SIMULATION OF I.430 D-CHANNEL ACCESS PROTOCOL

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Abstract

It is well known that the fundamental goal of ISDN is to provide fully digital communications facilities for sophisticated voice and data applications and eventually lead to a single world-wide ISDN network. To ensure compatibility of ISDN networks around the globe, ISDN standards committees recommended a user-network interface protocol in the CCITT "red book". One of the central features of the ISDN is the user-network interface with separate channels for user and signalling information. The D channel is primarily intended to carry signalling information. Although it may also be used to carry telemetry and low speed packet data.

The primary goal of the work reported herein is to evaluate the performance of systems implemented with I.430 D-channel access protocol under a wide variety of traffic loads. Three complementary approaches, analysis, simulation and measurement, will be employed for the performance evaluation.

This short paper first presents some tutorial background information on Basic Rate Interface (BRI) ISDN and then introduces the simulation model for OPNET, which is the simulation tool used in our work. Finally preliminary simulation results are presented.

1 Introduction and Background

The ISDN I.430 procedural specifications state a procedure for active terminals to bid for control of the D channel [1]. A terminal which contends for the D channel first monitors the D-echo channel bits and counts consecutive 1's. When the count equals a number representing the current priority level (8 or 9 for high priority and 10 or 11 for low priority), the terminal begins to transmit a LAPD frame if it has frames to send. The terminal monitors the D-echo bits and transmits the frame as long as each echoed bit is identical to that sent. If these two differ, the terminal stops transmitting immediately, resets its count to zero, and restarts its attempt. In the D channel access algorithm, the *signalling* message is assigned high priority and user *packet* and *telemetry* messages are assigned low priority.

In a recent paper [2] on the D channel access protocol, Lee and Un gave a queueing model and solved for the mean message delays analytically. The performance of symmetrical systems with constant- length and exponential-length information fields in a layer-2 frame, and an asymmetrical system with proportional message arrival rates (1:2:3:4) and constant-length information fields were studied in their paper, and the analytical results were verified by simulation.

The primary objective of our research work is to study the performance of systems implemented with D-channel access protocol under a variety of traffic loads. Three approaches will be employed toward solving this problem: analysis, simulation, and measurement. However, the evaluation of the performance of systems under the traffic load of a real environment will be accentuated in our work. For instance, we will study the system behavior under asymmetrical and time-varying traffic loads since these are quite common in real environments.

OPNET, a simulation tool, will be employed for the simulation work. The first case, which is the one reported in the present paper, is a four-terminal symmetrical system with terminals generating constant-length messages. The design of system models on OPNET has been completed and the preliminary simulation results are described in this paper.

Section 2 gives an introduction for the system model used for the OPNET simulation of D channel access protocol and the preliminary simulation results are presented and discussed in Section 3.

2 OPNET Simulation Model

System models on OPNET are hierarchically structured in such a way that simulations are based on four separate modeling domains: *network, node, process* and *link.* In the simulation models we designed, the network model consists of a transmitting station and a receiving station which are connected by a D channel link. The node model of the transmitting station consists of several *Terminal Equipment* units (TEs) which are connected to a *Network Termination 1* device (NT1). Figure 1 shows the wiring configuration at the transmitting station. The process models for each Terminal Equipment are implemented with the I.430 D- channel access protocol. Two separate message generators produce signalling and packet messages, respectively, for each TE with specified interarrival-time and service-time distributions.

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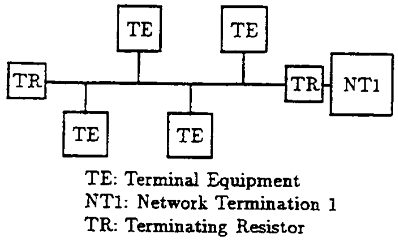

Figure 1: Wiring configuration at the transmitting station.

Our primary interests are the mean delays experienced by signalling and packet messages in queues. This statistic represents the current mean of message waiting times [3]. A new sample of mean-delay is generated as each message is removed from the queue. Multiple simulations with respect to various message arrival rates are executed on this OPNET model. The final mean delay samples which are obtained from each simulation are employed for scalar analysis.

In order to compare our simulation results to the results that Lee and Un predicted, we have made similar assumptions in this preliminary work:

- the number of TE's is four
- the elementary time unit is a D-channel bit time
- each TE generates signalling and packet messages independently, subject to the Poisson distribution process
- A LAPD frame consists of an information field and additional 7-byte overhead field
- the length of the packet information field is 128 bytes and the length of the signalling information field is 9 bytes
- the signalling utilization, ρ_s, is considered up to 0.4 and the packet utilization, ρ_p, is up to 0.9-ρ_s. It is noted that $\rho_i = \lambda_i E(b_i)$, where λ_i denotes the total signalling ($i = s$) or packet ($i = p$) message arrival rate and $E(b_i)$ denotes the corresponding expected service time
- all the signalling messages and all the packet messages have the same service time distributions
- A uniformly distributed random integer ranging from 0 to 255 is assigned to the address field in a LAPD frame after being translated to a natural binary code

Since the binary pattern in the address field of a LAPD frame is assumed to be random, the probability for any TE to get the control of the D channel should be equal if more than one TE with the same priority level message bids at the same instance. According to the D channel access protocol, the mean delay of high-priority messages is expected to be lower than that for low-priority messages under the same traffic conditions. Furthermore, for symmetrical systems, the steady-state mean delay of messages measured from each TE should be approximately the same.

3 Preliminary Simulation Results

Figure 2 shows the mean delays of signalling (Fig. 2(a)) and packet (Fig. 2(b)) messages as a function of packet utilization and signalling utilization in a four-terminal symmetrical system with constant-length messages. The mean delays actually represent the averages of four mean delay values which are measured from the queues in the four TEs respectively. The simulation duration is specified to simulate 20 seconds in real time.

It is observed that part of the mean-delay data collected, especially the mean packet delays, are different than what we expect. The primary reason for this phenomenon is that in those cases, the simulation duration is not long enough for the mean delay to arrive at a steady state. It is seen that the mean delay of messages in queues experiences a significant transient period before arriving at a steady-state value. During the transient period, the mean delay measured will strongly depend on the random number sequence generated during the simulation and the simulation duration.

Figures 3 and 4 show the mean signalling (Fig. 3(a) and Fig. 4(a)) and packet (Fig. 3(b) and Fig. 4(b)) delays in seconds vs. real time in the case of $\rho_s = 0.2$ and $\rho_p = 0.4$ for 20-second and 120-second periods, respectively. It is seen that the mean signalling delay arrives at a steady state quickly so that mean signalling delays observed at the time instances of either 20 seconds or 120 seconds are approximately the same. However, this is not true for the case of mean packet delay. It is noted that extension of the simulation duration produces more reasonable values. For instance, in case of $\rho_s = 0.2$ and $\rho_p = 0.4$ (which have been shown in Figures 3 and 4), the final mean packet delay increases to 776 bits for a 120-second period. In any case, it takes considerable computational time to simulate such a long period on OPNET. Generally speaking, the range of mean delays we obtained from simulation are very close to what Lee and Un predicted in their work.

4 Conclusion

A preliminary performance evaluation of the I.430 D-channel access protocol has been performed and part of the simulation results have been shown in this paper. It is noted that variation of packet or signalling utilization has little influence on mean signalling delay but has a pronounced effect on mean packet delay. The simulation results also show that mean packet delay measured is still in transience. Longer simulation would be necessary for achieving steady-state conclusions. Work is currently proceeding on the more general case of asymmetrical and time-varying traffic loads.

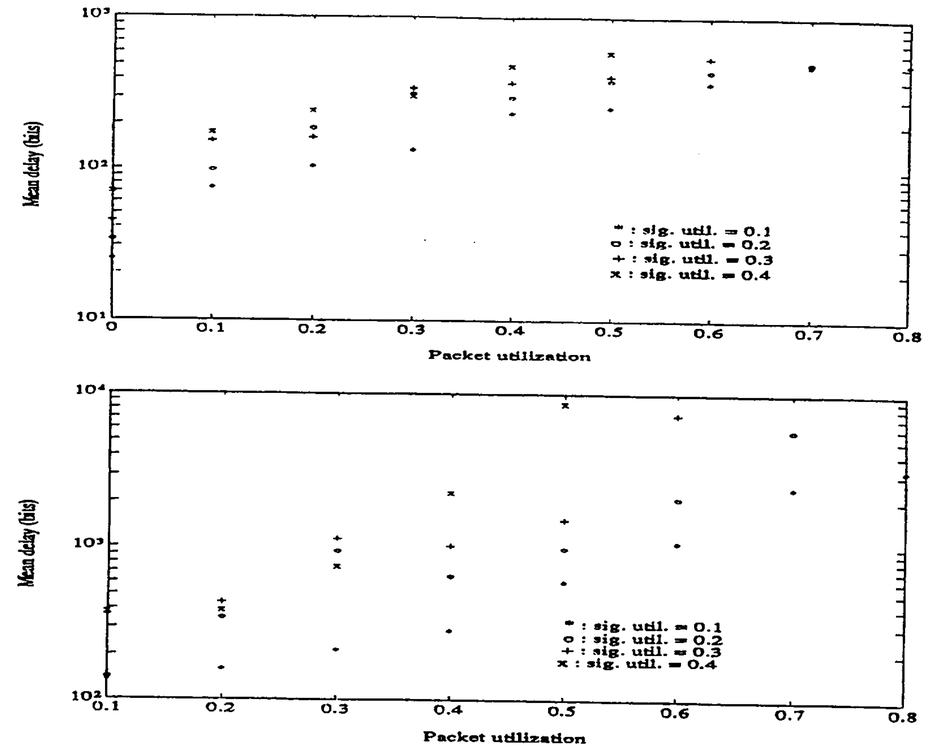

Figure 2: Mean signalling and packet delays vs. packet utilization in a four-terminal symmetrical system with constant message length: (a) mean signalling delay, (b) mean packet delay.

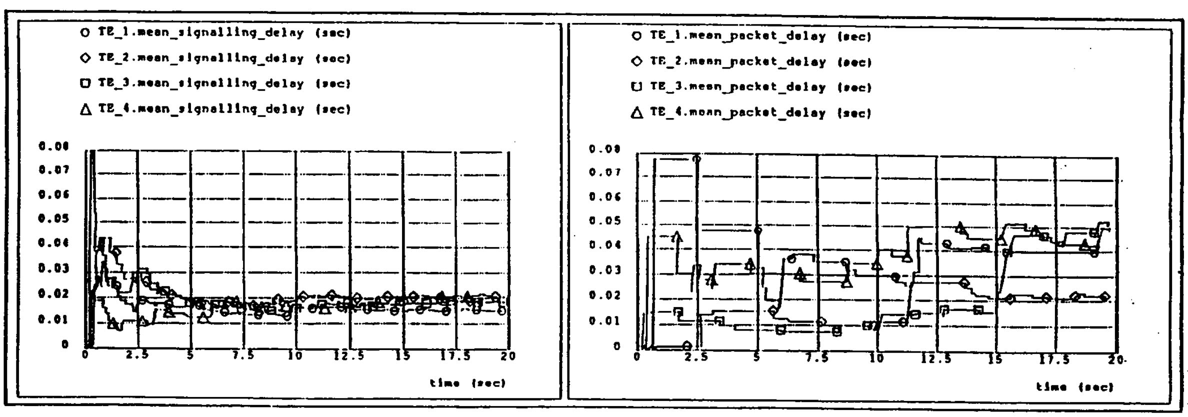

Figure 3: Mean signalling and packet delays vs. time for 20-second period (ρ_s=0.2 and ρ_p=0.4): (a) mean signalling delay, (b) mean packet delay.

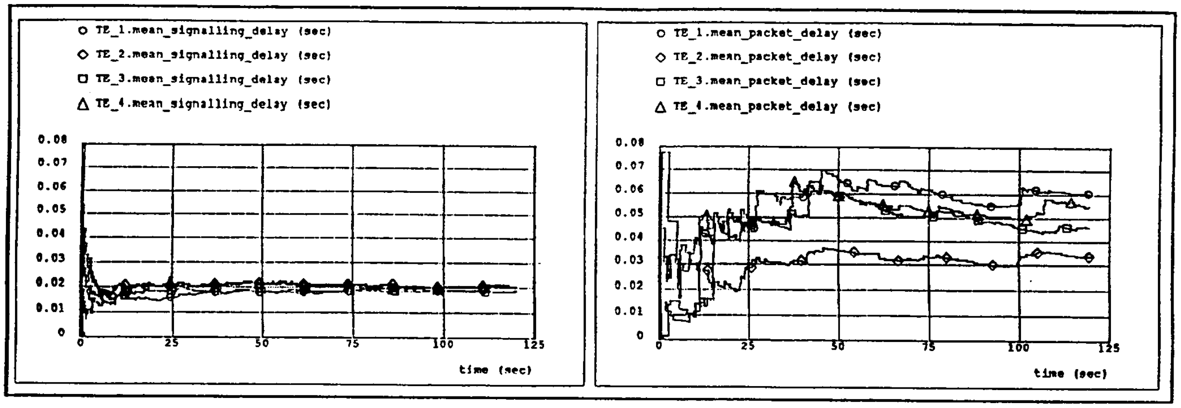

Figure 4: Mean signalling and packet delays vs. time for 120-second period (ρ_s=0.2 and ρ_p=0.4): (a) mean signalling delay, (b) mean packet delay.

References

[1] CCITT Recommendation I.430: ISDN User-Network Interfaces, Layer 1 Recommendations, ITU Red Book, Geneva, 1985.

[2] Goo Yeon LEE & Chong Kwan UN, *Delay Analysis of the ISDN D-channel Access Protocol*, Computer Networks and ISDN Systems 19 (1990) 25-41.

[3] MIL 3, Inc., *OPNET Modeling manual*, 1991.