PREPARING FOR CREATIVE RESPONSES TO "BEYOND ASSUMED LEVEL" DISASTERS: LESSONS FROM THE ICT MANAGEMENT IN THE 2011 GREAT EAST JAPAN EARTHQUAKE CRISIS

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Abstract

A survey of the municipal government ICT divisions during and after the 2011 Great East Japan Earthquake and Tsunami crisis reveals the need for creative responses for "beyond assumed level" disasters. Complexity and diversity of the damage were simply too great for any plans to assume. Resident needs toward the municipal governments were also diverse and changed quickly as the time went by. The research also indicates that there would be ways to strengthen the capabilities to execute such spontaneous responses. Creative solutions executed during the 3.11 crisis were supported by the existence of open source software available on the net and skilled engineers that were capable of exploiting them. Frugal information system will be useful to improve preparedness for creative responses.

Keywords*:* Municipal Government, Information System, Disaster, Preparedness, Creative Response

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1 Introduction

Six month after the devastating Great East Japan Earthquake and the subsequent tsunami on March 11, 2011, LASDEC (Local Authority Systems Development Center) requested Keio University to conduct a survey on how ICT (information and communication technology) systems and organizations coped during and after the crisis. The objective of the survey was to formulate a standard business continuity plan (ICT-BCP) for the local governments so they may be better prepared for future disasters. Structured interviews of 13 municipal governments in the hardest hit areas were conducted from November 2011 to January 2012. The data was supplemented by interviews of other municipalities conducted outside of the LASDEC study in writing this paper.

Shortly after the field work started, however, researchers came to the realization that the complexity and the diversity of the damages were huge among the municipalities surveyed. In fact, so huge that it would be unrealistic to expect that a single BCP will provide adequate preparation for all local governments. Diversity of resident needs toward municipal government services also varied greatly. This would make the task even more complex. Even if a comprehensive plan can be made, the cost of execution will be prohibitive.

Based on our survey of the municipal governments' struggle to maintain critical resident life support services, as well as theoretical frameworks provided by public health crisis management literature such as Settle (1985), the authors came to the notion of "preparedness for creative responses". We define creative responses in this paper as autonomous actions taken by local officials to deal with damages that were not assumed in disaster response plans.

We assert the usefulness of this notion based on our observation that many unplanned activities were necessary to cope with "beyond assumed level" situations, while such activities were helped by libraries of prepared tools that were available. In summary, we assert that preparation for disaster should include both action plans for assumed events, AND development of creative response capabilities to deal with damages beyond assumed levels.

We believe that "frugal IS" notion (Watson et al, 2012) will be helpful in preparing for creative responses in future crises in municipal government ICT systems.

2 The Great East Japan Earthquake

The Great East Japan Earthquake occurred at 14:46 Japan Standard Time on March 11, 2011. At a Richter scale of 9.0, it was the largest earthquake on record for Japan. More damaging than the quake itself, a tsunami of up to 40 meters hit the coastline, devastating cities and towns. The Fire and Disaster Management Agency reported 16,131 deaths, 5,994 injuries and 3,240 missing as of January 2012. It also reported 128,497 houses totally lost and more than 900,000 partially destroyed.

The tsunami also destroyed all power supply to the cooling systems of the nuclear power plant in Fukushima causing a meltdown. As of January 1, 2012, 159,124 people from Fukushima had still not returned to their homes.

ICT division played an important support role in the recovery processes of all municipal governments. It would have been impossible to execute tasks without the support of ICT systems. ICT divisions were responsible for maintaining the infrastructure for various information systems.

ICT systems themselves were also hit. The interruption of communication and the loss of information system capabilities for operations were significant hindrances to the entire recovery process. People and organizations were deprived of the information and the processing capabilities necessary to deal with the situation. The effect was particularly noticeable at the municipal government level. There are 1742 municipal governments in Japan as of October 1. 2012. In the three layer (national prefectural and municipal) structure of Japanese government, municipal governments are the closest governments for the people serving their daily needs directly.

Most significantly municipal governments are in charge of keeping resident information which serves as the foundation for government.

3 Diversity, Complexity and Temporal Shifts of the Crisis

Both the extents and the scales of the earthquake damage were diverse, as the damages were combinations of quake and tsunami damages. The affected areas were also very large with different geographical conditions.

The expectations of ICT divisions and the requisites for and processes towards recovery varied greatly along several variables. The variables included structural damage to government facilities and server rooms, loss of data, whether power supply and network connectivity could be resumed immediately, whether communication tools such as cell phones remained functional and the degree of mass emergency evacuation to locations outside the affected area.

Also notable were temporal changes in the situation. As the situation changed with time, required capabilities to deal with the situation also changed.

The capabilities necessary in the initial phase was as follows:

Immediate response measures in the municipalities that experienced major devastation focused on saving lives and guiding survivors to evacuation centers, and in some areas little priority was given to reopening resident service counters (there was however a sense of urgency regarding the need for access to residents' personal information in order to facilitate rescue operations). Some ICT divisions even dispatched employees to do relief work with just skeleton staff remaining at the office. At these municipalities, as well, providing support to the affected people at various post-disaster stages was difficult without the use of ICT(including information system). It became more evident than ever that post-disaster expectations toward ICT divisions change as time passes.

4 Could a Uniform Plan be Effective?

4.1 Planned Response to Assumed Level Damage

In general, regional disaster response plans drawn up by each municipality specify the scope of action to be taken by the relevant organization during a disaster, such as setting up disaster response headquarters and confirming the safety of residents. Some plans also clarify the role of each operational division in the event of a disaster.

After the disaster response headquarters were started up, many of the municipalities dispatched personnel for tasks such as operating evacuation centers and transporting goods under instructions from those headquarters. Further, although several of the regional disaster response plans stipulated that the role of the ICT divisions during a disaster would be information services for the residents this was not possible because key communication means were disrupted.

The response measures summarized below require a large number of people working at the disaster site to carry out numerous activities, including creating lists of survivor names and other information, manning resident service counters to issue Disaster-victim Certificates required to avail of disaster relief and other support systems, distribution of relief money, accepting applications for temporary housing, and tearing down damaged buildings and clearing debris. Municipal governments are mandated by law to perform these tasks. An ICT supports the role.

The disaster response measures taken by the ICT divisions of 13 municipalities surveyed can be primarily divided into the following:

1) Documenting evacuee names and other information (on paper and computer)

2) Restoring operation of information processing

systems

– Upgrade of existing systems

– Development and introduction of new systems

3) Verifying information in various lists with previously documented residents' information

4) Issuing of Disaster-victim Certificates

I) is extremely labor-intensive tasks and most of the municipalities made significant efforts to complete this unexpected post-disaster duty that employees also found demanding.

4.2 Damages Beyond Assumed Level

The types of damages observed at the 13 municipal government office buildings following the earthquake and tsunami and beyond assumed situations that arose subsequently were as follows:

- Loss of lives of majority of executives in the higher tier.
- Collapse of government office buildings.
- Damage to the server, ventilation systems and other equipment.
- Loss of data.
- Suspension of power supply.
- Damage to telecommunications cables and equipment (disruption of communications).
- Destruction of office automated systems.
- Difficulty in getting employees and other personnel to the government office building.
- Inability to enter the server room (malfunction of electronic locks due to power outage).
- Relocation of the server room.
- Relocation of administrative functions.

In addition, in areas affected by the nuclear accident, access to the government offices became difficult for local and outside personnel despite no damage to the buildings themselves, and relocation of data servers outside the region, and of administrative functions is increasingly apparent.

Post-disaster risks could potentially give rise to diverse situations. In particular, a power failure will upset the operation of information processing systems and disrupt communication with the outside. Hence measures to ensure uninterrupted power supply are of utmost importance. During the survey as well, most of the municipal governments emphasized the need for stable power supply. The time taken for commercial power supply to be resumed at the 13 government office buildings varied greatly by municipality, ranging from one day to several months. Although it may be close to impossible to anticipate the time required for power supply to be restored, measures must be implemented to clarify beforehand the tasks that must be carried out during a power failure and to create systems that will ensure uninterrupted power supply to essential ICT equipment. Initiatives must also be taken to prepare for other responses such as the relocation of some administrative functions, in the event of prolonged power outages.

4.3 Response beyond assumed events by ICT Divisions

With regard to ICT divisions, however, none of the 13 municipalities surveyed had drawn up action plans that included business continuity planning, and responses by the respective ICT divisions at the time of the disaster were mainly based on their own discretion.

The following is a typical timeline of responses, created based on activities conducted by employees of ICT divisions at the municipalities that were surveyed, in the months that immediately followed the disaster on March 11.

1) Immediately after disaster struck, checked the condition of the servers and other equipment in the server room.

2) Confirmed resident whereabouts, and helped with transporting goods and other tasks related to the operation of evacuation centers.

3) After power supply was resumed, worked on restoring information processing systems, networks and other related equipment within the facility.

4) Studied the introduction of and developed information processing systems that can be used for disaster response activities.

5) Worked to restore public data networks in the region.

5 Plan vs. Preparedness

Settle (1985) argued that emergency management should be financed in four stages, i.e., mitigation, preparedness, response and recovery. Shoaf et al (2000) adopts same four stage model in the analysis of disaster management. In the context of this model, our research is about preparedness and response stages. We place a particular focus on preparedness for responses to damages that were not assumed before the event.

An important aspect of preparedness is planning. Gebbie and Qureshi (2002) emphasized the importance of emergency response plans which should include the chain of command and the agency roles. They also emphasized the importance of regular practices asserting that "plans that are never practiced or that are poorly understood will probably be useless". On the topic of practices, Watkins (2000) points out that FEMA (The Federal Emergency Management Agency) is adopting a five category model, i.e., orientation, drill, tabletop, functional, and full-scale.

As mentioned above all of the 13 municipalities we interviewed in the LASDEC survey had regional disaster response plans. The plans defined the chain of command and the tasks to be performed. ICT divisions, however, were simply out of scope of the plans in spite of their importance. We are supportive of the national government initiative to equip all municipalities with ICT-BCP.

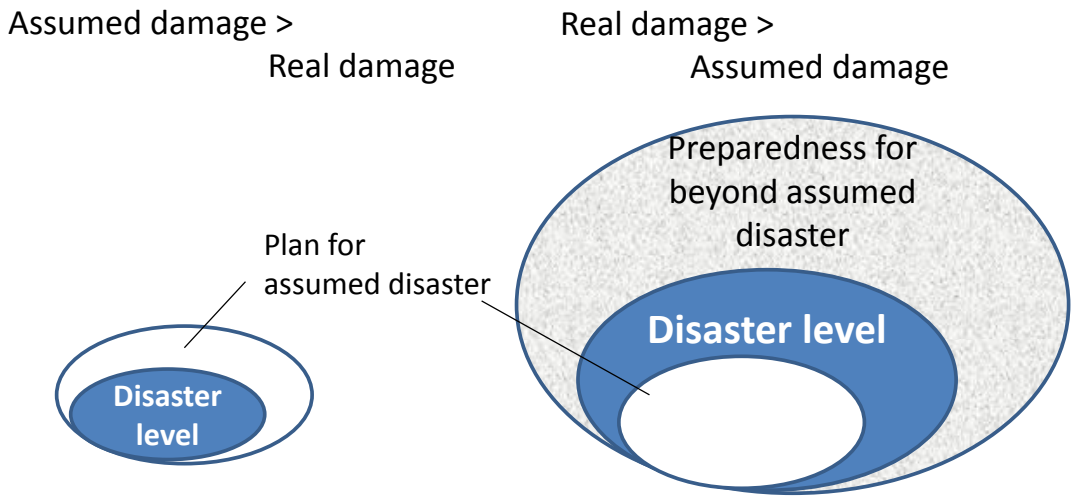
While we support better planning, our field research also revealed that the extent and diversity of the damage can be far beyond any prior assumptions. This implies that even if ICT-BCP existed, a uniformly prepared set of responses would have been insufficient to meet the diverse and rapidly changing needs of the residents.

This by no means reduces the importance of planning. It is naturally useful to make predictions of damages and make plans to respond to the situation. Determination of the chain of command is critical and it is wise to stock of supplies based on careful estimation of the need. Such plans should also be widely shared by all people concerned.

At the same time, we recognize the importance of flexibility in decision making in executing disaster management plans (Kunreuther and Miller, 1985). To respond to the changing situations, strategic incorporation of current information is essential.

We propose to apply the concept of preparedness in thinking about increased capabilities of officials to flexibly respond to unexpected events (See figure).

Figure 1. Preparedness for beyond assumed disaster



In this regard, preparedness is at the opposite of "plans" that are made based on predicted and assumed damage. Damages within assumptions can be dealt with by plans. We need to prepare capabilities for creative responses for damages beyond assumed level.

6 Comparative Study of Disaster Victim Support Operations

6.1 Uses of the Planned Solution and there limits

Disaster Victims Support System is a Linux based and national government endorsed comprehensive post disaster support system. (We call the system Nishinomiya system in this paper after the municipal government that developed it). It was developed after 1995 Hanshin Awaji Earthquake that killed thousands to prepare for future similar events. Source codes (program that can be read and written by humans) for the software had been made openly available for other municipal governments in 2005 and to everyone including private companies after the Great East Japan Earthquake in 2011.

In spite of this good intentions and investments, the system was not utilized as expected in the relief efforts of Great East Japan Earthquake.

Instead, municipal governments opted to use simpler measures such as the use of Microsoft Excel. Even in municipal governments where the Nishinomiya system were used, they had to modify original software to suit local requirements. In summary, all of municipal governments had to conduct ICT development work at a time when people were starving and freezing outside. We believe this was inevitable. We also believe such process can and should be done with minimal resources and time.

It would serve the risk management community to analyze why the use of the Nishinomiya system was limited.

One reason for the less than expected use of the package was lack of time to learn how to operate the software package in the disaster situation. It is notable that much ICT resources were spent in the most critical moments developing systems that meet the demands of the diverse local situations.

Information processing systems that were restored or newly introduced and the timing of measures taken differ by municipality. The system types may, however, be broadly divided into the following two types:

- Systems based on residents' information that link to all government functions.
- Individual systems for each function (issue of

Disaster-victim Certificates, distribution of relief funds, etc.).

The Nishinomiya system was one example of an existing system that is based on residents' information and links to all government functions. Survey respondents were also asked questions about the introduction of this system. Although none of the municipalities had installed the system before March 11, 2011, Miyako City, Ishinomaki City, Kesennuma City, Minamisanriku Town and Iwaki City have introduced it since and selectively use only those features of the system that are required for their individual operations. Miyako City utilizes the system to manage distribution of relief funds; Ishinomaki City for the issue of Disaster-victim Certificates; Kesennuma City for the management of debris removal; and Minamisanriku Town to manage distribution of relief funds and occupancy of temporary housing facilities.

Following the disaster, many municipalities considered introduction of the Nishinomiya system, but were forced to defer introduction for the following reasons:

- Installation on data server was not successful.
- Data processing is required, making use of the system cumbersome.
- A drop in performance was expected when handling large volumes of data.
- Study and modification to the system could not be completed in time for issue of the certificates.
- Operational differences with the developer (Nishinomiya City) regarding the format of the Disaster-victim Certificate and other issues.
- Information upload regarding disaster victims was already completed using a different application software.

In hindsight, all of the problems mentioned in the above comments may have been avoided if preparations had been made in normal times to configure the system beforehand and train personnel to be able to upload resident information immediately in the event of a disaster. The reality was that the ICT divisions were too busy to prepare for slim possibilities of catastrophe. And when the time came, the planned tool lacked familiarity among the officials who then avoided the use.

6.2 Creative Response to Impending Necessity: Case Tagajo City's Disaster Victim Management System

Ashenhurst(1972) asserted that information system "must have" modifiability in additions to capability (to and stability to be responsiveness to organizational requirements.

Juergens (1977) argued that "well functioning" systems have unsatisfied users and stressed the importance of user participation. In the context of this paper, these calls for modifiability can be interpreted as calls for developing capabilities among users to execute creative responses themselves.

Table below lists creative responses in ICT by 13 municipalities and their execution dates. We recognized an action as a creative response, when either original software was developed, or modification to the planned package (i.e., the Nishinomiya system) software by changing the source code was made.

Even among the adopters of Nishinomiya system Miyako, Ishinomaki, and Minamisanriku had to modify the system to meet their needs. As many post-disaster tasks cannot be foreseen, it is often difficult to determine beforehand what information installation will be required (and what will not) during a disaster. The following are examples of items that cannot be confirmed earlier and require some form of technical support to upgrade the Nishinomiya system as may be needed after a disaster.

- No record of relocation history of evacuees.
- Information on temporary housing choices of evacuees cannot be uploaded.
- Information on management of relief goods cannot be updated.
- No feature to record transactions at resident service counters.

The operation of information systems to deal with disaster response measures, including the Nishinomiya system, requires more than just installing the system on a server. As explained above, emergency preparedness measures must be taken to enable installation of resident information immediately after a disaster, and training to ensure business continuity and provide support to victims must be implemented beforehand.

In addition, steps must also be taken to ensure speedy coordination between systems to enable extraction of information from the existing resident information system and conversion to the new format.

Tagajo City that we interviewed outside of LASDEC inquiry is an example of a municipal government that developed a new system during in the recovery period. They did so because the Nishinomiya System could not meet its needs. Tagajo City opened its citizen support center on April, 1, 2011. The center's primary tasks were to identify residents' whereabouts/contacts, damages inflicted on their homes/properties, and to provide adequate information on the relief programs.

Information system became necessary to record the history of consultancies and relate them to resident records. The system development to meet the needs started five days before the service began. Faced with lack of resources and time, the city relied on open source software on the net. Necessary adjustments and additions were made to the software parts and were then integrated to fulfill the needs.

Table 1. Creative Responses by Municipal Governments Surveyed (As of January 2012)

Municipalities surveyed		Example of creative responses	Date
Iwate Prefecture	Miyako City	Modified the Nishinomiya system Developed Kyoto-u-system*	Mid-May Late-December
	Rikuzentakata City	Developed residents safety checking system by open source software	Mid-March
	Kamaishi City	Developed Kyoto-u-system*	Mid-April
	Otsuchi Town	Developed original victim support system (Supported by National Research Institute for Earth Science and Disaster Prevention) Developed Kyoto-u-system*	Late-April around May
Miyagi Prefecture	Sendai City	Modified existing tax collection system to develop victims support system	Early-May
	Ishinomaki City	Modified the Nishinomiya system	Early-May
	Kesennuma City	Developed original victim support system by Microsoft access	Mid-April
	Higashimatsushima City	Developed original victim support system	Mid-April
	Minamisanriku Town	Modified the Nishinomiya system	November
Fukushima Prefecture	Iwaki City	Developed original victim support system	Late May
	Minamisoma City	Developed checking residents safety system by MS access Developed original victim support system	March April
	Futaba Town	Developed checking residents safety system by Microsoft excel	March
	Namie Town	Developed checking residents safety system by Microsoft excel Developed original victim support system	March Late-March

*A system created and provided through collaboration between industry, government and academia, under the guidance of the Disaster Prevention Research Institute, Kyoto University.

Requirements for the system were 1) to give consistent advices to each resident based on integrated records of all advices given to him/her on separate occasions, 2) to have an integrated and simultaneously accessible database that can be accessed from multiple help desks, 3) to be available for long term use as residents will need long term assistance.

A popular CRM (customer relationship management) system in the commercial world, SugarCRM, was chosen as the core engine. SugarCRM could operate on browsers and some parts were offered free of charge. Thus by limiting the use of the software to narrowly defined areas (record of advisees, advising officials, and advices given), the city could freely customize and use the system.

Other tools used were PHP programming tools, MySQL database tools, Apache server software, Eclipse development environment. All were available on the net. Development was done at City's server room that survived the disaster. As the tools were open systems that required no more than browsers and little installation burden, existing equipment could be used. Number of terminals could be added liberally as many of the tools were also license free without the worry of paying more for license and/or violating copyright.

The system was used in following steps:

Step1: Resident identification; Data was imported from City Government official resident record and could be searched to be the key for subsequently adding records of advice.

Step2: Inputting resident problems; Interview records of residents are inputted. If a resident visits multiple times, new records are added on top of previous records under a single key.

Step3: Issuing consultancy records to advisees; To give sense of assurance to residents, copies of interview records and advices given are handed to the advisees. Advisee can bring the copy to the subsequent consulting opportunities.

The system was put in operation on April 1 in time for the opening the center. One hour guidance was given to the advising officials that operated the system. No major problem occurred and minor functional additions were made to the system as the system operated. The system served over 30,000 consulting occasions by 700 officials as of April 30, 2012, including those that were sent by other municipalities as relief staffs.

7 Preparedness for Creative Responses in ICT

7.1 Frugality and Flexibility

As illustrated above, system development became necessary at times of 3.11 crisis. Plans that are based on assumptions of damages are important, but we have to also prepare for damages that exceed our assumptions. Preparedness for creative responses is necessary.

How then, can we improve our preparedness? We would like to consider this within the scope of ICT.

The notion of "frugal information system" (Watson et al.,2012) provides a clue.

A frugal information is defined as an information system that is developed and deployed with minimal resources to meet the preeminent goal of the client. According to Watson et.al (2012), following "4U" information related design concept should be incorporated in order to build systems with frugality: Ubiquity (The drive to access to information unconstrained by time and space), Uniqueness (The drive to know precisely the characteristics and location of a person or entity), Unison (The drive for information consistency) and Universality (The drive to overcome the friction of information systems' incompatibilities).

We would like to apply the concepts in analyzing the cases we observed in our survey to verify the usefulness of the concepts.

7.2 4Us in Great East Japan Quake cases

In the case of Tagajo, while successfully started to serve the residents by consistent consulting, lack of unison in the systems subsequently became an issue. While consistency existed within the domain of consulting, it did not connect with other government services. Various databases were created for different tasks. Data about individual were stored in different databases. With the lack of effective link code, it was difficult to integrate the database later.

This experience suggests that lack of unison leads to failures in uniqueness and universality. Faced with the problem of scattered database, officials of Tagajo subsequently generated individual ID for linking purpose and integrated the systems. This action improved the efficiency of the operation greatly.

While unison, uniqueness and universality were lacking from Tagajo system, at least in the initial phase, we can say that ubiquity firmly existed. The system was developed by integrated open software that adopted standard interface and were available on the internet.

The central government endorsed Nishinomiya System, was on the opposite end of 4U spectrum. It had uniqueness, unison and universality features. In theory, it also had ubiquity feature as it was made with open software on Linux. However it was stored in a locked area that was not openly accessible. It also required highly skilled engineers. Faced with technical requirements that the officials were not using on daily basis, they tended to avoid the use the system in the fear they may not be able to launch the system. Many municipalities, that opted to avoid the use of the Nishinomiya system and also lacked the skill level of Tagajo City, instead relied on windows based systems with package software such as excel that were readily available.

Looking at above cases, it is important to incorporate flexibility building and operating information system to prepare for creative responses in emergency situations.

To this end, we may add a fifth U, i.e. "usual use". Ashenhurst(1972) asserts that information systems should have usability, operability, and maintainability to fulfill the users' needs.

Our survey confirms that it was far easier to fulfill usability criteria for systems that were used on usual basis than for special purpose tools that were not used ordinarily. Thus we should try to use tools that we usually use, rather than applying special tools designed for special occasions. It was the use of browsers in Tagajo case. It was the use of Microsoft packages in others. Officials' familiarity with tools is critical at times of emergency to realize creative responses.

In addition to application of frugal IS concept, importance of preparation for flexibility in ICT development should be emphasized. Tools that are not used daily cannot be used at times of emergency. Staffs should be trained to use frugal and flexible systems in normal times.

8 Applying Cloud Computing for Creative Response

Loss of important data, such as birth and resident records as a result of Great East Japan Earthquake is prompting the municipal governments to consider the use of emergent cloud computing technologies. Cloud computing is an information system architecture in which data and application are stored in the network instead of local machines such as PCs and servers. This technology can be used both to backup data in secure locations and to provide information processing capabilities to damaged area quickly. It is at the core of national government policies to prepare for the next big disaster.

We believe the introduction of cloud computing technology can and should be used to construct frugal information system with 4U (or 5U) features. This will be achieved by: (1) assuming use of internet and cloud infrastructures, (2) share open system for common "tasks" on the cloud, and by (3) developing locally customized interface software to fulfill the diverse needs of each municipality.

Separation of application software from the infrastructure is a major feature of this proposal. By having a nationally run infrastructure, small municipal governments will be freed from developing costly infrastructure. Cloud computing resources can then be applied via the internet to flexibly to whichever localities in need of using the resources to build creative responses to beyond assumed level events. In regular times, only minimal resources can be used. That will help to save costs for small municipalities with weaker financial foundations.

Use of cloud computing technology is still limited in Japan at this point time, but externalization (as opposed to internal ownership) of resources will be essential in enhancing the capabilities of municipal governments to handle ever increasing information processing needs.

A second opportunity is structuralization of application software. We observed that while there is a great diversity in the requirements for information processing, critical processes such as identification of residents, as well as many legally defined processes such as the issuance of relief funds, remains common. Thus, by separating the two and building a common engine for the common tasks, municipal governments can focus on areas that they need to customize. This will greatly reduce cost and more importantly, time to develop systems that meet the emergency needs of the residents. In summary, the use of cloud can add flexibility to the municipal governments operations to execute creative responses when they become necessary.

A prerequisite for adopting this technology is to have a reliable infrastructure. Here again, the system can be frugal. The infrastructure should provide minimal connectivity universally and ubiquitously. Having an open interface above all, is essential.

Software performing the common tasks as described in the previous section, can also be considered part of the infrastructure. Cost of developing such software can be shared by coalition of municipal governments to lessen the burden for each. Open interface for such systems should be created so that municipalities can creatively custom design whatever systems required to meet adhoc needs without having to develop basic systems from the scratch.

9 Conclusion

"Beyond assumed level" is a term that many Japanese heard almost every day in the days after Fukushima nuclear plant accident that followed the tsunami. What became evident in the experience was that when you assume certain extent of damage, you tend to forget preparing for damages beyond. We were unprepared for worst tsunami in recorded history because we prepared assuming the previous worsts in the history. It is easy to argue that we should have prepared for even worse, but that would have been economically unrealistic. It will continue to be unrealistic to prepare for infinite level of risks.

Great East Japan Earthquake taught us that events beyond assumed level do happen, and we should somehow deal with them creatively. Creativity may be partially god given and uncontrollable for humans. At the same time we can train ourselves to be creative and prepare tools to be creative.

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