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A GIS framework for improving the harbor security

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Abstract

This paper reports a research using GIS prototype for improving harbor security. Three types of systems cited as major tools in preventing terrorist attacks are critically examined here: First, a spatial coordinated sensor network for security monitoring and emergency responses, Second, distributed information management for data compression and knowledge discovery, and Third, the discrete simulation of plume evolution by incorporating real time climate and geophysical data. The monitoring system allows controlling the motion of sensors (e.g. camera) via internet by selecting a geo-spatial location of the target from a GIS map. A central temporal database was managed to maintain real-time ship tracking records from different remote areas with a data compression. These archived historic data can be used to analyze required knowledge to infer about possible terrorist's actions. Simulation of plume evolution was developed using cellular automata approach to assess the impacts of a disasters in coastal environment.

Keywords: Harbor security, Homeland security, Emergency response, plume simulation, sensors, data compression, knowledge discovery, ship tracking, shortest-path, network analysis.

1. Introduction

Homeland Security is a concept that has gained appreciable amelioration in recent years. The havoc wreaked by natural disasters such as earthquakes, hurricanes and flood, and the chilling consequences of chemical and nuclear reactor accidents and terrorists actions like involving weapons of mass destructions have starkly illustrated the inadequacy of pre- and post disaster government planning and action. The past events have demonstrated that the possibility of mass destruction resulting from natural and technological disasters is real and cannot be ignored at the local, national and international levels (White and Haas 1975, Hewitt 1997, Mileti 1999, Alexander 2000). As an outcome, a decisive discrete analysis, identified to make GIS and other related geospatial technologies easier to use for urban security (Nyerges et al. 1995, Neal et al. 1998, Mark et al. 1999, Slocum et al. 2001, Muntz et al. 2003). Several prototype designs of urban vulnerability have been proposed to address the natural and technical hazard impacts (Burton et al. 1978, Mitchell et al. 1989). In response to this need to predict damage and analyze consequences from natural and technological disasters in the harbor area, the University of Massachusetts, Boston and Navsea Newport, Naval Undersea Warfare Center, Rhode Island has created a GIS framework for improving the Boston harbor security and to develop the research on natural interfaces to computer systems. GIS prototype is the critical toolset for harbor security and to develop the research on natural interfaces to computer systems. GIS is the crucial technology currently being used for homeland security purposes since it employs a suite of hazard, casualty and damage estimation modules to estimate and analyze effects due to natural phenomena, technological phenomena, and terrorist incidents and industrial incidents and also depicts geographical areas of damage, probabilities and number of fatalities and injuries, and mitigates resource allocation.

Border of the nation, one among place where the greatest threats and vulnerabilities lay for natural, technological and terrorist's disasters. Harbor security is a pivotal function in protecting the environment from terrorists and their instruments of destruction. This research uses a framework to assist the decision makers in understanding the complex structure of the harbor. Harbor security is an important component of the overall homeland security effort. This effort can be seen as preventative measure launched outside the nation – for instance, preventing terrorist actions and their weapon destruction before they enter the nation. Another effort is protecting the critical infrastructure of the border of the nation; the next measure is the harbor transportation security management, which ends with the emergency preparedness and response. Further, Harbor security defends the catastrophic terrorism in the increasing integration of economy, developing society and towns and hence harbor area is commonly addressed as 'border regions'.

Every aspect of homeland security can be analyzed through the use of geo-spatial technology. In the past, most of the research using geo-spatial technology for homeland security is post event analysis or prevention analysis against natural or technical disasters.

The potential feature of GIS Framework for Improving Harbor Security (GFIHS) is Real-time analysis that aims at facilitating quick emergency response to terrorist attack as well as natural disaster situations. The use of real-time and embedded technologies of GFIHS is that it meets particular disaster situation requirements, up-to-date performance, speed and scalability in emergency responses, reliability in knowledge management, security, or other assessments of real-time and embedded technologies for particular application domains, mining of architectural and design patterns from applications, and technology transition patterns of the harbor.

In this paper, we outline system architecture and a network data model that integrates the ship tracking system in the harbor with the internal conduits within multi-level structures into a navigable simulation model in the system GIS prototype. The challenges of this prototype fall into classes. First, a new innovation for protection, response and recovery. Second, they are designed to identify and reduce the vulnerabilities of harbor facilities and infrastructure of the ships in seaports. Third, they try to seal the gaps in international supply chains, points where terrorists, their supplies, or their weapons could enter shipping channels. Fourth, it attempts to secure the ships flowing through caution/restricted area near the Harbor. Fifth, they enhance the awareness of the entire Harbor domain and include the technology upgrading to accomplish the real-time needs. Ultimately, getting Harbor security right is not only constructing barricades to fend off terrorists, but also taking necessary steps to the entire harbor to remain a prosperous, secured and globally engaged spot. We examine critical important issues of GFIHS, especially the need of new developing technology in GIS like wireless, peer-peer system and mobile deployment. Geospatial coordinated sensors networks and corresponding algorithms required for scientific and management support are also explored in GFIHS with the particular reference to the application of network based functionalities. Finally, we present the results of an experimental implementation of this GIS framework in the Boston Harbor. In addition, we evaluate the benefits of using such prototype and conclude that GFIHS have convincing potential for improving the speed of emergency response after the terrorist attack by predicting damage and analyzing consequences from past natural and technological disasters and serves as important tool of prevention and protection for the infrastructure by inferring the potential targets of the terrorist attacks on multi level structure in Boston Harbor to save lives and minimize the amount of damage inflicted by an attack.

2. Role of GIS Technology in Harbor Security

The effects of the disasters must be displayed pictorially on geo-referenced maps, photographs, satellite images, etc. to determine their spatial and temporal extents. The consequence of the projected disaster must be calculated (affected persons, land and buildings), and amount of necessary relief must be determined to ensure adequate contingency planning and post-disaster assistance. The system must reside on computers small enough to be practical, yet powerful enough to supply expedition's results when disaster strikes in the harbor. The technology infrastructure brings new variety of applications to emergency management. The technology not only involves powerful computers, Portable devices like PDAs, digital telephones, satellite imaging and sensors,

networks, both peer-peer and wireless applications but also current program applications, modeling software, and tele-communication warning system and support a variety of emergency management functions. Technology for tracking ship motion and real-time communication with the ships in the harbor allows for more effective preparedness activities including sheltering, evacuation, rescue operation, and damage assessment in disaster situations.

Although not as widely recognized by the general public, GIS is the crucial technology currently being used in data management for knowledge discovery. The national Science foundation defines GIS as “a computerized database management system for the capture, storage, retrieval, analysis, and display of spatial data.” GIS provides decision-makers with the data they need to properly address threats such as Terrorist attacks and natural or technological disasters. GIS enables its users to view the importance of potential terrorist’s targets and vulnerable lay.

This GFIHS addresses several important aspect of Harbor Security through the use of GIS. It possesses detection capabilities that allow users to perform accurate threat assessment so that likely target scenarios that can be properly identified and anticipated. Because of its ability to collect all the past disaster data and to identify possible patterns regarding security threats and potential terrorist attacks, GIS serves as an important tool for prevention and protection. The collection of data related to harbor infrastructure is a valuable tool for harbor security. GIS applications support this purpose as they can better prepare emergency workers and law enforcement personnel to deal with detection, prevention, protection, preparedness, and response and recovery in disaster situations.

3. System Architecture of GFIHS

The system is based on three-layer architecture: the a spatial sensor network layer for tracking ship motion and communication, the information management layer for knowledge discovery and analysis, and finally the Discrete simulation layer for visualize and analyze the spatial distribution of real time spills/toxic gas releases (see figure 1).

The spatial sensor network layer illustrates the integration of GIS application with Automatic Identification System (AIS) technology for tracking and communicating the real-time ship motion with the structure of multi-level route system to show the change of possible trajectories. Another layer is the information management layer: here, we collect the functionalities provided by the underlying GIS to support high-level spatial and temporal reasoning. As depicted in figure 1, and already pointed out in the previous section, the information management layer provides two different mechanisms that can coexist in an application. These mechanisms, which offer two different ways to access and handle the spatial data contained in a GIS, are called Data compression and Knowledge Discovery to GIS. Each mechanism is characterized by abstraction levels to provide the user with a more abstract and friendly set of operations and to make the system more independent from the data source. The first mechanism uses built-in predicates to directly invoke GIS functions, which allow one to manage the data stored in

the GIS (Raffaeta` and Renso 2000). The second mechanism translates spatial data from vector format into constraint database format (Mancarella et al. 2000). A detailed description of the two mechanisms is given in Sections 3.1 and 3.2, respectively. By using the first mechanism, we exploit the efficiency and amount of the data provided by GIS, but the spatial objects are treated as simple identifiers, and it is not possible to access their spatial extent and internal representation. The second mechanism can be exploited to obtain a logical representation of historical events, which, depending on the applications, can be needed to perform a more detailed analysis of the spatial objects at hand. Of course, such a larger expressivity has an impact on efficiency. It is worth noting that these two mechanisms have complementary benefits and drawbacks, and typically, both are useful in an application. On the other hand, when the spatial object has to be analyzed in more detail, or some properties of the events have to be particularly exploited. In the same way, the first mechanism is particularly suitable for data integration, since the translation process converts spatial data from possibly different formats to a uniform representation format. Clearly, the second mechanism explore within the realm of lacks of efficiency, a trade-off between the two methods has to be considered. It is important to note that both approaches exploit the potentialities of the underlying GIS for the visualization such as events, data and knowledge. Finally, the discrete simulation of plume evolution layer pictures the accidental release of chemical spill or toxic gas releases from a storage facility or a chemical transportation ships in the harbor to track the chemical's gas cloud or "plume" in order to determine its potential impact on nearby population centers, real-time weather data collection and dissemination that will be particularly useful for acquiring and conveying knowledge for disaster environment prediction.

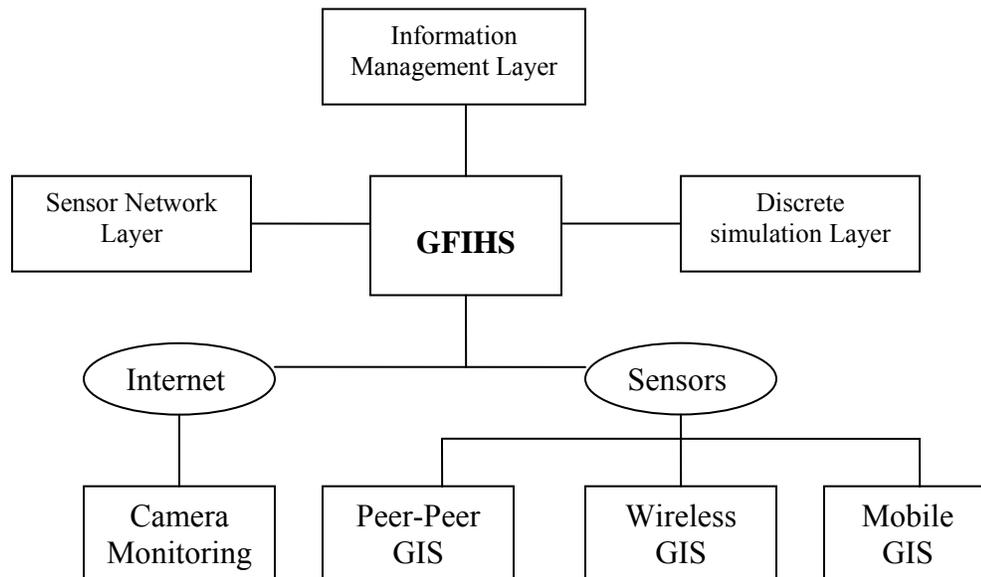


Fig. 1 System Architecture of GFIHS

All the layers of GFIHS are integrated with the latest technology applications using internet and sensors due to the development of the peer – peer, wireless and mobile GIS that have been stimulated by the increasing demand for up-to-date geospatial information. With the rapid development of these technologies, more and more GIS applications have emerged from these GFIHS layers using fields of location-based services, vehicles navigation, and tracking, and mobile mapping. Furthermore, the information management application in our integrated architecture covers both of these forms: direct calls to GIS functions provide an efficient mechanism for macro analysis, whereas the translation of vector data into compressed offers a uniform representation of data and some primitive operations to perform micro query analysis by any GIS users or decision makers. The strategy here is to exploit the efficiency of the GIS as much as possible and to translate data into the internal representation whenever necessary to perform operations that the underlying system does not offer.

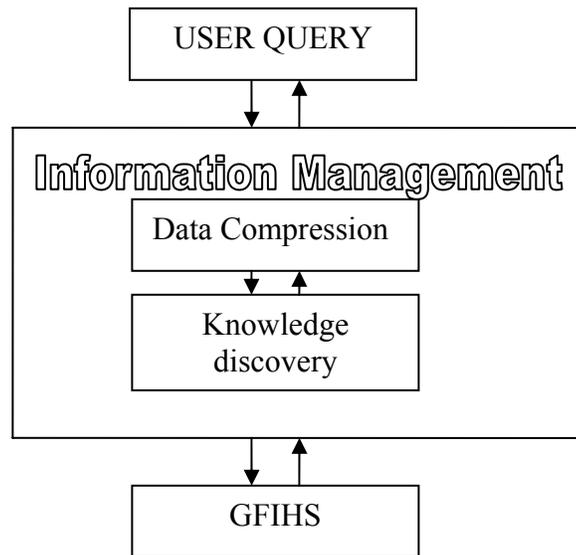


Fig. 2 Schema of Information Management Layer in GFIHS Architecture

3.1 A spatial coordinated sensor network for security monitoring and emergency responses

An important aspect of a GFIHS is a spatial coordinated sensor network for security monitoring and emergency responses, which uses advanced ability to visualize the enormity of the situation and also monitor the entry/exit of the ships in the ocean through internet. Coordinated visualization is a vital component in the harbor security, since it measures the area, judges the potential threats of moving objects by distance between the points in the application. The real-time visualization for security monitoring and emergency responses with spatial coordinated sensor network (e.g., Camera) is

extremely effective in helping strategic security monitoring and in developing complex interrogational routes for the ships and ferries that illustrates the complexities of the conflict. This spatial coordinated sensor network was originally included as an innovative application of advanced sensor technology using internet in transport and security monitoring management. Its real-time harbor monitoring acquires and updates dynamic motion of ships such as route condition and traffic delays. It performs search for optimum routes and provides navigation guidance to the ships in emergency situations and for quickly reaching disaster sites in the Harbor.

3.1.1 Prototype implementation of view shed analysis

A prototype toolkit of GFIHS for security monitoring is designed to serve as a testbed for the hybrid approach. Its implementation is on the basis of the desktop GIS ArcView together with Internet techniques such as Java, CGI and HTML. The server part of the toolkit has been made into an extension, which is similar to other ArcView extensions such as spatial analyst and network analyst. After checking that this extension is on, users just need to choose a Web server and connect it with the V&A (Visualization and Analysis) server, then this visualization server can provide services to camera view through the Internet from desktop GIS ArcView application. The toolkit, Maritime viewshed determines the visibility on a surface from a set of one or more locations based on height, angle of view and direction parameters. It helps in estimating real estate value to locating communicating towers or placing military troops. The viewshed analysis function identifies whether the observation points that are specified on the input observation theme can be seen from each cell in a surface or cell locations can be seen from each observation point (Fisher 1996).

This toolkit builds viewshed for image analysis, and spatial analysis and has strong ties to related efforts in scientific and information visualization more generally (e.g. JPL 1987, Kaufman and Smarr 1993, Treinish 1993) and to exploratory data analysis efforts in statistics (e.g. Cook *et al.* 1997, Carr *et al.* 1998) - see MacEachren and Kraak (1997) for a recent review and bibliography. Our focus here is on the common themes linking various visualization approaches with research activities. Key among these is a view of camera as a process, part mental and part concrete (involving human visual thinking, computer data manipulation, and human computer interaction), in which vast quantities of geo-referenced information are sifted and manipulated in the search for patterns and relationships. From the applications, our focus is on developing an understanding of the application domain and creating a target dataset from the entire harbor area of available data. The acquiring of data through this method of visualization involves both interaction and iteration, that humans repeat analysis steps repeatedly as knowledge is being refined thus our contention is really about knowledge construction rather than Discovery (Fayyad *et al.* 1996)

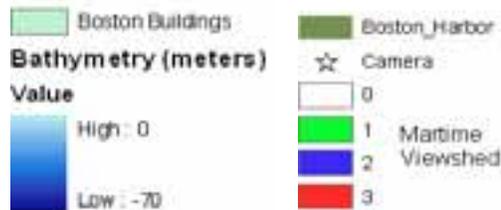
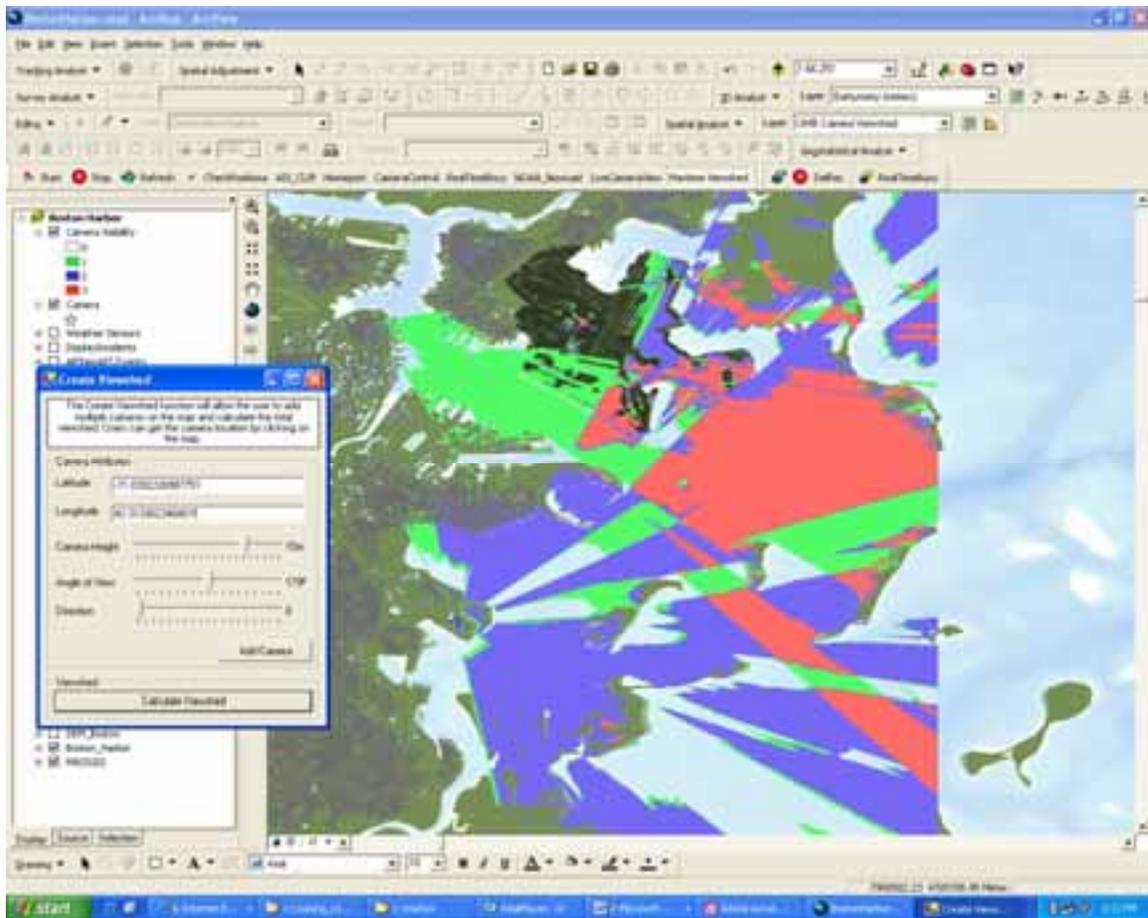


Fig 3. Implementation of maritime viewshed toolkit in prototype for creating the viewshed for analysis of security monitoring sensor (Camera view with maritime functionalities)

3.2 Distributed information management for data compression and knowledge discovery

Another important aspect of a GFHS is Distributed information management for data compression and knowledge discovery, which deals with the Ship communication and tracking data collection and storage in the real-time motion with the route system of the multi-level structures in the ocean to show the possible trajectories of change. Information becomes knowledge when the receiver acknowledges a new understanding (Boisot 1998, Earl 2000, Turban Aronson 2001). GIS provides powerful and flexible facilities for integrating spatial information with spatial reasoning, spatial data mining and knowledge discovery (Leung and Leung 1993). The Automatic Identification S

System (AIS) is a shipboard broadcast system that acts like a transponder, operating in the VHF maritime band, which is capable of handling well over 4,500 reports per minute and updates as often as every two seconds. It uses Self-Organizing Time Division Multiple Access (SOTDMA) technology to meet this high broadcast rate and ensure reliable ship-to-ship operation.

This distributed information management technology pictures a shipboard radar display, with overlaid electronic chart data, that includes a mark for every significant ship within radio range, each as desired with a velocity vector (indicating speed and heading). Each Ship identification could reflect the actual size of the ship, with position to GPS or differential GPS accuracy. By "clicking" on a ship feature in the GIS Desktop ArcMap, it illustrates the ship name, course and speed, classification, call sign, registration number, and other information. Maneuvering information, closest point of approach (CPA), time to closest point of approach (TCPA) and other navigation information are more accurate and timelier than information available from an automatic radar plotting aid. Display information previously available only to modern Vessel Traffic Service operations centers could now be available to every AIS-equipped ship. This information helps to call any ship over VHF radiotelephone by name, rather than by some other imprecise means. Further, it helps to dial it up directly using GMDSS equipment or to send short safety-related email messages to the ship, or receive from it.

The information broadcast includes unique referenceable identification; Navigation status; Rate of each turn - right or left, 0 to 720 degrees per minute (input from rate-of-turn indicator); Speed over ground; Position accuracy using radar indication; Longitude and Latitude (to 1/10000 minute); Course over ground - relative to true north to 1/10th degree; True Heading degrees and Time stamp (universal to nearest second). In addition, every 6 minutes the AIS unit broadcasts unique referenceable identification number which is related to ship's construction; international radio call sign assigned to vessel, often used on voice radio; Name and type of ship/cargo; Dimensions of ship (nearest meter); Location on ship where reference point for position reports is located; Type of position fixing device; Draught of ship (1/10 meter to 25.5 meters); Destination and its Estimated time of Arrival. (Source: See US Coast Guard Navigation Center).

All the data broadcasted has been collected and stored in the database. It is impossible to store all the data from the ships every time in the local database. The Distributed information management for data compression and knowledge discovery aspect of GFIHS is therefore responsible for several important functions with respect to the real-time critical data collection from the ship motion and compress the data for mining to predict the reason for the post disaster measures. Data Compression is important because it helps reduce the consumption of expensive resources, such as disk space or connection bandwidth. However, compression requires information processing power, which can also be expensive. The design of data compression schemes therefore involves trade-offs between various factors including compression capability, any amount of introduced distortion, computational resource requirements, and often other considerations as well.

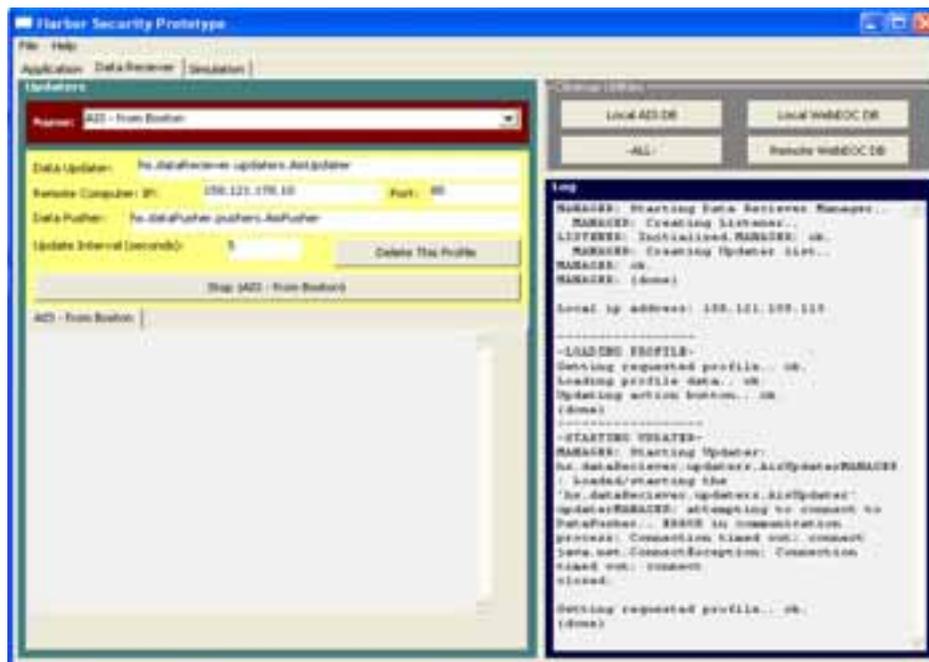
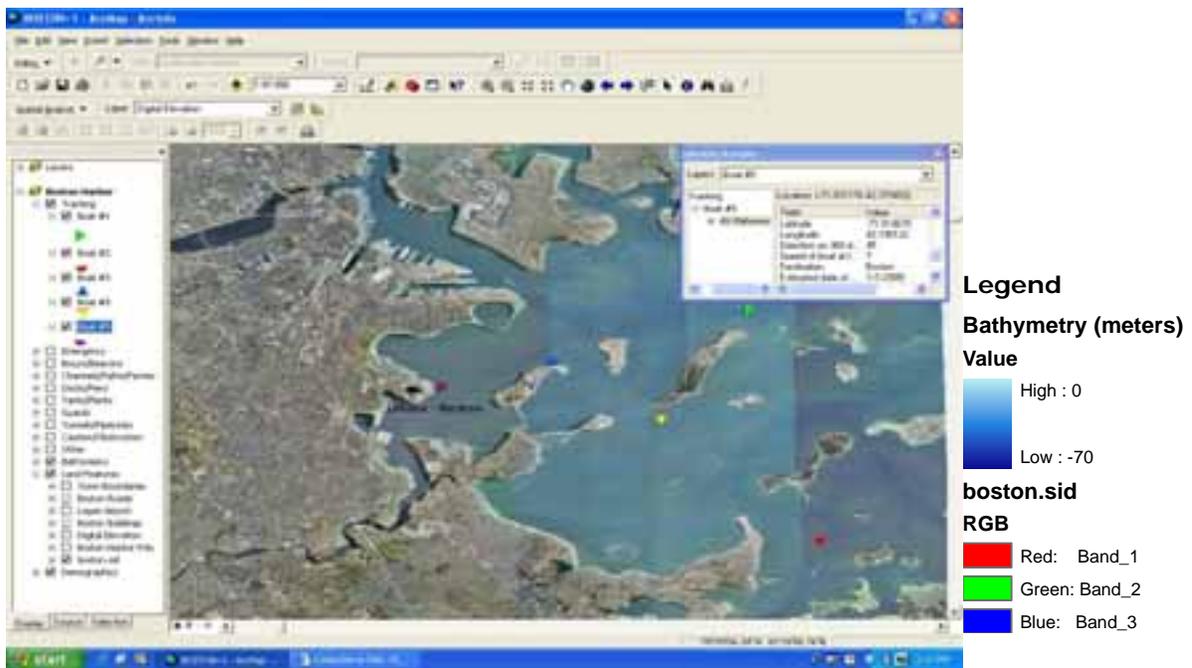


Fig 4. Ship communication and tracking data collection and storage in the real-time motion with the route system of the multi-level structures in the Boston Harbor using AIS system

Data compression or source coding is the process of encoding information using fewer bits (or other information-bearing units) than an unencoded representation would use through use of specific encoding schemes. As is the case with any form of communication, compressed data communication only works when both the sender and

receiver of the information understand the encoding scheme. Compression is possible because most real-world data have statistical redundancy.

In order to discuss the relative merits of data compression techniques, a GIS framework for comparison must be established. There are two dimensions along which each of the schemes discussed here may be measured, algorithm complexity and amount of compression. When data compression is used in a data transmission application, the goal is speed. Speed of transmission depends upon the number of bits sent, the time required for the encoder to generate the coded message, and the time required for the decoder to recover the original ensemble. In a data storage application, although the degree of compression is the primary concern, it is nonetheless necessary that the algorithm be efficient in order for the scheme to be practical. For a static scheme, there are three algorithms to analyze: the map construction algorithm, the encoding algorithm, and the decoding algorithm. For a dynamic scheme, there are just two algorithms: the encoding algorithm, and the decoding algorithm.

Several common measures of compression have been suggested: redundancy [Shannon and Weaver 1949], average message length [Huffman 1952], and compression ratio [Rubin 1976; Ruth and Kreutzer 1972]. The most common model is that of a discrete source; a source whose output is a sequence of letters (or messages), each letter being a selection from some fixed alphabets. The letters are taken to be random, statistically independent selections from the alphabet, the selection being made according to some fixed probability assignment $p(a), \dots$ [Gallager 1968]. Without loss of generality, the code alphabet is assumed to be $\{0,1\}$ throughout this research. The modifications necessary for larger code alphabets are straightforward.

When data is compressed, the goal is to reduce redundancy, leaving only the informational content. The measure of information of a source message x (in bits) is $-\lg p(x)$ [\lg denotes the base 2 logarithm]. This definition has intuitive appeal; in the case that $p(x)=1$, it is clear that x is not at all informative since it had to occur. Similarly, the smaller the value of $p(x)$, the more unlikely x is to appear, hence the larger its information content. The average information content over the source alphabet can be computed by weighting the information content of each source letter by its probability of occurrence, yielding the expression $\sum_{i=1}^n [-p(a(i)) \lg p(a(i))]$. This quantity is referred to as the entropy of a source letter, or the entropy of the source, and is denoted by H . Since the length of a codeword for message $a(i)$ must be sufficient to carry the information content of $a(i)$, entropy imposes a lower bound on the number of bits required for the coded message. The total number of bits must be at least as large as the product of H and the length of the source ensemble. Since the value of H is generally not an integer, variable length code words must be used if the lower bound is to be achieved. Given that message *EXAMPLE* is to be encoded one letter at a time, the entropy of its source can be calculated using the probabilities.

Redundancy can be defined as: $\sum p(a(i)) l(i) - \sum [-p(a(i)) \lg p(a(i))]$ where $l(i)$ is the length of the codeword representing message $a(i)$. The expression $\sum p(a(i)) l(i)$ represents the lengths of the codeword weighted by their probabilities of occurrence, that

is, the average codeword length. The expression $\text{SUM} [-p(a(i)) \lg p(a(i))]$ is entropy, H . Thus, redundancy is a measure of the difference between average codeword length and average information content. If a code has minimum average codeword length for a given discrete probability distribution, it is said to be a minimum redundancy code.

The amount of compression yielded by a coding scheme can be measured by a compression ratio. The term compression ratio has been defined in several ways. The definition $C = (\text{average message length})/(\text{average codeword length})$ captures the common meaning, which is a comparison of the length of the coded message to the length of the original ensemble [Cappellini 1985]. If we think of the characters of the ensemble *EXAMPLE* as 6-bit ASCII characters, then the average message length is 6 bits. This yields a compression ratio of 6/2.9, representing compression by a factor of more than 2. Alternatively, we may say that the encoding produces a file whose size is 49% of the original ASCII file, or that 49% compression has been achieved. A somewhat different definition of compression ratio, by Rubin, $C = (S - O - OR)/S$, includes the representation of the code itself in the transmission cost [Rubin 1976]. In this definition S represents the length of the source ensemble, O the length of the output (coded message), and OR the size of the "output representation" (eg. the number of bits required for the encoder to transmit the code mapping to the decoder). The quantity OR constitutes a "charge" to an algorithm for transmission of information about the coding scheme. The intention is to measure the total size of the data transmission.

3.3 The discrete simulation of plume evolution by incorporating real time climate and geophysical data

Many types of disasters, large and small-scale, natural and technological must be simulated. The effects of the disasters must be displayed pictorially on geo-referenced maps, photographs, satellite images, etc. to determine their spatial and temporal extents. The consequence of the projected disaster must be calculated (affected areas, land and environment), and amount of necessary relief must be supplies must be determined to ensure adequate contingency planning and post-disaster assistance. The system must reside on modeling simulation to be practical, yet powerful enough to supply expedition's results when disaster strikes in the Boston harbor.

In the real world, a disaster is a complex phenomenon. The wind velocity, the surface roughness, air temperature, and surface feature all contribute to the effects of natural events and chemical dispersion. With this inherent complexity, models which attempt to replicate a real world system must make simplifying assumptions. It follows that attempts to exactly model a natural or man-made phenomenon via a mathematical algorithm must, by the limitations of the technology, be only an approximation. The accuracy of the model's estimation of an event is determined by both the assumptions contained within the model and by the assumptions made by the user as the data sets are prepared for modeling or inputs are entered in the user interface with the model. Major developments will need to continue to enhance the sophistication of our representation of hazard events. These models must be easy to use and adaptable to changing local needs

by users. Unfortunately, many of the hazard models are too complex to be used by emergency managers and may not be adapted for unique local geographic, atmospheric or geologic conditions. Research by both the academic and military agencies will result in continuing developments in hazard models.

The collection of data relating to disasters is critical in emergency planning, response, recovery, and mitigation efforts. Data also allows the emergency management community to use the data to simulate potential disasters as in case of hydrogen gas leak or smoke based on by incorporating real time climate and geophysical data. Models have been developed to allow for the simulation of a disaster. Lepofsky and Abkowitz (1993) demonstrated that GIS can be used to integrate plume representation with real-time data to estimate consequences more effectively. These simulations require specific data concerning the natural or man made circumstances, the weather conditions, terrain, or physical structures.

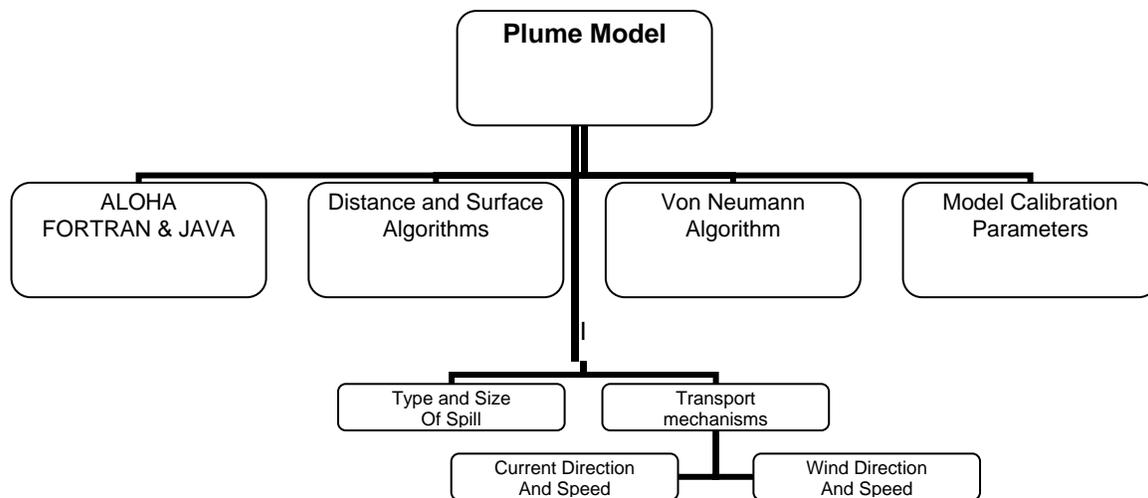


Fig 5. Conceptual model of Plume evolution by incorporating real time climate and geophysical data

It is a cellular automata based spatial model commonly used in air quality meteorology to simulate the plume dispersion based on Contamination levels, Emission and Weather conditions. An urban space simulation through a Plume Model implies not only weather condition measurements (for example, wind speed and direction), but also measurements on each air/water pollution source (for example, Toxic Gas leak). For wind direction, users select one of eight directions, associated with numerical constants. The value represents the direction from which the wind blows the smoke or spill. The plume will grow in the opposite direction. For greater precision, user enters a wind direction constant in degrees.

A common research has been made on these models for the plume Simulation in the Geographic Information Systems (GIS) software to visualize and analyze the spatial distribution of the real-time chemical spills/toxic gas releases. This type of spatial simulation describes the changes in a spatial pattern from time to time. They used raster data structure as the model of spatial simulation to define the flows or processes that

occur among cells using cellular automata theory, since raster datasets provides structures for representing entities and procedures for associating and transforming representations with each other. To cover Boston Harbor area, a spatial cell grid was built like space as discrete, meanwhile each cell center point was calculated because the pollutant concentration through each cell was assumed as the concentration on each cell's center point. In other words, the pollutant concentration was assumed as homogeneous inside each cell.

There are several methodologies to perform simulation using cellular automata (Burgess et al., 1996). The specification of the cellular automata is done in terms of the definition of the grid or model space, neighborhood and rules. The automata have different layers of neighborhood to define each discrete state, including multidimensional neighborhoods. Neighborhoods are specified using coordinate system to denote a neighbor cell that is currently being processed which has the coordinates. A generalized formalization governing the cell automaton function as follows:

$$a_{ij} s(t) \rightarrow a_{ij} s_k(t+1) = f\{ a_{i,j} s(t) ; a_{i,j+1} s(t) ; a_{i+1,j} s(t) ; a_{i,j-1} s(t) ; a_{i-1,j} s(t) \}$$

It is a Von-Neumann neighborhood of four direction relations called discrete space-time-state model, where the new state, s_k of cell a_{ij} at time $t+1$ is the function of current state of plume dispersion based on the direction of the wind, velocity and amount of expose of the spill/smoke related to the discrete time. The function f is the transition state rule applied for the cell propagation visualization on all the eight directions. Based on the simple transition rule, the cell under consideration possesses the discrete state functions. The operation for this simulation is a simple matter of polling the neighborhood and comparing against the transition rule. In this case, three neighbors possess state one. Thus, the state of the cell under consideration is set to 1, to be implemented at the next time step. Focus then shifts to the next cell that has to be considered for the dispersion and the application of the transition rule is repeated.

NW	N	NE
W	C	E
SW	S	SE

NW	$a_{i-1,j}$	NE
$a_{i,j-1}$	a_{ij}	$a_{i,j+1}$
SW	$a_{i+1,j}$	SE

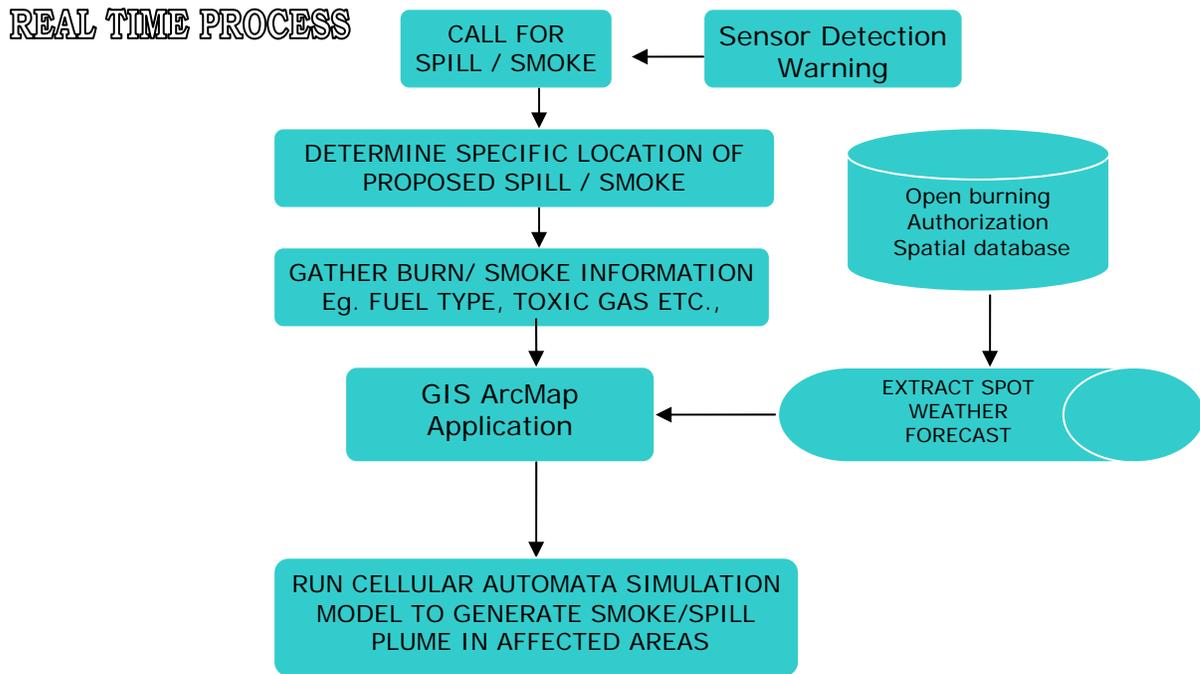


Fig 6. Architecture of the discrete simulation of plume evolution by incorporating real time climate and geophysical data

This model simulates the real-time disasters during a specified period of time and save the results of Simulation, using spatial-temporal data structure. It visualizes the automata simulation in a given time at discrete space on raster layer exported to the system and performs the spatial-temporal queries of simulation results for knowledge discovery.

4. Wireless, Peer-Peer and Mobile GIS implementation of GFHS

With the rapid development of mobile communication and wireless technologies, more and more mobile GIS applications have emerged from the fields of location-based services, vehicles navigation, and tracking, and mobile mapping. The wireless GIS architecture uses application logic type approach of client/server architecture. In this approach the main database resides in server-side and may consist of any traditional data formats. The server side application is responsible for listening to the requests of user and generating software language documents from the main database.

The development of the wireless mobile GIS has been stimulated by the increasing demand for up-to-date geospatial information, along with the improvements in mobile hardware performance and wireless network bandwidth. Wireless GIS can be divided into two broad classes, Short range, covers particular area within a limited scale

and Long range, covers metropolitan area, a state or a whole nation based on the wireless services. For GIS, the data is intensive and need high-speed data transfer. The latest wireless system using Code Division Multiple Access technology (CDMA) is 3G – Third generation network. The 3G systems has the capability of transferring data at a rate of 144Kbps to 2 Mbps along with the enhanced services like streaming video applications, multimedia messaging services and location-based services.

Wireless GIS technology has reached unprecedented advantages in Harbor security. Access to the spatial data through wireless is growing rapidly, and web-based GIS are becoming more prevalent. The Harbor security prototype provides effective tool for querying spatial and distributed data, displaying maps and performing limited spatial analysis tasks even from the remote area. It includes mobile devices such as PDAs to access the wireless GIS. With the support wireless communication, an on-site mobile spatial subsystem will provide users an effective tool for collecting data about the ship navigation and current weather information, data transfer and real-time database updates. A portable GPS receiver is attached to the mobile devices to access wireless GIS to collect the position of the ships in the Harbor for monitoring facilities. High resolution satellite ortho images in the prototype help to perform the visualization of the structure of harbor anytime.



Fig 7. MDA thin client with ArcIMS capability to access wireless GIS to assist field personnel in assessing a rapidly changing situation

GFIHS uses the collected data obtained from the wireless Mobile GIS to identify the event location (e.g., Fire or any disaster) in the harbor based upon sensor locations or sensor identities; to identify current situation, number of persons in the ship, neighborhood ships to implement quick and accurate emergency response plans. The entire sensor data obtained through systems is transmitted through wireless networks to the central unit of GFIHS. The unit then transmits the information to the emergency manager through wireless GIS application to the mobile devices. The implementation of

this system will definitely reduce the time for such on-site inspection and enhance capabilities for making efficient decisions in the critical emergency situations.

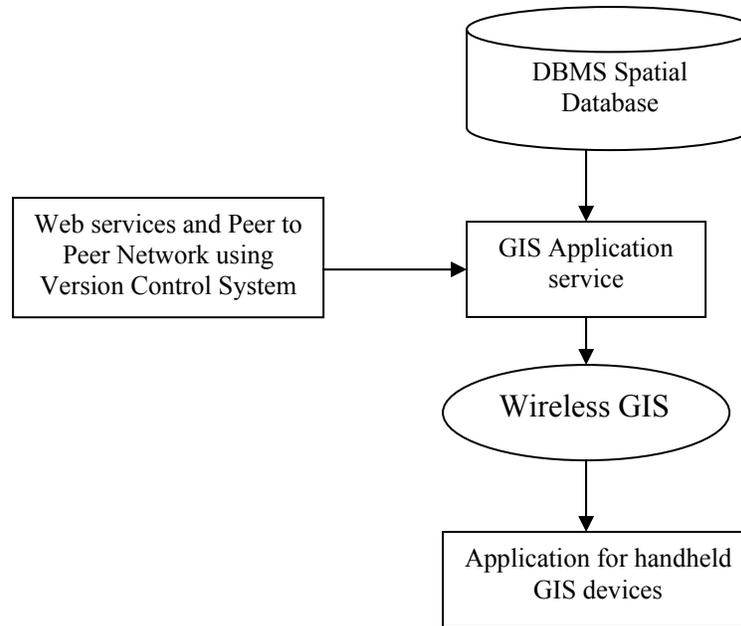


Fig 8. Wireless, Peer-Peer, Mobile GIS Architecture

Nowadays Peer-to-Peer (P2P) and Web services are two of the hot research topics in GIS network computing. Roughly, they appear as two extremes of distributed computing paradigm. Conceptually, P2P refers to a class of systems and applications that employ distributed resources to perform a critical function in a decentralized way. A P2P distributed system typically consists of a large number of nodes that can potentially be pooled together to share their resources, information and services. These nodes, taking the roles of both consumer and provider of data and/or services, may join and depart the P2P network at any time, resulting in a truly dynamic and ad-hoc environment. In addition, the distributed nature of such a design can eliminate the need for costly infrastructure by enabling direct communication among clients, and enable resource aggregation, so thus provide promising opportunities for novel applications to be developed. On the other hand, Web services technologies provide a language-neutral and platform-independent programming model that can accelerate application integration inside and outside the enterprise (Gottschalk, 2002).

GFIHS combines Web services and P2P technologies with the innovative technology called TortoiseSVN, a free open-source client for the *Subversion* version control system. Version control system is an art of managing changes to information. It has long been a critical tool for GIS programmers, who typically spend their time making small changes to software and then undoing those changes the next day. It also aims to add more flexibility and autonomy to prototype, and alleviate to some degree the inherent limitations of centralized systems. That is, TortoiseSVN manages files and directories

over time. Files are stored in a central *repository*. The repository is much like an ordinary file server, except that it remembers every change ever made to your files and directories. This allows user to recover older versions of files and examines the history of how and when the previous data changed. This is why many people think of Subversion and version control systems in general as a sort of “time machine”. Some version control systems are also software configuration management (SCM) systems. These systems are specifically tailored to manage trees of source code, and have many features that are specific to software development - such as natively understanding programming languages, or supplying tools for building software. Subversion, however, is not one of these systems; it is a general system that can be used to manage any collection of files, including source code.

Subversion system of GFIHS has an abstracted notion of repository access, making it easy for people to implement new network mechanisms. Subversion's “advanced” network server is a module for the Apache web server, which speaks a variant of HTTP called WebDAV/DeltaV. This gives Peer to Peer network of GFIHS a big advantage in stability and interoperability, and provides various key features for free: authentication, authorization, wire compression, and repository browsing. This Peer to Peer system through Web services expresses file differences using a binary differencing algorithm, which works identically on both text and binary files. Both types of files are stored equally compressed in the repository, and differences are transmitted in both directions across the network.

5. Network Analyzed Structure for Harbor Rescue Operation: The complexity of the challenge

The entire decision making capabilities in the GFIHS depends on the analytical, modeling and simulation functionalities. These include security monitoring visualization, spatial modeling and simulation, rule-based modeling, agent-based modeling, pattern recognition and spatial data mining algorithm. Simulation modeling needs to be developed for evaluating the propagation of risk to the adjacent areas of the disaster site, and to predict how a disaster situation will evolve and affect additional population and areas. Therefore, GFIHS uses network based functionalities for finding the fastest route to reach the disaster areas in the Harbor based on real-time conditions, providing navigation guidance using latest wireless mobile technology to emergency response manager, and finding most safest, fastest and effective way for evacuating the affected population in the ships or in the harbor area, and for the risk assessment and evacuation plans. In order to determine the optimal route in waterway transportation for rescue and evacuation in a multi-level disaster environment in the real-time, a GFIHS therefore needs to be built upon a relational network structure that handles the optimum and shortest time consuming route transportation.

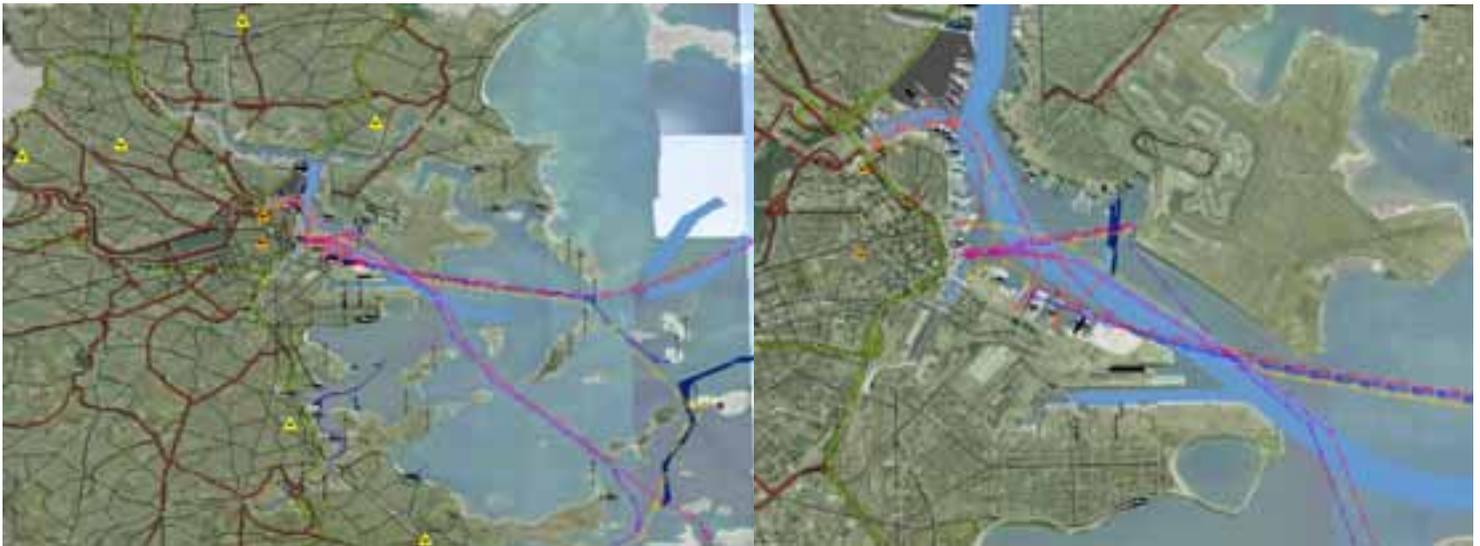
Finding shortest paths is a useful application in Geographical Information Systems (GIS). This topic has also received much attention in many other areas such as cartography, artificial intelligence, civil engineering and computer science. Potential uses include emergency rescue planning, military activities, cost effective purposes, and many

other applications. Most of the improvement of existing algorithms for finding shortest paths has been made on vector surfaces (Mitchell et al, 1987; Berg and Kreveld, 1997; Varadarajan and Agarwal, 2000), we present here an algorithm specifically designed for waterway planning that is suitable for use with raster data. Specifically, we consider in the algorithm spatial distances, time for travel based on the emergency scenarios. To find the shortest path between a starting point and a destination point in a given gridded geodatabase bathymetry model, there are two major steps. The first step is to create an accumulated time for travel in the ocean with respect to all relevant uncertainty factors. Dijkstra's (1959) shortest path algorithm is widely used to create a path on accumulated land surface. We modified the algorithm for functioning in the waterway transportation. The second step is to construct the shortest path with ferry route lines on the accumulated travel time in the ocean surface with all unexpected uncertainty factors (Warnz, 1957; Douglas, 1994). Alternatively, the back link mechanism (Xu and Lathrop 1995) can be used to connect the departure and destination locations when forming a shortest path on ocean surface.

Recent progress in studies of shortest-path algorithms has shown great promise in making realistic applications. These include constructing paths with constraints to avoid terrain obstacles (Mitchell 1988) by considering directional differences or anisotropy of the terrain surfaces (Zhan et al. 1993, Xu and Lathrop 1994, 1995, Collischonn and Pilar 2000), and improving the accuracy and efficiency of the resulting paths (Douglas 1994, Solka et al. 1995, Voros.J 2001). In addition, the shortest-path algorithms have been fine-tuned to solve many real world problems. For example, Feldman et al. (1995) utilized these algorithms for routing oil pipelines near the Caspian Sea. Stefanakis and Kavouras (1995) charted the shortest sea courses under various models of travel functionalities. Lee and Stucky (1998) computed hidden paths, scenic paths, strategic paths and withdrawn paths using visibility.

The research follows the node relation structure, which represents the adjacency, connectivity and hierarchical relationships among the complex structure of the Ocean ship pathways. In any disaster situations, the Goal is to find shortest and the most optimum path from source node A to each node in a graph. Brainard et al. (1996) demonstrated the use of GIS to find the routing by shortest time, to avoid population; and to avoid accidents. We begin the description of the node relation structure to find and manage sophisticated network data sets and generate routing solutions. It considers the network formally to be a weighted directed graph consisting of a set of vertices and selected edges between them; each edge has a strictly positive weight (its travel time or distance). It allows a "route" to start down an edge and retreat again. Thus, a route from vertex 'A' to vertex 'B' is a sequence of intermediate vertices V_1, \dots, V_n , such that $A \rightarrow V_1, V_1 \rightarrow V_2, \dots, V_n \rightarrow B$ are all edges in the network. The "cost" of a route is the sum of the vector weights associated with these edges. This node structure has to reach the particular adjacent node to incorporate turn restrictions. This network does not include parallel edges between vertices. That means that there exists at most one edge between any ordered pair of vertices. First computation of the shortest travel times from vertex 'A' (origin) to ALL vertices on the network (any disaster location) by modifying the Dijkstra's k-shortest path algorithm using vector weights associated with the motion of the ship. The set of vertices that abstract the topological relations that is likely to lie along the shortest, second shortest, etc., routes. Next

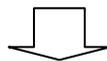
computation is the shortest travel times to vertex 'B' from all vertices in the network. Merging all the gathered data into a table that has one record for each vertex and two attributes: travel time from 'A' and travel time to 'B' are added in the attributes. This gives all the possible travel time for the shortest route from 'A' to 'B' that goes through each vertex. Then, the collected data are sorted by ascending travel time. This determines the lengths of the shortest, second shortest, etc., routes. The table to obtain the routes themselves is (1) Begin with a vertex 'C' having the smallest value for the sum of route lengths. (2) Compute the shortest route from 'A' to 'C' and the shortest from 'C' to 'B'. (3) Output the union of these routes. (4) Delete the records for all remaining vertices lying along either route. Repeat at (1). The limitations in the two-way streets, many of the near-shortest routes may not be optimum, it has to be proceeding through the shortest route, dart quickly down and back a short two-way street, and then resume along the shortest route.



Legend
boston.sid
RGB
 Red: Band_1
 Green: Band_2
 Blue: Band_3

Legend
 FairWay
 Dredged Area
Boston Roads
FUNC_CLASS
 4
 3
 2

Legend
Boston Ferries
ROUTE
 AIRPORT WATER SHUTTLE
 BOSTON-CHARLESTOWN
 BOSTON-PROVINCETOWN
 FLEET BOSTON PAVILLION
 HARBOR ISLANDS
 HINGHAM-BOSTON
 NORTH STATION-CHARLESTOWN
 NORTH STATION-SOUTH BOSTON
 NORTH STATION-WORLD TRADE CENTER
 QUINCY-BOSTON-LOGAN
 QUINCY-LOGAN-LONGWHARF



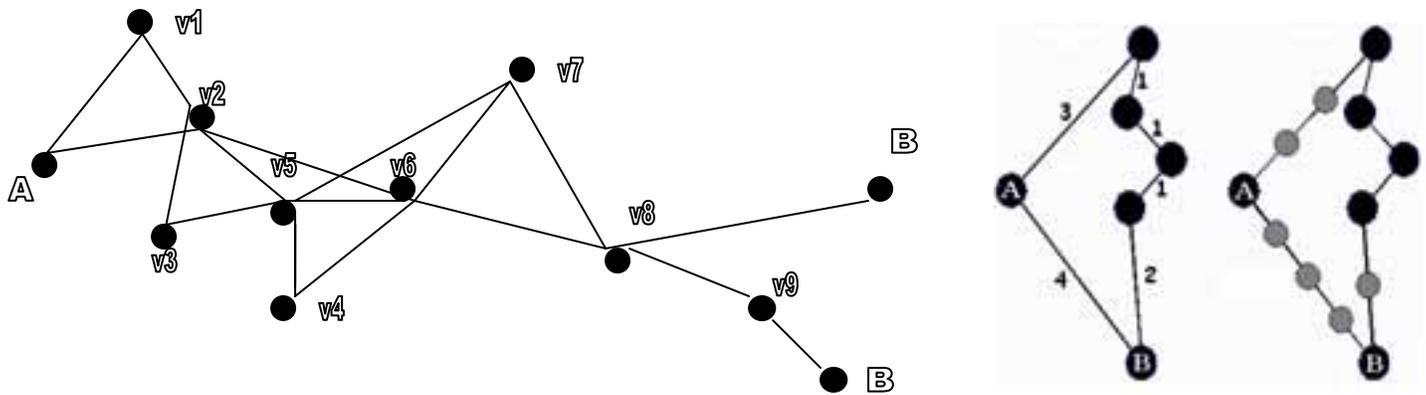


Fig 9. An example of node structure to determine the Boston Harbor waterway network

In this research, the Boston harbor vector data provided the Ocean pathway in the gridded geodatabase bathymetry data to conduct the network analysis. Once analysis was completed, a route representing the shortest travel distance and the route representing the fastest travel time were developed. It is important to remember that the shortest route is not always the fastest route, since travel time is always faster in one way network instead of two way ship routes or near residential access point routes (Mei-po Kwan, JiYeong Li., 2005). There are lots of factors influencing the travel time from vertex 'A' (source) to vertex 'B' (Destination), which includes Dredged pathway, fairway, underwater plants, underwater pipelines, tanks, fishing and swimming zones, ferries/ship traffic, caution and restricted access points and weather condition for the waterway transportation. Finding the shortest or fastest way includes the stops along the way in the port which facilities like hospitals, accident service, rescue shelters and police stations, etc. also has to be considered important for different scenarios. In this research, analysis for only certain scenarios was planned because of the difficulty of the modeling so many factors at once. Consider the following network pathway in the ocean waterways of the Boston port transportation illustrates the Dijkstra's K-Shortest path algorithm based on our modification.

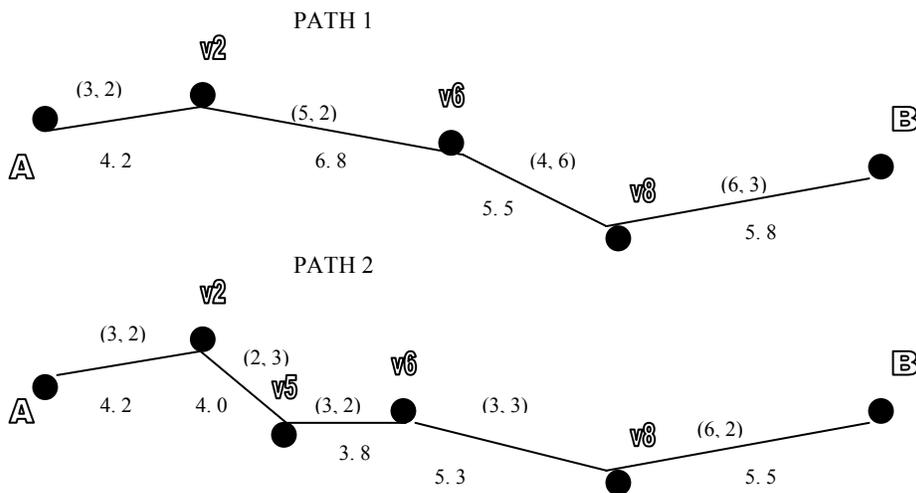
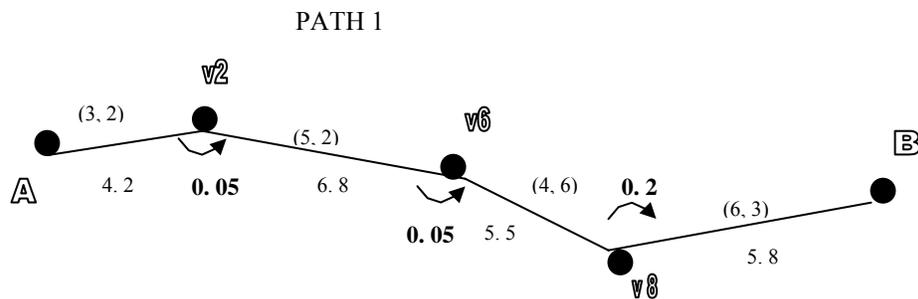


Fig 10. Illustration of Waterway network for vector weight and travel time

These above shown two paths have their individual vector weight and travel time for reaching the node B form node A. The time taken for the first path {V2, V6, V8} is 22.3 and the time taken for the second path {v2, v5, v6, v8} is 22.8, but the vector weight of the second shortest path is (17, 12) dominates the vector weight of the first shortest path (18, 13). The complexity of the vector weight of ship motion can be determined by arc-to-arc movement on the basis of angle of the turn (in degrees) and the direction of the turn (left or right) (Blue et al, 2005) and the underwater bridges and tunnels and restricted access point in the water way transportation near the harbor. Blue *et al* developed an algorithm to achieve an optimal quality multi-objective route with the minimum quality cost. So we have made small modification to the Blue *et al's* algorithm for time complexity in the waterway network. For example, the direction of the motion of the ship is straight ahead, there is a time complexity of 0. A right turn has a time complexity of 0.2 and left turn has 0.3 iff the motion of the ship is in the direction of the wind. If the wind or the wave direction is exact opposite to the direction of the motion of the ship, then the time complexity of straight motion is 0.3, the right turn has 0.5 and the left turn has 0.6. The table 1 illustrates the time complexities of the ship motion during the emergency operation in the waterways network.

Turn Movement	Time complexity in the direction of the wind	Turn complexity opposite to the direction of the wind
0° turn (straight ahead)	0	0.1
45° turn right	0.1	0.2
90° turn right	0.2	0.4
135° turn right	0.3	0.6
45° turn left	0.2	0.4
90° turn left	0.3	0.6
135° turn left	0.4	0.7
180° turn (reverse direction)	0.5	0.8

Table 1 Ship Turning movement time complexity



PATH 2

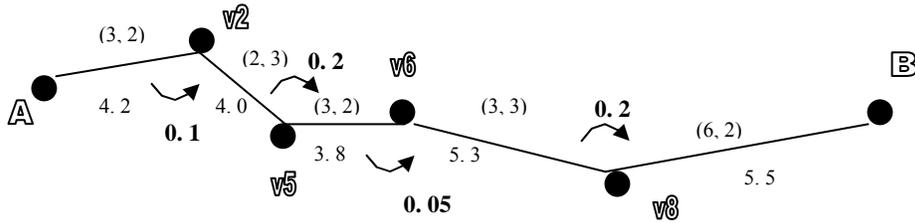


Fig 11. Illustration of Waterway network for Time complexity in the direction of wind

A minimally complex path can take more time, and a minimum time path can be more complex. Though the vector weight of the second shortest path dominates the vector weight of the first shortest path, the trip time complexity of the path 1 is much lesser than the path2. Hence, emergency responders may aim for a compromised situation in which path produces a good travel time based on emergency situation. The refined Blue *et al's* algorithm to define the concept of emergency to reflect the combination of both travel time and motion complexity:

$$E_r = \alpha(T / t) + (1 - \alpha) C$$

Where

- C = perceived value of trip having complexity,
- T = time taken to reach the destination node,
- t = time estimated to reach the destination node,
- α = trade-off parameter where $0 \leq \alpha \leq 1$.

For any emergency situation, the optimum quality Emergency route E_r is the multiple-objective route with the minimum time with minimum quality cost. Figure 10 presents a network that highlights four different shortest paths for a given source-destination pair. If only travel-time were considered as the objective, path1, having the lowest travel-time, would be considered optimal. However, if only shortest or cost were considered objective, then path 2 would be considered optimal. But in emergency response situations, all the three: travel-time, cost and safety have to be considered in any operation. Hence, the source node A has to be moved to the vertices 3 or 4, since the location facilitates the migration of emergency responder's starting position. Further, paths 3 and 4 presents a network that highlights the alternative paths for path 1 and 2, for a given source-destination pair. The source node from these two alternative vertices can create shortest and quickest paths (Path 3 and Path 4) to reach the destination node with the consideration of all uncertainty parameters (see Figure 12).

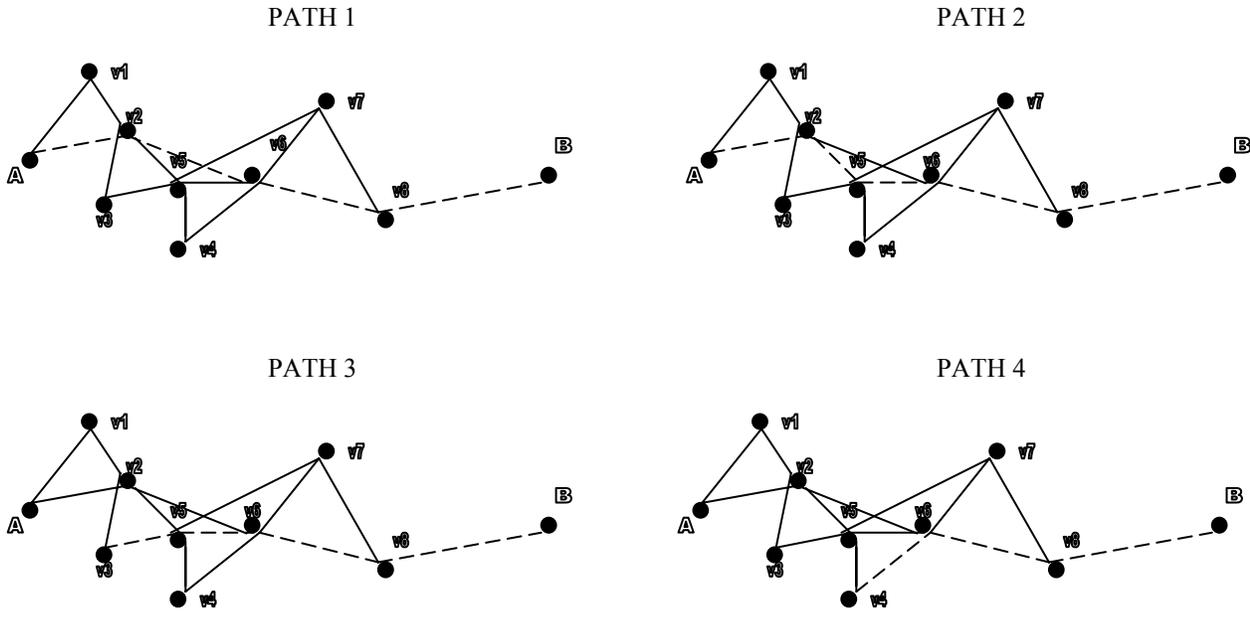


Fig 12. Illustration of alternative Waterway network

Travel Time Estimation Error

The time estimation between two nodes provides the criteria on which routing decisions are based. The quality of the path ultimately depends on the accuracy of the time estimation no matter what path computation algorithms are used (zheng wang and Jon crowcroft, SIGComm'90). In some respect, the estimation error can be used as measure of determining optimal solution for the path. The common approach of time estimation is to average the travel time in current route updating period and use them as estimated time for the next period.

Let us now examine the time estimation process of node A. If $D_i(t-T, t)$ is the measured average delay of node A during the time period $(t-T, t)$, where T is the route updating interval. The delay information $D_i(t-T, t)$ is then propagated and received by node B at time $(t+t_1)$, where t_1 is the propagation delay for the information to reach node B.

Node B updates the distance of link B with $D_i(t-T, t)$ and uses it as the estimated delay for the next time period $(t+t_B, t+t_B+T)$. Let $D_i(t+t_B, t+t_B+T)$ be the actual measured delay of node B during the time period $(t+t_B, t+t_B+T)$. The estimation error of reaching node B during the time period $(t+t_B, t+t_B+T)$ is given by

$$\Delta_i = |D_i(t+t_B, t+t_B+T) - D_i(t-T, t)|$$

During response operation, the military vehicle parameters have to be considering under any emergency situation. The approximate average delay of response is given by

$$D_q \approx \frac{\sigma_a^2 + \sigma_b^2}{2(1 - \rho)\tau}$$

where σ_a^2 , σ_b^2 and τ are the respective variance of the inter-arrival of the ship, variance of evacuation time and average inter arrival time. ρ is the respective utilization factors of the military vehicle during the time period $(t + t_B, t + t_B + T)$ and $D_i(t - T, t)$.

Using the real-time GIS framework for the study, the evaluation of the impact of several uncertainty responders often encounter in emergency situation on the speed of response. They are Ocean pathway network complexities, entry and exit point of the ships in the Harbor ports, uncertainty network structure, etc. This type of uncertainty exists because shortest path is not always the optimum path for the destination from the source. Undeniably, Challenges associated with uncertainty are involved in network analyzed structure for harbor rescue operation. The accuracy and effectiveness of waterway transportation system are naturally affected during the operation research. So uncertainty analysis is necessary in terms of improvement and maintenance of harbor transportation system. In this research, uncertainty is considered separately in data, hazard occurrence of real-time simulation, vulnerability and risk evaluation and evaluating multiple optional ocean pathways on its sources (Eastman 2001). Without proper mechanism of network structure in the real-time implementation, it may lead to considerable delay in reaching the disaster location. In the ocean, without proper knowledge about the starting point of the rescue ships from the harbor port leads to additional delay in the operation. Route uncertainty in the ocean with the consideration of underwater natural and manmade resources is the uncertainty about the feasible and fastest route from a feasible water-level entry point to a destination point within the Harbor islands. For instance, in an attempt to reach a nearby Harbor island, rescues may be blocked in the middle with the maritime traffic and have to go back to find another route to go up again. To evaluate the effect of these uncertainties, the Total travel time, T_i for individual path from source vertex to destination can be represented using:

$$T_i = E_i + \delta_i$$

Where, E_i is the expected travel time after the calculating the estimation error from source to destination and δ_i is the sum of all possible unexpected delays during the travel. The delays includes the factors of energy balance, wind velocity, roll angle of ship in waves, wave steepness, hydrodynamic coefficients, wave randomness, rolling in waves, stability, maximum flow, congestion control and failure transparency etc.

If there is more than one ship has to be rescued in the port, then more than one node will be assigned to the ship location in the harbor for developing the shortest path to reach the prioritized ship ranking for the rescue operation in various emergency scenarios. In priority response issue, creating a path using waterway network is a critical step. Special difficulties occur because (1) path contains variable number of nodes; (2) a random sequence of edges usually does not correspond to the path of the ship. To overcome such difficulties Cheng and Gen adopted a new encoding method, called priority-based encoding. In this method, the position of the ship was used to represent the priority of the node for constructing a path among candidates. The path corresponding to a given chromosome is generated by sequential node appending procedure with beginning from source node A and terminating at destination node J. At each step, there are several nodes available for consideration, only the node with the highest priority added to the path. Suppose we want to find a path from node A to node J, we try to find a node for the position next to node A. Node B and node C are eligible for the position, which can be easily fixed according to the adjacent relation among nodes. The priorities of them are C and D, respectively. The node C has the highest priority and is put into the path. The possible nodes next to the node C are B, E and F. Because node F has the highest priority value, it is put into path. Then we form the set of nodes available for next position and select the one with the highest priority among them. Repeat these steps until the path completes the entire destination nodes.

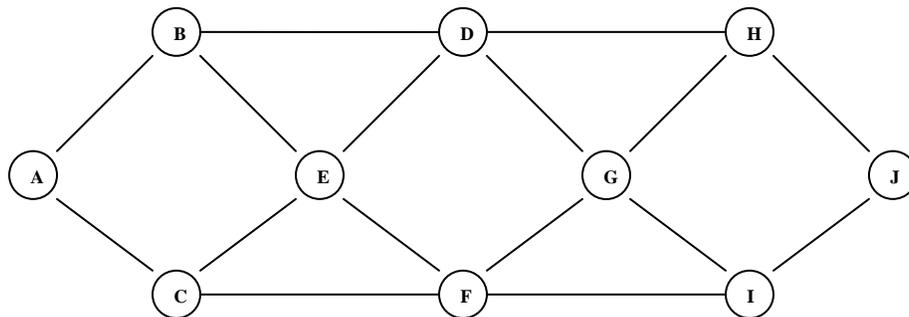
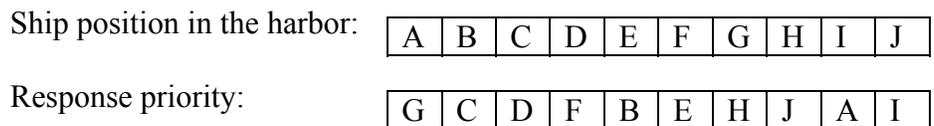


Fig 13. An example of priority based emergency response operation (Cheng and Gen)

If there is more than one military vehicle starts from the port for emergency response operation, at each step from source node A, the node B and node C are eligible for the position to rescue operation. The priorities of them are C and D, respectively. The node C has the highest priority and is put into the path. Then, the optimal way of solving the priority issue will be sending the second military vehicle to the node B and next to the node D. After, the possible nodes next to the node C and D are E, F and G. Because node F and G have their highest priority value, node F is put into path for first military vehicle

and node G for second. Then we form the set of nodes available for next position for every response vehicle and select the one with the highest priority among them.

All these network analysis applications of GIS are not only used to find the fastest and the safest route but also the traffic flow, delivery routes, service areas directions and closest facilities. There are several studies have been conducted to assess the risk imposed by shipment traversing each link in a network (Ang A., Briscoe J., et al. (1989), ReVelle D.J., Cohon C., Shobrys J. (1991), List G.F., Mirchandani P.B., Turnquist M.A., Zografos K.G. (1991), Lepofsky M., Abkowitz M., Cheng P. (1993), Zhang J., Hodgson J., Erkut E. (2000)). This analysis of network model with the help of Network analyst extension helps to create a route can mean finding the quickest, shortest or most scenic safest route depending on the time constraint and by assessing the potential risk imposed by shipment transportation. This analysis helps to determine the located stops, unlocated stops, errors, barrier information and time violation stops. Further, it enhances the network model to more realistic by using hierarchical relations. However, this is not an accurate representation of reality. The exact route may not take into account delays, such as, delay through starting times, underwater rocks, plants, tanks, pipelines in the water ways. The connectivity and hierarchical relationships can estimate such delays in determining optimum routes. Most of these data are obtained through various types of sensors and transmitted via the communication infrastructure of the research in the context of GFHIS.

6. Real-time Implementation of GFHIS

To evaluate the potential benefit of this GIS prototype for improving harbor security and the speed of emergency response, we undertake the real-time implementation of the system based upon the criteria discussed. The components of the system were constructed in the ArcObjects environment. These components include a relational database system accessible via open database Connectivity (ODBC), a GIS software package accessible via ActiveX controls. The other program routines for wireless GIS with real-time sensors and detectors were managed with visual basic environment and geodatabases using Microsoft Access integrated with Java programming and Python scripts. Preparatory work in transforming and visualizing these data has generated over 2.5 GB. For accessing the wireless GIS, we extract the compressed data through local host system to the wireless PDA devices.

The hypermedia web interface has recently provided a better environment for GIS applications (Li *et al.* 1997, Kearney *et al.* 1997, Dostie 1997, Dai *et al.* 1997). The real-time security monitoring sensor camera is integrated with the GIS application and hypermedia web interface for video tracking and still photography sent to and from the field personnel to monitor the ship motion and maritime updates. The sensor moves to the particular location using coordinate positions based on the “mouse down “function in the GIS application. The GIS prototype handles the operation of the camera with the internet based services. This provides mechanism to evaluate maritime security products in a collaborative environment with live data inputs. The view shed from real-time maritime security monitoring sensor device (Camera) has been planted relation to critical policy issues of the View of boat arrivals. If visible, then sensor must be designed in character with the surrounding environment. If isolated, then it needs to be screened.

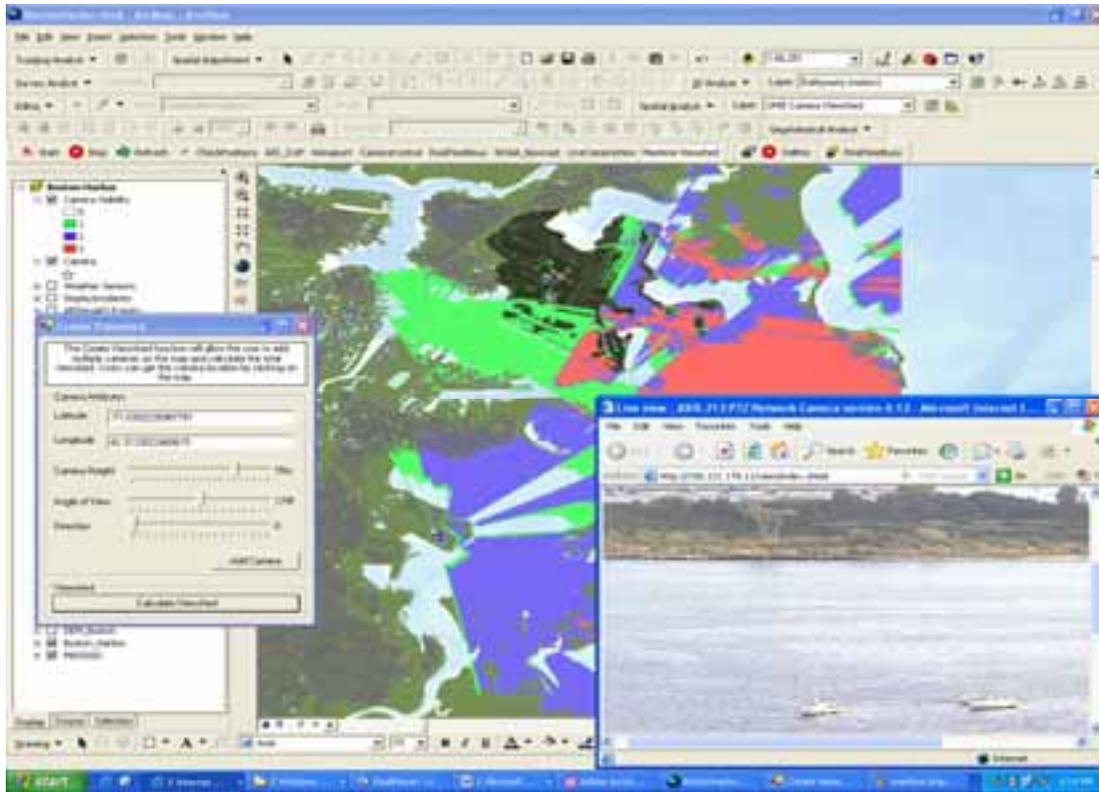


Fig 14. Real-time Integration of security monitoring sensor (Camera view with maritime functionalities) with the GIS application for harbor security updates

The distributed information management technology of this real-time implementation of the GFIHS simulates the real-time motion of the ships in the harbor and stores the data in the desktop and wireless GIS environment. It pictures a shipboard radar display, with overlaid electronic chart data, that includes a mark for every significant ship within radio range, each as desired with a velocity vector (indicating speed and heading). Each Ship identification could reflect the actual position of the ship. By "clicking" on a ship feature in the GIS Desktop ArcMap, it illustrates the ship name, course and speed, classification, call sign, registration number, and other information. Maneuvering information, closest point of approach (CPA), time to closest point of approach (TCPA) and other navigation information are more accurate and timelier than information available from an automatic radar plotting aid. Display information previously available only to modern Vessel Traffic Service operations centers is now under communication to every AIS-equipped ship.

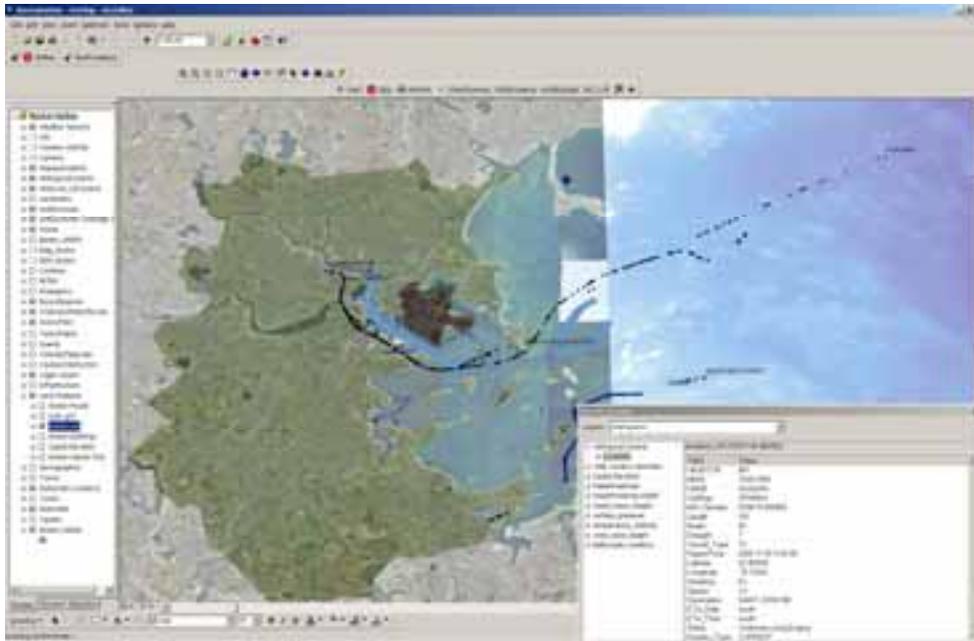


Fig 15. Ship communication, coordinate positions, speed and Maneuvering data collection of the real-time ship motion with the in the Boston Harbor using AIS system

The research area for this real-time implementation is the Boston Harbor, located in the east coast of United States of America, along with the coastal area of Charles River. For instance, we assume that if there is a Bomb exploded on any one of the residing ship in the Boston harbor location, the shortest path from the source to destination through waterways or street ways is found using the modified Dijkstra's K-shortest path algorithm along with the above calculated algorithms to perform the emergency response. We use the raster mode for implementing the K-shortest path algorithm, which is a node-link cell based representation: each centre of a cell is considered as a vertex and each vertex is connected to its neighbors by multiple links. Every link has impedance associated with it and derived from the weight of the cells at each end of the link. This impedance is also associated with the direction of movement through the assigned pathways in the GFHS. The result suggests that optimal routing using ground transportation differs entirely from the waterways. This experimental research illustrates that the travel time needed to reach a disaster site through waterways consumes more time and more complicated than the roadways.

The benefit of the GFIHS based upon an integrated and navigable network model would be even greater when the real time scenario is worse than the conceived in this research. In addition to improving the rescue operation, real-time information about the Boston Harbor’s waterway structure may also help to improve the overall speed and effectiveness of the rescue operation and evacuation process and this may have effect of saving many lives.

7. Conclusion

This paper outlines the important elements of the GFIHS, including the real-time security monitoring sensor camera, Automatic identification System functionalities, and discrete simulation of plume evolution, distributed geographic data compression techniques, peer-peer and mobile GIS technologies, analytical, network and modeling methods. The results of this research using network model indicate that GFIHS system has the potential to contribute in significant ways to quick emergency response to terrorists attacks.

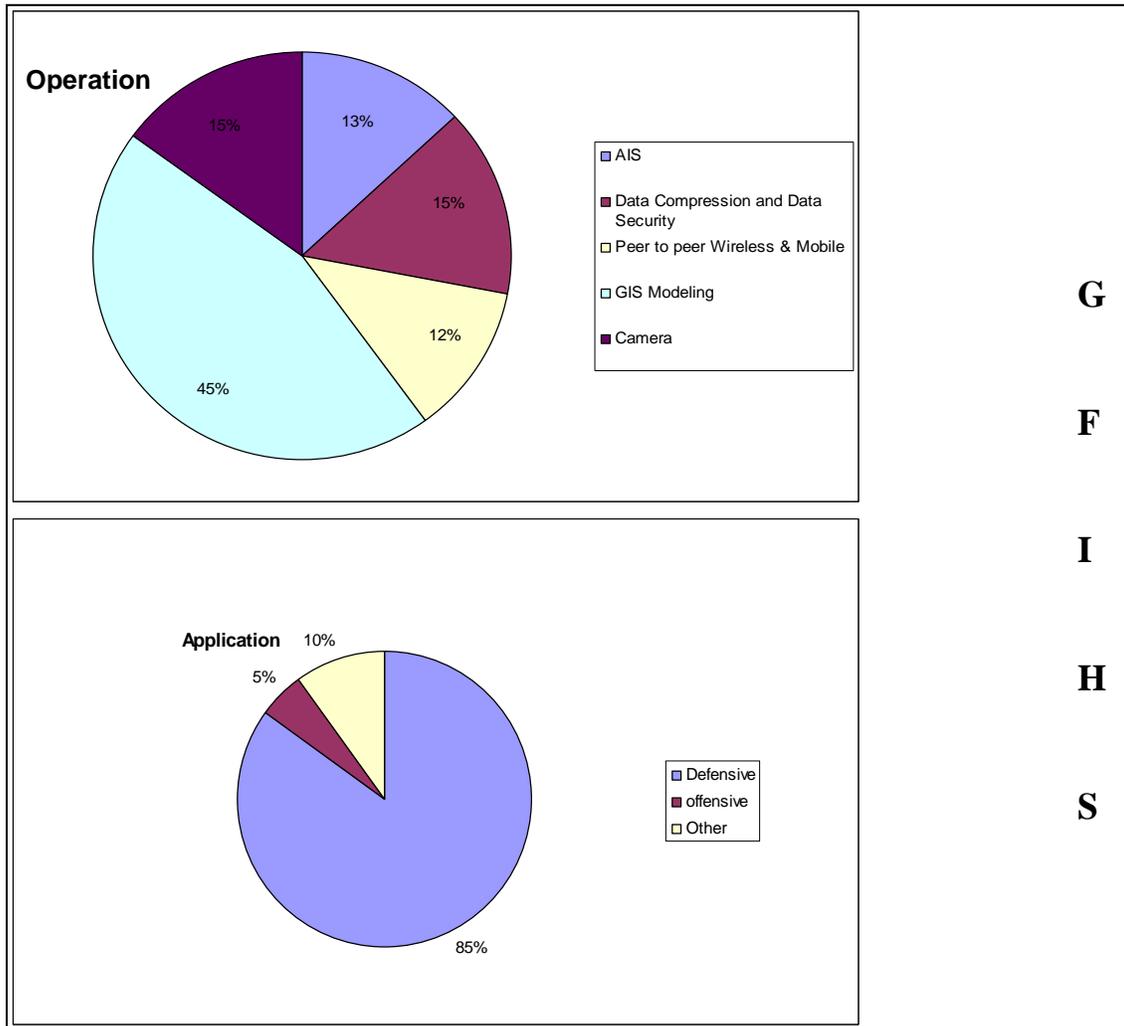


Fig 16 A pie-charts to represent the operation and Application overview of GFIHS

As the figure above illustrates, the focus of GFIHS is clearly on defensive applications which presents many challenges and opportunities for those in the field of GIS technology. GFIHS also categorizes the applications used in harbor security as offensive along with defensive. Offensive applications are destroying natural resources and enemies using tanks, bombs and missiles.

This paper ignores lots of in-depth research methods and issues on each modules of the research. At least, GIS data of the GFIHS themselves raises concerns about the importance of the data and issues of data security, as data assembled from all the above shown operations. With this GFIHS system, future users can do far more than merely display graphical representations of hazard footprints on map backgrounds. They can combine multiple layers of information: hazards, casualty probabilities, number of population affected, property damage, and effects on the infrastructure, to create quick and useful assessment of response for the total impact of the major disaster. This system provides the user the flexibility to incorporate the wide range of user-specific, geo-referenced and attributed infrastructure, resource and facility databases, all within the spatial context of geo-referenced scanned in maps, photographs or satellite images. Although these applications may termed defensive, not all the defensive applications are as reactive as the name would led one to believe. Regardless of the type of application being utilized, offensive or defensive, pre or post event measures, it is clear that GIS technology is and will continue to be vital in the development of entire homeland security system.

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