Communication and Tracking Ontology Development for Civilians Earthquake Disaster Assistance

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ABSTRACT

One of the most important components of recovery and speedy response during and immediately after an earthquake disaster is a communication and tracking which possibly capable of discovering affected peoples and connects them with their families, friends, and communities with first responders and/or to support computational systems. With the capabilities of current mobile technologies, we believed that it can be a smart earthquake disaster tools aid to help people in this situation. Ontologies are becoming crucial parts to facilitate an effective communication and coordination across different parties and domains in providing assistance during earthquake disasters, especially where affected locations are remote, affected population is large and centralized coordination is poor. Several existing competing methodologies give guidelines as how ontology may be built, there are no single right ways of building an ontology and no standard of Disaster Relief Ontology exist, although separated related ontologies may be combined to create an initial version. This article discusses the on-going development of an ontology for a Communication and Tracking System (CTS), based on existing related ontologies, that is aimed to be used by mobile phone applications to support earthquake disaster relief at the real-time.

Keywords

Ontology, Mobile Application, Semantic Web, Linked Data, Communication, earthquake Natural Disaster, Disaster Relief, Intelligent Systems, Decision Support Systems.

INTRODUCTION

In recent years, earthquake disasters have caused terrible losses, fatalities and missing people. Sichuan, China earthquake in 2008 killed at least 69,000 people, injured more than 374,000, and left about 4.8 million homeless. While, Haiti earthquake in January 2010, causing over 200,000 fatalities, 300,000 injuries and leaving over 1 million people homeless (Yates and Paquette, 2011). Another big impact earthquake is Pacific Ocean earthquake and subsequent tsunami in Japan in March 2011 that cost the Japanese economy more than $300 billion and caused unprecedented loss to the Japanese people, their environment, and the global economy.

A few of applications have been developed in a web and mobile systems to fulfil the domains of tracking missing people, disaster management and emergency response. SEA-EAT blog and PeopleFinder (Ratnam and Karunaratne, 2008), Nepal Earthquake Missing People on Facebook, Nepal Earthquake Missing People Website and others are amongst of the well-known applications developed for this purpose especially for very large earthquake disasters. Some of these applications are using a semantic web and linked data as a solution to integrate the information between multiple of agencies for top management to make a decision and also for reporting purposes. However, many of such systems are web based. This means that their layout and style of presentation may not be suitable for viewing using mobile devices, as it may not be possible to have access to a computer at all times. In addition, such systems do not make use of mobile devices' useful features, such as location-based information and services, built-in communication mechanisms, in-situ multi-gestures (e.g. vibration), that may indicate missing people's location and their well-beings. Other existing mobile systems, that we have found so far, provide general earthquake information of areas but does not focus on tracking missing people and rescue them at a personal level.

This article will discuss the ontology development in linked data and semantic web technologies by (Noy and McGuinness, 2001) that can be used in mobile phone applications to connect people with others during earthquake disasters. We are particularly interested in using ontologies as our backbone technology because it is a concise way of providing a standardized overview of a complex domain, involving many different stakeholders who may have different expertise and tasks. It is also system and platform neutral that may be used by a variety of different systems. It is also very portable that can be easily stored on a small device, such as a mobile phone. Based on these principles, we merged several relevant existing and stable ontologies, inc. AEMET Weather ontology (Atemezing et al., 2013), Disaster Management, Management of a Crisis (MOAC) (Ortmann, Limbu, Wang and Kauppinen, 2011) and FOAF, in a new Communication and Tracking Ontology (CTO) to facilitate the communication among multiple stakeholders and help tracking people using mobile phones as an instrument. The main motivation of reusing these ontologies is so that we do not re-invent the wheels; but more importantly, so that our built system can easily communicate with existing systems, when appropriate. In this paper, we will illustrate the development of this Communication and Tracking Ontology (CTO) in a step-by-step fashion. The remainder of this paper is structured as follows. In Section 2, we will provide related works and motivation for our ontology development, Section 3 describes the process of how the CTO was developed. The process of merging and building of CTO is provided in Section 4; while section 5 gives an overall conclusion and future work.

MOTIVATION AND RELATED WORK

The main motivation for developing a CTS is to provide effective communication and assist coordination between victims, communities, rescuers and organizations who are involved directly or indirectly during and just after an earthquake, thereby providing speedier recovery and relief to the victims as possible. With a mobile phone supporting internet connection on hand, people/organization may use their smart devices to know about how to help people especially nearby their location without knowing where the exact location, address, who's their family to contact and also they don't know even victims background information such as their name or blood type. The stakeholders (government agencies) of this domain find it increasingly difficult to coordinate and respond to emergency situations. The result of this has increased the number of deaths, delay in access to basic needs and slower recovery time (Ratnam and Karunaratne, 2008). There are many types of the disasters exist in the world such as Epidemic, Eruption, Fire, Flood, Forest fire, Hailstorm, Heat Wave, Hurricane, Ice storm, Lahars, Landslides, Limnic Eruption, Maelstrom, Mudslide, Sinkholes, Storm, Thunderstorm, Tornado, Tsunami, Typhoon, Volcano, Wildfire and Terrorist Bombing (Chou, Zahedi and Zhao, 2011; Malizia, Onorati, Diaz, and I, 2010; Sakaki, Okazaki and Matsuo, 2010; Sharmeen, Martinez-Enriquez, Aslam, Syed and Waheed, 2014; Yan, 2011). Among them, an earthquake is one of the most poorly-understood disasters that may happen with no warning sign and nobody will know for sure, including geologist scientist concerning where and when it may happen. Earthquake Reports from United States Geological Survey (USGS) show to the world that the big magnitude (magnitude > 6.0) impact earthquake happened yearly since 1990. The year 2010 history in Haiti indicated a large number of fatalities with 316,000 people and many of them might not be traced (missing) until today. The CTO is very important to enable the systems, find and collect the information from many resources on the net such as the name of victims, their places, their relative and their current coordinate. Therefore, the objectives to build up the CTO are:

a) To reduce fatalities and missing people in case of an earthquake.
b) To help personnel to monitor a real-time information about missing people during an earthquake.

Quite early on, a number of researches have shown that the emergency response domain can especially benefit from Semantic Web technology. Ontology has been used and some of the applications have been developed to find missing people and such as PeopleFinder that has been developed from the experience of Katrina hurricane and SEA-EAT blog that has been set up during the Asian tsunami in 2014. It was developed into an information exchange system for missing persons, requests for help and news updates (Ratnam and Karunaratne, 2008).

Efforts to apply linked data and ontology in the field of emergency response are presented in recent researches on various facets. In the context of Weather Ontology, it was discussed in detail about AEMET, the Spanish Public Weather Service in (Atemezing et al., 2013) where they are using the ontology to make meteorological data publicly available via their website, as registered by its weather stations, radars, lightning detectors and ozone soundings. They also discussed about the reusing of Time Ontology and Location Ontology to make it more suitable to fulfil for the Weather Ontology itself.

Many reports have shown that a lot of people, who needed to be evacuated, had problems finding the nearest evacuation centers that the government and companies had set up for them, thereby receiving necessary assistant in a timely fashion. Therefore, the way of providing information about evacuation centers for those people is an important issue in the future and research in (Iwanaga et al., 2011). In the article, they firstly design an Earthquake Evacuation Ontology and secondly, indicate that can computers provide the most suitable evacuation center, by using the ontology-based on earthquake victims' behaviors in real-time.

DEVELOPING A COMMUNICATION AND TRACKING ONTOLOGY TO ASSIST EARTHQUAKE DISASTER RELIEF EFFORTS

Tom Gruber defined an ontology as the following "An ontology is an explicit specification of a conceptualization." (Gruber, 1993). It is important to understand what ontology is for. The ontology is to enable knowledge sharing and data consistency and as such an ontology is a specification for making ontological commitments.

As mentioned by McGuinness (Noy and McGuinness, 2001), there is no one single "correct" way for developing an ontology. There are also many competing methodologies (Gomez-Perez, Fernandez-Lopez and Corcho, 2004). However, we have followed the seven steps from (Noy and McGuinness, 2001), as recommended by the Protégé community, where our main development steps are described below.

Determine Domain and Scope

Naturally, the concepts describing a communication and tracking during earthquake, weather, places, shelter, who to contact and etc. will figure into CTO. At the same time, it is unlikely that the ontology will include concepts for victims, help worker, community and families to trace and connecting each other. The ontology will be designed focused to make people's traceable during an earthquake, able to safe and secure after the earthquake such as how community or agencies can help peoples in their surrounding (walking distance) and also victims can find the nearest shelter from their current location to get food, water or blanket supplied.

Reusing, Merging and Tailoring Existing Ontologies

Many ontologies are already available in electronic form and can be imported into an ontology development environment. This method called reuse process where this process is a cost effective way to build ontologies. The CTO was built by means of reuse, following an evolving prototyping life cycle. From 13 main ontologies component in CTO, several of them were reused from existing stable and maintained ontologies such as Friend of a Friend (FOAF) (Bosch, Cyganiak, Gregory and Wackerow, 2013; Hsu, Lin, Yang and Huang, 2012; Liu, Brewster and Shaw, 2013a, 2013b), weather (Claypool and Moran, 2012; Liu et al., 2013b), Disaster (Liu et al., 2013b), Time (Atemezing et al., 2013; Peralta et al., 2004), Places (Atemezing et al., 2013; Liu et al., 2013a) and Location (Atemezing et al., 2013) ontology. Component from these ontologies has been selected and focused to the communication and tracking area.

Enumerate Important Terms

It is useful to write down a list of all terms that would like either to make statements about or to explain. The examples of listed terms are in Sources from (Becker and Bizer, 2008; Iwanaga et al., 2011; Lin and Sakamoto, 2009; Liu et al., 2013a, 2013b; Malizia et al., 2010; Peralta et al., 2004; Sotoodeh, 2007; Xu, Chen and Ma, 2010; Yan, 2011).

Table 1 below:

Terms			
Location	Mothers name	Latitude	ShakeAlert
Agent	Next of kin	Country/Region	PRESTo
Places	Nick name	Postal	Earthworm
Terrain	Cliff	State	EDAS-MAS
Network Connectivity	Race	Network available	UrEDAS
Time	Surname	Network down	Virtual Seismologiest
Event	Fault	Accommodation	Elarms
Weather	Disaster	Hostel	EEWS
Support Group	Chemical emergency	Hotel	Type of Message
Help worker	Damn failure	Service apartment	Military
Fire fighter	Earthquake	Agency building	Before Earthquake
Medical staffs	Explosion	Fire station	After Earthquake
NGO	Fire	Hospital	Support group
Police	Flood	Police station	Agencies
Red Cross	Flash flood	School	Family
Person	Riverine flood	Commercial resources	Friends
Date of Birth	Landslide	Shopping mall	Others
Blood type	Nuclear power	Shop	Colleague
Contact Details	Radiation	Houses	Neighbors
Peninsula	Tsunami	Apartment	Other individual
First name	Location	Flat	Time
Gender	City	Landed house	Date
Island	Coordinate	Other building	Duration
Religion Places	Longitude	Weather	Start
Church	Shelter	Humidity	End
Mosque	Available capacity	Pressure	Severity status
Temple	Total capacity	Temperature	Red
Valley	Mount	Wind	Green
Hill	Yellow		

Sources from (Becker and Bizer, 2008; Iwanaga et al., 2011; Lin and Sakamoto, 2009; Liu et al., 2013a, 2013b; Malizia et al., 2010; Peralta et al., 2004; Sotoodeh, 2007; Xu, Chen and Ma, 2010; Yan, 2011).

Table 1 List of Terms used in CTO

Define the Class Hierarchy

There are several possible approaches in developing a class hierarchy as mention in (Uschold and Gruninger, 1996) but in this cases, a combination of the top-down and bottom-up approached in the development process was used. The main classes in the present CTO are Event, Shelter, Places, Location, Weather, Support Group, Severity, Network Connectivity, Time, Weather and Agent.

Define Properties

For each property in the list, it will determine which classes will be described. The classes alone will not provide enough information to answer the competency questions. Once some of the classes defined, it must describe the internal structure of concepts. Current properties in CTO are Organize, Will-Be-At, Located-In, Affect, Cause, Belongs-To-Profile, Category-Of, Has-A, Has-Description, Has-Name and Has-Value.

Define the Facets of the Slots

Slots can have different facets describing the value type, allowed values, the number of the cardinality values, and other features of the values. For example, the value of a name slot (as in "the name of shelter") is one string. That is, name is a slot with value type String. A value-type facet describes what types of values can fill in the slot. Here is a list of the more common value types in this article:

- String : Is the simplest value type which is used for slots such as name: the value is a simple string
- Number : Value types of float and integer are used.
- Boolean : Yes–No flags.
- Enumerated : List of specific allowed values for the slot.
- Instance-type : Relationships between individuals.

Create Instances

The last step is creating individual instances of classes in the hierarchy for CTO. The example is to create an individual instance e.g. a mosque that is based in Edinburgh, UK represented as a specific type of Places. The value of 1,000 is an instance of the class Total-Capacity representing Shelters. This instance has the following slot values defined.

a) Total Capacity: 1,000
b) Places: Edinburgh Mosque
c) Location: City of Edinburgh
d) Coordinate: Latitude : 55.9449995, Longitude : -3.1860282
e) Event: Earthquake

MERGING AND BUILDING THE CTO

Ontologies have become core components of many large applications. Previous research shows a few ontologies for disaster management, emergency response and others have been done. For examples, AEMET Weather, Disaster Management, Management of a Crisis (MOAC), FOAF, etc. was developed and used in web application system for reporting purposes.

This article used the existing of ontologies mentioned above by other researches to addresses the issue on the CTS. To make this CTO suite with any application especially in a mobile application, a research to combine, reuse and create a new ontology was carried out.

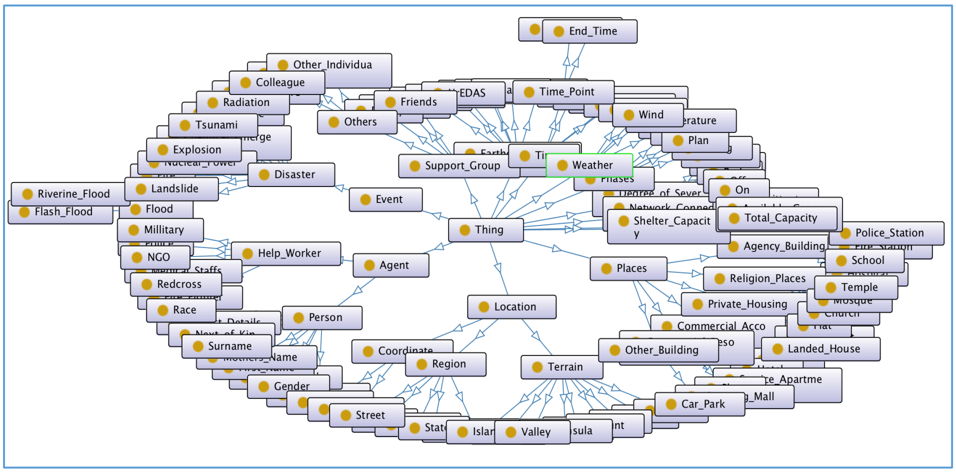

Figure 1 Details of Communication and Tracking Ontology

Figure 1 gives an overview of the CTO developed by using seven basic steps as mention above and it has been developed using Protégé v5.0.0. CTO posses 13 main classes in total to fulfill the communication and tracking issues during an earthquake and emergency response. The main classes and their function are described below:

Events – The main class in CTO. It is grouped all type of disaster which base from the research review in (Babitski et al., 2011; Chou et al., 2011; Ratnam and Karunaratne, 2008; Yan, 2011) and etc. All type of disaster in this subclasses may occur during the earthquake event. From this class, the information of the type of disaster can be traced from the system.

Agents – An important class in CTO which contains another 2 subclasses called Person and Help Worker. This classes are aims to spread the information about personal information and also the organization who can give a support for the community who maybe in a trap, injury and lost. The personal information can give a better idea to community or help worker to determine and get the background information during and before rescue process.

Places - A group of locations that consist of formal building information which may help rescuer to know the last places of earthquake victims and survivors. A part of this class will integrate with other classes in CTO such as Coordinate in Location Class and Shelter Class which will be described later in point no 5 and no 8 below.

Weather – **A** group of all the information about weather related to the earthquake. This class will help people such as just after the earthquake happen. It holds information for example about humidity, temperature, wind and pressure. It is very important for a rescuer to know about their safety or the impact on them before they can help people in their area.

Location - Is a simple class where it was assigned to group all the information about Coordinate and location such as Street, City, State, Country and Region. As mention in Places Class, Coordinate Class will integrate with Places Class to provide more detail information.

Time – A class contains an information such as the Date and Time Point (Begin, End). Victims or rescuer during an earthquake may know where the places are open as a temporary shelter.

Support Group - The function of this class is to group user relative or next of kin information and agencies that can support or help victims during or after an earthquake.

Shelter Capacity – A class that holds information about the capacity and current availability space to make rescuer or victims have a better choice to choose which shelter they want to take covered.

Degree of Severity – A class that group color code depends on the severity of the earthquake. This is important to know what are the action should be taken to follow the International Disaster Relief Organization Standard of Procedure (SOP).

Message – This class will have multiple of message type base on the current situation of users e.g. when users are in a running mode, CTS might be able to advise automatically to users to go and take covered before suggested to the nearest shelter.

Earthquake Trigger - To trigger when the CTS should start. There is a lot of early warning system that has been developed such as Elarms (Li, 2011; Satriano, Wu, Zollo and Kanamori, 2011) and ShakeAlert (Burkett, Given and Jones, 2014) that can be used as a trigger to launch the CTS.

Phases - Will contain phases which are earthquake plan, before an earthquake and after an earthquake. These phases are all important in the context of communication for civilians.

Network Connectivity – A class where functioned to identify either the mobile phone network down, intermittent or shut off because of low battery or faulty device.

CONCLUSION

In the disaster management domain, the use of ontologies promotes interoperability among systems within this domain. This will aid in access to information at the right time in the right format. The end result of this is a faster access to aid during earthquake and the ability to save a greater number of lives. In summary, this article has discussed about the development of ontology using 7 basic steps for communication and tracking issues during and after an earthquake. The CTO consist of 13 main classes to cater this issue.

For future research, we understand that are other relevant disaster management ontologies that we can make use of. It is therefore our plan to take a look at them and try to utilize and merge them in CTO. In addition, a CTS will be build using open source framework for mobile application development method to prove that the CTO discussed in this article can be used and function in mobile phone as a contribution to emergency response field, communication and as well as tracking issues. In order to ensure that the CTO will fulfill the requirements of CTS, we plan to carry out verification and validation processes with experts (academics and practitioners) in the field of emergency response using real-world scenarios. The Delphi technique will use as a method in this process because the technique is a widely used and accepted method for gathering data from respondents within their domain of expertise. The technique also designed as a group communication process which aims to achieve a convergence of opinion on a specific real-world issue.

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