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INFORMATION CENTRIC COMPUTING FOR URBAN EARTHQUAKE DISASTER SIMULATION – A MACRO VIEW VS. A MICRO VIEW

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SUMMARY

Damage to structures is a major consequence of a severe earthquake occurred in urban areas. Efforts have been made to study seismic response of individual structures for designing, constructing and retrofitting. On the other hand, the task of urban earthquake disaster mitigation and risk management is mainly based on a macro view of a city. This paper discusses the issue of simulating urban earthquake disasters from both a macro and a micro scene for disaster reduction.

INTRODUCTION

Severe earthquakes cause not only damage to structures but also social and economic impacts. Though seismic response of a single structure can be obtained, it is still not easy to simulate and estimate various kinds of damage and losses of a city caused an earthquake. Urban earthquake disaster mitigation and risk management is a complex and a long-term issue. In what way can advanced computer technologies play an important role on the mitigation task? Upon describing earthquake hazards in urban area, this paper discusses a strategy of simulating urban earthquake disasters based on integrating applications with an information centric computing with the web technologies.

EARTHQUAKE HAZARDS IN URBAN AREAS

Earthquakes, a kind of natural catastrophe, are of low frequency but high consequence. It is difficult to accumulate experiences. Though proper handling of seismic behaviour of a building or a structure is essential, it is still quite a local issue on concerning disaster mitigation for metropolises. During the 1995 Kobe earthquake, the traffic service system in the emergency situation experienced substantial difficulties as considerable damage happened in elevated bridges.[1] Collapsed buildings can also block roads. Fires

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during the earthquake may ruin several areas within a city for lack of emergent rescue. All the above-mentioned issues will cause losses of lives directly or indirectly. During an earthquake, city infrastructures such as power supply, electronic communication etc. might be out of their functions. Communication with the public becomes quite important for saving lives and keeping order of the society. To find efficient ways for communication should be a problem. Earthquake hazards in urban areas can be very wide. Figure 1 summarizes earthquake hazards with a panorama of various kinds of damage initiated by earthquakes.

Figure 1 A panorama of earthquake related disasters
(illustrated by Prof. Takeshi Nakamura, Kyoto Institute of Technology, before the 1995 Kobe earthquake)

Important characteristics of earthquake disasters in urban areas can be figured out as follow:

1) It is still very hard to predict a severe earthquake with precise location and time though a long-term precaution is applicable.

2) A severe earthquake causes direct damage of buildings and city infrastructures within a very short period of time. The impacted area can cover several adjacent cities.

3) Consequences of 2) include fire, shortage of living supplies and public panic etc.

4) Building collapse is one of the major reasons of deaths and injuries of people. Damage of city infrastructures can slow down the speed of rescue.

5) Economic impact is a mid- and long-term issue related to the degree of damage.

SIMULATING URBAN EARTHQUAKE DISASTERS

Disaster mitigation has been defined as: “taking actions to reduce the effects of a hazard before it occurs.” The term “applies to a wide range of activities and protection measures that might be instigated, from the physical, like constructing stronger buildings, to the procedural, like standard techniques for incorporating hazard assessment in land-use planning.”[2] It can be seen that there are three aspects in urban earthquake disaster mitigation. The first thing is to understand the earthquake hazards. The second is to understand the vulnerability of a city, people, buildings and structures, lifelines, communication systems and other elements. The third is countermeasures, which include planning (precaution), immediate responding (decision making and rescue) and recovering.

To conduct simulation of urban earthquake disasters, following points should be considered:

1) Technologies of detailed simulation for natural disasters, structures and non-structural components;

2) Integrated applications and data which can represent major factors of infrastructures for a living city;

3) Be capable of providing and distributing information, which is useful to and can be easily accessed by estate owners, city administrators and the public, establishing mechanism to communicate with the public reciprocally.

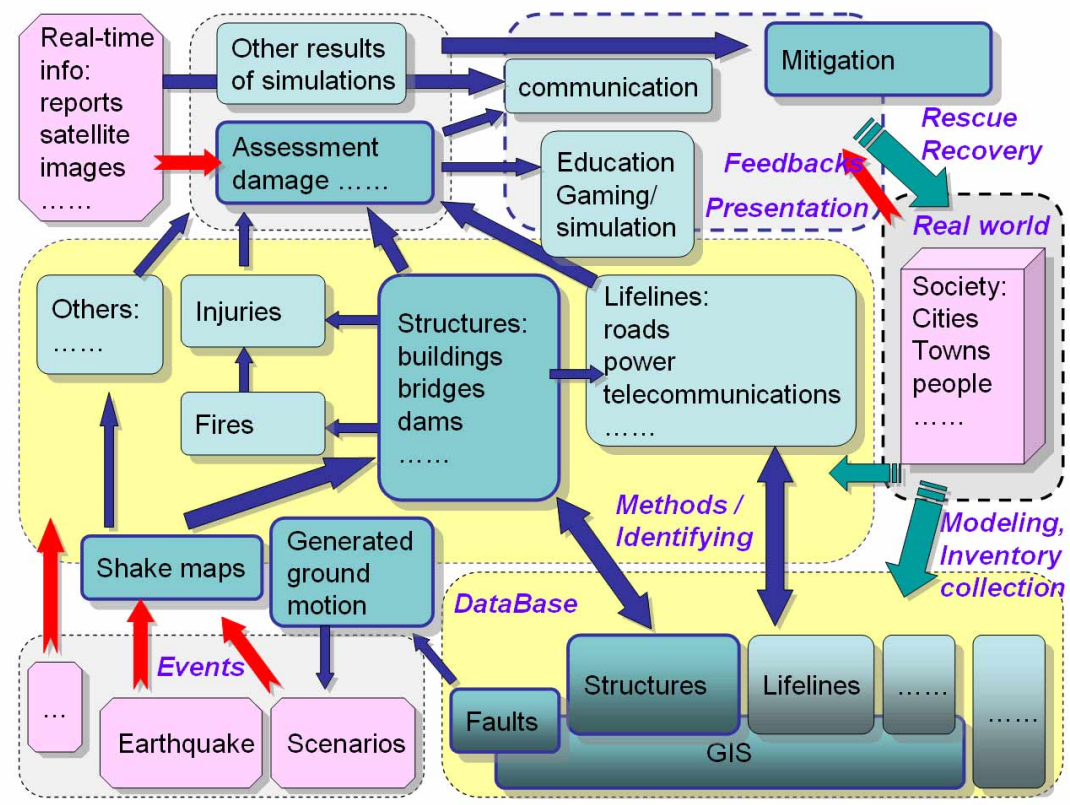

Figure 2 An Illustration of a platform of urban earthquake disaster mitigation

An Internet based platform that integrates applications, accesses data and provides interface to various kinds of users can be a good candidate to conduct the simulation. In response to demands, problems and challenges of conducting urban earthquake disaster mitigation, this paper offers a proposal of developing a platform of urban earthquake disaster mitigation. This platform attempts to identify and to arrange major

related issues of disaster mitigation with their consequences in a hierarchical way. As illustrated by Figure 2, the platform is composed of several sub-systems and modules. Modeling of structures and simulation of seismic responses are the core part of the platform. Consequent events, such as damage of lifelines, fires and injury of people, are driven mainly by the structure part. Input events include real earthquakes and scenarios in terms of a shake map generated by intensity of ground motion with locations. Assessment of damage is a major result of this platform. Real-time information of damage from an earthquake can be a direct input.

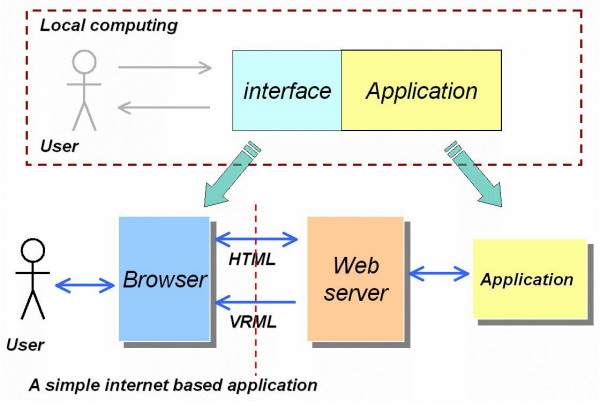

Figure 3 A simplified web computing prototype

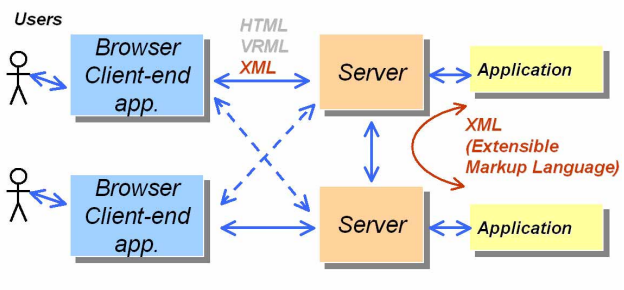

Figure 4 Distributed applications on the Web

The web technologies [3] can promote integration of applications. Figure 3 gives an image of shifting a localized engineering application to a web application by separating its interface with its computing core. Figure 4 illustrates the case of employing distributed applications on the web. An implementation of using web technologies is given in Figure 5. Figure 6 shows GIS data accessed through a web-based database server and presented by a Java3D view.

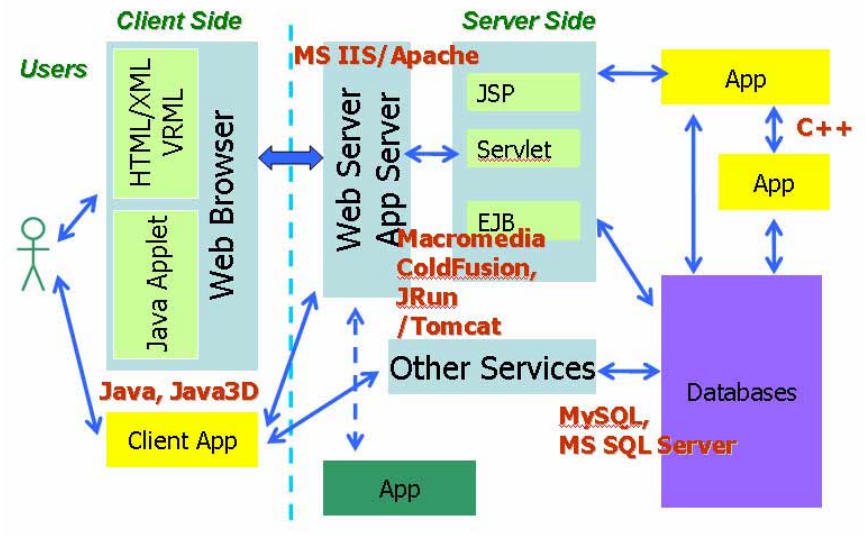

Figure 5 An implementation of the web-based platform

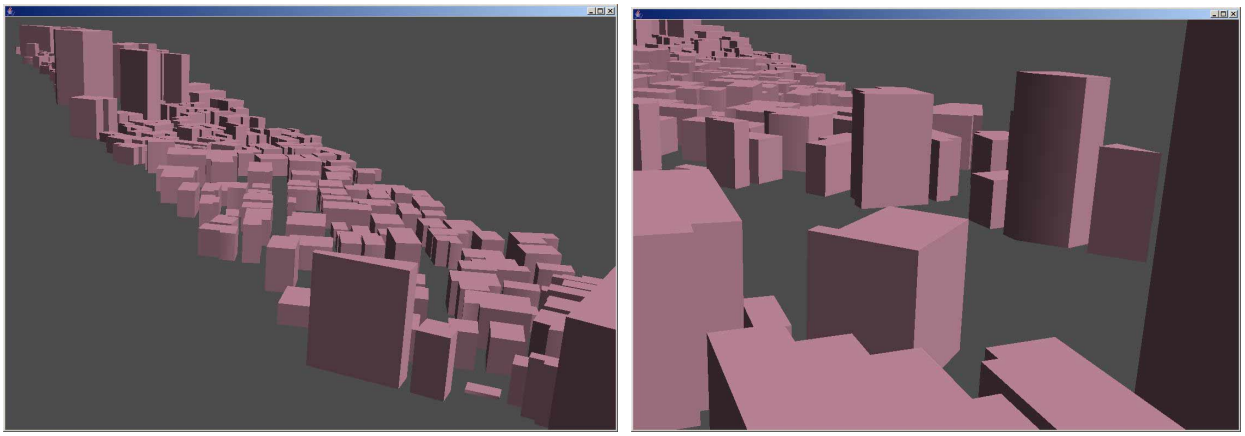

Figure 6 GIS database accessed by a Java3D viewer

The amount of buildings and structures in a city is huge. LOD of structure modeling (Figure 6) makes it easier to start the mitigation task with simplified models, which need less effort on building databases. Furthermore, low time consumption makes it possible to conduct a real-time simulation. The real-time simulation, which targets to provide damage information quickly (say, within one hour) by simulation according to a real-time earthquake, can be helpful to municipal government to take appropriate measures in time.

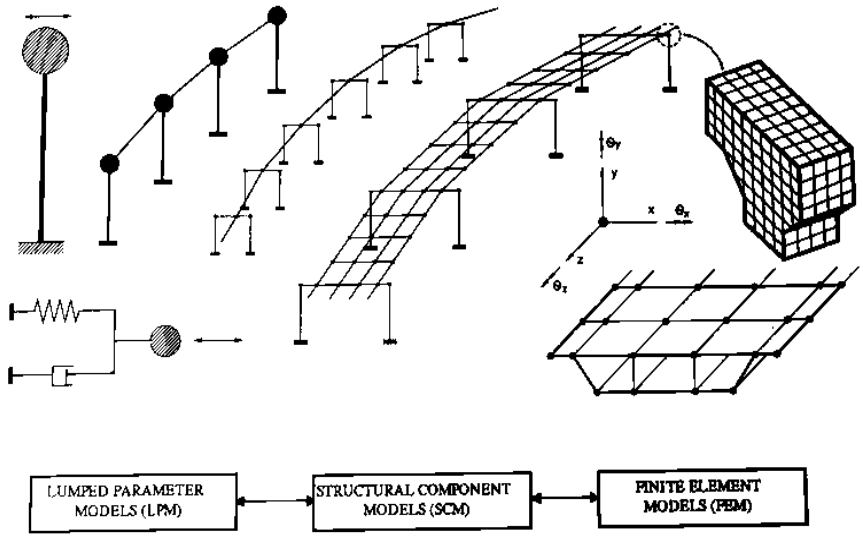

Figure 6 Level of detail in structure modeling [4]

CONCLUSIONS

This paper offered a proposal of simulating urban earthquake disasters using web technologies. Upon describing earthquake hazards and earthquake disaster mitigation in urban area, the paper highlighted technologies of web computing for engineering applications that can be used to simulate complex issues of earthquake disasters.

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