White Paper: Next generation disaster data infrastructure

CODATA LODGD Task Group 2017

Call for Authors

This call for authors seeks contributions from academics and scientists who are in the fields of disaster management, data science, information management, or computer science and engineering.

Write paper aims and objectives

This white paper aims to propose the next generation disaster data infrastructure, which includes the novel and most essential information systems and services that a country or a region can depend on in reality in order to successfully gather, process and display disaster data, and to reduce the impact of natural disasters. The white paper will focus on the key requirements of the next generation disaster data infrastructure, which includes (1) effective big disaster data collection, fusion, exchange, and query, (2) real-time big data analysis and decision making and (3) user-friendly big data visualization.

Motivation

Due to climate change and global warming, the frequency and severity of extreme weather has been increasing all around the world. According to the Sendai Framework for Disaster Risk Reduction, from 2005 to 2015, over 700 thousand people had lost their lives, over 1.4 million had been injured and approximately 23 million had been made homeless as a result of disasters. The severity of future disasters is expected to surpass the past in the foreseeable future. In addition, huge amount of disaster data collected from different sources, such as local sensors, remote sensing systems, mobile devices, social media, and official responders could easily overwhelm and impair disaster risk reduction related applications, systems, and underneath hardware platforms, especially for large-scale disasters.

In order to build resilience and reduce losses and damages, Sendai Framework prioritize its actions in the following four areas: (1) understanding disaster risk, (2) strengthening disaster risk governance to manage disaster risk, (3) investing in disaster risk reduction for resilience, (4) enhancing disaster preparedness for effective response and to “Build Back Better” in recovery, rehabilitation and reconstruction. In particular, Sendai Framework emphasized that government should strengthen the utilization of media, including social media, traditional media, big data and mobile phone networks, to support nationwide disaster management and damage reduction. The availability of access to multi-hazard early warning systems and disaster risk information and assessments to people should substantially increase by 2030. For this, governments should take into account the needs of different categories of users and data dissemination in order to enhance disaster preparedness for effective response. In addition, space and in situ information, including geographic information systems (GIS), are needed to be fully utilized in order to enhance disaster analysis tools and to support real-time access services of reliable disaster data.

The white paper is temporally organized as follows: first, several future scenarios of disaster management will be developed based on existing disaster management systems and communication technology. Second, fundamental requirements of next generation disaster data infrastructure inspired by the proposed scenarios will be discussed. Following that, research questions and issues are highlighted. Finally, suggestions and conclusion are given at the end of the paper.

White paper structure and explanations (call for sections or subsections from section 2 to 6)

1 ***Introduction:*** the motivation and the goal of the white paper

2 ***Related work***

2.1 Early warning and response system: a literature survey

2.2 Social media during disasters: a literature survey

2.3 Emergency communication system, network, and protocol: a literature survey

3 ***Future scenarios***

3.1 **Active emergency response system for living environments:** With the rapid development of disaster early warning technology and sophisticated network infrastructure, many countries have already adopted standard warning messages to inform the public that a natural disaster has occurred or will happen. For example, in the U.S., after an earthquake strikes, the official agency adopts the Public Warning System (PWS) to broadcast CAP (Common Alerting Protocol) warning messages to inform people in the affected areas through different media channels, such as radio, television, short message service (SMS), smart phones, internet or electronic signs. In addition, the XML (Extensible Markup Language)-formatted CAP messages are sent to active emergency response systems (AERS) to automatically start the process of disaster reduction, such as stopping elevators at the closest floor, cutting off the gas, opening doors and windows, slowing down high-speed trains and putting factory machines into a protection mode to avoid possible damages. In the future, the AERS will play a more important role in disaster prevention and become ubiquitous in our living environment. The AERS will support people with decision-making functionality rather than simply trigger actuators to control input and output devices. In addition, customized warning messages will be sent to different recipients based on their identities, spatial locations and the emergency levels of the disaster to assist people to be better prepared for natural disasters. Relevant city services, such as health care and transportation, will also be integrated with AERS to support mass crowd evacuation and emergency medical services. For people inside a building, unlike existing evacuation systems which provide only static information (i.e., evacuation map, fire equipment location, and emergency contacts), AERS will further provide them with dynamic evacuation instructions, real-time disaster information, and the progress of rescue operations so that people can safely leave danger areas or find a safe place to stay. For on-scene commanders, AERS will provide them with dynamic information of victims, such as their identities, spatial locations and physiological status, as well as the current situation of the disaster. Visualization technology will be used to highlight the severe level of affected areas and the status of both victims and responders. Intelligent decision-making services will also be applied to support rescue operations and health care resource management. In addition, for first responders, AERS will provide them with not only the information of victims, but also indoor navigation and real-time disaster information.

3.2 Crowdsourcing supported disaster information system: a future scenario where social network can be used to collect disaster information and support decision making.

3.3 Disaster emergency communications: a future scenario where emergency communication network can be used in a major disaster, such as 2011 Tohoku Earthquake and Tsunami and 2010 Haiti Earthquake.

3.4 Disaster data quality assurance and control: a future scenario of disaster data quality assurance and control.

3.5 Disaster data standards and format: a future scenario in using standard disaster data format.

3.6 Other future scenarios: open for contribution.

4 *Fundamental requirement analysis*

4.1 Big disaster data visualization: an analysis of user and system design requirements from the aspect of data visualization, such as meaningful information extraction.

4.2 Big disaster data processing: an analysis of the user and system design requirements from the aspect of big disaster data processing, such as real-time constraints.

4.3 Big disaster data collection and transmission: an analysis of user and system design requirement from the aspect of data visualization, such as traffic congestion.

4.4 Big disaster data quality control: an analysis of the user and system design requirements from the aspect of big disaster data quality control and assurance.

5 *The next generation disaster data infrastructure*

The next generation disaster data infrastructure is expected to be more intelligent than the existing one in coping with huge amount of disaster data collected from different sources, and will provide more customized emergency services in enhancing disaster preparedness and response. Based on the purposes of data processing, the next generation disaster data infrastructure is divided into three layers: application layer, data analysis layer, and data storage layer. Key research issues of each layer are listed as follows.

Table 1: Research questions of the next generation disaster data infrastructure

Layer	Purposes	Key research questions and issues
Application	User-friendly big data visualization tools and emergency services	Data virtualization for decision making in emergencies
		Indoor navigation for mass crowd evacuation and rescue
		Volunteer management for crowdsourcing disaster information
Data analysis	Real-time big data analysis	Social media assessment for disaster management
		Real-time distributed computing for disaster risk assessment
Data storage	Big disaster data collection, fusion, exchange and query	Relicense emergency network for big data collection
		Standard of disaster management supported IoT
		Standard of open disaster data
		Policies of sensitive disaster data exchange and sharing

5.1 Application layer

5.1.1 Big data visualization for decision making in emergencies: (1) methods, tools, and user interface to help responders to have a complete view of 2D and 3D disaster data, and (2) a discussion of scalability and dynamics issues for big data visualization.

5.1.2 Smart devices and applications for disaster response: (1) Indoor and outdoor navigation for mass crowd evacuation and rescue (2) navigation methods or system that utilize geographic information or building information modeling (BIM) to help mass crowd evacuation and rescue, and (3) dependability and safety issues of disaster response systems.

5.1.3 Volunteer management for crowdsourcing disaster information: (1) strategies for crowdsourcing for disaster situation information, and (2) participant selection for crowdsourcing disaster information.

5.1.4 Other applications: open for contribution.

5.2 Data analysis layer

5.2.1 Distributed computing for disaster data processing: (1) parallel algorithms, real-time scheduling, middleware, and architecture for disaster data processing, (2) internet of things (IoT)-supported data process, and (3) cloud computing for disaster management.

5.2.2 Social media assessment for disaster management: (1) verification mechanism for disaster information gathered from social media, (2) the effect of social media on disaster response, (3) fusion of social media and physical sensor data and (4) disaster data mining for disaster management.

5.2.3 Disaster data quality control: (1) data profiling, (2) data standardization, and (3) data tracking and monitoring.

5.3 Data sensing and storage layer

5.3.1 Resilience emergency network: (1) IoT-supported resilience emergency network, (2) traffic congestion problems of disaster data transmission, and (3) reliability and availability of resilience emergency network.

5.3.2 Standard of open disaster data: (1) open disaster data model, (2) open disaster format, and (3) structured data and unstructured data.

5.3.3 Disaster data exchange, sharing and accessing: (1) policies of sensitive data access, (2) transparency and accountability issues for sharing data, and (3) disaster data storage and database.

6 ***Suggestions and discussion:*** (1) suggestions for the public sector in developing the next generation disaster data infrastructure, (2) suggestions for the private sector in developing the next generation disaster infrastructure, and (3) private-

public sector collaboration in developing the next generation disaster data infrastructure, platforms and services.

7 ***Conclusion:*** conclusion of the white paper.

Schedule and contact information

- Volunteer recruitment deadline: 2017/7/31
- Writing team task assignment: 2017/8/7
- Submission deadline of each section and subsection: 2017/12/31
- The first draft of the white paper: 2018/1/31

If you want to participate in writing the white paper (one section or subsections). Please contact Edward Chu (edwardchu@yuntech.edu.tw), Bapon Fakhruddin (BFakhruddin@tonkintaylor.co.nz) or Zhao Jing(zhaojing01@radi.ac.cn) by 2017/7/31.