An Experimental Telecommunications Test Bed

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Abstract—**Although the computer and telecommunications industries have traditionally represented two very different cultures, recent advances in circuit and system technology have blurred many of their past distinctions. A digital system test bed environment has been implemented that not only supports but encourages the use of terminal, switching, and processing capabilities for both computing and communicating.**

One of our major goals was to provide a test bed environment for conducting telecommunications terminal (teleterminal) experiments in the context of work, school, home, and play. Model scenarios for each environment are briefly described. Physically, the experimental environment is a blend of model shop and commercial systems and components. Adaptability and versatility have been given higher priority than manufacturability. The testing of concepts is deemed more relevant than the testing of components. The resulting environment does not model all of the application areas but has provided a wealth of illustrative data and insights that are described in companion papers.

I. INTRODUCTION

MANY of the past distinctions between computer and telecommunications technology have been blurred by the increased application of digital integrated circuit technology to control and transmission within modern telecommunications systems. As Robert Lucky once said,

> "Computers and telephones have been living together too long. It's time they got married."

With this marriage, future telecommunications terminals could retrieve information from computer databases; they could store and retrieve voice messages stored in digital mass memories; they could be used for text editing electronic mail; they could be used for encrypting private messages and files; they would use computer graphics techniques to display advertisements [1], [2]. These are all things that could be provided in the context of the existing telecommunications network.

II. NEW TELECOMMUNICATIONS TECHNOLOGY

At Bell Laboratories, the digital services test bed environment that has been created forms a framework for innovating and evaluating a host of service concepts for both the home and office. The basic hardware components of the test bed are an experimental digital switch (XDS), a commercial multiprocessor minicomputer, and a variety of experimental teleterminals. While many of the initial services would be most useful in an office enviroment (e.g., electronic call memo), many seem particularly relevant to the residential environment as well.

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A. The Experimental Digital Switch

The experimental digital switch (XDS) [3], [4] was designed by C. Christensen and H. G. Alles and built by members of R. W. Lucky's Computer Systems Research Laboratory (see Fig. 1). The unique heart of the XDS system is the intelligent network [5]. Instead of just passing samples through, it can transform data on the fly to provide conferencing, encryption, amplification, padding, and companded to linear sample conversion. In the intelligent network, a two-way voice connection is effected by executing two network processor instructions each sample period that move the incoming sample of one subscriber to the outgoing memory location of the other subscriber and vice-versa. This makes switching a simple series of read and write operations. Each sample received from the subscriber contains eight bits of digitally encoded voice information and eight bits that may be used for either customer or system data. By including appropriate masking operations, the voice part of a sample can be treated completely independently of the data part of the sample. Thus, multiple simultaneous voice and data connections can be supported with ease.

The limiting resource in this network is not voice paths but network processor instructions. Since very low data rate connections require very few instructions per sample period (on the average), costs could be allocated on the basis of bit rate as well as holding time. Thus, a 24 hour data call from a teleterminal could be dealt with economically without overloading the network. This is very important since the traffic characteristics of voice and data calls can differ dramatically.

B. The UNIX[1] System on a NonStop[2] Computer

The UNIX operating system environment [6] has found wide use in a variety of time sharing, word processing, and data processing applications. Until recently, it was only available on single processor computer systems but now has been successfully emulated by D. L. Bayer and A. M. Usas on a nonstop multiprocessor computer system built by the Tandem Computer Company [7].

The Tandem system architecture is designed to tolerate any single system fault without interfering with the user program. This is accomplished by providing redundant hardware that can be configured for the $n + 1$ sparing of any major system component (see Fig. 2). A networking package is available for connecting up to 255 systems of 16 processors each, together into one large distributed computing network.

The UNIX system on Tandem provides many of the word processing, electronic mail, encryption, etc., programs needed to support computer-enhanced telecommunications.

[1] UNIX is an unregistered trademark of Bell Laboratories.
[2] NonStop is a trademark of the Tandem Computer Company.

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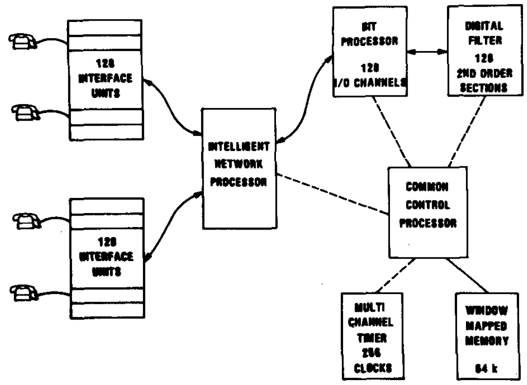

Fig. 1. The experimental digital switch.

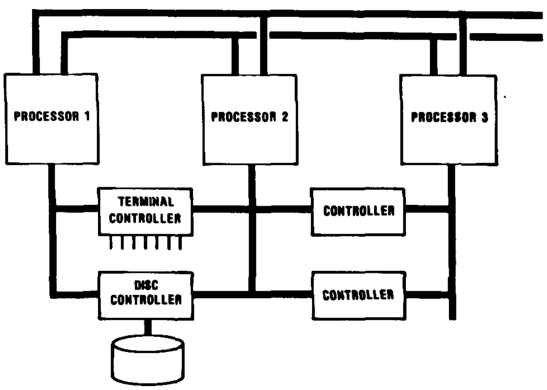

Fig. 2. The Tandem computer system.

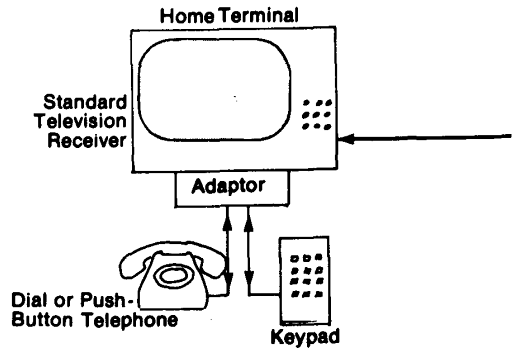

Fig. 3. A videotex terminal configuration.

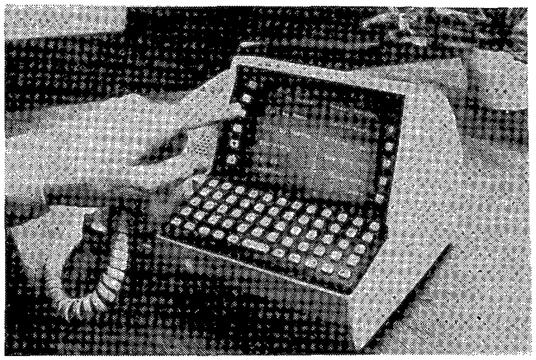

Fig. 4. An integrated teleterminal.

C. Telecommunications Terminals

A variety of model shop and general trade terminals have been considered for our digital services test bed facility. A representative videotex terminal configuration is shown in Fig. 3.

The Prestel system in England [8] currently uses terminals of this type for accessing pages of information stored in a central database that is maintained and administered by the telephone company (i.e., the British Post Office). Thus, the telephone company acts as a common carrier of *pages* of information that are downloaded to the Prestel terminal. Plans for the future include adding local intelligence to the terminal and then downloading computer programs (*telesoftware*) on call as well.

A more integrated experimental teleterminal has been built by Hagelbarger, Thompson, and others [9], [10] (see Fig. 4).

This telecommunications terminal assumes separate data and voice connections. While these connections are logically distinct, they may physically be sharing one common voice circuit to the central office where they will be switched as separate entitles. The cathode ray tube display (CRT) is used as both a general purpose display and for providing relabelable function keys.

For most applications only alphanumeric characters would be displayed but color and graphics capabilities could be provided for high-end terminals.

D. The Human Interface

Human factors elements are being studied that relate to both the users and developers of test bed services [11], [12], [13]. Of critical importance are studies dealing with how people can and will use these services. Are people willing to search through directory trees?

One recurring theme is the importance of providing sets of features that support each other in providing a truly integrated service. Privacy issues are just now starting to look tractable. The task of developing techniques for modifying software quickly and correctly continues to be of critical importance [14], [15].

III. NEW TELECOMMUNICATIONS SERVICES

The new telecommunications services described here could be broadly categorized as computer-enhanced telephony. In most cases, they assume the existence of a home telecommunications terminal, a telephone network that will simultaneously accommodate data and voice, and reliable data storage and processing facilities which appear to be provided from within the telecommunications network. Most of the technology required for implementing these services exists in our test bed enviroment today, but several raise interesting human factors and sociological questions that may be critical to their value and acceptance. In this section, computer-enhanced telecommunications services are discussed in the contexts of work, school, home, and play.

A. Work

Scenario: Harry is an expediter. He makes things happen. He gets things done. If he does not get the right material to the right place at the right time, the assembly line shuts down and everyone knows it is his fault. On the other hand, if he keeps too much material in stock, he ties up too much capital. His effectiveness is largely a function of how well and how quickly he can communicate with several hundred suppliers.

Harry is calling his pal John who works for the Quality Paper Company. He is using an integrated teleterminal with relabelable buttons. First he pushes the button labeled *personal directory,* then *suppliers,* then *Quality Paper,* then *John.* By pushing the appropriate buttons, Harry was able to place a call to John by just traversing his personal directory tree. The sequence of frames that appears on his teleterminal is represented schematically in Fig. 5. While the telephone is ringing, the *personal assistant* node (shown as the first frame of Fig. 6) comes up on the screen automatically.

Unfortunately John has "stepped away from his desk" so Harry will have to "try again later." But Harry does not like to play that game so he leaves John a *call memo.* He pushes the *send call memo* button, checks off the boxes for *called* and *please call,* then types in the message "IMPORTANT!" Alternatively he could have pushed *send voice message* and recorded a voice message for later delivery.

Later, John returns to his office and notes that there is a *message waiting* (see Fig. 7). He pushes his *read message* button, selects *Harry's* message, and finally, by pushing the *make call button,* he returns the call.

Note that neither Harry nor John ever had to know each others phone number. John's number was stored in Harry's personal directory and Harry's number was automatically left for John along with the *call memo.*

John and Harry are finally connected in a critically important voice conversation. Harry asks, "Who's driving for bowling tonight?"

System Issues: When Harry first went to make a call he merely pushed a button and started traversing his directory tree [9]. His voice line was not in use, but one of his data lines had been up since he logged in last Monday. Note also that Harry's personal directory had to be stored on a computer database. The delivery of the *call memo* implies either common access to a central computer or computer-to-computer communication initiated at Harry's request. Notice that it would have been just as convenient for Harry to send a voice message as a text memo. This implies that some sort of voice storage system (VSS) is available [16].

B. School

Scenario: Mary is working toward her Master's degree in business administration. She has just completed a self-paced programmed learning sequence on sociological problems that influence work performance. During the past several weeks she has worked her way through the programmed text using her teleterminal. Each chapter of the course included an on-line quiz that automatically directed her back through previously studied material or advanced her to new material as appropriate (see Fig. 8).

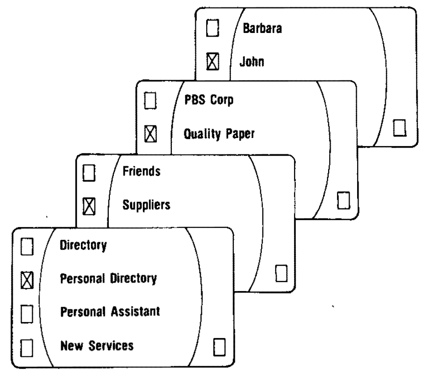

Fig. 5. Harry's personal directory.

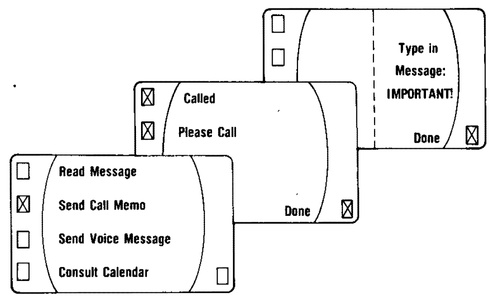

Fig. 6. Harry leaves a message.

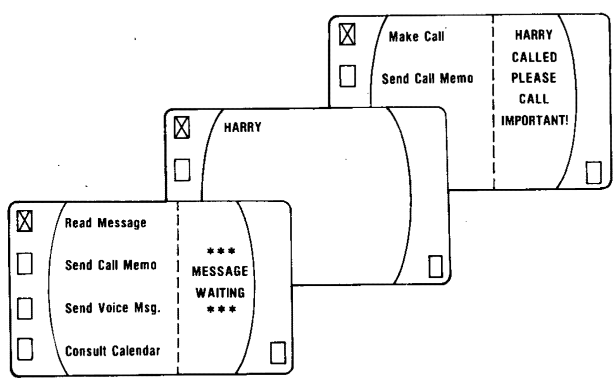

Fig. 7. John returns Harry's call.

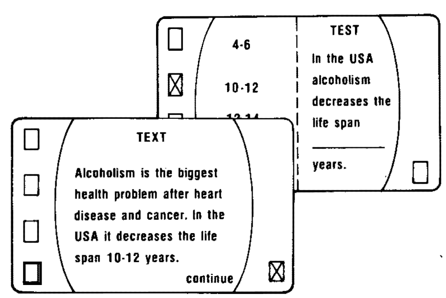

Fig. 8. Programmed learning session.

System Issues: The on-line library of programmed learning courses and reference material is clearly something Mary wants to access but doesn't want to maintain. One shared database that could interface with a variety of different teleterminals would be very desirable here. Since much of the information may be generated, updated, and accessed from different regions of the country, a geographically distributed implementation may be desirable.

C. Home

Scenario: Mrs. Brown is very interested in services that can save her time. As we look in, Mrs. Brown has just done her menu planning for the week using a modular teleterminal that uses her kitchen TV set as the display device. The *food service* program that she used [17] consults both her private file of recipes and a listing of nutritionally balanced recipes supplied by the state university home economics extension service (see Fig. 9).

She has selected recipes that meet the salt free dietary constraints of her husband and provide the nutritional needs of her growing teenage son.

At the end of the menu planning session, the *food service* program automatically forms a shopping list of items that she will need during the next week.

System Issues: The food service program used by Mrs. Brown uses both a personal database of her own favorite recipes plus a public database provided by an information provider. Any given meal may include entries from both sources so they should have a consistent and convenient user interface. Presumably, a fee could be charged for accessing the recipes provided by the extension service.

Finding the calorie count and nutritional value of each food item is conveniently delegated to the computer during the selection process. It can recommend portion sizes for each family member or can recommend substitutions based on historical preferences.

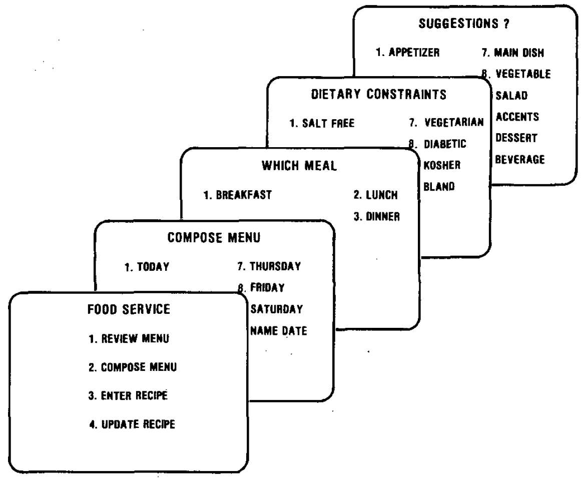

Fig. 9. Food service.

D. Play

Scenario: John Smith and his son Junior have gone all out in obtaining the latest and most elaborate telecommunications terminals money can buy for their game room. For starters, there is a small color bridge terminal with graphic output and touch screen input. This sounds nice, but it is nothing compared to the great American dream machine sitting in the corner.

Tonight John dials into *gamenet* [18] and is soon involved in a game of duplicate bridge with a fellow from Detroit and two women from Cleveland. The matching shows a small spread in national master points so it promises to be an exciting game. Since duplicate bridge can be serious business, the conference voice circuit connection is only put up between hands for the post mortem analyses. This voice conference connection gives you a chance to explain to your partner why you opened one club on a hand that 95 percent of the other players opened with two spades. Fortunately, this talk all ends when the dealer pushes the *next hand* button. Only the data conference connection stays up during the play.

Meanwhile, Junior is plugged into the great American dream machine. It has a 5 foot by 8 foot screen, stereoscopic vision, and quadraphonic sound. Tonight he is off exploring with his space buddy Joey who lives in Seattle. Junior is flying a nice sleek Starfire 7 spaceship (see Fig. 10).

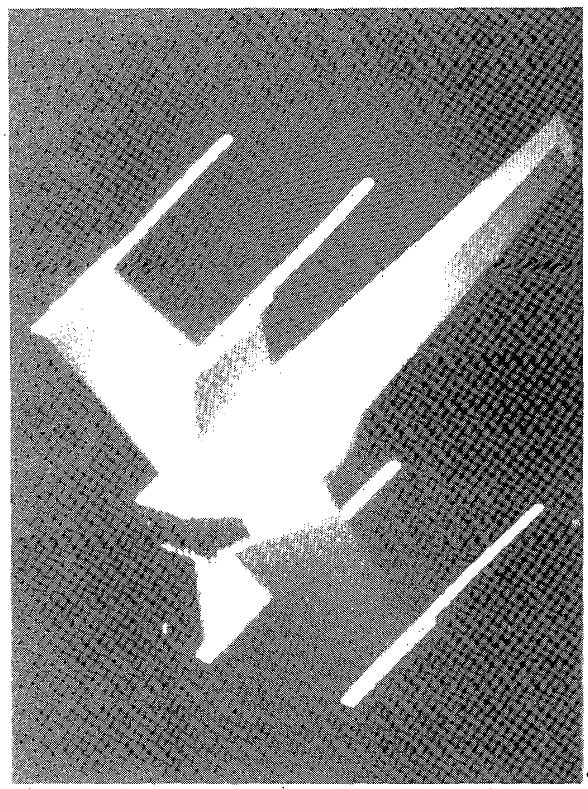

Fig. 10. Junior's Starfire 7 spaceship.

Suddenly he is caught in a space warp that blocks his vision and damages his instruments. He seems doomed but Joey miraculously talks him through it to the relief of one and all.

System Issues: Entertainment is one of the most likely reasons families will purchase a teleterminal in the first place. Apparently, the most heavily used services offered by the

Prestel information providers, thus far, are their games, even though they are confined to those that can be supported by calling up new pages of preformated information. The addition of processing power plus being able to play against real people, instead of just computers, would seem to be much more exciting.

By tearing down the voice connection during the duplicate bridge play, inadvertent signals between partners would be omitted and the telecommunications costs could be reduced substantially if the network supported low data rate connections.

Bridge is classified as an *I move you move* game [19], meaning that response time requirements do not influence the outcome of the game. Junior's space exploration game is quite the opposite. It is classified as a *simultaneous action* game and as such the response time of his terminal and the response time of the computer mediating this game can influence the outcome. Many of these problems are best solved by providing most of the *compute-power* locally while minimizing the amount of data which must pass over the network [20].

IV. CONCLUSIONS

Most of the technology for providing computer-enhanced telecommunications services for work, school, home, and play is rapidly becoming a reality. Early indications from the Prestel system in England are that the things they are least well suited to provide (games) are selling the best. In France, an electronic directory service is being planned which could eliminate the need for printing and distributing phone books. In this country Knight-Ridder and AT&T are cooperating in a trial where the newspaper provides the information and the telephone company delivers it—electronically.

In the scenarios discussed, a number of technology themes kept recurring. They were the need for concurrent data and voice paths charged for by the bit, the need for a network of computer systems which approach the reliability and availability requirements of current communications systems, the need for a variety of telecommunication terminal options, and, most important of all, the need for a good human interface.

ACKNOWLEDGMENT

Many of the ideas presented here were distilled from the thoughts and inputs of other people. Of particular note are the thoughts and philosophy of R. A. Thompson, R. D. Gordon, D. W. Hagelbarger, and P. S. Kubik regarding teleterminal services in general, plus inputs provided by R. W. Lucky and H. G. Alles on multiplayer game networks.

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