SEMANTICAL INTEROPERABILITY FOR ENTERPRISE DECISION SUPPORT SYSTEM IN ACTIVE ENVIRONMENT

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DEDICATION

In the memories of my NAANO (Grandmother). She is the one who actually started my educational journey. She is the one who cut off her basics for my joy.

You are being missed and you will be missed forever. You are the first chapter of my every success story.

MAY HER SOUL REST IN PEACE

DECLARATION

I hereby declare that the project work entitled "SEMANTICAL INTEROPERABILITY FOR ENTERPRISE DECISION SUPPORT SYSTEM IN ACTIVE ENVIRONMENT" submitted to Department of Systems Engineering RCMS NUST is prepared by me. All the coding are result of my personal effort. No work of this thesis nor materials has been previously presented for any degree in NUST or at any other educational organization, except where due acknowledgement has been made in the thesis.

Kashif Ayoub

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Kashif Ayoub

ABSTRACT

Semantics are playing key role in the area of decision making. Besides playing an importance role in web, semantics-based decision making is getting ingress in other fields, especially in war related technologies. Our proposed framework for rescue 1122 Pakistan, is also uses semantics and artificial intelligence combined, to enhance the decision making process and create situation awareness. A simple plane English string defining the incident works as input to our framework, from that string framework extracts contact information with the help of regular expression and extracts address information with the help of knowledge base and semantics. The rest of the string goes into lexical analyzer, which expands this string, converts it into new sets of ontologies, neglects/discards connecting words and parses new relationships inside newly formed sets of ontologies with the help of relationship builder. Newly formulated strings then are used to create new sets of semantical senses by implementing open source coreNLP and WordNet library rules. Each set of semantical senses, then represented in equally distinct numerical values for processing to ID3 algorithm implemented in Accord.Net library. This algorithm uses multiple iterations of Iterative Dichotomiser machine learning algorithm to predict results with a much more accuracy. Finally, decision are taken regarding resources to be utilized in the rescue operation, location of accident and victims, contact details of accident reporting person, incident type and related rescue activities to be carried out. This guides the rescue operation till hospitalization of the victim if required, with the help of geographical tagging of the location over the map inside rescue vehicle and control center's common operating picture.

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CHAPTER 1

1 INTRODUCTION AND BACKGROUND KNOWLEDGE

The term decision support system (DSS) and management support systems (MSS) are being used widely in the field of modern business [1]. Evolution of decision support system started in 1970 with the innovation of distributed computing for business [2]. Today's rapidly growing business world is converting national markets into global markets, which not only marking at the new levels of achievements but, also raising whole new issues for managers or decision makers. As the solution of such issues, it demands for fast as well as geographically distributed environment enabled computing power [3]. This geographical dispersion created many new attributes in business fields, which now became essential and must need to keep under observation while taking decisions. Such dispersion of the business world and evolving in the attributes are the key factors for any DSS.

When we talk about defense and rescue environment, similar issues exist here as well. With the evolutions in defense technologies and emerging concept of joint operations demands centralized system(s) to exercise the command and control over ongoing operations [4]. Network enabled or net centric operations are the main areas of research and development these days. Police, Recuse and hospitals are no more standalone entities for any net centric operations in some search and rescue operation. Infect, they are the key attributes of any such activities. Domination in such joint operations depends on a distributed information system providing filtered data at the right time and at the right place [5] and required strong centralized communication with zero barrier to guarantee the success of the operation. Real-time data generated from each such node with the heterogeneous nature [6] [7], is required strong fusion framework and interoperability technique to be applied [8] to map it over some centralized command and control center to support agile decision making. Every node or attribute will stick to its own system for sure which makes them heterogeneous and calls for R&D to provide a solution. Use of ontologies and semantics has given the evolution to the task of interoperability [9]. Formulation of the required semantics from such ontologies provides noticeable results.

Semantics are meanings, and these can be in either form of representation like a simple natural language representation like some English words or some proper mathematical values for further calculations [10]. To overcome these issues associated with joint operations, US Department of Defense (DOD) and NATO are working over different approaches. Military standard 2525 common symbology standards were introduced back in 1994 to aim to achieve same goal of interoperability in joint military operations [11]. After this finding, no significant work was carried out in the same field [11]. The R&D in defense department keep evolving. Though NATO did update its military standard 2525 common symbology to its second upgrade called MS common symbology 2525B but it is not proved fully fruitful. USDOD's current research works emphasizing highly at semantic interoperability concept for joint operation with centralized command and control centers [12]. USDOD is using semantics to improve situational awareness and to enhance its capability for centralized communication within and outside of its own military wings.

1.1 Rescue 1122

Rescue 1122 is known as highly professional and well established emergency response department in Pakistan. This department is the largest emergency humanitarian service of Pakistan with infrastructure in all 36 districts of Punjab and is providing technical assistance to other provinces [13]. They are working on different programs with the collaboration of local communities like capacity building of community response teams, training of the citizens in life saving skills ad school safety programs. These programs not only making the communities safe, but also creating a communication enabled environment and soft image of rescue in local communities.

The statistics of rescue 1122 shows that they have achieved a significant success in rescue activates. Rescue 1122 earlier established as a Punjab province's rescue department, but now is operating throughout Pakistan in all terrains and providing rescue facilities with the help of their fire brigade, medical and water rescue departments.

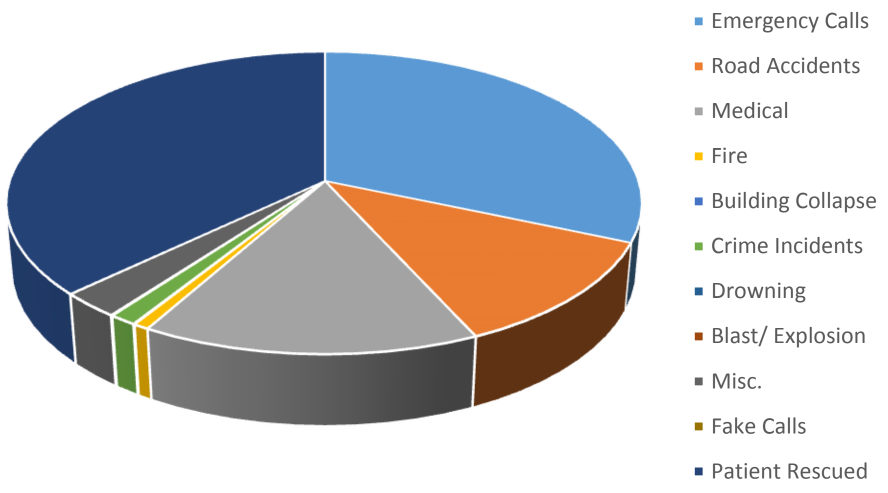


Figure 1: Rescue 1122 performance statistics [14]

Though rescue 1122 department has its significance and it is showing admirable results. Our framework can improve its output to new levels by merging Artificial Intelligence field with GIS system based Geo tagging. Both fields can play a huge impact over decision making by providing situation awareness (SAW). It can speed up in detecting multiple information from written reports like contact numbers, address and possible emergency type.

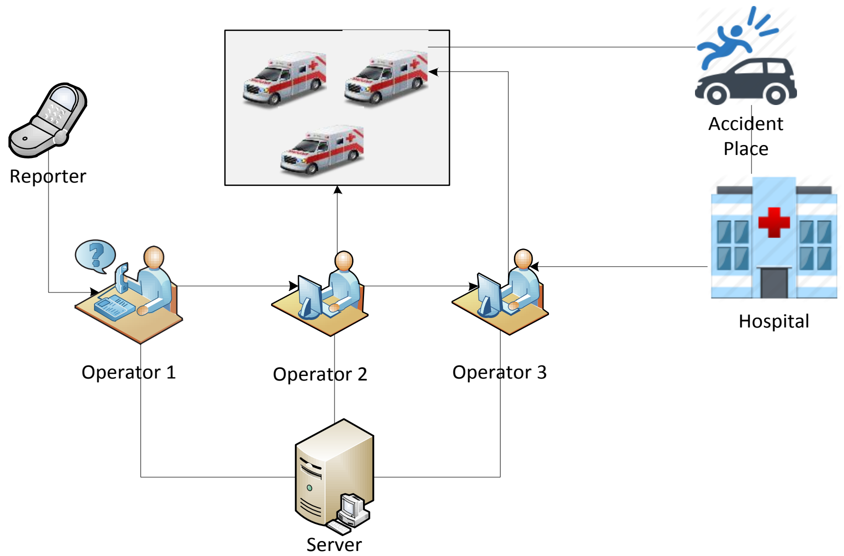


Figure 2: Rescue 1122 current functional station setup

Currently in rescue 1122 there is system deployed over a network, which keeps the record of all calls and emergencies. Operators (agents) filters out the genuine and fake calls and then initiates rescue activity. Due to lack of GPS based route mapping system either local rescue agents are being used for maneuvering inside the rescue vehicle or one agent leads rescue vehicle to the destination by keeping verbal communication over wireless handset throughout and passes on one contact number of the person present at the accident location. If hospitalization is required to any victim this will be a purely human based decision for selecting a hospital nearby with possible no real-time SAW.

The current rescue system also has lesser support to sequence of mishaps occurred in a single accident like fire in a property may lead to a heart attack to the proprietor. Also, some unexpected situations like disasters or terrorist activities also may lead multiple happenings in a row.

1.2 Semantics and Interoperability

Semantics and interoperability both were two different fields of research before 1988. Earlier semantics publications were more related to literature research articles. But the semantics of a child [15] was a pioneering science article which got huge citation. But still this article more tends toward literature theories. Semantics first implemented in networks control protocols, by computer sciences field, to control and transmit telephonic traffics [16]. But, if we specially talk about semantics and interoperability for enterprise systems, then this was seminally used by SANDRA HELER in 1995 relating it to American National Institute [17]. SANDRA talked about problems associated with interoperability by using semantical ontologies. Though in current times, American DOD is putting huge attention at this to use semantics in the field of defense and joint operation. But, still there are huge problems associated with it.

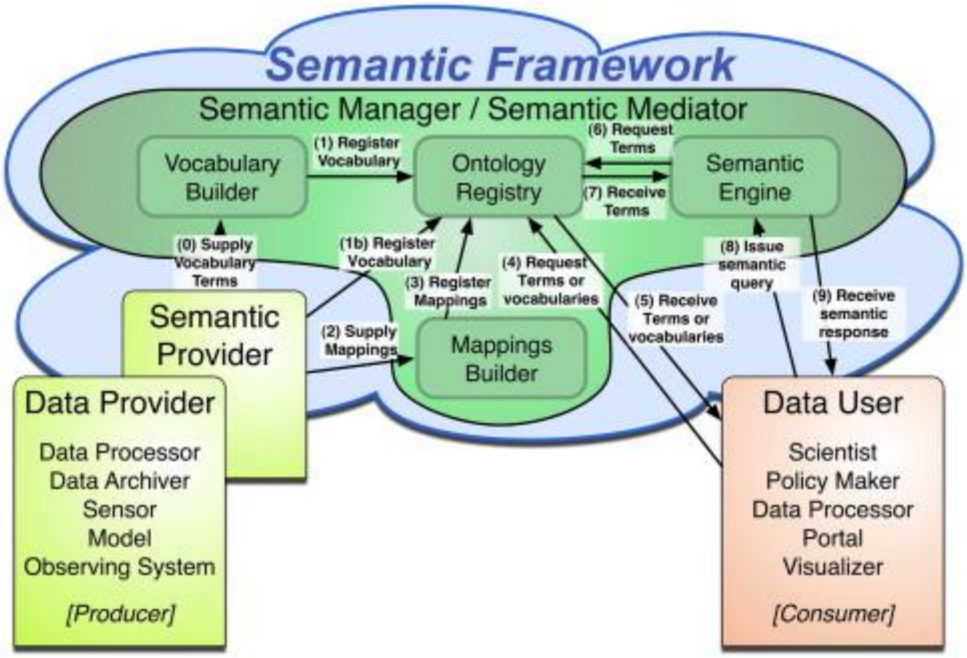


Figure 3: Semantic Framework [18]

1.3 Problem Domain

1.3.1 Current System

Though rescue 1122 department has its significance and it is showing admirable results. But, our proposed framework can help to improve its output to new levels by the amalgamation of Artificial Intelligence field with GIS systems based Geo tagging. Both fields can play a huge impact over decision making by providing situation awareness (SAW). AI and GIS based location mapping has already been proved their importance in the field of decision support systems and management support systems. These fields can add agility in sensing multiple information from written reports like contact numbers, address and possible emergency type and painting them on an emergency board.

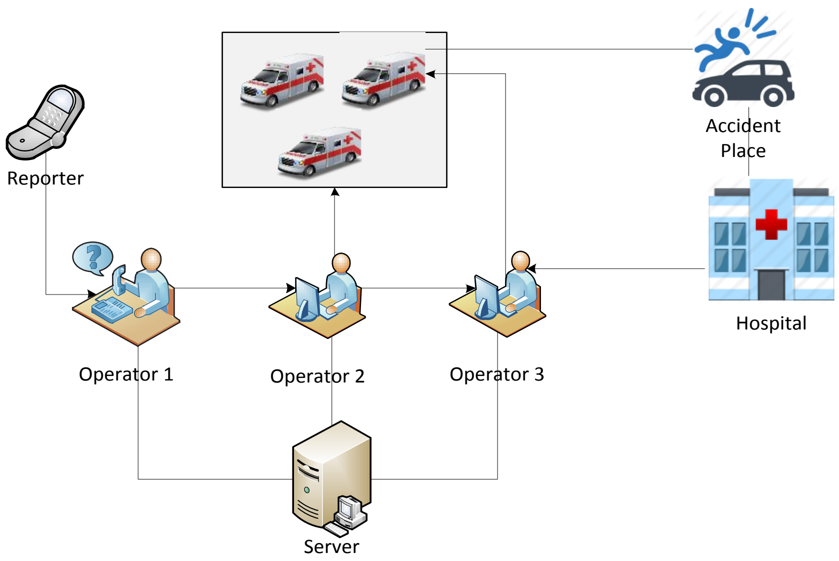


Figure 4: Rescue 1122 current functional station setup

Currently in rescue 1122, there is system deployed over a network, which keeps the log of all calls and emergencies being initiated or handled in. An emergency is initiated with the arrival of a call normally. When the call is arrived at their PSTN it first activates Computer Telephony Integration (CTI) server. Which alters the agent about the call and also initiated a query to the database server to retrieve its telephony history.

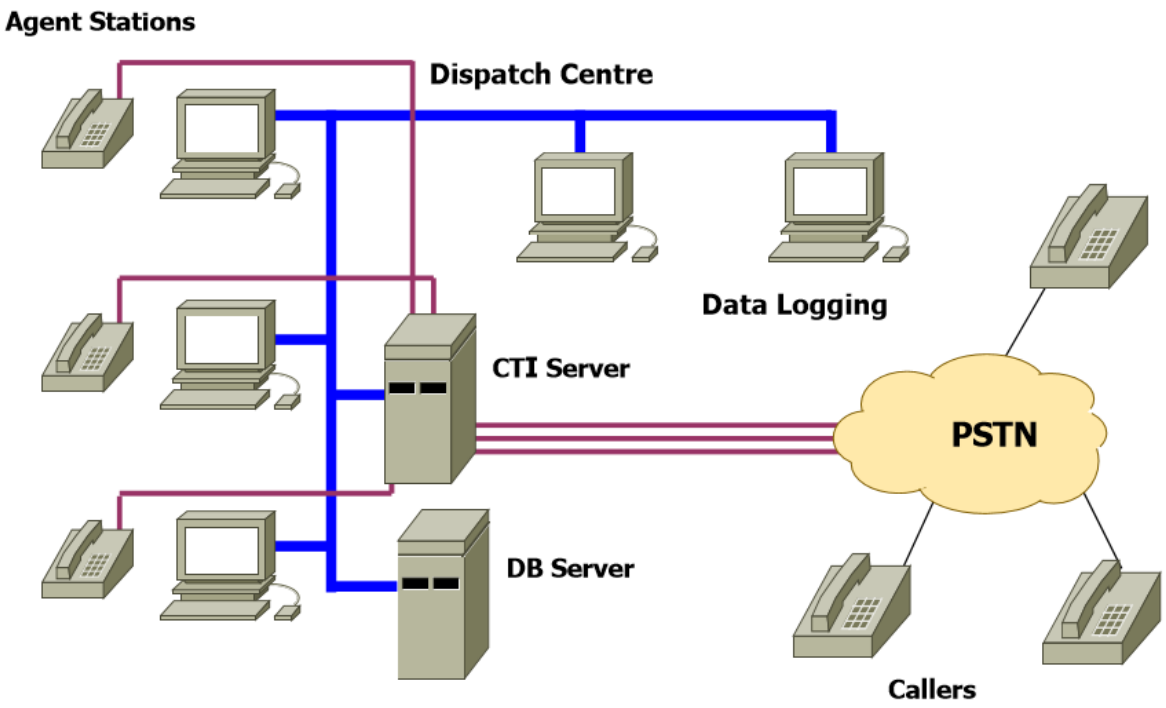


Figure 5: Emergency call center setup [19]

On the screen of the agent's computer, the interface changes its color to green as the indication of the emergency as soon as agent picked up the call.

Agent filters out the genuine and fake calls. This first filtered is applied using the human sensing, training and experience. Then, after the clearance of the first filter, operator initiates rescue activity through its computer by filling a simple emergency form. After filling out basic information related to the incident, a rescue activity is initiated officially.

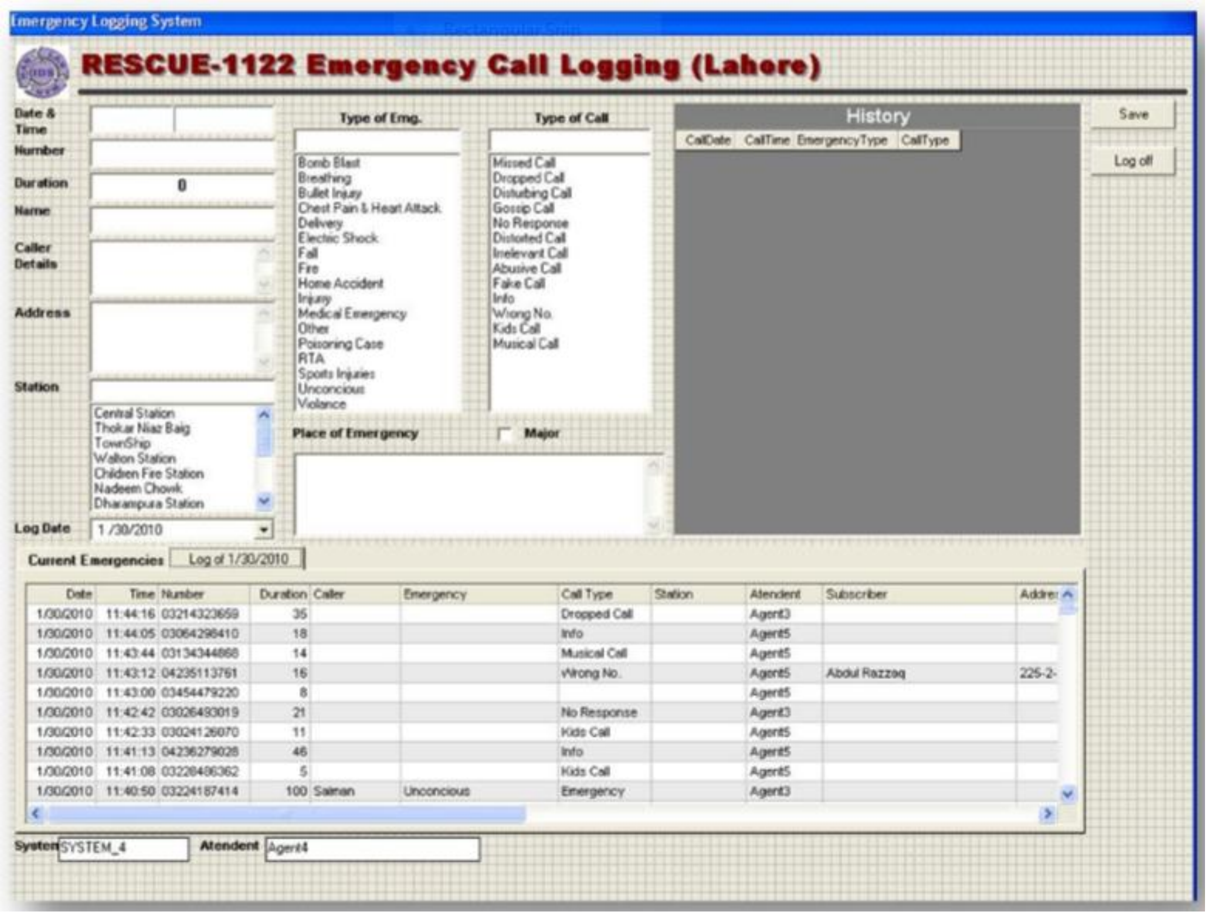


Figure 6: Emergency call logging form Rescue 1122 [19]

Due to lack of GPS based route mapping system installed, either local to operational area rescue agents are being used for maneuvering inside the rescue vehicle or one agent is assigned the duty to lead rescue vehicle to the destination by keeping verbal communication over wireless handset throughout till and destination and passes on at least one contact number of the person currently present at the accident location.

After researching to the victim rescue personals analyzes the situation. After first aid or during aiding, If hospitalization is required to any victim, this will be a purely human based decision for selecting a hospital nearby with possible no real-time SAW, they moves the victim to the hospital. There are normally two decision making authorities for this task. First authority is the family member or patient itself, depending on the condition of the patient and second is the rescue operation leading person.

When the decision is made to shift the victim to a hospital without knowing the hospital status, there comes another possible issue regarding to unavailability of related medical specialist in selected destination or unavailability of beds etc. On that particular time. If anything unplanned or against the plan happens, it can lead to some really serious level of situation.

During all these activities, back in the rescue station there are different statues marked on the application, marked against different colors to interface. Each status is marked by the operator at the station by taking acknowledgment from the rescue staff currently on the field handling operation.

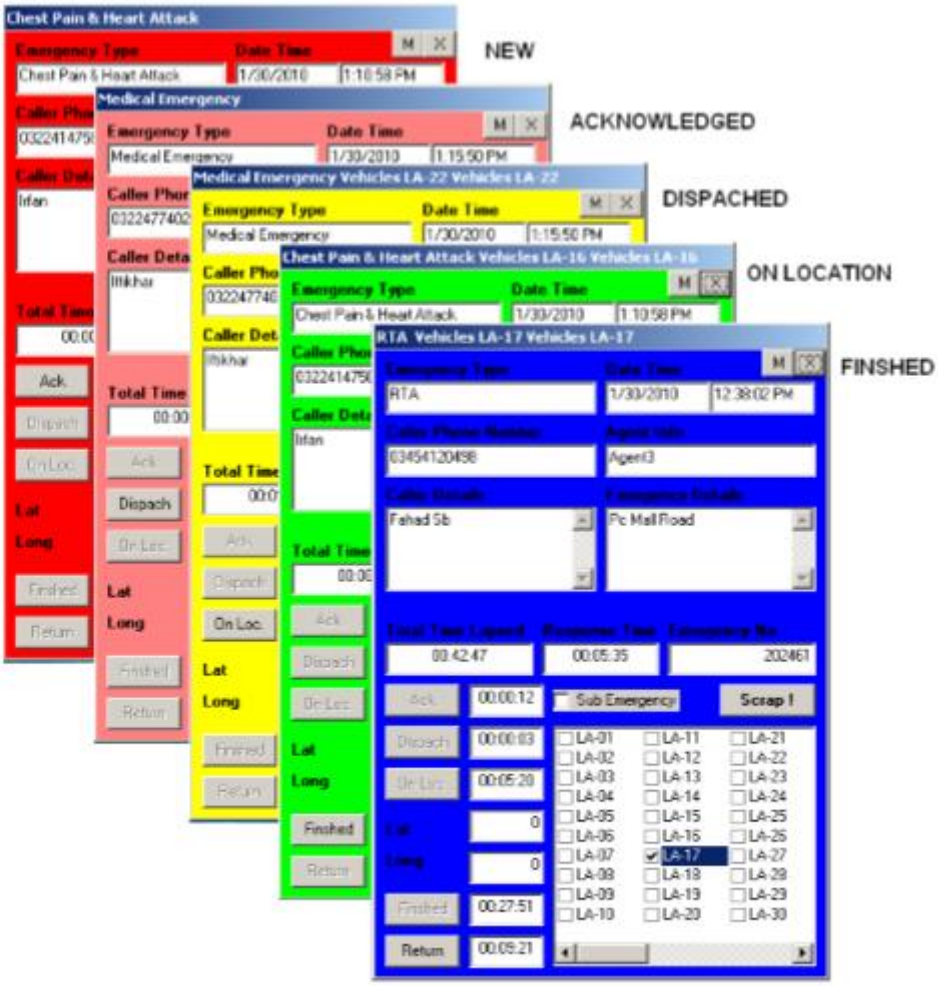


Figure 7: interface colors to indicate different Statuses [19]

The current rescue system deployed over the network for logging accidents, also has lesser support to sequence of mishaps occurred in a single reported accident like fire in a property may lead to a heart attack to its proprietor etc. Also, some unexpected situations like natural disasters or terrorist activities can lead multiple happenings in a row. This is not entertained properly in their current system.

Their system also binds them when it comes to selecting an accident type. There are few ambiguous divisions for accident types like medical is subdivided as breathing, chest pain, and delivery cases, while fire is not subdivided properly into category like class A, B, C.

1.3.2 Critical Analysis

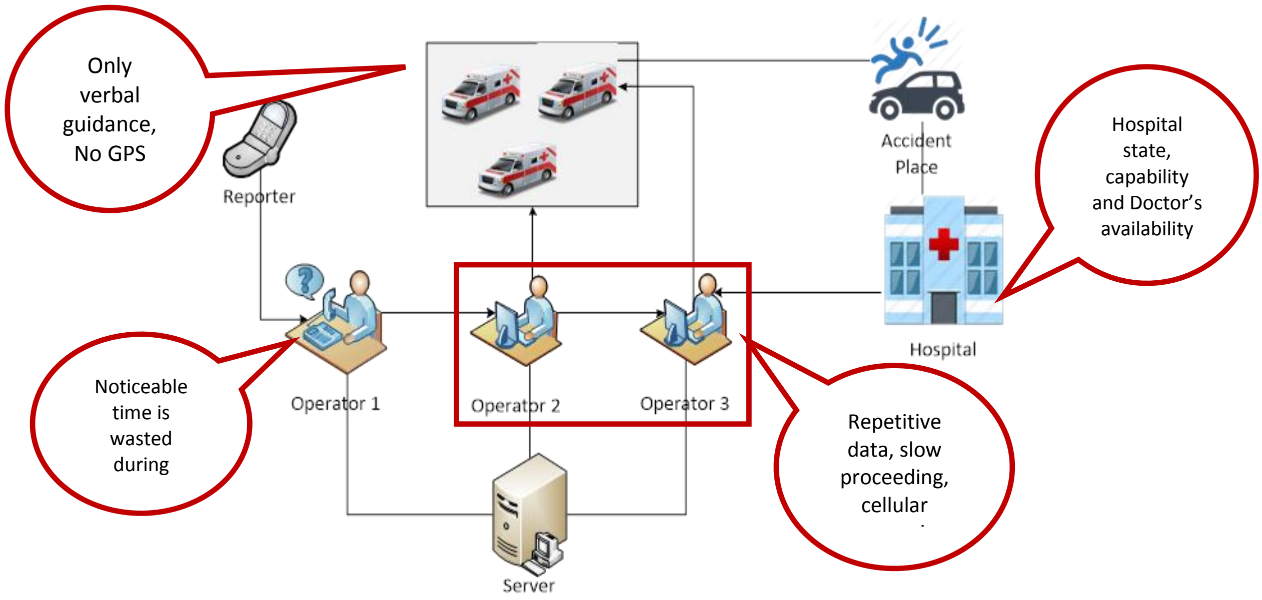


Figure 8: Critical points in current rescue 1122 system

In above figure there are four major marked problems in the current system of rescue 1122.

1. At the point where operator 1 is taking considerable time, his duty is to detect whether the call is genuine or not. It is a purely human cognition based detection. Where some hit and trail ways are used to check the originality of the call. Though those ways are formulated with the experience got from the rescue department, but still, this is an issue for the rescue department. Here if the less experience person is present, he/she can waste a serious amount of time

2. As a second point, there are operator 2 and operator 3 present. Their duty is to carry out the operation after the originality of the call. Operator 2 is supposed to input incident related data into server and operator 3 will lead the operation throughout. Here repetition of work is expected. Like operator 1, 2 and 3 are overlapping their working.
3. As the third point, there is no GPS based guidance system installed in vehicle to lead them to the place of incident. Most of the guiding communication is done over the wireless system verbally. Which sometime can lead to some problems.
4. There's no interoperability with the other departments like hospitals and police etc. Rescue personals are completely blind about the availability of required staff, doctor and related facilities in the hospital.

1.4 Problem Statement

Rescue 1122 has set their standard response time at 7 to 9 minutes for any rescue activity. But Department often fails to achieve this in most of the areas

Because

- Clumsiness in situation awareness
- Lack of asset management: state of rescue team unknown at a time
- Lack of interoperability with other departments like hospitals and fire brigade
- Slow cellular based verbal communication
- Lack of proper navigation system
- Lack of orientation (emphasis)

1.5 Theme of Study

The primary theme of this research work is to improve the decision making process in any active environment of any enterprise level. Active environment means the environment that is changing with the each moment of time. While for experimentation, we are implementing this research at rescue 1122 Punjab, Pakistan.

1.6 Contributions

Though this research can be proven effective in all environments deals with agile decision making and situation awareness. But, due to implementation in rescue 1122 department, this system will prove very helpful to enhance the response of rescue department and improve their professional levels. More lives can be saved. At the same time, more assets can be utilized in proper order to their maximum gain. Which will lead to economic benefits.

1.7 Organization of the Thesis

This thesis initiates the comprehensive introduction and background knowledge of the semantics and rescue departments. Then follows up with the problem domain which carries out the critical analysis of the current rescue system. The study is supported with some word from history under Literature review sections. The Proposed framework is explained in details, just before the algorithms. Experimentation sections define the testing of system in the original environment. Later, at the end Details comparison is carried out with the title of results and discussion. What are the further possibilities for this system are mentioned under future work.

1.8 Summary

In this chapter above, there is a clear history present about decision support systems and management support systems. How these fields emerged after the invention of distributed computing. How in today's global market, decision support systems are playing key roles.

This chapter also described about the rescue department, its professionalism and contributions to the society. This fact is supported by the statistics published by the rescue department. How the rescue department is operating. The chapter also discussed about the structure of the rescue department inside the rescue station and how they carried out any emergency operation.

In the middle, a detailed discussion about the semantics, it's used and its representation is carried out. Also, the importance of semantics, its contributions and possible contributions in different fields, including in the emergency response and defense department is discussed.

Then, a detailed representation of the rescue 1122's current system and its possible flaws comes under discussion. Earlier the system is defined as, how they operate, initiates an emergency by receiving a call and then carried out this emergency toward the finish.

Under the critical analysis, we tried to find out the possible areas of improvement in their system. Also, we did mention about the factors causing problems or wasting a considerable amount of time for any response time. Where the agility is compromised.

Than the concise problem statement is formulated to describe the all problems found, in précised manner.

Later on, healthy contribution of this research and possible contributions of this research comes under discussion. We talked about the contribution in the experimental field (rescue 1122) and possible contribution in the field of defense. How the overall structure of this thesis is carried out, is mentioned in this chapter.

Chapter 2

2 LITERATURE REVIEW

2.1 Interoperability

The significant amount of research works has been carried out to solve similar problems in different domains from different scholars. Every scholar tries to drive certain techniques for interoperability either in the shape of frameworks or methods.

The vital factors affecting the capability of ISR assets to support agile maneuvers thru OIF included concise engagement times, incompatible C4ISR systems, and planning considerations, a lack of artificially intelligent analysis tools, and lack of integration with the other Service ISR capabilities. The commander in charge can take several actions to cater the tide of significant ISR closures during OIF. Foremost among them is to engage JFCOM (Joint Forces Command) in its role as the DoD's decision maker for joint interoperability and amalgamation to support the joint exercises that focus on C4ISR trainings. Services developing for the C4ISR system must receive guidance through JFCOM to ensure future C4IISR systems are not developed in such a way to field stovepipe systems unable to function in a joint war [20].

With the evolution of net centric wars, only a few war systems operates as a standalone, enhancing the interoperability of networks of systems becomes the main research goal. Numerous heterogeneous networks of technological human, and organizational systems are deployed in all military operations. Within Depart of Defense (DoD), such systems and their functional uses are often explained by DoDAF (Department of Defense Architecture Framework) with their technical and operational views [21].

From a theoretical way, most of the research publications are satisfying most of the problem areas but from realistic implementation view, not all opt the simplicity and accuracy to the instinct of applicability. DoDAF index of interoperability measurement is not fully satisfied. Most of the research work either talks about a part of a system or a function of any system, but not most of them implemented or suggested a system level solution as practically. Michael R. Hieb recommended a practical way of semantical interoperability for mapping physical location over geographical information grid (GIG).

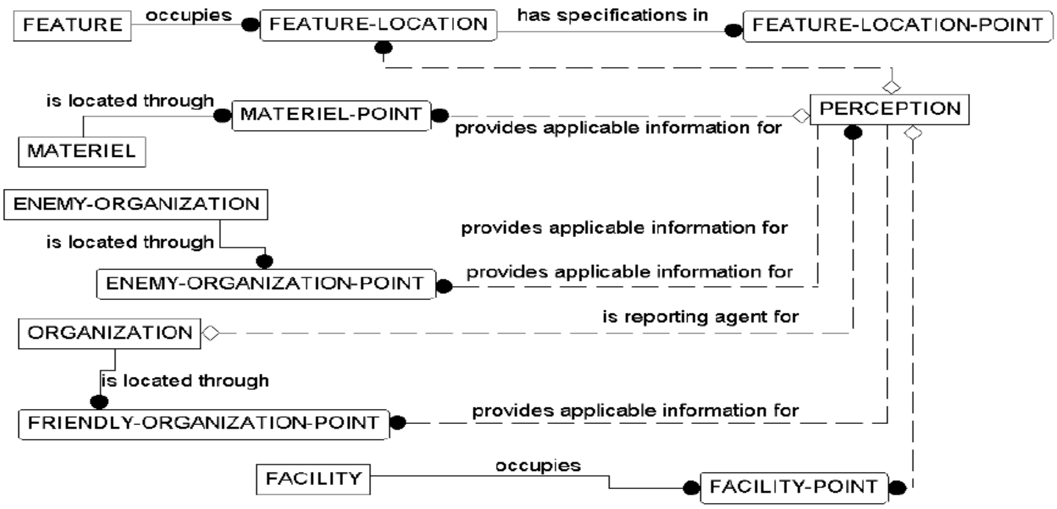


Figure 9 JTDM View of Unit Status [22]

In the above figures, the proposed framework is precise enough to map friend and foe forces over GIG. This framework can generate accurate points over the grid by receiving the up to the minute inputs from the devoted sensors. But, this incorporates a fixed pattern of natural language parsing techniques [22]; like feature must come first and then information about the location of the enemy must come before the accurate location points, etc. this fix pattern parsing is as similar as filling a form. Infect in a few cases we must prefer forms, then writing in fix pattern which exposes us to fewer mistakes. Keeping humans inside a shell, especially when there is a state of war, is almost impossible and unfeasible as well.

Author also didn't speak to the issues around the joint war of dissimilar nature of forces might be from different countries and regions. Differences in description code ad symbology cannot be incorporated in suggesting framework.

2.2 Natural Language Process (NLP)

Natural language processing is the way to extract patterns of the natural language from written sentences. Through NLP, we validate the input string through application of core grammar rules.

There are many approached and architectural frameworks available for this task. GATE is one of the frameworks have graphical development environment to enable a user for develop and deploy language engineering (LE) tools [23]. This framework has the noticeable capability to highlight different language rules and part of speech tokens [23]. There is the limit of this framework, it is not very well compatible to bad language constructions and processing.

TectoMT, a multi-layer, multi-purpose, open source NLP framework. It has a reputation for having fast and efficient NLP based application development supporting tools. It provides tools for sentence segmentation, tokenization, morphological analysis, POS tagging, shallow, deep syntax parsing, named entity recognition and tree-to-tree translation [24]. These tools are very helpful when we required to translate one langue to another in real-time. In our aim to parse low grammatical language, we are not required to use such library packed with a large amount of tools. Because, such libraries required a lengthy time to setup library requests in order to run them on developer PC. Simply we required some in between library from TectoMT and GATE.

If we try to join JVM methodology with another proposed approach of natural language processing (NLP) system to extract semantics with the aid of ontologies, then the effects can be more precise and closer to our problem area.

Stanford CoreNLP offers a complete set of NL analysis tools. It can parse base forms of words, their POS, whether they are noun of firms, people, etc. it can normalize dates, times, and numeric quantities, and detect the structure of sentences in terms of phrases and word dependencies, indicate which noun phrases refer to the same entities, indicate sense, extract open-class relations between mentions, etc. [25].

Here, firstly, with the help of NLP based processing, some word get recognized through NLP then lexical analyzer with the help of a knowledgebase process that extracted word and tries to find the meaning/semantics of the word against the scenario. These semantics, then passes to expert system for further scenario based mapping. After the while processing loop completes, that same word is feedback to the lexical analyzer with new mapping. Now parser gets the word as input and recognize the mapping. Generator joint it with other similar words to formulate the new pattern.

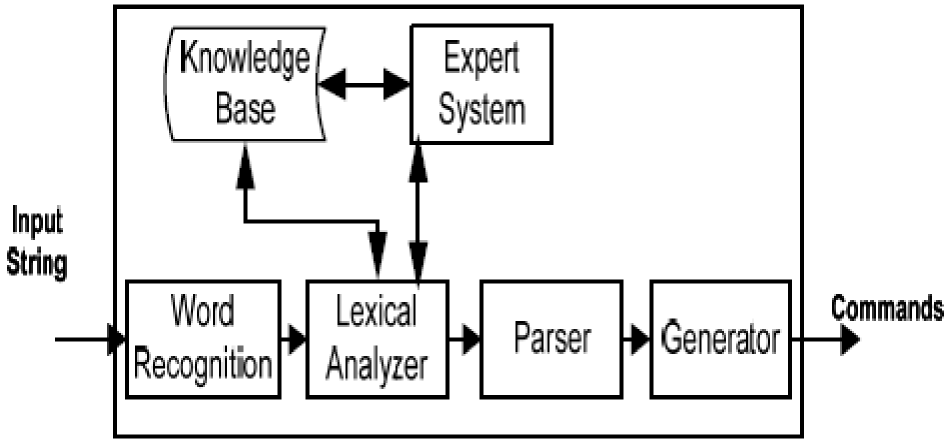


Figure 10 Natural Language Processing [26]

Now by linking both techniques of JTM and NLP based processing, issue related to natural language commands and its processing can be overcome. We can extract semantics any non-fixed pattern. But, now the level of complexity has increased intensively. This raises another critical issue of agility refusal. Too much involvement of clustering and classification of data will hold up the process [27]. Ultimately, agility will be compromised. While agility is the one of our prime goals in defense environment.

Still, the challenge of making fully adaptive and hybrid decision support system for dynamically changing conditions remains the challenge [28].

2.3 Decision Support System

With the invention of distributed systems, decision support tools becomes the key factors for all businesses [1]. There are many tools being utilized under the domain of data mining in business field and many or been discussed in research articles only. Most of the research articles are focused on a specific standalone information parsing system or at some sub-system level of a DSS as in above mentioned techniques. Those who worked over complete DSS mostly speak about decision trees. Few of such writers did propose implementation of decision trees over artificial neural networks (ANN) for agile outputs [29].

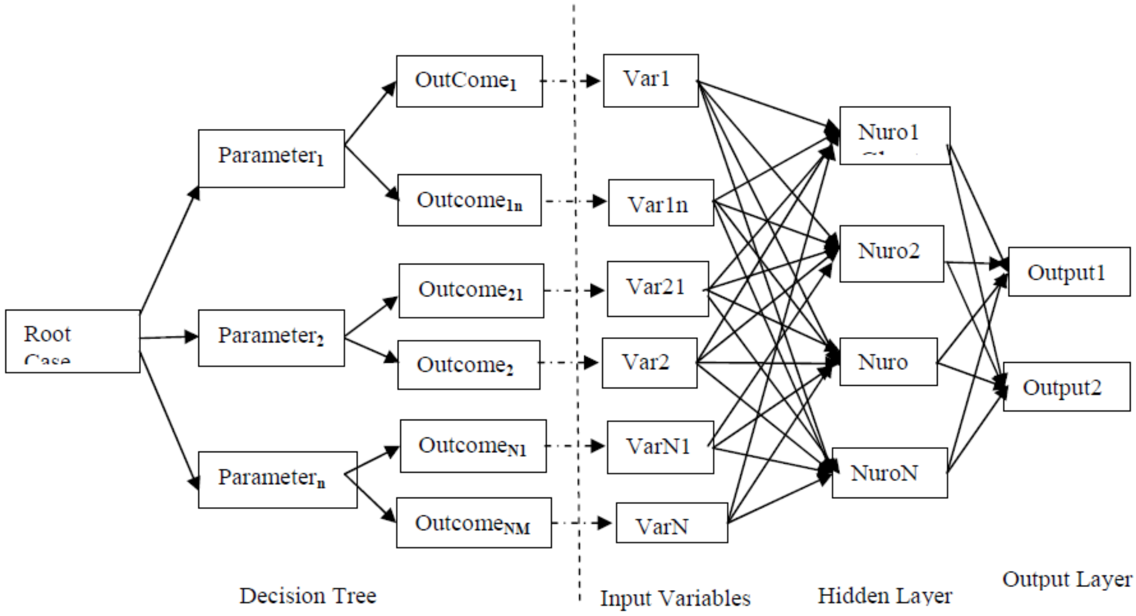


Figure 11 Decision Tree Neuro-Based Architecture [29]

Decision trees Neuro based approach surely created a huge impact in command and control (C2) systems for DSS. Agility considered as the key factor, is attained due to neural networks. Ability of neural network to adopt changing patterns also makes such system adaptations to active environment. At the same time, accuracy of decision tree makes the system a lot more reliable. This architecture proposes some new ways in making decisions.

2.4 Situation Awareness

Situation awareness is the capacity to detect and process critical elements of information about any ongoing operation [30] and keeping you up to date from changes being taken place. Situation awareness in rescue world is knowing what the emergency is, how to mitigate it and how to mobile rescue assets with agility. There are factors which directory or indirectly affects the situation assessment capability of a human includes the current and available cover of human, variety of operational field, observability, health status, range of operation and engagement of assets [31]. Other factors which are less clear to a human are also required to achieve better situation awareness like aggression, impact of using assets, impacts of actions overarching mission goals.

What is not situation awareness, is also required to know for any system. It is a fact that situation awareness is a necessary factor for decision support system. But, few things are not actually situation awareness like

- Decision making is not situation awareness. Actually SA helps to make decisions
- Performance is not situation awareness. Better performance is not directly related to better SAW there are other factors too.
- Situation awareness is not implicit knowledge.
- Situation knowledge is a separate entity then SAW. SAW means up to minute information about any situation while situation knowledge can be experience about similar conditions.

Proposed methodology enhances situation awareness by keeping the geographical location tagging track in central GIS based location map. Route selection is being simplified by using experience indexing over last selection of possible alternative routes. Knowledge base (KB) gets updated after each decision being taken and feeds forward its previous learning to new decisions by proposing alternatives. This knowledge base is also used for latest training of model iteratively. Which makes this framework as adoptive to any environment.

2.5 Summary

When we review the literature about the same topic we have found that interoperability is the one the hot topics for current time scholars. But, at the same time we found that most of the quality work or proposals either limited to some functions of the whole system or only scholarly work. Interoperability to system level is still a challenge.

While there is handsome abound of impressive and practical work is carried out in the field of natural language processing.

We also found that few scholars did tried to merge the fields of decision support systems with the natural language processing with some fixed pattern. Such approaches were related to defense forces.

When open the history pages for situation awareness alongside NLP. We found some great scholarly work for merged approached of NLP and decision making with ANN or decision trees.

CHAPTER 3

3 PROPOSED FRAMEWORK

This research proposed a practical framework as the solution of the problem mentioned above. The scope of our framework is at the system level. It describes or effects to all levels of rescue 1122 system. Our system not only focus about the improvement in response time but also it is focused on interoperability of all rescue teams and entities in any particular operation.

In proposed methodology, a collective approach of semantics and artificial intelligence to get interoperability to support decision support system is mentioned. Semantical parsing of input data is confirmed to be a time saving act when it comes to map the information over some structure by recognizing its patterns and taxonomy. Artificial intelligence has the capability to process the information to find some hidden patterns and formulate adaptive behavior. It can adopt the active behavior of dynamic environment over some training dataset. With the help of knowledge base (KB) of activities and combining it with the semantical approaching toward information parsing with some machine learning methodology to map the decisions, we have proposed new methodology named **SEMANTICAL INTEROPERABILITY FOR ENTERPRISE DECISION SUPPORT SYSTEM IN ACTIVE ENVIRONMENT**. Our area of application is the rescue 1122 department of Pakistan rescue response authorities. Major aims of this framework are agile the decision making, enhance the situation awareness and increase the interoperability within and outside the rescue department.

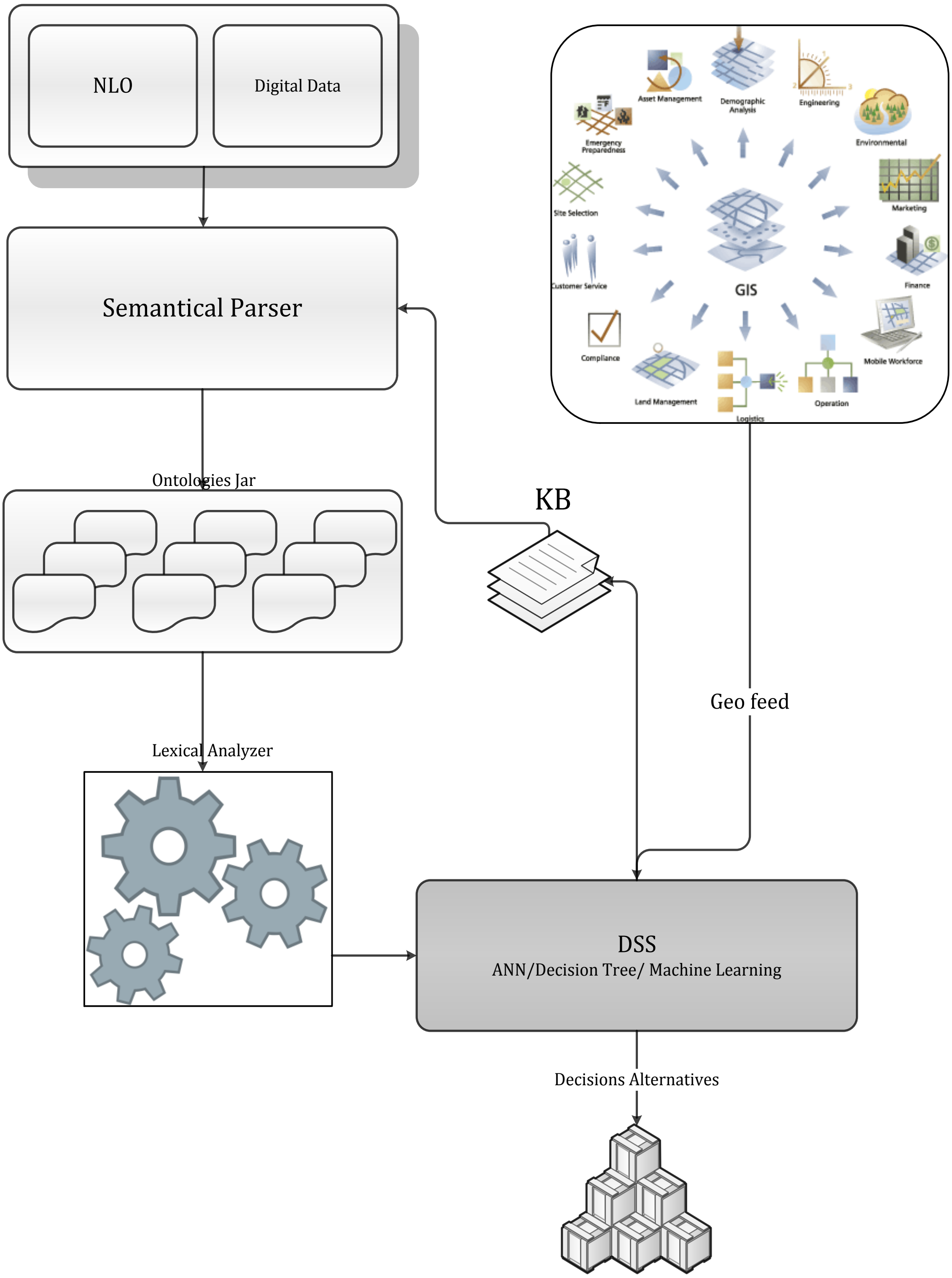


Figure 12: Semantical Decision Support System Framework

A. Natural Language Orders (NLO)

Here inputs from a real-time environment in some natural language will be fed to the framework. These inputs can be either a plain text written by the human, parsing of NLP from voice over data streams or given text orders from third party applications. Speech recognized from the friendly forces or commanders can be translated into text by using any speech to text commercial off the shelf (COT) third party application, in the case of speech data. In our framework we limited our scope to text parsing only.

B. Digital Data Feed (DDF)

This feed is in term of numbers getting from different sensors. Such sensors could be either like Geo tracking sensors, weapon signature sensors, reconnaissance sensors or location indexes from cellular companies in case within the country implementation etc. These numbers will be semantically parsed for clustering.

C. Semantical Parser

In this phase all information either in the form of numbers or natural language will parsed to map over the system. Parsing will breakdown the natural language sentences into small meaningful ontologies. These ontologies with meta-data feeds forward to the next phase. Digital data in the form of numbers with the correlation of other entities and will be converted to similar ontologies directly.

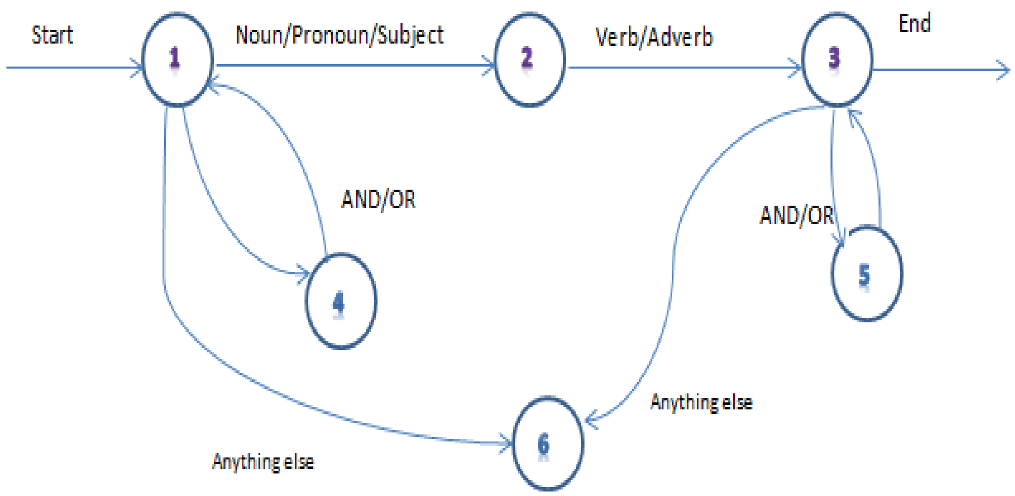


Figure 13: Ontologies relationship parser for NLP (Simple Preset Tense)

D. Contact Extractor

As the sub module of semantical parser, contact extractor has the duty to extract contact number information from the input string. It is supposed to map all local contact numbers appears anywhere inside initial string.

E. Address Mapper

Address mapper is also a sub module of semantical parser. Its duty is to detect and sense the address related information appears in the string got as input from the user. This module maps the address up-to street levels. The actual address is broken down into area, block and street level divisions.

F. Accident information parser

Remaining string after contact extraction and address mapping will comes to this module to map accidental information from the remaining string. This will map and convert such information into ontologies packets for further processing.

G. Ontologies Box

Ontologies box, is the place or organization of all real-time ontologies feeds getting from last phase. This will keep it in the form of relationships among these ontologies. Relationships of ontologies will be created with the help of the knowledge base (KB) and open source libraries.

H. Lexical Analyzer

Lexical analyzer reads the ontologies box on the bases of relationships exist in each set of ontologies and removes meta-information. This phase trims the ontologies and only keeps semantically acknowledged part(s) of all ontologies.

Lexical analyzer also converts this compact form of information (ontologies) into the quantifiable values. Quantified judgment model (QJM) for calculating lethality is the one way of converting all strengths and moral of forces into equally measurable values.

I. Geo Feed

Geo feed is a live data feed from active operations. Geo feed means geographical information with respect to the global information grid (GIG) about forces like, where forces are physically located, what are their postures and what is the type of terrain where operation is being carried out etc. This live feed will also keep track of the maneuvering form of the forces. So the system will be able to predict the next location of the force over the terrain.

J. Knowledge Base (KB)

Knowledge base KB is a repository of decisions taken earlier, their situational characteristics, and their measurable effectiveness outcomes. Every decision implemented, will be the part of this repository. Every new decision formulation will also get influenced by KB.

K. Decision Support System (DSS)

Here comes the application of A.I. based decision support system. This system, maps over the machine learning algorithm for dynamic environment refines the choices in term of decisions. It reads compact or trimmed output of the ontologies box from Lexical analyzer and formulate a set of decisions and its outcomes predictions. The output of this phase is a stack of available decisions inside its presidency of knowledge to the end user. It also updates its KB for further adaptability of the dynamic environment.

For the comparative agile decisions to gain maximum time superiority over the enemy forces we must require foe information. Information that can be converted into numbers for comparison. Information about their gesture, posture, moral, weapons effectiveness, in combined we can say their lethality measurement. Feed such quantities to similar system and perform comparative analysis so the decision or set of decisions can be turned into beneficiary solutions of real-time problem.

L. Communicator

The responsibility of this phase is to lead the operation from start to finish. Decision alternative to be communicated to assets. GIS based tagging to be forwarded to nodes of operations.

3.1 Summary

In this chapter, we proposed a full form framework supporting for a complete system. Our framework adopts simplicity of applicability. This framework, though supportive to all active environments for decision support and situation awareness, while we choose rescue 1122 department for experimentation.

Detailed explanation of the framework is presented. Starting from natural language based input to the framework. Then, the digital data feed from different nodes like Geo locational data. Sending theses inputs to the semantical parser to do some tagging to sense the required information out of it. After extraction of possible contact number and address, the rest of the string goes for further parsing and mapping of the emergency. Ontologies box is a container for semantical ontologies while the lexical analyzer tokenized and parsed information toward the decision.

Geo feed and knowledge base are the supporting modules which help to generate the accurate decisions. While communicator is the module responsible for interoperability.

CHAPTER 4

4 PROTOTYPE STRUCTURES AND ALGORITHMS

As the prototype for rescue system, we went through all possible points which a raise during the critical analysis and problem formulation. Time saving for any incident's response remain the key factor for prototype development.

4.1 Initial Reporting

When we analyzed the main interface used for reporting and logging of accident reports. We found following key areas for improvement.

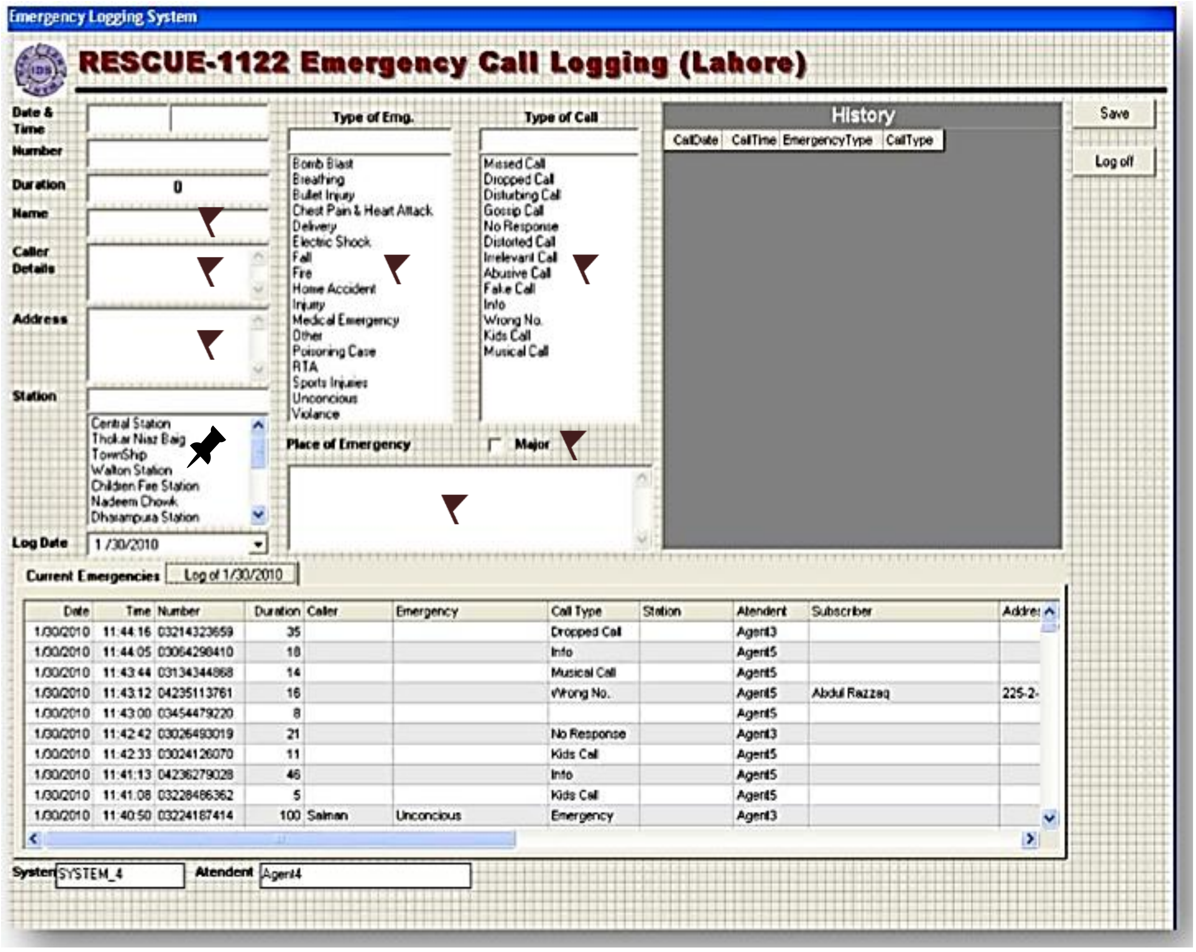


Figure 14: rescue 1122 current system interface

Major Key areas for consideration are flagged with  mark. All the key areas are being described as:

1- **Number field:** when a caller calls in rescue department, its number appears in this field automatically with the help of PSTN. And its calling history appears in the list for caller history.

2- **Name field:** this can be filled automatically when we have caller history. Manual entry can raise issues.

3- **Caller details:** this is another manual entry. Which is not required or not directly influence to the rescue activity. Caller details are not required to take action.

4- **Address field and place of emergency field:** these both fields are conflicting with each other. Address and place of emergency both are the same things for any accident. These are just the repetition of entries.

5- **Type of emergency:** this is the one critical thing being get selected manually. There are few fixed types of emergency added by the developing company. Rescue team cannot edit them directly. These fixed types raise multiple issues like

   a. All these types are not enough to cover all accidents throughout the country

   b. There are few unnecessary or unfair subdivisions of these categories. Like medical type is subdivided into breathing, delivery cases etc. while fire is not subdivided.

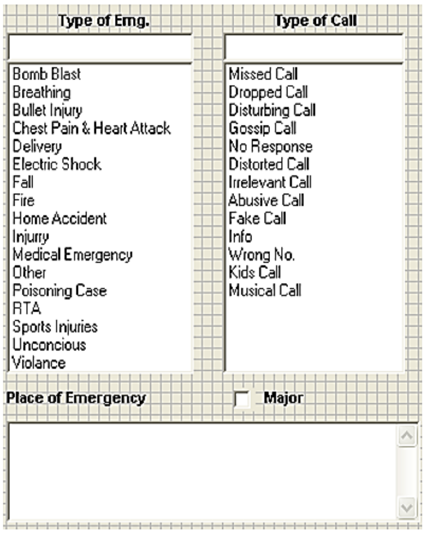


Figure 15: Emergency types

c. Human can select the wrong type for some emergency which can lead to some wrong results for analysis later on.

d. One category for one operator can be different to the other operator at the same time in the same station

e. There is a type “other” exists which can lead all planning to nowhere.

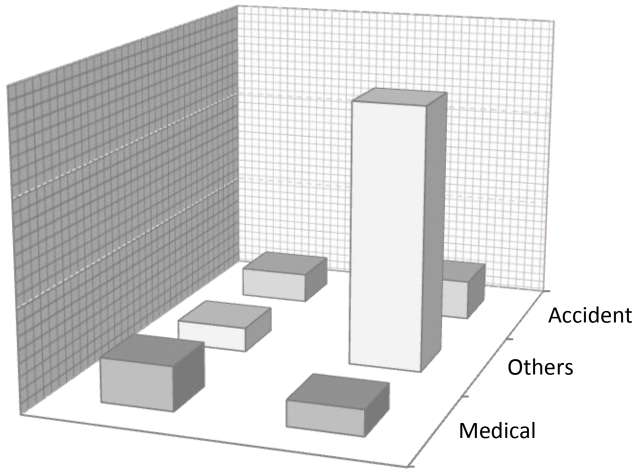


Figure 16: possible final analysis with current system

6- **Major emergency check:** operator is making this choice ether the emergency reported is major or not. Now there could be different thresh hold levels for every person to ark one emergency as major or not.

7- **Station field**: last but the most shocking manual entry is a selection of the station from where the emergency will be handled. This shocking. This should be done automatically. Because, one station can mark one emergency to another without any particular reason.

To overcome all issues listed above, we have redesigned the main interface for reporting. We tried to remove all mentioned points and kept most of the thing automated.

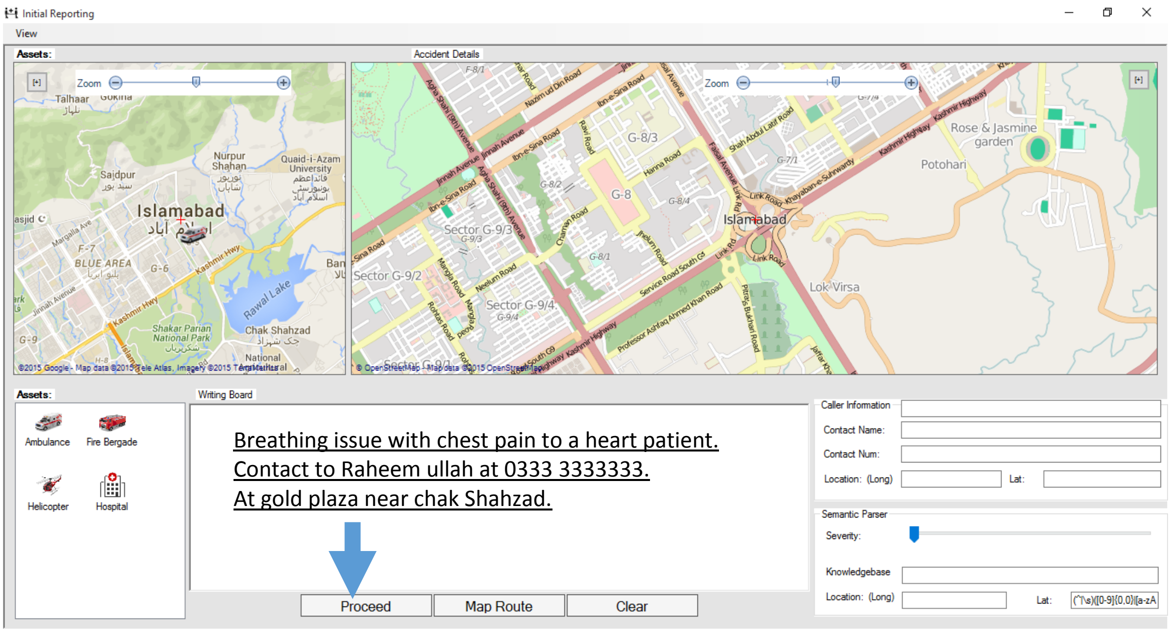


Figure 17: main interface redesigned

We included natural language processing (NLP) to replace the initial reporting from form filling to plain text. Where an operator is free to write in any sequence. The operator is bound to a couple of things just. Write the report in the reporting box and press process command. As soon as reporter presses the button in the background there are multiple process get initiated to perform their duties like extracting required information and mapping those at GIS system then communicating them with other rescue staff.

4.2 Mandatory Information Parsing

From initial reporting string, to lead an operation, there are few things must be marked successfully. A contact number is required to contact the person present at the place of emergency. If the contact number is present then it must be parsed. Secondly, location information from the remaining string. Location is divided into three further levels as location monuments. At the end remaining string should be reparsed to get the understanding of the emergency and decision making.

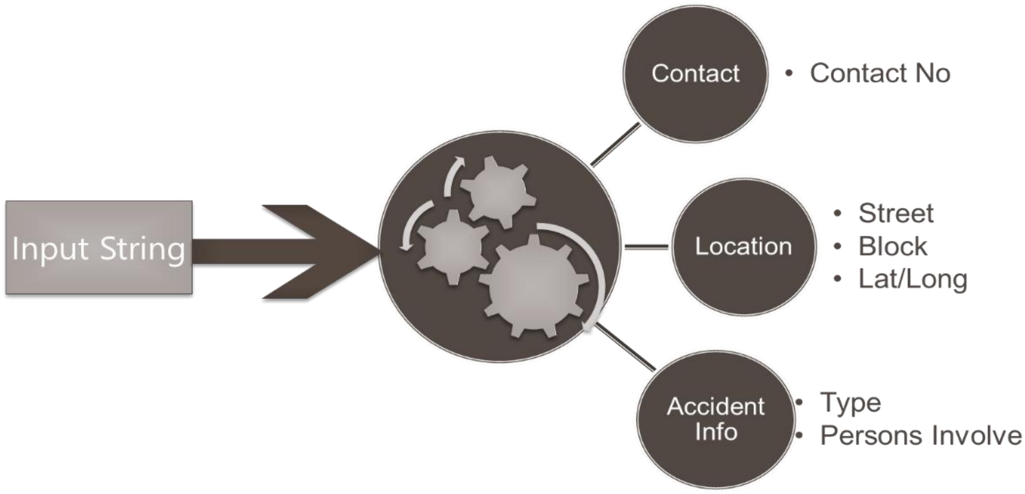


Figure 18: information to be parsed from initial reporting

4.3 N.L. Complexities in Reporting

When we include NLP it means we are exposed to a whole new world of processing and complexities. In rescue case, especially in Pakistani environment, where English is not native to people. We have to face some real asks. We are not supposed to get proper grammatical input from the report writing operators. After the experimentation we found following behaviors.

4.3.1 Fully Grammatical

There is a heart patient suffering with serious breathing problem. The patient also has chest pain. Please contact to Mr. Raheem Ullah on its mobile number 0333 3333333. He is standing near gold plaza of chak Shahzad area.

4.3.2 Partially Correct

Breathing issue with chest pain to a heart patient. Contact to Raheem ullah at 0333 3333333 on gold plaza near chak Shahzad.

4.3.3 No Rules

Heart patient with Breathing issue chest pain. Contact at 0333 3333333. gold plaza near chak Shahzad.

4.3.4 No Rules No Sequence

Heart patient cant Breath and has chest pain. 0333 3333333. gold plaza chak Shahzad.

So, our prototype is expected to cover all these types of ambiguities lies in our society particularly. Which we incorporated with the help of CoreNLP and WordNet APIs. These are detailed explanation about these in experiments sections. We did not only incorporate these local society's problems only, but, we also keep an eye over the regular NP issue comes with the English language processing like crash Blossom and Pervasive. Where a slight change in writing changes the meaning of whole sentences e.g.

4.3.5 Crash Blossom

- Ali strikes idle kid.
- Ali strikes, idle kid.

4.3.6 Pervasive

- KE raises interest rates.
- KE raises interest rates.

4.4 Algorithm for N.L. Complexities

After getting tokenizing and POS tagging from CoreNLP API. Issues related to crash blossom and pervasive get solved. While for grammatical problem we implemented following algorithm with as a solution.

- Extract amod, nSubj, nMod, numMod, compound, dObj sets from coreNLP definition file.
- Create sets based on seminaries like

  [(pain, with), (pain, chest)]

- Take every word of every set and keep matching with all sets and formulate new lists.
- Indexed new lists
- Combine all compound sets into a single element.
- Sort each list w.r.t to assigned indexed
- Merge each list.
- Remove duplicates again
- Return new lists

4.5 NLP Address Extraction Complexities

There are different behaviors for writing address generally during open typing. Because out system claim for out of the box way to express emergency details so, we have to implement algorithm for all possible address writing behaviors. Common formats found during analysis are:

- Address format
  - House 111, Street 132, Block G11/4, Sector G11.
  - House 111, street 132, Block G11/4
  - H# 111, St. 132, Block# G11/4
  - Street 3, Block A, Satellite Town
  - Street no 4, Muhallah Ali pura,
  - Fuel Station near bahtar moore, Qenchi chowk

Figure 19: Address mentioning possible formats

When we study it deeply, we found that even at some very small level, there are different behaviors for mentioning or writing same string in address like:

- Common behaviors
  - G11
  - G-11
  - G 11
  - Bahtar moore
  - 72 moore
  - Batti Chowk
  - 32 Chowk
  - etc

Figure 20; Address writing behaviors

For all such formats and behavior to be tolerated in the system. We have a wrapper CoreNLP library with some custom code. Which shows success for our local writing.

4.6 Algorithm for NLP Address Extraction

1- Get input lists from user as input.

2- Load KN of location monuments

3- Mark first possible monument and load its latitude and longitude.

4- Mark second possible monument by using indexing of the first marked monument.

5- If the second monument marked successfully, then, mark the third location monument from the index of 1st or 2nd. Otherwise go to line 7.

6- If 2nd monument is not found then pass the string to NLP based parser to keep looking for NOUN tagging.

7- Find each tag of NOUN go to its definition and load to list of expected address.

8- Browse list of expected address at map server cache and mark possible latitude and longitude

9- Mark the location on the map

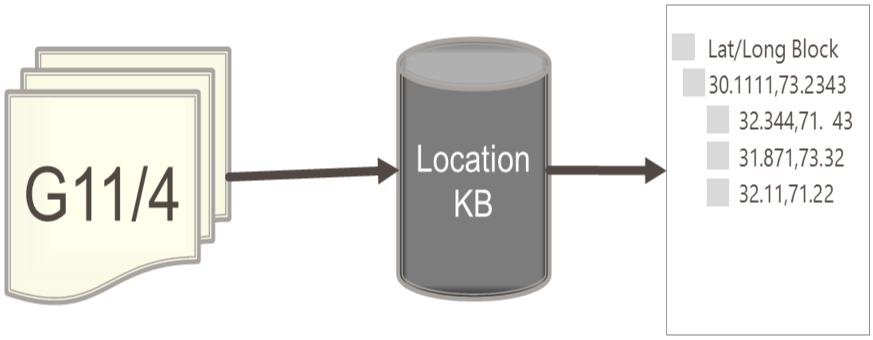


Figure 21: location monument marking with KB

4.7 Summary

In this chapter we presented the English narrated algorithm implemented in the solution. We started with the initial reporting of any emergency. Then we talked about the problem in initial reporting for the current system. Then we prototype the new interface for reporting.

In new interface we implemented NLP instead of form filling. Which made the life of an operator who is the person writing initial report, easily. Then we talked about the complexities and possible problems related to initial reporting with NLP. We discussed all possible problems in detail like grammatical issues, different behaviors for writing and few readings or punctuation related issues.

Then we presented our algorithms as the wrapper over the CoreNLP library from Stanford to make CoreNLP most useable for our local English and its writing behaviors. Which made the system adaptive for our society.

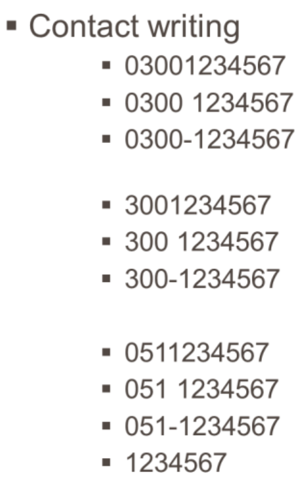
Later we presented an algorithm for address extraction and contact mapping.

CHAPTER 5

5 IMPLEMENTATION

This research work proposes a new framework for emergency response authorities. It starts with a simple report written in plain English language. The framework doesn't impose any fix pattern to write the report. It also don't ask for accurate English language grammatically because in Pakistan environment English is not a native to many. It is not possible to ask for grammatically correct sentences to mention initial reporting about any incident. Such approach also enables to reporter to feel free while writing incident details which makes this system more user friendly and adaptable to all.

After the initial report string is completed and process is began, framework parses it via regular expression and finds out contact number from the string(s), proposed framework can extract contact of Pakistan only written without country code.



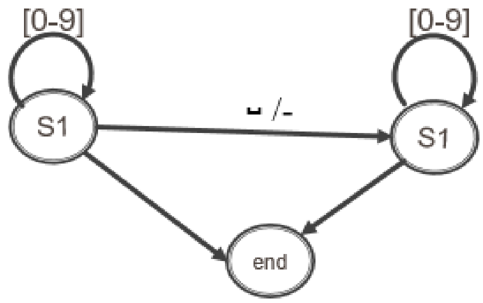


Figure 22: Contact parsing automata

The framework is starting finding string starting with some number. Then keeps iterating numbers until the desire length of numbers is matched/guessed or some dash "-" or blank space "␣" is detected. If the dash or blank space detected then it will move from state S1 to S2 and again will start iterating for numbers. If blank space or dash is not present and direct series of numbers is present for required limit of length, then it will keep iterating at state S1 till contact found. If in the case, required length of number series is not found, then contact parser will terminate without returning contact.

After completing above operation, it sends the remaining reporting string to lexical analyzer. Lexical Analyzer's duty is to analyze text and find relations among all words with the help of the CoreNLP library from Stanford University. Because in emergency environment, it is somehow a bad practice to keep the report writing agent under the constraint of writing the initial report with proper grammatical manners and waste his considerable amount of time. Our training based framework detects important information and discard remaining string just by creating semantical relationships among each word even if there is no proper grammar.

CoreNLP from Stanford University has its reputation for natural language processing. Here, we first expands reporting string into its basic details by putting part of speech (POS) tag at each word of the string. After discarding all interconnecting words and creating basic dependency relationships, our framework parses it again to keep required information only.

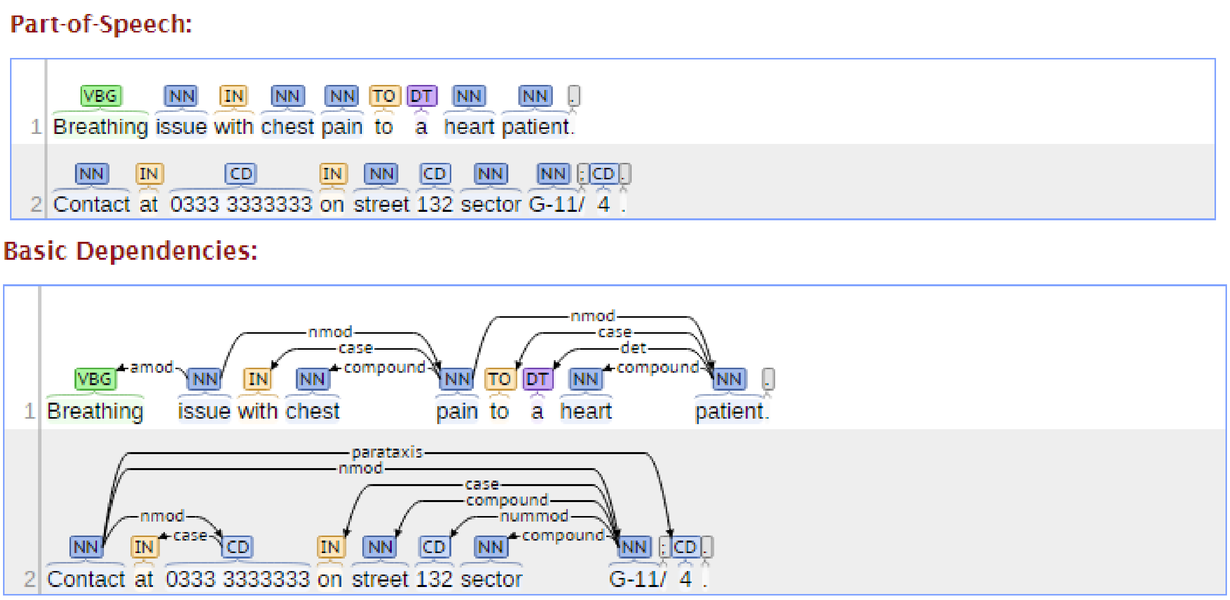


Figure 23: POS and Basic Dependencies from CoreNLP [33]

In this final parsing inside the lexical analyzer only nmod, amod, nsubj, compound, dobj information sets remain for further processing and the rest are discarded. Final selection is done on the basis of POS tagging and tagged relationships from CoreNLP.

New relationships are being formulated, in order to streamline the lexeme. Lexeme will keep all new relationships as string inside it and manageable for NLP operation. Token are created and marked into the pairing sets inside lexeme without disturbing original positions of tokens from a real string. Relationship builder picks up each token (word) from each set. It neglects the repetition and finds the next pairing set containing the same token and patch its unique 2nd token with the one already picked for parsing.

<table>
<tr><th>Input Lexeme of Relationship Builder</th><th>Output Lexeme from Relationship Builder</th></tr>
<tr><td>amod(issue-2, Breathing-1)
nmod:with(issue-2, pain-5)
nmod:to(pain-5, patient-9)
nmod:on(4-9, G-11-7)
nummod(G-11-7, 132-5)
compound(pain-5, chest-4)
compound(patient-9, heart-8)
compound(G-11-7, street-4)
compound(G-11-7, sector-6)</td><td>issue-2 Breathing-1 pain-5 patient-9 chest-4 heart-8

4-9 G-11-7 132-5 street-4 sector-6</td></tr>
<tr><th colspan="2">Sorted Lexeme</th></tr>
<tr><td colspan="2">Breathing issue chest pain heart patient
street 132 sector G-11 4</td></tr>
</table>

Table 1: Lexical Analyser and relationship Builder processing

After a plain lexeme string out from the lexical analyzer, it's being passed to next process call address mapper. Address mapper reads output lexeme line by line and then generates new tokens accordingly. The duty of this process is to map complete address divided into 3 parts as Area, Block and street level address. Area is the key location monument, while the block is the division of monument and street level address hints to actual accurate location. The framework uses KB for mapping /guessing area and block level address monuments. The only mandatory portion, to keep in KB is, area level addresses.

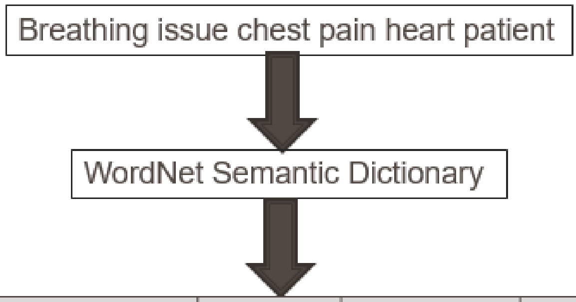
Figure 24: Address Division

With the help of KB when an area is detected now in the next phase of the process is block detection and as the last step, street level semantical detection done. The WordNet semantic sensing library is used for guessing the street level address. The framework uses its previous training to detect street level address with the help of WordNet semantical definition attributes. Here, at this level, each word gets its semantical sense definition from WordNet and then if there are multiple scenes like in Noun and Adjective files, it uses a voting mechanism to select one sense. Veto voting is given to Location type nouns while others have equal voting weights. At the end highest voted definition will be picked.

After mapping contact and address information. Remaining string gets another iteration through the lexical analyzer. Which parses it to formulate new tokens and relations. Output string this time is as:

Breathing issue chest pain heart patient

This compact string after extracting contacts and locations out of it, remaining string is used for semantical sense tree formulation. Accord.Net is well known open source machine learning library is used for decision making phase. Which implements many decision making, machine leaning and neural network based algorithms. In our cases we required the agility of neural networks while accuracy of decision trees. So, we are implementing Iterative Dichotomiser 3 (ID3) algorithm from Ross Quinlan [32]. This algorithm is famous for faster decision making due to the neural network oriented structure and it uses iterative based fuzzy logic at the backend. Which enables it to get accuracy of tree structural machine learning.



Breathing	issue	chest	pain	heart	Patient
Act	Cognition Communication Act Possession Phenomena Person Event	Body Artifact	State Feeling Cognition Person	Cognition Body Attribute Location Shape Food Feeling Artifact	Person

Figure 25: Incident string parsing into senses

Above string is further gets broken down into words and each word gets its set of senses from WordNet. There could be multiple or no sense of any word. Our structure should be enough flexible to store such senses.

Each sense set is then represented into a numerical format in order to parse for the decision making algorithm. Most of the machine learning algorithms work exceptional with numbers. So, to get a unique numeric representation in numbers, we are breaking each word and its sense definition into characters. Every character gets its unique UNICODES. Every UNICODE is then treated as string and concatenated with the next code. They get concatenated with the same sequence as the characters were present in the word. This new representation will be unique for each word.

Breathing

B	66
r	114
e	101
a	97
t	116
h	104
i	105
n	110
g	103

6611410197116104105110104

LOG(6611410197116104105110104**)**

24.82029/10=**2.482029**

Figure 26: Numerical representation for each word.

With new representation our dataset get shaped as.

[5.92425579741453]	[6.93925394604151] [7.28619171470238] [5.92425579741453] [7.06646697013696] [7.03966034986208] [6.58617165485467] [6.81124437860129]	[6.19847871649231] [6.81124437860129]

[6.4085287910595] [6.67456139181443] [6.93925394604151] [6.58617165485467]	[6.93925394604151] [6.19847871649231] [6.94889722231331] [6.82328612235569] [6.93925394604151] [6.94889722231331] [6.3818160174061] [6.18620862390049]	[6.58617165485467]

Figure 27: Numerical dataset representing actual incident string

Now this representation is passed to trained ID3 algorithm for decision making. There could be multiple iteration of ID3 depending on the series of incidents mentioned in a string. ID3 will return decision(s) based in training which decision includes assets to be moved, actions to be taken. While location KB will help to select possible shortest route based on its previous experiences.

After identification of assets and path now selection of assets will be done by the communicator module. The duty of communicator module is to map nearest available assets like ambulances or fire brigade as decided and lead them to the place of incident. Mapping and selection is done on the basis of geographical distance between the place of the incident and place of asset placed.

Service for hospital keeps the system up to date from the situation of every connected hospital nearby. Then the same communicator module leads the asset toward the hospital if required.

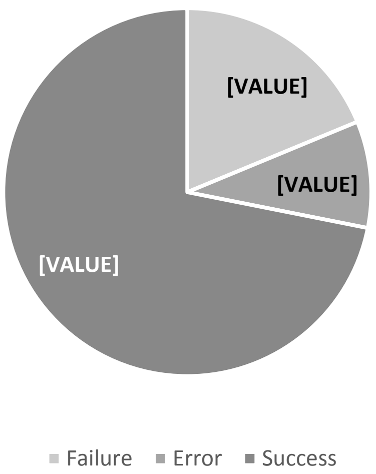
5.1 Accuracy Constraint

We have introduced a constraint in initial report writing to improve its accuracy of information mapping. Earlier user (reporter) was open to write report string in either way without impose of any rules. But now, report required to break information into multiple strings. Still no specific sequence of these strings is imposed. User only asked to write contact and address information in separate strings and accident description in another.

He/She is still allowed to use multiple strings to define accident. To separate these strings full stop "." is asked to be used as separator.

Blast in firework store. No injuries yet. Move to F-11/2.

With the introduction of this small constraint resultant accuracy of mapping required details for any accident is noticeable. Statistics for successful and accurate mapping without any error jumped to 87.5% from 71.9%, while mapping of accident details with some error, reduced to 3.12% from 18.75%. Total failure in the mapping of accident related information is now 3.12% instead of 9.37%.



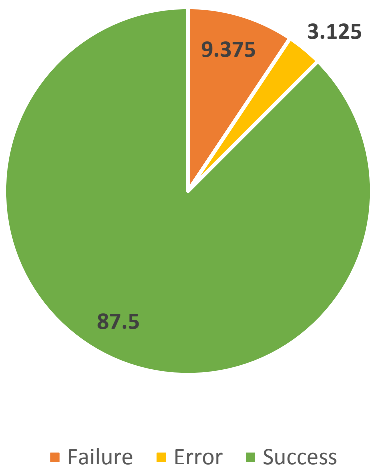


Figure 28 information extraction before and after introduction of constraint

CHAPTER 6

6 CURRENT SYSTEM STATISTICS:

When we analyzed results of current system being used in rescue 1122 department to handle emergencies, we found following stats.

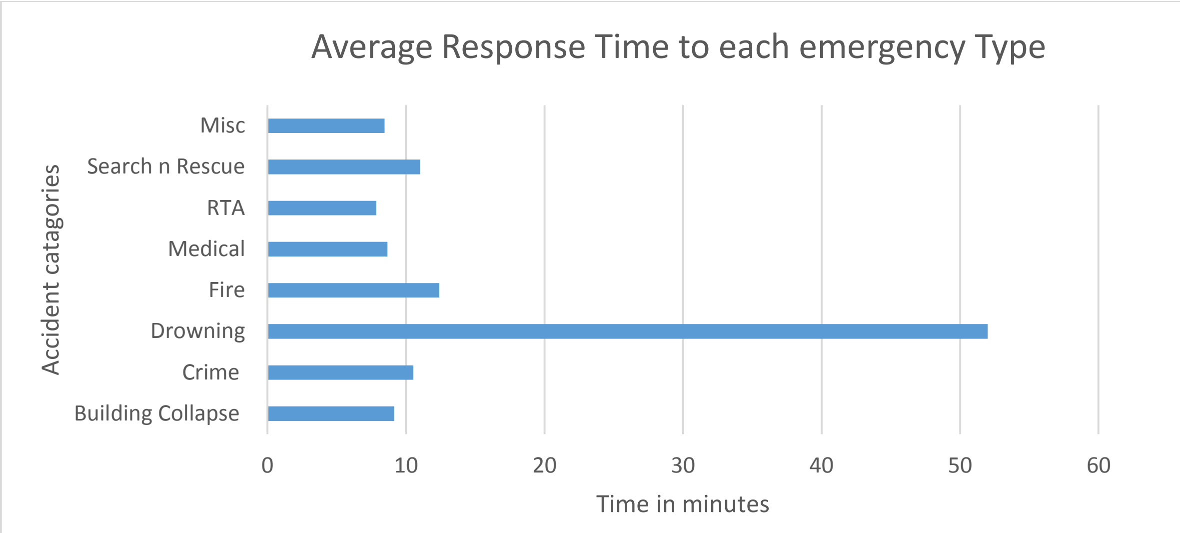


Figure 29: Average response time to each emergency type

We plotted emergencies of three different months in a single graph. Selected months were January, March and July. Because we want to merge all the behaviors of human response against the changing events and seasons, so we went to different months' data. A final plot shows that most of the emergencies categories got 9 minutes or higher response time on average. While drowning type is a special case in above figure, where only 3 emergencies were reported during the selected time in the dataset and such are the rare cases in the area whose dataset is under discussion. Because there is no such place nearby.

Higher response above is also due to the fact the emergency vehicle has to travel a very long distance to provide rescue services. If we include drowning cases than the average response time for selected dataset is 14 minutes and 12 seconds. But, if we exclude these cases just because they are rare one and were also out of the response area, then the final response time on average is 9 minutes and 29 seconds for the dataset.

Dataset									
	Building Collapse	Crime	Drowning	Fire	Medical	RTA	SOR	Misc	Total
No of cases	14	74	3	47	902	538	9	185	**1772**
Average Response	0:09:09	0:10:32	0:52:00	0:12:24	0:08:39	0:07:50	0:11:00	0:08:27	**0:14:12**
Average Response	0:09:09	0:10:32		0:12:24	0:08:39	0:07:50	0:11:00	0:08:27	**0:09:29**

Table 2: Dataset stats for rescue 1122

Above statistics prove that the selected area is a small town for rescue response services. Conditions are very ideal for rescue 1122 because of small town and almost zero staff to population ration issues.

We have selected this area because, firstly, if we remain successful to gain even a single minute faster response time here than it will be a sure success for more densely populated areas and cities. Secondly, here only it's a challenge to improve response time because of less route alternative options available. This though makes the conditions more though, but also made it easy to simulate the same reported cases on our system over GIS routing without disturbing to actual rescue activities. More closer to real results are expected.

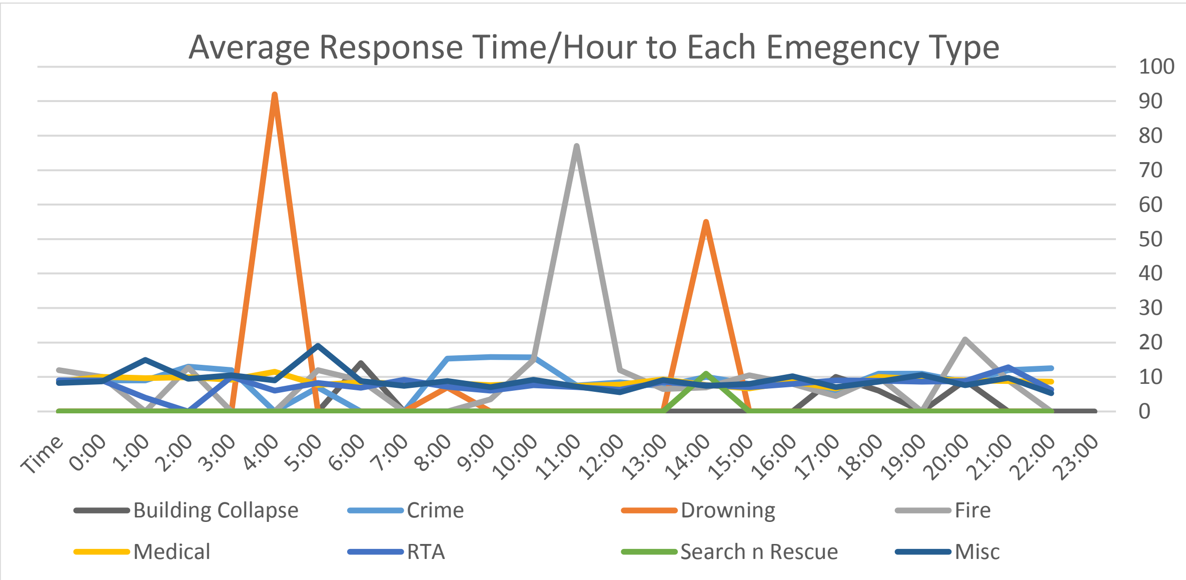


Figure 30: Hourly based average response time to each emergency category

When we divided whole dataset into hourly based timespans we found that there is almost similar response time in different events and environments. There is no big or noticeable change, other than the drowning cases, in the plotted response time. Which also confirms the professionalism and world standards maintained by the rescue 1122 department.

6.1 Categorical Response Time

If we study the current system's response time in details against all categories, then we found some results as:

6.1.1 Building Collapse

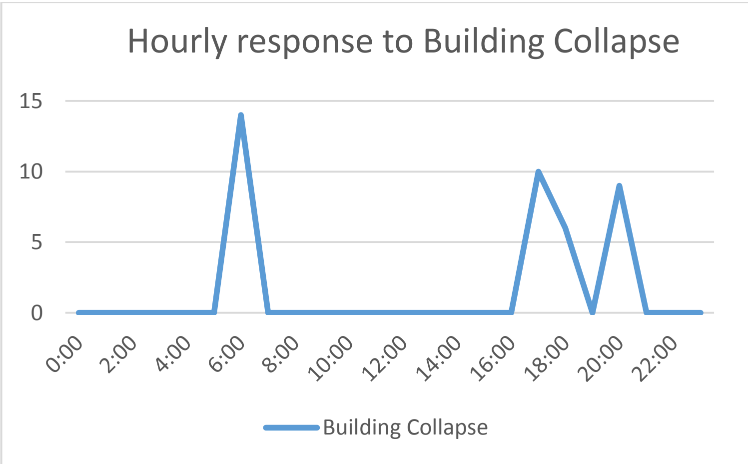


Figure 31: Current system building collapse response time

Total 14 cases were reported during the selected time. Their average response time was 09 minutes and 09 seconds. Longest response time was taken during the 0500 to 0800 hours.

6.1.2 Crime

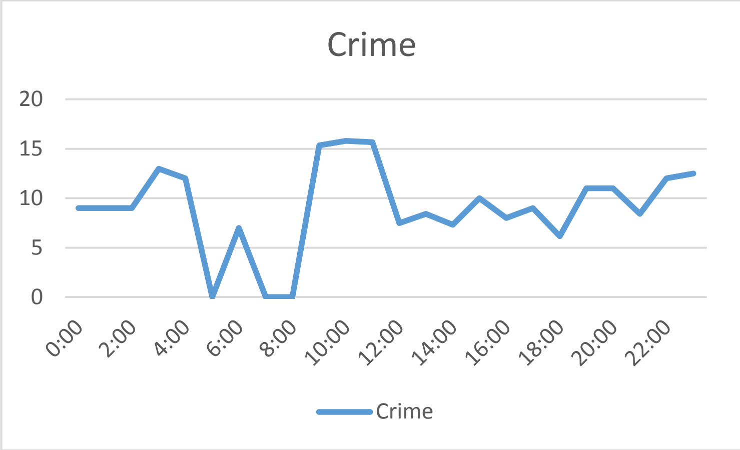


Figure 32: Current system crime response time

Total 74 cases were reported during the selected time. Their average response time was 10 minutes and 32 seconds for this category. Longest response time was taken during the 0800 to 1200 hours.

6.1.3 Drowning

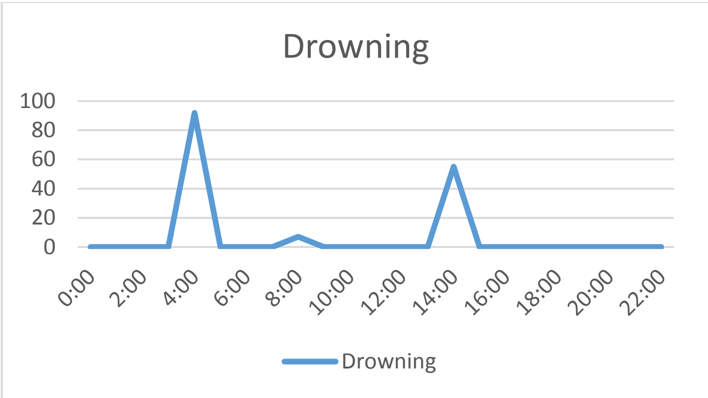


Figure 33: Current system drowning response time

Total three cases were reported during the selected time. These three cases were outside the response areas of the rescue department. But, they rescued the victims. They travelled a long way up to the height so that's why their average response time touched to 52 minutes. Because these are the rare cases so, we are not including this category for later comparison with our response times.

6.1.4 Fire:

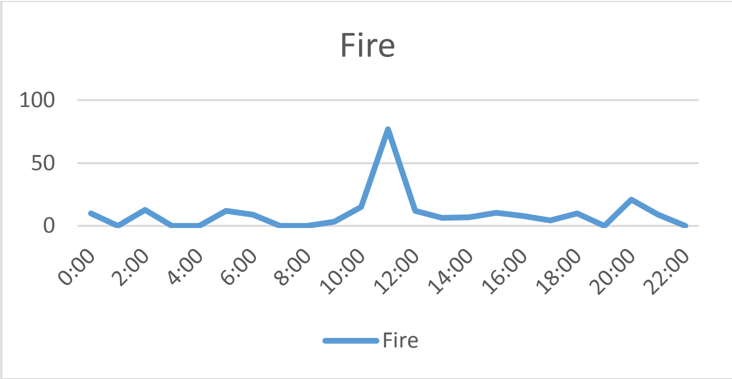


Figure 34: Current system fire response time

Total 47 cases were reported during the selected time. Average response time for this category remained 12 minutes and 24 seconds. Peak time was during 1000 to 1300 hours.

6.1.5 Medical

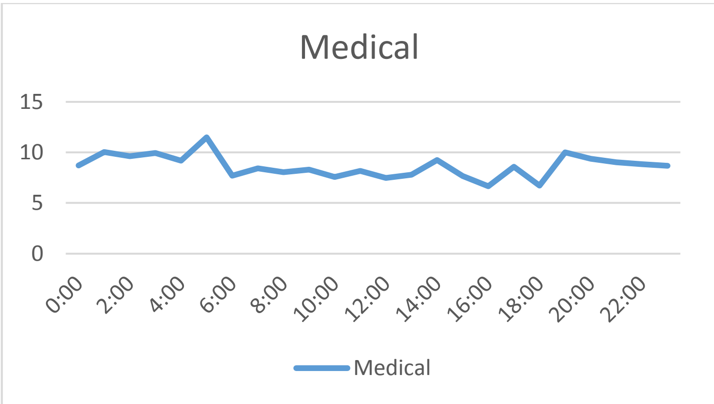


Figure 35: Current system medical response time

Most number of cases were reported in this category which are 902 total in numbers. The average response time is 08 minutes and 39 seconds. While peak hours for response time remained between 0400 to 0600 hours.

6.1.6 Road Traffic Accident (RTA)

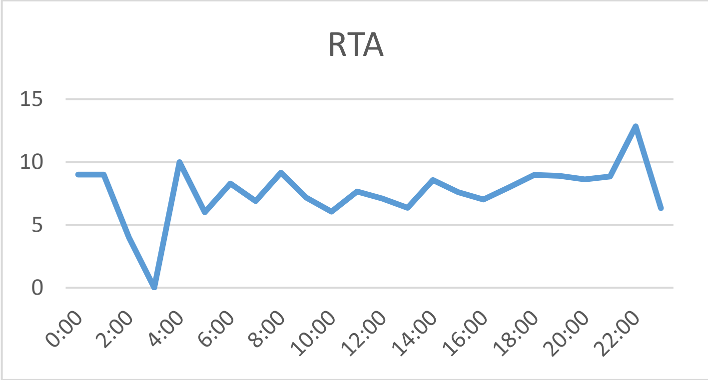


Figure 36: Current system RTA response time

This category has second most reported cases. Total 503 cases were reported. The average response time is 07 minutes and 50 seconds. While peak hours for response time remained between 2100 to 2200 hours.

6.1.7 Search and Rescue Operation (SRO)

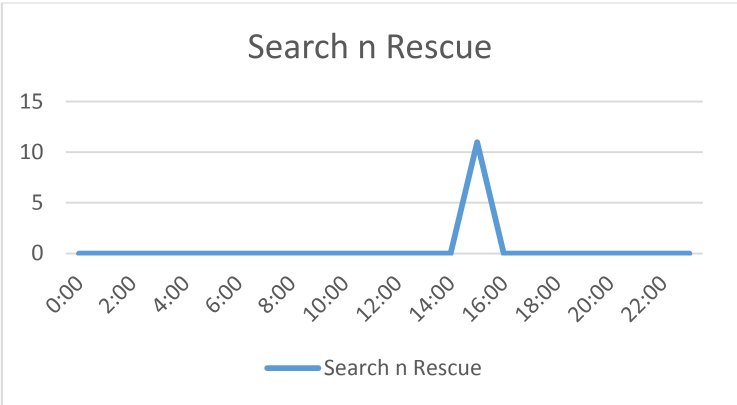


Figure 37: Current system SRO response time

Only single case was reported was selected dataset where 11 minutes and 13 seconds were consumed.

6.1.8 Misc

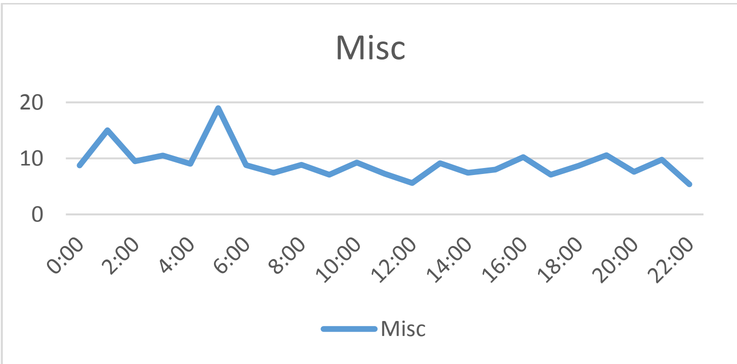


Figure 38: Current system Misc response time

Total 185 cases fell in this category. Average response time was 08 minutes and 27 seconds. While peak response hours remained between 0400 to 0600 hours.

6.2 Summary

In this chapter we presented the response time for the current system of rescue 1122. We mapped the original response time for three different months. Then we categorized the record emergencies. We discussed the repose time on average for each category, for the overall system. Later we represented in figures for each category against hourly based timespan.

Through these we tried to map the behavior of response department against different hours and seasons.

CHAPTER 7

7 RESULTS AND DISCUSSION

After simulating our system for 4 weeks simultaneously with the rescue activities happened in 1122 at daily bases, we have found some noticeable improvements in the all departments and categories of emergencies. We simulated same rescue activity over the same selected route from the populated route alternatives. Most of the time we saved was due to quick decisions and early warning generated from call agent to rescue response department. In most of the times our system produced better route and provided early alternative routing options to the vehicles.

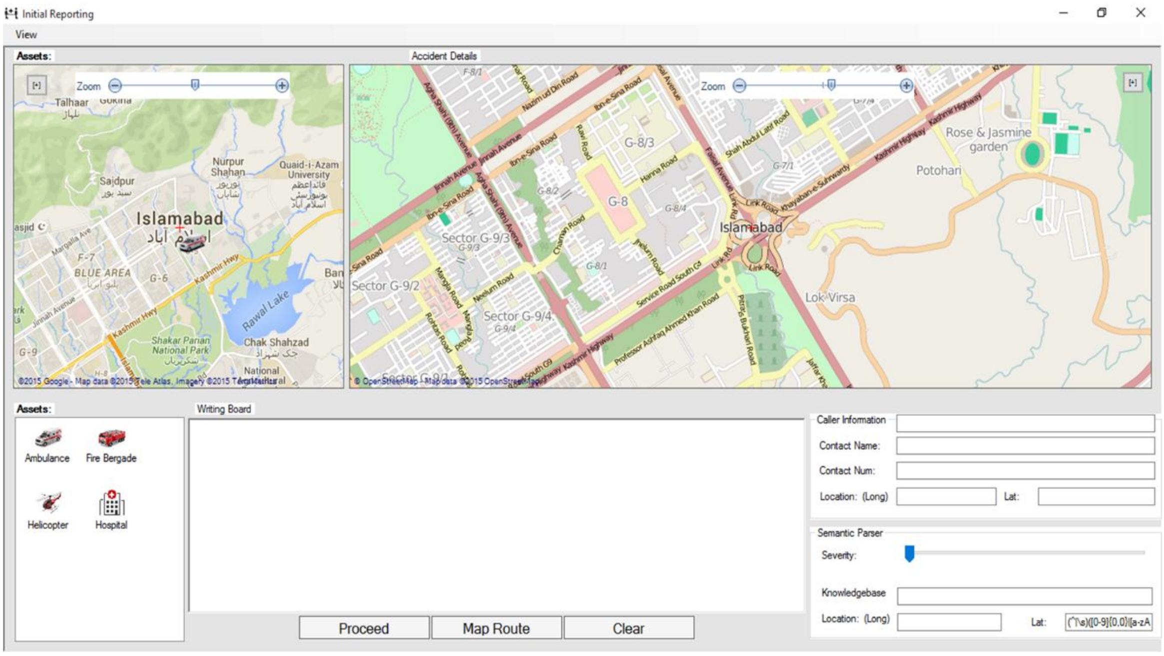


Figure 39: Rescue Decision Support System Interface

For the simulated duration our dataset statistic shows that we have simulated almost all types of emergencies except the drowning cases. There were zero drowning cases reported during the simulation. So we have produced our results without drowning emergencies. Still our system shows handsome amount of improvement. The average response time came down from 8 minutes and 54 seconds to 7 minutes 15 seconds.

Dataset									
	Building Collapse	**Crime**	**Drowning**	**Fire**	**Medical**	**RTA**	**SRO**	**Misc**	**Total**
No of cases	*9*	*22*		*22*	*330*	*162*	*1*	*64*	***610***
Avg ponse rescue	*0:09:07*	*0:09:00*		*0:09:19*	*0:08:39*	*0:07:54*	*0:11:00*	*0:07:19*	***0:08:54***
Avg sponse RDSS	*0:05:47*	*0:07:28*		*0:05:58*	*0:07:02*	*0:06:42*	*0:12:13*	*0:05:37*	***0:07:15***

After comparing the both datasets, one produced by the rescue's system and other produced in the semantical decision support system after simulating same rescue activities, we have found the following results.

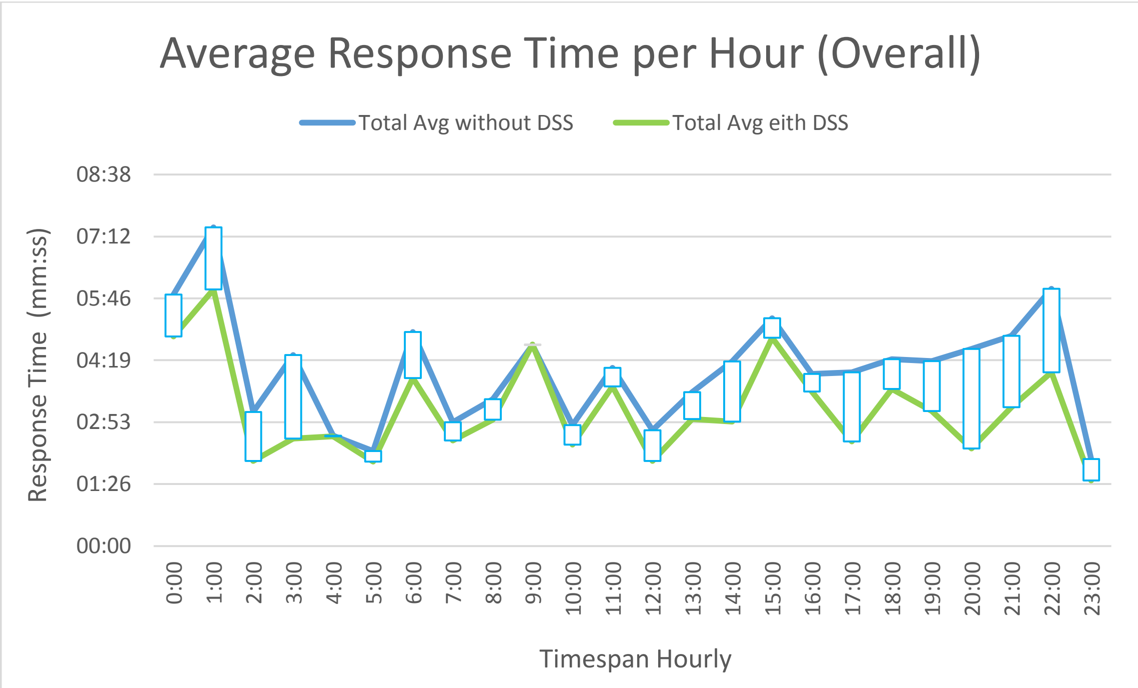


Figure 40: Average response time per hour (both systems)

Hourly based results indicate the improvement during all 24 hours. Green line in figure 16 shows the results from the semantical decision support system while blue line is the ordinal response time for the rescue department. Our system improved the response in almost all hours. While at 0500, 0900 and 1500 hours our response and the response from the rescue department is similar. There are two reasons behind this, one, the reported calls during these hours for the selected period of simulation, were less in numbers and secondly, these activities were carried out exactly the same route to the point of accident as originally selected by the rescue department. Which results the same response time.

While from 1600 hours to 2200 hours there is a significant amount of improvement in response time. The reason behind this behavior was due to the high number of emergency calls and most of these emergencies lies in the area of which our system got major training like in medical and RTA category. Our training set has 1440 similar category training examples present in the dataset of total 1764 accidents for training.

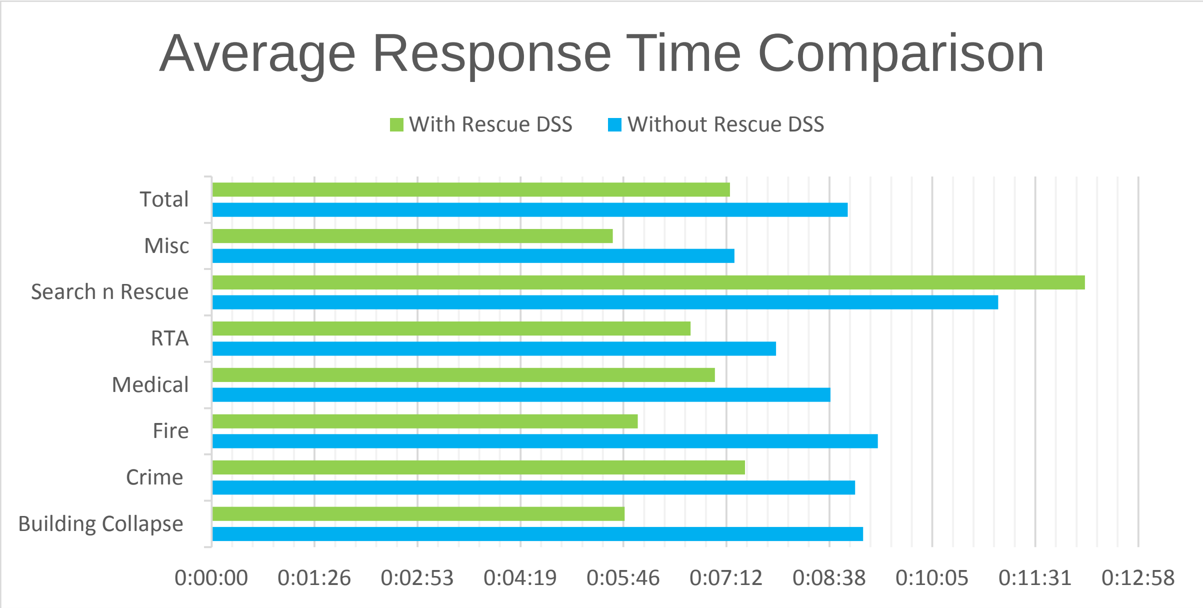


Figure 41: Average response time comparison

Average response time from both systems shows the improvement in all categories in green color except in the Search and Rescue operations (SRO). That's because there were very few examples to train the model for such accidents. Only 9 examples out of the dataset of 1764 accidents were not enough to produce good results. The rest of the categories showing some or lot of improvement. Improvement in the area where conditions are almost ideal for rescue department to operate, is a noticeable achievement.

As we already know the rescue department is maintaining high levels to keep synchronized the response time in all seasons, our system's results for four weeks' simulation will carry out almost similar differences in response time throughout. We are not expecting any major change in any particular season, event or environment for all 365 days of the year.

7.1 Categorical Response Time Comparison:

When we compare each accident type's response time improvement separately, we find out results as:

7.1.1 Building collapse:

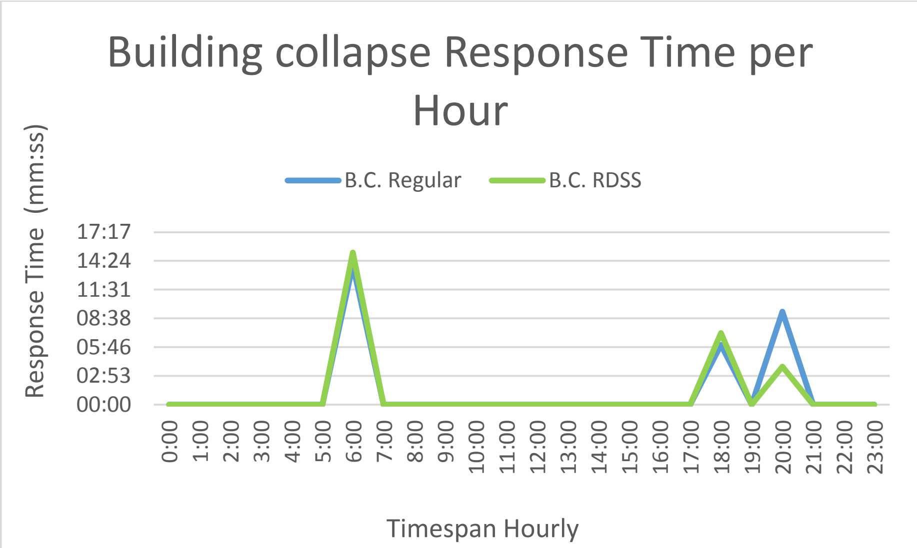


Figure 42: Response time comparison for building collapse category after DSS

The blue line in the above figure is for the response time got from the dataset without rescue DSS simulations and while green line maps the results simulated in rescue DSS. There were total 09 cases for this category. Average response time for rescue department was 00:09:27 while our system shows 00:05:47.

Finding shows that most of the time response time for the both systems was simultaneous, except at the 1200 to 1900 hours where rescue DSS consumed more time than the rescue's system. That's because simulated map shows the reach time was more than actually time taken to reach at the accident place. Second noticeable change is at 1900 to 2100 hours where our system shows the improvement. This improvement was because there were a noticeable number of cases during these ours. Which allow our system to adopt the condition and has more training for these hours.

7.1.2 Crime

There are total 22 cases in this category during the experimental time. Average response time from rescue department for this category was 09 minutes and 00 seconds. While our system improves it to 07 minutes and 47 seconds.

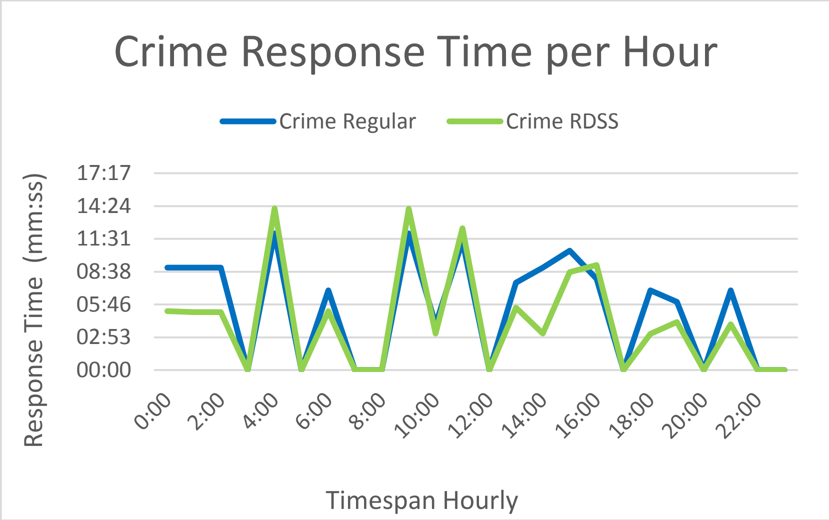


Figure 43: Response time comparison for Crime category after DSS

Here after plotting both response times from rescue department and from our system. There is mostly a close call for both response times except at the 0000 hours to 0200 hours and 1300 hours to 1500 hours. Where our system shows better response time or improvement in response time. To analyze the results better here we placed data trending line over average of response time at each hour. Then we find out that at all hours our system did improve the response time.

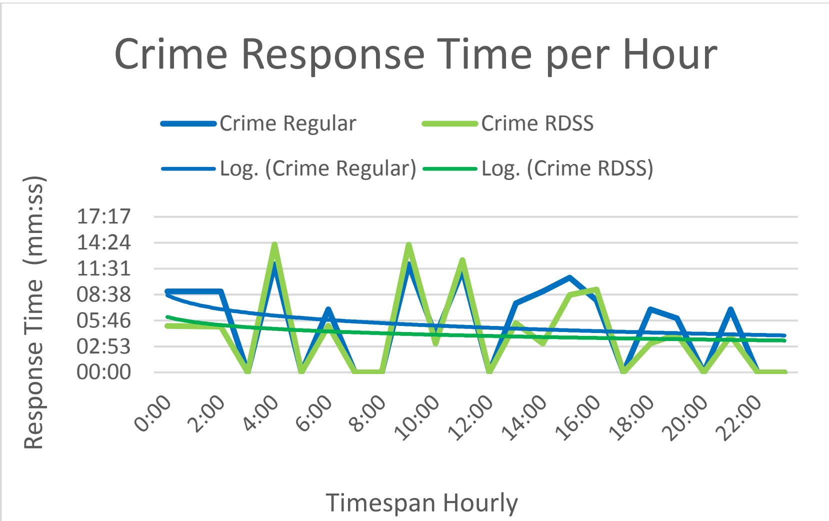


Figure 44: Response time comparison with data trend line for Crime category after DSS

7.1.3 Fire

There are total 22 cases in this category during the experimental time. Average response time from rescue department for this category was 09 minutes and 19 seconds. While our system improves it to 05 minutes and 58 seconds.

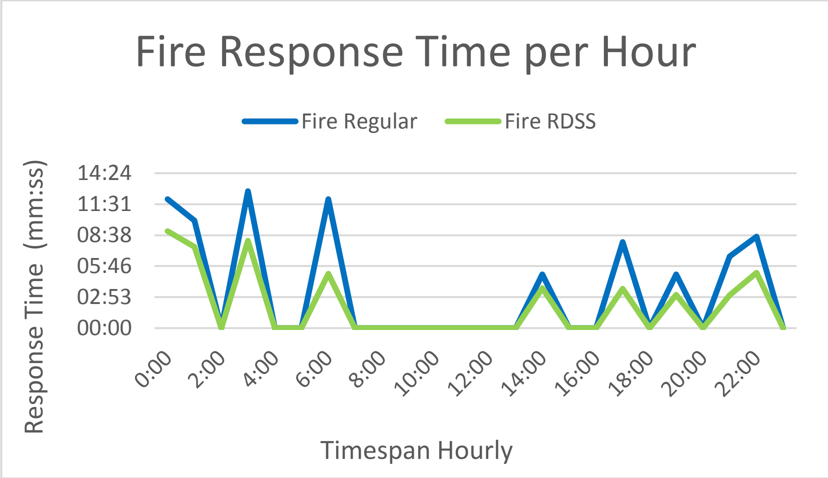


Figure 45: Response time comparison for fire category after DSS

On almost all reported hours our system shows the improvement. There is very clear difference between both plotting.

7.1.4 Medical

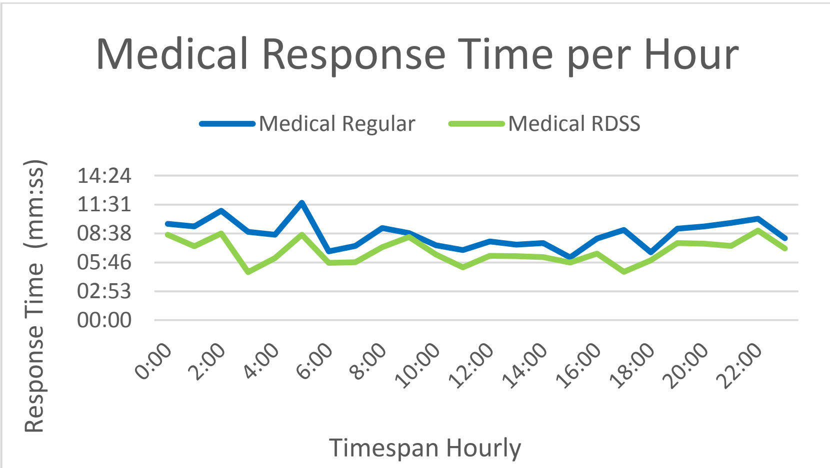


Figure 46: Response time comparison for medical category after DSS

There are total 330 cases in this category during the experimental time. Average response time from rescue department for this category was 08 minutes and 39 seconds. While our system improves it to 07 minutes and 02 seconds. There remains a clear improvement during all hours expect at the 0900 hours where both system shows similar response time.

7.1.5 Road traffic accident (RTA)

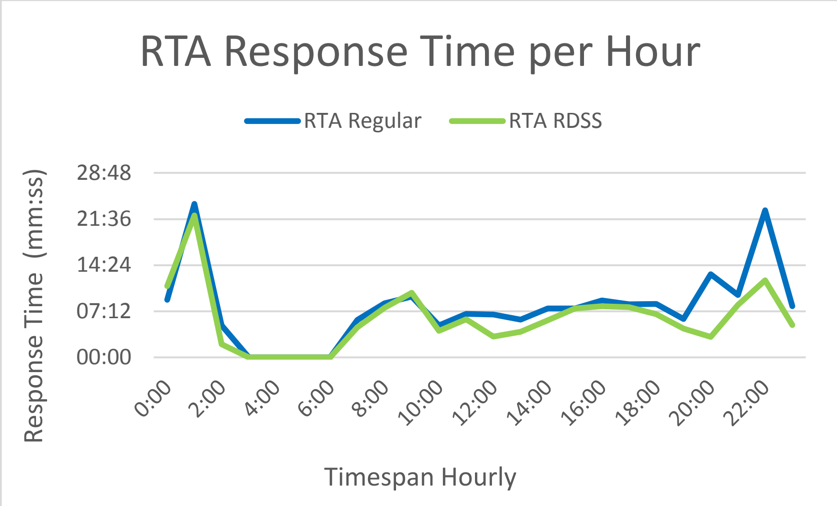


Figure 47: Response time comparison for RTA category after DSS

There are total 162 cases in this category during the experimental time. Average response time from rescue department for this category was 07 minutes and 54 seconds. While our system improves it to 06 minutes and 42 seconds. In this category there remain almost similar response times most of the time with little or, at 0800 hours, no improvement. But, from 1900 hours to 2100 hours there shows a big improvement in response time with rescue DSS.

7.1.6 Search and rescue operation (SRO)

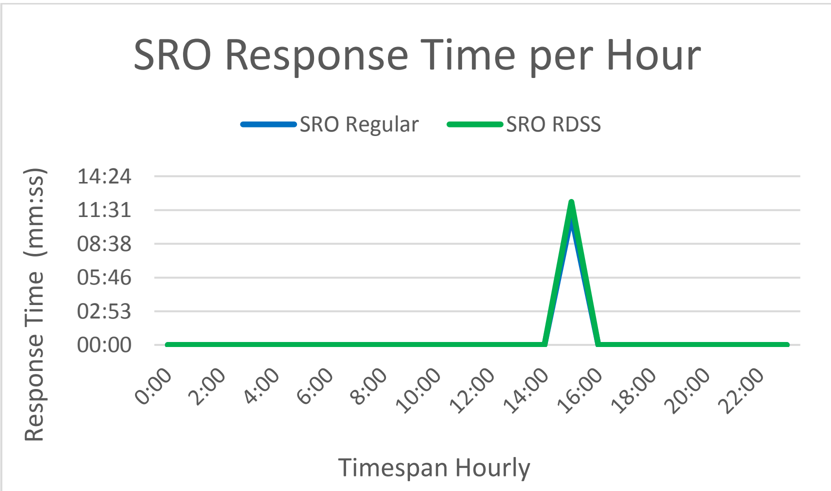


Figure 48: Response time comparison for SRO category after DSS

For this category there was only a single case reported during the experimental time. Response time from rescue department was 00:11:00 while our system took longer to respond to this category. Our system spend 12 minutes and 13 seconds for this category.

Reason behind this was due to lack of training for such incidents. Coincidentally, there was only single a case for training the kernel for such category and single case to respond to. Lack of training cause delay in response for search and rescue operations.

7.1.7 Misc

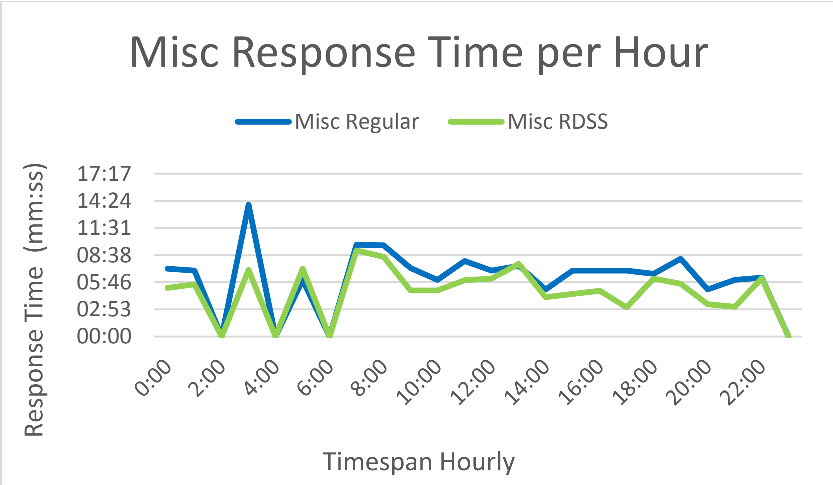


Figure 49: Response time comparison for Misc category after DSS

There are total 64 cases for this category during the experimental time. Average response time from rescue department for this category was 07 minutes and 19 seconds. While our system improves it to 05 minutes and 37 seconds.

In this category, there remain a clear difference between rescue department's response time and our system's response time. While at 0500 hours our system took more time to respond. While at 0700 hours, 1300 hours, 1800 hours and 2100 hours both systems responded on similar time.

7.2 Summary

In this chapter we have presented the original results from the actual emergences happened in rescue department. Those emergencies first reported in the rescue department, then simulated at our system. Then the response time of both system is recorded. Final graphical representation for both system's response time is shown in a figure. While we also compared every category's response time with our system's repose time separately as well.

CHAPTER 8

8 SUMMARY AND CONCLUSIONS

8.1 Summary of Thesis

As the enterprise decision support system for active environment, our selected active environment was rescue 1122 department. With the detailed study of rescue system we found that they are doing quite a professional work, but there were few areas of improvement available. Then we draw critical analysis and try to point out major reasons for delay in response. There, from our finding, major point remains the repetition of work, delay in orientation and difference in experience remained the major reasons for delay. One other critical point is that, there is no GIS based routing system to lead any rescue vehicle to the accident.

As the solution of above mention problems we have prototyped a full system where we implemented our proposed framework for decision support system practically. In our prototype, we replaced main reporting interface from form filling style to plain reporting style using the English language. We also incorporated loosely grammatical sentences. With the help of the NLP API from Stanford we have successfully parsed all types of writing style locally being practiced in Pakistan community. Then we extracted required information out of the written string like contact number, location address and accident type with details. Machine learning algorithms are applied to create decision alternatives. On the later part communicator module is assigned the duty to communicate the decision taken to all nodes/assets selected for any rescue activity and keep them centrally integrated throughout the operation.

We have practically simulated our prototype with original system and then compared both systems' results to figure out the areas with improvement and without any improvements.

Detailed technical description of a decision support framework, its components and algorithms is provided under the chapter on implementation. Where, detailed problem solution, possible algorithms with the support of simple English language description or graphics is presented.

8.2 Conclusions Drawn

This research work concludes that there is a clear space for improvement in the rescue's current system. As we proposed, replacement of their current system with semantics enabled and NLP based system is the solution for their problems. The GIS based routing system is one of the primary areas of improvement. While, semantics revolutionized the system and its response time. Inclusion of CoreNLP from Stanford enables the system to accommodate the badly structures sentences.

Adaptability of proposed system breaks the bounded environment of rescue where local to the area officers are preferred. It also enables all rescue department to utilize or spread their experiences across the country to enhance the professionalism throughout. Otherwise, currently, their offices are not as effective to the outside of the specific/local area as they meant to be.

The results section shows the improvements in all departments, while situation awareness in enhanced due to common operating picture and GIS based location tagging.

With the application of this prototype in the working field, this will not only enhance the response time with a big difference, but also will create situation awareness to all levels. Integration of assets with a GIS based system will enable authorities to better manage their assets to peak of it utilizations. Command and control in overall operation, during operation and throughout in all conditions, will be increased.

8.3 Future Work

As for future possibilities with this system concerns, there are a few possibilities. This system can be converted to parse Urdu language to perform the same actions. Which will make this system way more adaptive and supportive to the rescue department as Urdu is the native language of Pakistan society. Integration of Urdu language is very much possible as the center for language engineering (CLS) is already doing very considerable work in developing Urdu parsing libraries. The combination of those libraries with this system can ease the life of rescue department.

Another possibility is to integrate this system with speech to text technologies. Speech to Text technologies are getting very mature with different ancients and also adoptive to different pitches. Recent work in this domain from Microsoft in their Cortana project and google in their google speech search projects are enabling new possibilities in these domains.

So, the integration of this domain with proposed system will enable rescue department to enhance its response time, even more can be achieved by enabling direct calibration of caller and decision support system. Parse calls to the system and make intelligent detection over fake and actual calls.

A third possibility is to integrate this system with hospitals of the locality. Simply write few services for this system where hospitals get connected. Hospitals will record their activities through their system and synch all required information with the rescue's decision support system. Through this mechanism two sharing will can be enabled where, hospitals will share their present medical staff and faculties with rescue system and rescue system will let the hospital know if some emergency is coming to them so they will remain ready to handle that. This will also help to save lives of many by taking advance steps.

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