

Case Study: Developing the Bridging Systems Interface Core Profile

Summary

This Case Study details the formation of the Public Safety Voice over Internet Protocol (VoIP) Working Group and the development of their first specification: the Bridging Systems Interface (BSI) Core Profile. The Case Study will highlight a collaborative approach to examining a public safety issue; forming a partnership between emergency responders, industry representatives, and Federal partners; and creating a Profile that is implemented in multiple VoIP bridging devices.

Public safety agencies are investing millions of dollars in devices that allow agencies to patch disparate radio systems together. Commonly referred to as bridging systems, many of these devices use VoIP technology to send voice information to other bridging systems. Internet Protocol (IP) provides a common method of communicating data and voice information across the Internet. Although based on IP, VoIP technology is not always interoperable because it can be implemented in a number of different ways that are essentially proprietary.

To address the lack of interoperability between VoIP-based devices, the Office for Interoperability and Compatibility (OIC) within the U.S. Department of Homeland Security (DHS) and the Office of Law Enforcement Standards (OLES) within the National Institute for Standards and Technology (NIST) are leading a coalition of public safety officials and VoIP vendors. Known as the Public Safety VoIP Working Group, members are working together to create VoIP specifications, or implementation profiles. These profiles are being developed to ensure that radio systems can interoperate using today's VoIP technologies.

Through a consistent series of face-to-face Roundtable discussions, bi-weekly conference calls, and Plugfest testing sessions, the Group created the first VoIP interface specification: the BSI Core Profile. This Profile, now implemented in bridging devices from more than a dozen different manufacturers, helps emergency response agencies with disparate radio systems connect with one another.

Introduction

This Case Study highlights how a collaborative, user-focused approach successfully brought together a group with competing interests and varying viewpoints to create a common methodology for connecting disparate public safety radio systems.

As manufacturers began implementing VoIP in their products, there was growing confusion around its use in public safety communications. In response, DHS and NIST gathered key stakeholders from both the public safety and industry communities to address this problem. Led by OIC and OLES, the Public Safety VoIP Working Group's initial goal was to define and clarify expectations for VoIP in the public safety environment. Over time, the VoIP Working Group's goals evolved to include the prioritization and definition of requirements for specific applications of VoIP within public safety communications. Eventually, the Working Group began developing implementation profiles that enable interoperability for those application areas.

Background

The Nation's emergency responders have traditionally used two-way radios—known as land mobile radios—to communicate with each other when responding to day-to-day incidents and large-scale emergencies. Even the most powerful of these radios are often not interoperable because they broadcast in different frequency bands or they use proprietary mechanisms. When agencies need to connect radio systems, emergency responders rely on bridging solutions, which typically use an analog voice signal. Increasingly though, agencies are using VoIP-based connections to transmit voice communications between bridging devices. Although VoIP itself is standards-based, there are many ways to implement VoIP between bridging devices; as a result, each implementation is essentially proprietary. Currently, there is no way to guarantee that one manufacturer's VoIP-based equipment will successfully interface with another's. An implementation profile will effectively solve this problem. An implementation profile is the minimum set of standards, parameters, and values that must be defined to achieve interoperable implementations of a service.

What is VoIP and Why is it Significant?

VoIP is a broad, emerging technology area that allows for the transmission of real-time voice services through IP-based networks, including most corporate networks and the Internet. Because VoIP represents such a broad area of technology, the term is used in different, and sometimes inconsistent, ways.

VoIP's use of IP networks as a transport mechanism enables significant flexibility in call placement options, device addressing, and device placement. For example, calls between devices can be created on demand or as "nailed-up" connections. "Nailed-up" connections are permanent connections that are always available, but which only send data when voice information is being transmitted. Implementing "nailed-up" voice connections using VoIP is significantly cheaper than providing the same capability through a traditional telephone service.

Additional flexibility is achieved because devices can connect by directly addressing each other over any network without the burden of the switching, routing, and billing infrastructures that are typically used for telephone services. In contrast, the use of IP-based networks enables voice transport between any two devices connected to the network—provided the security policies allow access and VoIP has been implemented in an interoperable manner. This capability allows for significant flexibility in device placement as well; devices can operate in the same manner whether they are 100 feet or 100 miles apart. Due to these advantages, public safety radio manufacturers have begun to implement VoIP in bridges, consoles, radios, and other equipment that forms a radio system's infrastructure.

How is VoIP Used in Public Safety Communications?

VoIP technologies are still relatively new in the public safety community. By limiting discussions to agency-to-agency communications, the Working Group was able to develop a list of seven application areas in which VoIP can improve public safety communications. Each of the following application areas occurs as an interface, or connection, between pieces of communications equipment:

- Bridging Systems Interface – an interface between bridging or gateway devices
- Dispatch Interface – an interface to a dispatch console
- Radio Site Interface – an interface to a base station or similar device

- Radio System to Radio System Interface – an interface between two radio systems
- System to Subscriber Unit Interface – an interface between a radio system and a wireless VoIP-enabled device
- Subscriber Unit to Subscriber Unit Interface – a typically wireless interface between user devices
- Wired End Unit to System Interface – an interface that allows a network-connected device to connect into a radio system

How is the Working Group Addressing the Need for VoIP Interface Specifications?

After identifying potential VoIP interfaces, the Working Group developed a number of general principles for VoIP-based public safety communications systems. A VoIP-based system must meet these principles to ensure acceptance within the public safety community. According to the Working Group’s requirements, each VoIP interface must be:

- Compatible and interchangeable
- Reliable
- Affordable
- Scalable
- Manageable

In addition, the Working Group required all VoIP interfaces to include a common security framework, possess a minimum set of standards and features, and leverage commercial off-the-shelf products. Above all, the Working Group agreed that the ability to interoperate must be maintained in any new device using a VoIP interface. However, interoperability is still not guaranteed for all VoIP implementations. Interoperability between VoIP implementations can be obstructed by competing standards or differing ways to implement standards. With so many approaches, there is a need to standardize the implementation of each of the potential VoIP interfaces to ensure interoperability.

What does the Working Group Produce?

Given the need for standardized implementations, the Working Group is producing specifications, or implementation profiles, for each of the potential VoIP interfaces. When a specification borrows parameters and values from existing standards and combines them into one document, the final product is called an *implementation profile*. When developing implementation profiles for the potential VoIP interfaces, the Working Group’s goal is to select the minimum set of standards, parameters, and values that are required to define a fully interoperable implementation. In other words, the goal is to define the minimum elements required to create an interoperable environment. This ensures that the implementation profile is easy to implement.

Choosing the First Interface: Bridging Systems

In order to begin work on the implementation profiles, the Working Group prioritized the potential VoIP interfaces with regard to how each interface would:

- Further interoperability between disparate agencies;
- Benefit multi-agency, multi-jurisdictional responders;
- Provide the greatest impact in minimal time; and
- Allow for easy adoption without a substantial investment of resources.

The *BSI* emerged at the top of the priority list. The *BSI* is the interface between two bridging or gateway devices that can be used to connect disparate radio systems, typically through the use of an audio connection from a donor radio. Available for several years, bridging and gateway devices are typically used to interconnect radio systems; they are widely deployed in public safety agencies. As such, they are a powerful tool for providing interoperability between disparate systems.

However, even newer bridges and gateways that are based on digital VoIP technology must either connect to bridging systems from the same manufacturer or drop to a “lowest common denominator” connection. These types of connections hamper communications as they are prone to latency problems and do not support common features such as caller ID and encryption. For the *BSI* to support the features required by the public safety community and to adhere to the VoIP requirements set above, manufacturers must agree to use a common specification in their VoIP-based bridging devices.

Developing and Testing the BSI Profile

The Working Group created the BSI Core Profile through a series of Roundtable discussions between public safety practitioners, industry representatives, and Federal partners. Once developed, the Profile was tested at three different Plugfest events where manufacturers brought their bridging devices and connected to one another using the specifications of the BSI Core Profile. The BSI Core Profile was finalized in September 2008. It has successfully demonstrated support for basic voice interoperability within the public safety community. Because it is based on the implementation profile technique mentioned previously, the BSI Core Profile was developed in months instead of years. As a result, manufacturers were able to implement the Profile earlier and with greater ease. It is currently implemented in bridging devices from more than a dozen different manufacturers.

Next Steps

While the BSI Core Profile is currently being implemented in bridging devices, the Working Group has begun to focus on developing the BSI Enhanced Profile. This implementation profile will support additional functions, including the ability to transmit priority information, manage network information, and create secure links.

Once the BSI Enhanced Profile is complete, the Group will use it as a template for future implementation profiles. Ultimately, the Working Group's efforts will allow manufacturers to create VoIP-based radio equipment that can interoperate across all interfaces of a radio system.

While the Working Group's creation and dissemination of these interface specifications alone will not solve the interoperability problem, they will allow VoIP-based devices and standardized computer networks to further enhance public safety communications.

Methodology

Standing up the Public Safety VoIP Working Group was a highly collaborative process. Once the issue of VoIP in public safety was identified by DHS OIC leaders, they connected with their colleagues at NIST OLES. The team held a **strategy session** to define the problem and identify key players in the VoIP world. It is important to note that key participants changed throughout the process.

The team first conducted a series of **participant interviews** of key players in both public safety and industry to determine the current state of VoIP and to identify differences between the two groups' perspectives. OIC and OLES reconvened to analyze the interview results. Using this analysis, the Group developed a **meeting design** that outlined the goals and strategy for the first-ever VoIP Working Group meeting.

The Working Group held its **first Roundtable meeting in August 2006** in Washington, D.C. Key individuals targeted for this meeting were senior public safety and industry who had a broad perspective on the community they came from as well as an ability to affect policies and supply resources to address the issues. These key leaders discussed VoIP's strengths and limitations, defined the requirements for its effective use, and recognized the need for specifications to improve VoIP's value in public safety communications. The event offered an open, unscripted opportunity for the user community to educate industry on what their needs were and how they could be met. At this meeting, the Working Group defined the scope of their mission and agreed upon the seven VoIP interfaces they wanted to address. The process and effort that OIC and OLES went through to plan and execute the first meeting laid the groundwork for the success of the Group today.

Participants targeted for the **second Roundtable meeting, held in February 2007**, consisted of the senior leaders from the first Roundtable. However, this second meeting presented the opportunity to invite Engineering staff to participate as well. These were the individuals who would actually carry the load of defining and developing the product of the Working Group or who would be responsible for deploying and managing these systems once they were developed. During this meeting, the Working Group solidified their goal of producing implementation profiles rather than standards. Members decided that they would address the minimum set of standards, parameters, and values required to ensure interoperability between distinct implementations. Industry members worked with public safety practitioners to identify their requirements for the first interface they wanted to address: the BSI. The Group defined their work plan and created a Protocol Reference Model.

After the second Roundtable, the Working Group began **meeting via conference call**, on an as-needed basis. Working Group members typically included the technical staff from the second Roundtable. These early conversations enabled participants to discuss challenges and successes with one another. The calls also helped to keep the momentum of the Group between Roundtable meetings. Concurrently, the core team of OIC and OLES continued to meet weekly to create agendas for the Working Group calls, review the Group's work, set milestones, and handle logistics.

The **third Roundtable in May 2007** consisted primarily of technical participants and focused heavily on creating the BSI Core Profile. The Group decided that there would be two BSI Profiles—the Core and the Enhanced—and defined the features of each. Group members accepted drafting assignments and agreed to deadlines for their sections.

Per the Group's discussion, the BSI Core Profile would:

- Support group voice communications across multiple bridging solutions
- Support static or dynamic configuration and static or dynamic activation
- Meet access-time, latency, temporal clipping thresholds
- Prevent any “statistically significant” quality degradation as a result of improper codec selection or tandeming

In contrast, the BSI Enhanced Profile would:

- Have the ability to transmit priority information
- Allow for the arbitration of resources
- Use a control plane solution, which is extensible for features other than voice
- Offer an awareness of channels to which the user is connecting

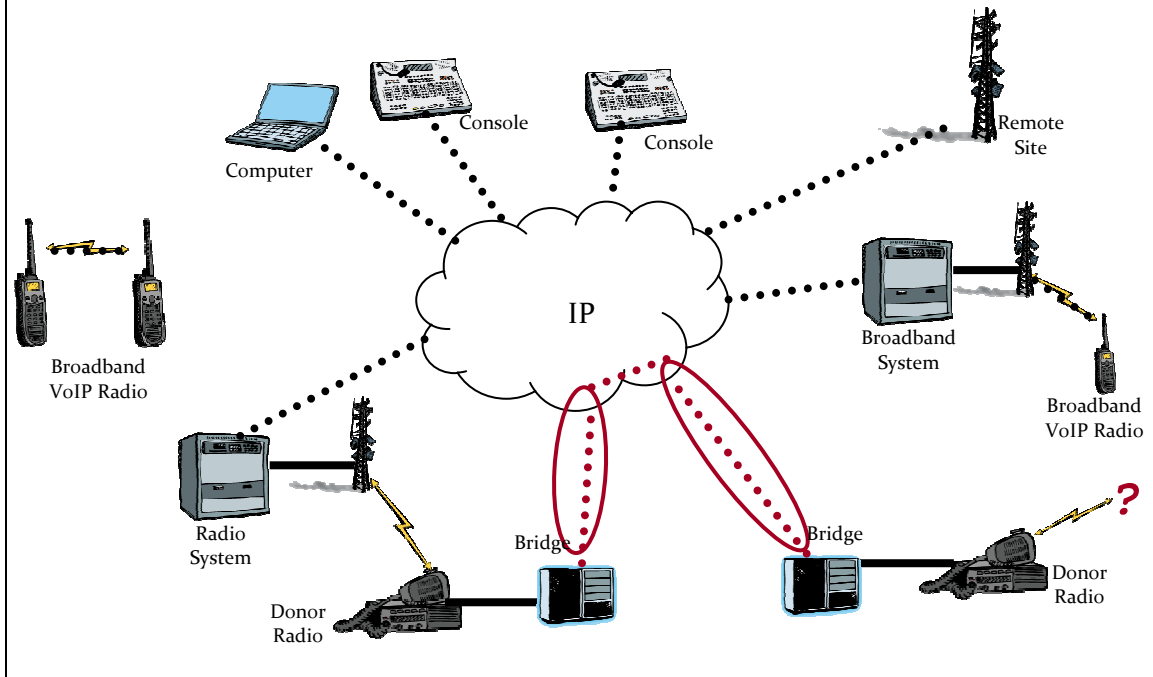
After the third meeting, the Group began working heavily on the BSI Core Profile. They decided to **meet bi-weekly via conference call** to monitor the progress of the document and work out issues as a group.

At the **fourth Roundtable in September 2007**, the Group solidified the BSI Core Profile draft into a release candidate. The BSI Core defined how bridging systems from different vendors connect to each other using IP; established simple one-to-one audio pathways between bridging systems; used Session Initiation Protocol (SIP) ([RFC 3261](#)), and its related RFCs, as the basis for an interoperable interconnect mechanism/model/profile; and used the Real-time Transport Protocol ([RFC 3550](#)) for the audio transport. The Group also planned the first Plugfest to evaluate implementations and work the kinks out of the specification. Lastly, the Group solidified the reference architecture for all interfaces.

The following is the VoIP architecture, which highlights the Bridging Systems interface:

Bridging Systems Interface

A defined IP interface for voice communication between two bridging devices that connect dissimilar radio systems.



The **first Plugfest** was held in **November 2007**. At this event, there were four implementations of the BSI Core using 86 test cases, including three from manufacturers, and one downloaded freeware SIP phone implementation. There was a 67 percent overall pass rate and an 86 percent pass rate on required features. The testing enabled finalization of the draft Profile.

The **fifth Roundtable and second Plugfest** were convened together in **April 2008**. At the Plugfest, the Working Group added four more manufacturers to the testing and hosted a demonstration for public safety practitioners. During the Roundtable, the BSI Core Version 1.0 was finalized and a path forward for the BSI Enhanced Profile was created.

In **September 2008**, the Working Group came together for the **sixth Roundtable and third Plugfest**. The Group added five additional vendors at the Plugfest to test the BSI Core. A 100 percent success rate in the required testing signaled that this would be the last Plugfest for the BSI Core Profile. Having just finalized the BSI Core at the Plugfest, the Group began the final stages of the BSI Enhanced development during the Roundtable. Keeping true to their user-driven approach, the Group also decided to connect again with public safety practitioners to validate the Group's course and to make adjustments, as necessary.

Summary of Results

Finalized in September 2008, the BSI Core Profile is now implemented in bridging devices from more than a dozen manufacturers; this integration will further enhance basic voice interoperability between disparate public safety radio systems. In addition to increasing the safety of the public and emergency response community, the BSI Core Profile also provides a cost savings aspect for agencies. The recent \$1 billion Federal Public Safety Interoperable Communications Grant Program will be funding the purchase of many VoIP-based bridging systems over the next three years.

The Working Group's demonstrated ability to make a VoIP specification available quickly will:

- Reduce costs for system design and installation, saving local, state, and Federal dollars.
- Harness the benefits of IP technologies by helping one emergency response agency seamlessly connect its radio system to another agency's system—regardless of the system's manufacturer.

Recommendations

Asking a group of people with competing interests to agree on a solution can be both rewarding and difficult. While the Working Group has proven successful, it has not been without some challenges. To avoid problems in similar group situations, please review the following lessons learned for tips on how to create a comfortable, collaborative working environment:

Extensive planning and legwork is not optional.

- Conduct interviews with all participants prior to the first Roundtable meeting.
- Analyze interview results and use this information to inform the first meeting.
- Structure the meeting to produce successful outcomes.

Proper representation is required at all stages of the process.

- Comprise the Working Group of highly respected public safety and interoperability leaders.
- Seek representatives from agencies and corporations that have a stake in the outcome of the process.
- Engage corporate managers who have the ability to impact resource allocation.

Focus on the user by merging public safety requirements into the product.

- Facilitate requirements gathering in the presence of both public safety and industry representatives in order to keep requirements realistic and relevant.

Restricting the scope and defining the goals is imperative.

- Identify issues by revealing different perceptions of the topic.
- Categorize the areas that need the most attention and identify resources to develop a solution.
- Divide the work into manageable chunks with realistic timelines.
- Require Working Group members to commit to completing reasonable sections.

Technical staff should be incorporated into meetings with managers.

- Obtain commitments from industry managers in the presence of those who will implement the solution.

Face-to-face time between public safety and industry is valuable.

- Use meetings to achieve consensus on difficult issues.

The Working Group should use conference calls to maintain momentum.

- Hold bi-weekly conference calls in the interim time between Roundtables and Plugfests.
- Reiterate to members that the work they are doing matters and people are interested.
- Make sure to have agendas prepared for these calls; agendas will keep discussions on track and provide reporting accountability for those working on documents.

Open issues must be closed out.

- Once the solution or profile is nearing completion, help the Group finalize the draft, or create release candidates.
- Help the Working Group develop criteria for success with which to measure the draft.

Plugfests allow the Working Group to celebrate successes but also reveal where the product needs improvement or clarification.

- Test the specifications at the Plugfest; these tests serve as a way for the Group to see their work come to life.
- Identify and document flaws in the solution during testing.

The Working Group should strive to develop and maintain a collegial atmosphere.

- Create an environment of cooperation, not competition.

- Watch out for strained relationships during major events in which competing interests may govern actions.

Recognize and accept when to move on.

- When it is evident that the solution or profile is stable, finalize and move on to the next task.

For more information on the VoIP Working Group and to access the BSI Core Profile, please visit the VoIP Project Web page at:

<http://www.safecomprogram.gov/SAFECOM/currentprojects/voip/voip.htm>