IOSR Journal of Computer Engineering (IOSR-JCE)
e-ISSN: 2278-0661,p-ISSN: 2278-8727, Volume 20, Issue 2, Ver. IV (Mar. - Apr. 2018), PP 43-53
www.iosrjournals.org

Flood Disaster Prevention and Management IOT Architecture for Tunisian National Security

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Abstract: *Recent research predict that sea level rising, storm event magnitude and frequency, and rainfall depths, intensities and patterns will be main effects of climatic parameters change. these climatic changes joint with the complexity of crisis management tasks, have revealed the need for system to support prevention and management of flooding disaster. this paper proposes an integrated ICT architecture leading to flood disaster prevention and management that permit optimized intervention taking into account data type and source diversity and diverse specific constraints.*

Keywords: *Artificial intelligence, Disaster management,flood, IOT, OODA, WSN*

Date of Submission: 26-04-2018 Date of acceptance: 14-05-2018

I. Introduction

Recent research, predict that changes in climatic parameters are projected to have impacts on sea level, storm event magnitude and frequency, and rainfall depths, intensities and patterns. Global mean sea level will rise between 0.18m and 0.59m over the 21st century and that this period will see more frequent heavy precipitation events as projected by The IPCC (2017) [1].

This increasing frequency and severity of natural disasters, will cause human and animals deaths and enormous damage to property through the world, removing people from their homes and ruin their livelihoods. Developing countries and poor communities are in particularly vulnerable to disaster. Many of lives and property losses could be prevented if detailed information were available on the exposed populations and assets, disaster risk environmental parameters, and the patterns and behavior of particular hazards. The ICT "information and communications technologies" can help in mitigating disaster consequences by getting earlier prevention information and contributing in management and response decision.

Disaster Management Systems that use Wireless Sensor Networks (WSNs) and IOT solutions have received much attention by researchers in the last years [2][3]. However, these solutions are mainly designed for disaster detection and early warning.The main contribution of this article is to propose an ICT integrated architecture leading to flood disaster prevention and management that permit optimized intervention taking into account data type and source diversity and diverse specific constraints.

This paper presents a concise overview of the different parts of our presented architecture where in the following sections we present flood and their facts, present OODA decision methodology and discus the main constraints and challenges in designing IOT architecture for disaster management. The latter section of this paper is reserved to present our proposed architecture.

II. Flooding disaster and facts

The water cycle is a balanced system; water flowing into one side of the cycle (like streams) is well-adjusted by water flowing back to the sea. As flooding is a natural event caused by an unbalance in this hydrological system, sometime the amount flowing into one area overpass the system capacity to retain it within its natural boundaries. This situation engenders a flood, which occurs when the mass of water received by the land (from rainfall, snow melt, surface flow, flow in watercourses or inundation by the sea) overpass the capacity of the land or drainage-system to discharge that water. floods can occur on any location but land adjacent to watercourses (fluvial flood plains) or low- lying ground next to the coast (coastal flood plains) or ponding of surface runoff in urban areas are more exposed to that events.

Floods can be classified by their source of event [4] where each source of event will assist in determining measures to alleviate the flood consequences. We can distinct three flooding source; River/Fluvial, Coastal and Dam Burst, defense Failure or Over-topping.

The principal source of river flooding is excessive rainfall or snow melt for a limited duration, overwhelming the land drainage capacity or drainage systems, notably when the soil is already saturated or when drainage pipes become blocked. Weather patterns determines the amount and location of rain and snowfall. Unfortunately, the amount and time over which precipitation (rainfall) occurs is not consistent for any given area. thus, exceptional precipitation can be combined with a number of factors to exacerbate flooding like; heavy snow melts, water-saturated ground, unusually high tides, and drainage modifications.

A flash flood can occur when extensive saturation of high ground accompanied by intense short-duration rainfall in a small catchment or in a heavily urbanized catchment. In these circumstances, the sudden release of large volumes of water along narrow channels from high ground to low-lying locations can overwhelm them. This situation can be aggravated by an airflow over mountains, weather fronts and convective storms. The most extreme events involve a rapid uplift of moist air in the same location for a long time. This type of meteorological event can cause other effects including landslides. Characteristics of the local flood catchment area is another determinant factor that determine if and how the flood develops.

The coastal flooding is caused by unusually high tide, storm surge, hurricanes (cyclonic storms) and wave activity including tsunamis or a structural failure of defenses within some locations subject to combinations of tidal and river impacts. Long-term processes like subsidence and rising sea level due to global warming can lead to sea encroachment on land.

Dams are constructed by human or naturally resulted of either landslides, or ice blockages. Human constructed dams are a barrier constructed to hold back water, the resulting reservoir being used in the generation of electricity or as a water supply or for flood mastership. Flood defense systems (e.g. levees, earthen banks, walls) are designed to hold water levels above the surrounding natural ground level and protect vulnerable low-lying areas.which make that dams failure can result in the sudden release of large volumes of water leading to catastrophic flooding causing potential loss of lives and properties.

Flood disaster can beget many other structural failures that aggravate the situation and raising damages. the occurrence of these phenomena depends on the structure of the location of the floods.Floods can cause significant economic consequences, serious structural damage and human live, health and security risks.

Diverse structural damage can arise under a flood condition;

- services disturbance: floodwater may hamper road transport and access;
- Power failure caused by flooded power station.
- Power outages at pumping stations and sewage treatment plants causing additional flood and pollution risks;
- Damaged or blocked hydraulic structures by floating objects;
- walls/properties collapse and manhole covers/scour holes displacements may present new underwater hazards.
- The surfaces become slippery, which makes them dangerous;
- Disruption of communications

The health impacts can be significant and affects many people at the same time. Floods can cause anxiety and psychological impact on affected communities. Polluted sewage and other pollution can cause contamination of water containing a number of pathogens. People may be displaced (potentially for periods up to or beyond one year) physically injured or exposed to chemical and biological hazards or homeless people due to loss of property.

In flood panic condition distributions of law and order can arise.

III. OODA Methodology

OODA is a making decision recurring cycle of observe-orient-decide-act aiming to improve decision effectiveness, initially developed by military strategist and United States Air Force Colonel John Boyd [5].

The (OODA) loop decision methodology facilitate fast and accurate decision making that can be very useful in disaster management and response activities [3] with very changing parameters and a continually changing situation. OODA loop concept formalizes the situation response process; observes actual circumstances to obtain an overview of the situation before placing a plan into action. It also involves making predictions based on observations when obtaining an overview.

Our target architecture is based on the OODA methodology. The Fig.1 depicts an overview of disaster response architecture components conducted through OODA cycle.

Using OODA loop concept in the disaster prevention management and response solution permits to overlays the rapid incoming flow of disaster information onto a global view managed in temporal-spatial terms, which improves decision making and helps achieve a nationwide coordinated.

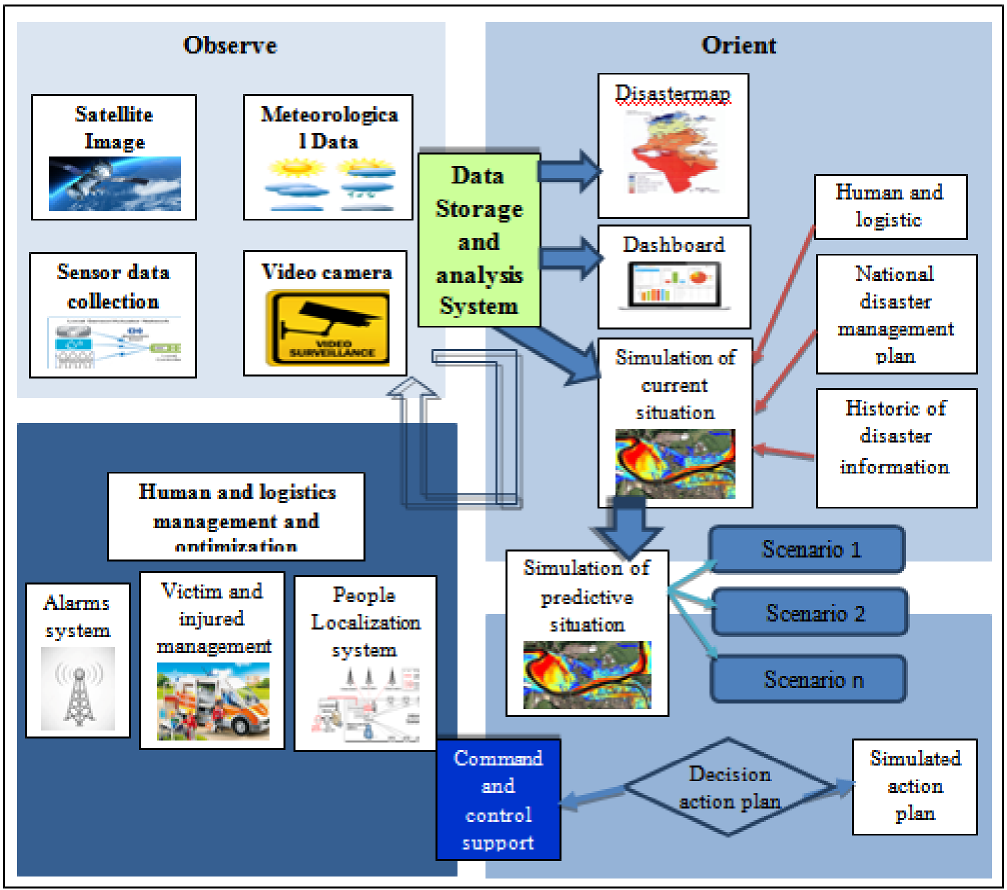

Fig.1: *OODA Loop for Disaster Management and Response*

Observation is the task that detects events within an individual's, or group's, environment. Information's can be gathered from heterogeneous sources like sensors, surveilling camera, satellite and so on. While it is not the sole basis for Action, it is a primary source of new information in the behavioral process.

Orient is the crucial phase in making decision process where we will quickly and accurately develop mental images, or schema, to help comprehend and cope with the vast array of threatening and non-threatening faced events. This image construction, or orientation, is nothing more than the process of analysis and synthesis. The gathered information by the observation, will be treated, analyzed and presented in a comprehensive form by using intelligent systems that make effective synthesis from the huge and very changing information leading to accurate and efficient decision.

Observations that match up with certain mental schema call for certain decisions and actions. Decision is an action plan face to threatening situation. Disaster countermeasures decision is a coordinated actions and stakeholders in a coherent workflow with alternations command-action. this recurrent cycle must be repeated with each detected change in the observed system.

IV. Constraints and Challenges in flood disaster

Defining a flood disaster solution is submissive of a number of constraints, mainly logistic and human scarcity and poor infrastructure.In major case, there are no a sufficient human number within in rescue team placed in risk area, and in some case, not all team member was qualified and specialized in flood hazard. The lack of necessary and specialized equipment for the rescue operation make that this first intervention is inefficient.Under this conditions, the first team intervention is generally incommensurate with the field situation of the disaster. the reinforcement arrival may take too much time to be on the scene of disaster, leading in some cases to enormous losses in human life.The Sanitary Sewer Service Area infrastructure and rainwater harvesting system quality can be an aggravation parameter of flood hazards risk.In another hand, random neighborhoods built without taking into consideration the riskiness, particularly the risks of flood, which contribute to rise the final toll of damage and loss of life. People mobility in disasters may be restricted or otherwise affected due to cultural and social constraints.

People often die disproportionately in disasters, if they do not receive timely warnings or other information about hazards and risks or are prevented from acting on them. Advances in flood forecasting have been constrained by the difficulty of estimating rainfall continuously over space [6]. Many complex and interdependent issues will be considered in flood emergency risks management making the flood planning task very challenging where time management is fundamental for the success of evacuation process [7]. identifying the early warning signals for the crisis is the key of effective crisis planning. Crisis management plan (CMP) formulation which consists of a full range of thoughtful processes and steps that anticipate the complex nature of crises [8] dealing with organization and coordinationcomplexity mainly where contributors number increase.

Sustainable development and disaster risk management needs an ever more active role in successful disaster risk reduction from private sector and civil society to support the government efforts. it is recognized widely that disaster risk management at the local level is a key element in any viable national strategy to reduce disasters hazard [9]. A participatory approach in disaster risk management [10] by decentralizing the leadership and authority of disaster risk management to the regional or municipal level will encourages local participation and engages people to volunteer based on their own self-interest and community well-being where people at risk can take part and effectively contribute to disaster reduction efforts.

These constraints shape the target technological solution for disaster management jointly with challenges to overcome. the architecture designing for a disaster solution is very challenging task where real time response, solution reliability and response effectiveness are the main challenges.The challenges towards fulfilling the visions for the disaster management system base in OODA methodologies include at least the following aspects:

Cost effectiveness: disaster management is a life-saving task, hence researchers should consider the development of cutting edge technologies in this regard, to bring down the cost further. large-scale deployment of sensors is the key technology for disaster detection and observation. Their low price contributes to reduce the cost of the solution.

Information and Communication Technologies: the deployment of sensors in a large-scale and geographically distributed to collect data and eventually send alarms in disaster conditions which must be communicated and analyzed in real time and reliably.This large number of deployed sensor will generate a tremendous number of data that may not be feasible to be treated and analyzed by the user group. Context-awareness based techniques need to be used to help decide what data needs to be processed.

Disaster systems should analyze a large variety of data from different sources type with different semantics, formats, sizes, and contexts in form and formats. These spatial-temporal datasets gathered from various disaster sites at different point of time should be analyzed in a real time manner. Hence, a seamless data analytics platform in terms of cloud service [11], should efficiently be associated.

Natural disaster, is generally not under human control due to its highly dynamic nature. which impose, a hard real-time analytics solution for real-time decision-making process. The dynamic nature of disasters and the huge resulting data make the knowledge discovery task very challenging leading to the use of the potential of big data could [12] for data correlation with efficient data meaning algorithms. A generic data model may be appropriate to handle different data, complexity, and privacy requirements.

In disaster response the main Objectif is to save human life which leads to earliest alarms and victim localization challenges. Disaster solution will implement efficient alarm techniques based on accurate previsions. Victim localization by tagging technologies and wearable sensors can be very useful to improve rescue operations.

The end user information presentation need to be friendly and efficiently gather necessary information to all actor.The end user information presentation need to be friendly and efficiently gather necessary information to all actor especially for rescue deciders that need a multi-level presentation with multi-context and business oriented view.

Fault tolerance is one of the most important issues that will be taken in consideration when designing a disaster system solution. To make a flawless system, the fault tolerance level of a system should be kept very high in all extreme conditions.Flood disaster can lead to communication disruption make that maintaining a network itself places hard constraints.

In addition, the generation of erroneous value by a sensor, faulty calibration, and failure in communication may develop a faulty situation.For the challenge problem the success metrics should be a combination of qualitative and quantitative measures that can be used to analyze, evaluate, and subsequently improve performance of a team towards the overall goal of reducing disasters during flooding.Sensors may fail due to the depleted battery or other reason. Besides power consumption, rigid sensors design is another inclusion where the package shall be done in the pre-disaster mode so that disaster has less impact on it.To maintain the system alive in disaster conditions distributed deployment and equipment redundancy with network management components is recommended.

Security and privacy: the disaster solution shall take in consideration the information security and privacy aspects. in disastrous case, personal and private information are being collected. The collected data from devastated sites or events may not be hampered by any malicious attackers. Thus, a secure and collaborative framework may be defined.

V. Architecture Overview

Flooding in Tunisia is an old phenomenon causing significant damage and live loss. The floods of 1969 (the whole country notably the Centre and the North), 1973 (medium and low Medjerda), 1982 (Sfax), 1990 (Region of Sidi Bouzid), 1995 (Tataouine), 2003 (Grand Tunis), 2007 (Sabbalet Ben Ammar), 2009 (Redayef)... are all episodes that have marked for a long time the hydrological chronicles of the country. The annual inform global risk index indicates that Tunisia is with high tsunami risk index (7.2) [13]. This situation incites Tunisian government to take strategic decisions to mitigate disaster caused damage. within this optical, we propose an integrated architecture that cover all risk management cycle phases [14]. the target architecture design is influenced by the pre-cited constraints and challenges. This IOT architecture will bring an effective solution for disaster management. Disaster response solution must operate in a constantly changing environment. In particular, defining a rapid and accurate response is arduous if the disaster has caused large amounts of damage over a wide area with numerous unforeseen events. Hence our proposed architecture implements the earlier presented OODA loop for decision making.

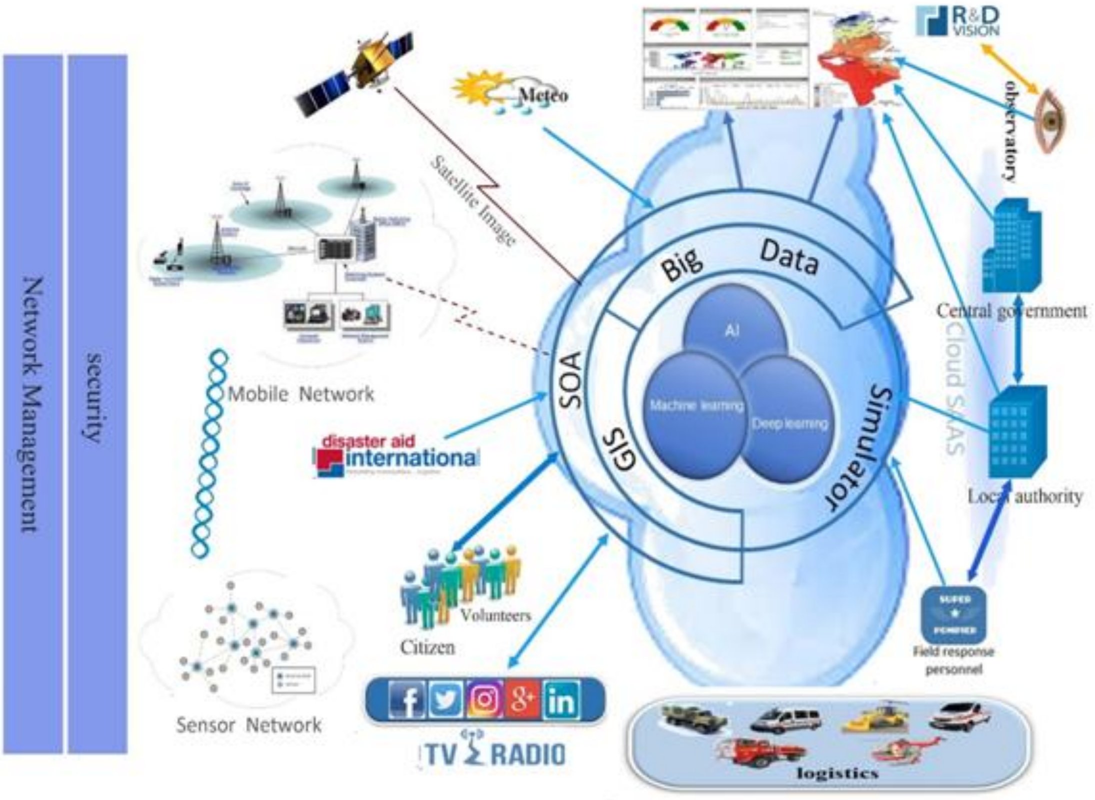

Fig2. Disaster management solution Architecture

5.1 Architecture components view

IoT can be seen from two perspectives; “Internet” centric and “Thing” centric. Internet centric architecture will imply that internet services being the main focus while data is contributed by the objects, whereas in the object centric architecture the smart objects take the center stage. The distributed nature of our solution with multi-actor, multi-context and multi-level view make that Internet centric approach seems to be effective. In order to realize the full potential of cloud computing as well as ubiquitous Sensing, our architecture, as presented in Fig 2, with a cloud at the center seems to be most viable. This will give the flexibility of dividing associated costs and highly scalable solution. Sensing service providers can save their sensed data through a network in a storage cloud. this data can be exploited by analytics based software solutions, data mining and machine learning tools to convert information to knowledge and visualization tools.

For distributed system with multi-actor needs SOA “Service-Oriented Architecture” will be very efficient thus she can include reusable services with well-defined, published interfaces. The development of an architecture based on services clarifies the role of each component, how this role affects the other components in the system and how it is affected by the roles of the other components which offer a flexibility in system maintenance and extension. developers can re-use system components in different scenarios and can even modify the architecture of the system by adding or extracting components and by this way adjusting the whole system to the requirements of a specific scenario.

Data collection: In the present architecture, diverse data sources are supported. Traditionally the disaster data collection for detection and prevision are processed based on meteorological report and warnings signaled by in distress citizen by hot line that cannot give sufficient and pertinent data for situation assessment. Remotely sensed data from satellite-borne or airborne like MAV “Micro Air Vehicle » sensors are used in disaster mapping. According to the needs of emergency preparedness and affected area prevision the satellite imageries were used to detect area susceptible to hazard. Whereas MAV is one of the efficient approaches in a disastrous scenario mainly for the safety of victims in a disaster. During the disaster the amount of exchanged data in social networks can be very useful for disaster assessment, disaster information dissemination, warning information spread and victim localization and their safety situation. micro-blogging service like Facebook ``safety-check" launched During Nepal earthquake that enables trapped victims to inform their locations and status of their safety to their family and neighbors can be very effective solution for rescue operations.

In Cyber Surveillance for Flood Disasters, a visual flood monitoring system for near real-time flood overflow detection and flood risk evaluation using remote surveillance videos can produce a vision in line with the real situation with precise results for small local areas.

Smart sensor networks can provide a good solution for timely report through actively monitoring and well-timed reporting emergency incidents to base station. smart sensors measure hydrological data in river, city, dam and ocean or sea. Diverse sensor types will be implemented to collect physical parameters. Rain gauge sensors to measure rainfall amount and intensity and sensors for water stream velocity that gather information about the torrent in city road. For river we need level sensors for information about water level to detect his rise above a pre-set reference value. Whereas, optic sensor can be used to detect dam leakage detection [15] in addition to sensors for dam monitoring measuring parameters as water level, rain fall, gate position, temperature, humidity...

For tsunami detection, we can use sensor nodes collect underwater pressure readings and sensors for sea water level detection across a coastal area. since decision-makers requires collection and interpretation of precise data related to tsunamis generation, propagation and impact on coastlines, sensors in deep water will measure seismological parameters to evaluate the parameters of potential tsunamigenic earthquakes.

Data storage and analysis:Crowdsourcing is an emerging computing paradigm [16] which is a process of acquisition, integration, and analysis of big and heterogeneous data generated by a diversity of sources in a cyberspace. Crowdsourcing connects unobtrusive and ubiquitous sensing technologies, advanced data management and analytics and novel visualization methods, to create solutions that improve disaster decision making. In this context Big Data analytics techniques and tools can be useful in all phases of disaster management. Acquired data from the heterogeneous sources in our architecture shall be analyzed correlated and synthetized in real time. Hence we can beneficiate of the potential of big data technologies and analytics algorithms to meet these objectives.

Spatial Data Infrastructure (SDI) [17] can meaningfully enhance efficiency in; short-term emergency response capacities, long-term risk reduction, development and environmental protection activities sectors. In which, allowing easy access to geospatial reference data and giving multi-layer and multi-view maps information. Coupling data collection scheme with centralized geographic information system GIS with data classification, data discovery and data sharing functions are crucial for ensuring that all risk cycle activities are executed efficiently and effectively.

Each country represents a unique situation with regard to its readiness to use the space-based information for disaster management depending on its organizational structure and technical capabilities. In the case of Tunisia, Baseline and thematic spatial data are available, but sprinkled at different locations with non-uniform data standards that restrict data integration needed by our proposed architecture.

Spatial data, non-spatial data (attributes) and field based data should be linked to be presented in the form of maps. Obtained maps can moreover be used in map based modelling to provide datum-points for risk mapping. Spatial data should serve the needs of pre-disaster and post-disaster activities.

the main goal of comprehensive disaster management is to reduce the devastating impacts of natural hazards. This will be achieved through resilient and accurate activities undertaken throughout the disaster management cycle from pre-disaster risk modelling, to post-disaster mitigation and emergency response where risk is expressed in the form of hazard maps. This maps can contribute significantly to better understand specific risks and also to prepare specific and tailored disaster management plans. Web-GIS service can help disaster actors, or whoever supports particular activities to have a clear view of the situation.

Data to knowledge transform:Disaster and crisis situations are characterized by high dynamics and complexity. The combination of complexity and dynamics makes the understanding and predictions of the disaster situations extremely difficult due to that disasters often undergo rapid substantial evolution. The disaster management is making unprecedented volumes of data available to the decision makers. Emergency managers are faced with daunting amounts of information and from an increasing number of sources which introduces new challenges related to the effective data management.

stressed subjects, like emergency managers, focuses on the general outline of the problem rather than in-depth analyses. Automated advanced analysis of the collected data that permit the creating of new knowledge from available data can enhance decision making by providing this analysis when time-constrained situational conditions would not permit it. The two fields that offer techniques for creating new knowledge from data are data mining DM [19] and machine learning ML [20] permitted to discover new patterns, trends, or deliver predictions. DM and ML are widely recognized tools to support decision-making in many areas and they are very complementary in disaster management context. ML is more concerned about the process of knowledge discovery, (algorithms that analyze data), while DM focuses on extracting and exploiting useful information from available data. The ML and DL are considered as the brain of our architecture that interact with all component to deliver decision making support in the different disaster and crisis management phases.

3D simulation: Disaster management can take profit from the advanced 3D simulation solutions for emergency operation training for rescue agent and volunteers. Recent years have seen a specialinterest in so-called ‘serious game’ applications in humanitarian operations and disaster risk management. Serious games applications use a variety of multimedia and strategies that allow the learner to interact with a graphic simulation of a disaster [21]. In our architecture, as shown in Fig 3, the use of simulator based on serious game applications is not limited for training purpose. We think that real time simulation can play a big role in all phases of flood disaster management. Coupling real time simulation with ML can contribute in disaster forecasting, situation assessment and can help in making decision accurately and effectively.

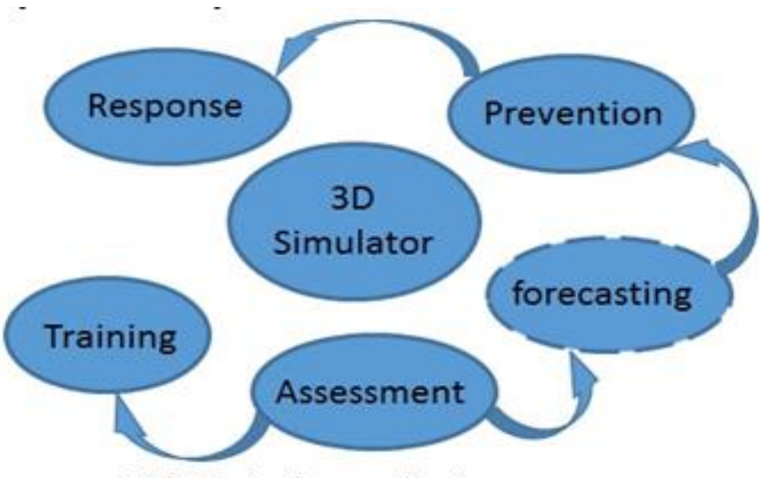

Fig3. 3D simulator applications

Dashboards and command interface services:Flood disaster severity and frequency with the crisis organization complexity have revealed the need for an organized system and common command interface to support search and rescue operations. The dashboard based on the intelligence module of our architecture will help in the more efficient distribution of tasks for the first responders and it will improve cooperation of the different services.

The Dashboard will provide:

- Disaster summary information,
- Real-time simulated situation and predictive situation,
- Multi-level maps of the affected area,
- direct communication between community members and first responders,
- content management system to monitor the dedicated disaster social media pages, headlines and alerts,

- communication and management system that enables the public to participate, in an ethical and lawful way, in the process of emergency communication for the purpose of community members' security in emergency situations and for search and rescue actions.

The Command Control and Intelligence Dashboard offer a number of functionalities, such as the real-time Disaster Monitoring through filtered messages (Photos, Videos, Sound), the provision of a timeline of the Disaster evolution, the establishment of geo-location of disaster incidents, mapping of Danger Zones, Safe Routes, Distress Signals, and disaster events summaries. Furthermore, the Command interface will supply disaster alerts and headlines for community member protection, communication capabilities among all concerned operation members.

5.2 architecture functional view

The present architecture aims to respond to the 5 priorities for action identified by Hyogo Framework [22] towards strengthening community and country resilience to disasters. thus the solution implements several services that support and assist disaster management in all cycle phase.

Fig4. Multi-layer Architecture view

As depicted in the Fig4, the architecture is structured in five layer where the first layer is for data collection that will be transported by the communication layer infrastructure and saved in the information layer solutions, treated and analyzed by intelligence layer to extract knowledge's and presented in different forms for end users.

The acquired data from different data sources are analyzed and treated by the intelligence layer technologies to offer diverse services to support disaster management in all cycle phases as presented in Fig5:

Mitigation: The main objective of mitigation phase in the disaster management cycle is reducing the risk of occurrence of the disaster and its possible consequences. Training and education is crucial for effective and quick response during an emergency for the professionals of emergency response and the general public. The 3D simulation can be a good support for training especially when is based on recorded disaster parameters.

The risk level in an area is calculated based on hazards and exposure, Vulnerability and coping capacity. Actual collected data mainly satellite image with flood histories in the area permit to calculate risk level based on hydrologic equations. This analysis permits the delineation of the flood-prone areas and propose recommendations for buildings and infrastructures resilience.

Preparedness: It is demonstrated that early warning and intervention can significantly save lives and property. The ML and DM will develop a forecasted situation presented in the simulator based in collected data. This intelligence component in the architecture cantrigger a warning by diverse medias (TV, Radio, SMS, Social networks, maps and so on) when forecasted situation indicate the possibility of flood. This warning will gather many parameters for general people to have a clear idea about the forecasted situation like water level, threatened Areas, area that shall be evacuated…

One of the most challenging problem in the preparedness phase is evacuation planning. Evacuation planning involves the need for combining spatial data and capturing evacuee behaviors and identify potential threat and safe areas. Based in the forecasted situation, the ML and DM module elaborate a logistic plan and evacuation plan.

Response: Rapid reaction and an effective response when a disaster occurs requires that information about the available situation and shared it with relevant contributors. A common command interface based in SOA is defined to improve effective coordination. In disaster situation trained volunteers can contribute and coordinate with in the field rescue agents. To this end, Zello solution that emulate a Walki-Talki by smartphone can effectively met this goal. The support system for disaster response is designed around machine learning and data meaning technologies that manages and utilizes generated data and presents it on a map and simulator to provide a visual representation of the situation. The simulator is used for many purpose in this architecture like actual situation and forecasted situation simulation in addition to near real-time decision simulation. ML can propose simulated decision scenarios based on situation assessments and forecasting.

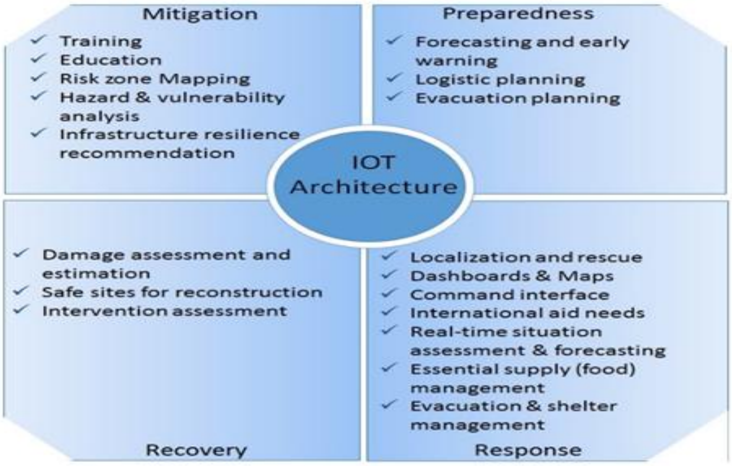

Fig5. Disaster management architecture services

As presented in the Fig6, the intelligence module uses collected data, national disaster plan and recorded data of disasters occurred in the area in last years to produce forecasted situation and develop intervention plan, evacuation plan and communication plan. The system integrates a management support for essential supply, evacuation and shelter helping to optimize evacuation operation.

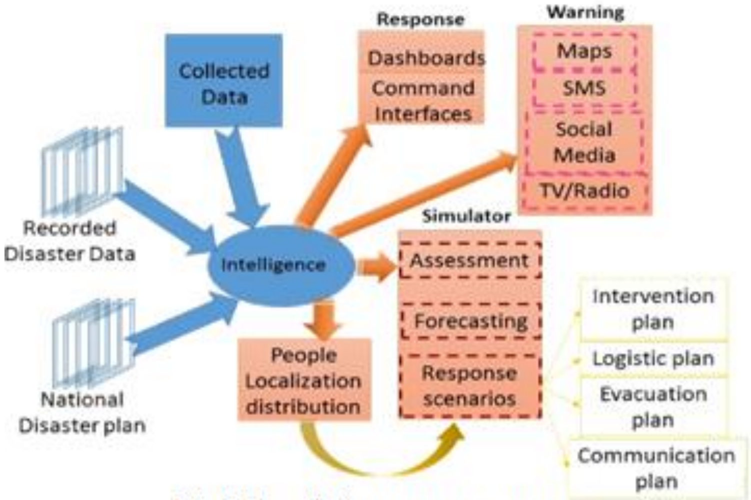

Fig6. The solution response process

The safety of victims in a disaster is closely depending of efficient localization and positioning system. For that a number of technologies can be used like RFID-based localization, microphone based localization and UWB-empowered textile antenna. These sensors can be distributed in the preparedness phase or during the flood occurrence within the safety jackets. Social networks can contribute in localization for example Facebook safety check service that enables trapped victims to inform their locations and status of their safety to their family and neighbors.

generally international aid does not correspond to the real needs of operations on the field. In this framework an interface that specifies the real needs if the catastrophe exceeds the local capacity.

Recovery: Recovery is the last phase of the disaster management cycle and can be referred as rehabilitation, reconstruction of the disaster affected systems and re-establishing basic infrastructure. In this context the presented system can assesses damage caused by the disaster, make financial estimation and indicate safe sites for reconstruction.

Since all intervention parameters and decisions are saved, this can be a good material for intervention evaluation and getting learning from. Stored information can be also useful for all linked research fields in developing new resilient solutions.

VI. Conclusion

This article presents our proposed architecture for flood disaster management. This ICT infrastructure aims to optimize disaster management and support accurate and effective decision making. Our proposed architecture is designed to support disaster management process in all phases; from mitigation to recovery. This work can be considered as a framework for national disaster management system leading to a multi-disciplinary future research works. The architecture is thought to be easily adapted to other disasters types. Thus by implementing tailored data collectors we can use the same process to manage other natural and man-made disaster types.

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IOSR Journal of Computer Engineering (IOSR-JCE) is UGC approved Journal with Sl. No. 5019, Journal no. 49102.

* Mr. B. Gopi Krishna. "Hierarchical Attribute Based Revocable Data Access Control For Multi Authority Cloud Storage." IOSR Journal of Computer Engineering (IOSR-JCE) 20.2 (2018): 43-53.