By Tony Burge

3.65 – 3.7 GHz: A Data Option for Private Wireless

Evolving security requirements, extended feature offerings from hardware vendors and field expansion because of acquisitions and mergers are straining existing throughput capabilities for industrial, private infrastructure wireless networks. To meet the demands placed on current multiservice, industrial wireless networks, several hundreds of kilobits up to megabits of deterministic throughput are required for point-to-multipoint networks. Two categories of frequencies — licensed and unlicensed — have served industrial and mission-critical operations well. However, each category is experiencing phenomena that are reducing throughput capabilities when more capacity, not less, is required.

To address the need for more throughput, the FCC allocated 50 megahertz of spectrum from 3.65 – 3.7 GHz as a nonexclusive licensed band under Part 90 rules. The designation of nonexclusive licensing coupled with the large amount of allocated spectrum pull the best from the licensed and unlicensed paradigms to create a high-capacity, protected band for private infrastructure and wireless Internet service provider (WISP) deployments. In this article, licensed frequencies refer to licensed frequency pairs below 1 GHz for private infrastructure wireless, point-to-multipoint use. Unlicensed refers to the unlicensed 902 – 928 MHz industrial, science and medical (ISM) band. While other unlicensed bands, such as 2.4 and 5.8 GHz, are available, the 902 – 928 GHz ISM band provides the best combination of range and speed for wide-area point-to-multipoint industrial deployments. Nonexclusive licensed refers to the 3.65 – 3.7 GHz band under Part 90 of FCC rules.

A Hybrid Solution

To provide more throughput for the industrial market, the FCC allocated 26 megahertz of spectrum at 902 – 928 MHz as part of an ISM allocation in the late 1980s. Several hundred kilobits per second and acceptable ranges were achievable in this band. Mass commercial devices in this band, along with relatively few rules for protection, have resulted in saturation, which in turn introduced high levels of in-band interference. Smaller channel sizes can mitigate the increasing interference; however, this results in lower throughput. The ISM band continues to serve industrial markets well; however, throughput must often be sacrificed to overcome in-band interference.

The FCC responded with a hybrid of licensed and unlicensed approaches — 50 megahertz of spectrum at 3.65 – 3.7 GHz based on FCC Part 90 rules designated as nonexclusive licensed. From the licensed perspective, this nonexclusive licensed band mandates more technology and coordination requirements to reduce potential interference. From the unlicensed perspective, this newly allocated band provides wide channel sizes to facilitate several megabits per second of deterministic throughput while providing moderate range.

Any organization that registers is provided a nationwide, nonexclusive license, which means the registered organization can deploy anywhere in the nation providing it follows the equipment registration requirements, including obtaining written permission if a base station is to be deployed in an area with protected grandfathered operations. Each category of frequencies — licensed, unlicensed and nonexclusive licensed — has corresponding strengths and weaknesses.

Throughput

Licensed. With narrowbanding, the maximum throughput is decreasing accordingly — to as low as 7 – 9 kilobits per second (kbps). It's possible to lease spectrum from a license holder that provides more throughput, perhaps several hundred kilobits per second. However, when deployed, channel planning and often-required RF redundancy forces a channel to be divided, which reduces the throughput.

The designation of nonexclusive licensing coupled with the large amount of allocated spectrum pull the best from the licensed and unlicensed paradigms to create a high-capacity, protected band for private infrastructure.

Unlicensed. Some manufacturers of equipment in the unlicensed bands advertise throughput as high as 8 megabits per second (Mbps). However, with band congestion forcing retries and no required coordination between organizations and consumers using the band, throughput is often nondeterministic beyond a few hundred kilobits per second.

Nonexclusive licensed. With wide channel sizes accompanied by technology and coordination requirements, the 3.65 – 3.7 GHz band is capable of throughput up to 14 Mbps or higher with practical, deterministic throughput likely up to 5 Mbps.

Range

Licensed. With high output power, no legal in-band interference and the best RF propagation characteristics of the three categories, this option provides exceptional range — perhaps up to 50 miles.

Unlicensed. Output power is significantly limited and RF propagation characteristics are a little poorer in this band compared with licensed frequencies, which reduces range accordingly. To maximize range and reduce interference, smaller channel sizes may be used to achieve 20 – 25 miles of range. Using smaller channel sizes correspondingly reduces throughput.

Nonexclusive licensed. The higher frequency has weaker RF propagation characteristics. Range for this band will be limited to a maximum of about 10 miles. However, because the band is regulated more than the ISM band, wider channels may be used to keep throughput high and deterministic even at these distances.

Regulatory Protection from In-Band Interference

Licensed. Only one entity is granted a license in a geographical area by the FCC. This is the purest form of regulatory protection, which provides virtually complete deterministic performance.

Unlicensed. Aside from limited technical requirements for equipment deployed in the band, there is no required coordination between competing entities. As the saturation of this band increases, the amount of in-band interference increases and throughput becomes less deterministic.

Nonexclusive licensed. Use of this band requires levels of content-based protocol technology to play well with other systems that don't exist in unlicensed bands. Additional coordination is required by the FCC to ensure that organizations deploying in the same area implement approved technology and work together to mitigate possible interference.

The 3.65 – 3.7 GHz nonexclusive licensed band, with its additional technology and coordination requirements and wide bandwidth, facilitates high-capacity, mid-range point-to-multipoint solutions with more deterministic deployments for private, industrial communications. Two aspects of the FCC rules protect this band more than unlicensed ISM bands. First, organizations must register use. This band does not facilitate mass marketing of commercial use for residential cordless phone systems, for example. Registered organizations are required to work with other registrants in their areas to avoid unnecessary interference. No priority of use is given to those who register first; all registrants are required to work together to most efficiently share the frequency band.

If the area of deployment is congested with other 3.65 GHz deployments, the additional 25 megahertz provides additional channels to use in planning.

Second, technology rules were adopted requiring a contention-based protocol to be implemented in all equipment deployed in this frequency band to facilitate system-based cooperation. To assist with interference mitigation, two levels of contention-based protocol were established:

- Restricted Contention. A system that is aware of the presence of other similar systems and can adjust operation in the presence of such systems. Equipment following this version of the protocol is limited to the lower 25 megahertz of the spectrum.
- Unrestricted Contention. A system that adjusts operations for similar systems as well as dissimilar. Equipment that follows this protocol can use the full 50 megahertz of spectrum.

Equipment authorized to use the full 50 megahertz of spectrum provides the following benefits over equipment that is authorized to use only the lower 25 megahertz of spectrum:

- Channel Planning. If the area of deployment is congested with other 3.65 GHz deployments, the additional 25 megahertz provides more channels to use in planning. For example, if 5-megahertz channel sizes are required for throughput, a system that can only use the lower 25 megahertz would have, at most, five channels from which to plan. A system authorized to use the full 50 megahertz would have up to 10 channels to use for planning.
- Throughput. WiMAX-based technology supports channel sizes up to 14 megahertz. With this channel size, throughput can be up to 37 Mbps, depending on the spectral efficiency of the equipment deployed. If higher throughput than offered by a 5-megahertz channel is required, channel sizes must be increased. This affects channel planning as previously stated. If a 10-megahertz channel is required for throughput, equipment authorized to operate only in the lower 25 megahertz would have two channels to use for planning purposes; whereas, unrestricted contention-based equipment would still have up to five channels to use.

What are the maximum power limits permissible in this band? Specific rules for equivalent isotropic radiated power (EIRP) exist for use in this band as with the unlicensed ISM bands. However, unlike unlicensed ISM bands in which smaller channel sizes often result in improved range, range remains relatively equal independent of channel size. Part 90 rules dictate a proportional power algorithm; that is, the smaller the channel, the less EIRP permissible. Deploying with a smaller channel size provides more channels to use in frequency planning and designing for RF redundancy and overlap.

Fixed Power. According to FCC §90.1321 Power and antenna limits. 47 CFR Ch I (10-1-05 Edition) (a), Page 507, "Base and fixed stations are limited to 25 watts/25 megahertz

EIRP. In any event, the peak EIRP power density shall not exceed 1 watt in any 1-megahertz slice of spectrum." For a 5-megahertz channel size, the maximum EIRP for a fixed deployment is 5 watts or 37 dBm.

Mobile Power. According to FCC §90.1321 Power and antenna limits. 47 CFR Ch I (10-1-05 Edition) (c), Page 508, "Mobile and portable stations are limited to 1 watt/25 megahertz EIRP. In any event, the peak EIRP density shall not exceed 40 milliwatts in any 1-megahertz slice of spectrum." For a 5-megahertz channel size, the maximum EIRP for a mobile deployment is 200 milliwatts or 23 dBm.

Nomadic (parked vehicles or personal handsets). This type of deployment appears to fall under the same rules as those for mobile power. According to FCC §90.7 Definitions, 47 CFR Ch. I (10-1-07 Edition), Page 243, a mobile station is defined as "[a] station in the mobile service intended to be used while in motion or during halts at unspecified points. This includes hand-carried transmitters (emphasis added)." Because vehicles may be moved to unspecified points without a verification process by the FCC, the author's opinion is that parked vehicle use (nomadic) potentially falls under the same power restriction as mobile use.

The use of this band as described is limited to the United States. There are areas in the United States that require specific approval beyond FCC registration and are designated as areas of grandfathered fixed satellite service (FSS) operations. Registrants may operate in these areas only with approval from the affected FSS operator. The full listing of grandfathered FSS stations and a chart indicating the grandfathered areas are contained in Appendices E and F of the document available from the following link: http://fjallfoss.fcc.gov/edocs_public/attachmatch/FCC-05-56A1.pdf. The licensees are listed in the table, which identifies the organizations to contact for approval, if a deployment falls within one of these zones.

Licensed frequencies provide limited throughput relative to the other options discussed for point-to-multipoint, industrial deployments. Unlicensed ISM bands are the easiest in which to deploy from a coordination aspect; however, these bands are saturated. The 3.65 – 3.7 GHz nonexclusive licensed band provides high deterministic throughput with moderate range for mission-critical, industrial deployments. ■

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