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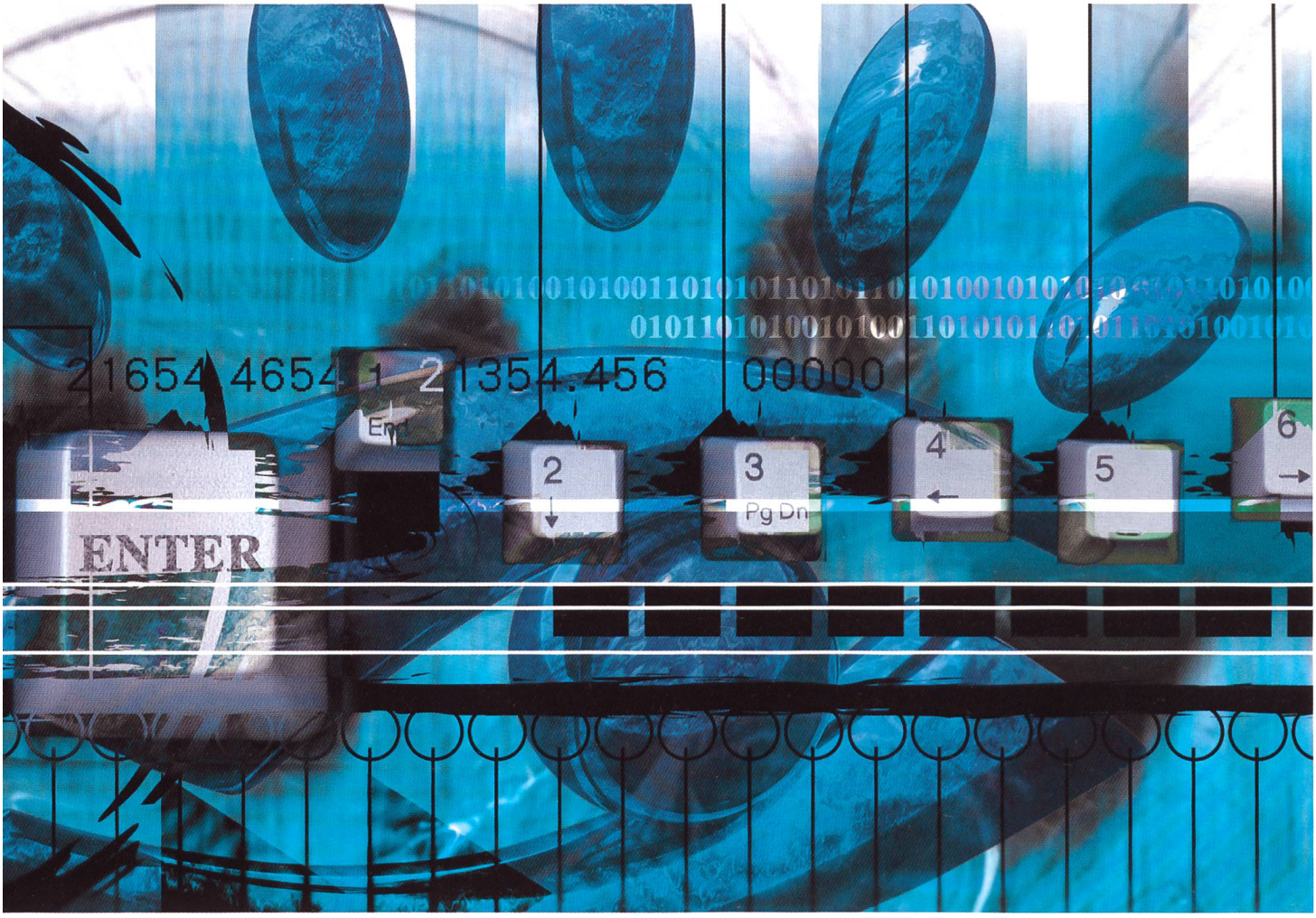
UWB Interference to Wireless Systems



CHRISTIAN FISCHER **Ultra-Wideband (UWB) radio has received a lot of attention recently in both industry and academia. The regulatory process in the United States was accompanied by strong opposition to the emission limits, mainly by users of licensed bands, worried about the impact on their existing services.**

In this article, we present the results of a Swisscom Innovations study to assess the interference potential on GSM networks, Wireless Local Area Networks (WLANs) and Bluetooth. Specifically, we consider the impact of a UWB mass deployment with devices conforming to current U.S. Federal Communications Commission (FCC) regulations, as well as proposed European Telecommunications Standards Institute (ETSI) regulations.

Introduction

UWB is a new, very low power communications technology that has been the subject of significant interest in the telecommunications industry over the last two years (see Comtec 07/08, 2003). Due to its very large bandwidth of up to 7.5 GHz, very high data rates are possible. In the IEEE 802.15.3a working group, concerned with standardising a UWB physical layer, data rates greater than 100 Mbit/s are expected for a 10 m transmission range. From the extremely large bandwidth, it is evident that UWB cannot be assigned a designated frequency band. Instead, UWB will have to coexist with other technologies that are currently present in the 3 to 10 GHz band, notably IEEE 802.11a WLANs. The basic idea is to limit the UWB transmission power to a level so low that it will not cause significant

interference to existing narrowband services.

In this article, we present the results from a Swisscom Innovations study, aimed at determining the effects of UWB interference on other wireless systems. We consider a UWB mass deployment in consumer devices that are operated either according to existing FCC regulations or proposed ETSI regulations.

UWB Interference to GSM systems

In GSM systems, the base stations are generally placed high and are inaccessible to the public. Therefore, when considering UWB devices, mostly handheld and with a short range due to power and frequency constraints, the interference from UWB devices at base stations will be fairly low. The situation is different when we consider the downlink, i.e. when the base station is transmitting and the mobile telephone is receiving. In this situation, the mobile phone will be surrounded by UWB devices integrated in either office electronics or personal communications devices carried by people. This situation is depicted in figure 1. Hence, we consider the downlink in GSM systems as more prone to interference. In order to compute the amount of interference to which a mobile phone is subjected, we consider a situation where the interfering UWB devices are uniformly distributed in the area surrounding the mobile phone with a certain device density per unit area. In this case, it is clear that the total interference generated by the UWB devices will be proportional to the UWB device density, the transmit power of the UWB devices and also will depend on the environment in which the mobile phone is placed. For example, in a typical indoor environment such as an office, furniture and walls will attenuate the interfering UWB signals much more than in the open field, resulting in a reduced total interference level, especially from UWB devices that are farther away.

Given a certain amount of UWB interference, the question is how this interference will affect the mobile phone. The key performance indicator for any communication system is the Signal-to-Interference-plus-Noise Ratio (SINR), a measure of the quality of the signal the mobile phone receives. For GSM, the interference consists of the UWB interference and the cochannel interference, due to other base stations that transmit on the same frequency. It can be shown that the level of cochannel interference is maximum at the cell limit.

Thus, we consider a downlink situation with the mobile phone placed at the cell limit. Our study's results indicate that no harmful interference is to be expected for GSM systems operating in the 900 MHz band for realistic UWB device densities. We consider the maximum realistic device density to be 0.2 UWB transmitters/m^2 or about 2 UWB transmitters in a three by three meter area. Since in reality, not all devices are continuously transmitting, the density of physically present devices can therefore be substantially higher. Furthermore, we have assumed the devices to be transmitting at the maximum power possible according to both the FCC and the proposed ETSI regulations. The ETSI and the FCC regulations are actually very similar. Indeed, the permitted transmission power in the main band from 3 to 10 GHz is the same, the two only differ in the power attenuation required out-of-band, i.e. for frequencies less than 3 GHz and greater than 10 GHz. For out-of-band frequencies, the ETSI proposal is more stringent than the FCC regulation. Note that the 900 MHz band of the GSM services is clearly outside of the main transmission band of UWB. This is also true for GSM systems in the 1800 MHz band. However, in this case, the GSM band is much closer to the main transmission band of UWB and therefore the UWB interference is also much greater. In fact, the study revealed that the current FCC regulations afford insufficient protection for GSM 1800 services when the mobile is placed at the cell limit. This is in contrast to the proposed ETSI regulations that seem to have addressed the issue satisfactorily with more stringent out-of-band limits, leading to a maximum transmit power that is 19 dB lower than the corresponding FCC limit at 1800 MHz.

UWB Interference to WLANs

For WLAN systems, we consider the common IEEE 802.11a and IEEE 802.11b WLAN standards. The methodology employed was essentially identical to the one employed for GSM systems, however, without cochannel interference. While IEEE 802.11b systems operate in the unlicensed band at 2.4 GHz, IEEE 802.11a operates in the unlicensed band at 5 GHz and therefore in the main UWB transmission band. Our study has found that both systems are severely affected by UWB interference. In particular coexistence between UWB and IEEE 802.11a devices will be near impossible. For a single, continuously transmitting UWB device, the separation between the Access Point and the UWB device needs to exceed six metres for the loss in SINR to remain below 5 dB. Figure 2 shows a comparison between 802.11a and 802.11b, without and with UWB interference for a UWB device density of 0.2 transmitters/m^2. It can be seen that the range of IEEE 802.11b systems is approximately halved when UWB devices according to the proposed ETSI regulations are interfering. In the case of FCC-conformant UWB devices, the range is reduced by a factor of four. As mentioned above, the ETSI proposal and the FCC regulations permit equal transmit power in the main band between 3 and 10 GHz. Thence, there is no difference between the two when considering coexistence with IEEE 802.11a and the range is approximately divided by a factor of 7.

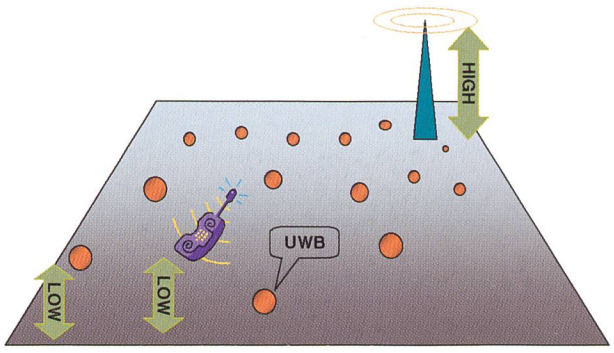


Fig. 1. In a GSM system, the base station location is high and inaccessible, whereas the mobile is lower and surrounded by UWB transmitters in office or personal communication devices. Therefore, the downlink is more critical regarding interference.

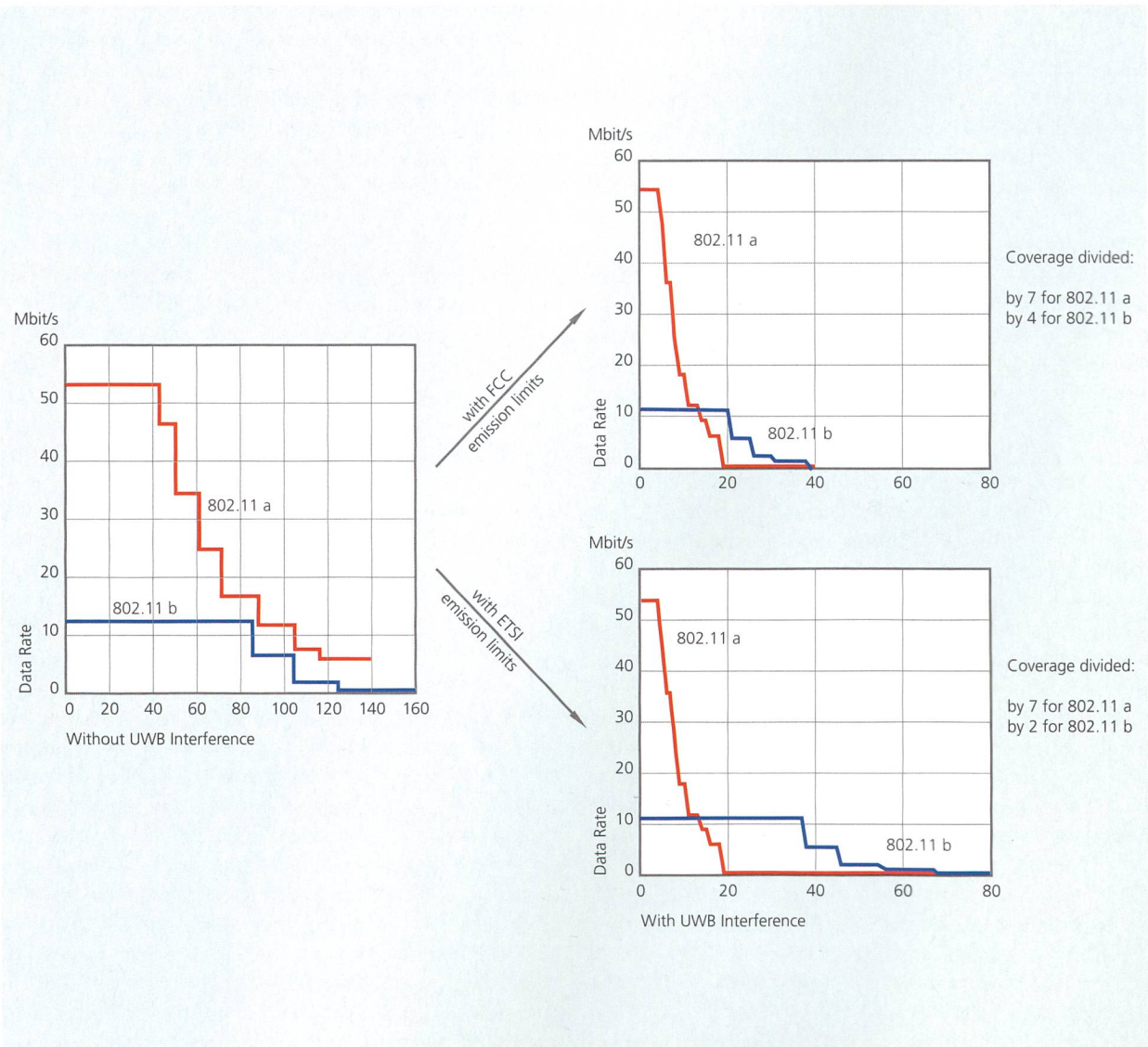


Fig. 2. Comparison of IEEE 802.11a and 802.11b, with and without UWB Interference.

Finally, it is interesting to remark that IEEE 802.11b systems are able to provide higher throughput than IEEE 802.11a systems for distances greater than about twenty metres, something that is not true in the absence of UWB interference where IEEE 802.11a systems outperform IEEE 802.11b systems at nearly any distance.

Bluetooth

Like IEEE 802.11b, Bluetooth operates in the unlicensed 2.4 GHz band. Hence, a priori, one would assume that the effects would be about the same. However, Bluetooth was designed from the very beginning to be able to coexist with other services in the same band. This presumably led the designers to incorporate much larger interference margins. Computations have shown that Bluetooth can tolerate densities of up to 9 UWB devices/m^2, according to proposed ETSI regulations, and 1 UWB device/m^2, according to FCC regulations.

Hence, due to the large interference margin, Bluetooth is a lot more robust against UWB interference than IEEE 802.11b and coexistence will be possible.

Conclusions

The study found that no harmful interference is to be expected from a UWB mass deployment for GSM 900 systems for both current FCC regulations and proposed ETSI emission limits.

In the case of GSM 1800 systems, however, the protection afforded by the FCC regulations appears insufficient at the cell border, whereas the proposed ETSI limits are sufficiently stringent to avoid any significant interference. IEEE 802.11a/b systems will both potentially suffer significantly from UWB interference, whereas Bluetooth will be much more robust due to its larger interference margins. ■

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