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A Study on Cordect Technology

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Abstract-- **The traditional wired native loop accustomed connect every phonephone subscriber to the closest exchange is pricey and unreliable. Wireless native Loop (WLL) systems for the most part eliminate these copper wires exploitation wireless technologies and will give a value effective answer. corDECT is one such WLL system, supported the DECT (Digital increased conductor Telecommunications) commonplace, that gives toll-quality voice and knowledge capability at a value well below that of a wired local loop. A closed Queueing Network Model (QNM) is projected for the corDECT system. The model is validated against actual measurements. Our model predicts that the one,000-line corDECT system would meet a Busy Hour decision try (BHCA) of thirty six,000 calls/hr, that is way larger than its demand of twenty,000 calls/hr. The bottlenecks that limit the BHCA to thirty six,000 calls/hr were known by the model. We show however the system might be dilated to a ten,000-line exchange with a BHCA of over two,10,000 calls/hr. We additionally investigate the practicability of implementing sixty four kbps knowledge service in conjunction with voice. It is shown that this requires modest hardware improvements.**

I. Introduction

Traditionally, a try of copper wires is employed to attach every phonephone subscriber to the closest exchange. Such a wired native loop poses the subsequent problems:

- The giving birth and maintenance of copper cable up to the subscriber's premises incurs high value. The wired native loop contributes regarding simple fraction of the value in providing a line to a subscriber. Also, this value is increasing with time because the value of copper will increase.
- The per-line value for rural areas is considerably higher thanks to the big quantity of cabling infrastructure needed to require even a couple of phonephone lines to remote villages.
- Most faults are in the local loop, due to water-logging, damage or theft of cables.
- fast readying is tough thanks to the restrictive and alternative issues in giving birth buried cables.

Wireless technology will give an economical answer to the native loop issues. The wireless service facilitates simple enlargement of the network as installation is simpler.

Further, the value of wireless technologies is primarily in physics and is predicted to come back down with time. In order to be helpful in urban areas of developing countries like Asian country, the wireless local loop technology must cater to high subscriber densities of 1,000–10,000 subscribers/sq.km. It should additionally give toll-quality voice and knowledge and FAX capability on par with a wired phonephone.

1.1 The Cordect WLL System

One such wireless system is the corDECT Wireless Local Loop system (WLL) developed by the TeNeT Group of the Indian Institute of Technology, Madras, India; Midas Communication Technologies (Pvt.) Ltd, Madras, India and Analog Devices Inc., USA. The corDECT system consists of four major subsystems as shown in Fig. 1.1

DECT Interface Unit (DIU) : performs system control and interfaces to the Public Switched Telephone Network (PSTN).

Compact Base Station (CBS) : provides wireless access to subscribers in an area on twelve simultaneous channels.

Wallset (WS) : a wireless fixed terminal adaptor, with extended range, that can be connected to any standard telephone, modem or fax machine.

Handset (HS) : a portable telephone providing voice service to a user. corDECT uses a micro-cellular design with a typical cell size of 50–300 m. This enables support for subscriber densities of up to ten,000 per sq. km. It additionally has the advantage of fine speech quality and an occasional transmit power of solely 250 mW.

corDECT uses the DECT (Digital Enhanced Cordless Telecommunications) standard for communication between a portable and CBS. DECT uses a variation of the Time Division Multiple Access (TDMA), the Multi-Carrier TDMA (MC-TDMA). The standard defines 24 time slots (termed full slots) so that up to 12 simultaneous calls can be handled (one full slot is used for receive and one for transmit). DECT divides its 20 MHz bandwidth into 10 frequency bands, hence a channel is a time-slot/frequency pair, resulting in 120 channels.

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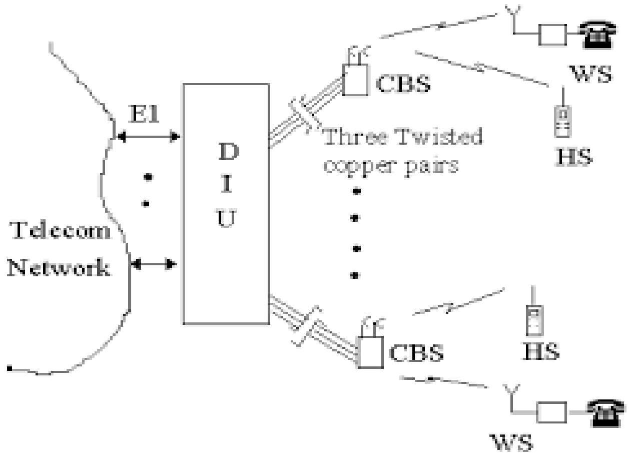

Fig.(1.1) 1,000-line corDECT system architecture

Mobile cellular systems such as GSM use Fixed Channel Allocation (FCA) scheme (where each base station is allocated a set of frequencies for its use). This requires careful frequency planning and usually results in a monopoly operator in each area (city or even state). In DECT, on the opposite hand, the frequency is selected by the portable using Dynamic Channel. The portable constantly monitor signals from various CBS around to switch to another CBS and channel if reception is better there. DCS provides for economical information measure utilization, channel allocation supported the particular traffic interference things and, most importantly, does not require frequency planning. To be accepted by a service provider, the corDECT system must not only reduce the per line cost but also meet the performance requirements laid down for a wired local loop system. Hence, it's vital to analyse the performance characteristics of the corDECT system. An approximate analytical model of the corDECT system which could fairly accurately predict the performance characteristics of the system is developed. The model is employed to review the system capability, to identify and improve the bottleneck subsystem, to examine the feasibility of expanding the capacity of the system and to investigate the feasibleness of supporting knowledge additionally to voice within the corDECT system.

II. CORDECT ARCHITECTURE AND IMPLEMENTATION

The DECT customary utilized by the corDECT system is intended for prime density, micro-cellular systems that support voice telephony, high speed data, video and other multimedia applications. The main features of the DECT standard are:

- DCS, a method whereby the transportable unendingly scans all the channels and dynamically selects higher channels once they become accessible.
- Roaming anywhere in the radio coverage network.
- Seamless bearer (or channel) relinquishing from channel to channel or from cell to cell. This is clear to the user even throughout a oral communication.
- Authentication and cryptography, which provide a high-level of security and privacy.

2.1 The DECT Protocol Stack

The DECT customary has been structured per the Open Systems Interconnection (OSI) model. DECT has defined four protocol layers for the air-interface. These correspond to the lower 3 layers of the OSI model. The functionality of these layers is discussed below:

Physical (PHL) Layer: This layer specifies the radio frequencies and transmission characteristics, the division into 10 ms frames and subdivision of each frame into 24 slots. It monitors the standard of signal altogether slot and frequencies utilized by the DECT instrumentation.

Medium Access management (MAC) Layer: This layer provides connections used for user knowledge and a few management, connectionless channels for control information flow and broadcast service to page a portable. It handles relinquishing of a affiliation from one channel to the opposite thanks to link quality degradation (within a CBS), called bearer handover.

Data Link management (DLC) Layer: mistreatment bearers provided by the raincoat layer, the DLC layer creates and maintains reliable connections, provides connection-oriented and connection-less service to higher layer, handles handover of a affiliation at transportable from one CBS to the opposite thanks to link quality degradation or CBS failure, referred to as affiliation relinquishing.

Network (NWK) Layer: This layer establishes, maintains and releases calls (Call Control), handles quality management, registration and authentication of portables. This layer along with MAC and DLC supports encryption of signalling, user voice/data information.

2.2 corDECT Architecture and Implementation

In wireless systems whose cell radius is very large, a single base station can serve subscribers in a city and hence it can even be located at the exchange. Serving a subscriber density of 10,000 subscribers/sq.km. requires a micro-cellular architecture with a cell radius of around 200m.

Hence, many base stations distributed throughout are required to serve subscribers in a city. All these base stations can not be situated at the exchange. The local loop now consists of a wireless or a wired connection (employing N-ISDN, HDSL on copper cable) from the exchange to the base station and a wireless connection from the base station to the subscriber. The exchange is connected to the national network. Base stations would be mounted in posts, walls, roofs of buildings, etc.

The corDECT system employs a similar architecture as discussed above for a micro-cellular wireless system. The exchange here would be the DIU and it consists of a OMC (Operation and Maintenance Control), SWITCH (Voice/Data Path Switching subsystem) and BIMs (Base Station Interface Modules).

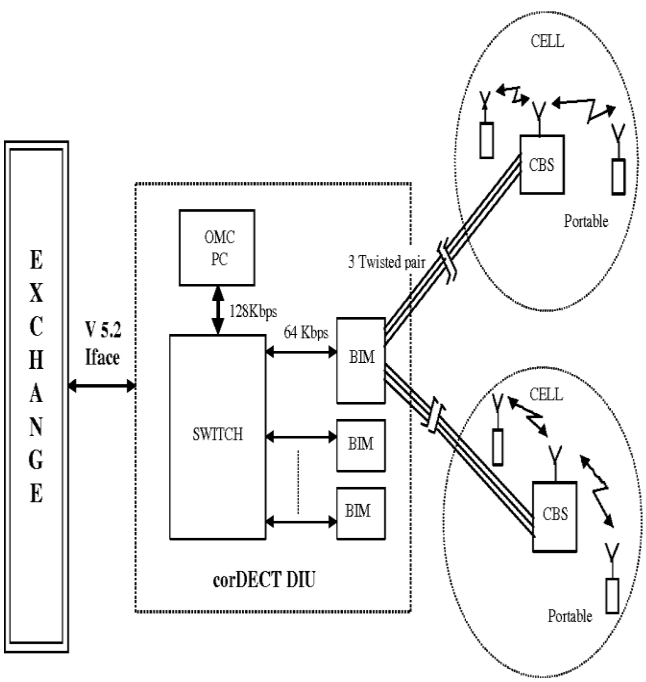

Fig. 2.2 corDECT 1000-line system architecture

The OMC is a standard Personal Computer (PC) running LINUX OS. The OMC performs call processing, and runs the DECT NWK Layer. The OMC provides user interface to the operator of the corDECT system, performs the system operation, maintenance, remote fault monitoring, subscriber registration and billing.

The OMC is connected to the SWITCH through a 128 kbps signalling link. The SWITCH is responsible for switching the voice between the subscribers and runs a part of the DECT DLC Layer viz., LAPC (Link Access Protocol for C-plane). All the base stations (called Compact Base Station (CBS)), distributed across the region are connected to the DIU through three standard subscriber wires that may already be laid for Wired Local Loop. The link between the CBS and the DIU provides 16 kbps signalling bandwidth. The CBSs square measure connected to the DIU at the BIM and every BIM supports 2 CBS. The BIMs square measure connected to the SWITCH through sixty four kbps signalling link. The SWITCH monitors the health of the BIMs and CBSs connected to them. The CBS provides 12 duplex radio links supporting 12 simultaneous calls. The CBS runs the other part of the DECT DLC Layer viz., Lc Layer (MAC layer interface), the entire DECT MAC and DECT PHL Layers. The portable runs the entire DECT protocol stack.

In addition to these layers, the Inter-Working Unit (IWU) layer that handles the user interface at the portable and at the OMC performs subscriber billing, registration, etc. and connect the DECT subscribers to the conventional Public Switched Telephone Network (PSTN) is implemented in the corDECT system.

2.3 Call Scenario

The call scenario of a portable A calling portable B, keeping the call active for sometime and then portable A releasing the call is shown in Fig.3.1. It shows the sequence of events at the DECT DLC, the DECT NWK layer messages exchanged in this call scenario.

III. PERFORMANCE EVALUATION

3.1 Objectives

In this work, we study the performance of DIU and CBS of the corDECT system. An analytical model of the corDECT system that would fairly accurately predict the performance characteristics of the system is developed. The model is employed to review the system capability, to identify and improve the bottleneck subsystem, to examine the feasibility of expanding the capacity of the system and to investigate the practicableness of supporting information additionally to voice within the corDECT system.

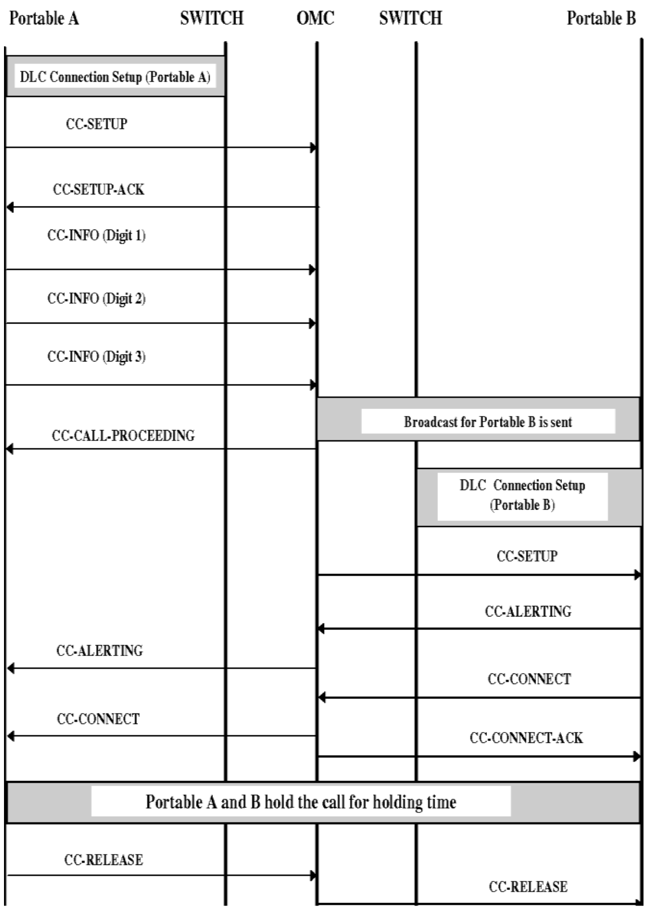

Fig.3.1 Network Layer messages exchanged for one complete call

3.2 The Model

Performance measurements with a large system such as a 1,000-line corDECT system is difficult. Hence, we have a tendency to develop an easy Queuing Network Model that may be expeditiously wont to study the corDECT design. Mean Value Analysis (MVA) is associate degree economical resolution technique for networks of queuing centres. The exact MVA technique is employed to unravel the corDECT Analytical model.

3.2.1 Job Identification

We are interested in investigating the performance of the corDECT system with increasing number of calls. Hence, we define a job as a complete call between two subscribers. A call is initiated by a calling subscriber, the called subscriber answers the call. Here, calling and called subscriber form a portable pair. After the call holding time the calling subscriber releases the call. We study only one type of call i.e. a completed call, and hence have only one job class for the model. In the call attempt, User A and B are valid subscribers with three digit subscriber number, B is free when A calls B and call loss due to non-availability of air slot is assumed negligible. The call answering time at B is 1 sec, while the call holding time and time between subsequent calls (inter-call time) can be varied.

The system is analysed with maximum of four pairs of portable per CBS and DCS is not activated at the portable. With the job and the performance objective being defined, we find that there will only be a finite number of jobs in the corDECT system. This type of system is best modelled as a closed Queueing Network Model (QNM). For this model, we use a non-executable, probabilistic, interactive type of workload.

3.2.2 Analytical Model

The proposed corDECT closed QNM is shown in Fig.4.1 In this model, the terminals of the conventional closed QNM are the subscriber's portable attempting calls and have a think time, Z. A portable can select a free channel in any of the CBSs. Hence, the CBSs are modelled as M/M/s queue (where s is the total number of CBS in the system) with service demand† DCBS. Since, 2 CBS ar connected to a BIM, the BIM-SWITCH link is modelled as M/M/b queue, where b = s/2. It has a service demand DBIM-SW.

We need s links to connect CBSs and BIMs, hence CBS-BIM link is modelled as M/M/s queue having a service demand DCBS-BIM. BIM isn't concerned in DECT decision process, hence, is not modelled as a separate server. We have a central SWITCH, OMC and a communication link connecting them. These three components are modelled as M/M/1 queue, and these servers have service demands DSW, DOMC, DSW-OMC respectively.

IV. VALIDATION

Validation of a performance model involves comparing measured performance values with the performance values calculated by the model.

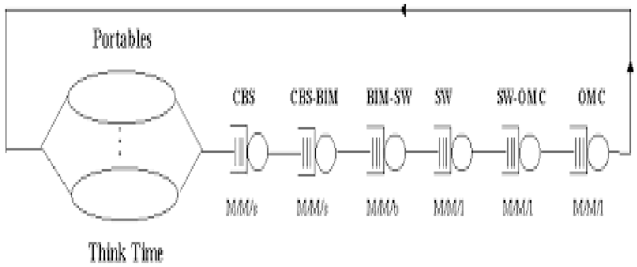

Fig.4.1 corDECT closed QNM

4.1 Validation Procedure

Using the measurements in the corDECT system. we estimate the mean Analysis (MVA) parameters (service demand at every server) for one job within the corDECT system. Given the demands in each server and the number of servers in the system, we solve the analytical model using the MVA algorithm and predict the performance parameters viz. response time, throughput and queue length for more than one job in the system.

4.2 Measurement Tools

A software probe module is added to the corDECT software without affecting its normal operation. This module is built

In each subsystem of the corDECT system except OMC. This module provides functions to start and stop the probe timer. Using this timer, the time interval between the transmission of a request and reception of a response can be measured.

4.3 Estimating Service Demands

4.3.1 SWITCH service demand

We start a timer at the CBS when a request is generated and it is stopped when the response for the request arrives from the SWITCH. We accumulate this time interval for all requests and responses for a call. Let this time be TCBS. We have,

TCBS = DCBS-BIM + DBIM-SW + DSW + DSW-OMC + DOMC

We use a similar timer at SWITCH for measurement. Let the total measured time for a call be TSW. We have,

TSW = DSW-OMC + DOMC

To obtain SWITCH service demand DSW

TCBS - TSW = DCBS-BIM + DBIM-SW + DSW

The service demands at link servers namely, DCBS-BIM, DBIM-SW, DSW-OMC can be calculated from the given data rates and message length, and is a constant. Hence, the SWITCH service demand can be estimated as,
DSW = TCBS - TSW - DCBS-BIM - DBIM-SW

4.3.2 OMC service demand

we calculate OMC service demand as,

DOMC = TSW - DSW-OMC

4.3.3 CBS service demand

At CBS, we use additional timers to measure the processing time of all messages of a call. We measure the time interval between the time when a message arrives from SWITCH and the time when the message is transmitted on air. We also measure the time interval between the time when a message is received on air and the time when the message is transmitted to SWITCH. We sum up the time interval recorded for all messages of the call and we thus obtain DCBS.

4.3.4 Think Time

Let the total time for a call measured at the portable be, TP. Then,

TP = Z + DCBS + DCBS-BIM + DBIM-SW + DSW + DSW-OMC + DOMC

Since all the service demands are known, think time (Z) is calculated as,

Z = TP - DCBS - DCBS-BIM - DBIM-SW - DSW - DSW-OMC – DOMC

4.4 Validation Results

The response time obtained from measurement is expressed as confidence interval with a confidence level of 95%. From Table 3, we observe that the error in the analytical model with respect to measurements is less than 10% almost always. There is a similar observation for varying call holding time and time between calls, when N = 1. Thus, the analytical model can be used to predict performance measure of the corDECT system with fairly good accuracy.

V. RESULTS

In this section, we use our validated analytical model to investigate the performance of the corDECT system and its enhancements. We first consider the corDECT system used only for voice and then study the performance with data traffic also.

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5.1 corDECT Voice Network

5.1.1 Busy Hour Call Attempt (BHCA)

Conventionally, the capacity of a telephone switching system is measured by the maximum number of call attempts per hour (during busy hour of the day) that can be handled by the system. This measure is referred to as BHCA. The corDECT system is a 1,000-line exchange and is expected to meet a BHCA of 20,000 call attempts/hr. The BHCA experiment was conducted victimisation portables programmed to mechanically generate calls. A number of parameters such as the time between calls and call holding time could be varied. In this experiment the call answering time was fixed at 1 sec, call holding time was fixed at 100 ms and time between calls at 1 second. With 15 pairs of portables generating calls the average response time for a job completion (i.e. complete call setup and release) including the time between calls was found to be 4.8 sec. Hence, the BHCA is,

= (1/4.8) 5 3600 5 15 5 2 call attempts/hr

= 22,500 call attempts/hr

Note that, each complete call has two call attempts, one between the calling portable and DIU and the other between DIU and called portable.

In this experiment, there is no blocking. Hence, we can use the analytical model to predict BHCA. The average response time for a complete call predicted for 15 pairs of portables (N=15) including the time between calls is 4.2 sec, and the throughput obtained from the analytical model is 0.003574 call attempts/ms (Fig. 5.1). Hence, the BHCA is, 25,732 call attempts/hr. This error of 14 July compared to the measured worth is suitable.

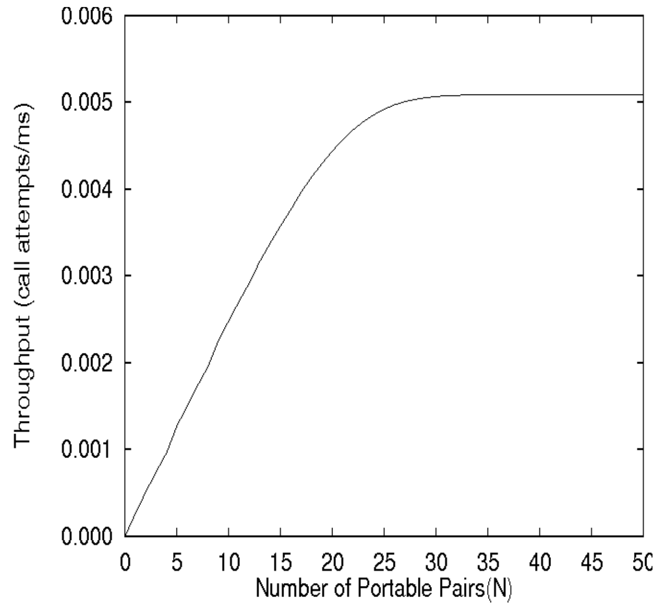

Fig.5.1 System throughput characteristic from analytical model for varying N. (At the Saturation worth, N = 30, Throughput = 0.005 call attempts/ms).

5.1.2 Throughput

Fig. 5.1 shows the throughput characteristic of the system from analytical model for varying number of portable pairs, N, attempting calls simultaneously. From the throughput characteristic, we observe that at around N = 30 the graph saturates at a throughput of 0.005 call attempts/ms. Hence, the maximum BHCA that can be achieved is 36,000 call attempts/hr. The outturn of the system will be improved by characteristic and rising the bottleneck server. The bottleneck server can be identified from the utilization graph (Fig.5.2).

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Corresponding to the throughput saturation, the utilization of SWITCH approaches 1.0 at around N = 30. Hence, this is the bottleneck server. The graph also shows that the next bottleneck server is the OMC and the next is the CBS-BIM link, when the system is examined at N = 50. In the utilization graph, the utilization of the link servers namely, CBS, CBS-BIM and BIM-SWITCH exhibits two important characteristics namely, a saw-tooth behaviour and decrease in utilization as N increases.

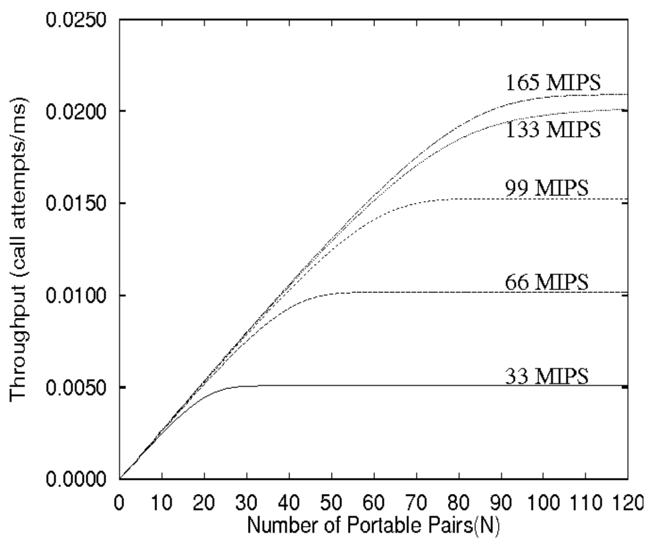

Fig.5.2 System utilization characteristic from analytical model for all servers in corDECT system for varying N.

In the corDECT model discussed in Section 3.2.2, the CBS and CBS-BIM link are modelled as multi-server M/M/s queues, where s is the number of CBS in the system. We analyse the system with four pairs of portables per CBS, adding a CBS for every four pairs of portables in the system (s = (N + 4 - 1) / 4). We observe an increase in utilization from N = 1 to 4 and then a decrease at N = 5, since, a new CBS is added at N = 5 but, there is only one portable pair corresponding to the new CBS. Thus, the new CBS and the corresponding CBS-BIM link are less utilized and we observe an overall decrease in the utilization characteristic. The utilization of these servers increases from N = 5 to 8, and then decreases at N = 9, and so on. Thus, we observe a saw-tooth behaviour in the CBS and CBS-BIM utilization characteristic. The BIM-SWITCH link is modelled as an M/M/b queue, where b = s/2 i.e. one BIM is added for every two CBS in the system.

Hence, we observe a similar saw tooth behaviour as in the CBS and CBS-BIM utilization characteristics, but at N multiples of 8. As we add more CBSs to the system, the central components namely, SWITCH and OMC get overloaded and their utilization starts saturating at 1. Hence, beyond this saturation the utilization of CBS, CBS-BIM and BIM-SWITCH servers decreases as N increases. Thus, We observe an increase and then a continuous decrease in utilization of CBS, CBS-BIM and BIM SWITCH link.

5.1.3 Improving Bottleneck Server

In the corDECT system, we identified SWITCH server as the bottleneck. We study two different ways of improving the server,

- Increasing the processing speed at SWITCH employing increased MIPS processor
- Shifting some percentage of the service demand from SWITCH to any other server MIPS increase at SWITCH using the analytical model we observe that as MIPS at SWITCH increases the values (N) at which the utilization of SWITCH saturates at 1 increases. At 165 MIPS,SWITCH server does not saturate at utilization of 1, hence, the SWITCH is no longer the bottleneck.

5.1.4 Different CBS Configurations

Owing to vendor requirements, the corDECT CBS may be configured with 1 to 4 CBSs per BIM. We find that there is no significant difference in the throughput among the above system configuration. The response time and utilization (at the SWITCH) also show no significant difference for these configurations.

5.1.5 corDECT as a 10,000-line Exchange

The corDECT system currently supports 1,000 lines. If the corDECT system is to be redesigned for supporting 10,000 lines, we can estimate the requirements of the system from the analytical model. For a 1,000-line exchange we achieved a BHCA of 20,000 call attempts/hr . In a similar proportion, a 10,000-line exchange has to achieve 2,00,000 call attempts/hr. We use the study of improving the bottleneck server for analysing the feasibility. We investigate here one chance of rising the capability of the corDECT system, assuming no faster processor is available. We introduce the following changes in the current corDECT system,

- Shift ninetieth of SWITCH process from SWITCH to BIM
- Increase the speed at SWITCH server by using 2 thirty three unit of measurement processors (assuming a communication overhead of 100 percent within the service demand).
- Upgrade the OMC, which currently uses a 100 MHz Pentium processor to 166 MHz.
- Upgrade the switching matrix in the SWITCH subsystem to a 5120 5 5120 matrix from the existing 512 5 512.
- DIU is upgraded to support 100 BIMs.

5.2 corDECT Data Network (Wireless LAN)

Wireless LANs provide flexibility and services to users who cannot be well served by the traditional wired LAN, and can extend or even be used as a substitute for a wired LAN. A system that can offer both wireless speech and data services over the same infrastructure may provide extremely flexible and cost effective solutions to users. The users of wireless LANs would be organizations that

- need local terminal mobility and the ability to flexibly re-configure their LAN,
- require a temporary LAN,
- square measure placed in buildings wherever the installation of additional cabling is expensive, disruptive or forbidden.

Today, Internet access is becoming increasingly important. In corDECT, the native loop upto the subscriber unit is digital. Hence the system could offer both wireless speech and data services over the same infrastructure in an extremely flexible and cost effective manner.

5.2.1 DECT Support for DATA Service

A range of DECT Data Service Profiles (DSPs) has been developed to permit efficient use of the DECT radio resources for data transmission purposes, and to provide throughput data rates of up to 552 kbps. The DECT DSPs make use of the powerful mechanisms for data transmission provided by the DECT Common Interface (CI) standard. Compared to modern solutions using a voice channel, the DECT DSPs, exploit the full capabilities of the DECT CI standard that provides, high throughput, lower bit error rate, better reliability, improved spectrum usage and better battery economy. In systems complying with the Generic Access Profile (GAP), ETS 300 444, the integrated voice/data system may be implemented efficiently.

The DECT standard defines two planes of operation, the Control plane (C-plane) used for signalling information transfer and the User plane (U-plane) used for transfer of user voice/data. Although U-plane services are defined for DECT DLC and MAC layers. We discuss here, only the U-plane services at the DLC layer. The DECT DLC Layer defines different types of U-plane service, referred to as LUx service. The U-plane services currently defined are, LU1 Transparent Unprotected service: used for applications that do not need processing of U-plane data e.g. speech and this service is currently supported in the corDECT system.

LU2 Frame Relay service.

LU3 Frame Switch service.

LU4 Forward Error Correction (FEC) service

LU5 Basic Rate AdapTion (BRAT) service: no FEC, but provides reliable delivery of data packets through the Automatic Retransmission Requests (ARQ) protocol. It provides transparent transport of synchronous data at 8, 16, 32, 64 kbps/s data rates.

LU6 Secondary Rate AdapTion (SRAT) service: operates in conjunction with the LU5 service and enables rate adapt data terminal equipment with V-series interfaces to be interfaced to one of the input rates provided by the LU5 service.

LU7 64 kbps data bearer service.

LU16 Escape service: allows for implementation-specific U-plane protocol. Akerberg concludes that DECT-based WLL systems are suitable for POTS (Plain Old Telephone Service), general ISDN services, Internet and other packet data services. The DECT MAC layer provides several alternatives for data:

a) A full-slot duplex bearer carrying unprotected 32 kbps ADPCM. This full-slot provides telephony speech quality for bit error rates, BER, 10-3 on the air interface. The 32 kbps ADPCM channel supports transparent voice modem services up to 4.8–9.6 kbps when the transmission on the air interface is essentially error free.

b) A double-slot duplex bearer carrying protected transparent 64 kbps PCM. The protection service is LU7, which adds ARQ and Forward Error Correction (FEC) to the unprotected 80 kbps double-slot. This ensures BER < 10-8 for the PCM service when BER ≤ 10-3 on the air interface. Thus 28.8 kbps transparent modem services, V.34 and unrestricted 64 kbps ISDN services are supported for BER ≤ 10-3 on the air interface.

c) A full-slot bearer carrying 24 kbps protected packet data with BER < 10-8 when BER ≤ 10-3 on the air interface. The corDECT system currently supports the bearer service defined in (a). To support data we need a protected service. We currently plan to provide 64 kbps protected service, defined in

d) Hence, we investigate the LU7 service in detail.

5.2.2 Modelling LU7 Service

Voice band modem data rates over unprotected 32 kbps ADPCM may be as low as 1.2 or 2.4 kbps at BER 10-3, depending on the error distribution. This property is not DECT related, but typical for all radio technologies using the unprotected 32 kbps ADPCM coding, including CT2, PHS and PACS. Of these standards only DECT provides a protected (LU7) 64 kbps bearer service as required for ISDN and V.34 modem services. The LU7 service is an immediate requirement for the corDECT system in supporting ISDN services at the portable. The requirements for the LU7 service and service demand estimates at various layers are discussed in the following sections.

Physical Layer

The LU7 service requires that the physical layer support double slot operation as against the full slot operation used for unprotected 32 kbps voice service [23]. Each double slot occupies two full slots and hence there can only be a maximum of six simultaneous data calls through a CBS.

MAC Layer

At the MAC layer, the U-plane/B-field requires the support for duplex unprotected normal delay service and is currently supported. It also requires, the support for advanced MAC connection set-up, full format page message, B-field signalling and B-field offering a data rate of 80 kbps. These features have to be newly added to the corDECT system. It is estimated that the LU7 service requirements for the PHL and MAC layers in supporting the services above, do not increase the service demand at any server significantly.

DLC Layer

At the DLC Layer, the service requirement can be broadly specified as,

- Forward Error Correction (FEC) exploitation Reed-Solomon (R-S) committal to writing
- Automatic-Repeat-Request (ARQ) algorithm
- Computation and Verification of checksum on data packets

The Control field is used by the ARQ procedure. The Information field carries the user data. The Checksum field carries the checksum computed on the control and information fields. The R-S field holds the parity symbol information for FEC. The LU7 service at the DLC layer, is best implemented at the CBS since transporting 80 kbps U-plane data across to SWITCH would require changes in the corDECT architecture. Also, LU7 tasks done at a central subsystem (e.g. SWITCH) would require more processing power.

FEC computation

It is estimated that the FEC algorithm would require at most 5 MIPS of the CPU for a data call from DIU to portable. For an entire decision from transportable|a transportable|a conveyable} to a different portable ten unit of processor is consumed. Hence, for a 33 MIPS ADSP 2181 CPU it occupies 30% of the CPU.

ARQ procedure

At the DLC Layer, well-defined Automatic-Repeat-Request (ARQ) procedures and the checksum ensure reliable delivery of data packets. A window protocol with a window size of eight is outlined. In addition to the sequence number, all packets have a checksum. Packets that have checksum errors are stored and marked as error but not delivered to the higher layer for a fixed duration. If an error-free packet is received with the same sequence number as the packet in error then the stored packet (in error) is overwritten by the error-free packet. If an error-free packet is not received within the fixed duration the packet received in error is delivered to the higher layer. All packets sent to the peer entity are acknowledged and if no acknowledgement is received within a fixed duration the packet is retransmitted.

A data packet is received each ten ms and process must be done on this packet. The ARQ procedures used for LU7 service is almost similar to the ARQ procedures defined for the Control plane (C-plane) at the DLC layer. Hence, from the knowledge of current implementation it is estimated that the ARQ algorithm would require about 700 instructions on ADSP 2181 processor to process one LU7 frame.

Checksum computation

The checksum algorithm used in LU7 service is almost similar to the MAC Layer A-Field (which carries the C-plane information at the MAC layer) CRC algorithm. In the current implementation the algorithm for x 16-bit words require, 13 5 x + 10 instructions in ADSP 2181 processor.

The checksum in the LU7 service is computed over the 720 bits of information field, 16 bits of control field and a 16-bit constant. Number of bits on which checksum is computed = 720 + 16 + 16 = 752 bits

Number of 16 bit words = 752/16 = 47 words

VI. Summary And Conclusions

The corDECT system and also the subsystems that Associate in Nursing effect on} the performance were examined and an analytical model of the system was developed. The analytical model was validated using measurements in the actual system. The error was found to be but ten you just about continually. Hence the model will be wont to predict performance measures of the corDECT system fairly accurately. Using this model the corDECT system is predicted to exceed the BHCA requirement of 20,000 calls/hr. This result was verified in the actual system during the Telecommunication Engineering Centre (TEC), India, validation of the corDECT system. The SWITCH subsystem was identified as the bottleneck. To improve the system performance, using the analytical model we studied the effect of increasing the processor MIPS at SWITCH, and shifting part of the protocol processing from SWITCH to BIM. We found that with a one hundred sixty five unit SWITCH processor, the SWITCH is no longer the bottleneck, and OMC becomes the bottleneck. Based on this study we found that the corDECT architecture could be extended to a 10,000 line exchange by several relatively modest changes such as increasing processor MIPS and reassigning of protocol processing. The corDECT system was examined for feasibleness of information support exploitation the analytical model of the system. We found that LU7 64 kbps data service can be implemented without significantly affecting the performance, provided Forward Error Correction (FEC) algorithm using Reed-Solomon coding is performed using a separate DSP or hardware.

VII. Future Work

The model does not consider the effect of bearer or connection handover and mobility management procedures and could be refined to study the effect of these on the performance of the system.

The model doesn't take into account decision block at the air interface. It may well be changed as a block closed QNM to check the block chance of calls within the system. The model considers only one type of call.

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