Advanced Voice and Multimedia Communications System for the ODOT ITS Network

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By:

Monte P. Tull, Ph.D., P.E. – Principal Investigator
Joseph P. Havlicek, Ph.D. – Co-Principal Investigator
Mohammed Atiquzzman, Ph.D. – Co-Principle Investigator
Thordur Runolfsson, Ph.D. – Co-Principal Investigator
James J. Sluss, Jr., Ph.D. – Co-Principal Investigator

University of Oklahoma
ITS Laboratory
Norman, OK

ODOT Technical Advisor: Alan R. Stevenson,
Technical Services Division

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16 . ABSTRACT

Across the State of Oklahoma there are a multitude of agencies, at the federal, state, and local levels, all responsible for responding to emergency situations. Many of these agencies have a presence on the private ODOT ITS Network; however, these ITS console operators, heretofore, relied on public switched telephone network (PSTN) communications for coordination activities. In addition, many of these agencies use shortwave radios as a means of internal agency communication. Due to the independent nature of these agencies they are unable to communicate with each other using their agency specific radios. The goal of this project is to determine how these communication issues can be resolved by utilizing the large private ODOT ITS Network connecting these agencies. This work addressed both the ITS Network inter-console communication and the inter-agency radio voice bridging. In both cases, a low cost solution, as well as, preservation of the ITS Network integrity and security were primary considerations.

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1. Introduction

Across the State of Oklahoma there are a multitude of agencies, at the federal, state, and local levels, all responsible for responding to emergency situations. Many of these agencies have a presence on the private ODOT ITS Network; however, these ITS console operators, heretofore, relied on public switched telephone network (PSTN) communications for coordination activities. In addition, many of these agencies use shortwave radios as a means of internal agency communication. Due to the independent nature of these agencies they are unable to communicate with each other using their agency specific radios. The goal of this project is to determine how these communication issues can be resolved by utilizing the large private ODOT ITS Network connecting these agencies. This work addressed both the ITS Network inter-console communication and the inter-agency radio voice bridging. In both cases, a low cost solution, as well as, preservation of the ITS Network integrity and security were primary considerations.

1.1 Project Overview

Section 2 describes solutions implemented for Voice over Internet Protocol (VoIP). Both VoIP solutions are available for the ODOT ITS Network. The first solution relies on a freely available (no license required) VoIP software package, Ventrilo, capable of peer-to-peer calls, conference calls, and text messaging. The second solution, oVoIP, is a software package developed by the ITS Laboratory and is capable of peer-to-peer calls, conference calls, text messaging, file transfer, and video conferencing using the Polycom PVX software, if a license is available. Section 3 describes a low-cost solution for bridging state agency radio systems using the ITS Network.

2. ITS Network Console VoIP and Text Messaging

ITS consoles are standalone computers connected to the ITS Private Network. All consoles run the Statewide application software developed and maintained by the University of Oklahoma ITS Laboratory. Statewide is a distributed application that allows users, with proper permissions, to control any ITS Network asset, such as pan-tilt-zoom (PTZ) cameras, dynamic message signs (DMSs), etc. Statewide consists of a MySQL database and a set of VB .NET, C++, JavaScript, PHP, and MapServer GIS libraries. Via the Statewide software ITS consoles automatically communicate between themselves using the Microsoft Message Queuing (MSMQ) service, which allows them to be updated and synchronized without the need for a central server. Through MSMQ each console is immediately aware of any change or event occurring in the network such as another console dropping off-line or a PTZ being seized and controlled by a user. If the network is severed, each remaining leg of the network remains operational and available assets, cameras, DMSs, etc. are available to the users. This capability is unique among ITS networks throughout the country.

In the event of an emergency, responding agencies, such as fire, EMSA, and enforcement, may require a coordinated effort that relies on the ODOT ITS Network. Heretofore, ITS Network console operators were required to use telephones for this coordination and communication. In a severe disaster these public communication resources become scarce or unavailable. To insure that communications are available, a voice and text messaging capability was developed for the ITS Network by the OU ITS Lab. Both peer-to-peer and conference calling capabilities are provided for each console.

Research into VoIP capabilities meeting our objectives revealed that commercial VoIP applications, such as the Polycom products, were expensive and generally priced on a per PC basis, which would require a large license fee for the 50+ ITS consoles. Evaluation of custom software and/or open source software revealed that, in general, these packages relied on a central server for call setup, signaling, call teardown, conference call voice mixing, etc. *The central server requirement means that there exists a single point of failure, which is contrary to basic design principles for the ITS Network and its inherent distributed control capabilities.*

Two solutions are provided for VoIP and media communications. Both solutions are available and meet the non-centralized control requirement. The first is based on the freely available Ventrilo VoIP software. This package was integrated as an ITS application and can be initiated by the Statewide software. Capabilities provided include peer-to-peer calling, conference calling, and instant text messaging. (In addition, the Ventrilo software is used to support inter-agency radio bridging. See Section 3.) Figure 1 shows a voice call being initiated by an ITS console from the Statewide software. Figure 2 shows the called ITS request window seen by the called ITS console. Once a call is initiated and accepted, the calling console functions as the control server. Additional ITS consoles added to the call are considered as clients to the calling console. Unlike other VoIP software, Ventrilo offers this unique capability, making it acceptable for use in the Oklahoma ITS Network. Figure 3 shows an ITS user conference call in progress. Finally, Figure 4 shows the text messaging capability offered by the Ventrilo software. ITS console users can select the other ITS consoles for reception and interchange of text messages.

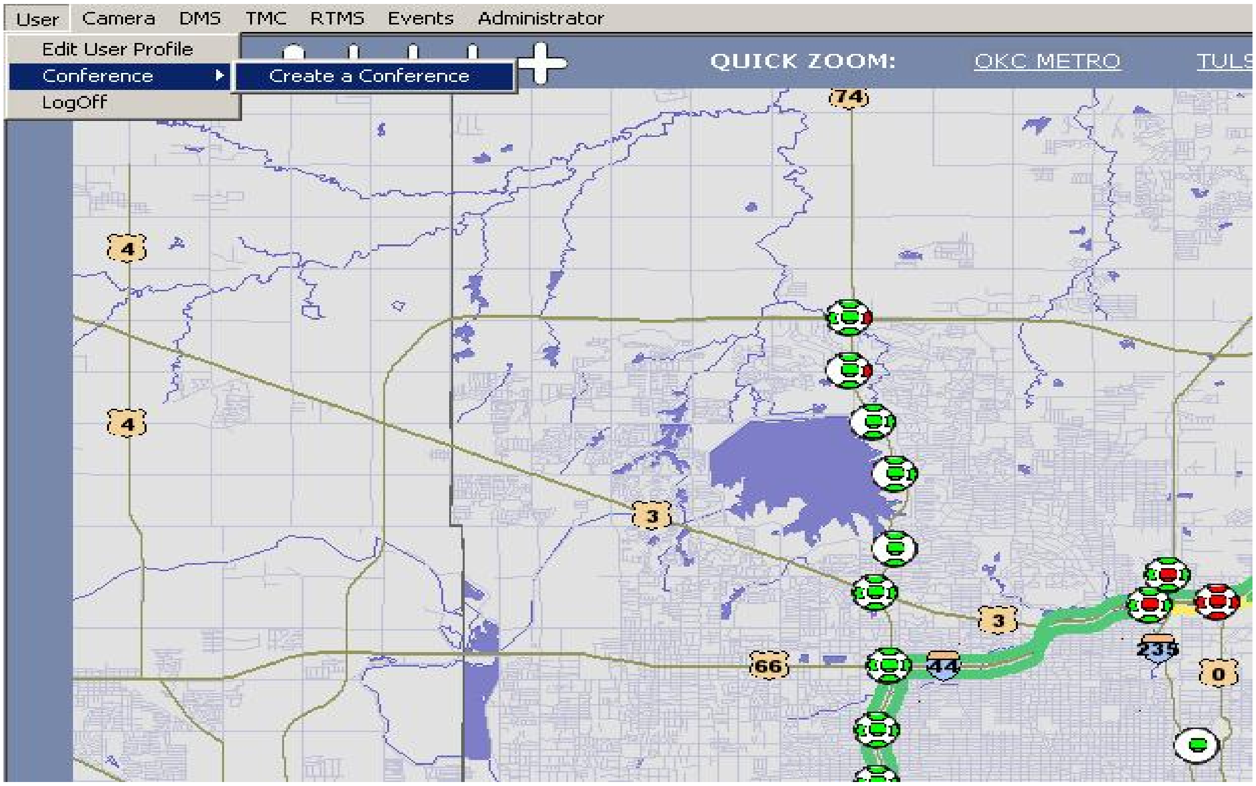

Figure 1. Conference Call Initiation Menu in the Statewide Software

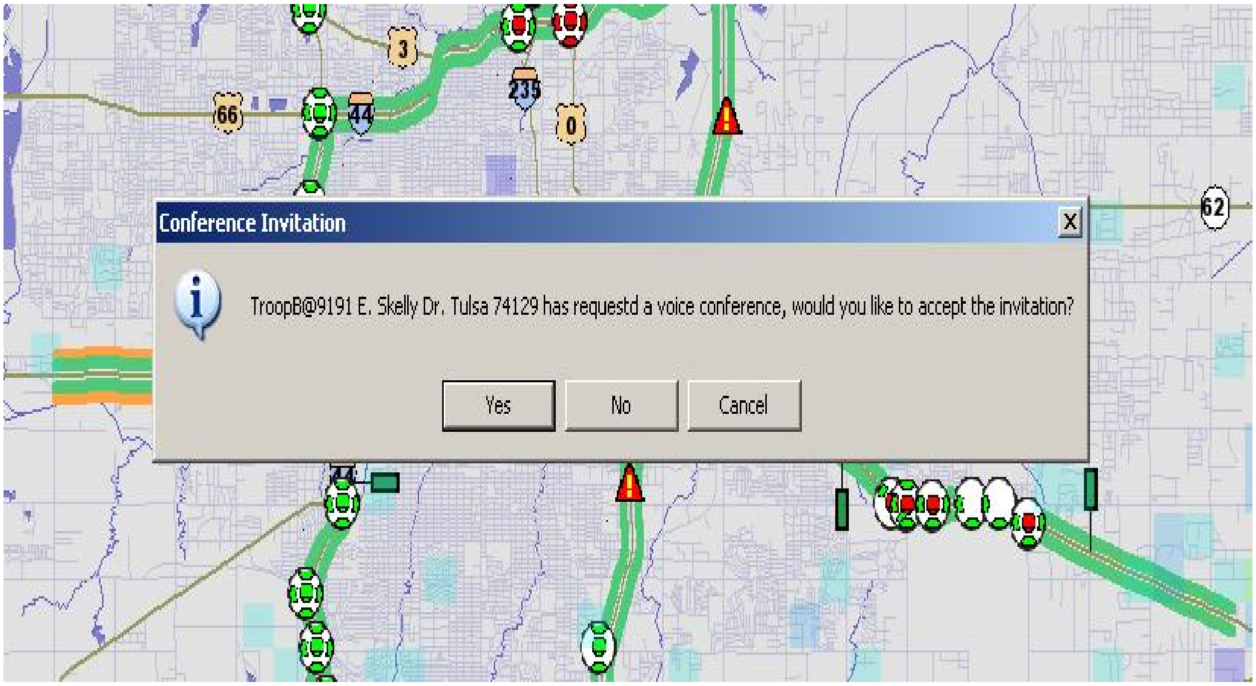

Figure 2. VoIP Call Request Sent to the Called ITS Console

Figure 3. An ITS Console VoIP Conference Call in Progress

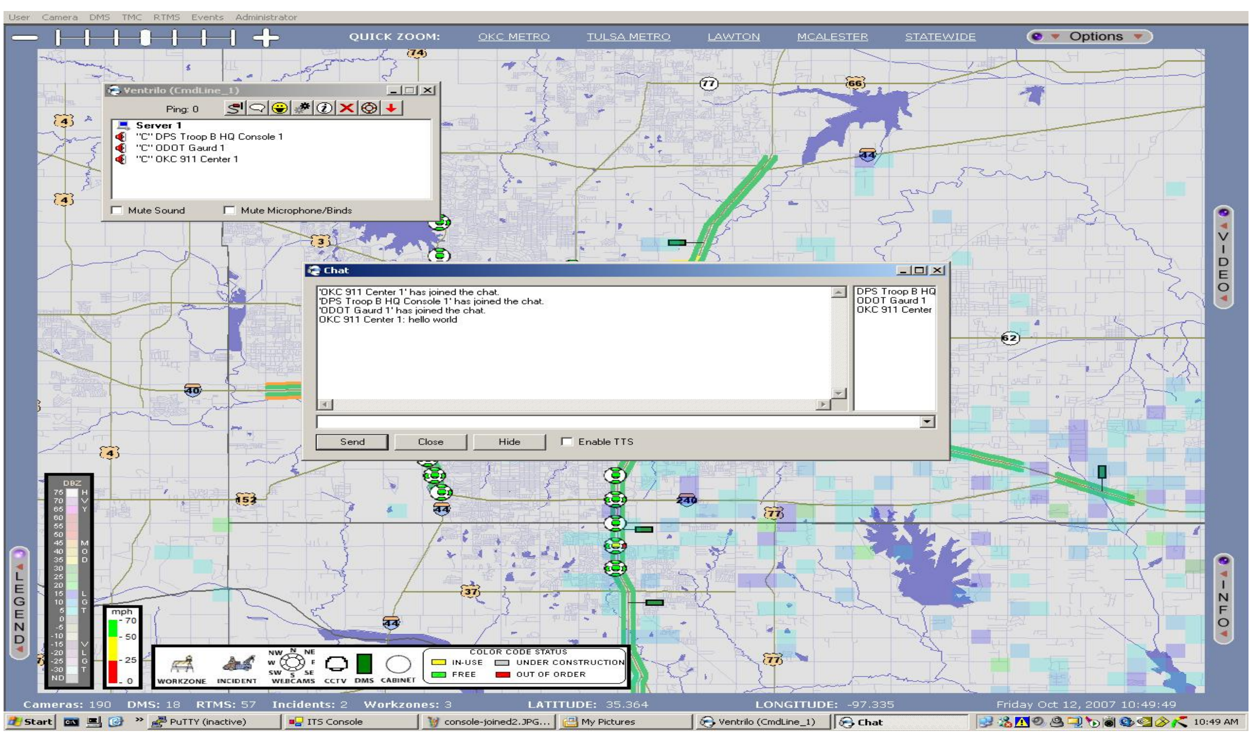

Figure 4. Text Messaging Windows

The second available VoIP and text messaging solution, oVoIP, is a custom application developed by the ITS Laboratory. The development of this software began prior to locating an acceptable free license software solution (Ventrilo) and is based on previous work performed at the University of Oklahoma for a project entitled "EduSketch". The previous EduSketch work permitted a virtual classroom setting that broadcasted (and received from) voice and multimedia information to/from remote internet users using arbitrary non-specific server functionality. These unique EduSketch capabilities were modified to accommodate the necessary functionality required by the ITS Network, namely non-centralized VoIP calling and media interchange.

The oVoIP software offers some advantages and additional capabilities over the Ventrilo-based software, namely the ability to send documents and utilize the Polycom PVX for video conferencing. The oVoIP software does not rely on a central server for coordination. The ITS console that initiates calling, messaging, etc. functions as the central server. Figure 5 shows the oVoIP application initiating a conference call. Available conferences are also viewed by selections in this menu. The window in Figure 6 shows the result of this selection. At this point the ITS user can select to join an existing call at which point the controlling ITS console will see the request shown in Figure 7.

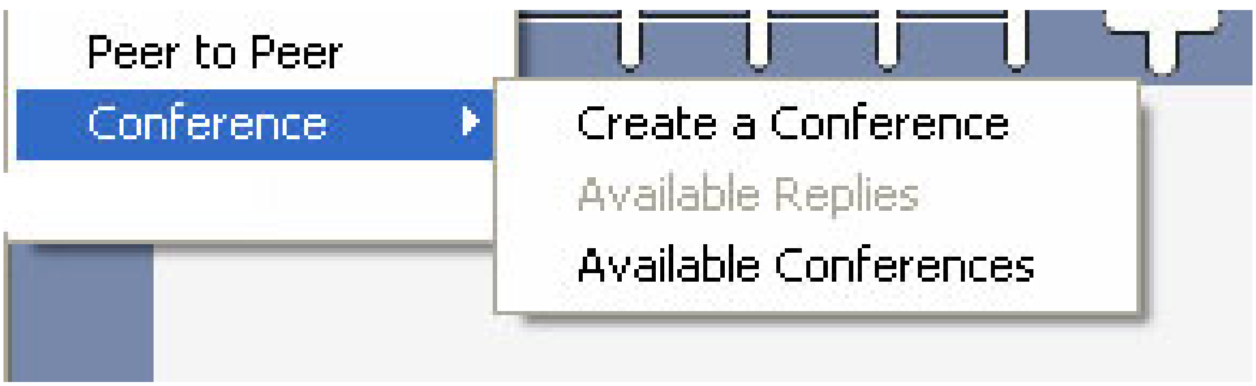

Figure 5. oVoip Call Initiation Window

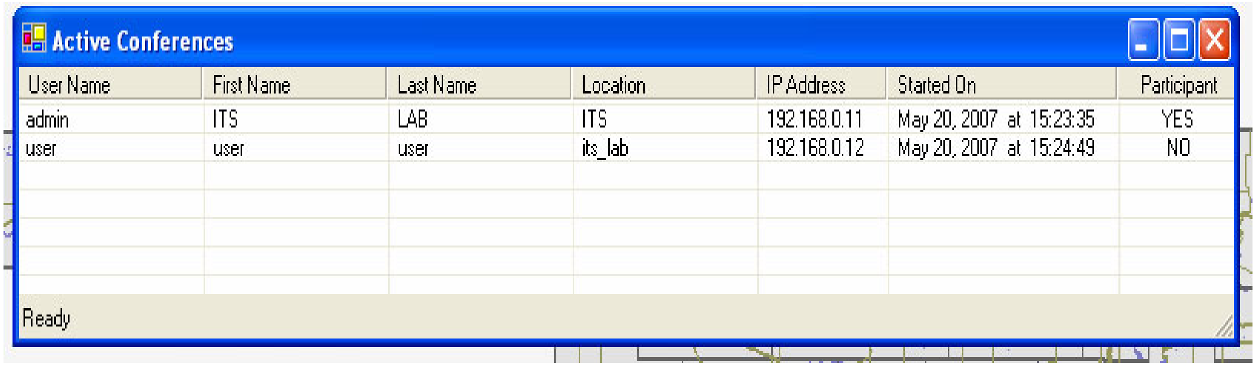

Figure 6. oVoIP Selection of Conference Calls In-Progress

Figure 7. oVoIP Request to Join a Conference Call In Progress

ITS console users can also view all other ITS active consoles, i.e., those consoles that have a logged-in user. See Figure 8. This scenario would likely be the prelude for establishing communication to specific consoles. From the window shown in Figure 9, the user can initiate a contact via VoIP, initiate text messaging, send a file, and/or start the Polycom PVX application (if a PVX license is available).

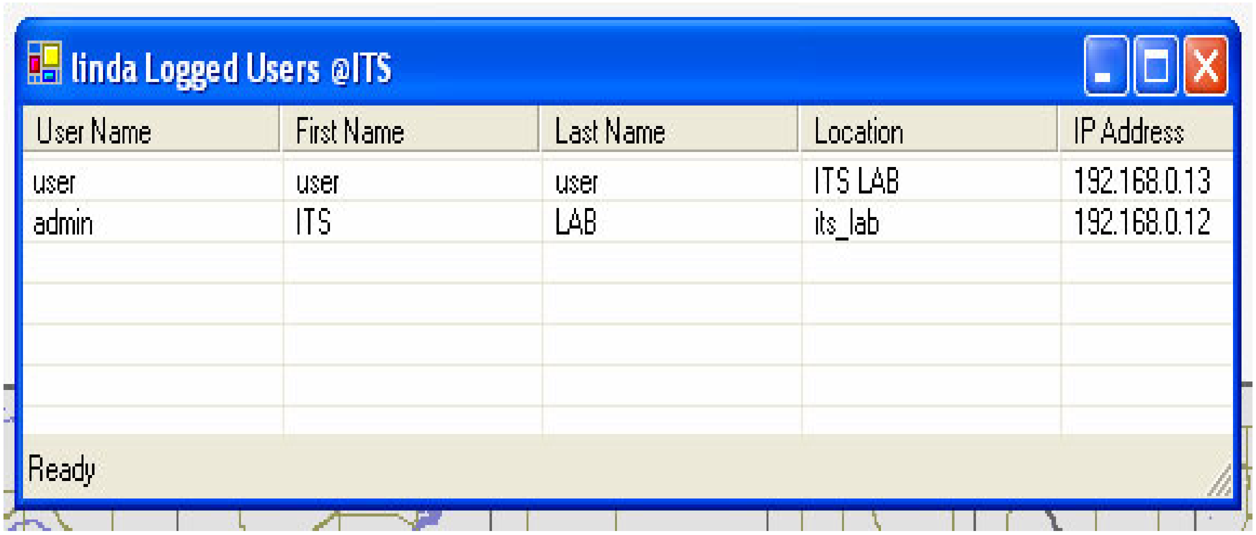

Figure 8. oVoIP Viewing of Active ITS Consoles

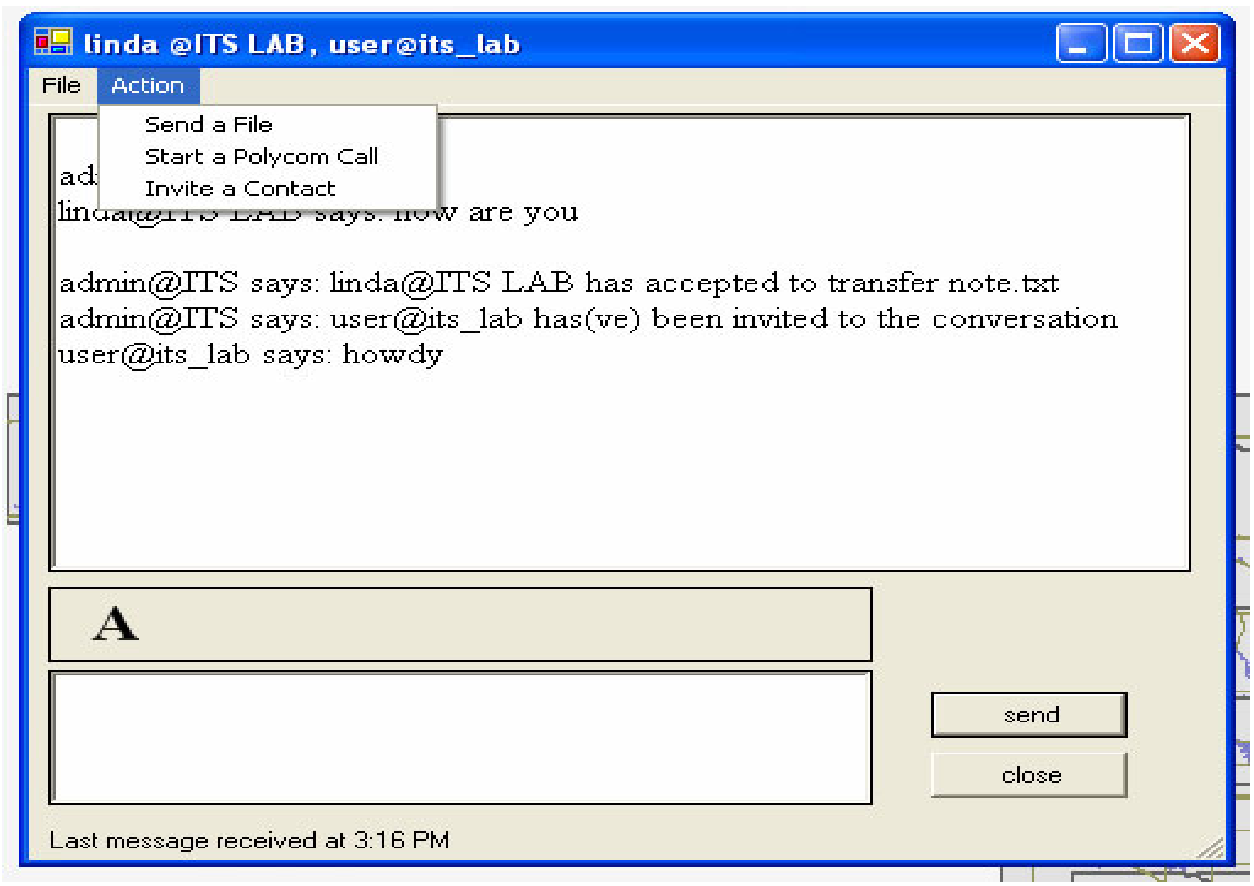

Figure 9. oVoIP Initiation of Contact

In summary, both the Venrilo-based solution and the oVoIP solution are available for the ODOT ITS Network. Both applications can reside on ITS consoles. Either or both can be in simultaneous use across the network in support of numerous VoIP calls. For example, during a Ventrilo conference call, oVoIP can be used to transmit documents to the call participants. Together, the VoIP packages provide a rich set of capabilities that provide ITS console users convenient communication options that may prove invaluable in emergency situations.

3. Inter-Agency Radio Bridging

This portion of the research investigated methods for bridging state agency radio systems. Most all state agencies, fire, OHP, county sheriffs, local police, and EMSA operate radio systems that utilize different frequencies. Consequently, any inter-agency communication takes place through agency dispatchers that have both radio systems; otherwise, the cellular telephone system must be relied upon. Both of these options slow the voice traffic interchange between responders, which could be critical in an emergency coordination effort. It is much more desirable to permit responders to communicate directly, if needed.

Several methods were investigated for achieving the inter-agency communication capability. Generally, the solutions are very expensive, requiring a good amount of new hardware. These systems are also quite centralized and more nearly fit the centralized Traffic Management Center model, wherein most agency representatives are present. This is not the decentralized and distributed control approach of the Oklahoma ITS Network.

For completeness and comparison, we describe possible solutions below, followed by a description of a very low-cost solution developed at the OU ITS Laboratory. This novel low-cost method leverages the Ventrilo VoIP software described in Section 2.

3.1 University of New Hampshire Solution

John H. Mock of the University of New Hampshire has developed one possible solution for the interoperability of agencies using different radios. As can be seen from Figure 10 their solution has two main components. The first component is a central server. This server hosts an application called the "conference server." This application hosts the initiated chats from the client and controls each chat, allowing users to connect and disconnect at will. The second main component is the agency client computer known as the PC class voice server. This computer also has custom voice conferencing software. Each agency has one of these PC class voice servers and initiates voice conferences with other agencies by connecting to the conference server. It is unclear if the radio itself is able to interface with the computer and thus transmit its received communication over the voice conference or if only the operators can talk to each other. Even if the radios are able to be interfaced with the computer, there is one inherent flaw in this system; there is a single point of failure with the Voice Conference Server. If this server is unavailable, for whatever reason, then inter-agency communication would not be possible. In an emergency such a failure would be detrimental to the ability of the agencies to work together, potentially costing lives. Inter-agency communication methods must be independent, i.e. not having a single point of failure which would prevent all agencies from communicating with one another. This single point of failure is not in keeping with the ODOT ITS Network philosophy of distributed control, wherein the basic Network functionality is preserved in the event of console failures and/or network outages.

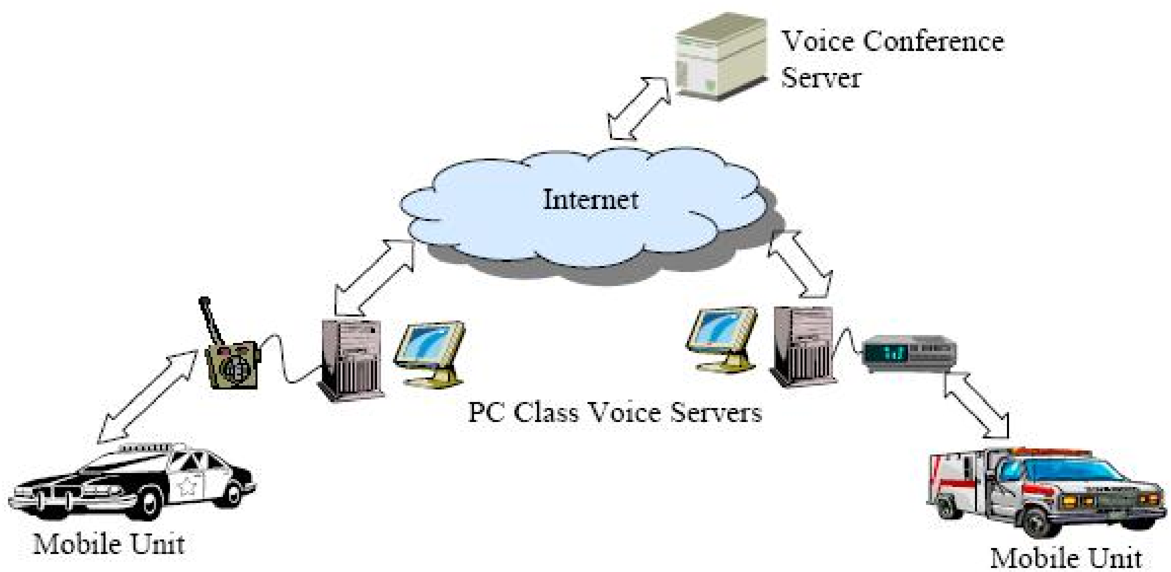

Figure 10. Overall Diagram of Univ. of New Hampshire Solution (Mock & Miller, 2002)

3.2 M/A-COM Solution

Perhaps the most comprehensive solution is that offered by M/A-COM. Their solution comes in two different flavors, the NetworkFirst package or the OpenSky package. The NetworkFirst package is designed to operate with existing radios and an already existing network backbone. It consists of a multitude of IP gateways, Interoperability gateways, switching centers, and switching servers. These devices are incorporated into an existing network. A console is then provided to each agency. This console is designed to interface with an agency's given radio and convert the signal to a digital signal. The digital signal can then be routed through their proprietary hardware and software to other agencies, thus facilitating inter-agency communication.

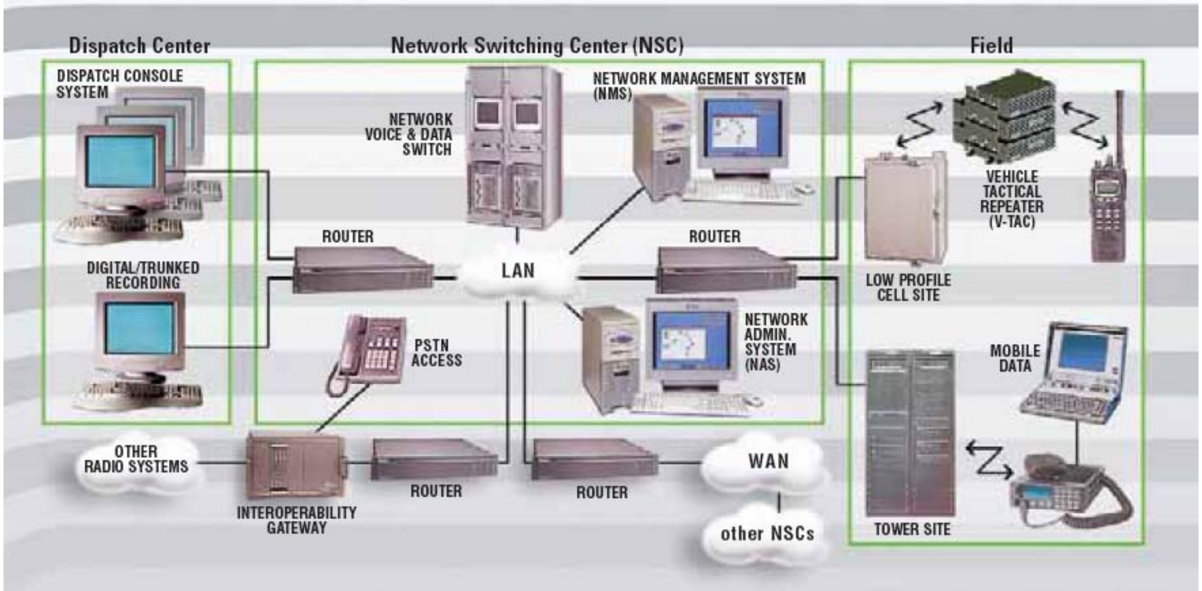

Figure 11. OpenSky Solution by M/A-COM

The OpenSky package offered by M/A-COM is an even more comprehensive solution. It contains the same components as the NetworkFirst package, as well as some additions. Specifically, the OpenSky system includes the addition of a multitude of tower and pole based radio towers as well as radios specifically designed to operate with the system. These radio towers are capable of handling both analog and digital communication. Also included in this package is the building of the underlying network infrastructure to carry the digital communication. Both of the solutions offered by M/A-COM are comprehensive, but also expensive. The price can range from a few million dollars to upwards of the 2 billion dollars the state of New York paid for their OpenSky solution.

3.3 OU ITS Lab Solution

The State of Oklahoma already has a large fiber optic ITS Network created by ODOT. The low-cost OU-ITS Lab solution, shown in Figure 12, relies on utilizing this high-speed network to act as a digital relay for these interoperating analog radio signals. Since the network already exists, only the hardware to convert and transmit the radio signal is required. In addition, areas that are not on the state deployed ITS Network can use a local high-speed internet service provider to provide the necessary bandwidth for the VoIP communication.

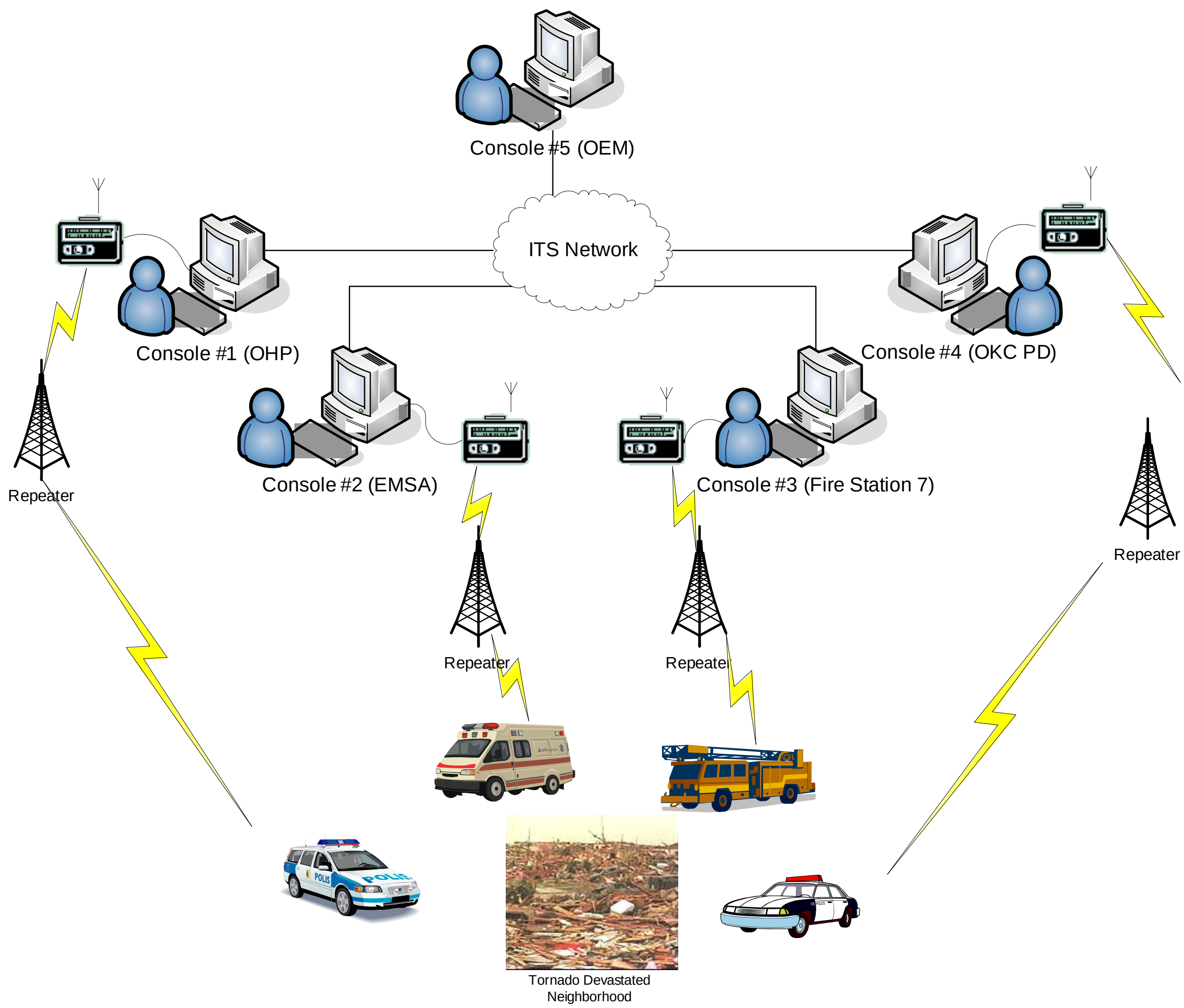

Figure 12. Overview of Agency Radio Interoperability using OU-ITS Lab Solution

3.3.1 Hardware

There are three main components required to implement this solution (Figure 13).

1. Basic PC w/ sound and network capability
2. SignaLink PC-Radio interface device
3. Radio compatible with local agencies radios

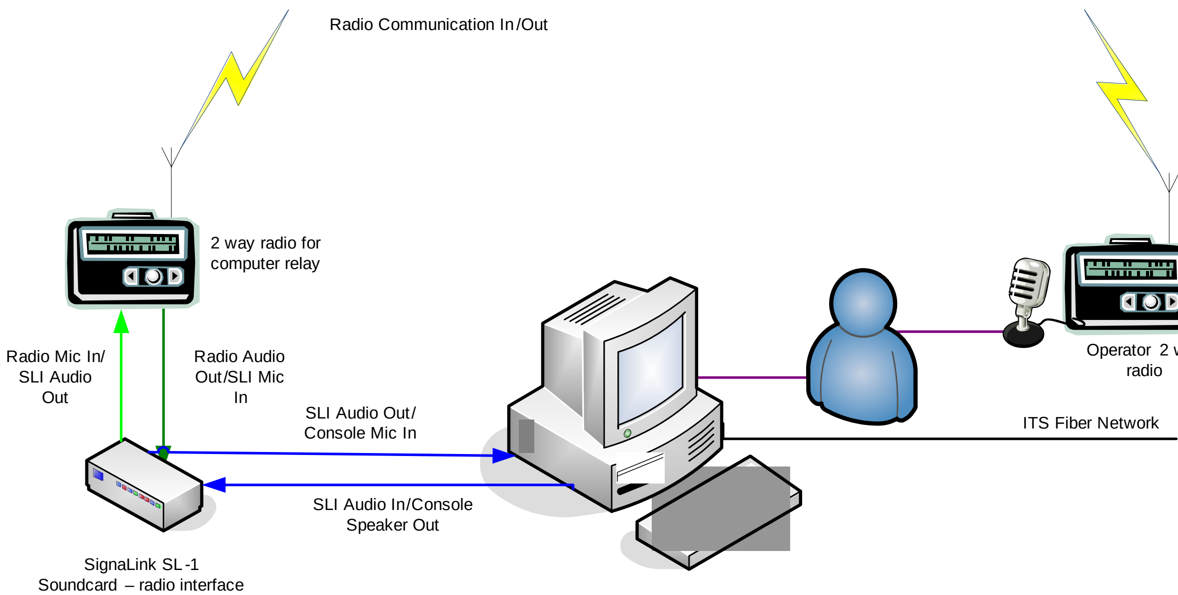

Figure 13. ITS Console System to be Deployed at each Agency

3.3.2 Software

1. Windows based operating system (XP/vista)
2. Ventrilo Software (described in Section 2)
    a. Server
    b. Client

3.3.3 Configuration

3.3.3.1 Hardware

To configure the hardware for this inter-operative solution there are a few simple steps. First, the TigerTronics SignaLink SL-1 module (see Figure 14) must be configured. Since each radio is different and there is not a standard for the wiring of the microphone input, it is necessary to configure the SignaLink by connecting jumper wires within the unit itself. The manual that comes with the SignaLink unit provides full instructions as to how to jumper the connections for any given radio.

Figure 14. SignaLink Module (Rear View)

Once the SignaLink module is configured, it should be wired to the computer. This requires two cables which come with the SignaLink unit, one to connect the SignaLink's MIC port to the microphone jack on the computer and another to connect the SPKR port to the primary speaker output of the soundcard in the computer. Finally, the SignaLink should be connected to the radio using the supplied cable that came with the SignaLink.

3.3.3.2 Software

There are two parts of software that must be configured. First, the Windows sound system must be configured. Specifically, the microphone input must be adjusted and un-muted. The actual level will depend on the radio and the sensitivity of the soundcard.

Finally, the Ventrilo software must be configured correctly. Specifically, the input and output sound levels should be adjusted. This adjustment will need to be done on a per computer basis since the levels for each radio will be different. However, once the settings are made no further adjustments should be needed.

3.4 Use and Results

To use the solution an operator at one agency will start a Ventrilo server session. The operator can then invite users (operators at other agencies) to join their session. Once other operators have joined the session it is as simple as talking into their respective radios. Any communication that is made over each agency's respective radio will be captured by the SignaLink device and relayed, through Ventrilo, to the other agency's computer. Their computer console will then send the signal to its SignaLink device and transmit the message over their respective radio (Figure 12).

In our tests we were able to successfully transmit voice communication between radios on different frequencies using this solution. One problem that surfaced was that sometimes crosstalk appeared, caused by the high amplitude signal coming into the soundcard. The only way to solve this was to disable the automatic push-to-talk feature in Ventrilo. This then required the operator to press a button on the keyboard whenever a message needed to be transmitted.

Overall, this solution proved that it could work, utilizing the existing network infrastructure of the ODOT ITS Network as well as high-speed internet carriers. There are a few minor issues with getting the volume levels of the devices just right, but this simply requires trial and error. Also, it would be advisable to have each computer contain more than one soundcard. This would likely eliminate the cross-talk problem encountered and allow both agencies to communicate without a person having to activate the push-to-talk feature of Ventrilo.

4. Acknowledgements

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5. Resources

Ventrilo VoIP Software, www.ventrilo.com.

Douglas, M. (December, 2005). In The Field: New York to get Massive Network. *Mobile Radio Technology* , 51-53.

Mock, J. H., & Miller, T. W. (2002). A voice over IP solution for mobile radio interoperability. *Vehicular Technology Conference, 2002, Proceedings* (pp. 1338-1341). IEEE.

SignaLink Model SL-1, www.tigertronics.com/sl+main.htm.