

Pathfinder: Multi-cloud architecture for disaster management using UCaaS model

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Abstract: A natural calamity is an aspect, which is uncontrollable, but predictable with help of disaster sensing facilities available in a country, however saving the life of millions who reside in the disaster prone area plays a key role in disaster management. Without alerting the people of upcoming calamity and making them evacuate the area and go to safer places, the concept of disaster management is never fulfilled. We bring forth the usage of cloud computing facility to address the issue. The three governmental bodies of National Telecommunication Authority, Disaster Management Authority and Municipal Authority to unite for a cause by allotting them a individual application connected via cloud and each application has a separate task to perform on sensing the natural calamity through sensors. The application was web based one and cloud database that plays a key role in this system will be a separate cloud database for all the three systems. The Disaster Management Authority on receiving alert regarding calamity through their sensors will use this application to transfer the alert to respective municipal authority of the region and the municipal authority uses its cloud database to store information regarding the safer places which can resist the calamity in that area and along with the information regarding the safer places the municipal authority sends the message to National Telecom Authority and the National Telecom Authority will identify the number of mobile devices active in that area and sends an alert message through SMS and voice calls. On giving a separate caller identity for that message and voice call and enabling the public to know about the id through mass media, we can expect them to act in time.

Index Terms- UCaaS (Unified Communications as Service), DMA (Disaster Management Authority), GIS (Geographical Information System), NTA (National Telecommunication Authority), SMS (Short Messaging Service), SMSC (Short Messaging Service Center)

I. INTRODUCTION

Cloud computing has become one of the most important technology that has ever set foot on the IT field. The facility to store data in any remote location and to bring together the systems working in different remote location together were the two important features of cloud computing. As for now cloud is used in various enterprises like Amazon, Microsoft etc. which were available to public use and there are also various other industries which sought to use a private cloud to maintain the records of their own company and also interconnect the systems working in their own enterprises. The concept of disaster management is quite new to the field of cloud but the remote storage facility and ability to project a group of systems working together to give a single image of a system has paved way to develop several new application in years to come. The disaster management and sending the inhabitants of a particular area to safety in case of any natural calamity is one of the first and foremost things to do in order to save million of life in time. Thereby in the proposed system Path Finder we project the Disaster management systems, Municipal authority systems and National telecom authority system

all three as a single system view with each one has a separate cloud for their own and are interconnected to form a multi-cloud which was named as Path Finder solely for the purpose of evacuation through prior intimation. In architecture diagrams we mentioned certain areas called as nodes, in which it is nothing but an area, which performs a certain task that forms the basic concept of networks.

II. ARCHITECTURE OF THE PATH FINDER SYSTEM

The architecture of the pathfinder system will mainly revolve around three governmental organizations of DMA, NTA and Municipal authority. The three organizations will have a separate web application dedicated to a specific responsibility of each organization and the three applications use a separate cloud database for storing the data. Since the implementation part of this Path Finder system was only a prototype used for analyzing how we can promote effective evacuation of millions during the time of disaster. Our architecture deals only with the safe evacuation of people living in that particular area by alerting them via SMS and voice calls

prior to the disaster taking place but not the aftermath since saving people’s lives beforehand is of outmost importance that every government wants while compared to evacuation of people on aftermath of the calamity. UCAAS model is used because this will connect heterogeneous devices and facilities like database, application, mobile devices etc. UCAAS is not widely adopted architecture since it was new and also expensive to maintain. The architecture will be fully efficient if we have separate communication towers in safe areas which cannot be easily flooded or winds cannot cause much damage like some slope areas. In such way we need not rely on other regular communication towers. But these special towers must be directly controlled by NTA in order to not rely on mobile phone operators. To validate the architecture we used three separate web application built in PHP along with the facility to access cloud database through Eucalyptus via LAMP server. The Disaster management authority has is application in which the scientists can enter the details of the calamity and also its area of effect with respect to latitude and longitude. The scientists will already know which municipal authority to contact on verifying the possible area of effect. The application was nothing more than a form comprising of certain details like area of effect, latitude, longitude, calamity type, expected time, level of danger etc. and the messages were simply transmitted through HTTP to another node which is the respective application used by municipal authority of the area. We use simple HTTP messaging for this purpose since during initial stages the system should not draw too much investment in designing the network infrastructure. The municipal authority will maintain a cloud database to store data regarding safer places which were resistant to the calamity like temples, churches, hilly regions etc. for example during tsunami in the region of Kanyakumari of the state Tamil Nadu in India, people took shelter near the Thiruvalluvar statue which has a landscape on which waves cannot reach. Since many people were not aware of this it had cost their lives. The application used by the municipal authority will deliver the message to national telecom authority which has a facility to identify the number of registered mobile devices in the particular area with respect to the district and sends SMS and voice call to all the mobile devices in that area. The platforms and facilities used to validate the architecture was tabulated below.

Server	LAMP
Browser	Firefox

Table.1 Platforms used to build the system

III. DESIGNING A MULTI CLOUD ARCHITECTURE

The multi cloud architecture is achieved by inter connecting two or more clouds to give one or more output. The output can only be achieved by establishing interface between three cloud architectures used by the three organizations. Here every organization has its own cloud dedicated for various purposes like storing of any data related to organization and this disaster management scenario is one of the functionalities we offer to the cloud. The messages are sent and received between the cloud systems is done through simple messaging method form one port to another through network. The very basic network messaging concept was used to validate the architecture and the SMS messages were sent to the inhabitants living in that particular area were accomplished through a new concept called as SMS gate way in PHP. Since we introduce three independent organizations each having a separate task to perform during the scenario of disaster management multi-cloud architecture will be most appropriate one for this project.

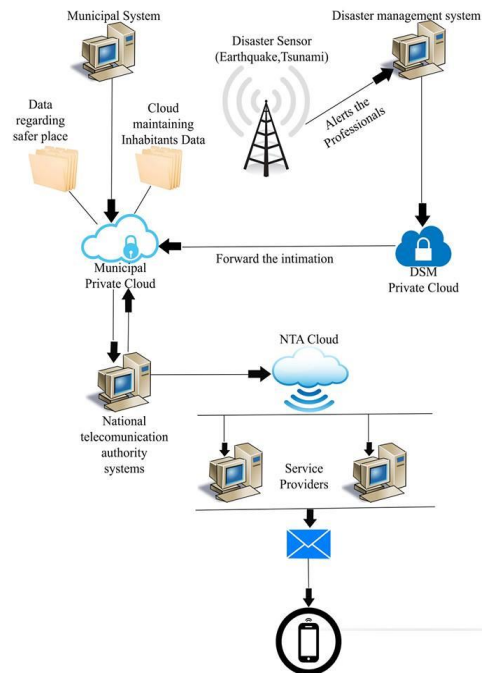


Fig.1 Architecture of the Pathfinder cloud system

Component	Platform
Application used by three ends	PHP
Cloud platform	Eucalyptus
Database	MYSQL

The application designed in web programming platform along with its cloud storage and systems used for identification of any natural calamity forms the cloud architecture for Disaster Management Authority's system. The application designed for Municipal authority for receiving messages from Disaster Management Authority and a cloud database comprising of the region's safer places to hide and easy evacuation routes will be stored in it and the application also has facility to check the available evacuation teams in that area and also can intimate them after checking. This forms a separate cloud architecture for Municipal Systems,. The National Telecom Authority systems are quite a complex system which requires presence of all possible mobile phone operators. The mobile phone operators are included in this system for a reason that they will have a ready to use registered telephone contact numbers of inhabitants living in the area. The first phase we can gather data from the cloud database regarding registered mobile devices in that area and intimate them via SMS and in lateral stage if NTA can identify the number of mobile phones active in the particular area and send intimate them in worst case for certain situation like most of the people went to some other place for vacation or any official business. The process of identifying number of mobile devices active in the area is a separate task done by NTA through sensors and was not included in this architecture, only sending messages to registered mobile devices in the area after gathering the data from the cloud database maintained by NTA on which various telephone operators store the data regularly.

IV. SENDING MESSAGES TO INHABITANT'S MOBILE PHONE THROUGH SMS GATEWAY

The application used in the NTA system will gather information regarding the number of registered mobile devices in the particular area stored in the cloud database after verifying the area which was about to be affected by the calamity and the message regarding the safer locations with respect to the particular area which was received from the concerned municipal authority was created as the group email in that application. This facility is recently introduced one in which the email can be converted into SMS through SMS gateway facility and the SMS was sent to SMSC which hands it over to inhabitant's mobile phone through a wireless network. Since the research project purely comprises of evacuation of people in a calamity prone area prior to the disaster, we need not worry much about signal bandwidth cramming.

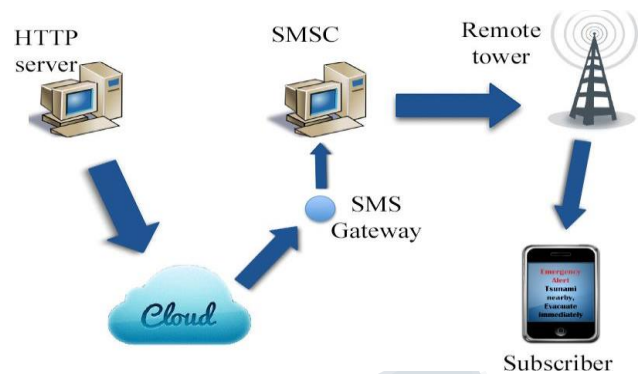


Fig.2 Sending SMS over network through SMS gateway

V. AVOIDING NETWORK CONGESTION AND OTHER ISSUES

In certain cases chances are there for network congestion and signal bandwidth cramming while making the whole process automated. The signal bandwidth cramming can be best addressed by keeping the number of messages transmitted from one organization to another as minimum as far as this architecture is concerned only a limited amount of message is transmitted form one organization to another through network. In the worst case when communication towers are completely down in a particular area we can search for nearest possible municipal authority to reach in order to alert the people living in the area where communication towers are down.

So far the discussion regarding the prototype is one manual premises in which a government must allot a separate team and keep the track of application status whether any possible calamity alert is received or not. But in order to make system more effective we have to automate the process in Municipal and NTA ends. This is because the Disaster Management Authority has only calamity monitoring responsibility all the time 24 hours a day but we cannot expect the same from NTA and Municipal since they have other major responsibilities to care about and also during night time the professionals will not be present to monitor the application especially in municipal authority since it is the lowest level of authority in a country comprising of districts and areas present in the district. So to be in a safer side we have to automate its responsibilities during the process. To further enrich the safety and security the database used in Municipal authority can be kept in common which can be shared by both NTA and DMA. We have to do this because problem will arise in case if a particular municipal authority does not respond to the request particularly in some huge

countries like India, China, Russia etc. since disaster management is quite tough in countries with huge landscape and population. The automated process is nothing but a simple event trigger mechanism.

The SMS service does not promote any kind of huge network traffic since we all know that at least 5-6 service messages will be delivered in a single mobile phone of an individual per day. This happens to all of the mobile users. But there are certain areas where network congestion occurs while the process. The possibilities of Network congestion are high only on NTA systems more accurately on gathering inhabitants data in a particular area and sending SMS intimation to them.

A. Network congestion while sending the SMS intimation by NTA systems

In an over populated country like India there will be millions living in a particular area especially in metros. So there occurs network congestion while gathering contact numbers of people living in a particular area and sending SMS to their numbers through the SMS gateway method we implemented since during this process the email will be converted to SMS. On setting a maximum and minimum traffic limit we can make sure that a particular amount of contact numbers were sent messages first and thereby only after the traffic fall below a necessary threshold the other data are processed.

B. Network congestion during gathering of inhabitants data

The process of gathering the inhabitant's data from the database is through simple querying mechanism involving the application and a database. The main problem in this mechanism is if the team allotted to monitor this calamity application should keep the session alive in order enables the automated process to take place. The data report comprising of the inhabitant's data is filtered by gathering the contact numbers from the report and only to these contact numbers the SMS intimation is made. If the quantity of data is huge we can order the hierarchy of gathering the data with respect to parameters like areas which are closer to seas or the area where precisely the landslide about to take place. The priority we give to area with maximum danger followed by average and minimum values. The priority is given based on time and areas closer to calamity event. The professionals working on the application can opt for manual method of process while on duty but the automated process is advised to be kept active only when they are off-duty.

C. Network congestion during overall automated process
Automated process requires precise event triggering mechanism in order to avoid network congestion. Possibilities of network congestion in overall automated process are when the DMA systems has to send calamity alert to multiple municipal systems. For instance, Tsunami occurred in multiple places like Chennai, Nagarcoil, and DanushKodi (Fully devastated to ruins after the event). So in order to avoid network congestion in this process the disaster management authority must have a look at the time constraints of the calamity and the area with extremes short countdown must be given preference first. The extreme time constraint we fixed is 6 hours. However if the area of effect is reasonably short with respect to 4-6 districts at a time we can expect a good throughput. In later stages of the system's improvements we can have separate network architecture and can create separate nodes for processing additional requests.

D. Difference between automated and manual process

We seriously recommend a separate team must be assigned to monitor the system every time in shifts especially in disaster prone areas like coastal regions, Hill regions prone to landslide, Villages below the vertical heights prone to avalanche etc. must be given maximum priority and the process should be manual during verifying the alert type, regions, decisions to make etc. and the automated process is nothing but based on event triggering mechanism in which the DMA sends the alert message followed by municipal node receiving the alert and National telecom Authority sending SMS intimation to residents will occur in a flow when the session is kept alive but there is no professional to watch. However when the professional is present he can perform certain operations precisely like exact number of contact numbers to be intimated, acting with respect to alert depth etc.

VI. THE NATURE OF DATA STORED IN CLOUD DATABASE OF EACH ORGANIZATION

The data stored by each organization with respect to the scenario in the cloud database was tabulated below and the database we used to experiment is SQL and the details are as follows.

Organization	Data stored in the cloud database
Disaster Management Authority	1. District, State, Area with respect to its latitude and longitude. 2. Possible disaster

	counter measures with respect to type of disaster.
Municipal Organization	<ol style="list-style-type: none"> 1. Data regarding approximate number of inhabitants living in the particular area. 2. Safer spots of hide in a particular area which were resistant to calamity. 3. Data table regarding the evacuation teams and personnel.
National Telecommunication Authority	<ol style="list-style-type: none"> 1. Contact Id and Contact numbers of all people with respect to operators 2. List of network operators and communication towers in the country. 3. Number of mobile devices registered with respect to the mobile phone operator.

Table.2 Contents present in cloud database with respect to the organizations.

VII. PERFORMANCE OF THE PATHFINDER SYSTEM DURING TSUNAMI AS SAMPLE SCENARIO

We can describe the components of the individual cloud architecture through Cloud platform, cloud storage, cloud infrastructure and cloud service. The individual system refers to the cloud used by the individual organization. The three organizations the municipal authority, Disaster management authority and national telecom authority has separate cloud for themselves and various systems interconnected inside them. These three clouds combine together to form a multi-cloud architecture for the purpose of disaster management. In order to cut down the costs creating a separate private cloud or community cloud one can make use of multi-cloud architecture so that disaster management can be included as the special feature among the cloud infrastructure inside these three organizations. The emergency intimation and evacuation can be initially introduced as one of the several features available in the cloud systems and in future development of smart cloud

systems solely for the purpose of disaster management can be introduced as technology reaches its peak.



Fig.3 GIS image of Tsunami occurred in Tamil Nadu 2004

A. Disaster Management systems

The disaster management systems comprising of the remote sensing facility to detect the occurrence of earthquake, tsunami, cyclones beforehand and will provide the alert message to the DMA systems, DMA cloud platform was mainly a Web Frontend based so that information transfer and retrieval becomes easy. The cloud database stores information regarding areas prone to natural calamities and also the data gathered from monitoring stations. The node which we call a Disaster management authority node receives the emergency message and identifies which municipal authority to contact with respect to the region details intimated by the GIS sensors and along with the information regarding latitude and longitude of the region creates a message and will forward it to the municipal systems by HTTP and this is the service offered by the disaster management system.

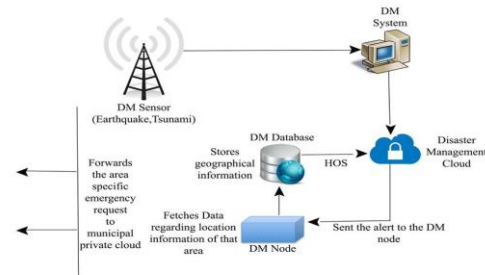


Fig.4 Architecture of the DMA cloud system

B. Municipal systems

The municipal system comprises of a cloud database in which the details regarding all inhabitants living in that particular area and also it is necessary for them to maintain records regarding the safer places to hide for natural calamities of all sorts like tsunami. So the evacuation of millions to safer places will be made easy and also in time.

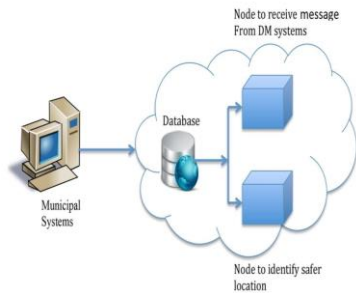


Fig.5 Architecture of the municipal cloud system

C. National telecom systems

The location information and also the safer spots received from Municipal node is processed and forwarded to all mobile phone operators. The mobile phone operators will identify how many mobile devices using their service and operating in that particular area and sends alert messages to all mobile devices after gathering the necessary data regarding the contact information of people living in Chennai, Nagarcoil, Danushkodi etc. and arrange priority to the contact information which should be intimated at first hand based on the time left for calamity to take place and the area which were prone to calamity first. In this way network congestion can be avoided.

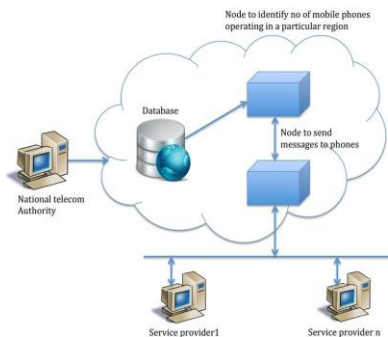


Fig.6 Cloud architecture of NTA system with various service providers interconnected

CONCLUSION

The smart evacuation system based on cloud will be more useful while compared to other means of intimating people during emergency situation. The tsunami which occurred in Tamil Nadu at 2004 was the most grievous disaster consuming more than 10,500 people in each and every coastal districts of Tamil Nadu, India but the signs of this disaster which was about to occur was detected by Indian Remote sensing facility six hours before, but it was not taken to public in time due to various communication hardships and also public were unaware of the seriousness. Thereby this Pathfinder architecture will help millions migrate to safer places during times of disaster.

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