Using the home TV screen, videotex networks can provide easy, inexpensive access to vast amounts of information. Here, we consider planned and possible network structures.

Videotex Networks

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The service for which the word "videotex" was originally coined is essentially a low-cost public data or information retrieval service. Since success depended on rapid public acceptance and quick market penetration, simplicity and economy were the principal design objectives of the first-generation systems.[1] Generally, they were tree-structured, single data base, menu-based systems using modified TV sets as terminals. Their basic technology, principles, and projections are discussed at length in *The Viewdata Revolution* by Fedida and Malik.[2]

Now, following some operational and field-trial experience with England's Prestel and other systems, second-generation systems are being planned and discussed, and viable videotex services are rapidly evolving into public information utilities. These utilities will offer a variety of information services and transactions, such as retrieval from multiple independent data bases, messaging, electronic mail, conferencing, banking, teleshopping, and interest matching. In second-generation systems the emphasis is more on videotex as a communication medium rather than as a simple information retrieval system. Future systems will move toward two-way communication among users as well as between users and information providers.

The trend toward public information utilities is also apparent in two parallel developments: the emergence of home computer networks[3] and proposals for integrated broadband distribution systems[4,5] carrying various information traffic such as digital telephony, video, videotex, alarm, and metering services to/from subscribers.

In June 1980, a workshop held at the Département d'Informatique et de Recherche Opérationnelle, Université de Montréal, assessed videotex development in different countries and explored technological trends. This article reflects workshop results in the area of videotex network structures; other works deal with data base structures and information providers.[6,7]

Here, we consider both planned and possible videotex network structures. We use the term "videotex network" to stand for the overall system, including not only the means of communication but also the user terminals and the hardware/software of the computer systems providing the services. In the following sections, we introduce videotex network components and describe existing and planned network structures, ranging from simple star-like configurations to sophisticated ones involving distributed processing. Then, we discuss design issues and present a tentative generic structure for future videotex networks.

To facilitate comparison of some typical network models which have been—or soon will be—implemented, all diagrams use the set of symbols and acronyms defined in Figure 1. The sites of some typical network functions (such as accounting) are also shown in the network diagrams.

Network components

Before considering particular networks, let's review the main functions and physical components found in videotex networks.

User terminals. The user terminal is the equipment at the subscriber's home or office. A typical videotex UT is connected to a communication medium, uses a conventional TV set for display, and has a keypad for selecting the desired information or service. The terminal provides a basic character-oriented display mode (alphamosaic coding), and in some systems more advanced capabilities

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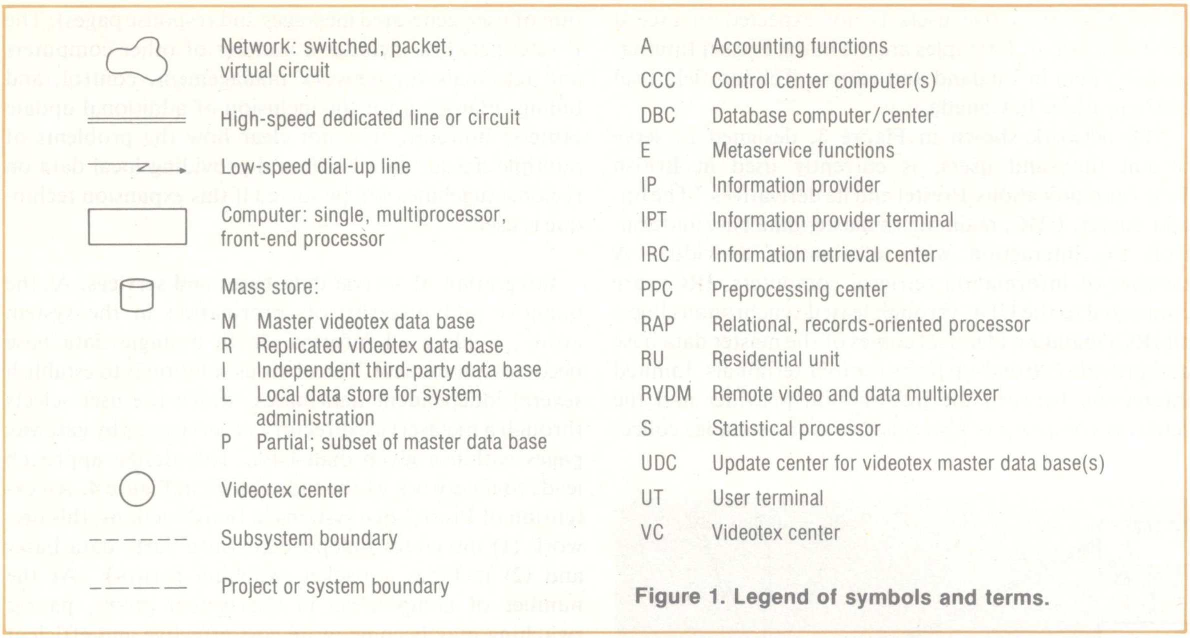

Figure 1. Legend of symbols and terms.

such as graphic (alphageometric) and photographic modes. A variety of extensions of this basic videotex terminal can be foreseen, ranging from the replacement of the pad by a standard alphanumeric keyboard to the addition of home computers, hard-copy printers, alarm detectors, etc.

Services. A subsystem of the videotex network which provides a particular service to the user is called a service. The main videotex service is information retrieval, but others, such as electronic mail and transactions, may also be accessible. A service is usually implemented on one or several computer systems and/or data bases, which we consider to be part of the videotex network. Conversely, a given computer system or data base may be involved in the implementation of several services.

Communication media. Components of the videotex network are connected by communication media. For communication with the user terminal, different media—broadcast or cable TV, the telephone system, or integrated service networks based on cables or optical fibers—can be used. For communication among other network components, general-purpose media are employed—for example, dedicated or switched circuits, satellite links, or packet-switched data networks.

Information provider terminals. A user terminal is the instrument of the consumer; the information provider terminal is the equipment used by the information provider to prepare and maintain the information available in the videotex network. IPTs range from simple character-oriented interactive terminals with editing functions provided in the data base computers, through special-purpose terminals for picture editing with local storage, to general-purpose computer systems.

Videotex centers. Also called concentrators, videotex interface machines, videotex switches, or local access, videotex centers are gaining importance as sites of local intelligence where network size and complexity require distributed functions. VCs provide the effective interface between the network and user terminals. Minimal functions include line control, terminal handling, echoing; error detection; code translation; log-in, user identification; concentration; some of the accounting and statistics; and a directory of available services called *metaservice*[1].

Existing and planned videotex networks

Networks with centralized data base(s). Figure 2 shows the simplest possible videotex configuration, consisting of a single computer with a centralized data base. All user and information provider terminals are connected directly to the central computer complex through dedicated or dial-up telephone connections, but similar systems could be implemented using two-way cable. The obvious disadvantages of this system are the cost of connections over longer distances and the performance bottlenecks which quickly develop for line handling and data base access. Such configurations are typically used in situations where

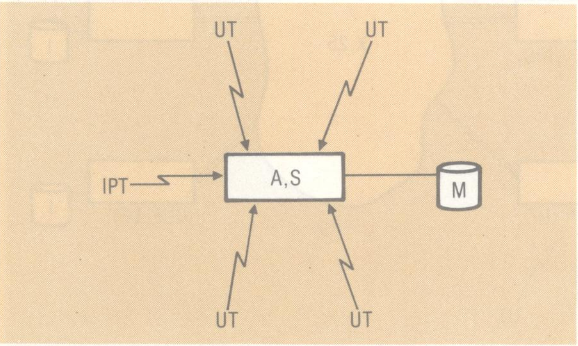

Figure 2. Simplest Videotex system.

the number of active users is not expected to exceed several hundred. Examples are the initial Prestel International system in England and various Telidon field-trial configurations in Canada.

The network shown in Figure 3, designed to serve several thousand users, is currently used in British Telecommunications' Prestel and its derivatives.[8] The update center, UDC, maintains a master data base and controls the interaction with information providers. A number of information retrieval computers, IRCs, are connected to the UDC through leased synchronous lines; all IRCs maintain identical copies of the master data base and provide 200 dial-up ports for user terminals. Limited interaction between the information provider and the retrieval computer is also possible (for example, collection of user-generated messages and response pages). The Prestel network includes a number of other computers and terminals for network management, control, and billing. Plans call for the inclusion of additional update centers; however, it is not clear how the problems of multiple master data bases and providing local data on regional machines will be solved if this expansion technique is used.

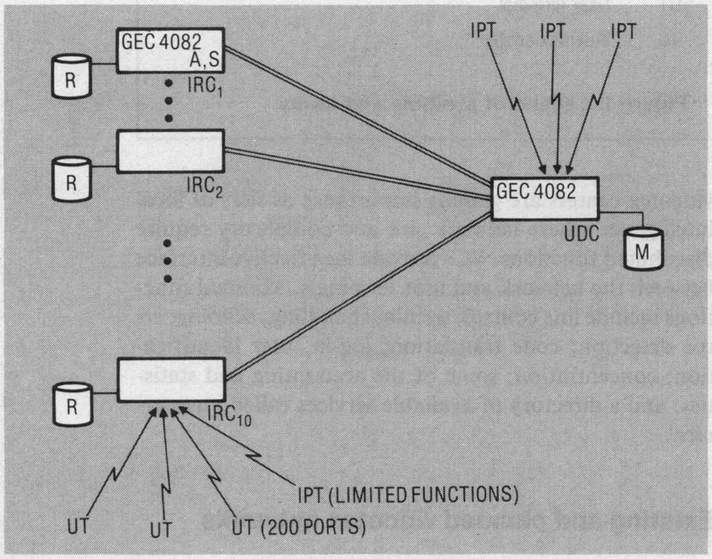

Figure 3. Prestel and derivative systems.

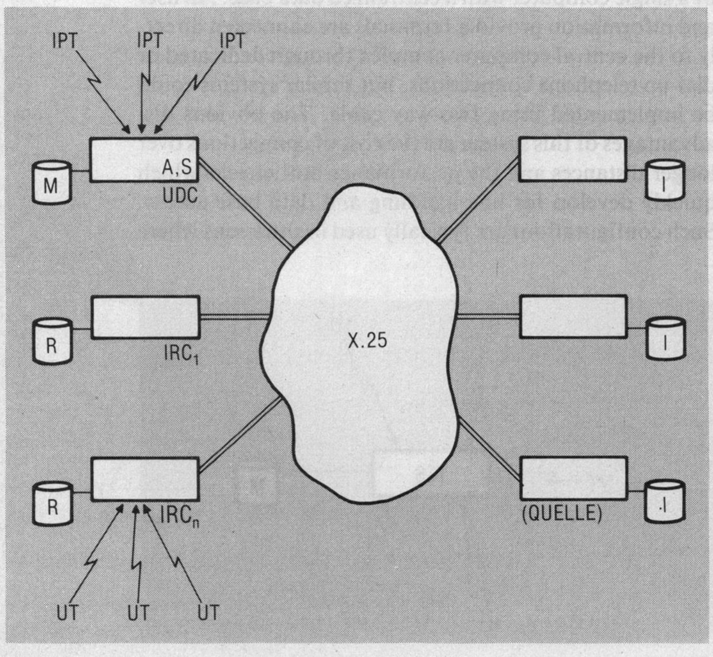

Figure 4. Videotex and external data bases.

Integration of several data bases and services. As the quantity and diversity of information in the system grows, holding all information in a single data base becomes impractical. The obvious solution is to establish several independent data bases, which the user selects through a metaservice directory of services or by gateway pages within a given data base. This design approach leads to a network of the type shown in Figure 4. An extension of Prestel-like systems in two directions, this network (1) integrates independent third-party data bases and (2) includes a packet-switching network. As the number of components in the system grows, packet switching may become more cost-effective and efficient than dedicated point-to-point links.

At least two such systems are currently planned, Bildschirmtext[9] in Germany and a field trial at Velizy, France.[10] Both systems, much like Prestel, have several videotex retrieval computers with replicated data bases and one update center. (The published material on Bildschirmtext, however, is not clear about the existence of an update center.)

Independent third-party data bases and possibly other services may also be accessed by the user. Such services are implemented on external computers connected to the public data network. An example of such a service is the catalog-lookup and order processing offered by the Quelle department store in Germany. Another example is a planned link between Germany's Bildschirmtext and Prestel.

In the networks discussed above, all network functions are performed in a single computer (possibly enhanced with front-end computers). Figure 5 shows the structure used by the French Antiope system,[11,12] where network functions are distributed. Users are connected through switched (dial-up) telephone lines to videotex centers, which handle interface functions for the user. The videotex centers, videotex data bases (e.g., Star systems[12]), the update computer with the videotex master data base, and independent third-party data bases are all connected through the Transpac public data network. Another type of data base for broadcast videotex (called Didon in the French system) is also connected to and accessible through the same network.

Multiservice integrated networks. Although highly sophisticated, the network in Figure 5 is a special-purpose structure designed to deliver a relatively narrow class of digital information services to business or home users. A more general network architecture, the Omnitel system shown in Figure 6 and described by Coyne,[4] will distribute a much larger class of information services through a single communication medium—initially two-way cable, later optical fibers. Services will include digital telephony, digital data transmission, videotex, teletext, cable TV, pay TV, switched video, meter readings, alarms, and polling. Such integrated broadband systems are especially feasible in North America, where CATV cable systems have widespread penetration. One, the Omnitel system, will be used in a field trial in Manitoba, Canada (Project Ida).

Although this type of network is necessarily designed with different optimization criteria than a purely digital videotex network, it incorporates several features that might be applicable in less generalized systems.

The backbone of the Omnitel system is a two-level coaxial cable distribution structure (shown as a switched-cable network in Figure 6). The cable's 300-MHz band is split and dynamically allocated to different users and services. Generally, downstream transmission is between 50 and 300 MHz, upstream between 5 and 30 MHz. Most of the bandwidth is consumed by the analog video services; digital transmission for approximately 300 homes is carried on eight 1.5 megabit-per-second channels. Since these channels are time-multiplexed among different services to different subscribers, the digital portion of the system is in effect a packet switching subnetwork.

In addition to two levels of intelligent control within the cable system (not shown in the figure), there is one more level of concentration between the cable network and the residential units. These concentrators, called remote video and data multiplexers or RVDMs, are partly analogous to videotex centers and are typically shared by 12 subscribers. Besides controlling data concentration, packet addressing, and similar communication functions, RVDMs contain videotex display generators. These are time-shared by 12 subscribers, which allows for a very low cost, "dumb" user terminal; only a TV set and keypad are required. A microprocessor-based residential unit interfaces the RVDM to the keypad, sensors, alarms, etc. The RU polls all devices for signals and distributes returning responses to the appropriate device(s) inside the residence.

The cable network described above is controlled by a minicomputer control center and communicates with the telephone network, public data networks, videotex, and independent data bases as shown in Figures 4 and 5.

Design issues

Data distribution. The merits of the two extreme solutions—complete duplication of all data in each data base vs. partial data bases at different sites—are frequently discussed in the literature.[13] For videotex applications, we can distinguish the three reasons for data bases with partial information:

(1) Information providers could provide access to a particular kind of information in independent third-party data bases. In some cases, the data base would exist for purposes unrelated to the videotex application.

(2) Some information providers might prefer to manage their own data base instead of storing information in the communication carrier's main videotex data base. Small IPs could store their information in independent

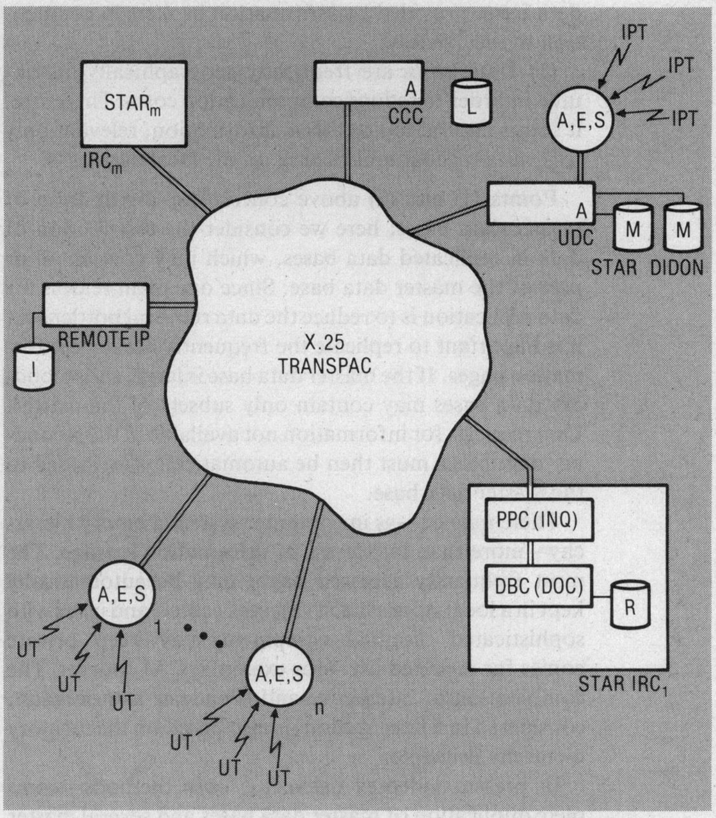

Figure 5. Distributed Videotex system used in Antiope.

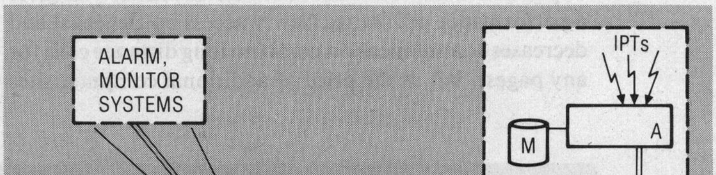

Figure 6. A multiservice, distributed processing system such as Omnitel.

data bases provided by information brokers in competition to the carriers.

(3) Data bases are frequently geographically distributed in order to reduce communication costs. Therefore, it seems natural to keep local information, relevant only to a certain geographical area, in the local data base.

Points (1) and (2) above concern the distribution of master data bases; here we consider the distribution of data in replicated data bases, which may contain all or part of the master data base. Since one main reason for data replication is to reduce the data retrieval bottleneck, it is important to replicate the frequently accessed information pages. If the master data base is large, the secondary data bases may contain only subsets of the master. User requests for information not available in the secondary data bases must then be automatically forwarded to the master data base.

There may be—as in computer system memory hierarchy—more than two levels of information storage. The most frequently accessed pages may be automatically kept in a local store at each videotex center, and users with sophisticated terminal equipment may keep private copies for repeated use—for example, CAI courses. The combination of interactive and broadcast transmission, considered in a later section, is also based on the memory hierarchy principle.

In present videotex networks, both methods—complete duplication of master data bases and several master data bases together with partial (non-overlapping) information—are used. In Prestel, for example, all data are duplicated in each information retrieval center. This gives a performance advantage (fewer access bottlenecks) and decreases communication costs (no long distance calls for any pages), but at the price of additional computer sites and some difficulties in simultaneous updating. Due to update scheduling, temporary inconsistencies are a potential problem in such applications as stock market listings and sports results (betting, etc.). Architectures like Antiope, on the other hand, permit greater flexibility since the contents of each constituent data base (Star) can be independently defined (i.e., contain a subset of the available services).

Directories and transparency. Partially overlapping data bases together with independent third-party data bases require some kind of metaservice directory[1] to guide the user to the desired service or application. In Antiope, directories are implemented in the videotex centers.

A related issue is whether or not the distribution of information into several data bases should be visible to the user. Both possiblities seem applicable: when logically related information is partitioned into several data bases with similar retrieval procedures, the user should not be aware of transitions between partitions (an example is given in Bochmann and Gecsei[14]); on the other hand, he should be permitted to choose between logically distinct applications or different versions of the same service. Ideally, the user should see the logical but not the physical aspects of data distribution, provided no user charges are associated with the physical distribution.

The two approaches can be combined. For example, in Bildschirmtext (Figure 4) the videotex data base contains gateway pages which transfer the user into a specific application on another data base. Although transfer is automatic in the sense that the user does not log-in to the new database, it is not transparent—the user is notified of the transfer.

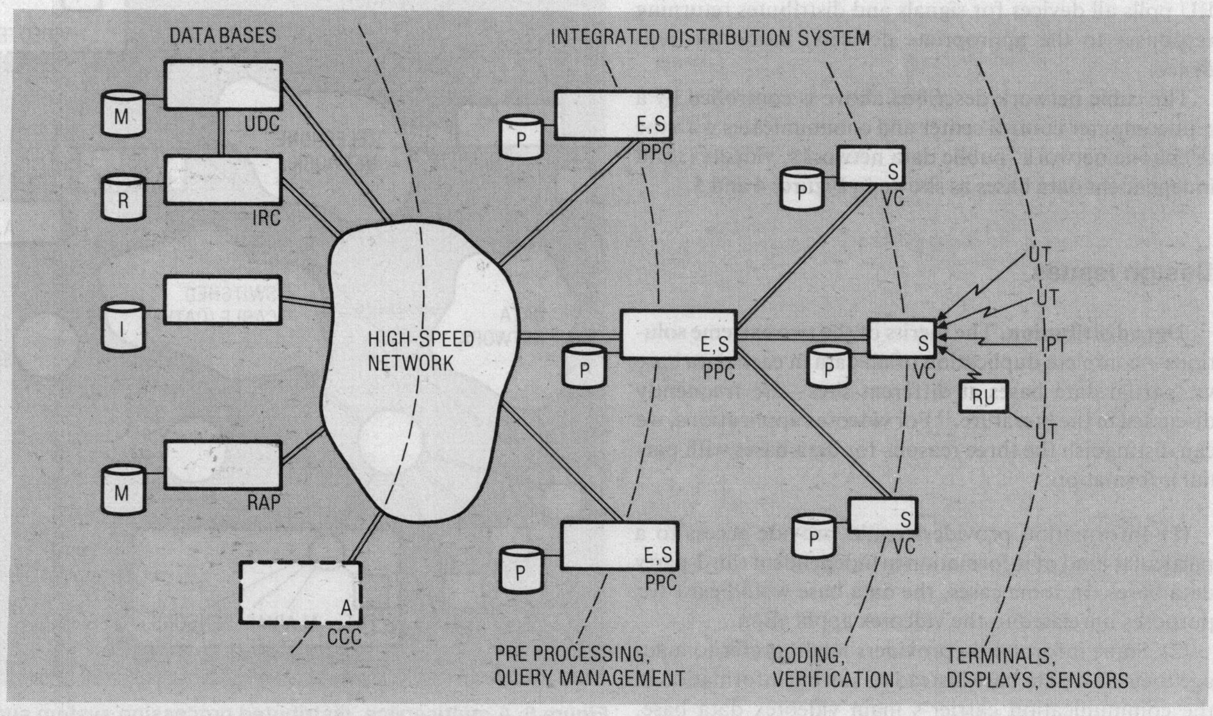

Figure 7. Generic Videotex system.

The role of videotex centers. Basically, VCs act as concentrators that save communication costs and provide the interface to user terminals. With the growth and decentralization of videotex systems, their intelligence and importance will inevitably increase. Additional functions naturally fitting into the VC include

(1) *Metaservices.* The VC could provide a directory of available services and applications, HELP commands, user advice, and automatic routing of calls.[12]

(2) *Virtual terminal standardization.* To simplify the interworking of several independent services with different types of home terminals, the VC might present a standard virtual terminal protocol to the different network services, independent of the particular home terminal. Functions to be considered include code conversion, page formatting, form display, and data entry (especially for transaction-oriented applications).

(3) *Access and control.* VC functions could include log-in, user identification, access control accounting functions, and possibly encryption.

(4) *Storage management.* Down-loading and local mass storage of frequently accessed data from distant data bases are functions that could be activated by the user (e.g., for a CAI course) or by the system management (e.g., for recent football information).

(5) *Software.* As an intermediate form of telesoftware,[3] the VC could execute software supplied by service providers.

(6) *Personal computing.* Making the VC a substitute for a sophisticated personal computer raises many interesting possibilities—economic program development, personal file keeping, maintenance of user-specific directories, labels, and profiles—for satisfying personal data-retrieval needs.

Technically, the last three features are equally feasible in intelligent user terminals. However, from a cost-effectiveness (and thus user-acceptance) point of view, sharing such advanced facilities in a common VC might be a better solution. An example of this approach is the RVDM in Omnitel, where videotex display generators and memories are shared by 12 subscribers. Similar assumptions underly an experiment by a Montreal cable company[15] in which Apple-II computers at the cable head are shared by users playing interactive TV games.

Transaction-oriented retrieval. In most existing videotex data bases, the system must keep dynamic status information about the progress of a retrieval session. This *user-context* information contains items such as traces of previous index choices and billing and statistical information. Context-keeping becomes a burden when many active users have long sessions, and it can be further complicated when there are transfers to other services within a session.

A solution to such problems would be to keep all context pertaining to a user session in the corresponding videotex center or a preprocessing center (see Figure 7); interactions between such centers and data-base computers would be in terms of simple transactions (such as a page request). The data-base computers would not need to keep traces of such transactions; the VC would handle user-related accounting, updating CCC files at the end of a session. This solution would also help protect the user's privacy since VC records could be erased once the CCC was updated with aggregate data.

Furthermore, transaction-based retrieval would make it easier to access data bases with conventional record-oriented file structures. It would also simplify adaptation of existing data-base systems with different query languages. Imagine, for example, a large videotex data base with a sophisticated subject index that is actually a relational data base running on a separate specialized host (see Figure 7).

Combining transmission channels. Another use of VCs would be in a system employing both interactive and broadcast transmission of a large page-oriented videotex data base. The most frequently requested subset of pages would be transmitted in a broadcast cycle (e.g., on a full TV channel, readily available in most CATV systems); only those pages not actually in the broadcast cycle would be interactively accessed from the data base. This would alleviate some serious access bottlenecks. To keep the system flexible, the content of the broadcast cycle should be allowed to change dynamically in response to user access patterns. A suitably coded index of the cycle's current content would be periodically broadcast and stored in each VC. User requests for new pages would be examined in the VC and forwarded to the data base for selective retrieval only if the page is not found in the index. A similar "request intercepting" mechanism could be used in cases where information is stored locally in the VC. All such processing should be hidden from the user, who would have the impression of working with a single logical data base.

Future network structure

The foregoing discussion leads us to conclude that future videotex systems will have distributed architectures similar to the one shown in Figure 7.

Information providers, user terminals, and residential units will be connected to an integrated local-information distribution system through videotex centers. This distribution system will provide access to a variety of services, including videotex, via a high-speed data network.

Services will be provided by a number of computers operating in transaction mode and dedicated to specific tasks such as page retrieval, messaging, mail, and financial transactions.

A query from an individual user will be processed by a videotex center(s) or larger preprocessing center(s), which will transform the query, route it via the high-speed network to the appropriate service computer, receive the reply, and return the requested information or service to the user.

Although considerable development work remains to be done, the basic skeleton of such systems is visible in both the Antiope and Omnitel implementations. ■

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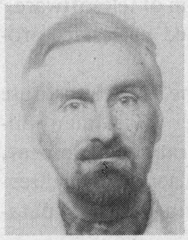

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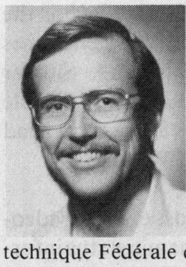

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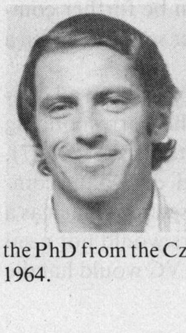

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