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Paper:

IT Framework for Disaster Mitigation Information Sharing

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The robust, loosely coupled network-based Web-service design and standard module-integrating protocol we propose serve as a general-purpose framework for information sharing supporting post-disaster rescue and restoration. Results of experiments confirmed the feasibility of our proposals. A noteworthy feature of our work is the simplicity of its elements and implementation.

Keywords: Disaster-Mitigation, Information-Sharing, SOA, GIS, XML

1. Introduction

Local and national government disaster rescue and mitigation[1]plans and manuals prioritize information sharing to facilitate postdisaster decision-making and remedial actions. The larger the disaster, the greater the amount of reported and required information and the greater the number of organizations involved. This necessitates the use of computer-aided support for the widest possible types and amounts of information among users, i.e., humans, not computers.

Shared information involves more than text data, i.e., character strings and numbers, extending to location indices, time, and multimedia data such as images and movies. Information handling involves sending, receiving, recording, modifying, retrieving, and searching for data. Searching is considered perhaps the most important of these functions in this age of the world wide web (WWW), given large amounts of information handled. It is difficult to imagine to use WWW without search engines such as Google or Yahoo. Similarly, even if rescue staffs have professional skills to retrieve desired information from the piled reports about disasters, they will be a bottle-necks in a case of complex and large-scale disasters, while such professional skills may work in the case of small scale. The search functionality is a key issue to discuss about the information systems.

The information sharing systems should also be able to connect with various types of systems. Because a disaster is not a single phenomenon but complicatedly combined ones over various domains like medical organizations, enterprises, and infrastructures maintainers, information sharing embraces a wide variety of needs functions, and organizations. Therefore, Information-sharing system must span

- divisions of local to nationwide governments and organizations and
- public and private apparatuses and enterprises.

Given the ongoing emergence of technological and other advances, information-sharing systems must also be flexible and robust enough to continuously implement progressive innovations while eliminating outmoded aspects.

Conventional information-sharing researches and systems have exchange information mainly between human and machine rather than among machines [7, 8]. It is important, of course, to consider human users as primary movers in information sharing. It is also important, however, to emphasize automation that facilitates machines interaction [1, 2]. The conventionally specialized aims

1. Note that we use "mitigation" to mean reducing the spread of postdisaster damage rather than predisaster damage.

of operation, unfortunately, have narrowed rather than broadened information-sharing applications [5, 6].

The information technology (IT) framework for disaster-mitigation information sharing we developed based on the above considerations combines the concepts of service-oriented architecture (SOA) and "keep it simple and stupid" (KISS) principle. This paper is organized as follows: section 2 discusses technical requirements for disaster information systems, section 3 proposes a framework, which is detailed in the examples in section 4. Section 5 presents conclusions.

2. Technical Requirements for Information Sharing

2.1. Data Representation

In considering an information-processing framework, especially for long-term use, the importance of data representations outweighs that of system architecture because data-representation the life-cycle generally outlasts that of system architectures.

Data representation design is, for discussion purposes, divided into (i) the types, what kind of information should be represented as data, and (ii) data format, how the information should be notated.

2.1.1. Data Types

A disaster-mitigation information system handles a wide variety of data due to the diversity of phenomena and activities involved. We consider the following four types of data as the minimum to be handled.

Primitive Data (Numbers and Texts):
Real numbers and integers are primary types used for various numeric information such as populations, size of damaged area, degrees of injuries, and so on. Text is also an important format for human to express complex information. This data type includes not only free style sentences such as memo and names, but also semi-structured strings such as address or restricted keyword lists such as the triage indicators , 'red,' 'yellow,' and 'green.'

Geographical and Temporal Data: Much disaster-related information is geographical, mapped to summarize damage and rescue activities. Because such data is often dynamic and changes rapidly over time, temporal data must be handled. Also, meta-level time information like timestamps of detecting, confirming, reporting, and modifying are also binded to the information itself to indicate the dynamism of the changes of informations.

Multimedia Data: Reflecting a proverb "one picture is worth a thousand words," pictures and movies add directly dramatic depth and impact to information about disasters to us directly. Because of diffusion of the Internet and ubiquitous sensing devices such as webcams, digital cameras, and mobile phones, the chance to get multimedia data that explain damaged situations increases so much.

Structured Data: The most of data does not exist – nor could it have meaning – alone, and depends for its meaning on its relationship to other data. A picture, as such, has little meaning unless anchored, for example, by a geographical designation or a timestamp. Such aggregations usually have constructive structures instead of flat lists. For example, a summary report consists of several items each of which includes numbers, descriptions and reporting timestamps, where each descriptions may has some items. A structured data format should also enable multiple combinations, e.g., of geographical data. While only single geographical index is permitted traditional geographical data format such as SHAPE, we may need to handle an information that includes multiple geographical indexes, for example, observation and object locations of a sensing data, starting and destination points of a vehicle travel data, pair of dangerous zone and safety margin of damaged area, and so on.

As most computer languages handle *information*, computers can theoretically manipulate using primitive and structured data[13]. Reason for defining geographical, temporal and multimedia data as primary data types are mainly pragmatic, because geographical and temporal information are primary indexes for human cognition and memory that require special handling such as checking relationships of 'intersection,' 'overlap,' and 'during' that are difficult to be realized by operations of the primitive data types. Multimedia contents are also important information for human cognition, and are generally represented in various binary formats and encodings, whose variation causes a trouble to handle the data. Fortunately, there already exist several standards for representing multimedia contents and their encoding, e.g., for Internet applications, such data is self-explanatory. The multimedia data following such standards is therefore treated as a basic type instead of as composed structured data.

As mentioned in section 1. search capability for these data types should be discussed. There have already exist many technologies to handle primitive data types as a searchable one. Geographical and temporal data become available as g searchable ones recently. Most of database systems provide effective spacial indexing facilities. On the other hand, technology to search multimedia data is still in research phase. Instead, we can supply meta-level information about the multimedia data like the timestamp and location of a picture. Searching structured data can be realized simply by logical combinations of search facilities for each part of the structured data.

2.1.2. Data Format

Data types can be represented in different data formats, e.g., binary, ASCII, and compressed. Because we are considering to integrate several systems, the data formats should meet the following requirements:

- Open:
  Because we suppose to integrate various types of systems, data formats must be open and clearly defined, preferably using widely used standard having

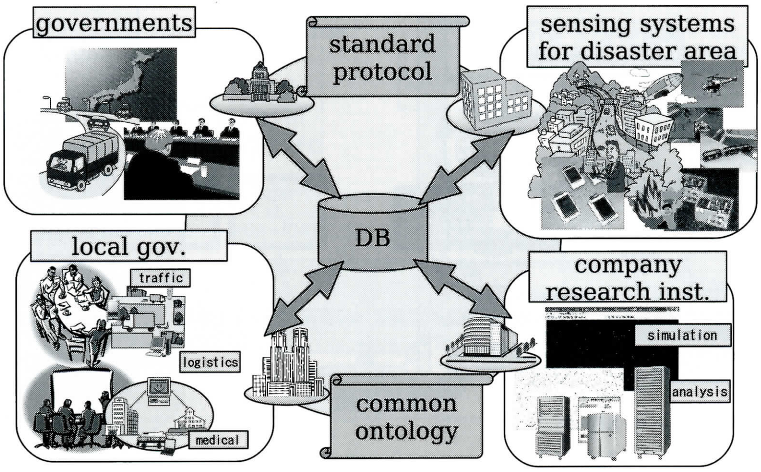

Fig. 1. Conceptual framework of the proposed platform.

a number of various tools available.

- Human-readable:
  Readability of data formats by their human users is important especially during development and debugging phases. As mentioned in section 1, the development of information-sharing systems is an ongoing and unending process. So, data should remain readable to such users at all times.
- Machine-readable:
  The use of data by computers mandates that formats are machine-readable, and the structures and types of machine-readable data must be formally described and standardized. To make it easy to develop complex systems based on service-oriented architecture (SOA, described later), it is common to denote definitions of data structure in a formal way such as XML schema or CORBA IDL[2]. In addition, several efforts are also ongoing to formally describe the meaning of data ontologically in semantic web activities such as Resource Description Framework (RDF) [14].

Another issue of data format may be compactness of the data. However, because of recent progress of information technology, data size is no longer a serious matter except picture or movie data. Therefore, even if the size of text format is two or three times larger than binary, using text format to denote numeric data can be reasonable because numbers in text is readable for any kind of machines and programming language. In the same reason, we can permit redundant format, in which the same information is denoted doubly using the different expression to help human understanding and processing by machines.

2.2. Service-Oriented Architecture

Requirements for system architecture are, as suggested section 1, mainly met assuming the concept of Service Oriented Architecture(SOA).

SOA is a software design methodology for constructing large complex systems as aggregations of "services." A service is a software unit providing a specific function via a standardized interface, i.e., a service is an application software with an interface for cooperating with other software, enabling individual services to be developed relatively independently [3]. In the context of disaster information systems, individual systems can be developed as needed by individual sections or organizations independently. Only the rule is each system follow a standard.

While standard interfaces and protocols may be ineffective in a certain case, such ineffectiveness is not a matter in applications discussed in this article. It is true that the standards require some overhead in processing and/or data representations. Such overhead is critical in the case of high-performance computing using super-computers. On the other hand, as discussed in section 2.1, it is not a big problem in the disaster and rescue application, because the processing speed of the computer is quite faster than human decisions.

3. Common Protocol and Standard Platform

3.1. Design Concepts

In designing our system architecture, we focus on simplicity and an information-sharing protocol.

Based on the principle of "KISS (Keep It Simple and Stupid)," we focus on simplicity, which is essential in designing large, long-term systems. We might be able to use complex cutting-edge technologies and a design specialized for it. However, the life-cycle of the latest information technology (IT) is short, while the time-frame of disaster is long. We thus decided to keep the system architecture simple enough so that it will be easy to replace individual modules as technology progresses.

Based on the KISS principle, we define our proposed system architecture as a simple server-client system, in which a database server play a hub of information sharing among information (sub-)systems (**Fig. 1**). Sub-

2. XML: eXtensible Markup Language. CORBA: Common Object Request Broker Architecture [4]. IDL: Interface Definition Language [10].

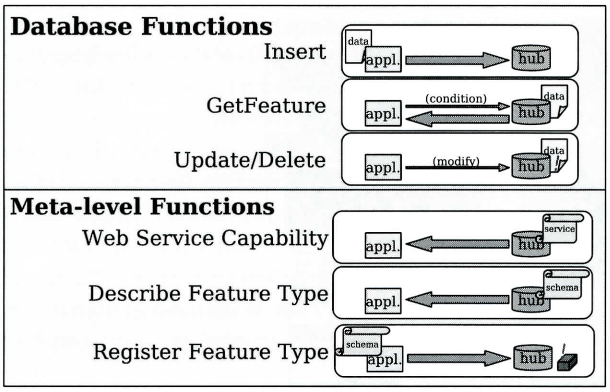

Fig. 2. Basic protocols of MISP.

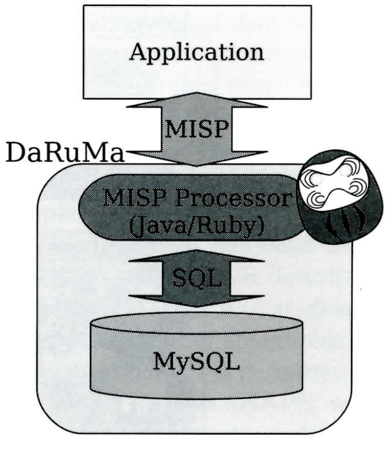

Fig. 3. System overview of DaRuMa.

systems, representing rescue information systems of individual governments and organizations, sensor systems, or advanced rescue assistance systems such as a disaster simulators, are connected to the database server as clients. Client/server communication is established using the common Mitigation Information Sharing Protocol (MISP).

To join this architecture, a rescue information system needs only have an interface for processing the protocol. This need not be a direct MISP interface, but may be any connection to the server via files using helper tools that convert data files of several formats to MISP.

3.2. MISP: Mitigation Information Sharing Protocol

The common protocol we designed, called MISP, provides functions for access and for maintaining geographical information databases over networks. We assume that the overall system using MISP is a client-server type, in which the server is a database and clients are data providers and/or data requesters. The protocol consists of simple XML representation making it easy to develop systems handling this protocol.

In MISP, geographical properties are represented by geographical primitive types of Geography Markup Language (GML) [12]. Most Geographical Information Systems (GIS) use ESRI/SHAPE format for the geographical information. This format is originally designed to describe objects on the maps. Therefore, a unit of information in the format is optimized to represent simple geographical features whose structure is restricted a geographical values and their associated non-geographical data. GML does not, however, specify top-level structures of the information unit, but provides just a primitive expression of geographical values in XML. Because XML can represent various structures flexibility, we can handle complex disaster mitigation information as is.

While GML provides widely varied expressions for geographical primitives, we currently use only points, linestrings, polygons, and geometry collections. This set of primitives is rich enough to construct rescue GIS, and can be handled effectively using spatial indexing techniques such as R-tree.

As a database protocol, we use Web Feature Service (WFS) [11] with a Simple Object Access Protocol (SOAP) envelope as a base. The simple WFS protocol is used to access a geographical XML database, and was standardized by Open Geospatial Consortium (OGC) as part of a geographical web service protocol family including Web Coverage Service (WCS) and Web Map Service (WMS).

It is important that WFS already has a query facility that can be specified numerical, text, geographical and temporal conditions and their any logical combinations. In the case of huge disasters, a large number of information should be shared among peoples and systems. Generally, required information for a certain purpose is just a part of the information. Therefore, we need to have a way to find suitable information from a large collection of shared information. WFS's simple but powerful enough query facility can satisfy requirements in the information sharing for disaster and rescue.

Currently, the following protocols of WFS are available in MISP (**Fig. 2**):

- **GetFeature:** Query data in the database.
- **Transaction:** Manipulate data in the database.
  - **Insert:** Add new data to the database.
  - **Update:** Modify part of existing data in the database.
  - **Delete:** Remove data from the database.
- **GetCapabilities:** Ask information about available database functions.
- **DescribeFeatureType:** Request information about an XML structure of a certain type of data the database handles.

In addition to these WFS protocols, MISP also has the **RegisterFeatureType** protocol for defining a new type and its XML structure using XML schemes (**Fig. 2**). This lets users add new types of data without having to stop and re-design whole systems. This kind of flexibility is important for the rescue and disaster mitigation system because

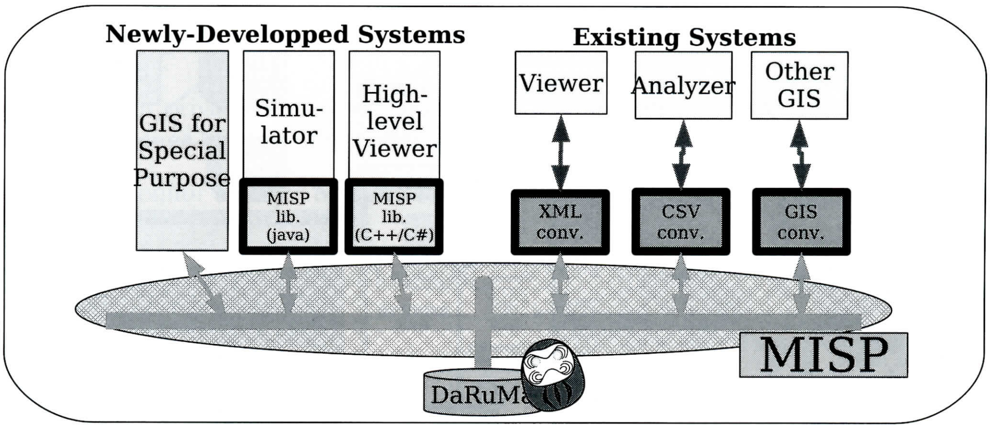

Fig. 4. System integration framework via DaRuMa.

of the difficulty of predefining everything beforehand in disaster. The RegisterFeatureType protocol enables new systems to be connected and new types of information to be handled in emergency situations.

3.3. DaRuMa:DAtabase for Rescue Utility MAnagement

DaRuMa (DAtabase for Rescue Utility MAnagement) is a reference system that is compliant to MISP. DaRuMa consists of a MySQL server and a middle-ware written in Ruby/Java. The middle-ware translates between MISP and SQL. **Fig. 3** shows an overview of DaRuMa system.

In order to utilize effectivity of MySQL as RDBS, DaRuMa's middle-ware flattens XML structure into SQL table as much as possible. In addition to it, DaRuMa makes indexes of geographical properties in XML structure, because most of queries in rescue situation are related to locations of data.

Because MySQL, Ruby and Java support widely-variated platforms, we can run and port DaRuMa on various OS and hardwares.

The way of the integration using DaRuMa is simple. DaRuMa becomes a kind of blackboard, to which each information system connects using MISP to write and read sharing information as shown in **Fig. 4**. In this figure, existing and newly developed systems can connect to DaRuMa directly or via libraries ('lib.' in the figure) and converters (conv.). Because of the generality and flexibility of XML representation, it is easy to develop such a libraries and converters. We have already developed such tools called 'DaRuMa tools,' which is designed to convert data between CSV and XML for the general purpose.

3.4. Advantage of DaRuMa/MISP

As described in section 3.2, MISP is designed based on WFS. But also, we add several original features to this specification. In the rest of this section, we explain two of the features, RegisterFeatureType protocol and symbolic timestamp representation, and show their advantages.

3.4.1. Utility of RegisterFeatureType

The original specification of WFS does not include a protocol to declare structures of information the database can deal with, while SQL can do it by "CREATE TABLE" protocol. This means that WFS assumes that information structures are defined before the database runs. While this assumption is reasonable in normal usages of GIS, it is too rigid for the rescue purpose. As described in section 1, we may switch some modules on-the-fly because of damages and/or situations of the systems. So, we need to re-design information structure or add new structure during running the database. The RegisterFeatureType protocol provides this flexibility.

The utility of this flexibility was shown when we tried to integrate ten existing rescue information systems developed by different institutes via DaRuMa/MISP. It took only three days to integrate whole systems from the scratch without any experiences. During the integration, many information structures were re-designed again and again in order to make a consensus among institutes. The re-design process was very smooth because we did not need to stop DaRuMa, which interfere other the operation of institutes' systems. This is an episode of developing and debugging of a system. But, we should suppose that the disaster situation is a kind of debugging process because we may need to add and replace modules of the system. In such a situation, the utility of the RegisterFeatureType will be effective to establish information infrastructure for disaster mitigation.

Unfortunately, it is difficult to show such a kind of utility and advantage by an objective measure. Instead, we try to illustrate them by showing an analogical example that utilizes the same methodology. 'Wiki' (WikiWikiWeb) becomes a popular and important tool to construct web pages and to share information. The key feature of the wiki is seamless-ness of designing and publishing phases of a web service: Users not only can view and add contents to the wiki, but also can create new pages or re-design existing pages freely without terminating the service. In other words, the designing and publishing phases co-exist in a wiki service. Because of this simple but convenient mechanisms, peoples are encouraged to share

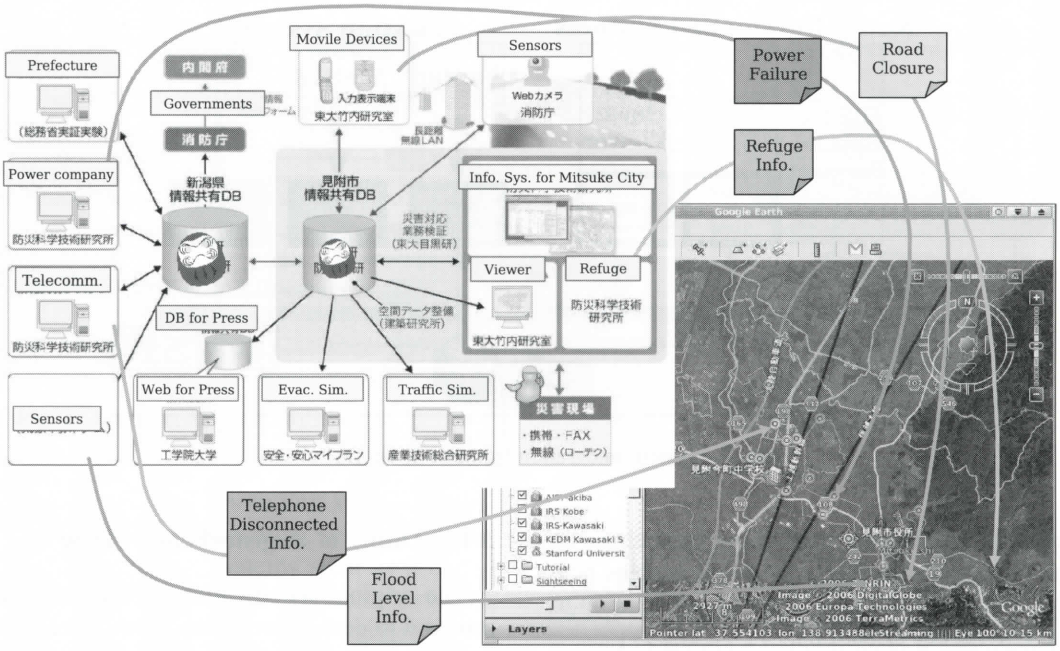

Fig. 5. Integration among different oganizations (in Mitsuke case).

their ideas. The RegisterFeatureType in MISP also provides the same feature to the proposed framework. As a result, it enables the short time integration as shown in the above example.

3.4.2. Symbolic Timestamp of Transaction

Because sensing and usage of information under disaster and rescue are performed simultaneously, DaRuMa/MISP should respond multiple requests in parallel. Therefore, a well-formed timestamp facility is necessary for DaRuMa/MISP. Especially, when a client of DaRuMa/MISP like to process large amount of information incrementally, fine-grained timestamp facility is necessary.

In order to realize such a facility, we introduce symbolic timestamp of the transaction, called 'transactionID.' DaRuMa/MISP assigns each transaction operation a transactionID, which is a symbol (UUID string). The whole set of transactionIDs in a DaRuMa is totally ordered. This means that all transactions are serialized in a DaRuMa. Each data entry records its create and update timestamp by transactionIDs. In addition, each MISP response also includes a transactionID that indicate a timestamp of the most recent transaction. Using this information, clients can process dynamic information stored in a DaRuMa incrementally.

Generally, timestamp is represented by a time value or serial integer number instead of symbolic one. However, we took a symbolic representation because of the following reasons.

- Time value representation of timestamp can not provides a enough granularity to serialize all transactions. If we use time values, we can not escape the limit of smallest time-tic of computer systems. While databases and operating systems has a fixed time-tic like 1 second, 1 millisecond, or 1 nanosecond, the processing speed of CPU is getting faster and faster day by day. Also, multi-CPU and multi-core technologies are becoming common recently. This means that we can not avoid the situation that the several transactions are done in a time-tic.

- Serial integer number can not handle distributed processing of multiple databases. While serial integer number can serialize transactions in a single database, it can not represent orders of transactions among multiple databases. In future, rescue information database will form a GRID to provide robustness and performance. This means that timestamp representation should have a capacity to represent complicated orders of transactions among databases. Integer representation is not enough to handle this, because we can not guarantee every timestamp is unique. On the other hand, UUID guarantee that every ID is unique as it definition.

4. Examples of Experimental Systems

4.1. Integration Among Different Organizations

Our first example is to integrate several existing and newly developed information (sub-)systems by sharing disaster mitigation information via DaRuMa.

We have developed a information system for flood disasters at Mitsuke city in Japan (**Fig. 5**). The system consists of the following sub-systems:

- disaster management systems for the local government that cover operations of three related sections, civil engineering section, welfare section, and fire department.

- information systems in private companies, (power and telephone) to exchange life-line information.
- sensor systems that monitor changes of water level in a river.
- mobile data terminals for rescue members to report disaster situations.
- integrated general purpose GIS viewer.
- refuge information systems.
- evacuation and traffic simulation systems to help rescue planning.
- a system to inform disaster situation to the prefecture government and the national government.
- a web service system for press and general public.

In a field experiment conducted for a training of rescue actions against flood damage, the system showed a remarkable performance to share disaster information among sections and institutes, and among traditional and novel systems.

The main objection of this experiment is to show how effective the proposed framework is to connect various types of systems with each other. We succeed to integrate the systems only three days in total. The key of this effectiveness comes from simpleness of the system architecture. As describe in previous sections, we take a simple server-client architecture in which a database becomes a hub to exchange information. Because the protocol and the database can handle various types of data flexibly, it is easy to adapt other sub-systems to communicate with the database using the common protocol. Also, the database take a simple role as a blackboard that store and retrieve information. Therefore, development and modification of each modules can be done without stopping whole systems because each sub-system can start and stop independently. By these feature, we can avoid a bottle-neck of the development.

4.2. Integration of Simulation and Rescue Information System

In the second experiment, we focus on an issues utilization of advanced supporting systems via under the proposed framework (**Fig. 6**). The scenario of the experiment is that a huge earthquake hit Toyohashi city. A large number of civilians must evacuate to refuges. They report fires and damages of houses and roads they find when they arrive a refuge. When their reports are gathered into DaRuMa, a simulation systems of fires, traffics, and waking-evacuation starts to predicts changes of situations and to suggest effective plan of evacuations. These simulations are dependent with each other: Results of the fire simulation (spread area of fire) is utilized in traffic

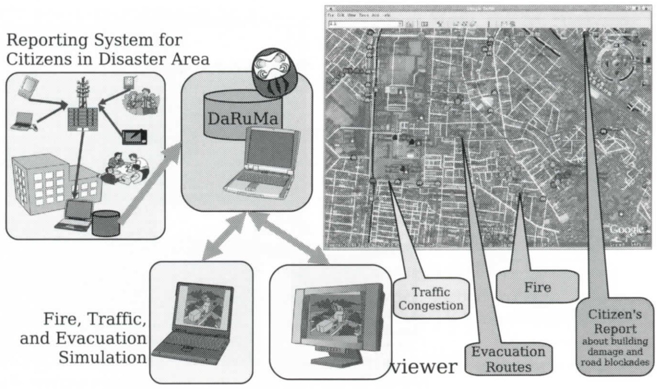

Fig. 6. Integration of simulation and rescue information system (in Toyohashi case).

and evacuation simulation as a dangerous area, and traffic and evacuation simulations are interact with each other. DaRuMa plays a role of hub to exchange results of the simulations among them. Because the architecture of the proposed framework is kept simple, developers of each simulators take only care to receive configurations from and send result to DaRuMa rather than to think about relation among simulations. Therefore, it takes only two days to integrate them with other part of the information sharing system.

We also evaluate the performance to handle a large number of information reported by citizens. In the experiment, we put more than 8,000 reports to DaRuMa in two hours, while the DaRuMa also provides services for other systems like simulations and information viewers in the same time. Although the amount of the data is not so hard for recent computers to handle, this result is important because a low-spec note computer (Mobile Pentium III 933MHz, 512MB memory) is used for DaRuMa in this experience. This means that the core of the framework does not require high spec hardwares. In some case, we can setup and run DaRuMa on normal laptop computers used in daily works of local governments even if mail servers for DaRuMa may be damaged by a disasters.

4.3. Utilization of Existing Information by Visualization via DaRuMa

The proposed framework also can utilize information that will be able to contribute to rescue activities but not used effectively now. **Fig. 7** is a system that analyzes a traveling information transmitted from probe cars[3]and show available roads that are used by the cars after the disaster. The figure shows an actual data taken just after Chuetsu-Oki earthquake. This result was published on the web to help rescue and recover teams for the earthquake.

Figure 8 is another example of information utilization, in which contents on EMIS (Emergency Medical Information System)[4] are visualized on Google Earth via

3. A probe car is a vehicle with a car navigation system that can recored travel data of the vehicle and transmit it to a service center in real time via wireless communication.
4. EMIS homepage: http://www.wds.emis.or.jp

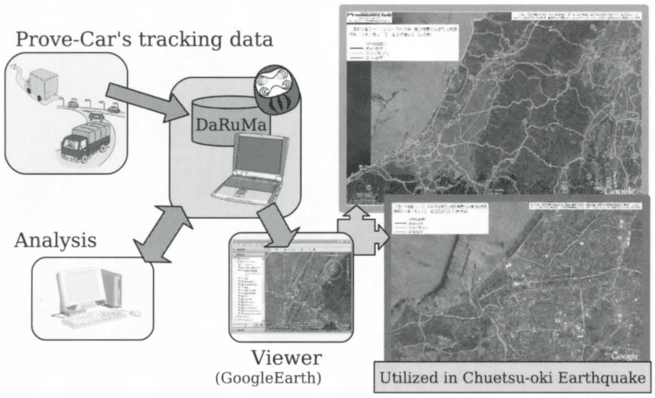

Fig. 7. Utilization of probe car information by visualization via DaRuMa (in Chuetsu-Oki case).

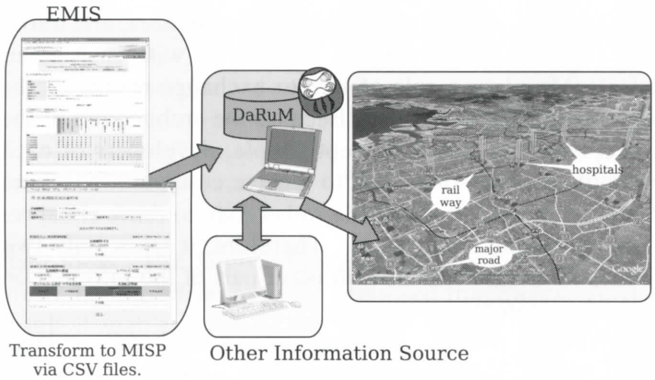

Fig. 8. Utilization of emergency medical information by visualization via DaRuMa.

DaRuMa. EMIS is a system that store capability information of all emergency hospitals in covered area and provides them to related organizations. Currently, the system is closed and has poor interface. Therefore, its utilization is quite limited. Our experimental system shown in **Fig. 8** has been trying to show usefulness of sharing the capability information visually instead of the original poor interface by text format. The point of the system is we just combine a general tool called 'DaRuMa Earth' that converts data in DaRuMa to a KML file that can be displayed on Google Earth, a widely used general purpose GIS viewer. Currently, we suppose that EMIS can provide its data as a CSV (comma separated value) file instead that EMIS connects with DaRuMa directly. If EMIS provides more sophisticated network-based interface, it will be able to develop a tool to connect EMIS and DaRuMa easily.

4.4. Integration of Novel Sensing Systems

We also conducted several experiences to integrate sensing systems of rescue robots and GIS viewers [9]. **Fig. 9** is an overview of the system to share informations acquired by robotic sensors and transfer them to several GIS viewers. In this schema, a robot takes various types of data like picture, movies, sounds, and so on with its position, and sends them to a DaRuMa. In the same time, a

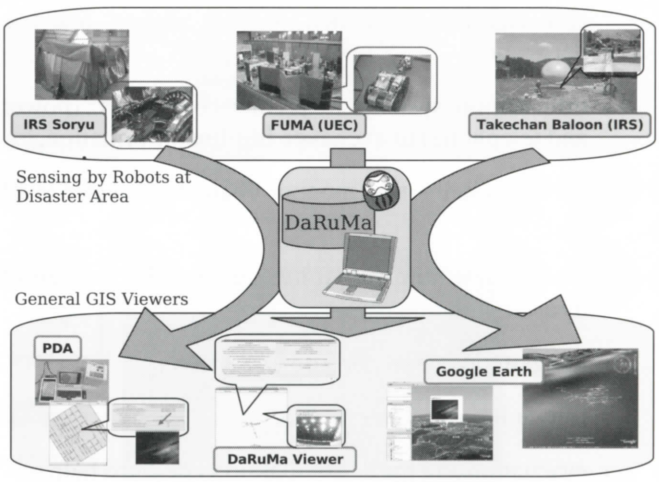

Fig. 9. Integration of information sensed by rescue robots.

GIS viewer sends a query to get information taken by the robot real-time. When the viewer needs only changes of information from the previous access, it can utilize transactionID facility described in section 3.4. In this case, the viewer can show changes of acquired information in animation.

In these experiments, we took various pictures using rescue robots (IRS Soryu and FUMA), and sent them to DaRuMa with location and time stamps. Taken pictures were retrieved and shown on several GIS viewers (Google Earth, DaRuMa Viewer, and PDA viewer). Because these robots can go into debris and run over dangerous area, we can get and utilize visual informations in broken buildings. We also stored movies taken by aerial robot (Takechan Baloon), and place its information that include 3D trajectories of the robots on GIS. We did this experiment in Yamakoshi area where a huge mudslide occurs in Chuetsu Earthquake in Oct. 2004. While the mechanism of these experiments is very simple, the usefulness is quite significant. As same as the example shown in section 4.1, integration of robot systems and DaRuMa took less than one day, and effect of the integration is obvious. Here, simpleness of the proposed framework plays important role.

5. Conclusion

In this article, we proposed a IT framework for disaster mitigation information sharing by MISP, a standard protocol for rescue information sharing platforms, and DaRuMa, a prototype implementation of MISP-compliant databases. They were designed to answer several requirements of disaster mitigation described in section 2.

As mentioned in section 3.1, a rescue system should be designed based on KISS principle. Our examples shows the effectiveness of KISS principle in integration of various systems. As mentioned above, time span of disaster and rescue is quite longer than life-cycle of the progress of technologies. So, the simpleness will play an important role in continuous developments of total systems.

We proposed DaRuMa just as a prototype system. It can be replaced by other commercial or open-source products that have facilities compliant to MISP. Also, DaRuMa itself is released under the modified BSD license, which permit to use it as a part of commercial products without publishing source codes. This will encourage developers to use MISP.

There also remain the following open issues:

- Dual Use: While we only described the rescue application, the system also should have a capability to handle general-purpose geographical information for daily use. It is difficult to keep large budget to develop and improve the system only for disaster mitigation for long years. Daily use will enforce to keep the system active and novel over time. Fortunately, the proposed framework is not specialized for disaster and rescue, it is easy to utilize them for general purpose.

- Flexible Knowledge/Inference: While MISP can accept any type of data structures, it has no mechanism to map data among these structures. In particular, in the case of daily operations of local governments, many types of data are overlapped over different departments. in general, it is difficult to maintain correspondence between data in different departments. Therefore, we need an ontology and clearinghouse mechanism like CSW (Catalogue Service for the Web) and WPS (Web Processing Service) to map such correspondence semi-automatically.

- System Robustness: As mentioned in section 3.2, a rescue information system should have a capability to run on GRID/P2P environments. MISP uses SOAP Envelope to guarantee its smooth operation on such a distributed processing framework, but it has not been specified how to realize it.

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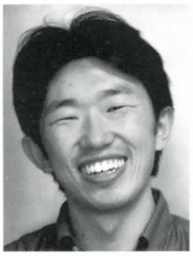

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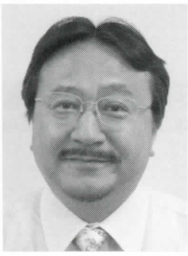

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