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Wide-Area Incident Management System on the Internet

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ABSTRACT

The incident management process consists of four sequential steps - incident detection, response, clearance and recovery. Each of these components comprises of a number of operations and coordinated decision making between the agencies involved. The provision of computer based support tools for the personnel involved will help develop appropriate incident management strategies and increase the efficiency and expediency of the entire process.

Existing incident management systems are developed on various traditional computing platforms, including UNIX, and Windows. However, with the advent of World Wide Web and Internet based programming tools such as, Java, it is now possible to develop platform independent decision support tools for the incident management agencies. Any agency will be able to use these Web based tools on a computer with a Java enabled browser. Thus, Web based tools offer an invaluable opportunity to develop next generation on-line decision support tools for real-time traffic management. The major objectives of this paper are:

1. to explore and demonstrate the applicability of WEB based tools for the development of on-line decision support systems for incident management and,
2. to develop and test a prototype incident management Decision Support System (DSS) which has most of the capabilities of similar UNIX based DSS support systems.

The paper briefly describes the implementation and development of a prototype Wide-Area Incident Management Support System using WEB based tools. It also describes the implementation architecture and the individual functions of this prototype.

1. RESEARCH OBJECTIVES AND BACKGROUND

The incident management process consists of four sequential steps - incident detection, response, clearance and recovery; each of which comprises of a number of operations and coordinated decision making between the agencies involved. The provision of computer based support tools for the personnel involved, will help develop appropriate incident management strategies and increase the efficiency and expediency of the entire process. The major objectives of this paper are to:

1. explore and demonstrate the applicability of WEB based tools to the development of on-line decision support systems for incident management.
2. develop and test a prototype incident management Decision Support System (DSS) which has most of the capabilities of the UNIX based DSSs such as the Wide-Area Incident Management Support System (WAIMSS) (Özbay et al., 1996).

The development of incident management support systems has been attracting considerable attention over the past few years. These systems play an important role in aiding decision makers

in a situation where they have to deal with cognitive overloads arising from the ill-structured nature of the problem, dynamic conditions and/or multiple operations.

Existing incident management systems are developed on various computing platforms, including UNIX, and Windows. They have employed the rule based reasoning capabilities of expert systems to present operators with high level analyses and recommendations concerning incident response. Ritchie [2], discusses a knowledge-based decision support architecture for advanced traffic management. Incident management was an important component of the system. The proposed architecture employs a blackboard model to integrate knowledge sources at different agencies. The design envisions a network of real-time knowledge based expert systems (KBES) running on separate microprocessors at each agency. The design of this system provides decision support to traffic management personnel through five integrated modules - detection, verification, response planning, and recovery. In a subsequent paper, Ritchie et. al. [3] describe a real-time decision support system for freeway incident management and control. The system, Freeway Real-Time Expert System Demonstration (FRED) operates on a simulated freeway network and addresses important decision support components such as, 1) management teams to be present at incident sites, 2) posting static alternate routes and 3) ramp metering.

The expert system of Gupta et. al. [4] for the Massachusetts turnpike selects alternate routes from a set of existing alternate route plans. Real-world implementation issues of the system are not discussed in detail in the paper. Gartner and Reiss [5], discuss a traffic control system design for New York that can be used for diversion, ramp metering and signal re-timing. However, these systems are not specifically designed for real-time incident management operations as they do not address other issues such as incident clearance, duration and delay.

The system developed by Siegfried et. al. [6] recognizes the spatial aspect of incident management by using an Geographic Information System for the development of an automated incident management plan for the Houston area. The study evaluates the use of a GIS to relate incident locations with the transportation network and to make decisions and calculations for incident management. By using a GIS development platform, it was possible to develop interrelated maps, databases, and incident management applications. The prototype applications developed for the automated incident management plan are grouped into two. The first type pertains to incident management operations like alternate routing, incident response and resource-management. The second type pertains to planning and analysis for incident management, like network and incident information query.

An important finding of this study is that a PC platform may not be suitable for real-time traffic management systems, using technologies such as automatic vehicle identification for traffic monitoring, where new data is received at short intervals of few seconds. The study strongly recommends the use of a workstation environment and the use of a programming language that parallels a higher level programming language.

Wide-Area Incident Management Software System (WAIMSS) was developed at the Virginia Tech Center for Transportation Research as a decision support system for coordinated incident management (Ozby et al., 1996). It was implemented in a UNIX environment in order to take advantage of UNIX operating system's powerful networking and computation capabilities.

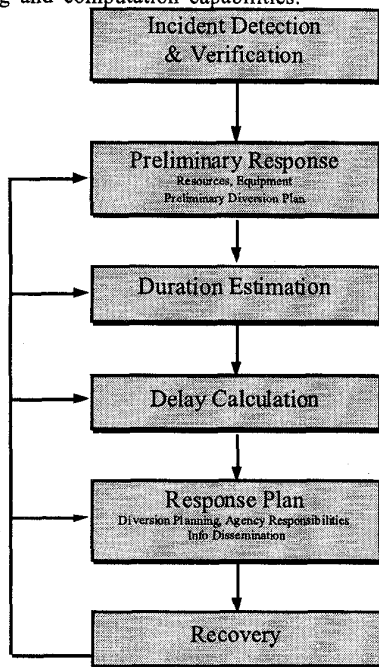


Figure 1. Modules of WAIMSS

WAIMSS was developed with the goal of assisting the various incident management personnel involved in finding the appropriate strategies to manage incidents, and in the execution of steps required for their implementation (Figure 1). Since these strategies usually call for a cooperative effort by several agencies, WAIMSS not only concentrates on addressing strategy development but also on supporting the various individual and agency level interactions that take place. Thus WAIMSS addresses two important facets of incident management:

- **Problem Content Support:** Content support may be described as the extent to which the computer based-system (hardware, software application programs, algorithms, heuristics, etc.) is capable of providing support to its users (individual or a group) in addressing issues related to incident management. These include incident duration estimation, delay prediction, clearance and diversion strategies etc.
- **Group Process Support:** This support task of WAIMSS facilitates and improves the dynamic group

decision process by enhancing participation and information exchange among the different groups working to manage each incident case.

In summary, existing systems address some specific aspects of the incident management process using tools that are mainly platform (operating system) specific. However, there are several issues that are not addressed by none of the above systems. These are:

1. The decision support system should be easily accessible by all the incident management agencies independent of the computer platform they use. It has to have very advanced networking capabilities to encourage real-time coordination among agencies.
2. It has to be easy to use and maintain. It should be located at a central location such as the Traffic management Center, but should be available to a number of agencies located at remote facilities.
3. The system should be easy to integrate with major database management and GIS tools. Most of the expert system shells such as NEXPERT-Object, that are used to develop the above DSS tools are not easily integrated with external programs.
4. The system should be user friendly. It has to have easy to use user interfaces. It should also be able to use real-time video, and sensor information efficiently.

With the advent of World Wide Web and Internet based programming tools such as, Java, it is now possible to satisfy all of the above requirements. Such Web based decision support systems will be platform independent and incident management personnel will be able to use them on any computer that has a Java enabled browser.

1.1 Internet and Transportation

The field of transportation is not new to the Internet. The Internet and the WWW are currently being used in a variety of different transportation-related applications mostly in the areas of electronic information dissemination, public relations, and conducting different types of business transactions. For example, several DOTs provide contractual services on the Internet. The WWW is also being used to provide real-time static, quasi-static and fully dynamic traveler information in different parts of the U.S. These ATIS applications employ text, graphics, maps, real-time video, and / or audio to disseminate information. Some of the current applications include Seattle Traveler Information Systems at Seattle, Atlanta, Blacksburg, VA, Phoenix, and Montgomery County, MD.

However, the use of Internet and Web based tools for real-time traffic management is a quite new concept. Web based tools offer an invaluable opportunity to develop next generation on-line decision support tools.

2. ADVANTAGES OF DEVELOPING A WEB BASED INCIDENT MANAGEMENT DSS

Some of the advantages of developing a Wide-Area Incident Management System on the Internet (WAIMSI) are:

1. This WEB based DSS can be used by any incident management agency that has access to the Internet and that has a Java enabled browser. The final product is thus platform independent.
2. Java provides excellent Graphical User Interface development tools for the development of very user friendly interactive interfaces.

3. Unlike traditional programming languages such as, FORTRAN and C, Java is object-oriented. It allows the development of highly modular programs that can be expanded or modified easily.
4. New Java compilers that have become recently available are 20 times faster than the olds versions of Java. This solves most of the speed problems related to the virtual compiler concept of Java.

3. WIDE-AREA INCIDENT MANAGEMENT SYSTEM ON THE INTERNET (WIMSI)

WIMSI is developed using the Symantec Visual Java development tool. The architecture of WIMSI is shown in Figure 2. According to this implementation architecture, WIMSI is accessible to any agency regardless of the computer platform they use. This is expected to reduce equipment purchasing costs, and eliminate training costs for learning new operating systems. For example, if an incident management system is developed in UNIX or OS2 operating systems, an agency that wants to use the system is required to purchase, install, and operate a UNIX or OS2 based computers. This, in turn means extra costs to that agency. New WEB based systems such as WIMSI will eliminate these extra costs. WIMSI can also be connected to data sources of all the involved agencies via the Internet. This will allow the incident management agencies to easily share different types of incidents and thus improve their efficiency.

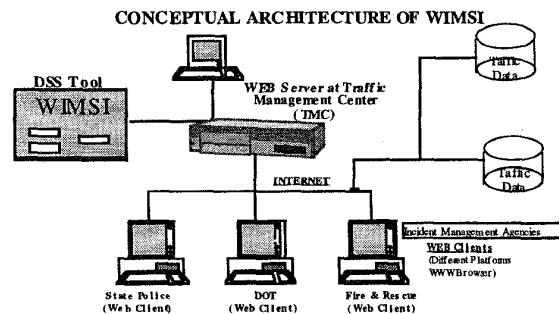


Figure 2. Conceptual Implementation Architecture of WIMSI

WIMSI is divided into 6 parts and 2 classes. The first class, **WIMSI.java**, executes all the main calculations and decisions based on the incident input values provided by the user in the input window. (Figure 3) The second class, **Response.java**, displays all the values calculated by the WIMSI.java class (Figure 4). The seven different parts of WIMSI are:

Part 1. It creates the input window program using elements from the class library Java.wat or Java's Abstract Windowing Toolkit available in the Java Developer's kit compiler.

Part 2. It calculates the number of response units needed using the response rules developed by Ozbay et al. (1996) and Ozbay et al. (1997).

Part 3. It calculates the estimated incident clearance time based on the models developed by Ozbay et al. (1997), and Kachroo et al. (1996)

Part 4. It dynamically generates the number of check boxes that correspond to the number of lanes entered by the user.

Part 5. It calculates the delay time and the time to normal flow using the clearance time calculated at Part 3.

Part 6. It sends all the calculated values to the Response.java class.

The complete prototype model that demonstrates the working of WIMSI can be run at (<http://www.civeng.rutgers.edu/trans>). The major functions of WIMSI are described in the next section.

3.1 Functions of WIMSI

WIMSI has 4 major functions:

1. User Interface and Incident Data Input Function(Figure 3)
2. Incident Clearance Duration Estimation Function (Figure 4)
3. Incident Delay Estimation Function
4. Incident Response Function

The screenshot shows the 'Incident Input Window' with the following sections:

- Operator:** Name, Agency (STATE POLICE), Date (11-01-97), Time (12:00), Location (7th Flrd 11).
- Network Status:** Select Agency, No. Lanes, No. Shoulders, No. Closed Lanes, No. Closed Shoulders.
- Lane Information:** No. of Lanes, Closed Lanes (checkbox), Closed Shoulders (checkbox), No. of Lanes After Closing (checkbox).
- Other Information:** Weather Condition, No. of Emergency Vehicles, No. of Closed Lanes, No. of Closed Shoulders.
- Weather Information:** Conditions (Change), Light (Bright).

 A 'Show Response' button is at the bottom.

Figure 3. User Input Window

The first function of WIMSI is the incident data entry function. The incident characteristics data include location, type, occurrence time of the incident, number of resources used to clear the incident, environmental conditions, and the number of total and closed lanes and shoulders. The preliminary resource determination is assumed to be made by the involved agencies. Later, WIMSI determines more accurate resource information based on the historical data and simple resource rules (Kachroo et al., 1996).

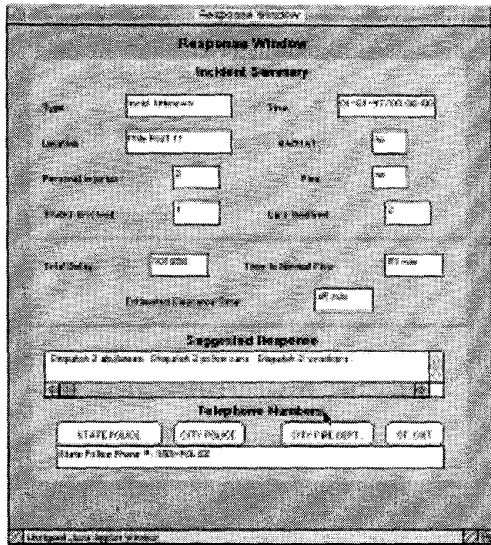


Figure 4. Output Window of WIMSI

The **Duration Estimation** module is probably the most important component that will add value to a preliminary response plan. Duration refers to the time interval that the incident is expected to last until completion of all clearance activities. The data for the duration module comes in from the agencies which inform the module about resource availability, and resources dispatched to clear the incident. The data used by the model is shown in Table 1. The incident duration and delay calculation functions use decision / forecasting trees to calculate the duration of the verified incident and the resulting delay (Ozbay et al., 1997). These trees are constructed using an extensive incident database developed as part of another related project (Ozbay et al., 1997). Each decision tree deals with a specific type of incident and uses incident characteristics to determinate incident clearance duration. The WIMSI architecture allows the various agencies to update the central incident data needed by this module. This data is then directly accessed by the duration estimation module and used for forecasting. Note that duration estimation will be continually improved as more data becomes available.

Table 1. Input Data for Duration Estimation

Input Data	Source Agency
Incident Type, Location & Time	Any client of system
Lane Closure Information	Any client of system
Weather	Any client of system
Wreckers Used	Towing Company/Police/VDOT/VSP
Police Vehicles Used	Police
Ambulances Used	Hospitals/Red Cross/Rescue Squad/Other Medical Agencies
Fire Trucks Used	Fire
Roadway Information	Static Data Base at TMC

The duration predicted by this function is used to calculate resulting delays due to the incident in the **Delay Calculation** module. In a routine operation, the incident clearance duration can be used to determine necessary incident management strategies. For example, at present, in

the Northern Virginia region, an alternate routing plan is generally established only if an incident is expected to last over 2 hours, especially during or just preceding peak travel periods [VDOT, 1990]. For such applications where there is a set traffic management strategies, it might be sufficient to rely on the predicted incident duration. But in most cases, such an approximation may not lead to efficient strategies because a given duration of incident has drastically different consequences depending on the time of day, the location of occurrence, and other factors. An incident on a freeway lasting 45 minutes during an a.m. peak could cause much more delay than one on a primary road lasting over two hours at 10:00 p.m. at night. Hence, it is very important to calculate the delays caused by the incident to measure the total impact on the traffic conditions over the network. Based on the estimated duration of the incident, the delay is calculated using appropriate queuing models. The system currently employs deterministic queuing theory for the delay prediction.

The **Response** function is employed to finalize the response plan based on the delay, duration, and current information on resource availability. A simple rule base that classify the severity of the incident occurrence based on the input parameters and to indicate the equipment required to clear the incident have been developed.

4. CONCLUSIONS AND FUTURE DIRECTIONS

New work is underway to enhance the capabilities of WIMSI. Among the future enhancements planned are:

1. Integration of WIMSI with Arc-View Internet server. This will provide WIMSI with the capability of presenting spatial information regarding each incident using a powerful GIS tool.
2. Integration of a powerful database management tool such as Oracle to handle large amounts of incident and traffic data.
3. Development of new functions for saving, sharing and analyzing incident data collected by the different agencies.
4. Integration of the real-time traffic video available through the DOT cameras in most of the major urban areas.

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