TWISTEDPAIR
Rethink Critical Communications

WAVE® Technical Brief

Understanding the Technology Behind WAVE

WAVE is a distributed and highly reliable Voice over IP (VoIP) software application that enables Unified Group Communications and interoperability by connecting platforms as well as users together regardless of device type. The software-based WAVE solution is compatible with almost any type of existing communications system including radios, traditional analog phone systems, new IP phone systems and industry specific proprietary devices such as hoot and holler systems for financial markets. WAVE can support thousands of groups of simultaneous users and connect these users to any type of communications system across geographically dispersed networks. WAVE provides Push To Talk (PTT), alerting, text messaging, and recording capabilities in both multicast and unicast IP environments. Multiple Windows-based WAVE Communicator applications supporting everything from PC-based dispatching to handheld PDAs for field workers are also provided. The WAVE Software Development Kit (SDK) enables developers to create market and customer specific desktop applications and communication solutions. WAVE supports local and remote systems administration capabilities with Call Detail Record reporting and failover.

WAVE is based on open software standards to provide flexibility and a low total cost of ownership to users. Customers use their existing devices and infrastructure to achieve interoperability and don't need to replace their radios or other communications tools.

WAVE has been proven in many of the world's most demanding communications and interoperability environments including the U.S. Army, major brokerage houses, international airports, public safety agencies, nuclear power stations, and utility companies. WAVE now enables Unified Group Communications with other industry leading platforms such as Microsoft Office Communications Server and IBM Lotus Sametime and includes new functionality such as SIP and a client for Nortel IP Phones.

WAVE still includes Supernode functionality, enabling administrators to configure WAVE to maximize network bandwidth savings across any network configuration. Proven deployments coupled with newly-added flexibility to adapt to different network topologies makes the latest release of WAVE the ideal Voice over IP solution for Unified Group Communications.

A robust Software Development Kit (SDK) has been developed to enable partners and customers to customize most aspects of the WAVE

Introduction

Unified Group Communications is a real problem for many organizations and is not easy to solve. In the past, you might have bought communications systems and devices that solved a problem at that time; but these systems and devices have now created a new problem—how do you get them all to communicate with each other?

The first part of this document will discuss the technology behind creating Unified Group Communications and describe solutions using the assets you likely already have. The second part will discuss how to access the Unified Group Communications using a variety of software clients.

Unified Group Communications

Unified Group Communications can mean different things to different organizations. For some, it might mean carrying radio traffic across an IP network to geographically remote areas (e.g. your dispatch center is located in Houston and the dispatchers are communicating with radio assets in San Diego). For others, it might mean bridging different radio technologies or frequencies together (e.g. your company may use 800mhz and VHF radios that can't communicate). For a financial markets organization it might mean the worldwide deployment of a solution that lets traders communicate in real-time. A hosted conference call that allows telephone users to dial in is another example of group communications.

Regardless of your organization's needs for unified group communications, creating the environment that allows people to communicate can be challenging because so many barriers exist. The barriers can be physical, technological or financial. Other complications of setting up unified group communications can include operational policies or the size of the organization. These barriers can be so daunting that many organizations don't actively pursue solutions to their group communications needs.

An example of a physical barrier might be the actual device that is being used. Natively, most devices can't talk directly to each other. User communication devices may be handheld radios, PDAs, personal computers (PCs), telephones (analog, digital or IP) or overhead paging systems, from a variety of manufacturers. A technology barrier might be different radio frequencies. Today, a VHF and UHF radio can't communicate with each other; let alone with newer radio technologies like trunked, P.25 or TETRA radio systems. Cost barriers are typically raised because many vendors take a "replace everything and start from the ground up" approach to unified group communications or interoperability. That does not need to be the case. An organization does not need to perform a fork-lift replacement of their radio systems in order to achieve group communications.

In addition to the barriers already mentioned, the sheer size of the group with which you are trying to communicate can make the task of unifying group communications unattainable. Take, for example, the situation where you might have 1,000 users on a VHF radio system and an additional 5,000 employees who want to participate in your group communications. This seems like an extraordinarily large amount of users to incorporate, but this technical brief will show you how to establish group communications to satisfy the needs of all users.

Finally, ad-hoc group communications that cross political, geographic or organizational borders take time to coordinate and establish. While strictly enforced operational procedures are paramount to creating cross jurisdiction group communications, this document will describe how you can effectively create and manage these groups in the proper environment.

The Solution

WAVE provides a flexible, software solution that leverages the pervasiveness of IP networks and operates on Commercial Off The Shelf (COTS) computing equipments. This paper shows how WAVE leverages an IP network to build a highly reliable, scalable and survivable infrastructure that can be used for real-time unified group communications anywhere on a corporate network or around the world. It describes how to use COTS equipment to deploy WAVE technology without requiring expensive, proprietary hardware. Also discussed is how you can integrate WAVE with your Microsoft OCS or IBM Lotus Sametime platform as well as with your IP telephony system and extend IP-based communications to radio systems—all using standard network equipment.

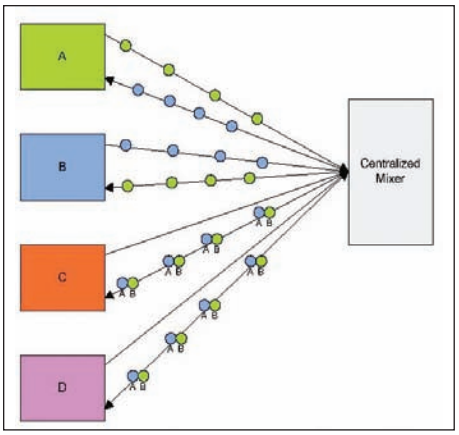
Before jumping into the details of WAVE though, let's first set the stage by describing network architectures, IP multicast technology and group communication technologies.

WAVE is a Peer-to-Peer Communications Solution

WAVE operates as a variation on the traditional definition of peer-to-peer computing—making use of a peer-to-peer design for carrying audio and other types of media between users on a computer network. These users can be Microsoft Windows™ PC, telephone, IP phone and PDA users, as well as personnel in the field with wireless radios.

The peer-to-peer nature of WAVE brings with it a number of benefits, including massive scalability, simple maintenance, and survivability. A peer-to-peer network does not rely on centralized servers, which can become single points of failure. WAVE's peer-to-peer architecture also permits bringing new endpoints and features online with minimal impact to the overall system.

IP Group Communications Using a Centralized Mixer



Consider the following communications scenario where WAVE is not being used: a group of four people speaking requires the resources of a centralized audio mixing service (potentially located on a proprietary hardware platform). Each device in the conference establishes a point-to-point pathway with the mixing service, transmitting the participant's voice and receiving an audio mix of all the other people in the group communication.

Depending on factors such as the CODEC in use and network design, adding more people to the conference increases the load on the network as each new conference participant needs to receive a mixed copy of the audio transmitted by the other devices. The increase in bandwidth requirements when adding participants is linear in nature– each new participant requires additional bandwidth to receive and transmit audio. In a typical case, each new participant could add up to approximately 84 kbps to the network bandwidth requirement if the G.711 codec was in use.

In a simple group communications environment where only a few people are on a conference, this unicast model works fine. It does not scale well, however, when larger numbers of participants are present. Consider a conference with 50 participants

WAVE SYSTEM SUMMARY:

Description

WAVE software technology lets our partners and customers build and operate secure and scalable communications systems in the world's most demanding environments. WAVE software unifies diverse communications technologies including radios, telephones, computers, and mobile devices across any network and is trusted when communications are absolutely indispensible.

Client Types

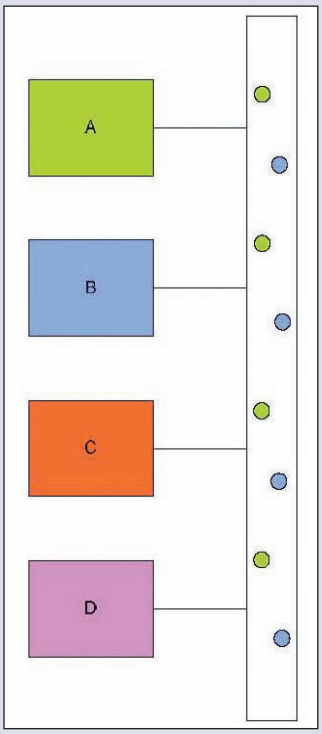
- Microsoft Windows PCs
- Mobile, office and home phones
- Land Mobile Radio (LMR) systems
- IP Telephony systems supporting H.323 and SIP
- WAVE IP Phone Communicator for Cisco 7940/7960/7970 and Nortel 1140e IP Phones
- Windows Mobile devices such as PDAs
- Embedded WAVE client on other group communication platforms
- Partner-developed desktop applications and communications solutions

Quick Features

- Browser-based system administration
- Massively scalable and bandwidth-efficient using IP multicast
- WAVE's patent-pending Supernode technology allows multicast, unicast or mixed-mode configurations for PC clients
- Microsoft Office Communications Server and IBM Lotus Sametime integration
- Based on COTS products and open standards (TCP/IP, H.323, SIP, RTP, UDP)
- Stand alone or browser-based PC clients
- Real-time status & presence
- Real-time and historical reporting
- Simultaneous multichannel, multispeaker, and multicodec support
- Instant playback for PC clients
- Centralized archival and playback of system-wide recordings
- Dynamic VAD (Voice Activity Detection) on clients and servers
- Transmissions optionally encrypted using built-in or customer provided algorithms
- SDK allows organizations to develop custom solutions

CODEC Defined

A CODEC (COder/DECoder) is a software algorithm that compresses and decompresses audio and video data for transmission across a communications link. While CODECs are typically associated with VoIP communications, they are also used in other areas such as cell phones and digital connections between telecos for long-distance phone connections. WAVE supports CODECs ranging from 2.15 kbps to 128kbps, giving you greater bandwidth management flexibility. WAVE can also easily incorporate other CODECs not already supported.



(say a meeting of a medium-sized project team), or an "All Hands Meeting" where the company president addresses each employee in a 30,000 person organization. Your network should be able to handle the 50-person conference but it's hard to imagine an affordable centralized network configuration that can handle 30,000 simultaneous transmissions. Imagine the cost of the mixing equipment required to handle such an enormous conference! In fact, many organizations would not even consider such conferences because their network is not capable of handling the increase in IP traffic.

Fortunately, solutions exist today that overcome this technological barrier.

An Introduction to IP Multicast

A typical computer network consists of a complex array of hubs, switches, routers, and other network devices that make communication between end users possible. These devices collaborate to bring network traffic—mostly using Internet Protocol or IP—to endpoints such as PCs, servers, PDAs, and IP phones.

At the two ends of the IP communications spectrum are IP unicast and IP broadcast. Unicast communications describe a point-to-point pathway between two devices, such as PCs or IP phones on your network. Broadcast, on the other hand, describes a "point-to-everyone" communication design where the sender of information "broadcasts" their data on to the network so that everyone else will receive the data—whether they need it or not.

IP multicast technology falls between these two extremes and can be considered a "controlled broadcast" where only the endpoints that are interested in receiving a transmission actually receive that data.

Until the broad-based adoption of IP telephony (aka VoIP), most organizations typically did not need multicast technologies. With the advent of IP telephony and other bandwidth-intensive technologies such as video streaming, implementing IP multicast-enabled networks has become more prevalent.

IP Group Communications using IP Multicast

By using multicast to propagate the audio stream of a speaker, you only need a single stream per speaker, which all participants receive at the same time, no matter how many participants are on the call.

Even with 30,000 participants present on a group communication, the total bandwidth required is directly proportional to the number of people speaking rather than to the total number of participants—as is the case in a unicast environment.

Compare the diagram on the left with the earlier diagram showing centralized mixing. In this diagram, A and B are both speaking (as before) but because all participants have direct access to the transmissions from A and B, there is no need for a centralized mixer and as a result, there is no bandwidth duplication.

This design requires that mixing be performed at the endpoints themselves instead of by a centralized server dedicated to the task.

How WAVE Works

WAVE technology consists of a set of software building blocks and development tools designed around a simple and elegant concept: convert all forms of communication to IP packets, use the network to carry those packets between endpoints and build distributed intelligence and management capabilities at the network edge to connect the endpoints together.

WAVE converts communications from individual user devices into group-level IP packets that can be forwarded to other platforms, devices and users. Once having been brought into a WAVE Domain, these interoperable communication sessions are subject to management and security controls, and may be bridged, recorded, joined into conferences, or routed to devices outside of the system. WAVE supports both voice and data media types. In addition, status, presence and adaptive transport network management provide for rich collaboration among group communication participants. The result is that groups of people can talk and share real-time data, with full control, regardless of the devices or systems used.

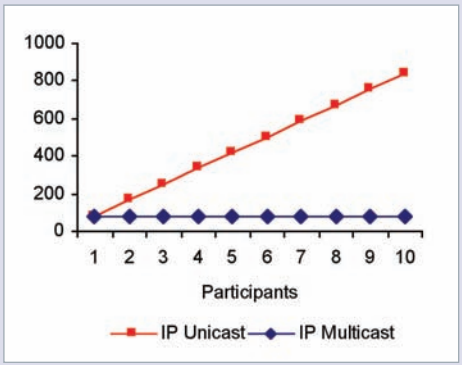
Group communication participants joining a conference can "tune in" to a WAVE "channel" using IP multicast, receiving and transmitting audio with no centralized mixer required. WAVE Supernode technology allows for non-multicast connections. Please refer to the WAVE Supernode section later in this document for more information.

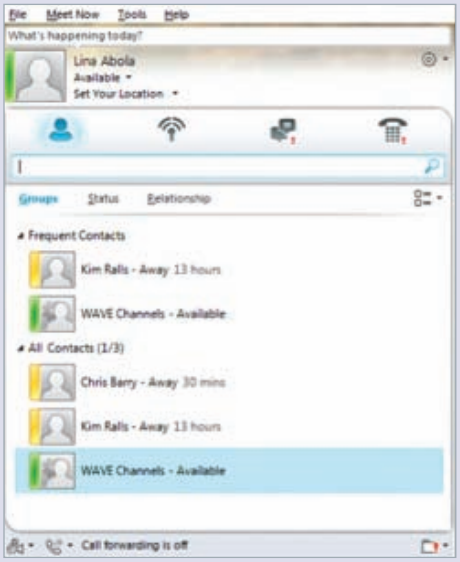
Audio mixing is performed at the endpoint, which isn't a problem because the WAVE Communicator clients perform that function. This design allows the system to operate in a completely peer-to-peer environment, meaning that there is no single point of failure and there is no need for mixed streams to be propagated to individual participants. WAVE's peer-to-peer architecture reduces network bandwidth requirements and the expensive bottlenecks caused by centralized mixing resources.

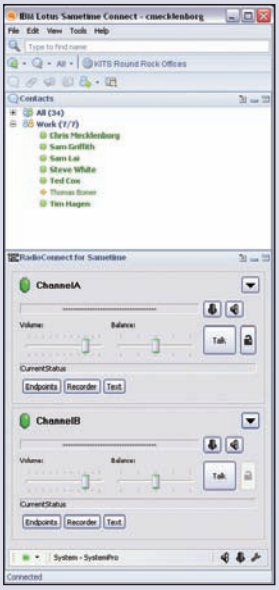
For those clients such as phones, IP phones, PDAs, and radio systems that cannot handle multiple sources, channels or codecs, the WAVE Media Server is invoked to provide mixing services. The Media Server operates much like a centralized mixer but propagates mixed audio to multicast streams instead of to unicast streams. The result: even though a software mixer has been brought into play, the bandwidth requirements on the network are directly proportional to the number of output streams from the Media Server rather than by the number of participants receiving those streams.

The Media Server also has a number of additional features that make it a compelling solution in different scenarios; these features will be discussed later in this paper.

Bandwidth Requirements: Unicast vs. Multicast







With embedded WAVE functionality, Microsoft Lync and IBM Lotus Sametime can be extended to include push-to-talk radios.

Unifying Group Communications Platforms

Several platforms have come into the market that allow customers to create group communications for different purposes. These platforms unify communications by combining phone calls, text messaging and other communication applications into one. However, these powerful platforms often overlook certain devices and types of users that WAVE can inherently work with, like radios.

Many customers are looking to these platforms to consolidate a host of applications and take up less real estate on the users' desktop. More importantly, customers are moving to a Unified Group Communications approach to decrease the number of applications and servers that require support. WAVE can seamlessly integrate with Microsoft Office Communications Server and IBM Lotus Sametime to extend the capabilities of these platforms. WAVE can even be used as an intermediary between these two platforms.

One type of device these two platforms currently do not support are radio systems. WAVE inherently provides support for radios and can easily be embedded in the clients of Microsoft OCS and IBM Lotus Sametime thus giving the user the full flexibility and functionality of all platforms – WAVE, Microsoft OCS and IBM Lotus Sametime.

WAVE Management Server

A collection of WAVE components controlled by a single WAVE Management Server is called a WAVE Domain. Every WAVE Domain has at least one WAVE Management Server, which is a web-based application used to enter and store Domain configurations and to distribute them to endpoints. The WAVE Management Server defines the administrative control of the communication assets it manages. These communication assets can then be shared with other WAVE domains based on requirements.

The ability to share assets between WAVE domains is extremely beneficial allowing WAVE customers to extend their collaborative capabilities across organizational boundaries as needed. In emergency situations, the ability to communicate across WAVE domains provides critical intercommunication between otherwise isolated departments and teams.

Since the WAVE Management Server is used only for configuration rather than audio processing, the WAVE Domain can operate for up to 30 days with no connection to the WAVE Management Server.

WAVE Media Server

The WAVE Media Server is a software component that is used to perform a number of functions, including media conversion or "transcoding," tone injection, centralized recording, media file distribution, and proxied mixing.

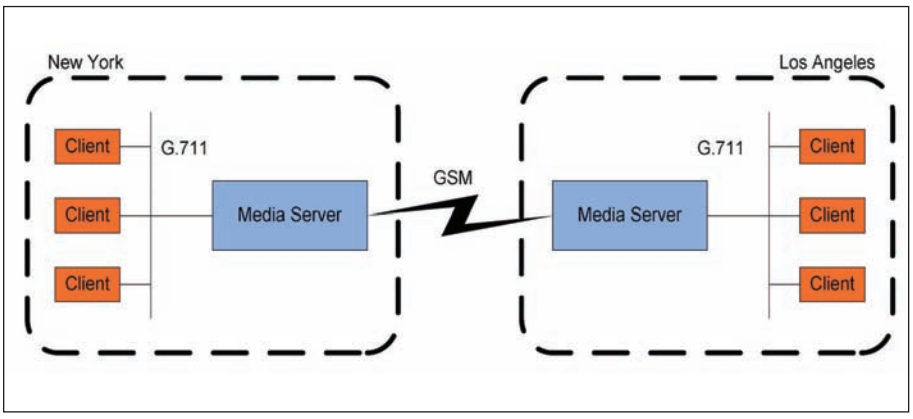
The best way to understand the features of the Media Server is to examine the ways in which it is typically used.

Cross-WAN Transcoding

Consider a situation where two high-speed LANs (10 mbps or better) are on opposite sides of the country (in New York and Los Angeles, for example). WAVE users on each LAN are configured to communicate locally using the G.711 codec, which uses about 84 kbps of network bandwidth per unidirectional stream. Now imagine that the New York and Los Angeles networks are linked through a low-speed WAN connection provisioned for 56 kbps.

To carry audio from one network to another, a WAVE Media Server in each location will pick up a WAVE channel's traffic at that location, combine transmissions from each of the speakers on that channel, and transcode to a more WAN-friendly codec (such as GSM, which uses 13 kbps). The new output stream is then directed across the WAN link (using unicast or multicast) to the far-end Media Server, which transcodes back to G.711 or simply forwards the incoming stream to the local multicast address. In this way, we minimize the WAN bandwidth required and only need a single transmission stream from one location to the other, even if multiple people are speaking onto the channel at a time.

If the wide area connection is an open network (say the Internet for example), the Media Servers on either end can also be configured to use encryption, ensuring that the media stream on the WAN is unintelligible to any unauthorized person trying to gain access to communications between the locations.



MANAGEMENT SERVER TECHNICAL DETAILS:

Operating Systems Supported

- Microsoft Windows Server 2003

Machine Requirements

- Microsoft Windows systems: Intel Pentium 1.8 GHz+, 512MB RAM, 500 MB available disk space (additional disk space required if recording is performed)
- Microsoft Internet Information Systems (IIS) 5.1+
- Microsoft Internet Explorer 5.5+
- Network Interface Card (NIC)
- Add CPU speed, memory and disk space for a more robust production installation
- Note: the WAVE Management and Media Servers are often installed on the same physical hardware platform

MEDIA SERVER SCALABILITY

Depending on the hardware and operating system used, the Media Server can typically handle hundreds of simultaneous sessions—more than enough for most organizations.

In-house tests show that a WAVE Media Server deployed on an 800 MHz single-CPU, 128MB Intel Celeron laptop can transcode, mix, and retransmit more than 150 simultaneous multicasts sourced and distributed to over 5,000 conference participants. Remember that the number of conference participants available through multicast does not affect the Media Server's processing power.

MEDIA SERVER TECHNICAL DETAILS

Operating Systems Supported

- Microsoft Windows Server 2003

Machine Requirements

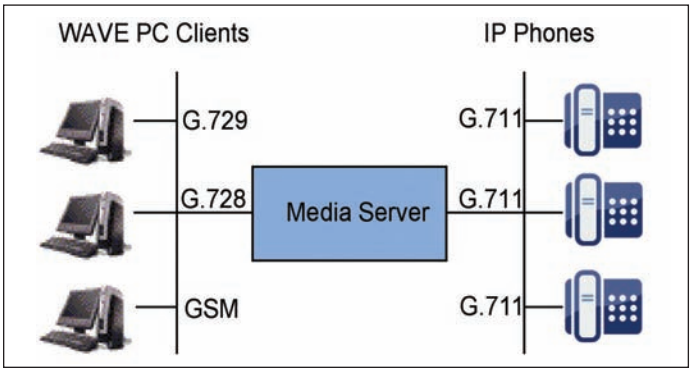
- Microsoft Windows systems: Intel Pentium 1.8 GHz+, 1GB RAM, 50 MB available disk space (additional disk space required if recording is performed)
- Network Interface Card (NIC)
- Add CPU speed, memory and disk space for a more robust production installation
- Note: the WAVE Management and Media Servers are often installed on the same physical hardware platform

TECHNICAL NOTE

"E&M" describes the electrical connection between two devices to carry signals. Over time, the term has come to stand for "Ear & Mouth," "Earth & Magnet," or "rEceive & transMit," depending on the individual using the term and the context it is applied in.

This generalized approach to Radio over IP (RoIP) is very powerful and differs from other offerings in the marketplace where proprietary solutions have been created to address the needs of radio integration alone. WAVE's approach is that a radio is simply an extension of the existing communications channel infrastructure.

Speaker and Channel Aggregation for Non-Mixing Clients



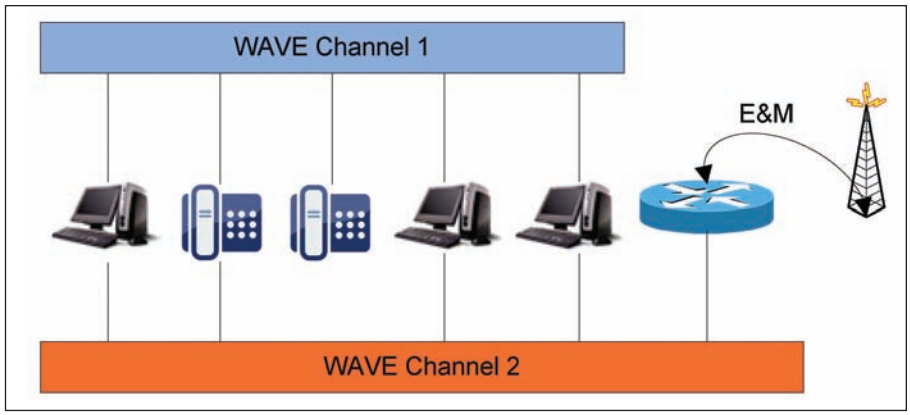
In this example, the WAVE Media Server is used to combine streams from multiple speakers and/or multiple channels (possibly using a variety of codecs) into a single stream output targeting devices (such as IP phones) that do not have the mixing and decoding features available in the WAVE client. As you can see in the diagram, the Media Server acts as a proxy for the IP phones, combining audio from each of the Communicator clients into a single G.711 stream output to a multicast group that the phones tune into. The Media Server can even be configured to act as a proxy between the phones themselves, allowing for "open microphone" use by phone users. This allows anyone using a phone for their multicast communications to speak—even while others are speaking—and not run the risk of a phone omitting audio from all the other speakers on the conference.

Radio System Integration

WAVE's unique architecture allows for a very exciting addition to the IP communications infrastructure—radio integration.

Through the use of a COTS radio gateway, transmissions from wireless radio systems can be propagated onto the network (in unicast or multicast) and received by WAVE endpoints, such as Communicator clients or IP phones. Supported radio gateways include standard Cisco routers provisioned with an E&M interface, the JPS/Raytheon ACU-1000, ACU-T or NXU-2, Daniels UIC, Telex/Vega IP-223 or NI-223, C4i gateway, the AM360 gateway from Voice Interop and several others. Transmission back to the radios from WAVE clients is achieved by taking advantage of a client's ability to embed tones in the audio stream for tone-based radios or the radio gateway's ability to provide Push-To-Talk (PTT) control.

Tones serve to change channels on radios, switch power levels, and "key up" the radio to begin (and continue) transmission.



Connecting a radio interface with a WAVE channel is a straightforward process of configuring the radio gateway and WAVE channel with the same unicast or multicast IP address and port number. If you have a tone-based radio, simply define tone patterns that are associated with a radio and select those tones as an extension of the WAVE channel. This design means that an organization can use any number of radios from any number of manufacturers.

Hardware installation is simple too, requiring only the installation and configuration of the radio gateway. There is no proprietary WAVE hardware or software required to interface with the radio.

Once a channel has been configured with the radio interface, WAVE users speaking onto the channel will automatically key up the associated radio. Audio received from the radio is seen by WAVE as a stream similar to any other audio stream in WAVE (e.g. as if it were coming from another Communicator client) and is processed as such.

This generalized approach to Radio over IP (RoIP) is very powerful and differs from other offerings in the marketplace where proprietary solutions have been created to address the needs of radio integration alone. WAVE's approach is that a radio is simply an extension of the existing communications channel infrastructure. This means that radios are "just another device" in the WAVE Domain, along with phones, PDAs, IP Phones, and PCs. In fact, WAVE doesn't even know that it's communicating with a radio system; nor should it. Group Communications need to be flexible and you shouldn't have to know every single device with which you are communicating.

Tone Injection

While it's possible to perform complete end-to-end signaling between a WAVE client and a radio system, it may be desirable to have tones "injected" by a third party. This may be necessary in many different situations. For example, you may have remote users connected to the network using a dial-up connection. These users are, by default, on a low bandwidth connection and are therefore given a low bandwidth codec to use for communications. This low bandwidth codec likely isn't dynamic enough to carry full-range tones to a radio system. If the radio system doesn't receive the proper tone sequence to carry out the requested function (e.g. key up, key down or change channels), the radio system will ignore the audio communication. Another possibility is that your users are connected via a network segment that is notorious for high packet loss. Like in the previous example, if packets carrying tones to a radio are lost, the radio will not act appropriately.

In these scenarios, the WAVE Media Server is brought into play, configured to inject tones on behalf of clients who are transmitting to radios. The tone injection is carried out either at the request of the client or automatically when incoming audio streams are detected.

A side-benefit of this design is that multiple people can speak into a radio at the same time. The Media Server will only key the radio once. This is something that is not otherwise possible with many of today's radio systems.

Tone injection is also used when WAVE users on Cisco IP phones want to communicate with radios. In these situations, the Media Server is used to generate tones on behalf of the phones either when phone users press their "Talk" buttons (in a "push-to-talk" configuration), or when audio streams are detected (in an "open microphone" environment).

REAL-WORLD EXAMPLE

United States Coast Guard

The United States Coast Guard uses WAVE Communicator clients to monitor radio traffic from their ships at sea, planes in the air, and personnel on the ground. Using WAVE, Coast Guard personnel with access to multimedia Windows PCs can listen in during rescue operations and speak back to radio systems right from their computers whether they're at the base, at home, or anywhere on the Internet! WAVE has also allowed the Coast Guard to setup network-based intercom sessions, allowing for quick and easy ad hoc communications between personnel.

WAVE Control Channel

The WAVE Control Channel enables WAVE to efficiently carry data messages throughout the network. Data messages include status & presence information, text messages, GPS coordinates from radio gateways, timestamps, system properties, and other values. The Control Channel is based on an implementation of secure reliable multicast which ensures that all endpoints that need to receive the control channel messages actually do receive them. If a data message is "lost" in the network, it will be retransmitted.

When a WAVE Communicator user hits the talk button on their screen, a control channel message is sent out along with the transmitted audio. The control channel messages notify other users of who is speaking on the channel. This information will be displayed on the listeners' screens. Similarly, when a Communicator user sends a text message on a channel, that text message is sent out over multicast to all users who are tuned into that channel.

If a radio gateway is able to provide GPS coordinates or Unit ID's of individual handheld radios to WAVE, the WAVE Domain can pass these coordinates to end-user clients. Using our SDK, this information can even be integrated into a GIS mapping solution at the desktop; thus providing users with a more complete picture of the situation.

WAVE Supernode

Now that we've discussed WAVE and some of its uses, it is important to talk about other ways to make WAVE more useful for your group communications needs. This White Paper has discussed the notion of IP multicast and its use to carry audio across the network. What happens if multicast is not available throughout the network? One solution is to use WAVE Media Servers to convert streams from multicast to unicast and then back to multicast again on the far end. This was discussed in the Cross-WAN Transcoding section. But what do you do if multicast isn't available on your Local Area Networks? Use WAVE Supernodes.

WAVE Supernodes allow customers to use a combination of unicast, multicast, mixed-mode or federated unicast. This patent-pending technology was developed to help customers overcome network bandwidth and technology limitations by not requiring network-wide IP multicast and by allowing customers to choose TCP or UDP as their transport method.

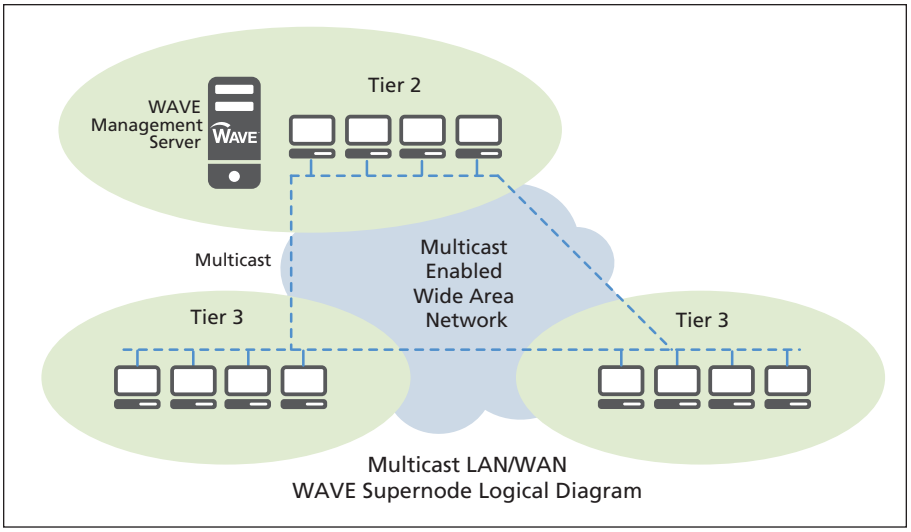
While WAVE Supernode technology has many configuration options, this White Paper will only discuss Supernode technology at a high level.

Supernode Configuration Options

To better understand WAVE Supernodes, it's important to visualize the different configuration options available. These configurations vary depending on the network bandwidth and transport mode available (e.g. TCP/IP vs. UDP and multicast vs. unicast).

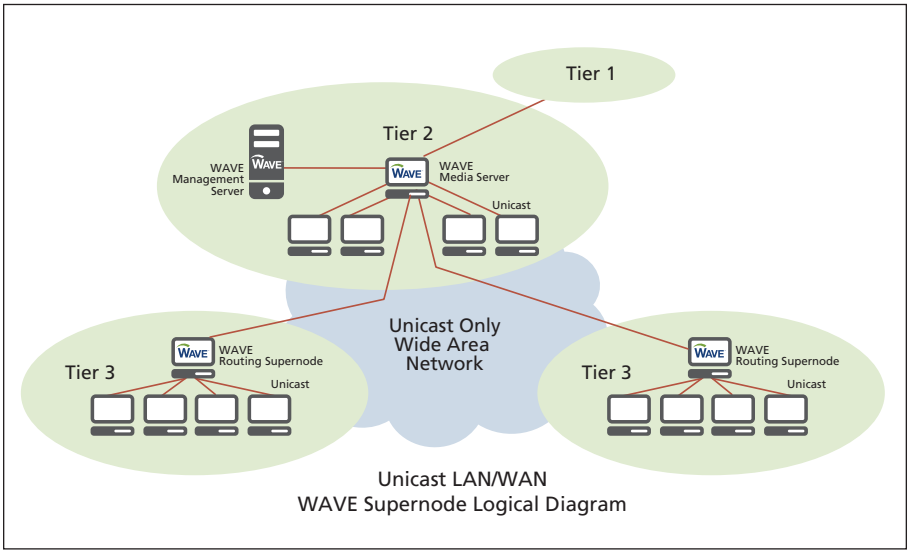
The diagram at right shows IP multicast is available throughout the network between the two Tier 3 systems and the Tier 2 system as well as within each local network. WAVE is most easily configured when multicast is available throughout LAN & WAN segments; it also provides for the most scalability.

In the diagram on the right, IP multicast is not available anywhere on the network, either on the LAN or WAN segments. WAVE still works well within these network confinements. Each Tier 3 system has its own WAVE Routing Supernode which



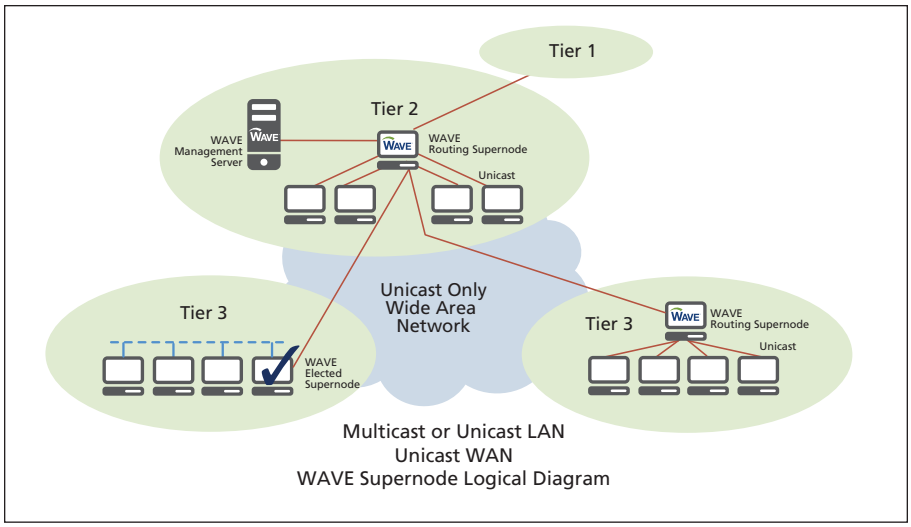
allows each client to connect to it using unicast. The WAVE Routing Supernode then connects to another WAVE Routing Supernode to pass audio and control traffic back and forth using unicast, thus making it a federated unicast architecture. Using this method, all connections are over IP unicast and WAVE Routing Supernodes can be configured to talk to any other number of WAVE Routing Supernodes for redundancy.

WAVE Supernode can also accommodate mixed networks where some LAN segments support multicast but other LAN segments or the WAN support only unicast. In this mixed-mode operation, each WAVE Zone is configured for the appropriate connectivity. In the diagram at right, one Tier 3 LAN has multicast capability and therefore uses multicast for scalability and network bandwidth preservation. At the same time, this multicast-enabled Tier 3 system will use the Supernode election feature to determine which client (or server) should become the WAVE Routing Supernode for that particular channel on that network. Once the election process is complete, the elected WAVE Routing Supernode will forward all audio and control traffic data for that channel to the appropriate upstream WAVE Routing Supernode using IP unicast.



FEDERATED UNICAST WITH WAVE SUPERNODES

Federated Unicast is a WAVE Supernode feature that allows for tiered IP unicast connections within a WAVE Domain or between WAVE domains. With WAVE Supernodes, endpoints are now able to connect to Routing Supernodes using IP unicast. To make these connections federated, Routing Supernodes then connect to upstream Routing Supernodes using IP unicast. Please see the Supernode Configuration Options section for an example of Federated Unicast.

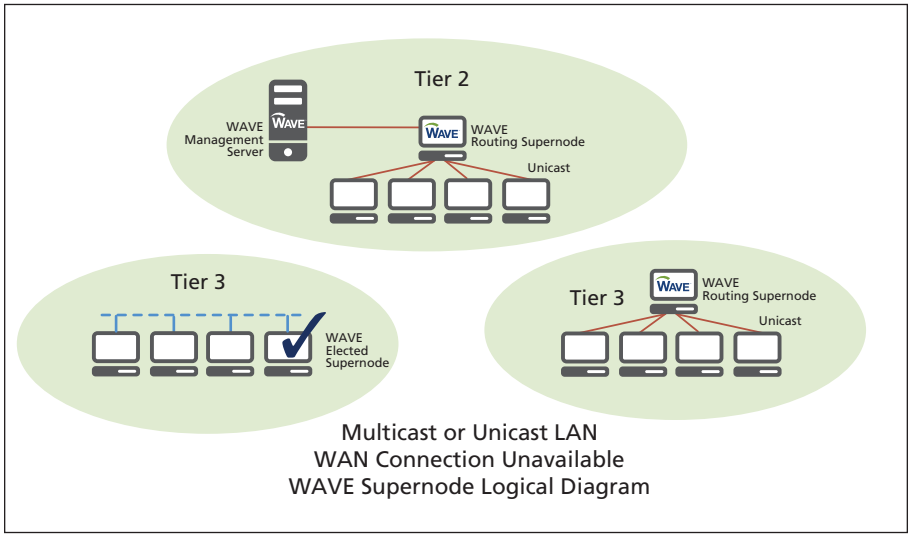


Meanwhile, a separate Tier 3 system may be configured to operate in unicast mode. This does not differ from the WAVE Supernode functionality mentioned with the previous diagram above.

This WAVE Supernode diagram also constitutes a federated unicast architecture because each Tier 3 system connects to the Tier 2 system using IP unicast. The Tier 2 system then uses unicast to connect to the Tier 1 system.

If hardware or network failures bring down the WAN, WAVE still continues to operate. Even though there are no cross-tier communications available, audio and control traffic data are still functional on the individual LANs (assuming LAN connectivity is still available). In the background, the WAVE Supernode clients and Routing Supernodes are continually trying to reconnect to their appropriate nodes. When the WAN becomes available again, WAVE will have already reconnected and cross-tier communications are automatically re-established without network administrator intervention. This feature makes WAVE self-healing in that it can easily deal with network interruptions and automatically reconnect without manual intervention.

WAVE Media Servers are typically used as the WAVE Routing Supernode, even in those domains where Supernode elections take place.



Resiliency & Redundancy

WAVE has built-in abilities to recover from many hardware or network failures and faults. In most cases, this recovery is automated and end-users have no idea that a fault occurred.

WAVE takes a multi-level approach to resiliency and redundancy. Although WAVE is reliant upon the network to transport IP packets, some of these network segments may fail. If that occurs, WAVE Supernodes will automatically attempt to connect using other network routes. While this may cause a momentary break in active communications, the amount of time it takes to re-route this traffic is usually less than 5 seconds.

WAVE Media Servers are a very important part of most WAVE Domains, providing most of the audio processing power in a WAVE Domain. Media Servers tie channels together for both scheduled and ad-hoc communications as well as allow the WAVE Domain to accept inbound calls and patch them into radio or other systems. If a Media Server were to stop processing audio due to hardware, software or network failure, a redundant Media Server can take over automatically and pick up processing where the failed Media Server left off. This redundancy is built into the WAVE Media Server and can be enabled by installing a backup Media Server in the network.

The WAVE Management Server, although not used for audio processing, is still an integral part of any WAVE Domain. It used to configure the domain, store centralized recording files and serve the XML for the WAVE Cisco IP Phone Client, among other tasks. If the WAVE Management Server were to go offline, the Media Servers would store all recording files until a connection to the Management Server could be re-established. To ensure constant operation of all clients and the ability to make ad-hoc changes to the WAVE Domain configuration, the WAVE Management Server can be replicated on a separate machine for redundancy purposes.

Application Background

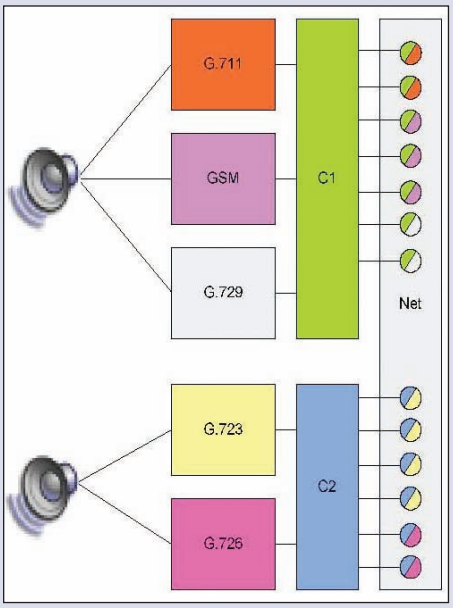
WAVE was originally designed to operate as a peer-to-peer, massively scalable, IP-based conferencing solution for financial markets with Windows PCs as the initial endpoints. An easy way to understand this concept is to think of WAVE as an IP-based intercom or "hoot and holler" system with PCs as endpoints.

Design requirements included the ability for endpoints to tune in to many multicast WAVE channels at the same time, receive audio from any number of sources (or speakers), and be able to process that audio—even if the audio format is different for each speaker.

As shown in the diagram, a WAVE Communicator client is capable of joining multiple channels ("C1" and "C2"), receiving audio from multiple sources within each channel, and processing audio from each source using a variety of media compression algorithms (codecs).

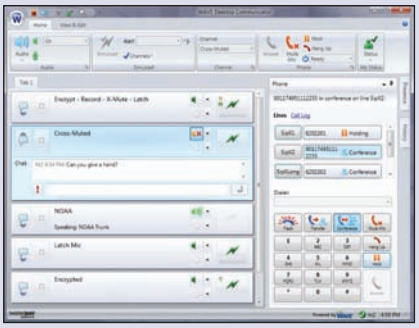
Each channel can also be directed to a specific audio device such as the PCs primary or secondary speakers or a headset.

A further goal of the design was to develop an open layer of abstraction, which would allow extensions to be made to the system as time progressed and customer needs changed. This design consideration has become a key advantage and has allowed us to add new features to WAVE (such as integration with radio systems and IP phones) without affecting the core operating environment. Partners and



customers who have special requirements can also take advantage of this open design methodology by modifying the existing WAVE software or developing add-ons to the system to suit their needs.

Of course, because WAVE was originally designed for financial markets, it required features such as encrypted transmissions and recording facilities that are not always needed in other sectors. Inclusion of these features has resulted in WAVE becoming a solid communications platform not only for financial markets, but also for a broad range of applications across different market sectors.



WAVE Desktop Communicator™

WAVE Desktop Communicator

Desktop Communicator is an intuitive PC-based application that allows office-bound and mobile workers to quickly and effectively communicate and collaborate in distributed environments. Desktop Communicator provides easy access to channels and groups, telephony, simulcast, recording and instant replay.

The WAVE Desktop Communicator comes in two flavors: a stand-alone installed executable or an ActiveX control that can be hosted through a web browser. The web-based client does not require installation at the local PC.

The Desktop Communicator client has a number of standard features that make it a perfect fit for many organizations, including:

- An easy-to-use interface
- Status & presence
- Group text messaging (not available in the web client)
- Master volume controls
- Color-coded buttons showing status
- Channel-by-channel relative volume levels
- Left-right audio panning on stereo output devices
- An activity record, which graphically depicts activity on a channel for a user-defined period Local recording of channels, allowing one to play back audio received while the user is away from the desk
- Option to save recordings to disk
- Selection of audio devices to be associated with individual channels
- Selection of an audio device to be associated with all channels
- Selection of separate microphone and speaker devices on a channel-by-channel basis or across all channels
- Selection of network interface to use for transmission—ideal for users who have multi-homed machines or who are accessing the corporate network via VPN or dialup connections
- Radio-specific buttons for WAVE channels that map to radio systems
- Ability to use “free-seating”. This allows users to logon to WAVE from any computer and have their settings automatically downloaded for them.

WAVE Dispatch Communicator

Dispatch Communicator is a state-of-the-art IP dispatch console system designed for critical communications dispatch applications. Built on WAVE, the industry's original and only pure software communications interoperability platform, Dispatch Communicator employs the latest Voice-over-IP (VoIP) and Radio-over-IP (RoIP) technology to provide the console operator with full dispatch functionality via an intuitive, easy-to-use desktop client running on a single, industry-standard PC.

Dispatch Communicator supplies the complete range of features and functionality that critical communications command and control centers require, and offer unmatched levels of communications system interoperability and network scalability. It is designed to meet the needs of the full range of dispatch operations personnel who interact with the system, including dispatchers, administrators, supervisors, and technicians.

Dispatch Communicator can display and process unlimited numbers of channels of secure, encrypted audio with mixing, transcoding and instant replay available at the click of a mouse. All audio processing is managed by the software itself, requiring no additional specialized audio hardware typical in legacy IP dispatch systems.

The WAVE Dispatch Communicator includes all of the previously listed features of the WAVE Desktop Communicator with the following additions:

- Ability to create patches on-the-fly. These patches could include WAVE channels (e.g. radios or chat channels) as well as phones or any other devices
- Ability to deactivate the above mentioned patches with one click of a button
- Multiple line soft phone that can be used for inbound or outbound dialing
- Select/Unselect audio
- Expanded device support that includes foot pedals and other dispatch-specific devices

WAVE Dispatch Communicator™

WAVE Mobile Communicator

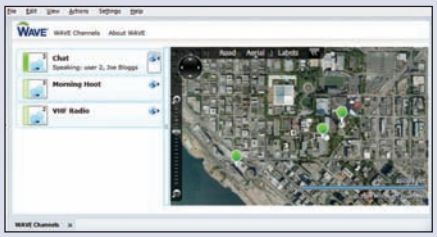
Mobile Communicator allows smartphone users to access Push-to-Talk (PTT) radio channels from their phones, converting devices they always carry with them into inexpensive alternatives to expensive mobile radios. When equipped with the WAVE Mobile Communicator, a smartphone acts

like a multi-channel radio handset that sends and receives secure audio. Audio processing, management and distribution are managed by WAVE servers residing in an enterprise data center, in a cloud environment or, if needed, on an individual PC.

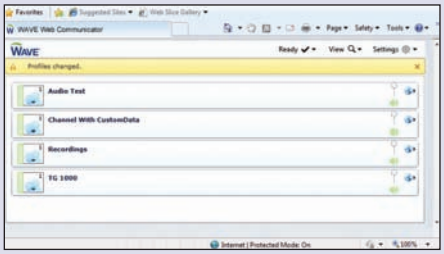
The Mobile Communicator is a very small application that combines the power and military grade security and encryption of the WAVE platform with a breakthrough Radio-over-IP (RoIP) communications protocol. This solution is the first of its kind to eliminate device and network type as a barrier to communication with two-way radio systems. Mobile Communicator architecture minimizes any security risks as no audio data or significant application content is resident on the device. If a device falls into the wrong hands there is no opportunity for reverse engineering of the application to produce a security threat to the user or system.

WAVE Mobile Communicator applications are currently available for select BlackBerry® and Windows Mobile smartphones. An Android™ version will be available in 2H 2011.

WAVE Mobile Communicator™



WAVE Lync Communicator™



WAVE Web Communicator™

WAVE Lync Communicator

The Lync Communicator extends Microsoft's Lync unified communications platform by adding direct voice communications between users no matter what time it is, where they are located, or what type of device they are using. With the Lync Communicator, Lync users don't have to navigate different platforms to get in touch with those persons in field. They can simply track and talk with two-way radio and smartphone users as they would anyone else in their Lync network—making interactions easier and more accessible. Lync Communicator appears as a panel within the Lync client and shows what communication channels are available. When a Lync user wants to communicate with an individual or group of users they simply click on the appropriate WAVE communication channel and talk or text with the user.

The Lync Communicator also has the ability to display presence information directly on a Bing map from users of WAVE Mobile Communicators and GPS-supported push-to-talk radio users. See and Speak with Mobile Workers WAVE Lync Communicator offers the ability to display presence information directly on a Bing™ or Google map from users of WAVE Mobile Communicators and GPS-supported PTT radios. This capability is extremely important when it is essential to know where field resources are deployed.

WAVE Web Communicator

WAVE Web Communicator removes one of the most common barriers to universal communications access for fixed and mobile workers—it removes the need to possess an authorized device running a dedicated application. Instead, users of a WAVE system can monitor or fully participate in critical communications from any PC or device by using a web browser.

WAVE Web Communicator is a feature-rich web application that allows any office-based or mobile worker to monitor, transmit, and receive audio from multiple communication systems such as two-way radio networks and telephones using a browser-based application. Built using Microsoft's latest Silverlight technology, Web Communicator can run in a wide variety of web browsers and applications with an intuitive and easy to use display. Web Communicator can manage more than 20 channels of secure, encrypted audio from inside a web page or application. Using a lightweight proxy to access WAVE processing and management functionality on remote servers, in a hosted environment or as a Cloud-based service, any web browser attached to any network (wired or wireless) can provide access to WAVE-enabled communications.

The Web Communicator also has the ability to display presence information directly on a map from location-enabled Mobile Communicators and GPS-supported push-to-talk radio users. This capability is extremely important when it is essential to know where field resources are deployed. When not in use, the web application runs in the background enabling users to manage other tasks while still monitoring audio from multiple channels. Intended for users who do not have dispatch responsibilities, a Web Communicator runs as a standalone browser application or as a plug-in for web-based portals like Microsoft SharePoint. Each time a user logs off the system, preferences are cached on the machine so that at the time of the next login Web Communicator will open the same way as it was closed. Web Communicator is designed to be easily localized into any language.

IP Phone Integration—Cisco & Nortel

Integration with Cisco's CallManager or Nortel's BCM50 and CS1000 systems allows customers to extend their WAVE functionality, enabling users of IP phones to use WAVE channels in much the same way that users of the WAVE Communicator clients do.

WAVE takes advantage of the multicast features built into these IP phones to allow those phones to transmit onto WAVE channels and receive multicasts from other WAVE endpoints, including Communicator clients, other IP phones, and even radios.

Users of IP phones use a built-in interface on their phones to log in to WAVE. Once logged in, an IP phone user is presented with a list of WAVE profiles and channels they can tune to, allowing them to select the channel (or channels) to listen to. Upon selection of a channel, the phone begins receiving audio directly from the WAVE multicast or proxied through a WAVE Media Server, which performs mixing and transcoding on behalf of the IP phone client. This design makes it possible for an IP phone to participate in conferences with multiple speakers and to receive proxied audio encoded in a variety of transmission formats. It also allows the IP phone to receive multiple channels simultaneously.

WAVE Software Development Kit

A software toolkit for developers, the WAVE SDK provides programming interfaces to the communication functionality of the WAVE Engine and shields developers from the complexities of inner systems enabling them to get products to market quickly. Developers use the WAVE SDK to create interoperable, custom client applications or incorporate WAVE within current applications to build a fully-integrated, robust solution architecture.

The WAVE SDK is packaged as a set of Java or .NET classes that present clear and consistent interfaces to key WAVE components. The SDK documentation is presented in HTML Javadoc format. The sample applications supplied include complete source code providing best design practices and reusable pieces of code.

WAVE Solution Developers create power behind the voice from three membership tiers: Registered, Certified and Premium. Registered members try the technology in a lab environment on the Internet called the WAVE Sandbox to learn about WAVE and build custom applications. Certified and Premium members experience in depth training, tools access, support, plus marketing and sales assistance to showcase the partner and their unique solutions. The program provides developers with everything needed to try, build and sell customized solutions.

WAVE CORE FUNCTIONALITY

Operating Systems

— Windows XP/Vista/Win7
— Windows Server 2003/2008
— Redhat Enterprise Linux 5.1
— Includes support for 64-bit operating systems

IP Telephony

— SIP and H.323

IP PBXs

— Asterisk
— Avaya Communications Manager
— Cisco Integrated Services Router (ISR)
— Cisco Call Manager and Call Manager Express
— Cisco CUCM 7
— Nortel BCM and CS 1000
— SIPx 3

Radio Gateways

— By-Light TRICS
— C4i RIU
— Cisco 2800 Series Router E&M
— Dialogic DMG4000
— JPS NXU-2 / ACU-1000
— NICS RAVIN Audio Gateway
— Telex IP-223 / NI-223
— Voice Interop AM 360

Embedded UC Integration

— Adobe Connect
— IBM Sametime
— Microsoft OCS 2007

SDK APIs

— .NET 2.0 / 3.5 SP1
— Java JRE 1.6.0

Supported Smartphone Devices

— BlackBerry® Torch™ 9800
— BlackBerry® Bold 9000[1]
— BlackBerry® Tour 9600[1]
— Windows Smartphone[2]

1. *RIM OS 4.6/4.7*
2. *Windows Mobile 6.0/6.1/6.5 Professional/Touch*
   Windows Mobile 6.0/6.1/6.5 Standard/Smartphone
   Windows CE 5.0

Conclusion

This White Paper was developed to provide you with a better understanding of WAVE and the technologies it uses to deliver secure, scalable, reliable Unified Group Communication solutions for your organization. With WAVE, organizations can take advantage of the resources available within their existing IP network and create a system to enable group communications for many types of disparate users and devices. WAVE provides a robust suite of applications that can be used to access other platforms and devices. In addition, WAVE provides a robust SDK to allow Solution Developers to customize WAVE to meet the specific needs of their customers. To learn more about WAVE and how it can help your organization, please contact your authorized WAVE reseller, or visit Twisted Pair Solutions on the web at www.twistpair.com.

ABOUT WAVE

WAVE software empowers your mobile workforce with critical communication applications for secure, real-time collaboration anywhere on any device built upon a battle-tested communications interoperability platform that delivers voice, video, location, presence and other forms of data deployed as an enterprise product or cloud based service throughout commercial, public sector and defense organizations worldwide. Proven in thousands of the most complex deployments around the world, WAVE helps you integrate and control a truly unified communications system so that office-based and mobile workers can simply talk, make decisions and act. WAVE has a Certificate of Networthiness from the U.S. Army and is on the NATO Approved Fielded Products List.

CORPORATE HEADQUARTERS
3131 Elliott Avenue
Suite 200
Seattle, WA 98121 USA
(T) +1.206.442.2101
(F) +1.206.812.0737
(E) sales@twistpair.com

EMEA
Davidson House
Forbury Square
Reading, RG1 3EU
(T) +44.118.900.1110
(F) +44.118.900.1111
(E) sales.emea@twistpair.com

APAC
2 St Peters St
Glenelg East, Adelaide
South Australia, 5045
(T) +61.(08).8376.5905
(F) +61.(08).8125.6570
(E) sales.apac@twistpair.com