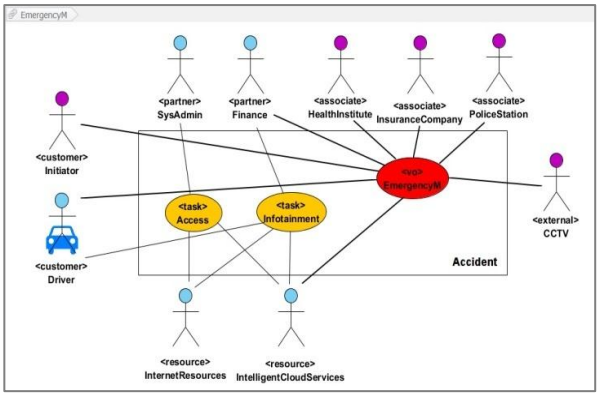

Fig.3 Use Case Diagram of the Accident Scenario

Figure 4 demonstrate the behavior of Emergency VO according to the scenario mentioned above. IN (Initiator) and DV (Driver). The partner interface FN is specified as Finance and the associates' interfaces are HI (HealthInstitues), IC (InsuranceCompany), and PO (PoliceStation) respectively while CCTV (Closed-Circuit Television) is a service acquired externally.

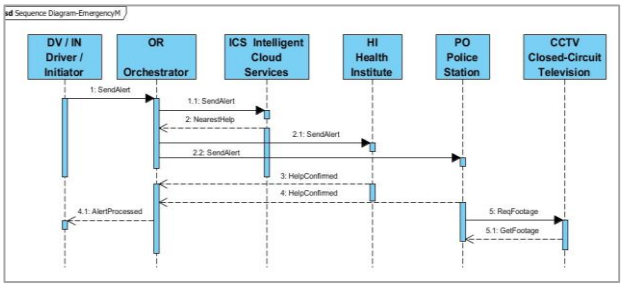

Fig.4 Sequence diagram of the EmergencyM VO

Case 2: Traffic Jam Scenario (TrafficM VO

We consider the following scenario for our second case study:

Mrs. X is stuck in a traffic jam. Using an app on her Smartphone, she requests the VBE (Vec-VBE described in Section 4.2) to propose an alternative route to get her to her destination. In this case, traffic analyzer software, intelligent cloud services and the nearest traffic police collaborate to recommend the best alternative route.

In this case the Software Provider sends traffic analyzer software results to the nearest traffic police. The TrafficM VO shown in Figure 5 is linked to some of the actors of Vec-VBE i.e. Driver and Intelligent Cloud Services. The other actors linked to the TrafficM VO and they are:

1) A customer: Initiator (i.e. vehicle driver (Mrs. X), other vehicles) which initiate the creation of the TrafficM VO
2) An associate: TrafficPolice which collaborate and share resource with other members of the VO to find alternative route for the customer.
3) An external member: SoftwareProvider which provides real-time analysis and findings of the traffic.

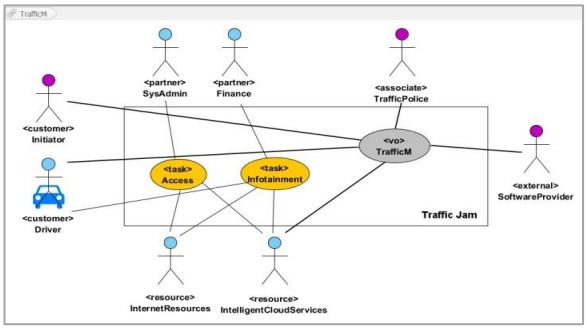

Fig.5 Use Case Diagram of the Traffic Jam Scenario

5. Discussion

As presented in the literature review, there are a number of researchers trying to find ways to improve road safety and our proposal is a contribution to this literature. We have presented a conceptual framework with the primary aim of bringing together necessary resources and making it available to relevant parties to better the services provided to road users and which in result improves road safety. The aim is not to prescribe how humans or vehicles should perform the tasks; instead it is targeted at considering the integration of software and current trends of vehicle technology with relevant organizations. The notations used in [9]were extended to enable a more flexible representation of the new actors. However, the technical aspects (i.e type of signals, type of connections) are beyond the scope of this paper. We designed the models at a conceptual level, nevertheless, it is possible to propose communication primitives that would represent direct vehicle and human involvement, which could improve the framework and make it more representative. We have shown In two case studies that using the framework in a specific geographical area may help to anticipate the appropriate steps necessary to execute the tasks, as well as aid in avoiding future problems and delays (for example another accident in the same geographical area). The framework shortens the systematization time since VO contain Service Level Agreements (SLA) and ensures the optimal assembly of the VO team that would achieve the main goal of the framework and enable the movement towards better road safety. In addition, the model can be reused and adjusted for further projects.

Conclusions

Every year throughout the world people die because of road traffic accidents and to elaborate more we have provided some statistics in the introduction section. Researches show that some of the death can be prevented if the right emergency response is provided at the right time. In this paper, we have proposed a resource sharing management framework between different entities concerned with providing services to drivers. The framework combines VANET, VBE and VO concepts that aim to show, conceptually, how different technologies and theories can be utilized to improve road safety. We have modeled two common traffic related scenarios using the framework. The evaluation of the framework showed that it is effective and scalable. The practicality of how to implement the framework is beyond the scope of this paper and it is our intention to implement the framework in the future. The outcome of this research contributes towards finding a suitable and effective solution for road safety management and improvement.

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