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Unrestricted Permits for Ultrawideband Devices

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Before the
Federal Communications Commission
Washington, DC 20554

Docket 98-153

In the Matter of

Revision of Part 15 of the FCC's Rules Regarding Ultrawideband Transmission Systems

Unrestricted Permits for Ultrawideband Devices
Comments of Jon M. Peha
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Summary

Ultrawideband (UWB) technology offers tremendous benefits. It enables new applications, and makes other valuable applications more cost-effective than was previously possible. However, this technology creates novel challenges for regulators. UWB devices share spectrum with existing licensed systems, potentially causing interference. Moreover, some UWB applications raise serious privacy concerns. This submission proposes an alternative spectrum management approach for UWB devices that will encourage deployment while managing spectral interference and privacy abuses. Under this approach, the Federal Communication Commission (FCC) would distribute permits to manufacture or import devices, instead of the more traditional approach of distributing licenses to use the devices at a given location. This would allow the FCC to monitor, and if necessary, regulate the number and type of UWB devices deployed, without placing onerous restrictions on users.

Applications of UWB

UWB has many beneficial uses, as demonstrated by the responses to the recent Federal Communication Commission (FCC) Notice of Inquiry [1,2]. UWB supports high-resolution radar that can penetrate surfaces to detect target objects. For example, ground-penetrating radar can locate structural flaws in bridges, or buried hazardous material. Such uses improve public safety, with little chance of interfering with other wireless devices because the signal goes downward from ground level. The same capability could allow law enforcement to identify the location of hostages or potential threats before entering a building, or allow home-owners to locate pipes and wall studs. In these cases, signals pass through walls, so there is greater potential to interfere with other devices. There are even mobile applications, such as use of UWB radar for proximity detection in automobiles to reduce the chance of accidents. For mobile applications, some degree of mutual interference is inevitable.

UWB can also be used for high-speed communications across short distances, possibly passing through walls and other impediments. This could connect computers, printers, set-top boxes, televisions, and speakers in the home, in competition with emerging standards like Bluetooth. UWB could similarly allow new providers of last-mile connectivity to distribute signals throughout an office or apartment building. This clearly serves the public interest, because such distribution is a potential impediment to competition to the established local-exchange carriers and cable companies [3].

It is clear that UWB can be used for important applications, some of which cannot easily be supported in other ways. This may lead to wide-scale deployment. If many homes adopt UWB-based security systems to detect intruders and UWB-based communications systems to replace wires, while many new cars are equipped with UWB-based proximity detectors, there could easily be tens of millions of UWB devices used every day in the US. Regulators must consider this possibility when making spectrum available.

Privacy

A property of UWB that has received remarkably little attention should ultimately be the most controversial. UWB technology gives individuals an unprecedented ability to peer into their neighbors' homes - and their neighbors' lives. This is clearly a benefit when used by a fire department to plan a rescue. However, it can also be used to invade personal privacy, or to plan a successful burglary. To prevent abuses, some restrictions may be needed on the types of devices that are manufactured, imported, marketed, and/or used, except where use to enhances public safety.

Such restrictions must be imposed at the federal level to be effective. While the FCC might claim jurisdiction, because privacy protection serves the "public interest," it would be preferable for such directives to come from elected policy-makers in Congress. There is precedent for such legislation. For example, Congress prohibited the sale and use of devices that can intercept cellular telephone calls. Unfortunately, such laws are not easy to enforce. Moreover, scanners designed to eavesdrop on cellular telephone conversations (without a warrant) have few socially redeeming uses. In contrast, since UWB is in its infancy, it is unclear at this time how to restrict inappropriate use of UWB without prohibiting desirable uses as well. Continued scrutiny will be necessary as the technology evolves.

UWB Is Ill-suited For Licensed Spectrum

A traditional spectrum license provides the license-holder access to spectrum (to the exclusion of some others). In return, the license-holder must operate at the stated location under specified restrictions.

UWB technology has all of the properties [4,5] that make it inappropriate for traditional licensed spectrum. First, there are potentially a large number of low-cost, low-power devices. If all such devices had to obtain a license from the FCC, then the licensing overhead would be a significant portion of system cost. Moreover, a single device would probably not drastically increase interference levels for its neighbors. Second, UWB devices inherently share spectrum efficiently, so granting a single device any kind of exclusive access to spectrum resources would significantly reduce spectral efficiency. Finally, many UWB applications require mobility or portability. (For example, a device that checks the structural soundness of bridges must be portable, so it can move from bridge to bridge, and an automotive proximity detector must be mobile.) It is not practical to license such devices for every location where they might operate.

UWB Is Ill-suited For Unlicensed Spectrum

Devices that are inappropriate for licensed spectrum are usually deployed in unlicensed spectrum bands. Unlicensed spectrum has a few inherent disadvantages, and UWB technology could exacerbate these disadvantages. First, there can be no upper bound on the number of unlicensed devices that will be deployed in a given area, so there is no limit to the amount of interference that these devices will cause. Moreover, since unlicensed spectrum is shared, there is a natural tendency to consume more spectrum than necessary. Designers of individual devices must balance competing objectives, such as maximizing spectral efficiency, maximizing performance, and minimizing cost. When spectrum is shared, spectral efficiency becomes less important, so devices may transmit at greater power, duration, or bandwidth than necessary [6,7,8]. Indeed, there are cases in which some unlicensed devices seeking to optimize their own performance consume so much spectrum that none of the devices get adequate performance [6,7]. The most common solution when resources are shared is to calculate appropriate usage-based prices, but that is not possible here. In many spectrum bands, an *etiquette* can be imposed which creates the needed incentives for spectral efficiency [7,9], where an etiquette is a set of constraints on the access protocol. However, it is not clear whether this approach is applicable with UWB. Thus, we do not know the number of UWB devices deployed, and we cannot assume that the devices will be designed to minimize interference for neighbors.

Given this potential for interference, another troublesome property of UWB is that transmissions traverse many spectrum bands, thereby sharing spectrum with many systems that already have a license. Allowing new devices to interfere with license-holders is always disturbing, especially for applications like global positioning (GPS), for which moderate interference could cause failure, and failure could cause loss of life. This issue is important in many frequency bands, but it is especially important if UWB devices are allowed to operate below 2 GHz, where interference is likely to cause more problems for existing license-holders.

Another concern is that the output of many UWB devices may look more like noise than an interfering signal. As a result, when a licensed system experiences excess interference, it may be hard to determine that a concentration of UWB devices is the cause. Because of this, and because some UWB devices will be mobile, it may not be possible to force the UWB devices to cease transmissions when there is a problem, even if regulations require it.

Given these properties, the FCC must take steps to insure that UWB devices do not cause excessive interference. The FCC can limit the interference of individual devices through restrictions on transmission power (or transmission duration). If the devices are unlicensed, the FCC cannot limit the number of deployed devices. Consequently, unlicensed operation is only viable if power limits are strict. Moreover, the FCC cannot tell when the number of deployed devices is becoming large enough to cause interference problems.

An Alternative Approach: Unrestricted Permits

While traditional licensing is not practical for some UWB applications, the FCC needs an effective means of monitoring and regulating the deployment of UWB devices. It must be possible to determine the number of devices that are being deployed, and the extent to which these devices can cause interference. For example, the FCC should know how many UWB-based security systems were deployed in the last year, their transmission power, duration, and frequency range. If the number of devices grows large, the FCC should be able to limit growth. Also, the FCC should know the extent to which such devices may compromise privacy, so they can keep policy-makers apprised as new applications emerge. If policy-makers eventually prohibit some types of devices, the FCC should know who is producing those devices.

To meet these objectives, we propose the creation of *unrestricted permits* for UWB devices. The FCC would allow a fixed number of devices to be introduced in a given year, provided that all devices conform to stated power limits and frequency ranges. Rather than requiring individual users to obtain a license to use an UWB device, the FCC would require a permit be obtained to

manufacture or import an UWB device. (Devices manufactured for export would not need a permit.) Since a single request to the FCC would cover all of the devices produced or imported in a given year, the burden per device is negligible. The only requirement would be reporting to the FCC about the actual number of devices produced or imported and their characteristics, including the devices' purpose, transmission power, frequency range, and anticipated lifetime. Permits are unrestricted in that there would be no restrictions on where and how these devices would subsequently be used. Thus, consumers carry no burden.

The FCC would determine the number N_t of new UWB devices that can be introduced in year t, based on the number of UWB previously deployed and the extent to which interference problems have been observed. If the number of requests for permits in year t does not exceed $N_{t,}$ then all requests would be granted for free (or for a small fee that merely covers permit processing costs). If the number of requests exceeds $N_{t,}$ then permits could be distributed as follows. Let each permit request include a monetary bid. The N_t highest bids would be granted permits, at a fee that equals the $(N_t + 1)$'th highest bid. This form of auction is known to have several important properties. First, the process is fast and simple. It could easily be automated to run over the Internet. Second, the optimal bidding strategy is to set the bid equal to the value of a permit to the bidder, independent of what others bid. As a result, those who value the permits the most will get them. Also, regulators can use both the number of bids and the value of those bids when estimating demand for UWB. If demand is high, they may work harder to make spectrum available. Note that this auction is not designed to maximize proceeds to the government, as some might suggest. Maximizing proceeds probably includes the artificial creation of scarcity by reducing the number of permits N_t, but this strategy does not make best use of the spectrum [4].

If UWB devices are sufficiently heterogeneous, then the FCC could require manufacturers and importers to obtain multiple permits for some types of UWB devices. Thus, a device that transmits continually at higher power for many years might require more permits than a device that transmits sporadically at lower power for a few months.

Conclusion

UWB technology poses unique challenges for regulators. The technology has too many valuable applications to ignore. However, imposing a traditional licensing requirement would be overly burdensome to users, and would preclude applications requiring mobility or portability. On the other hand, adopting a typical unlicensed approach runs the risk of causing undue interference to existing license-holders, including some safety-critical systems, unless UWB is relegated to high frequencies. UWB can also create new opportunities to invade personal privacy and lay the groundwork for criminal activity. This may ultimately lead policy-makers to prohibit some types of devices.

A new approach is needed that allows regulators to observe the number of UWB devices that are deployed, the extent to which they can cause interference in spectrum bands of interest, and the extent to which they can be used to violate privacy. It must be possible for regulators to limit the number of devices deployed if interference becomes problematic, particularly if UWB devices are allowed to transmit below 2 GHz, and it must be possible to ban certain kinds of devices if legislation precludes their import or manufacture.

Unrestricted permits can achieve these goals. Unrestricted permits impose minimal burden, because manufacturers and importers could get their permits in bulk over the Internet, and there are no subsequent obligations or restrictions on individual users. If UWB advocates are correct that unlicensed operation would not lead to significant interference, then the demand for permits will never exceed supply, and this provision will have little effect. On the other hand, if interference does become problematic, then the FCC would have the tools to prevent the problem from escalating.

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