Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Cognitive Radio Technologies and Software Defined Radios	)	ET Docket No. 03-108
	)	
	)	

COMMENTS OF TEXAS INSTRUMENTS

Texas Instruments Incorporated ("TI") submits these comments in response to the Notice of Proposed Rulemaking in the above-captioned proceeding, FCC 03-332, released December 30, 2003.

Summary of Position

Texas Instruments proposes development and deployment of a wide area network (WAN) based on unlicensed spectrum. Such a system would exploit recent advances in wireless technology to provide significant benefits to existing wireless users and open access to a number of segments of the population that are not presently served by wireless. A regional database would be available over a wired and wireless control channel network to allow base stations to know, on a real-time basis, what spectrum is available for use in any given area at any given time. The precise location and power level of each transmitter would be recorded in this database to provide a complete real-time map of spectrum availability. Limited capability peer-to-peer communications would extend wireless services to users outside the range of base stations.

User stations would employ cognitive radio techniques to help populate the spectrum usage database. User stations would have access to the complete regional database when connected to a base station (tethered mode), and otherwise would have access to the more limited information based on their own cognitive capabilities and those of other nearby cognitive user stations (untethered mode).

A key advantage of such a system is that it would allow primary owners/controllers of spectrum to offer spectrum for temporary use through the regional database. Temporarily unused spectrum could be posted to the database for free use or possibly paid use. In the event that the primary owner/controller needed the spectrum back suddenly, the real-time database would only need to be updated to reflect that the spectrum was no longer available. This ability to easily manage the use of spectrum by persons other than the primary owner/controller would hopefully encourage as much spectrum as possible to be offered for use.

Such a system would be of clear and substantial benefit to network operators and service providers. Since some spectrum would be available without charge, service costs would drop, especially for data services that will invariably consume much greater levels of spectrum versus voice service. While peer-to-peer service offerings in unlicensed bands may appear to compete with today's wireless network operators, technical limitations impose significant limitations on this service. For example, peer-to-peer services might not support high speed mobility, allow for routing calls to handsets, or provide range beyond a few kilometers.

Wireless technology has progressed considerably over the past several decades. Old system limitations that dictated a licensed spectrum model in the past have now been overcome. The days of bureaucratic licensing, long and financially risky auction processes, and business models that restrict competition and keep wireless services beyond the reach of many in society can and should be put behind us. Unlicensed WANs can meet the needs of the data-hungry consumer, extend service to the financially disadvantaged, and offer service to those in remote rural areas. At the same time, development and deployment of unlicensed WANs will stimulate the technical community, inspire innovation, and provide a business environment that extends the prosperity the wireless revolution has brought.

TI's Interest

Texas Instruments Incorporated is the world leader in digital signal processing and analog technologies, the semiconductor engines of the Internet age. The company's businesses also include materials and controls, and educational and productivity solutions. TI is headquartered in Dallas, Texas and has manufacturing or sales operations in more than 25 countries.

For more than six decades, TI has created innovations in mobile communication, including the first commercial silicon transistors in 1954, the first integrated circuit, and the first electronic handheld calculator. Advances in solid state technology increased the performance while lowering operating temperatures, enabling the miniaturization of electronics —a major step forward for mobile communications. Over the years, TI developed even higher-performance and lower-power semiconductors and worked with its customers to develop smaller and lighter-weight wireless phones, the first and second generations of wireless technology. TI chips today process billions of instructions per second providing the power behind all points in telecommunications—from wireless handsets and Internet devices to networks.

TI’s programmable DSP technology is key to maximizing companies’ investments in a state of evolving technology. Programmability allows manufacturers to reuse valuable engineering design from previous generations to build multiple product lines, enabling backward and forward compatibility for smooth transitions as standards evolve. This results in shorter time-to-market and lower development costs.

TI’s technology provides benefits to all areas of wireless communications, from the handset manufacturer to the telecommunications service provider.

Handsets and Handhelds

TI has established itself as a market leader in wireless semiconductors shipped in handsets today. Further establishing TI as the leader for 2.5 and 3G, the top wireless

handset and handheld manufacturers across the world have already chosen TI's technology for their future devices. Similarly, multiple operating system vendors have worked with TI to port their software platforms on TI's processors.

TI provides complete "antenna-to-applications" chipset solutions, including families of digital baseband modems, analog and power management integrated circuits, configurable RF processing (software defined radio), and powerful application processors. To enhance system flexibility, TI also includes a complete range of peripheral support including USB, Bluetooth™, IEEE802.11, UWB/802.15.3a, 1394, removable flash cards, camera controllers, stereo codecs, drivers and other capabilities. Importantly, in addition to these silicon and software building blocks, TI provides complete wireless reference designs that enable designers to rapidly develop and deliver new products.

TI also offers its widely adopted OMAP™ platform that includes high-performance, power-efficient processors, robust, easy-to-use OMAP software and technical support. With TI's OMAP platform, equipment manufacturers and software developers can quickly get to market with differentiated voice and multimedia applications for 2.5G and 3G wireless phones, PDAs and advanced mobile Internet appliances.

Cellular Infrastructure

Wireless service providers have invested heavily in developing the marketplace and in purchasing bandwidth to deliver their services across the next-generation wireless infrastructure. Now, wireless infrastructure companies are looking to companies like TI to help them quickly deploy as many channels of next-generation, media-rich wireless connectivity as possible, thereby maximizing capacity. A higher capacity translates into the ability to service more customers, which provides a higher return on investment for infrastructure providers as well as service providers. TI's DSP technology increases capacity by providing the highest performance DSP tailored for 3G wireless infrastructure applications. Beyond the most technologically advanced hardware offered by TI for this purpose, many novel DSP algorithms are also developed by researchers at TI, offering advantages such as receiver performance enhancement in the presence of

interference, a key factor in capacity maximization. Also important for base station manufacturers, TI's solutions offer the flexibility needed to support all industry standards.

Wireless Networking – 802.11

As home and office networking continues to gain momentum, wireless LAN technology and its effectiveness in spectrum usage will become increasingly important. With the availability of IEEE 802.11b (also known as Wi-Fi) and the Bluetooth™ technology, consumers can easily, without wires, connect multiple PCs, peripherals and other Internet appliances to rich content including voice, data and video information. Outside the home and office, consumers are also finding that they can stay connected to their personal business by using PCs with wireless modem cards, that work with the wireless networks now found in many hotels, airports and coffee shops across the country and internationally.

As a leader in both Wi-Fi and Bluetooth technologies, as well as in coexistence solutions for them that alleviate the impact of their "competition" over the shared spectrum, TI is well positioned to drive silicon and software trends toward longer reaches and higher data rates, while maintaining the highest levels of performance and maximizing spectral usage. TI utilizes Bluetooth technology for creating personal area networks and other short distance wireless applications, such as wireless headsets for cellphones, while leveraging its Wi-Fi solutions for wireless local area networking. Committed to enabling the price points required for widespread adoption of wireless networking technology, TI delivers highly integrated, high performance solutions with its low-cost Bluetooth and 802.11 chips.

Unlicensed WANs

TI supports the use of cognitive radio technology, coupled with a control channel or beacon mechanism (NPRM, para. 58-60), for the deployment of unlicensed Wide Area Network (WAN) systems. Control channel networks can employ wired, wireless and a combination of wired /wireless channels. The wireless channels can include both coded

one-way beacon signals and two-way telemetry and telecommand signaling. Fixed access points and base stations can be connected together using wired channels, and handsets can interact with base stations and with other handsets over wireless control channels.

The control channel network can regulate access by WANs to all spectrum that is available on an unlicensed basis, as a function of frequency, time and location. Handsets (and base stations) must continually know their location, using some form of geolocation technology. They must monitor both the spectrum and control channels, looking for available service (spectrum, time slots, codes, etc.). Once available spectrum is identified, the handset and base station can broadcast an intention to use it over the control channels. The broadcasted message would indicate the technical parameters for the intended communications, including its duration and location.

The control channel network would include a clearinghouse function that includes a map or database of spectrum availability. The clearinghouse database could be accessed over the Internet, for example. We believe such a spectrum clearinghouse capability is technically feasible today. This mechanism enables the user to access available spectrum.

Use of a control channel system is an improvement over the Commission's proposal for dealing with the "hidden node" problem (NPRM, para. 25). While technology may exist to detect signals 30 dB below the noise floor[1], we believe it will only work if the properties of the weak signals are known well enough to permit efficient correlation. But there is no way to assure incumbent licensees of the effectiveness of this technology in protecting their specific receivers from interference. Moreover, detecting transmissions is only effective in protecting receivers when transmitters and receivers are both co-located and co-channel, but may not help with adjacent channel interference issues or receive-only sites. In contrast, a control channel system solves the problem fully. A

[1] Based upon TI experience, frequency agile radios capable of noise temperature measurement over a number of different frequencies and their ability to transmit over different frequencies with different modulations appear to be feasible.

transceiver desiring to use a given band first senses the band and then declares its intentions over a control channel network. All users would monitor the control side channel associated with their band of interest at all times while the spectrum is being used. If a new user declares an intention to use their band, an incumbent user would issue an objection to ensure that its communication is not jammed by such a new user.

The TI approach for cognitive radio technology is a dual mode approach. In the tethered mode, the user stations are in effect slaves of a base station. They gather the spectrum usage information for their vicinity, and deposit it in the regional database that is shared by all stations. When the user station seeks permission to transmit messages, the base station decides on the optimal spectrum assignment. In the untethered mode, user stations engage in peer-to-peer communications and make their spectrum selection based on the spectrum usage information that they can gather themselves. Since their spectrum usage information will be less complete than that of a regional base station network, their spectrum selection decisions will necessarily be suboptimal. More nodes will be "hidden nodes" to the untethered user stations than would be hidden to a regional network of base stations and tethered user stations. Of course, in areas where there are no nearby base stations, it may be that spectrum usage is sufficiently light to eliminate interference problems. Moreover, lower transmitter power limits for untethered operations, consistent with the lower quality of the spectrum database, would help to minimize interference from untethered peer-to-peer communications to hidden nodes.

Benefits

TI's unlicensed WAN approach allows primary spectrum owners/controllers to offer their spectrum for temporary use. It allows the government to improve spectrum resource utilization over time, manage the efficient use of spectrum, and designate higher priority uses over lower priority uses.

While the notion of unlicensed WANs may promote the entry of new commercial service vendors, we note that incumbent wireless network operators and service providers are

very well positioned to gain considerable benefit from such a system. Because of their existing infrastructure in antenna towers and backhaul links, these commercial incumbents can integrate the spare capacity from private and Government licensees into their networks for temporary use.

Past efforts to enhance wireless systems have focused mainly on improvement in the basic aspects of spectral efficiency, with many decades of past research completed in this field. But the real advantage in adopting newer modulation systems is limited. In contrast, a flexible unlicensed system for wide-area communications would create a new avenue for innovation and improvement in system operation. It would put the United States in a leadership role around the world in development of the most modern, flexible, spectrum efficient, and cost effective spectrum management system available anywhere.

Moreover, unlicensed WANs may promote national security goals. Since such systems are envisioned to incorporate a non-centralized control, they could be made more robust to hostile or terrorist acts. Since spectrum is shared, destruction of a single antenna tower, for example, would not necessarily take any available spectrum out of service.

Conclusion

The U.S. public highway system is arguably the most successful public infrastructure system that has ever operated in the world. In contrast, U.S. licensed spectrum policy is much more like a system of toll roads; and U.S. unlicensed spectrum policy is the equivalent of opening up public lands for use by dune buggies and dirt bikes. It is technically feasible to create a system that offers fair access to our limited and extremely valuable spectrum resources that mirrors the public highway system. Such a system can stimulate our economy, offer an increased level of robustness to terrorism, drive us to the forefront of communications technology, provide communication services to the financially disadvantaged, and provide the fuel to propel our incumbent wireless operators and service providers to new and attractive levels of service offerings.

Respectfully submitted,

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