WIRELESS OFFICE DATA COMMUNICATIONS USING CT2 AND DECT

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Introduction

Advances in personal communications technology have been accompanied by parallel computer developments. Technology synergy has shown the technical feasibility to develop wireless data applications, and both CT2 and DECT provide support for office data communications. In this paper we describe the services supported and address some implementation issues.

These new generations of cordless telephones were primarily designed to support digitally encoded voice and employ digital transmission techniques in order to improve both the spectral efficiency and the grade of service. This same radio radio system architecture can also be used to carry data traffic; there are however some important implementation considerations that must be addressed before such services can be supported.

The CT2 standard, [1], is being enhanced to support circuit-mode data-bearer services, which would potentially allow cordless data links in the office for a range of low rate (up to 19.2kbits/s) services, eg E-mail, file printing, small file transfer, etc. The DECT standard, [2], can support multiple 32kbits/s data channels, offering a capability for higher rate services, thereby facilitating applications requiring larger volumes of data exchange. Systems based on these existing cordless standards, rather than newer spread spectrum technology, would offer economic benefits arising from the economies of scale expected from the high volume cordless telephone market, as well as, in the longer term, facilitating integrated voice and data services in the office environment, [3].

Radio Architecture

Both CT2 and DECT were designed with the primary aim of providing cordless telephony services. Although the potential for carrying data was recognised this was a secondary issue in the development of the system. This means that the organisation of the frame structures are specifically tailored to a form required to carry digitised speech; this does little actual harm to the potential for carrying data but it does result in frame formats which need careful use if data is to be handled successfully.

(i) The CT2 radio interface uses frequency division multiplexing, FDM, to provide 40 channels at 864.1MHz to 868.1MHz. Time division duplex, TDD, is used to give a bi-directional cordless link. Gaussian Frequency Shift Keying, GFSK, at 72kbps is used with bursts of 72 bits, 1ms, transmitted and received alternately. Once the call has been established properly, 64 of these bits are available for traffic, normally speech but in our case data, giving an unprotected data rate of 32kps in each direction.

(ii) The DECT radio interface operates at a carrier frequency in the region of 1.88GHz to 1.9GHz using GFSK at 1.152Mb/s. Time division multiple access, TDMA, provides timeslots for up to 12 users, with TDD giving the duplexing. A TDMA frame is 10ms long and contains 24 slots, 12 for the base station to handset, downlink, and 12 for the uplink: each slot carries 320 bits of information, giving a data rate of 32kb/s. For data applications a single link is allowed to use more than one slot in each direction to increase the user data rate, asymmetric assignments are also permitted.

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Radio Channel Behaviour

The channel characteristics enjoyed by the radio system will dictate the performance that can be delivered to the users. There are three essential elements which characterises the channel: propagation, interference and noise. The statistics of these are used to select the types and levels of error control to be applied. In the classical treatment of error control, steady channel statistics are assumed and the error control can be finely tuned to give optimum performance. In our present case however, the propagation and interference can vary wildly with time and the error control regime must be carefully designed to cope. First of all then, we must determine the essential channels statistics.

(i) CT2 uses a carrier frequency in the region of 866MHz,using a narrowband modulation. For indoor, wireless office applications the noise and interference are expected to remain fairly constant, but the received signal envelope is expected to have a Rician probability density function with dynamic range 30dB and fading bandwidth of ~4Hz. These temporal variations are due to movement in the vicinity of the cordless radio link causing shadowing and frequency selective fading. Multipath and inter-symbol interference effects are expected to be negligible for this application since the bit period is much greater than the maximum measured delay path. The CT2 error statistics are therefore expected to be bursty in nature: within a 1ms transmission frame, the bit error probability will change very little and can be regarded as a constant. For the most part the error probability will be very low and slowly changing, depending mainly on the range between transmitter and receiver, but occasional signal fades will occur causing error probabilities of up to 50%.

(ii) DECT operates at a carrier frequency around 1.9GHz, using a wideband modulation. As with CT2, the noise and interference are expected to remain fairly constant; the propagation characteristics however are likely to be quite different. The measured delay spreads are reported as being only of the order of tens of nanoseconds, consequently the intersymbol interference is dominated by frequency selective fading. This generates narrowband notches in the wideband modulation causing the demodulator to create effectively random errors as the modulation frequency sweeps across a notch. The temporal nature of the error statistics is again governed by movement, with infrequent error bursts of short duration. The DECT channel can be expected to provide a normally low background bit error probability, 1 in 10^4 to 1 in 10^3 with rare, short bursts of errors.

Error Control

As mentioned earlier, both CT2 and DECT were designed to carry speech traffic and as such do not provide any in built error protection. This is quite adequate for speech where an occasional error would be indiscernible to the user, and a short burst of errors would manifest itself as a click and not disrupt any conversation too greatly. Such errors on a data channel would, in general, be disastrous: an average error rate of 1 in 10^5 bits would be totally unacceptable, and this is far better than an unprotected radio channel could be expected to provide. So some form of error control must be applied to give a user error rate better than 1 in 10^{10}, if any data service is to gain a useful place in the market.

There are two basic ways of ensuring a low error rate to the user. Both require the addition of redundant information to the users information to generate a message which can be decoded at the receiver, [4]. In the first, the decoder detects the presence of errors in the message and requests a repeat, ARQ; in the second the decoder is able to both detect and correct the errors (forward error correction FEC) without the need for a repeated transmission. In general terms, ARQ will give a low undetected error rate at the cost of reduced throughput whilst FEC will maintain throughput at the cost of an increased undetected error rate.

Any realistic system must provide a balanced service to the user and consequently a combination of ARQ and FEC is often chosen. Another important factor is the amount of redundancy required to provide the degree of protection required by the user: ARQ needs less redundancy than FEC in order to provide the same undetected error rate. But when errors are detected, a re-transmission is required which reduces the channel throughput. For a medium error rate channel, which stays fairly constant, it may prove more efficient to use FEC, which despite having an initially lower throughput achieves a higher overall throughput because of the absence of re-transmissions.

(i) As discussed above, the CT2 channel delivers a wide range of error probabilities which are fairly slowly changing. The scheme designed to cope with this channel uses both error correction and ARQ for the asynchronous services and FEC alone for the synchronous services. Reed Solomon block codes are used to provide the redundancy and a procedure, LAPR, (based on CCITT LAPB) controls the flows of data in the asynchronous mode. The codes used are based on 8 bit symbols and are shortened to be 63 symbols long. A frame is made up from one codeword and a single 8 bit synchronising symbol: thus it takes 8 bursts lasting 16ms to transmit. The amount of information contained in each codeword depends on the service being supported and the rate selected, varying from 2 symbols to 44 symbols: this information must contain the control field for the procedure as well as the user data.

The Reed Solomon codes are a powerful set of block codes which are able to detect and correct errors on a symbol by symbol basis. (A single bit error in a symbol or all eight bits in error are classed as a single symbol error.) The code is used to correct a small number of errors, but if this number is exceeded, a repeat request is issued by LAPR. Simulations and experimentation have shown that this protocol is able to support the specified data rates at extremely low error rates, 1 in 10^{12} was calculated for the asynchronous service, [5].

(ii) The DECT channel changes quite rapidly and covers a medium range of error probabilities. A scheme to cope with this uses ARQ alone, accepting the occasional losses and retransmissions with the compensation of a simpler implementation. This latter point is of great importance when multiple slots are used. Depending on the protocol being used, one of two fixed length packets containing information, control field and checksum are sent. The checksum is used purely for error detection; retransmissions are requested when errors are detected. Simulations have shown that this scheme is able to support very high rate data transmission at acceptably low error rates. [6] shows that rates up to 400kbits/s can be supported for single users and rates around 80kbits/s can be achieved for multiple users.

Services

Cordless telephony provides the business user with the freedom to roam around his organisation's premises with the ability to both receive and make telephone calls. In the same way cordless technology can provide similar facilities for data communications. With the increasing use and decreasing size of computers, the business user is likely to become more dependent on data communications and expect the same mobility as for telephony applications. Other scenarios include the interconnection of less portable devices such as workstations in an efficient and convenient way; cordless technology offers a simple low cost way of providing these connections.

(i) CT2 offers two main classes of service: full-duplex asynchronous and full-duplex synchronous. In the first of these, an asynchronous packet assembler/disassembler, PAD, provides a CCITT V24/V28 (RS232) device to the user . In the context of the wireless office this could be used to provide a wireless connection, for example between a terminal and a computer or between a workstation and a printer. The standard data rates specified for this service are 300, 1200, 2400, 4800, 9600, 14400 and 19200bits/s; these will be suitable for small file transfers and electronic mail type applications, but quite impractical for large file transfers. The synchronous service offers the same standard data rates and in addition an unprotected 32kbit/s mode. This service could be used to provide a wireless connection into an ISDN for example.

(ii) The DECT protocols include options for interworking with local area networks, LAN. This makes their application in the wireless office very appealing. Where either small file transfers, or a wireless connection to a host computer via a LAN are required, the data rates needed can be supported using a single time slot in each direction. Where high data rates are needed, for example to transfer large files, then multiple slots can be used to increase the data rates.

Conclusion

The inclusion of data communications services into the CT2 and DECT standards offers the facility to provide wireless office capabilities in cost effective manner. The CT2 standard offers a range of asynchronous and synchronous services. The DECT standard offers the possibility of higher data rates and includes access to local area networks.

References

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