Proposal of Multi-Agent Simulation for Earthquake Disaster Recovery Process

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1. Introduction

Making a better strategy or tactics after a large earthquake becomes an important issue as infrastructures are being use by an increasing number of residents and industries. It is usually a case that each sector which is in charge of particular infrastructures does its best to restore their function when they are damaged or malfunctioned, with paying little attention to benefits of users.

In this report, we are proposing a multi-agent simulation for earthquake disaster recovery process, in order to examine the effectiveness of changing recovery strategy. The multi-agent simulation is a solution to solve complicated processes of the earthquake disaster recovery; the use of the structures is increased as they are fixed by engineers and the benefit of users is increased.

2. Design of Agents

In general, a multi-agent simulation consists of agents and environments. In the present simulation, the environment is a set of structures which are initially damaged. As the structures are fixed, the use is increased. There are two agents in the present simulation.

The one is an engineer who fixes a damaged structure using given limited resources, and the other is a user who uses the structures, getting some benefit. The class diagram of the model is shown in figure 1.

The change in the structure damage, denoted by D, is formally expressed as

$$D = F(W_1, W_2, ..., W_n)$$

where W_i is work done by the ith engineer, and F is a decreasing function. The capacity of the structure, C, is given as a function of the damage, C=G(D). The jth user of this structure has benefit, B_j, when his use is U_j, i.e.,

$$B_j = H(U_j) \qquad \sum U_j < C$$

Thus, the sum of all the users' benefit changes depending on how the damaged structures are fixed. Thus, we can find a most suitable policy for the engineers to fix structures, in order to maximize the sum of the users' benefits.

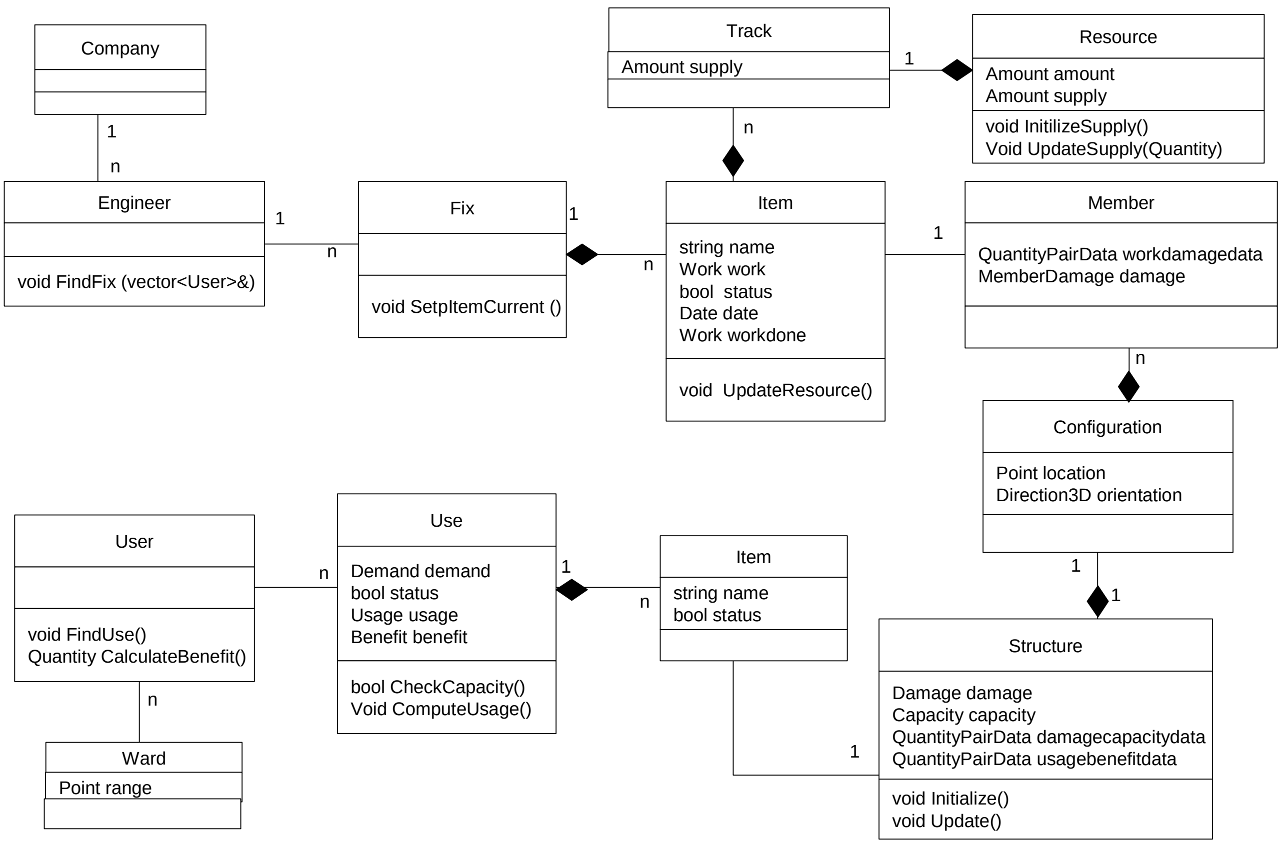

Figure 1: Class Diagram of the Model

3. Examination of Agents

To examine the behavior of the agents, the simulation is run with four structures, four engineers and twelve users. The data for the structures consist of initial damage level and configuration for each structure member. The data for engineers are the structure members to fix and the data for the users are the uses and the demand for each use. The results were obtained for total damage and total user benefit for each day during the recovery processes. The total damage is the sum of damage level of the structures and the total user benefit is the sum of the benefits of users. Results are presented as total relative benefit and total damage versus day (figure 2) and total relative benefit versus total damage (figure 3).

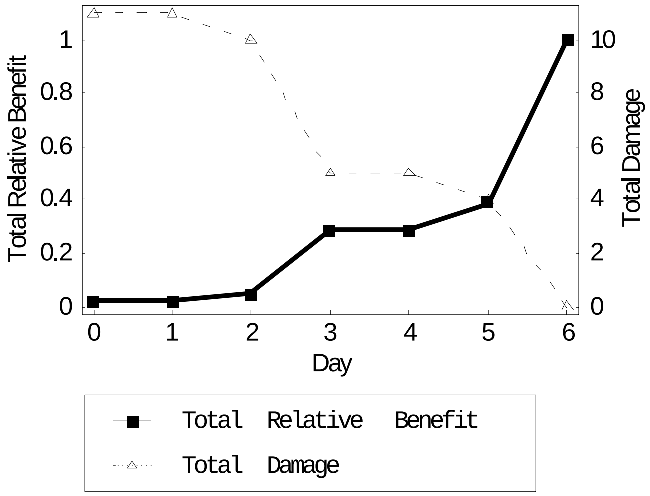

Figure 2: Total Relative Benefit and Total Damage vs Day

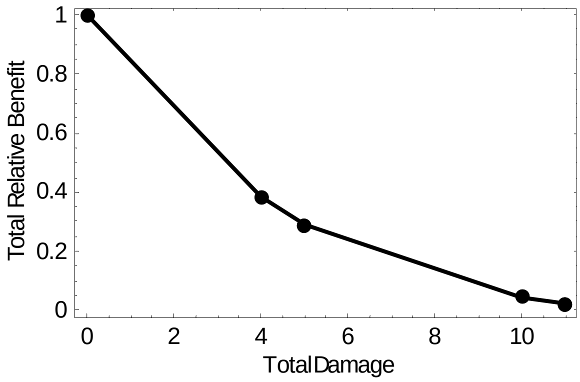

Figure 3: Total Relative Benefit vs Total Damage

4. Policy of Recovery

As a preliminary study, two simple policies are examined, i.e.,

Policy 0 – An engineer selects the first (or last) structure member from the structure member sets that they are responsible to fix.

Policy 1 – An engineer selects the structure by calculating the total user benefit for each structure. The sequence diagram of this process is shown in figure 4.

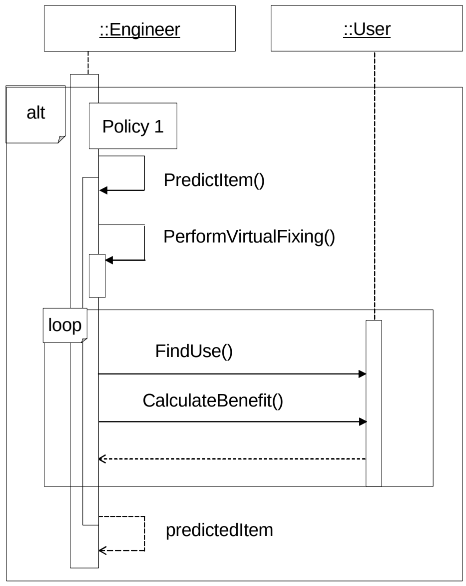

Figure 4: Sequence Diagram for Policy 1

The above two policies were simulated in the model and a phase diagram was drawn for total relative benefit versus total damage (figure 5).

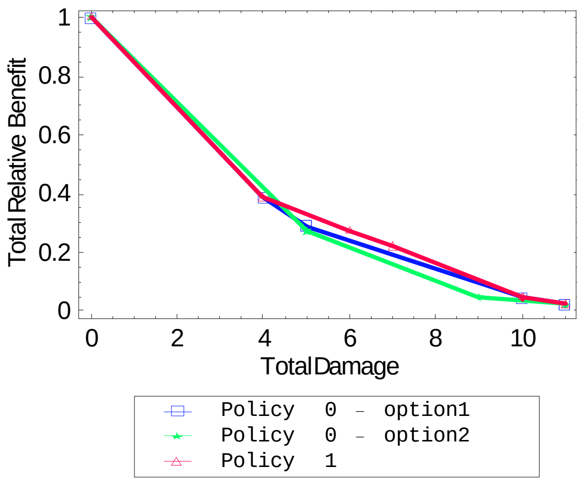

Figure 5: Comparison of Total Relative Benefit vs Total Damage for Different Policies

As for the figure 5, when the total damage is comparatively low, the policy doesn't have a significant effect on users' benefit. But when the total damage is comparatively high, the policy makes an identifiable effect on users' benefit.

6. Concluding Remarks

This paper contains the preliminary study carried out to evaluate the effects of engineer allocation policy on user benefit. To evaluate the performance of the policy, further simulations needed to be done for medium and large scale domains.

References

Robert Axelrod, The Complexity of Cooperation, Princeton University Press, 1997.