Purpose: show how DECT is likely to perform in a real LAN system
Audience: technical experts

DECT and LAN use, an Analysis

DECT, the Digital European Cordless Telephone cum telecommunications system, has been quoted as giving high performance packet oriented data services in additions to its voice and circuit switching services. Transfer rates of up to 1.152 Mbps per terminal and more than 5 Mbps per site are given to support this. Although these figures are basically correct, they no not by themselves prove that DECT would function well in a LAN environment. As shown below, there are signficant differences between the way LAN systems use the (wire) medium and the way DECT uses the (radio) medium. DECT is connection oriented. Setting up connections takes time and this limits the rate at which DECT can handle packets. Since most LAN operating systems are designed around fast connectionless packet transfer, such systems do not work well over DECT connections. DECT offers highly valuable business communications services. However, it must be complemented by a Radio LAN service that is designed to meet the needs of the LAN user community. The bandwidth reserved for DECT extensions could be used for such a service.

LAN System Requirements

The crux of the matter is not the raw bitrate but the way the LAN software makes use of that capacity. LAN software has become established among the computer user community in the form of LAN Operating Systems; Novell and Microsoft are the leading suppliers. The installed base is huge, it covers millions of sites running all kinds of applications. The investments made by users and suppliers are large and changing the LAN OS to accommodate a medium such as DECT is out of the question. Instead, it is the other way around, new products aimed at lower level LAN services must accommodate the way these LAN systems work.

The Novell LAN Operating System (Netware) and TCP/IP based systems cover more than 80 % of the installed base of LAN systems. All LAN systems work with some form of Transport layer sessions between LAN stations, the bulk of these sessions are between workstations and servers although direct workstation to workstation sessions also occur. However, at lower layers, most of the LAN systems work in connectionless mode so as to make optimum use of the available medium. The network layer of the LAN OS converts the session identifier into a message destination address and at lower layers there is no further concern with connections to that destination. See Figure 1. As an aside it should be pointed out the LAN Manager OS made by Microsoft uses the connection-oriented LLC-2. One purported reason for its lack of success in the market is the fact that it is noticeably slower than Novell systems.

Measurements on Novell servers show that they are capable of sending and receiving messages at a rate exceeding 500 messages per second. These messages typically have a maximum size of 512 or 1024 bytes. But many messages, e.g. requests for service, are as short as 64 bytes. A workstation may send and receive more than a hundred such messages per second.

The DECT MAC

The Media Access layer of DECT provides both connectionless and connection-oriented services. The former has a limited bitrate. The latter makes use of dynamic bearer set-up and release to allocate bandwidth on demand. However it takes time to perform this allocation. In typical LAN applications this bearer set-up and release consumes a lot of system capacity; the result is a "slow" network.

Jan Kruys
NCR Systems Engineering BV - The Netherlands

DECT in Connectionless Mode

Using DECT's connectionless Cf service is possible: the bitrate is limited to 25.6 kbps but the message length from PP to FP is limited to 640 bits unprotected and 512 bits protected data transfer.

DECT in Multi-bearer Mode

Using DECT's connection oriented services over multi-bearer facilities is one alternative to transport LAN packets. The two frames for multi-bearer set-up plus one frame for bearer release give a maximum of some 33 messages (packets) per second (disregarding data transfer time) on one physical channel.

The following example shows the effects of bearer allocation on total throughput in a given cell. Packets of some 600 bytes (average of request and response) are the average. Assuming Ip service and six bearers, the transfer time for 4800 bits is 31.25 mseconds. Added to the 30 mseconds bearer set-up and release overhead this gives 16.3 messages per second at the workstation, about a tenth of what it can handle. The average throughput works out at 16.3 x 4800 = 78240 bps per terminal. In actuality it will be lower because six bearers will not always be available simultaneously and, more importantly, because the server performance is also limited by the bearer set-up process.

At the server side, things are different. The total number of bearers in a given cell is 24. If a terminal typically uses a set of 6 simplex bearers, only 4 terminals can be active at any one time assuming no telephone use. In the above example, the occupation of a bearer set lasts around 50 mseconds, and at least 10 mseconds are lost in allocation to another terminal. Therefore, bearer sets are reusable at a rate of about 16 times per second. This gives 16 x 4 = 64 messages per second at the server end. Again, this is about a tenth of what a typical LAN OS is capable of. For the user, the noticeable effect is a server that seems very sluggish and that hinders people in getting their work done.

In a ten terminal cell, 64 messages per second means roughly 6 messages per second or 6 x 4800 = 28.800 bps at the terminal. At this rate writing a full screen on a CRT requires more than half a second. These figures assume six bearers allocated in parallel. The actual throughput is sensitive to this number: as it goes up, throughput actually goes down.

Using the Cf type connectionless service delivers the same level of performance to all terminals and thus gives a better level of overall throughput although response times go down.

It should be noted that in terminal emulation mode, packet size goes down to about 64 bytes and packet frequency is driven by the typing speed of the user: one packet per character. In such conditions DECT performance falls below the limits of acceptability because the server can not deliver its response packets fast enough.

Bearer Suspend/Resume

A possible alternative is to use bearer suspend and resume operations to control the medium more efficiently. However, this too does not appear promising. Bearer suspend and resume operations each require 10 mseconds (one frame) for execution between PP and FP. The gain relative to bearer set up and release is marginal, also because some hold time has to be built-in to cater for fast turnarounds.

Fixed Bearer Allocation

Permanently allocated bearers between LAN stations and FPs give a continuous 32 kbps in both directions, something that the e-mail user probably can live with but not users doing fast transaction processing, heavy database use or document processing. Note that fixed bearer allocation excludes any reuse of frequency for telephone connections; it is spectrum inefficient.

Multiple Physical Channels

Throughput per cell can be increased by using more than one physical channel simultaneously but that reduces the total number of terminals that can be served. Using multiple channels increases the size of the bearers used simultaneously but does not affect bearer set up time; the actual throughput therefore goes down because relatively more time is spent on bearer allocation.

LAN Broadcasts

In addition there is the issue of LAN level broadcast. The LAN OS uses broadcasts for management purposes. Although these make up only a small part of the total throughput their effect could be considerable because of separate transmissions would be needed to all destinations. The FP would have to perform this broadcasting, it requires special facilities above the DLC layer. It is not clear from the DECT IWU specification that this is actually supported.

Special LLC Designs

It may be thought that a special LLC, designed to make optimum use of the DECT MAC could solve this problem by intelligent control of bearers. For example, the server's LLC could hold on to a bearer until it has a response to send; this would eliminate one bearer set-up and release cycle of 30 mseconds and increase performance by 25%. This is not true in most cases because of the internal processing delays in the server which may range from a few to 100 mseconds. Holding a set of bearers during that time is less efficient than releasing them for use by others.

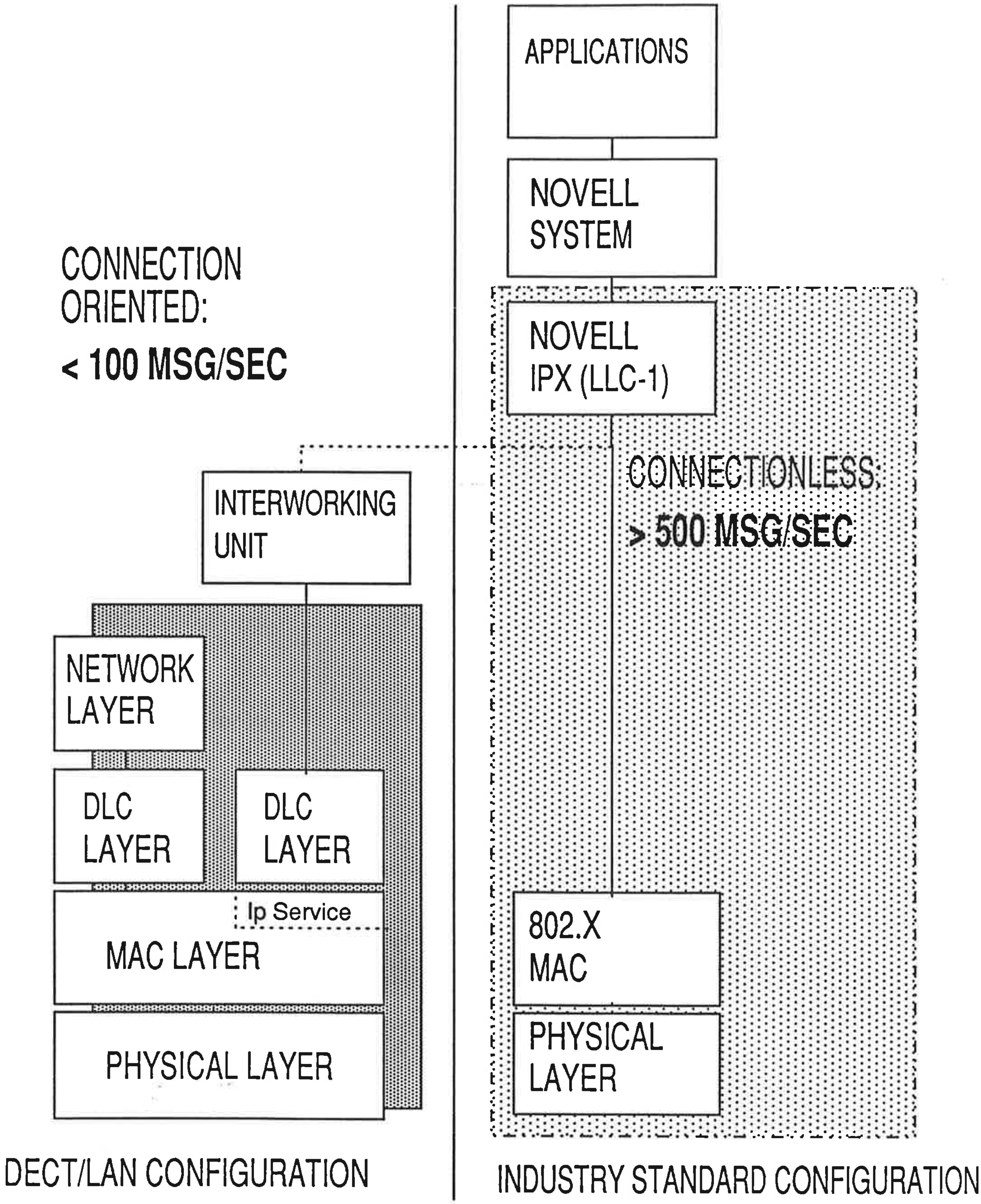
Summary

The bottom line is that in a real LAN environment where stochastical link usage for short messages is the rule, DECT's resource allocation scheme does not work well. The underlying reason is of course that the data transfer times are typically shorter than the connection set-up times. Fixed connections and connectionless modes circumvent the allocation problem but pay the price in terms of response time: the effective bitrates are 32 kbps and 25.6 kbps respectively.

In summary, DECT is not as good for LAN use as it seems from the raw bitrate figures. Radio LANs, with a connectionless MAC service designed to match the LAN OS behavior, are needed to satisfy the needs of the LAN user community.

Extending DECT

DECT has strengths that make it well suited for a variety of business applications. Its weakness lies in its meagre performance in LAN based systems. Therefore, the user community would be interested in an extension of DECT that would support efficient medium sharing as needed for LAN use. The EC regulation that provides spectrum for DECT has a reserve bandwidth of 30 MHz. It is worth the effort to look into making use of that capacity for LAN oriented services. One way of achieving this is to open up the additional bandwidth for spread spectrum use. Each DECT system would then support voice and connection-oriented applications over the currently defined frequencies and it would support LAN applications using the other frequencies. It seems likely that the signaling services of DECT could be used in some fashion to manage the "LAN" use of the other part of the band.



REAL LAN SYSTEMS AND DECT

Postscript for those interested in the details:

The throughput per cell **Tc** is proportional to the message size and inversely proportional to the media occupation (sum of bearer set-up/clearance and message transit time). n is the number of bearers allocated per request, M is the message size in bits; the raw data rate per bearer is 25.6 kbps in protected mode.

For a multi-bearer arrangement the formula is:

$$Tcm = (24 \times 25600 \times M) /((.03 \times 25600 \times n) + M) = < 614400 \text{ bps}$$

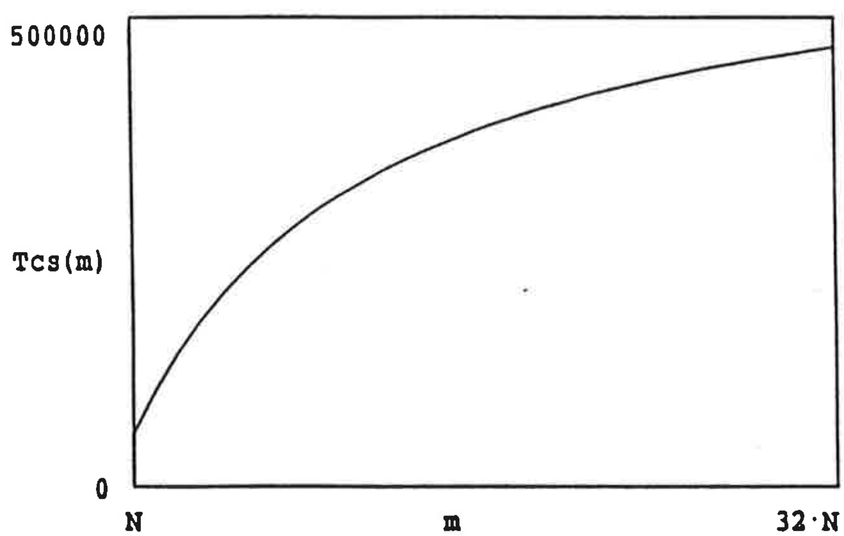
Using single simplex bearers, the cell throughput is:

$$Tcs = (24 \times 25600 \times M)/ (.02 \times 25600 + M) = < 614400 \text{ bps.}$$

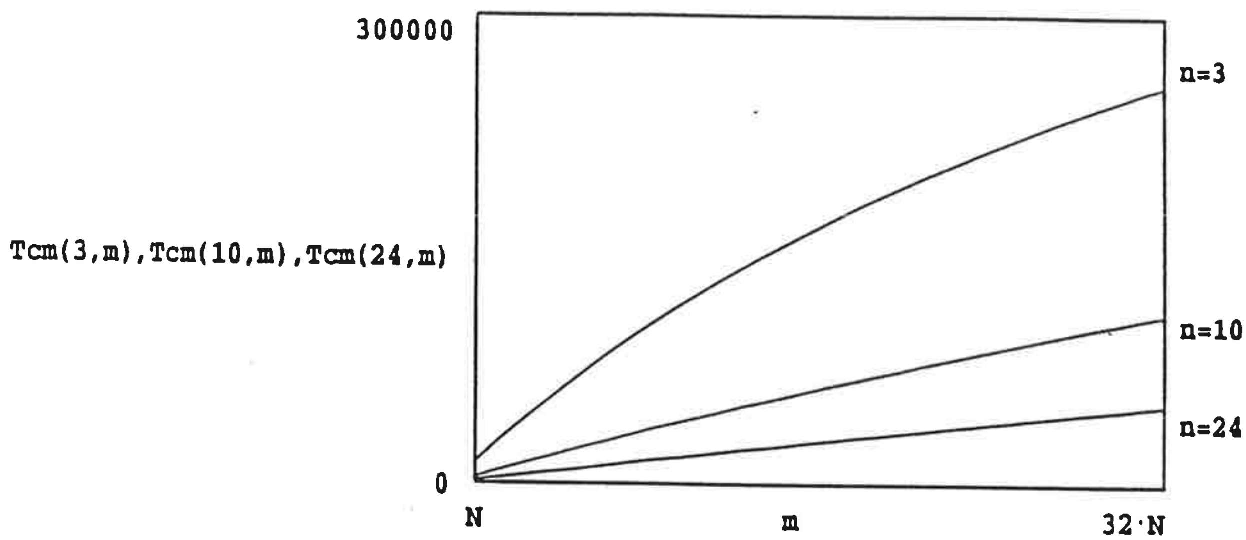
For fixed bearer allocation the bearer set-up/clear time disappears and maximum performance is reached (with all telephone use disabled):

$$Tcf = (24 \times 25600 \times M)/(0 \times 25600 + M) = 24 \times 25600 = 614400 \text{ bps.}$$

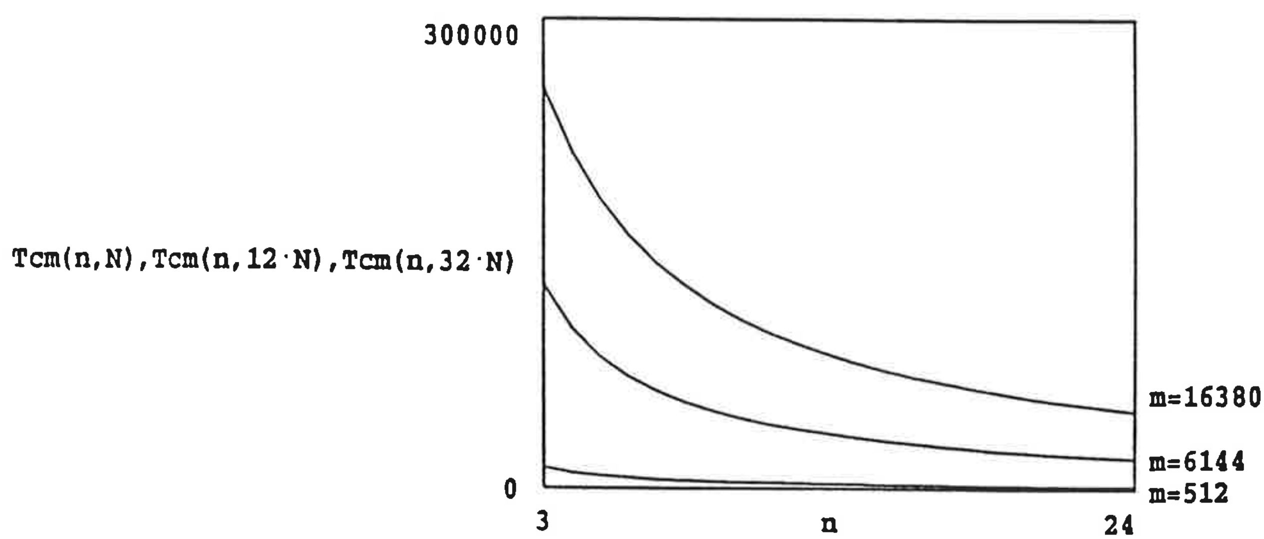
The following graphs show **Tc** as a function of M for different size bearer sets and as a function of the size of the bearer set for different message sizes.



DECT, cell throughput as function of message size with simplex bearer allocation. (message length unit N = 512 bits).



DECT, throughput as function of message size for different numbers of bearers per connection.



DECT, throughput as function of numbers of bearers per connection for different message sizes.