

4.9 GHz – New Public Safety Spectrum Requires New Thinking

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4.9 GHz PUBLIC SAFETY BAND

In early 2004, one of the largest transfers of radio spectrum in US history took place when the federal government allocated 50 MHz in the 4.9 GHz band to Public Safety agencies and jurisdictions. In a major departure from previous Public Safety spectrum allocations, the Federal Communications Commission placed only minimal requirements on spectrum usage, granted licenses to use the whole band to multiple co-located agencies and left issues dealing with channel allocations and interference to be worked out by the end-user agencies. Simply put, the FCC's message to Public Safety was, "Here is a bunch of spectrum, you figure out how to use it." While this approach is quite common in the general public and enterprise markets with multiple unlicensed frequency bands and industry standards such as 802.11a/b/g, the concept is new to Public Safety and thus requires new thinking.

CLASSIC PUBLIC SAFETY RADIO

Public Safety as a whole is very well versed in radio engineering, installation and operation. This knowledge is based on many years experience with 2-way voice radio systems; and in many respects, 2-way radio evolved through years of Public Safety use. This is both an asset and a liability. Originally each separate police, fire, ambulance, and rescue department developed their own radio system to aid communications within their own operation. Interference was a major issue because any interference could easily render a voice channel useless. The primary method to avoid interference was to assign specific frequency channels for the exclusive use of an agency within their geographic territory. Channels were assigned such that one agency would not interfere with another agency as long as the assigned channel was used only within the prescribed area. This method generally resolved interference issues and served Public Safety well for many years, but was not perfect.

As each city and each department developed their own radio systems to operate on their own assigned channels, there was little commonality between systems. Many "communication islands" developed where an agency could communicate well with its own members, but communication with other agencies was limited or non-existent. As radio communication evolved into a critical component of emergency response, lack of communication between responding jurisdictions became a serious problem. Even assigning a series of common-use channels for communication between the "islands" did not always solve the problem as different agencies had radios that worked on different air interfaces and protocols.

Analysis of the emergency response to the September 11th terrorist attacks placed new emphasis on interoperability problems with Public Safety communications systems. Disasters such as the World Trade Center attack in New York are far larger than any single Public Safety agency can handle on their own. Public Safety has a long history of mutual aid, often requiring large redeployment of resources to geographic areas far from home. Under these circumstances it is imperative that multiple agencies be able to communicate with each other. There is now a federal government mandate and nationwide effort to bring communication interoperability to all Public Safety jurisdictions.

4.9 GHz SPECTRUM

In 2004, the FCC designated the frequency band 4940 to 4990 MHz for Public Safety use. The intent was to use the band for emergency incident Wi-Fi type hot spots giving first-responders the capability to connect to WANs, databases and the internet. The FCC, however, did not limit the band's use to this function.

4.9 GHz

NEW PUBLIC SAFETY SPECTRUM REQUIRES NEW THINKING

QUALIFIED USERS

Any Public Safety agency may obtain a license and use the 4.9 GHz band. FCC rules permit any agency qualified to gain a license in the 700 MHz band to receive a 4.9 GHz license. Generally this applies to government agencies, private companies sponsored by government agencies (such as private ambulance services) and organizations with critical infrastructure (pipelines, power companies, etc.). The overall purpose is to use the 4.9 GHz band for the protection of lives and property.

APPROVED USES OF THE BAND

The band may be used for any type of service including data, voice, and video, provided such use is terrestrial-based. Typical topologies and uses are shown in the following table:

Topology	Typical Use
Temporary Point-to-Multipoint	Ad hoc networks for emergency incidents
Temporary Point-to-Point	Backhaul for incident ad hoc networks
Permanent Point-to-Multipoint	Citywide Public Safety "Wi-Fi" type networks
Permanent Point-to-Point	WAN data links, repeater backhaul, other Video security, monitoring or surveillance systems T1 line replacement Mobile data for off-site workers

Aeronautical use is not currently allowed, however some jurisdictions are attempting to get an FCC waiver to use the band for helicopter-to-ground video transmission. Any commercial use of the band is prohibited.

All multipoint networks and temporary point-to-point links (those in operation for less than 1 year) are primary uses of the band. Permanent point-to-point links are allowed as secondary uses. Interference between users of the band can often be eliminated by operation or design changes to the networks involved. Examples are using more focused antennas, changing antenna polarization, and reassigning channel usage. In cases where interference cannot be eliminated by these means, primary users take precedence over secondary users.

CHANNEL PLAN

The 4.9 GHz band consists of 18 channels as detailed below:

Channel Number	Center Frequency (MHz)	Channel Bandwidth (MHz)	Channel Number	Center Frequency (MHz)	Channel Bandwidth (MHz)
1	4940.5	1	10	4967.5	5
2	4941.5	1	11	4972.5	5
3	4942.5	1	12	4977.5	5
4	4943.5	1	13	4982.5	5
5	4944.5	1	14	4985.5	1
6	4947.5	5	15	4986.5	1
7	4952.5	5	16	4987.5	1
8	4957.5	5	17	4988.5	1
9	4962.5	5	18	4989.5	1

There are plans in many areas to combine the 5 MHz channels together to make either four 10 MHz channels, two 20 MHz channels or a combination of 5, 10 and 20 MHz channels. The wider channels handle increased data throughput rates and are allowed to transmit at higher power greatly increasing coverage areas.

LICENSING

The licensing process is simple and there is no charge. Any qualifying Public Safety entity may obtain a general 4.9 GHz license by submitting a form on the FCC ULS (Universal Licensing Service) web site. The license is usually delivered within a day. Unlike 2-way voice radio, no frequency coordination is needed to obtain a license. Permanent point-to-point links require site-specific licenses in addition to the general license. The same process is used to obtain a site-specific license with the only additional requirement that endpoint coordinates of the link must be specified.

FREQUENCY COORDINATION

A general 4.9 GHz license grants an agency the right to use the entire 4940-4990 MHz frequency band. Interference can be a significant issue because several agencies may gain licenses for the same geographic area. Interference normally can be prevented or eliminated by affected agencies working together on a technical solution.

The FCC gave existing Public Safety 700 MHz Regional Planning Committees the option to perform 4.9 GHz frequency planning, but has not required them to do so. Many of the committees have chosen to take on this responsibility. Under the current rules committees have no enforcement power in the 4.9 GHz band, however there is general recognition by the Public Safety community that there needs to be a coordinating body to ensure efficient use of the band and help prevent interference.

Legally, any agency may use any part of the band upon obtaining a license with no frequency coordination. There is the potential for some chaos in heavily populated areas, however most agencies are willing to work with each other and with the RPC to ensure orderly use of the spectrum. If the band is used intelligently, interference will not be a significant issue until such time that the spectrum is in full use in a given area.

ADVANTAGES OF DEDICATED PUBLIC SAFETY BROADBAND SPECTRUM

Actual operation of the 4.9 GHz band has many parallels and some significant advantages to usage of the unlicensed 2.4 and 5.8 GHz frequencies. The unlicensed bands and specifically 2.4 GHz Wi-Fi band have proven that multiple users with equipment from different manufacturers can be operating together simultaneously with minimal interference issues. The unlicensed bands have also demonstrated that poorly designed networks can experience interference and can get overloaded. These problems occur because there is unlimited public access to the bands which can create chaos.

The 4.9 GHz band has the capability of taking what works in the unlicensed bands and reducing or eliminating what causes problems. Multiple agencies may simultaneously use the frequency band in similar fashion to the unlicensed bands. Unlike the 2.4 and 5.8 bands, where anyone may power up a radio at any place and time, use of the 4.9 band requires a geographically based license so all users are known and any interference issues can be dealt with between the affected parties. The same philosophy applies to data throughput rates. Channel usage in the 4.9 band can be agreed upon by the licensed users so that the spectrum is used most efficiently by all.

Lastly, Public Safety can operate with a higher degree of security using a licensed frequency band excluded to the public. There is never a guarantee that someone cannot "sniff" the 4.9 GHz band and hack into computer networks, but the process is much more difficult than it would be in an unlicensed band. Any individual can purchase an 802.11 radio from Best Buy, Circuit City or numerous other sources and intercept unlicensed band traffic with few legal implications. Radios operating in the 4.9 GHz band should be available only to Public Safety agencies, thus making it harder for the general public to monitor or interfere with data transmissions.

CONCEPT OF SHARED SPECTRUM

In the 2-way radio world, order was brought to chaos by assigning specific channels for exclusive use by an agency or department. Even with full interoperability between radio systems, the available spectrum is still broken into small channels and assigned either temporarily or permanently to specific users. With broadband data such channelization is not necessary and in many cases is not possible. With only eight 5 MHz channels available (ten if the 1 MHz channels are aggregated) there may not be enough channels to assign one to each jurisdiction in a given area. This is further complicated when geographic boundary and frequency reuse issues are factored in. The answer is for many users to share the same spectrum.

In theory, all 50 MHz of the 4.9 GHz band could be aggregated into a single channel and used by all agencies at the same time. The radio becomes the physical layer interface, similar to the Ethernet cable on a computer network. Internet Protocol addressing is then used to separate and route data to the correct destination. In this scenario there is no need for a department to have its own frequency channel. While theoretically possible to aggregate all channels together, this does not follow FCC rules. A likely use of the band will see a combination of 5, 10 and 20 MHz channels.

Broadband data traffic by nature is “bursty”, meaning high throughput is needed by an individual computer during transmission bursts, but not needed at other times. Sharing the 4.9 GHz RF spectrum amongst many users causes the bursts to be aggregated leading to highly efficient use of the spectrum. A negative of spectrum sharing is that channels may become overloaded leading to slow data transmissions and general slowing of network response. These are the same constraints that apply to wired computer networks and can be reduced or eliminated in similar fashion by using good network design and monitoring techniques.

ISSUES

Interoperability

Interoperability takes on even more importance than in the 2-way world. At an emergency incident, all the interoperability issues associated with 2-way also apply to broadband data. Each agency must be able to pass data traffic to other agencies in similar fashion as talking to other agencies. In addition, the ad hoc network will consist of one or more access points established by one agency. All other responding units from all agencies must be able to pass data to and from the established access point(s). For true interoperability to exist, a common channel band plan and standard air interface must be established. Functionally, this must operate in the same manner as Wi-Fi does today in the 2.4 GHz band.

Authentication

While not directly a 4.9 GHz radio issue; registration, authorization and authentication become critical issues when any 4.9 radio is allowed to talk with an established access point. Users must be assigned, controlled and given appropriate access privileges as in any well-managed computer network. There is nothing unique or unusual about the requirements; only that a truly interoperable data network cannot rely on the radio alone to keep out unwanted traffic.

Interference

Interference is always an issue whenever radio frequency transmission is used. The potential for interference exists in the 4.9 GHz band because channels are not specifically licensed to individual end-users. Interference in the 4.9 GHz data world is often less destructive than in 2-way radio. While interference in a 2-way system will quickly render effective 2-way voice communication impossible, interference in a data network only slows network speed and reduces capacity. Obviously, severe 4.9 GHz interference can render a data network ineffective as well, but minor interference may degrade network performance only slightly and may not be worth the time and effort to eliminate.

Fixed networks can be designed to avoid interference with other fixed networks using well-known network engineering techniques. The major interference problem arises from deployment of ad hoc networks. Ad hoc networks will be deployed temporarily at an emergency incident which may occur

at any location at any time. In ad hoc networks multiple 4.9 GHz licensees will be operating in the same physical space. That space may be at or near fixed 4.9 GHz networks. To ensure all these co-located networks operate without interfering with each other, good frequency planning must be in place. Possible solutions are to assign separate channels for fixed and ad hoc use and using opposite antenna polarization for fixed and ad hoc networks. Other solutions are also possible, but all require planning and coordination which needs to be in place prior to turning up an ad hoc network at an emergency.

Backhaul

Any computer network is only as good as its interconnection to other networks. For an ad hoc network to be useful, a backhaul connection to the internet must be established. There are a number of ways to provide the backhaul link, but in most cases this link will be established using one or more 4.9 GHz channels. Proper planning and coordination is required to reserve necessary channels for ad hoc network backhaul. Establishing the backhaul link for an ad hoc network may become very difficult due to poor antenna alignment and lack of line of sight (LOS) to the interconnection point.

Line of Sight

Unlike Public Safety 2-way radio frequencies, lack of clear line of sight between transmitters and receivers may significantly affect transmission performance in the 4.9 GHz frequency band. Fixed permanent networks can often be engineered using high towers and good antenna locations to ensure line of sight from all nodes to the central access point. Under some circumstances LOS will be blocked; however near line of sight (NLOS) conditions will exist. Under NLOS conditions the transmitted signal reaches the receiver by reflecting off surfaces that are near the obstacles that block line of sight. Modulation schemes such as orthogonal frequency division multiplexing (OFDM) can be used to provide high-quality transmission using the reflected signals under NLOS conditions.

Emergency incident ad hoc networks must be established at any location without time-consuming engineering. Incoming emergency response units are placed by the incident commander where they will be most effective in mitigating the emergency and not necessarily where they will gain line of sight to the 4.9 GHz access point. LOS may be further compromised by buildings, vehicles coming and going, physical topography and landscaping. As in the fixed case, OFDM will greatly improve transmission where conditions are NLOS.

Mesh network technology can also be used to combat ad hoc network LOS problems. Traditional wireless networks require each client or node to link to a central access point or base station. Mesh technology allows each network node to link to any other network node instead of only to the central access point. In other words, each node need only have line of sight to another node. Most nodes in an ad hoc network will have either LOS or NLOS to at least one other node. Any lack of LOS to any part of the network can easily be corrected by proper placement of an additional node to act as a repeater. Mesh technology offers a fast and easy solution to ad hoc LOS problems.

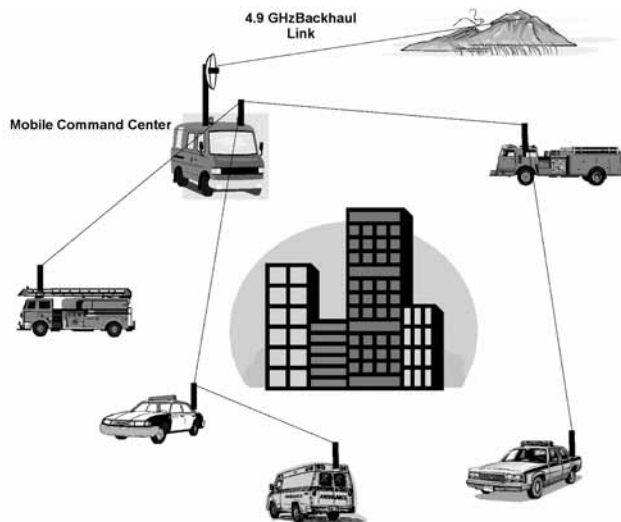
Using equipment that supports both OFDM and mesh technology gives the network engineer the flexibility to put a quality network together in less than optimal conditions. This becomes particularly important for emergency incident ad hoc networks where an engineer may not be present and where there is no time to develop complex solutions.

Emergencies Require Communications Officer

To make ad hoc networks operate correctly and with proper security, an on-scene communications officer knowledgeable in both radio and computer networks is required. The issues of authentication, network operation, network overload, and access privileges must be dealt with along with radio issues dealing with channel selection and usage, antenna polarization, line of sight (or lack of) and backhaul.

AD HOC NETWORK EXAMPLE

A multi-agency emergency is shown pictorially in the following figure.



Police, fire and ambulance have responded to the incident along with a Mobile Command Center. The Mobile Command Center has set up a 4.9 GHz Backhaul Link to a repeater on a local mountain. The Communications Officer has chosen an appropriate 4.9 GHz channel to use on-scene that will not interfere with any nearby fixed use of the band or with any other emergency incident in the vicinity. If line of sight or near line of sight exists, each incoming unit will link directly to the Mobile Command Center. If line of sight cannot be established, mesh technology is used to link to another unit that has established a connection. All responding units then have data connectivity.

CONCLUSION

The 4.9 GHz Public Safety band is a great resource available to all fire, police, ambulance, rescue and emergency response organizations. The primary use of the band is to provide wireless broadband data capability for Public Safety over a dedicated frequency band not subject to general public interference. To be used effectively, the spectrum must be shared by multiple agencies giving wider coverage and more efficient spectrum use. A common band plan and air interface is required for spectrum sharing and interoperability so that all departments responding to an emergency can connect to a single broadband network. Techniques such as OFDM and mesh technology should be deployed to combat line of sight restrictions. A trained and knowledgeable communications expert is needed on major emergencies to set up an ad hoc 4.9 GHz network with proper security, backhaul and without interference.

With 4.9 GHz, Public Safety organizations have a unique opportunity to combine years of 2-way radio knowledge with industry experience with unlicensed bands to produce very efficient and effective wireless broadband access in a dedicated licensed frequency band.

INFINET WIRELESS 4.9 GHz PRODUCT LINE

InfiNet Wireless is a leading global vendor of Last Mile connectivity solutions utilizing Fixed Broadband Wireless Access (FBWA) and emerging WiMAX technologies. InfiNet Wireless' routing products represent more than ten years of intense engineering efforts by world-class Russian development laboratories, with extensive field experience in the design and deployment of thousands of wireless carrier-class networks. InfiNet Wireless is a member of the WiMAX Forum™ and is committed to bringing WiMAX-compliant products to market based on the emerging 802.16 standard. InfiNet has earned a clear leadership position in fixed wireless installations in Russia and Eastern Europe and has more than 300 carrier-class wireless networks throughout the world.

InfiNet Wireless Series 5000 features a rich and unique mesh technology called InfiMESH. From an RF spectrum usage standpoint, this technology utilizes shared channels with 5, 10 or 20 MHz width defined by software. Another very important feature is dynamic spectrum scanning. It is very useful for mobile clients allowing them to automatically (without operator being involved) scan the entire 4.9 range, find and select the operating frequency for the MESH network and connect to it. This permits the creation of a 4.9 citywide network using different frequencies in different parts of the city. It also allows any mobile units within this coverage are to automatically connect to the network without any setting changes.

The topology for InfiNet Wireless MESH networks is also very flexible. It represents a mix of Point-to-Point, Point-to-Multipoint and dynamic MESH topologies. The network consists of fixed MESH nodes (master nodes), slave nodes (PtMP CPEs) and mobile MESH nodes. Fixed and mobile MESH nodes create true a MESH (self-organizing and self-healing) network. Every packet will be transmitted using an optimal route from the source to the destination. During this course each packet can go through several nodes (or make several hops) and the network will decide itself the best route for each particular packet. The topology itself no longer matters - the network will make all key decisions for optimization. In case of any node is dropped, the network will create an alternative path for packet transfer. The InfiNet Wireless MESH system can dynamically create a mobile network. For example, the system can create a network for first responders at the scene of an incident: the command vehicle will choose one particular frequency and all other mobile units will be automatically connected to it.

Reduced frequency planning work is another significant benefit of using the MESH topology. In fact, MESH offers the most effective way of using spectrum for the narrow 4.9 Ghz band; all devices run the same frequency and there is no need for complicated network planning, avoiding major headaches and delays during field deployments.

Unlike some other MESH vendors, the InfiMESH system uses Layer 2 (MAC layer) for creating MESH infrastructure (not Layer-3 or IP layer). This allows InfiMESH to have ultra-fast connecting and node-to-node switching time. In fact, handover time is milliseconds (not seconds like some other vendors). This means that one can stay connected while in a moving car and your network session will not be dropped during handover. InfiMESH was successfully tested at high vehicle speeds (over 100 mph) with zero dropped connections. Furthermore, InfiMESH nodes can act as a Layer 2 switch, Layer 3 router or any combination of these options creating greater flexibility for planning network infrastructure.

The InfiNet Wireless 5000 series also offers a wide variety of other useful features such as:

- different security, authorization and authentication mechanisms to authorize neighbors and create connections with them
- automatic power gain and speed control and adjusting
- SNMP v.3 support for simplifying network administration and management
- Support of several frequencies - the Multilevel Multiradio MESH network can utilize several frequencies at the same time, significantly increasing network performance, noise-immunity and throughput.
- Firewall/NAT/DHCP/VLAN/Access List and other standard network features
- Support of data, video and voice communications at the same time

FOR MORE INFORMATION

Technical information on InfiNet Wireless fixed BWA and MESH solutions is now available. To discuss your company's business requirements and applications as well as for further product details, please email sales@infinetwireless.com or call **954-610-8097** (Sergey Kryukov, US & Canada Channel Manager).



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