DISTRIBUTED SIMULATION OF AN EMERGENCY SYSTEM FOR THE FLOOD DISASTER IN HAT YAI, THAILAND

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ABTRACT
The paper presents an approach to create a training simulation system for emergency rehearsal in case of flooding at Hat Yai municipality, Thailand. The simulation system applies the concept of demand and supply as well as distributed interactive simulation using High Level Architect Framework.

INTRODUCTION

In many areas, flooding is a natural disaster that causes enormous damage both physically and economically. It has been the cause of catastrophes in the past and at the present. No community areas are absolutely free or safe from flooding. There are still flood problems occurred in many countries including Thailand. It is also not practical to evacuate communities or industrial sites out of the locations in order to avoid the flooding problems when the flooding does not really occur every day. Therefore, human beings need to learn to prepare, prevent and deal with flooding situations.
There are many ways to prevent or reduce damage caused by flooding, for example; on engineering issues such as building dams, installing water pumps, surveying risky areas; and on social issues such as giving knowledge of self care in flooding situations and rehearsing aid units or related organisations. In this paper, we present work on preventing and reducing damage to communities after flooding occurred, focusing on virtual rehearsals of related aid units.

BACKGROUND

High Level Architecture(HLA)

HLA is a software architecture that allows creating distributed simulation. The HLA has been adopted by the United States Department of Defense (DoD). In September 2000, the HLA was approved as a open standard by IEEE and in mid 2002, the HLA framework has been adopted to full commercial application.
In HLA, a simulation node called a *federate*. By using *OMT (Object Model Template)*, HLA can integrate many individuals models or federates to form a complex system that called a *federation*. Federates can communicate with one another through *Runtime infrastructure (RTI)* that is the HLA middleware. The RTI software allows federates to cooperate together, to synchronize federate events and to form a federation as shown in Figure 1. Information of every federate must be sent to RTI first. Then, RTI will send the information to the destination or desired federates by the mechanism of publication and subscription.

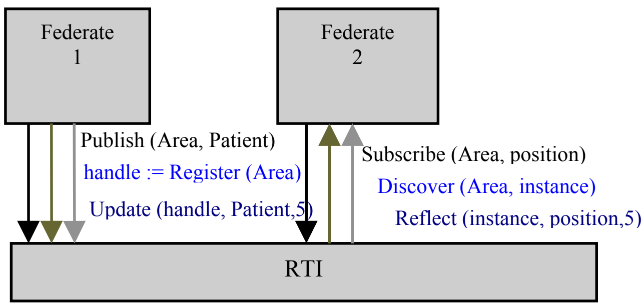

Figure 1. Federate/RTI Interface

Publication and subscription mechanism is analogous to newsgroups because the publishing federate or producer of information must define a means of describing data it is producing and the subscribing federate or receiver must define a means of describing the data it is interested in receiving in form of OMT. (Wyne 1999, Kuhl et al 1999, Fujimoto et al 2000, IEEE STD 1516)

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Physical system

This work concerns a case study of Hat Yai municipality in Thailand where there were two recent big floods considered a century case occurred successively in only about a decade (1988 and 2000). Hat Yai municipality with the area of thirty one square kilometers is located in the Intertropical Convergence Zone. 80% of the area is a flat basin. There are two canals called Uhtapao and Toey. The flood type is a flash flood that once the soil is saturate with water, water can be collected and floods the municipality rapidly in a few hours. It normally happens after several days of heavy rain.

The structure of Hat Yai municipality in aiding flooding situations is shown in Figure 2 and consists of the followings.

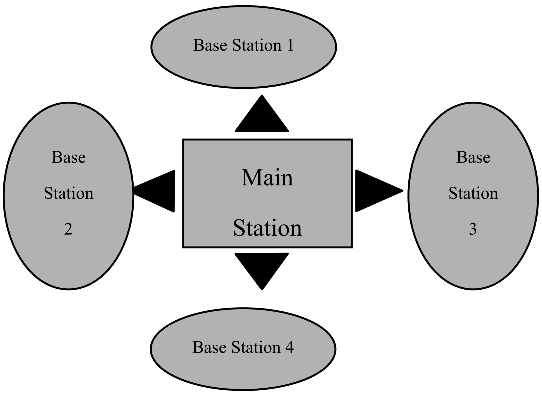

Figure 2. Physical System.

1) Director centre (Main Station) and coordinating centres (Base Stations)
2) Three types of work units contacting with the inhabitants including parking centre, shelter centre and healthcare centre.
3) Specially organised centre for coordinating between other centres and the inhabitants such as flood preventing unit, public relation unit, welfare unit, rescue unit, first aid unit, evacuation unit, security or guarding unit, healthcare unit, aid unit, restoring unit and donation unit.
4) Four areas of inhabitants and thirty local communities. (http://www.hatyaicity.go.th/)

SIMULATION SYSTEM

From the physical system mentioned above, we modified it by adding and removing some details in order to create a simplified simulation system that can integrate the components together in a better way. Therefore, the simulation model consists of the following.

1) Three simulation models including the *control models* that concerns general control of simulated situations at all communities together, the *main station model* or the director centre that acts as the main part for commanding helps and aids for all areas, and *base station model* or coordinating centres for the four areas of inhabitants that helps and aids inhabitants in the area in charge and cooperate with the control model or the main station.
2) Three kinds of work units as appeared in the physical system including parking centre, shelter centre and healthcare centre. These are under supervision of its base station.
3) Simplified other units including repairing unit, transportation unit, rescue/guarding unit, first aid unit, evacuation unit, aid unit, restoring unit and resource finding unit.
4) Four areas of inhabitants and thirty local communities as appeared in the physical system.

The overall of the simulation system is shown in Figure 3. The hierarchy of the simulation models is shown in Figure 4.

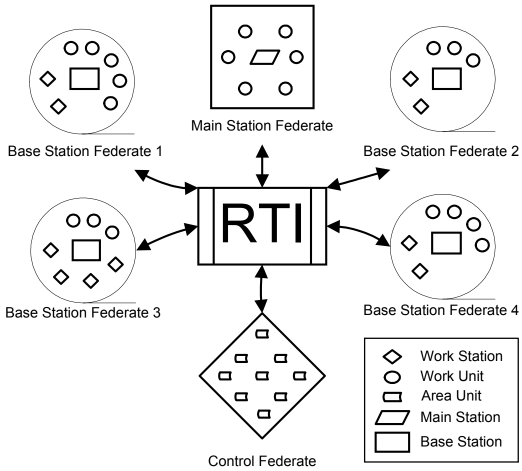

Figure 3. Federation Overview

The control model works as a simulation executive and involves all simulation models. It randomises situations occurring in the simulation as a whole. The controller or the user who works on the control model can add/schedule events at run-time. The main station is also needed in a federation to coordinate works done by the four base stations. However, at a time, there can be at least one base station or more, for more flexibility in increasing or decreasing the number of participating base stations according to the simulation.

Table 1. Interactions in the federation.

	Main Station	Base Station	Work Station	Work Unit	Local Unit
Control Model	S	S	S	S	PS
Main Station Model	PS	S	S	PS	S
Base Station Model	S	PS	PS	PS	S

P: Publication S: Subscription

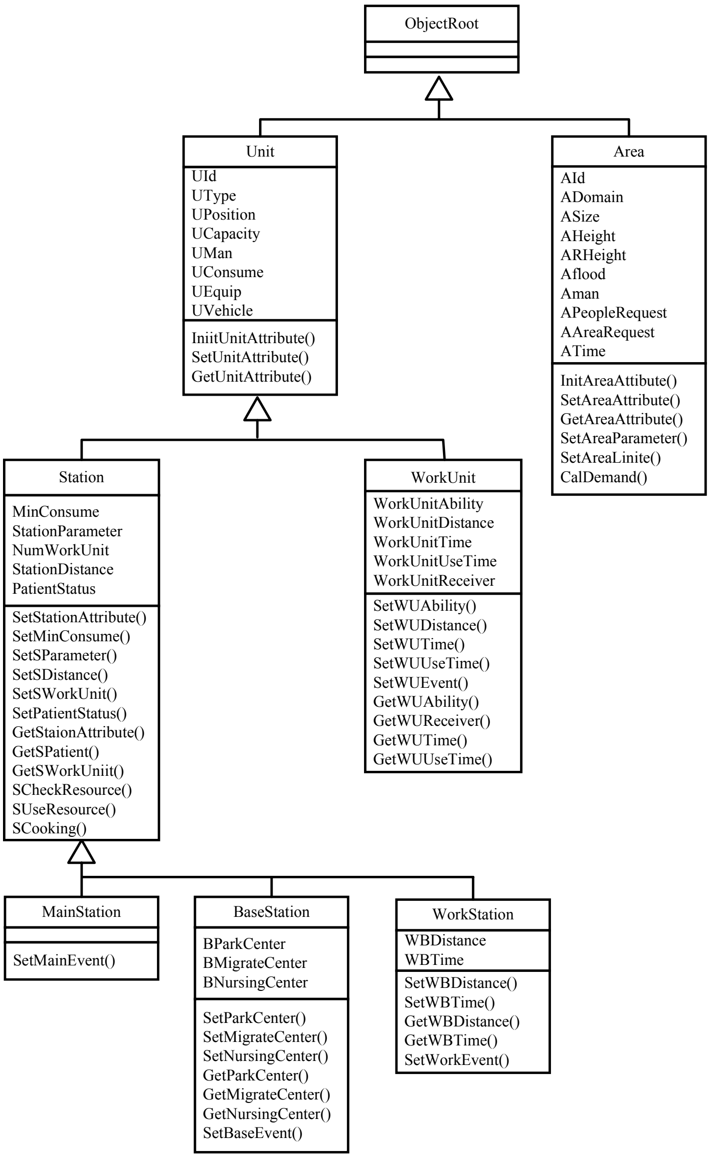

Figure 4. Class Hierarchy

Table 1 shows the interactions in the simulation models in terms of publication and subscription. About exchanging information, the simulation models also have the following relationships.

1) The main station directly connects to the control model.
2) Each base station connects to the main station.

Therefore, the main station work as an agent or a middle person in connecting each base station to the control model. There is no direct connection from a base station to another base station, as happened in the real organisation, due to authority in distributing work and resources.

RESOURCE MANAGEMENT

Resources exchanged in the simulation can be divided into four different types; human resources or workers, consumable resources, equipment and vehicles. Entities in the consumable group are to be deleted after being used or consumed, and require replacement. The resource management for this group is such that the requiring centre or unit asks for resources from other centres.

1) In case of the stock for the inhabitants, an automatically decreasing stock has been made for simulating real simulations. The stock of consumable resources decreases continuously when it still floods and the inhabitants are stuck in the place. It will soon increase when the level of water decreases that means the inhabitants can collect the resources themselves. From the experience of the Hat Yai municipality, the stuck inhabitants need to live by themselves in order to survive during the first 2 days in case that the life support can not get through the location. This implies that they are required to collect their own life support resources such as food and drug before flooding and after. Equation 1 calculates food decrease at a flooded area.

$$X = (A * AS/PN) * FR \quad (1)$$

When X is collected food

A is a coefficient

AS is the size of the affected area

PN is the number of inhabitants in the area

FR is a food-consuming ratio that has been set of a constant at the begining of flooding simulation and automatically decreases as time advances. When there is no flood anymore, it will then increase.

Note These parameters are adaptable. The food-consuming ratio is added because different areas can have different consuming rates.

2) The decrease of consumable resources in the simulated centres or units is caused by distributing resources to community areas, transferring resources to other centres or units and local consumption. However, the change of resources in the consumable group does not occur in case of dry food for distribution. From

our observation, cooked food has a relationship with raw ingredients and the amount of water used for cooking. To simplify the model, we do not consider seasonal ingredients and oil. Therefore, Equation 2 is used for calculating food transforming.

$$Ax = By + Cz \qquad (2)$$

When x is the amount of processed food
y is the dry food
z is water
A, B, C are adaptable coefficients

EMERGENCY SERVICES IN FLOODING SIMULATION

The service simulation is considered in terms of demand and supply. The simulation is driven in two patterns. First, it is stepped by simulation time which is a normal working simulation. Second, it is driven by events happening during the simulation. The first case concerns with all centres and the latter concerns with changes in each community while it is flooding.

Demands for aids

Time advance in the simulation typically sets demands according to the increasing demands of the inhabitants, and leads to more damage at the areas. This can be put into the calculation of local demands in Equation 3.

$$D = D + ((A*People)+(B*Patient))*(C*T) \qquad (3)$$

When D is the demand from local people that can be divided into demands of food, dry food, water, drug, life vests and life bags. The specific demands lead to different coefficients in the equation.
A, B, C are adaptable coefficients.
People is the number of inhabitants at the considered area.
Patient is the number of patients at the location.
T is the period that the location has not been visited, calculated from the last time that this location receives help.

Demands of local people increase when time steps. In other words, when time advances and the community has not yet received supplies responded to the demand, the demand will increase, too.

Demands for restoring the area

Flood damage increases exponentially according to the flood height and the height of buildings (Berning et al 2001). Therefore, we take this conclusion to calculate the demands for restoring the affected area as shown in Equation 4.

$$Z = Z + (X*(AS/PN))*(Y*(FH-AH)) \qquad (4)$$

When Z is the demand for restoring the area that can be divided into solving the fuss, restoring building, demolishing ruin, and cleaning.
X, Y are coefficients that are adjustable according to the type of demands
PN is the number of inhabitants in the considered area
AS is the size of the considered area.
FH is the average flood height comparing to the sea level.
AH is the average height of the area considered.

Apart for computing the demands, computing the resource usage time is also another key issue. Some resources are available or to be used within a period of time due to some reasons such as expired date in case of food or availability in case of equipment .

Event driven simulation is adopted in the supplier site. The users need to control the main station and the base stations in order to response to the demands from the affected areas and to manage the resources at the centre and local units involved. If the resources are in sufficient, the users need to find resources from other sources. Demands can be randomed by the simulation or fed by the users at the controller. In addition, when a demand reach a threshold, it can cause some events to happen. The number or amount of resources when reduced below the threshold can trigger some events to happen, too.

LOOK AND FEEL

Situation reports in the simulation are both text and graph based. Figure 5 and 6 show examples of dialog views and simulation reports. In case of text based reports, user can trace the dialog display to check each event occurred during the simulation or the changes to the resources. The tracing commands can be saved into log files. The users can also set current parameters of the simulation.

After finishing the virtual rehearsal, the application will summarise the number of resources left and used, demands, damage, patients and death bodies found at each unit.

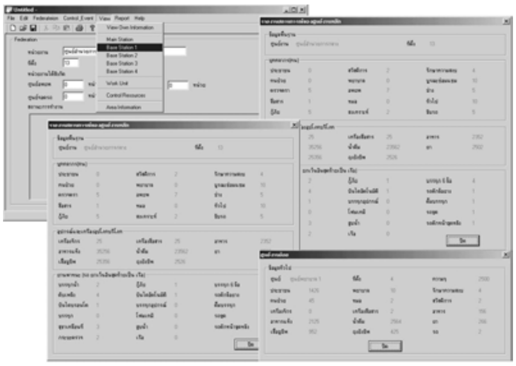

Figure 5. Dialog Views during the Simulation

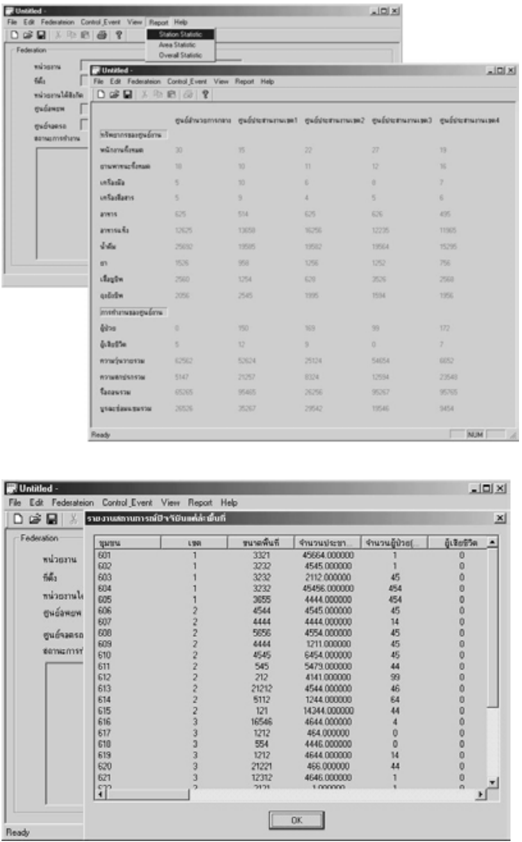

Figure 6. Example of Simulation Reports

CONCLUSION AND FUTURE WORK

This simulation concerns simulating emergency rehearsal in flooding situations in the case study of flooding in Hat Yai municipality, Thailand. The distributed interactive simulation focuses on preparing the work units involved, including staff and interest people, to deal with real situations. The simulation applies the concept of demand and supply. The simulation is simulated into three parts according to the structure of the physical system being simulated. First, the control model acts as a simulation controller that controls the overview of the simulation as a whole. This model concentrates on demands for serving people and demand for restoring the area. Each community has different demands for resources. Second, simulation model of the director centre called main station and the coordinator centres called base stations. These models concerns suppliers that manage existing resources and find additional resources to serve the demands of their communities. Third, the simulation is driven by both time stepping and events. When a simulations ends, summary of resources usage at each centre and unit, and demands from each community will be made.

Currently, this work is still on progress. More details are still required to serve real organisations.

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