Intelligent Transportation Systems:
Development of Transportation Information Management System for a Small Urban Community

A Thesis in TCC 402
Presented to
The Faculty of the School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Systems Engineering

By
Daniel J Barrett

March 20, 1998

On my honor as a University student, on this assignment I have neither given nor received unauthorized aid as defined by the Honor Guidelines for Papers in Humanities Courses.

Signed_______________________________________ ____________________
Date

Approved _______________________________________ ____________________
Technical Advisor: Brian Smith **Date**

Approved _______________________________________ ____________________
TCC Advisor: Edmund Russell **Date**

Preface

This project was a collaborative effort between my Capstone team, my technical advisor, Brian Smith, and the two clients, the Jefferson Area Planning District and the Virginia Department of Transportation. I would like to thank the members of my Capstone team, Aaron Hagey, Tony Duus, Tracey Phillips and Paul Meszaros, for their efforts in making this center a success. I would like to thank my technical advisor Brian Smith for the advice and feedback he has provided throughout the year. I would also like to thank the representatives from both of our clients. Hannah Twaddell, Senior Planner, and Dave Roberts, GIS/Transportation Specialist, from the Jefferson District Planning Commission, and Emiliano Lopez and Rob Alexander, from the Virginia Department of Transportation (VDOT). Ms. Twaddell and Mr. Roberts helped the team understand and cope with the many political factors that went into the design of this center, while Mr. Lopez and Mr. Alexander helped us with many of the technical questions we had throughout the year. I also owe VDOT my thanks for contributing the money for the project. Finally, I would like to thank Professor Smith, and the representatives from both the clients for their efforts to find a place for the center to operate so all our hard work won't go to waste.

Abstract

The Jefferson Area Intelligent Transportation System (ITS) Study proposed several initiatives for Jefferson Area. The first in a series of four projects is the design and development of a Transportation Information Center (TIC). The central purpose of the TIC will be to enhance the transportation system be providing a service that collects, compiles and distributes transportation information. The availability of this information benefits many groups of people, including commuters, University of Virginia Students, Parents, and alumni, and tourists. It also provides the groundwork for the other ITS projects.

Intelligent Transportation Systems attempt to use computers and communications technology to improve complex transportation systems, making them safer and more efficient. Most of the current systems in place are in large cities, where traffic is a major problem and large amounts of money are available to develop and maintain them. The challenge in designing the TIC in Albemarle County, therefore, was to determine how to design this center with a limited budget.

The design of the center's information management system required several steps. The first steps concentrated on the design of the center as a whole. They included the problem definition, goal development, functional requirement analysis, and the preliminary designs of the information collection and distribution systems. Once we completed these steps, we designed the information management system by determining alternative methods, evaluating the methods and choosing the optimal solution.

The final design of the center is a robust design that has a lot of room for expansion. With it, we met the requirements we set out to and did it all within budget.

Table of Contents

Chapter 1 Introduction

Intelligent Transportation Systems (ITS), transportation systems employing computer and communications technology to make them safer and more efficient, have proven beneficial in many major cities across the globe [Lindley, 1997; Taylor, Feb. 1997; Wright 1996]. However, as of yet, there is little attempt being made to achieve these benefits in small urban areas [Taylor, June 1997]. The Jefferson Area ITS Planning Study addressed this problem by developing a market strategy and a strategic deployment plan for ITS in the Jefferson Area [Taylor, Feb. 1997; Taylor, June 1997]. The first project presented in the strategic deployment plan is the design and development of a Transportation Information Center. The center's overall purpose is to gather, compile, and distribute transportation information for Albemarle County. The availability of this information benefits the public and lays the groundwork for future ITS projects [Taylor, June 1997]. The focus of this thesis is the design of the center's information management system. The information management system is a combination of computer hardware and software that allow the TIC to manage the information flowing in and out of the center.

1.1 Rational

The transportation system in Albemarle County is plagued with many of the same transportation problems faced in major metropolitan cities. While the number of vehicles traveling on Albemarle's roads may be significantly less than in major cities, the limited number of primary roads and lack of alternate routes cause daily congestion problems. Events held by the University of Virginia and Albemarle County add to the problem, making it a nightmare to travel across town during them. In many major cities, Intelligent Transportation Systems have helped to reduce these problems.

As there is currently no model for ITS initiatives for small urban areas, the Virginia Transportation Research Council for the Thomas Jefferson Planning District Commission began the Jefferson Area ITS Planning Study in June 1996. This study's purpose was twofold. The major purpose of the study was to evaluate the effectiveness of available ITS market packages in solving the transportation problems of the Jefferson area. The study also served as a test case for planning ITS initiatives in Virginia's smaller urban areas. Upon completion, the study outlined the ITS market packages it found would best support the area in solving its transportation problems, and proposed a strategic deployment plan to implement these packages.

The first project that the study proposed to implement was the Transportation Information Center (TIC). This project combined the network surveillance and traffic information dissemination market packages. The study recognized the area's need for a central location to collect, compile, and distribute transportation information from the area. This service will provide a tremendous resource for travelers and act as the basis for future ITS projects.

Currently, there are many organizations in Albemarle County that, through their daily operations, know when and where traffic problems exist. The emergency 911 center and the police receive reports of accidents that back up traffic. The public works department, power companies, and phone companies create congestion when they close lanes of traffic to do work. Event coordinators know the times and places of events, expected turnouts for events, changes in traffic patterns made for events, and parking locations for events. The police or event staff in charge of directing traffic for an event may know where congestion is the worst and the status of the parking lots.

The TIC uses these organizations as a major source in creating a complete, up to date, reliable picture of the Albemarle County transportation network. Additionally, the TIC uses surveillance sources, including inductive loops and acoustic detectors to further enhance this information. Each of the surveillance sources will allow the TIC to constantly monitor the conditions of one particular high problem area on the roadway. Finally, the TIC provides access to information about regional and inter-regional transit and ridesharing, maps of bicycle paths, and directions to tourist attractions.

Many different groups of people will benefit from the information provided by the TIC. The police will no longer need to contact the local media when there is an incident on the roadway. They will simply contact the TIC, which will forward the information to the appropriate organizations. These organizations will have more reliable information to report, as the TIC will constantly monitor the situation. Local commuters will be able to obtain traffic reports before leaving for work, allowing them to plan their trip accordingly. University of Virginia students, parents, and alumni will be able to access directions, traffic reports, and parking information to better prepare them for big university events, such as move in weekend, graduation weekend, homecoming, and sporting events. Tourists will be able to navigate the area more easily. Potential travelers can access the current state of the roadways, allowing them to make an informed decision as to whether they should leave or wait. Finally, the TIC will lay the groundwork for future ITS projects.

1.2 Objectives

In developing the information management system for the TIC, several objectives were defined to measure its success. These are:

To provide an operating environment that will allow the TIC operator to easily manage the information coming into the center.

To provide the TIC with the communications network needed to receive and transmit the transportation information.

To enable the transportation information to be easily distributed.

To furnish the TIC with the resources needed to meet its functionality requirements in the defined budget constraint.

1.3 Review of Relevant Literature

Intelligent Transportation Systems research began in 1991when the Intermodal Surface Transportation Efficiency Act was passed, authorizing a program to research, develop, test, and evaluate the application of advanced electronic systems in transportation systems [Gangisetty, 1995; Lindley, 1997; Taylor, June 1997]. The act launched the ITS initiative in an attempt to improve the safety and efficiency of existing transportation systems. The Intermodal Surface Transportation Efficiency Act foresaw the current transportation infrastructure, equipped with ITS, providing a large portion of the new capacity that the continuing increase in travel demand will require [Lindley, 1997; Yamada, 1996]. Since then, the ITS program has identified several projects that are currently underway. These include the development of ITS standards, the research of enabling technologies, the field operational testing of over seventy ITS technologies and services, and more than seventy-five ITS deployment planning studies in metropolitan areas [Lindley, 1997]. Until the Jefferson Area ITS Planning Study, however, there has never been a project initiatives identified that focus on the implementation of ITS in a small urban area. According to this study, a conservative estimate of the benefit cost ratio of the proposed ITS projects is 3.5 to 1 [Taylor, June 1997].

ITS projects in large cities require multi million dollar budgets due to the tremendous size and usage of the transportation networks in these areas. The high costs have brought about questions of funding sources. The SmarTraveler Information Center in Washington, D.C., for example, has a 12.2 million-dollar budget over the next three years [“SmarTraveler”, 1997]. These centers operate with resources including complex systems of automated detectors, large computer networks, volunteer probes, cooperation from many public organizations, and full time staffs. The transportation network in Albemarle County is not on the same scale as those in cities such as Washington D.C., and as such, the amount of money available for this project was a fraction of that available in these larger cities. The major challenge in designing the information system of the TIC, therefore, was to determine the best mix of high and low cost design options to allow the TIC to meet its needs within budget.

There are two major classes of data sources that other centers use, fixed-location surveillance, and all other sources [Ivan, 1997; Taylor, Feb 1997; Taylor, June 1997; Yamada, 1996]. Fixed-location surveillance sources are hardware components installed to take traffic measurements of one location in the roadway. Examples of these sources include video systems, inductive loop detectors, laser detectors, weigh-in-motion technology, and acoustic detectors. The benefit of these sources is that once in place, they can monitor a specific location constantly. The disadvantages of these sources, however, are that the data coming in from them is not always accurate and needs to be interpreted, installing them can disrupt traffic, and communications links can be expensive.

The other class of sources includes information gathered from public organizations and vehicle probes. These sources allow the center to hear about incidents by listening to scanners, or receiving a phone calls or faxes. These communication links required for these sources are very easy and inexpensive to establish. With the cooperation of the right mix of sources, the center can obtain a good overview of the transportation system. However, getting and maintaining this cooperation can be difficult.

The design of the information management system must take into account the human factors involved in the operation of a TIC. Human operators are a crucial component of the effectiveness of a TIC. Studies have shown that "the design of the [system's] concept of operations and the design of the operator-system interfaces, such as system controls and computer displays, and have major impact on the efficiency of the operators" [Sobhi, 1997]. Experiments at the Georgia Institute of Technology were conducted to develop a set of design guidelines that account for human factors in the development of traffic management centers [Sobhi, 1997]. These centers have many of the same operational procedures the TIC will have, allowing the guidelines to apply to the design of the TIC.

1.4 Report Outline

The next two chapters outline the design process of the Transportation Information Center's information system in two phases. The first phase includes steps taken by the group that provided the basis for the design of the center's information management system. The second phase was the process used to actually develop, implement, and test the design of the information management system.

The last chapter reports the results of the final design of the system and how it enables the TIC to function properly. It also explains changes that have occurred in this project and describes possible future projects that would add to the system.

Chapter 2 Preliminary Design Development

Before the design of the Transportation Information Center's information management system could begin, the group needed to complete several steps of the design process for the entire center. First, we determined the problem the TIC was set out to solve and the goals of the TIC. Then we used the problem and goals to develop a set of functional requirements for the center. Finally, we designed of the information collection and distribution systems.

2.1 Problem Definition and Goals Development

Using the Jefferson Planning District Study as our basis, my Capstone team and I brainstormed to determine the problem the TIC set out to solve and the goals of the TIC. We saw the problem with Albemarle County's current transportation system to be that while many organizations gather transportation data independently, there is no central repository for transportation information, no analysis of the information and no distribution of the information to the public [Barrett et al., September 1997]. Using this problem statement, we set out to determine the goals of the TIC. We organized the goals into a goals tree (Figure 2.1). The top goal, to enhance Albemarle County's transportation system is the highest level goal of the TIC. Each of the subordinate goals listed work to achieve the goal directly above it. Organizing our goals in this fashion left the bottom level of goals as a rough draft of the basic functional requirements of the system.

After completing this first step, the team met with the clients to report the progress we had made and get feedback from them about our ideas. The clients approved the work we had done and gave us some new insight on the project, including their preliminary ideas for the functional requirements and the design.

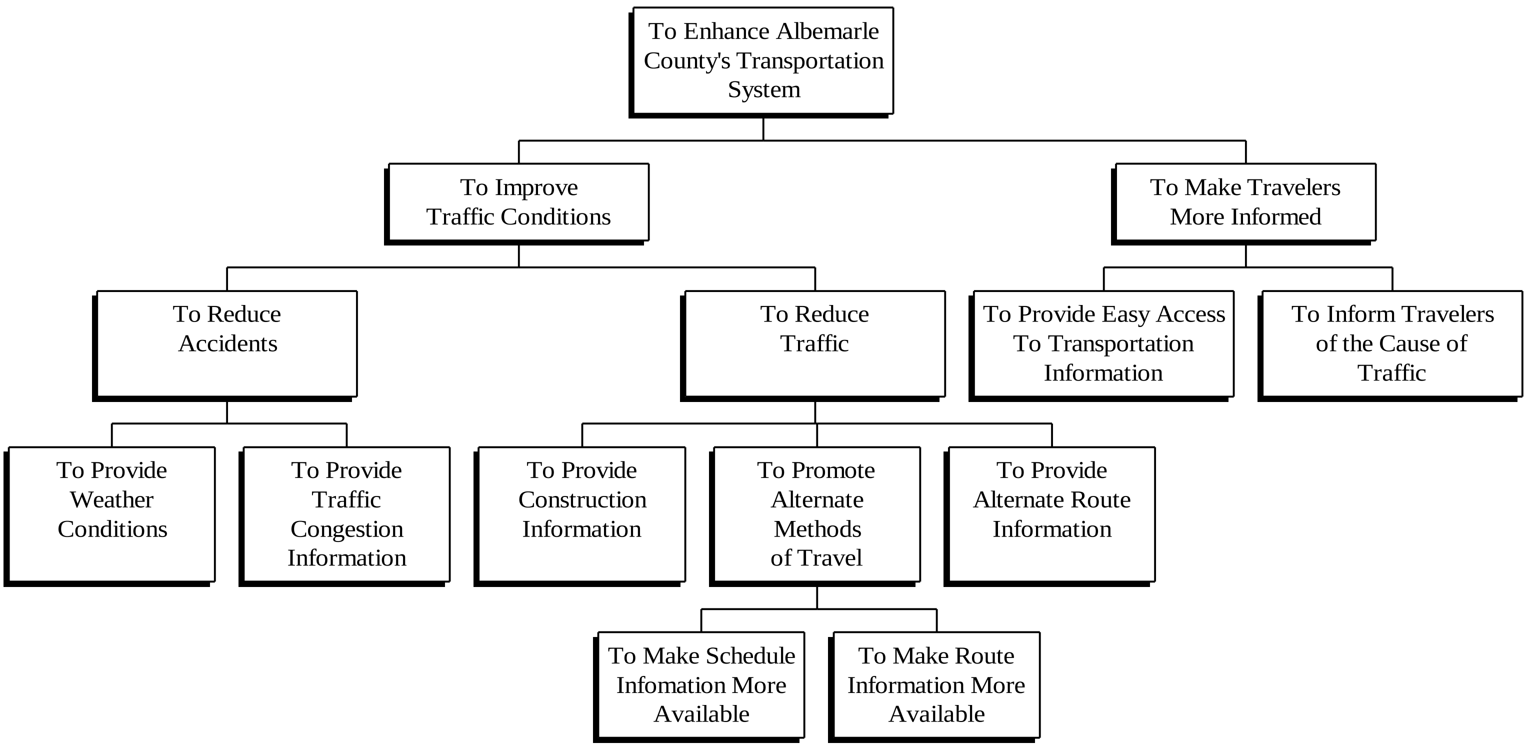


Figure 2.1 Goals Tree [Barrett et al., September 1997]

2.2 Functional Requirements

In the next step of the design, we determined the capabilities required of the center in order for it to meet its goals. During its development, the functional design went under several revisions based on feedback given by our clients and technical advisor. We also examined the operations of other centers to see the services they perform and the methods they employ to bring about these services. We visited the SmarTraveler center in Washington D.C. and the Traffic Management Center in Northern Virginia. We also used ITS Online (www.itsonline.com), a web resource that contains links to ITS articles and homepages of centers similar to the TIC, to aid us in drafting the functional requirements. The following section summarizes the functional requirements as written in the teams function requirements document [Barrett et al., November 1997].

The types of information that the center collects are broken up into two types, real-time information, and static information. The four varieties of real-time information the center collects are incident, construction, inclement weather, and special event. Incidents include any planned or unplanned event that affects traffic but does not fit into any of the other three categories. Accidents, traffic signal failures, and road closings, for example would all be labeled as an incident. The TIC should obtain incident information within five minutes of occurrence.

Construction that affects traffic can be either planned far in advance, such as highway renovation, or be the result of some natural disaster, such as a downed telephone pole. The TIC should have the information for planned construction activities entered into the system within a week of the start date. The TIC should have the information for the unplanned construction within five minutes of the construction start.

Inclement weather, such as snow, patches of ice and fog, make roadway conditions much less safe for travel, however obtaining accurate up-to-date information about how the weather is affecting the roadway would be very expensive. The requirements for collecting this information, therefore, are not that strict. The major requirement is that if the center does enter weather data into the system, the data must be verified and continually updated until it clears up. The basic real-time information the center collects for each of these instances is the start and end times, their location, and a description.

Finally, the center will provide information on all events held in Albemarle County. The TIC will enter general information, such as the name, location, and schedule one month before the event begins. One week before the event begins, the TIC should have parking information, any changes in traffic patterns, and directions to the event. Finally the day of the event, the TIC should track the availability of the parking lots and status of the traffic pattern changes. The credibility of the center is very important for its success; therefore, the most important aspect of all the real-time information is that it be accurate.

The types of static information the TIC provides access to are regional and interregional transportation options, bicycle routes, and local attractions. The TIC provides access to regional and interregional transportation information such as, the location of their stops, stations or airports, their routes, their schedules, and their cost structures. The TIC also provides maps of bicycle paths for the area. Finally, the TIC provides access to information on local attractions.

The information that the TIC collects is stored in a relational data model. The database management software package the TIC uses to store the information must use Structured Query Language (SQL) to manipulate data. It also must be compliant with Open Database Connectivity (ODBC) standards to allow the data transfers over a network.

The information management software should have an easy to use graphical user Interface (GUI), with look and feel of common windows programs. The TIC operator should be able to use a map interface to enter in any location fields required for a new entry. The software should also use maps to allow the operator to quickly view the current information in the database.

The two mediums the TIC should use to distribute its information is through the World Wide Web and faxes to local organizations. Web pages must be able to access the TIC database in order to display the most current information. The web interface should allow the user to view customizable maps that display the information they want to see. The maps should also be used extensively to highlight direction and route paths for easy viewing. The users should also able to access links to regional and interregional transportation organizations and local attractions. When the operator enters new information that other organizations want to have, the faxes should be generated and sent automatically.

There were some requirements that we discussed including but decided not to. The first was to include alternate route information when there was an accident or construction work backing up traffic. We decided however, since the majority of alternate routes would suggest that people use neighborhood roads, that we may anger people in these neighborhoods and we shouldn’t do it. The center, therefore, provides information on where problems exist, allowing the users to do what they wish with the information and relieving the center of any liabilities.

Another requirement that was not accepted was to provide real-time traffic flow data for primary roads. The two reasons we rejected this requirement were reliability and money. Again, the reliability of the information supplied by the TIC is paramount to its success. The resources currently available to TIC to get information on traffic flow are not very reliable. The cost to implement new equipment that would be reliable would be too costly for the current TIC budget. As such, we decided that in developing our design we would determine the potential benefit these sources would provide and leave room in our design to possibly incorporate these sources in the future.

2.3 Design of Information Collection and Distribution Systems

Before designing the information management system, it was first necessary to determine how the information would be collected and how it would be distributed. The next two sections describe the development of these designs. The first section describes process we used to determine and evaluate the design alternatives for the center. The second section reports the final design.

2.3.1 Design Alternatives

We determined our design alternatives by conducting interviews and continuing our research of the designs of other centers. With help from our technical advisor and feedback from our clients we evaluated the effectiveness of these alternatives.

After visiting the SmarTraveler and Traffic Management Centers and viewing web pages devoted to providing real-time traffic information, we found two hard data sources that most of them used: inductive loop detectors and video cameras. Inductive loop detectors are used to provide traffic counts, to measure highway speeds, and to aid in incident detection. The detectors consist of coils of wire that are positioned in a square and buried in the road. The inductance, which measures the amount of charge running through a coil of wire, of the wire increases when the metal from a car passes over it. Computer systems, located in a roadside cabinet, detect this change in inductance and can tell when and for how long a car is passing over the loop. With this data, the computer systems can tell the approximate travel speed of the vehicles ["Seattle Area"].

Intersections on Route 29 between the 250 bypass and Rio Rd. have loop detectors that the TIC can access. While these detectors perform the same functions as the ones used on the freeways by the larger centers, they would not provide as much useful information. This is because cars on Route 29 are continually stopping and going over the loops because of the traffic lights. While the count information from the detectors is still fairly accurate, the speed information would be hard to interpret.

The video cameras used by other centers allow the operators to get a visual picture of the current traffic conditions. They provide information on accidents, approximate car speeds, and areas of congestion. The centers also feature these video feeds on their web site, allowing users to get live pictures of different corridors at regular intervals. While installing cameras would enable the TIC to get a lot of the information it needs, we determined that this information could be obtained at a much lower cost through other means.

Another hard data source available to the TIC is the Afton Mountain Fog Detection System. This system contains sensors that detect the amount of fog present on the mountain and turn the fog lights on when they are needed. The TIC can receive this information and pass it on people through the web site.

Soft data sources are a much lower cost and less technical, class of sources that some of the centers used to obtain information. The two types of soft data sources the centers used were public agencies and vehicle probes. While some centers used these sources sparingly and many other centers that did not use them at all, the team felt that since we were designing this center in a small urban environment, these would be the most cost-effective sources of information for the TIC.

To determine what agencies could act as data sources for the TIC, the team conducted interviews with the potential agencies that set out to determine four things:

- What information the organization has
- How they get their information
- Who do they currently contact with the information
- How can the TIC get the information

During these meetings, we also attempted to explain the benefits the TIC would provide, in order to persuade them to help us. We interviewed the following organizations:

- Police
- E-911
- Emergency Medical Services
- VDOT Resident Engineers
- Regional Planners
- Public Works
- Local Utilities
- Events Coordinators

2.3.2 Design Documentation

The team depicted the design of the TIC information collection and distribution systems by creating a set of system flow diagrams. These diagrams show the flow of the inputs and outputs of processes that enable these systems to function properly. The first, or context, diagram describes the most general flow for the operation of the system. Each subsequent diagram takes a process and decomposes it into sub-processes, showing more detail. We described the final design by documenting all of the lowest level decompositions. After these, we described the design of the web interface.

Information about special events comes from the event coordinator in charge of the event, the police officers or event staff in charge of directing traffic for the event, and any information the TIC has in its database from previous instances of the event. The operator enters the information into the database. Any time the status of a parking lot or traffic pattern changes, the police officers or event staff in charge of directing traffic will notify the TIC and the operator updates the system. Once the event is over, the TIC stops tracking the event.

Public utility companies (Virginia Power, Charlottesville Public Works, and Sprint Centel) and the Virginia Department of Transportation are responsible for road construction in Albemarle County. Contacts from these organizations will notify the TIC of their construction plans. The TIC operator will enter the construction information into the system.

The TIC operator will use weather reports and direct observation to determine when to track snow coverage on the main roads. When plowing information comes in about a particular road from the Virginia Department of Transportation's Resident Engineers, the operator will update, the status of the road. Vehicle probes will report information on flooding roads, icy patches of road and fog. The operator will check this information for accuracy before entering it in the system. When the weather condition becomes clear, the operator will close out the entry.

Most of the time, early detection of an incident will come from listening to the scanner or from a probe calling the center. The operator will follow this up by either calling the police or waiting for the police to contact the TIC to validate the information. Once the operator verifies the information, it is entered into the system. One piece of information the operator will get is the approximate time until the incident will be cleared. After this amount of time elapses, the operator will check on the status of the incident by contacting the police. The operator will enter any new information into the system until the incident is cleared.

When someone requests the TIC web site, the page that the TIC server generates is based on the inputs selected on the page (or the defaults specified in the HTML documents). These inputs tell the server what information the user wants to see. The server generates queries in order to retrieve the correct information from the databases. One query accesses the data in the TIC database to get any textual, descriptive, information and another query accesses the map data to generate the correct map. The server inserts the results of these queries into the base HTML document and generates the final page to display in the client browser.

When the TIC receives any information, the operator must decide whether or not to send the information to anyone and who to send it to. The operator will base the decision on predefined lists of organizations and the information they would like to receive. The operator will use discretion when small events occur or a situation only changes slightly. If the information is accepted as faxable data, the system will generate a report of the event and send it out over the computer.

The TIC will archive out of date data. The system makes a decision date the record was deactivated is used to a decision is made on whether a particular record in the database meets the archiving requirements. If it does then it is transferred to a zip disk so that it can be archived permanently. The data will then be deleted from the database.

The TIC homepage will use a MapObject map control to display a map. By default the page will display a map of Charlottesville, although other standard views (e.g. Albemarle county, UVA, Emmet Street, Downtown) will be available from a pull down menu. Next to the map is a list of check boxes with all the available reports, Incidents, Construction Sites, Inclement Weather and Special Events, the map can display. Each report is displayed in a different map layer labeled with different icons. By default all layers will be selected. When changing the report options, the user must hit the Refresh button to redraw the map to the new specifications. The HTML Form will post the new parameters to the web server and the new page will show the map with only those layers selected.

Above the map will be a group of radio buttons that allow the user to pick the function they want to perform on the map: pan, zoom in, zoom out, get details about one of the icons, or refresh. After selecting the appropriate button and then clicking on the map, the browser sends a request to the server to perform that operation on the map. The server generates and displays the desired result.

Chapter 3 Design of the Information Management System

Once the team determined how the information was going to come into and out of the system, we were able to begin developing how the information management system would process the information once in the center and make the information available for output once in the system. The first step we took was to evaluate design alternatives. After this, we used the design alternatives and the functional requirements to document the proposed design for the system. Finally, we implemented the design.

3.1 Design Alternatives

Each of following sections describes a particular design issue. We determined the alternatives for each issue and evaluated them. Then we chose the best alternative.

3.1.1 Database Server

Based on the functional requirements, there were many options for the database server. After meeting with J. W. Gentry, a Network Administrator in the McIntire School of Commerce at the University of Virginia, we narrowed our options down to three. These were Oracle, Microsoft SQL Server, and Microsoft Access. While the first two options were very robust and flexible, they were much more expensive and harder to use. According to Mr. Gentry, Access is reliable for databases with twenty thousand records or less and a small number of users accessing the data. Since we did not foresee the database ever getting that large or many more than two users using the system at once, we chose to use Access.

3.1.2 Computer Network Architecture

The TIC computer system is connected in a client – server network (Figure 3.1). The server contains the Web Server Software and the Database Server. The client contains the information management system.

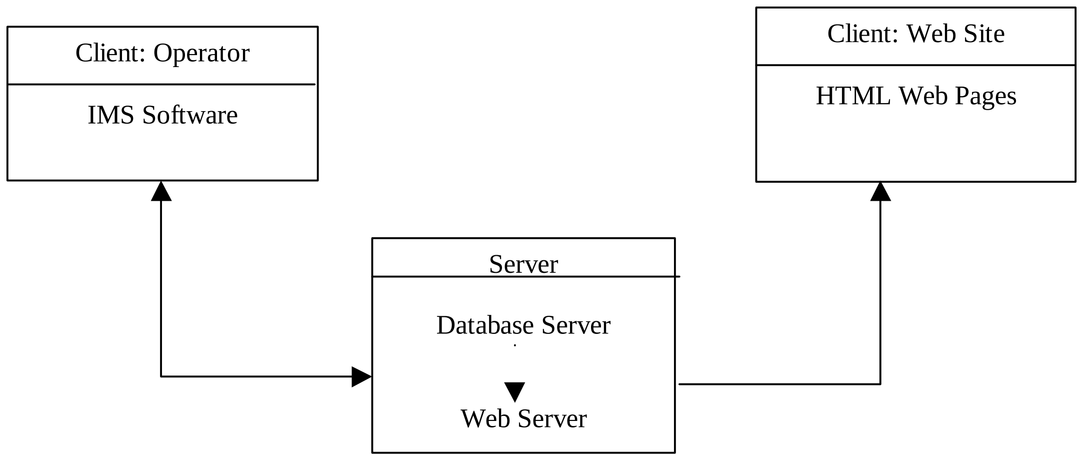


Figure 3. 1

The absence of a final location for this center produces two possible network scenarios. It may be possible that the center will operate in a location that is not able to provide Internet access. In this case, the TIC needs at least two computers. The computer that serves the web page has to be located at an Internet Service Provider. The computer that contains the information management system, therefore, would have to connect to the server through the Internet Service Provider over a TCP/IP connection in order to transfer data back on forth.

If the center operates in a location that is able to provide Internet access, then the computers could be connected on a local area network. In this case the computers could communicate using the NetBIOS protocol. The design of the system must be able to account for both of these scenarios.

In our conversation with J. W. Gentry, he told us that the most important aspect of choosing the operating system for the TIC was to consider who would be maintaining the system after we leave. Another important factor was the operating system we were most comfortable working with. Since VDOT and we both use the Windows NT operating system for the most part, this is what we chose.

3.1.3 Software Development Environment

There were several different characteristics we examined in determining the software development environment to use to develop the information management system. They were:

- Ease of use
- Cost
- Scalability
- Mapping capabilities
- Maintainability

Based on these criteria, we chose to use Visual Basic to develop the system. We also decided to use MapObjects, which is a collection of ActiveX controls that allow you to add maps to your program. MapObjects also has an internet server that is used to publish these maps on the web.

3.2 Design Documentation

The information management system will allow the TIC operator to manage all of the information that flows into and out of the center. Each of the functions of the system will flow from the main screen. The top of the screen will have a menu and a toolbar creating easy access to all of the functions of the software. The map will appear on the right of the main screen as a tool-window. This window will always be visible and always remain on top of the other windows. The remaining space provides an area for the operator to view information and enter information into dialogue boxes.

3.3 Design Implementation

The final phase of the design is the implementation. During this phase, we are developing three prototypes, adding more functionality to each. After each prototype, we are testing the functionality and allowing the clients to use the software to test its user friendliness. Currently we are finishing the second prototype.

The first prototype simply contained the design of the interface, including the windows, menus, and dialogue boxes. The menus and command buttons on the interface were given limited functionality in order to demonstrate how windows would flow from one another, but no other functionality was incorporated into this prototype. The major objective of this prototype was to give the clients an idea of what the software was going to look like and let them test the user friendliness of the design. After hearing the comments given by the client, we decided to change the application from a single document interface to a multiple document interface. We also decided to include the map as a tool-window that would always be visible and always be on top of everything else.

The second prototype added the functionality allowing the software to interact with the map database and the TIC database. The third prototype should be a fully functional system. After the third prototype, final testing will take place. These tests will include simulated and actual run-throughs of the daily operation of the TIC. We will test many situations to make sure that all of the functionality works and to determine operator performance and efficiency.

Chapter 4 Conclusion

The information management system for the Transportation Information Center allows an easy way for information to be stored, so the system can distribute it to the users. The design is robust allows for future additions and changes in the network architecture.

The implementation of the information management system is not yet complete. Preliminary prototypes suggest that the final product will indeed do everything that it set out to do in the design within budget, however the real impact the Transportation Information Center will have on Albemarle County's transportation system is still unknown.

The center should eventually attempt gathering data from more hard data sources, such as loop detectors. The center may also want to incorporate a telephone hotline to supplement the data distributed over the web. This would make the information more readily available to travelers already in their cars.

The Jefferson Area ITS Planning Study Strategic Deployment Plan outlines several future ITS initiatives that can use the TIC as the basis of operations. They include coordination of traffic signal systems, using automated vehicle location technology to improve the transit system, and enhancing the web site to aid in trip planning.

References Cited

Barrett, Daniel J., Anthony Duus, Aaron Hagey, Paul Meszaros, Tracey Phillips. "Design Document: Jefferson Area Transportation Information System." Unpublished Manuscript January 1998

Barrett, Daniel J., Anthony Duus, Aaron Hagey, Paul Meszaros, Tracey Phillips. "Functional Requirements: Jefferson Area Transportation Information System." Unpublished Manuscript November 1997

Barrett, Daniel J., Anthony Duus, Aaron Hagey, Paul Meszaros, Tracey Phillips. "Jefferson Area Transportation Information System: Introductory Presentation" Unpublished Presentation September 1997

"D.C. Area's SmarTraveler Information Center Opens." *ITS America News* August 1997: 8 - 9

Gangisetty, Ramesh, and Douglas W. May. "Traffic and Incident Management System for I-95 in the Philadelphia Area." *ITE Journal* February 1995: 37 – 44.

Ivan, John N., and Shyuan-Ren Chen. "Incident Detection Using Vehicle-Based and Fixed-Location Surveillance." *Journal of Transportation Engineering* May/June 1997: 200-215.

Kanninen, Barbara J. "Intelligent Transportation Systems: An Economic and Environmental Policy Assessment." *Transportation Research Part A – Policy and Practice* January 1996: 1-10

Lindley, Jeff. "Moving Forward Smartly: The Role of ITS in the NEXTEA." *Public Roads* Winter 1997: 57 – 60.

Scherer, W.T. "Proposed Development Plan: Charlottesville Transportation Information Center." 1 – 5.

Sobhi, Nazemeh, and Michael J. Kelly. "ATMS Human Factors Experiments Produce Design Guidelines." *Public Roads* Spring 1997: 7 – 9.

Taylor, Richard V., and Brian L. Smith. "Jefferson Area ITS Planning Study: Market Package Plan." 21 Feb. 1997: 1 - 26.

Taylor, Richard V., and Brian L. Smith. "Jefferson Area ITS Planning Study: Strategic Deployment Plan." June 1997: 1 - 47.

"Seattle Area Traffic Conditions: Frequently Asked Questions." http://www.wsdot.wa.gov/regions/northwest/nwflow/faq.htm

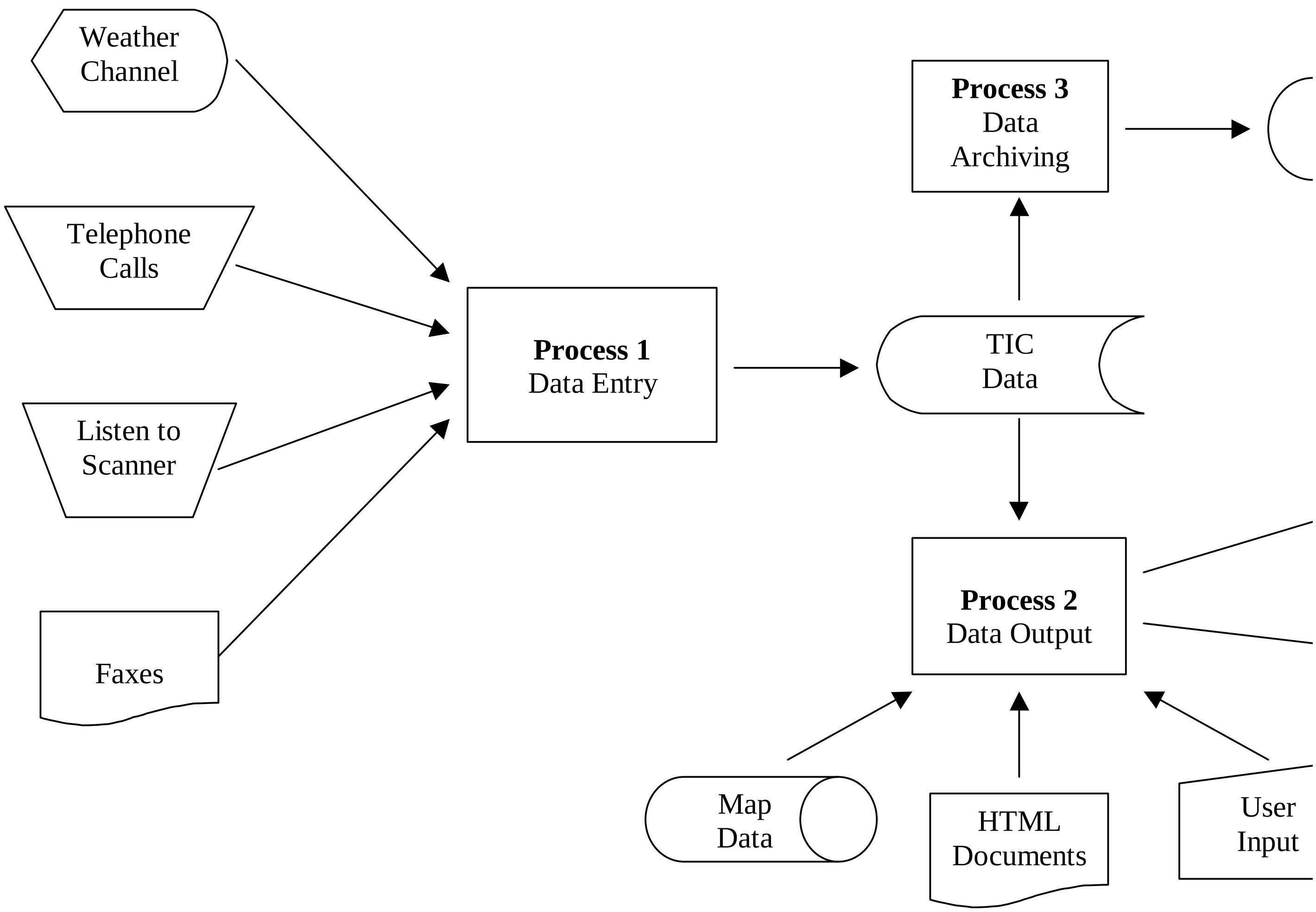
Wright, James L. "ITS Projects in St. Paul: DIVERT and Advanced Parking Information Systems." *ITE Journal* September 1996: 33 – 35.

Yamada, Shinsaku. "The Strategy and Deployment Plan for VICS." *IEEE Communications Magazine* October 1996: 94 – 97.

Appendix a System Flow Diagrams

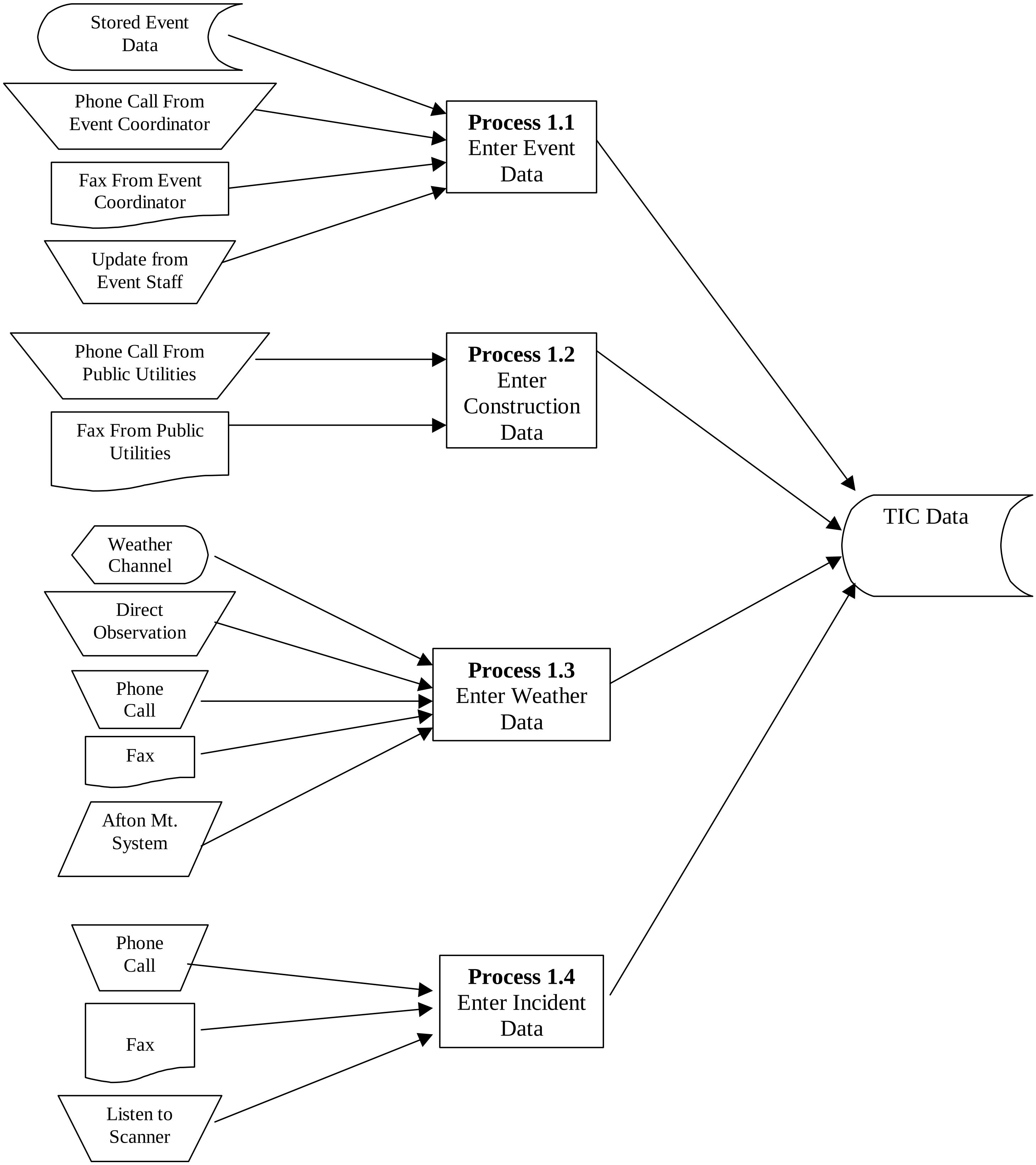
Context Diagram

[Barrett et al., January 1998]



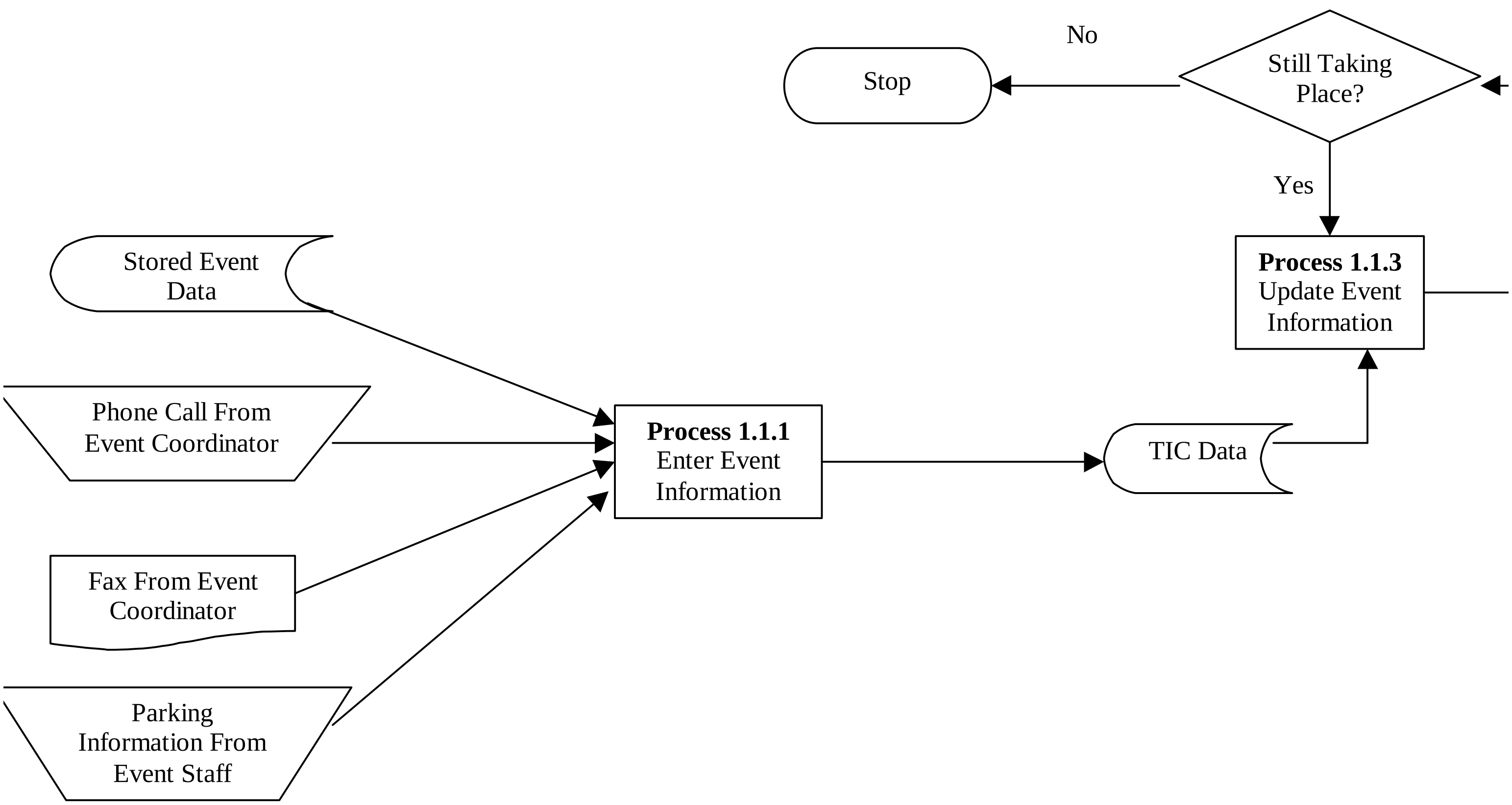
Decomposition of Process 1.0: Data Entry

[Barrett et al., January 1998]



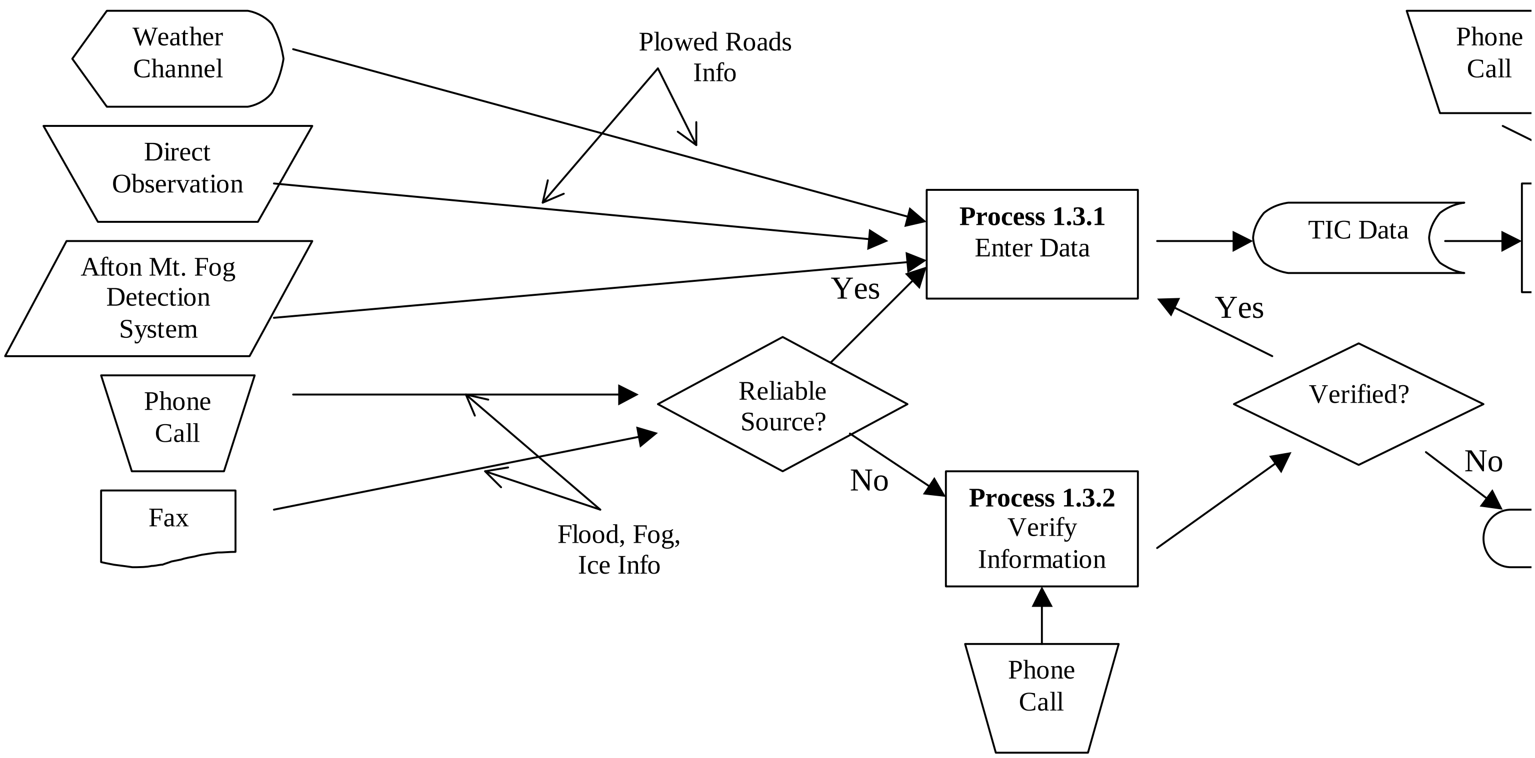
Decomposition of Process 1.1: Enter Event Data

[Barrett et al., January 1998]



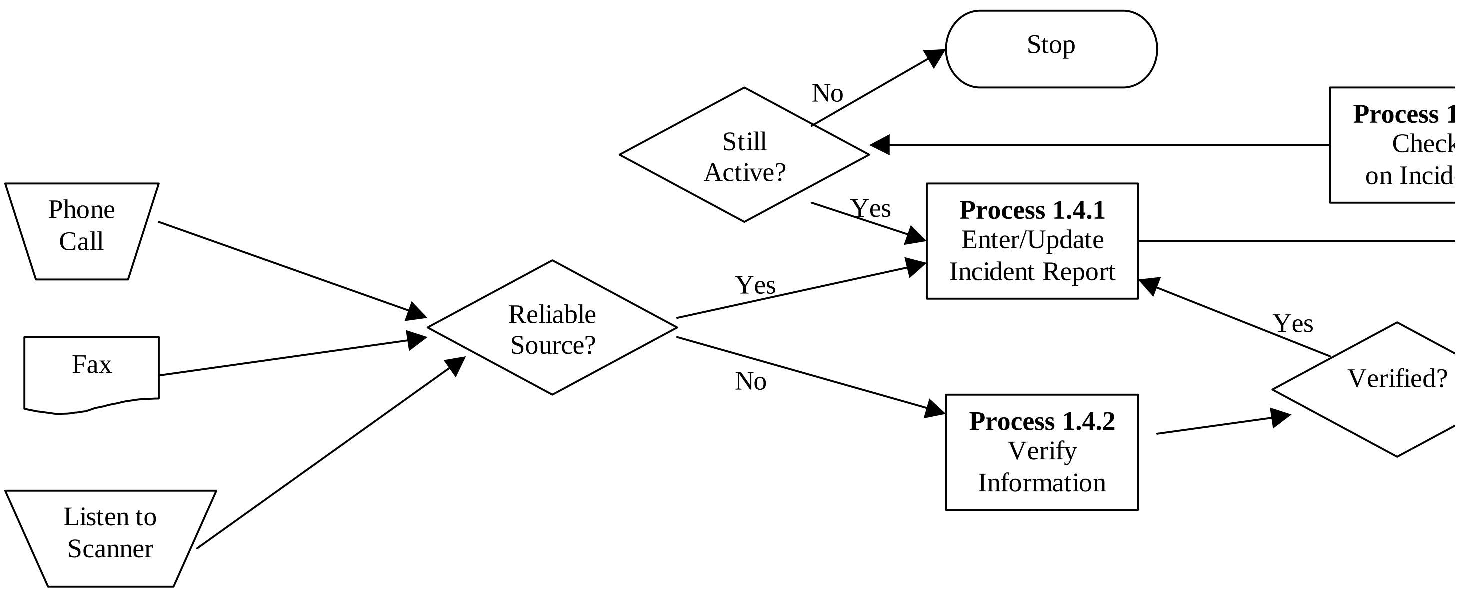
Decomposition of Process 1.3: Enter Weather Data

[Barrett et al., January 1998]



Decomposition of Process 1.4: Enter Incident Data

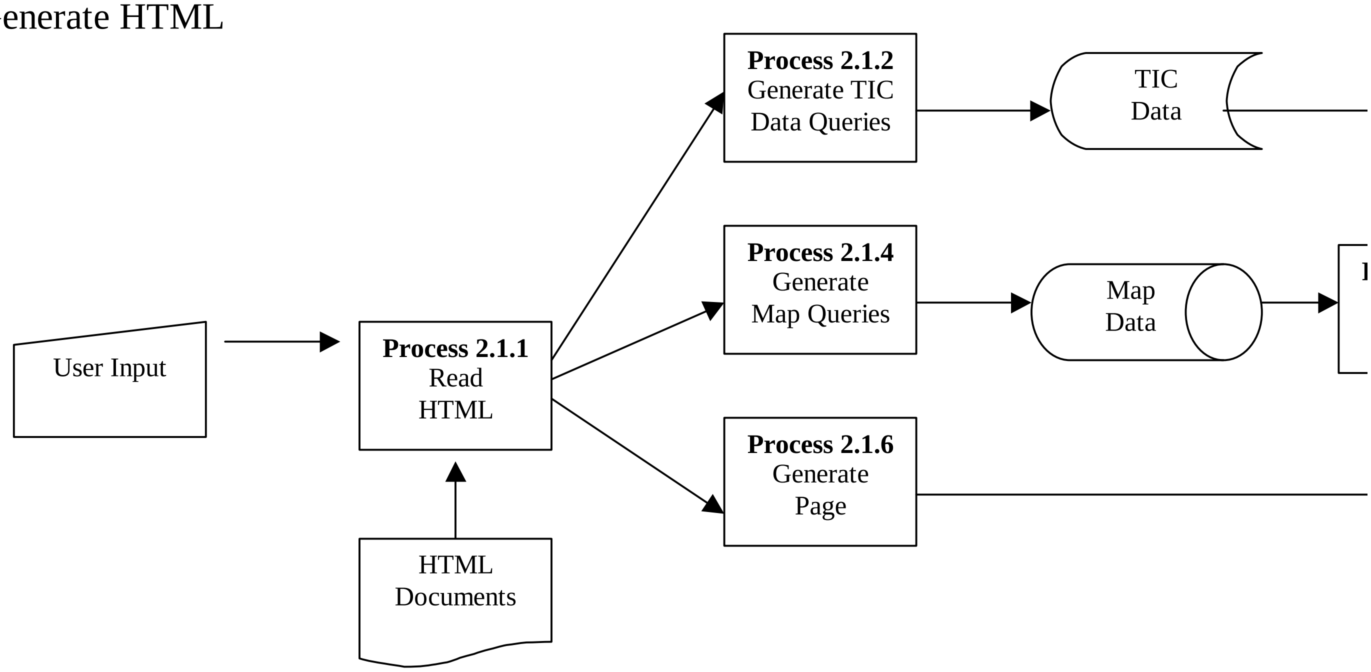
[Barrett et al., January 1998]



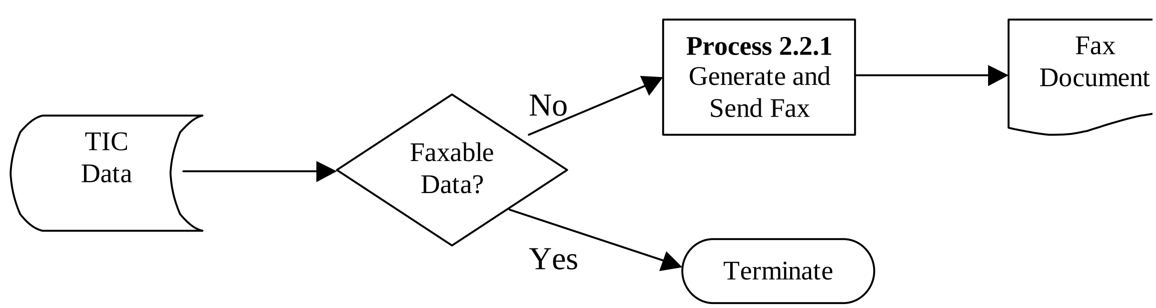
Decomposition of Process 2.0: Data Output

[Barrett et al., January 1998]

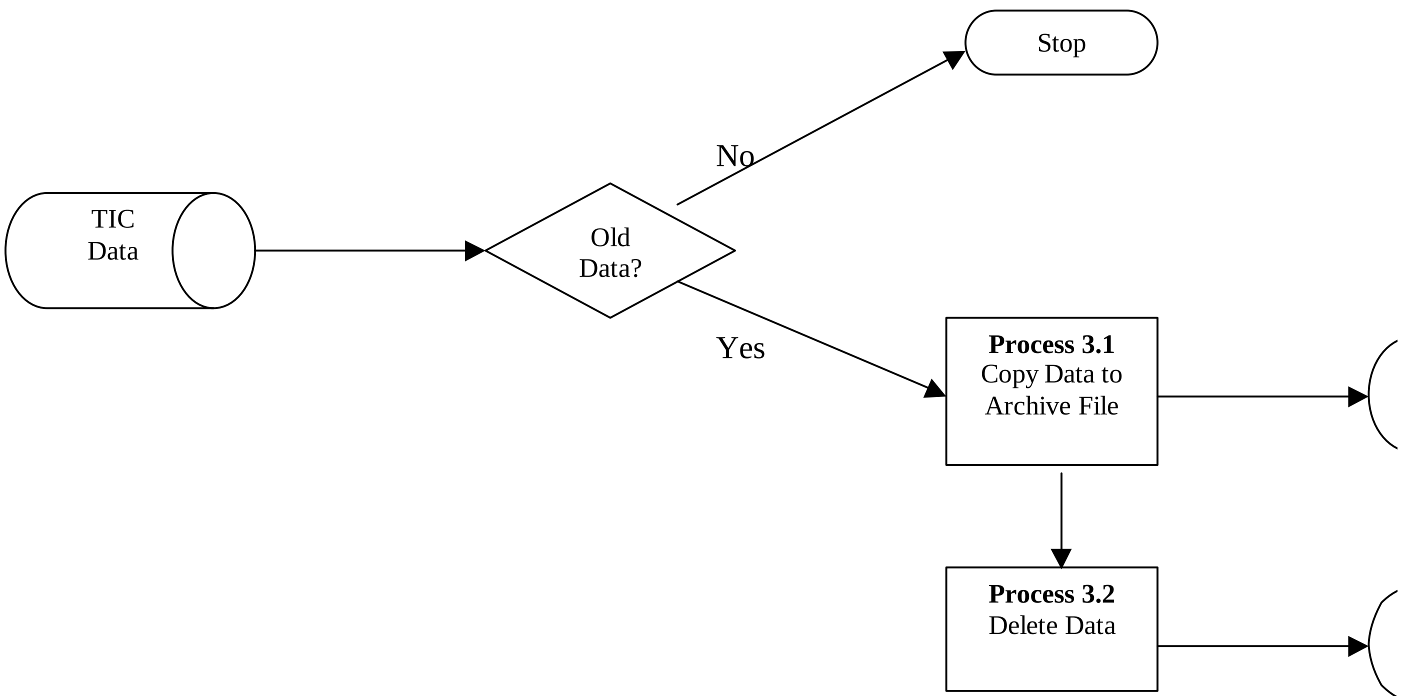
Generate HTML



Generate Faxes



Decomposition of Process 3.0: Data Archiving
[Barrett et al., January 1998]



Appendix b Database Schema