The Importance of Managing Context and Moving Objects Data for Emergency Management System

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***Abstract*--During emergencies, time is critical at all levels and requires efficient management of data and communication flow. When disaster strikes various agencies get involved. These organizations require timely interaction and diverse, detailed information to coordination of public emergency services in order to save lives and property. However effectiveness of emergency management depends on the data that come from various resources and format, and effectiveness of communication flow depends on the integration between and within various organizations and scheduling assigned by each frontline of organization personnel. Today, database technology is used in this field but still could be extent to tremendous potential for increasing the efficiency and effectiveness in coping with disaster situation. In this paper we outline the ubiquitous computing technology to be integrated in disaster management information and communication system in order to enhance in data management and scheduling issues during the response phase of disaster lifecycle.**

***Index Terms*— Adaptive System, Communication Networks, Context-Awareness, Context Data, Database Management System, Decision Making, Disaster Management, Emergency Response, Moving Object Data, Ubiquitous Computing.**

I. Introduction

Emergency or disaster can occur anytime, anywhere and poses new challenges to provide with better management either to data or communication flow to ensure that quality information is really delivered. Disasters are characterized by scope of emergency. When emergency exceeds the capability of the local resources to manage it, it's become a disaster. Disaster is any incident, which threatens human safety and/or damages, threatens to damage a building(s), an item(s) therein, equipment and system or cause pollution or injury or death to property of people. The disaster encompass either man-made or natural and has different category such as lithosphere disaster (landslide, subsidence, and earthquakes), atmospheric disasters (rain, lightning, and temperature), hydrosphere disasters (flooding, coastal erosion), biological disasters (forest fires and wildfires) and technological disasters (oil spills, transport accidents, failure of construction). Disaster management need to be carefully considered and properly planned, and need a people to make aware of the various risks and what is expected of them in a disaster situation. Typically disaster management system addresses three distinct phases [15], which are:

- Pre-Disaster (i.e. planning, mitigation, early warning, preparedness);
- During the Disaster (i.e. response);
- Post-Disaster (i.e. recovery, relief, rescue, and rehabilitation) [14].

This paper will focus on response phase, which is during the disaster happen. Response is putting preparedness plans into action. Response activities are during disaster phase and also can just after an emergency. These activities are designed to provide emergency assistance for victims, seek stabilize situations and reduce the probability of secondary damages and also to speed recovery operations. Or in other word, this stage includes the mobilization of the necessary emergency services and first responders in the disaster area. In this stage, a first wave of core emergency services, such as firefighters, police and ambulance crews mostly will take part. Normally, they may be supported by a number of secondary emergency services, such as specialist rescue teams. So thatm, optimal provision of information concerning the context involved in disaster is an essential pre-requisite. Police, fire departments, public health, and other organizations have to react in coordinated manner with efficient and effective. To achieve this result, intra and inter organization coordination at various hierarchy levels are needed. During disaster, the involvement of various organizations with various hierarchy levels (i.e. fire brigade department, police department, hospital, municipality etc.) is happen, from decision maker (personnel) inside the office to the emergency rescue worker(s) that responsible to turn down to the disaster location.

Effectiveness of emergency management is depended on the data that come from various resources and format such as building layout, accessibility, road network, electrical distribution, sewer system and so forth or dynamic data such as distribution of victims, rescue officer, ambulance, police cars etc. Beside that, also depends on the efficiency and

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effectiveness of communication flow usage during the disaster. Communication flow here means the integration between and within various organizations and scheduling assigned by each frontline of organization personnel. During the disaster, the individual or groups people that responsible in rescue tasks are known as emergency responder (ER). Decision-makers (DM) in the office are responsible to perform a scheduling and coordination job to each emergency responder teams. Or in other words, DM has to decide whose will go where to do what. Each organization has their DM that responsible to post a command. Currently, ER is not monitored systematically and efficiently. The only source of information is human reports channelled through phone-basis approach. And then, whose will take particular action will decide after DM knows location information of each rescue workers. And location information of each ER can change while they are moving. Thus if the objects is moving (such as fire brigade truck), location data reported is not valid yet or outdated. Other than information location, personal data of rescue workers such as job skill, experienced, and expertise also important to be known by DM to make a right coordination in disaster management. Here, DM plays an important role to decide the right person to the right place, at a right time and using a right way. Decision in the command posts is based on information received from required resources. For example DM of fire department make a decision regarding the coordination of fire workers task is based on the information reported from fire workers either outside the building or inside the building. From the information received by DM, appropriate instructions can be given to the fire workers. For both side it is important to get complete information, as incomplete information delivery may result in wrong decisions or actions. Decision-making in critical time is very crucial. Decision has to be taken quickly. Here means information and instruction have to be delivered or in other word, must be reliable and well performed.

Here shown that location information and context play a crucial role in disaster management. Location information here means the information of position object at time=t that known by a system automatically. By using and knowing location information (i.e. through GPS technology that attached in rescue team's mobile device) personal data about rescue team member might also be known. Then that information (location of moving object and personal) could contribute in sending appropriate information to a right person at right time using appropriate device.

II. MOVING OBJECT DATA MANAGEMENT SYSTEM

Updating task frequently is needed in management of highly dynamic data. The data that need frequent update we can call that as moving object data. Example of moving object data is locations or position of rescue units that geographically scattered in the area of disaster location. Currently, various mobile devices with the function of connecting wireless the Internet have emerged, which allow for performing numerous tasks while people are moving. People always have been appreciating the device or tools that can help their life become smoothly and easily, for example they can get the information from the small but powerful devices that they can hold by themselves and carry it at anywhere. In addition, it's become more valuable if they can interact with the device in any environments in order to access the information they need at different location and time or in other situation the device might give a valuable information to the user when they are really need at right time. This technology could help the decision maker and actors of disaster management in rescue tasks through information getting from the system and device. For example, decision maker can use the location information of fire workers at time=t to coordinate the task with fast by directly push the command to the related team leader rather than waiting for the all location information received. However by knowing the location information independently without context information can given a drawback to the system as instruction not delivered to the right person. Although

Generally, moving objects can be seen as spatio-temporal information in the form of data streams and can be managed in spatio-temporal databases. Spatio-temporal database is a database that is used for storing, accessing, indexing and querying spatio-temporal objects. This imposes the need for efficient analysis, modelling and processing of moving object data. In other word, DBMS should move from traditional database management system to another extent. It should be able to represent information about moving objects (e.g., location, time and speed) that can be called as Moving Object Database (MOD) application. Moving objects are subset of spatio-temporal database, where spatial attributes change continuously over time. Moving object data can be captured using different positioning technique, such as GPS, network positioning for cellular phone in GSM/CDMA wireless network, or Bluetooth, etc. Consider a MOD can answer a query such about "find a nearest ambulance and already finished their job to pickup an accident victims that currently within 1 mile of their current location"; this queries may originate from the moving objects database. Current DBMS may be able to manage not only static, but also dynamic and real time data to improve the quality of current location information system especially for emergency response usage. Indeed during the emergency it is critical to have the right data and at the right time and can displayed logically and accurately to respond and to take an appropriate action. So it is also very important to know the location (position of time=t) of the actors as a one of the main context data involved in this research. It is because location information about actors (such as fire fighters, polices, ambulance cars) either on moving (i.e. road network), or static (parking somewhere location, outside of the building) involved in disaster management are needed by decision maker in order to coordinate appropriate instruction.

III. CONTEXT-AWARE TECHNOLOGY

According to [4], context is any information that can be used to characterize the situation of an entity. An Entity is a

person, place, or object that is considered relevant to the interaction between a user and an application including the user and an application. This definition is clear where if a piece of information can be used to characterize the situation of a participant in an interaction, then that information is context. In disaster management, context entities can be divided by three categories or domains [18], which are user domain (such as user's profile, people nearby, user activity, location, and current social situations etc.), computing domain (such as network connectivity, communication bandwidth and nearby resources e.g. fire hydrant etc.) and environment domain (such as time, noise level, lighting, temperature, weather, traffic control etc.). A system can be called as context-aware if it uses context to provide relevant information and/or services to the user, where relevancy is depends on the user's task. Or in other words, context-aware computing deals with the ability of computer systems to obtain contextual knowledge in order to perform relevant tasks. There are several research effort aiming to integrate context in application such as Context-aware Mobile Personal Assistant (COMPASS) [13], Active Badge System [19], ParcTab [20], Cyberdesk [3], Ektara [2], Mediacup [10], TEA project [11], Owl Context Service [6], Kimura System [12], Solar [1], Aura project [9] and Context Toolkit [16].

A simple example to describe context-aware computing is if the system know the location of the user (through cell phone) and concert schedule, so a cell phone will always vibrate and never ring or beep in a concert or in disaster management, if the system of fire department know the location of the fire workers and task schedule, so an alert messaging or (appropriate information that related to the rescue task) will push to the only related team. Based on this example, individual context dimensions cannot be considered independently. It is important to analyze the different relationship among them. Most relationship exists between the user and other context dimensions (such as the location information and concert schedule or current task).

The user brings the mobile device, will determine device location, and also user's location indirectly. User has to access to the device and its functionality. System conditions also depend on the device location. The location also defines the current temperature, which has a great influence on the battery life. Activities are always situated in space and time and differ for distinct user roles. Location and time restrict certain activities influence the possibility or meaningfulness of activities, or change their quality. Depending on the time locations can have a different meaning, importance or accessibility. Figure 1 below outlines the possible values of context entities and their relationships. Several context dimensions may give significant impact on maps visualization and representation. For example, the role could influence the task assigned in the instruction or command and also features presents on the map and their symbolization. The current activity and the user role influence the map content, map style, map graphic etc.

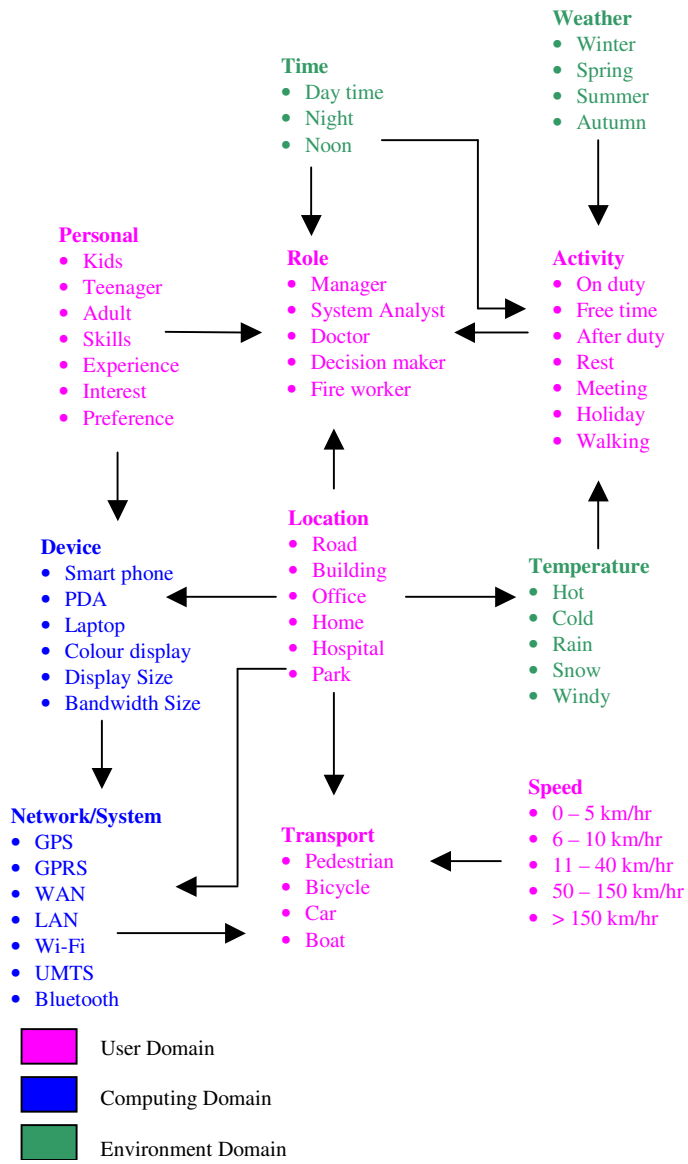

Figure 1: Possible value of context entities and their relationship.

IV. Motivation Example: Importance of Location Information and Context Information in Emergency Response

To illustrate the importance of location information and its relationship with context in emergency response, let's consider the following scenario, a road accident that involving lorry and trailer has occurred at road J had caused road congestion (See Figure 2). At the same time, an ambulance X was on the way to save fire victim in a location B, also involved within stated congestion. Although ambulance X can use emergency siren to get route, it could not as fast as if no road accidents involved. Because task has been given to ambulance X to location B, then it could not give help, which should to accident victim. Where else the accident victims should waiting for the next assistant. This can be occurred because of weaknesses of communication and presentation of information related their movement is unknowable directly by the system that could be

analysis on that time to give the appropriate information. If movement of each moving object can be known, indirectly their location also can be ensured. With knows the current location or position at time=t of each object, decision exchange could be implemented based on situation that happened. For example, because accident occurred in to which same road ambulance X stay, then as lifeguard, he responsible gives help to victim in need. In this case, ambulance X should help involved victims with stated accident, and task save fire victim which should in carry would be given other salvage to the members and with take into account distance and time factor more ideal for victims of the fire, base on location of the incident.

Figure 2: Car Accident in Road Highway

Unfortunately, to make a job change, it's not a simply task especially it involving with human safety and life. Thus context information plays an important role. By knowing the context in such an incident, system can respond and provide information absolutely required only. In other words, system can provide information based on context. In this case, situation in disaster location can be a context to disaster management system. For example, by knowing unfamiliar pattern in hierarchy network, it gives a sign that something happens (See Figure 3). Based on this information, system may provide with appropriate information that could aid that event. Besides situation, the user's profile, current task or goal, each object, also can be termed as context. By using combination of all relevant factors that we translating to context in software usage, rescue guide application may provide and give a map that relevant to salvage purpose only (of course base on the scope of their job position, or task and position at time=t (current location)) rather than present irrelevant information that not useful.

For example in order to present a risk map, the application should can adapt the symbol of the map used based on the user's profile or system could adapt the type of information that more appropriate to each actors that involved in disaster management. For instance firefighters may need information (such as fire hydrant symbol, restricted area, etc.) presents in risk map are different with the risk map produced to ambulance (such as hospital symbol, etc.).

Figure 3: Unfamiliar Pattern of moving objects Could Show That Something Happen in Real World

For the worse case, by knowing context information, temporary relief from the public may be given. For example in the case of car accident as describe above, with know personnel data (e.g. user's job) each moving object involved in certain radius, relevant information can be sent relevant user's mobile device. For instance, the information about condition of victim and kind of assistance needed can be sent to the nearest 'doctor' mobile device from that location (see Figure 4). However in this case, emotion and type of privacy needed by the user need to be considered too. Above scenarios shows that besides movement information and location, context information could take into consideration in application design.

In response management, moving object information may be captured and come from various techniques such as mobile device sensor, GPS receiver, network positioning for cellular in GSM/CDMA, wireless network, bluetooth, etc. Location information of each moving object needs a frequent update. More frequent update the more accurate we can get the information. For instance, by monitor and knowing unfamiliar pattern happen in database on location information, it describes that something happen. And to know what was happen, we need a transparent communication. Transparent communication is a communication that occurs in bilateral. And in user context, the most effective communication is whenever user may get the information without make a query. The related and relevant information will pushed automatically base on the context entities. Also, in response management of

such disaster, information may come from various and different sources and must sent to various and different hierarchical levels. In other words, in emergency situation, the system must be context-aware which task, assignment, related information that sent to the user's device could adapt the user's changing context to ensure the right information can be delivered to the right person, at right time at the right place using the right way. One possible way to make that things happen is integrate the context-based information into database management system.

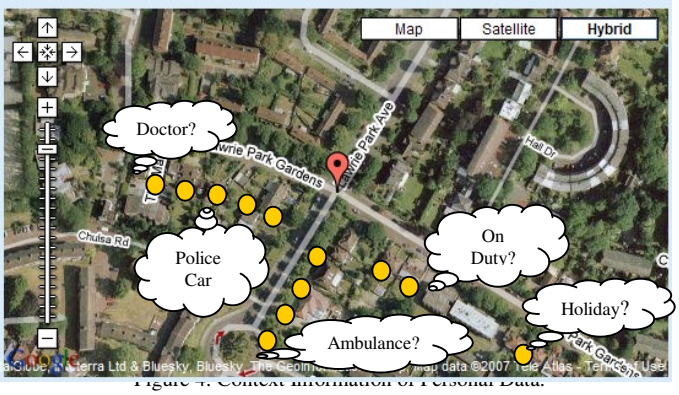

Figure 4: Context information of Personal Data.

V. SYSTEM REQUIREMENTS

The management of a disaster is very complicated either in communication or data management. And both of them seem has a good relationship. Inefficient in data management caused lack of communication, and vice versa. In this section, we discuss the requirements need for building the context-aware moving object data management system for disaster management. The subject that to be focus in order to manage moving object data management with efficient and integrating with the context data are data model, update policy and indexing technique, spatial analysis, interpolation and extrapolation handling and also location monitoring.

A. Database Management System

Database can be a backbone in this research. The efficiency of organization management is depends on the storage mechanism weather using the file system or database system. Right now, we can see each organization has their own database to manage their tasks with efficient. A database is a structured collection of spatial and non-spatial data. It may be anything from a simple shopping list to a big amount of data and information of universities, commercial company, public organization etc. On in formal description, it can be define as a structured collection of record or data (spatial and non-spatial) that are stored in a computer so that the program can consult it to answer queries. The record retrieved from queries becomes information that can be used in decision-making process. Databases can be described as a "heart" of application development. Their use extends beyond to many applications and environments where large amounts of data must be stored for efficient update and retrieval. An abstract architecture of information system for disaster management is shown in below that describes the location of database in system application.

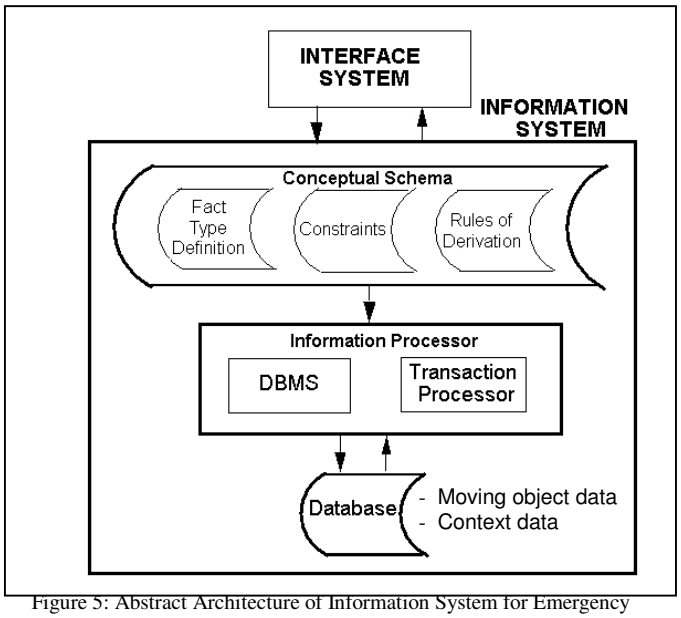

Figure 5: Abstract Architecture of Information System for Emergency Response.

And Figure 6 below shows DBMS as a central system, which provides a common interface between the data and the various front-end programs in the application. It also provides a central location for the whole data in the application to reside. The figure shows an example of DBMS and various applications that could involve in disaster.

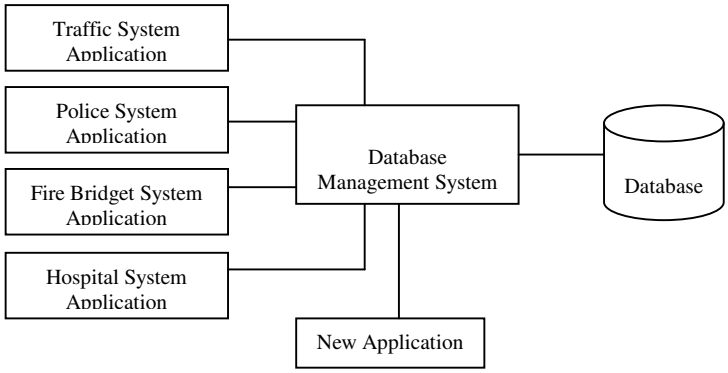

Figure 6: DBMS as Central System in Disaster Management System.

B. Data Model

The data model acts as a framework for the development of the new or enhanced application. Data model has a potential for fostering emergency response programs by guiding data management such as what data to be collected, format etc. especially under crisis condition specifically. From previous research, several problems in moving object database have been examined modeling and query language such as in [17], [7] and [8]. In emergency situation, each data spatial or non-spatial must be disseminated among organization and can be utilized rapidly by mobile technologies. However this efficiency of utilization is based on the structure and quality of data that serves the purpose of related organization. Thus data

model provides practical template that simplify the integration of similar data sets at different scales. There are some benefits from development of data model such as:

- Guidance: data model could be guidance in order to know what data to collect. Of course during emergency, worker or decision maker involved in time of stress may get confused and panicked about what data to collect and process. So a standard data model will be guidance and shows exactly what kind of data that needs to be collected and it is further processed.
- Data Standardization: data model will make sure that each of collected data sets fits into predetermined rules and criteria, thus separate and different organizations that using the same data model will have standardized data. So that smooth and fast dissemination of data among organization is enabled.
- Integration tool: Date model can be used to automate integration of various types of data coming from different agencies at different level.
- Application utilization: From data model, tools can utilize collected data. And then tools can be designed according to the specific data model. Data model can be used to ensure smooth processing of information is done with standardized operation serving to particular purpose.

Nowadays, various innovations in mobile computing drive many applications towards management of moving object's locations. Unfortunately, according to [17], current Database Management System (DBMS) are not used to develop that moving object application. The reason for this is that in databases, data is assumed to be constant unless it is explicitly modified. For example if the petrol price per liter field is 1.29, then this value is assumed to hold until explicitly updated. Thus the management of moving object location especially in disaster is very complex and need some extend of data model in order to combining with context data model. Currently various research study on moving object and context, are done separately. Besides that, critical sets of capabilities that are needed by moving object database applications are lacking in existing DBMS such as moving object location modeling, indexing dynamic attribute, uncertainty management of moving object and spatio-temporal operator. This kind of issues need some proper data modeling to ensure that future application become a complete and useful application.

C. *Indexing and Updates*

Efficiency processing of queries manipulating spatial relationship relies upon auxiliary indexing structures. The most problem faced in indexing is in update task. Frequent update is more accurate but caused poor performance and increases a cost. The relationship between update, cost and accuracy can be shown as Figure 7 below. Where else index maintenance is important and must be take into account in Moving Object Database application in order to get the information with fast. There are two main issues related to index update, which are "when-to-update" and "how-to-update" [5] that also could be a research question here.

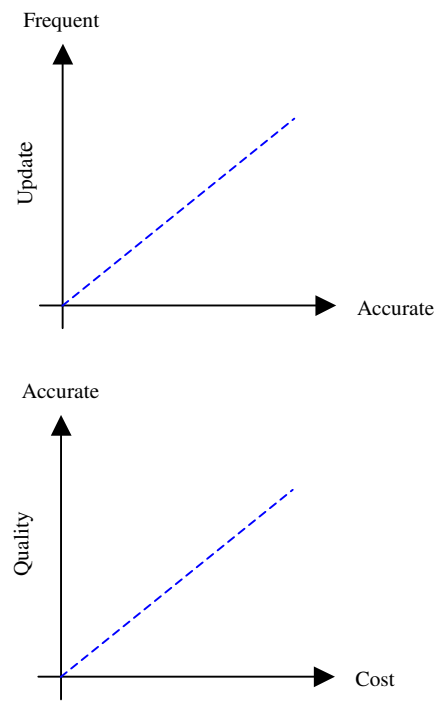

Figure 7: Relationship Between Update, Cost and Accuracy

Each moving objects has both spatio-temporal properties that represent the trajectory and non spatio-temporal properties represent the non-spatial data such as ID, phone number, name etc. In order to answer the question such as "show the nearest ambulance within 2 kilometer from location X", DBMS needs a Moving Object Database that could be storing, updating and processing queries trajectories of moving objects. Unfortunately, when the trajectory is update very frequently, it would impose a serious performance and wireless-bandwidth overhead, if not the answer to queries is not accurate at all or in other word is outdated. Ambulance information either in the field or not, could be known based on the speed ambulance involved (as context) in.

D. *Spatial Analysis*

Currently, in emergency response, moving object information is only for monitoring purpose and cannot be used to make an analysis. This drawback gives a problem to the emergency rescue to make a quick respond, where else in disaster management, quick respond is the most important thing in order to give a high-quality care to the public. For example to know information about moving object data (e.g. ambulance) in a database, the answer to the question of moving objects position (e.g. "How far is the ambulance with registered plate number MAM9777 from Street A?") needs continuously update task. When the database unable to handle or manage a dynamic attributes (attributes that change continuously as a function of time), cause the query that refer

to future values of dynamic attributes impossible to answer. It because to answer to a query it not only depends on the database content, but also on the time at which the query is request.

E. Interpolation and Extrapolation

Although traditional database may offer location information, actually it does not enable interpolation[1] or extrapolation[2]. For interpolation example, the user needs to know which police officers were within one mile from location of emergency that occurred at 3 p.m. This kind of question can be retrieved if object (in this case, police officers) generate an update at 3 p.m. or earlier than that. If not then its exact whereabouts at that time are unknown. Where else in extrapolation problem, without update data and current work schedule, any future location has requested might impossible to retrieve. For example, user needs to know, which police offices will be closets to a criminal location within the next 20 minutes? These interpolation and extrapolation capabilities also could be a challenge in this research in order to make the query more real like a human interact each other to know about something where else actually the conversation actually with the machine by integrate with the context information. Or in other words, current application is not applying a context-aware computing and adaptive service in order to give right information to right person and at right time.

F. Location Monitoring

Location of moving objects is inherently imprecise because the database location of the object cannot always be identical to the actual location of the object. So it encourages the production of incorrect information that could drive the wrong interpretation and decision. Imagine how many time wasted by police officer to wait the criminals pass through at particular location that actually the criminals had pass the road 1 hour ahead with 120km/hour because of there are no spatio-temporal information that could be given and could be monitor. However, again, an accurate picture of the precise location of moving objects would require frequent location updates that consume precise resources such as bandwidth, storage capacity and process power. Or in other words, to provide the correct and timely results of moving objects to mobile client, it's required monitor the locations of all the moving objects frequently. Since the objects are moving, the values of the data items, which record the current locations, can be highly dynamic. It will impose a serious performance overhead to the wireless bandwidth because if generation of updates is not frequent enough, the uncertainty of the location of the moving objects will be high and the correctness of the result of location query returned cannot be guaranteed. In this case, update policy has to design based on context entities involved in disaster management.

[1] Is the process of obtaining a value from a graph or table that is located between major points given, or between data points plotted. A ratio process is usually used to obtain the value

[2] Is the process of obtaining a value from a chart or graph that extends beyond the given data. The "trend" of the data is extended past the last point given and an estimate made of the value

VI. Conclusion

The demand for application involving location information opens a door for new research areas such as data collection, data management, discovery, integration, visualization and communication. Among the challenges is management and access of continuously moving objects and combining with context. This paper proposed the integrating of context usage and moving object data in database management system for emergency response activity.

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