Image system communications

by H. M. Morris
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This paper discusses the communication requirements to support the IBM ImagePlus™ system. The analysis and approach discussed are based on the experience gained in installing the initial ImagePlus systems at several business enterprises.

Image processing brings with it a number of unique communications engineering requirements. The key factor driving these requirements is the large record sizes (typically tens of thousands of bytes) associated with digitized images. The movement of image objects through a communications network requires planning and appropriate selection of system components and operating parameters. This paper describes a communications system to support ImagePlus™, IBM's operational image system. The challenge to the designers of ImagePlus is to move these large image objects through a data processing complex efficiently with acceptable response times, without adversely affecting overall system performance.

The analysis and design approaches presented were developed to support the first IBM ImagePlus installations at USAA (United Services Automobile Association) and Lincoln National Corporation for the MVS/ESA™ system, and Citibank for the AS/400™ system. The concepts have been validated and refined based on the experience gained during those initial system implementations, and are typically included as part of the ImagePlus installation planning process.

This paper presents an overview of ImagePlus operations and a description of the communications subsystem components, with emphasis on design considerations imposed by the data flows from the Multiple Virtual Storage/Enterprise Systems Architecture (MVS/ESA) and Application System/400® (AS/400) system hosts to and from the token-ring-attached IBM Personal System/2® (PS/2®) image workstations. (Early ImagePlus installations used IBM Personal Computer AT® [PC-AT] Model 339s as the base for the image workstation. Some are still in use, but they are no longer generally available and therefore will not be addressed in this paper.)

Use of the Systems Network Architecture (SNA) standards, Mixed Object Document Content Architecture (MO:DCA), Image Object Content Architecture (IOCA), and Presentation Text Object Content Architecture (PTOCA) for enveloping image objects is described, as is the implementation of Logical Unit 6.2 (LU 6.2) communications between the workstations and the host for the movement of image objects through the system. The communications requirements associated with the implementation of ImagePlus in a geographically distributed environment are also discussed.

Operational overview

The operating concept of IBM's ImagePlus system is depicted in Figure 1. Document images are captured in digitized bit map form by different types of scanning devices. The electronic images are then processed by an IBM PS/2 workstation which compresses each image using industry-standard algorithms (International Telegraph and Telephone Consultative Committee [CCITT], Group 4 or Modified Modified READ [MMR]). The resulting compressed image is known as an "object." The compressed image of each page is prepared for transmittal to the image system host by *wrapping* it in an Image Object Content Architecture (IOCA) envelope, consisting of header and trailer fields around the object itself.

IBM's PS/2 image workstation processes all image compression and decompression tasks.

When the last page of a document has been scanned, the collection of IOCA-wrapped page images is put in a document-level wrapper called a Mixed Object Document Content Architecture (MO:DCA) envelope, which adds header and trailer fields at the beginning and end of the document. The MO:DCA package then has Systems Network Architecture (SNA) header and trailer records added (see Figure 2). Using a Logical Unit 6.2 (LU 6.2) session with the ImagePlus host, the document object is then transmitted across the token-ring local area network to the host, where it is stored. For retrievals, the process is reversed to send objects from the host to the image workstation for display and print.

IBM's PS/2 image workstation processes all image compression and decompression tasks. Incoming images are compressed to provide resolutions of 100 and 200 picture elements, or pels, per inch (ppi). A single-spaced 8.5- by 11-inch typewritten page will compress to approximately 25 000 bytes at 100 ppi, or around 50 000 bytes at 200 ppi.

IBM offers users of the ImagePlus MVS/ESA system their choice of whether to send either or both of the 100- and 200-ppi objects to the host for storage. The ImagePlus AS/400 system stores 200-ppi objects exclusively. (All ImagePlus users to date keep the 200-ppi objects for their permanent files, which are retained on optical disk. Document images of 200 ppi have been accepted by courts of law as valid substitutes for the original documents.)

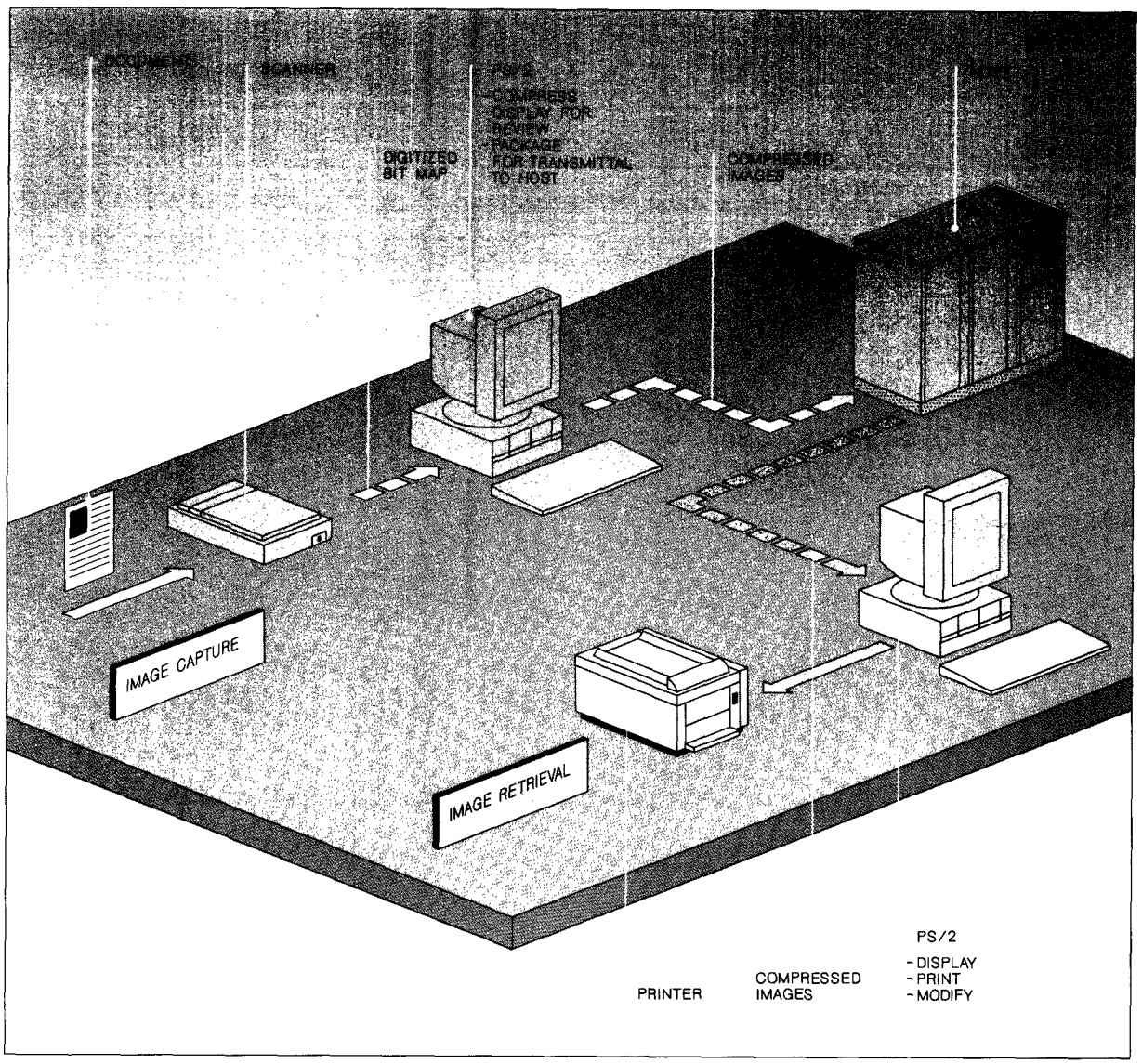
Some MVS/ESA users have opted to keep their most active files on a direct access storage device (DASD) at 100 ppi, to speed the retrieval time. This means sending both the 100- and 200-ppi images from the workstation to the host, which for a typical page will require transmitting approximately 75 000 bytes through the network.

Other users work with 200-ppi images exclusively, preferring to gain higher initial throughput rates at scanning and storage time since only two-thirds as many bytes (50 000 vs 75 000 per page) must be shipped from the workstation to the host when the document is captured. This is just one of many considerations that affect the design of the image system communications network.

Planning assumptions. The first key activity for the communications engineer is to study how the image system will be used in a particular application and to determine an accurate profile of that use. Daily average and peak input and retrieval volumes must be estimated for each type of document. Detailed information on the attributes of each document type is required. Such attributes include average and maximum number of pages, number of retrievals in the first 30, 60, and 90 days after capture, retention period, annual compound volume growth rate, etc. Other required information includes number of shifts per work day and number of productive hours per shift.

Representative examples of the actual documents should be obtained and scanned to develop a more precise measurement of the compressed size for each document type. Although the authors have found 50 kilobytes (50 KB) per 200-ppi page to be a good rule of thumb for rough estimating, in actual practice the number of bytes can range from less than half to more than twice that figure, depending on how "busy" the document is. Large continuous areas of white or black space enable the compression algorithm to work more efficiently, whereas just the opposite is true for pages with much fine print, scrollwork, etc.

Figure 1 ImagePlus operating concept



This early sizing activity is extremely important. The derived numbers will determine DASD and optical storage requirements, and the communications resources and configurations. If the customer has specified service level requirements for document storage and retrieval times, this analysis should provide the basis for determining if those performance parameters are readily attainable.

One additional consideration that affects the communication volume calculations occurs if the customer intends to store computer-generated data, also known as coded data, along with the image objects. ImagePlus stores coded data in its normal character format, rather than converting the characters on a page to an image. The coded data are enveloped in another wrapper, this one called Presentation Text

Figure 2 ImagePlus data packaging

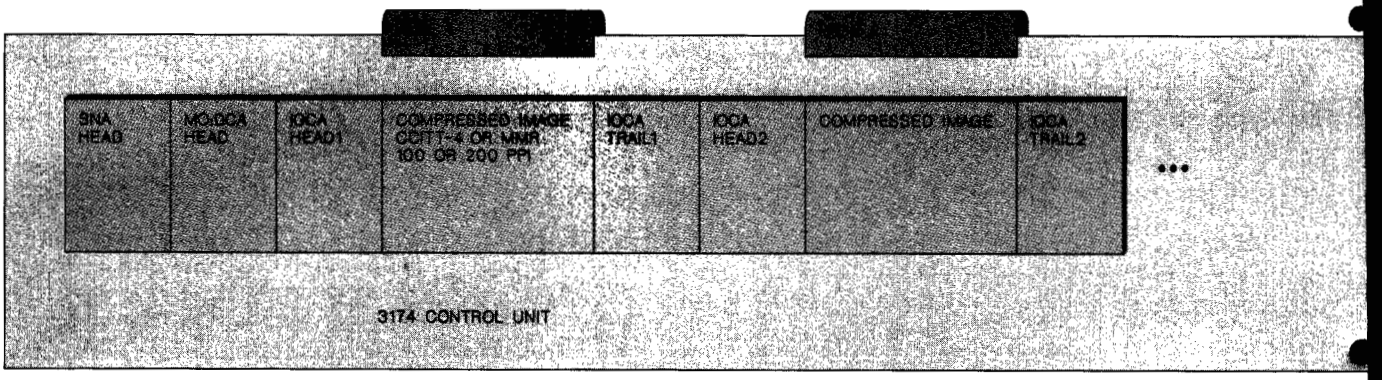
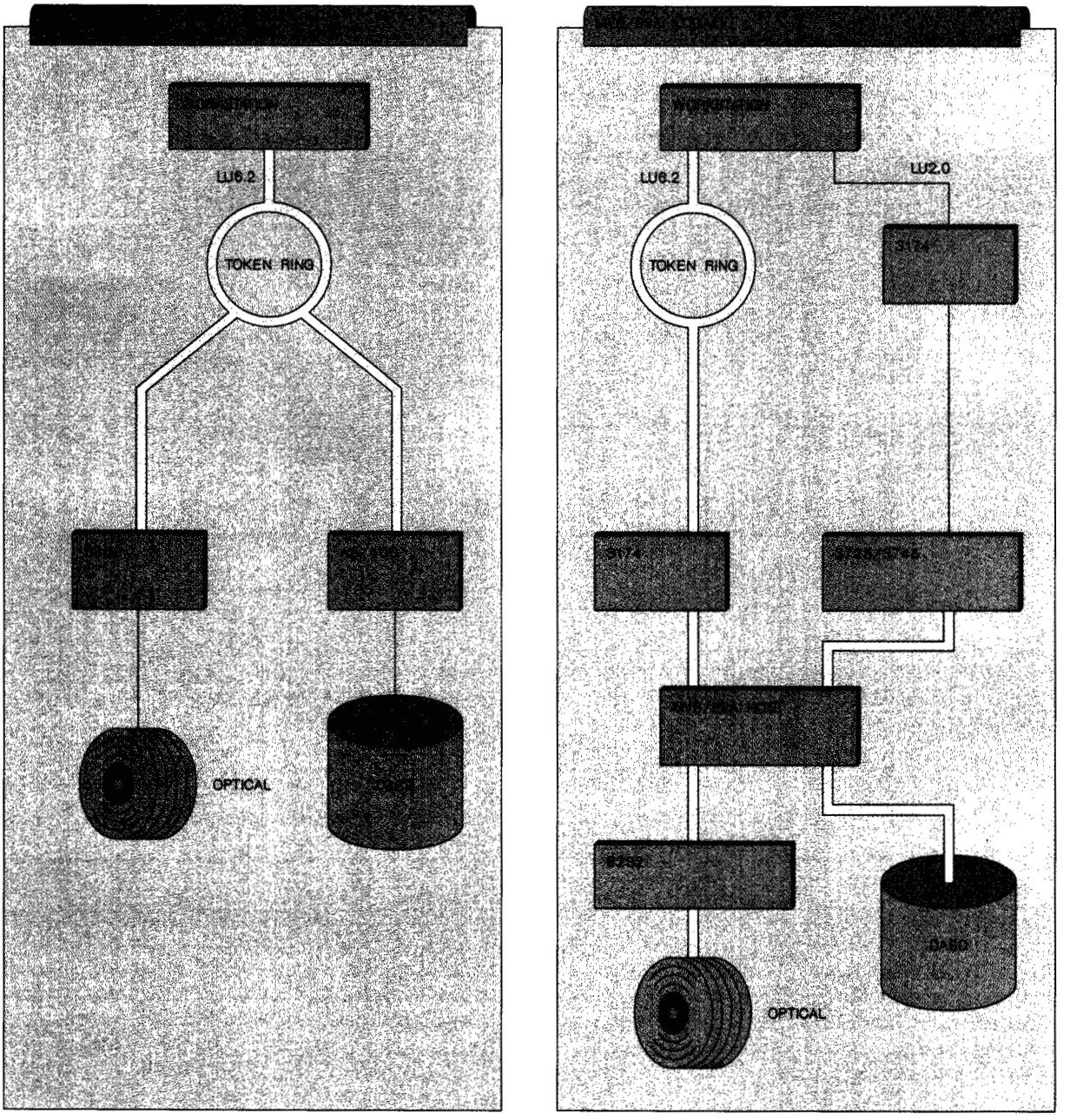
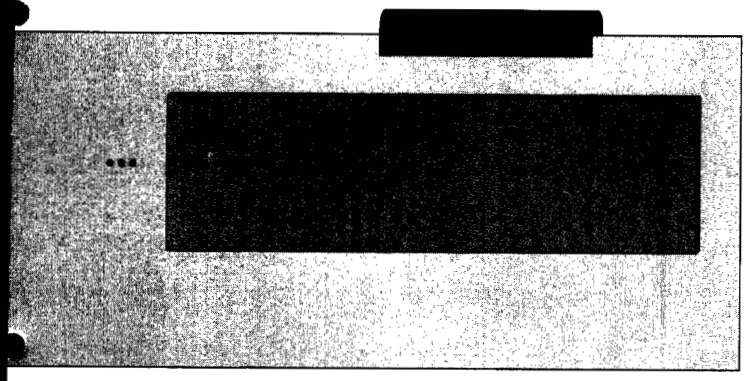
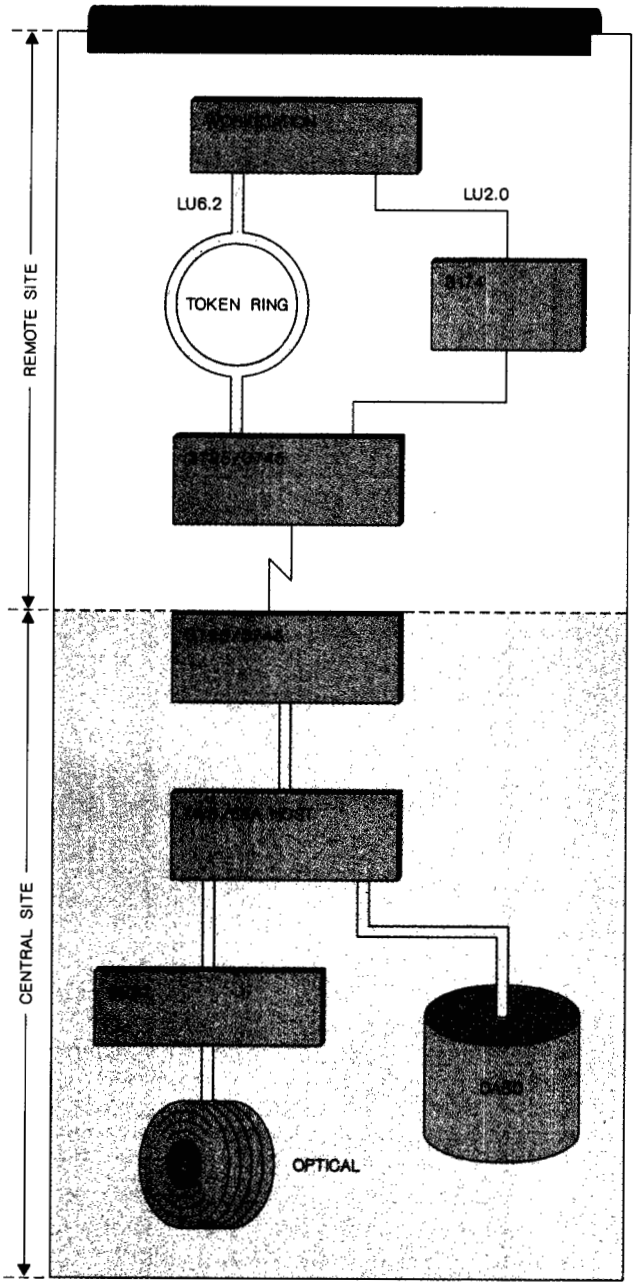


Figure 3 ImagePlus communications







Object Content Architecture (PTOCA), which allows coded data to be merged with images of standard business forms.

Implementation of the coded data function is practical where input to the image system includes large numbers of standard forms containing computer-generated data. It is only necessary to scan the image of a standard business form once; however, it can be retrieved and overlaid with the unique coded data for a specific display or print request. Considerable communication time and storage can be saved using the coded data, since a page of coded data will rarely exceed 2000 characters, each requiring only one byte, or about 2 KB per page, versus 50 KB if the same page were scanned and stored at 200 ppi.

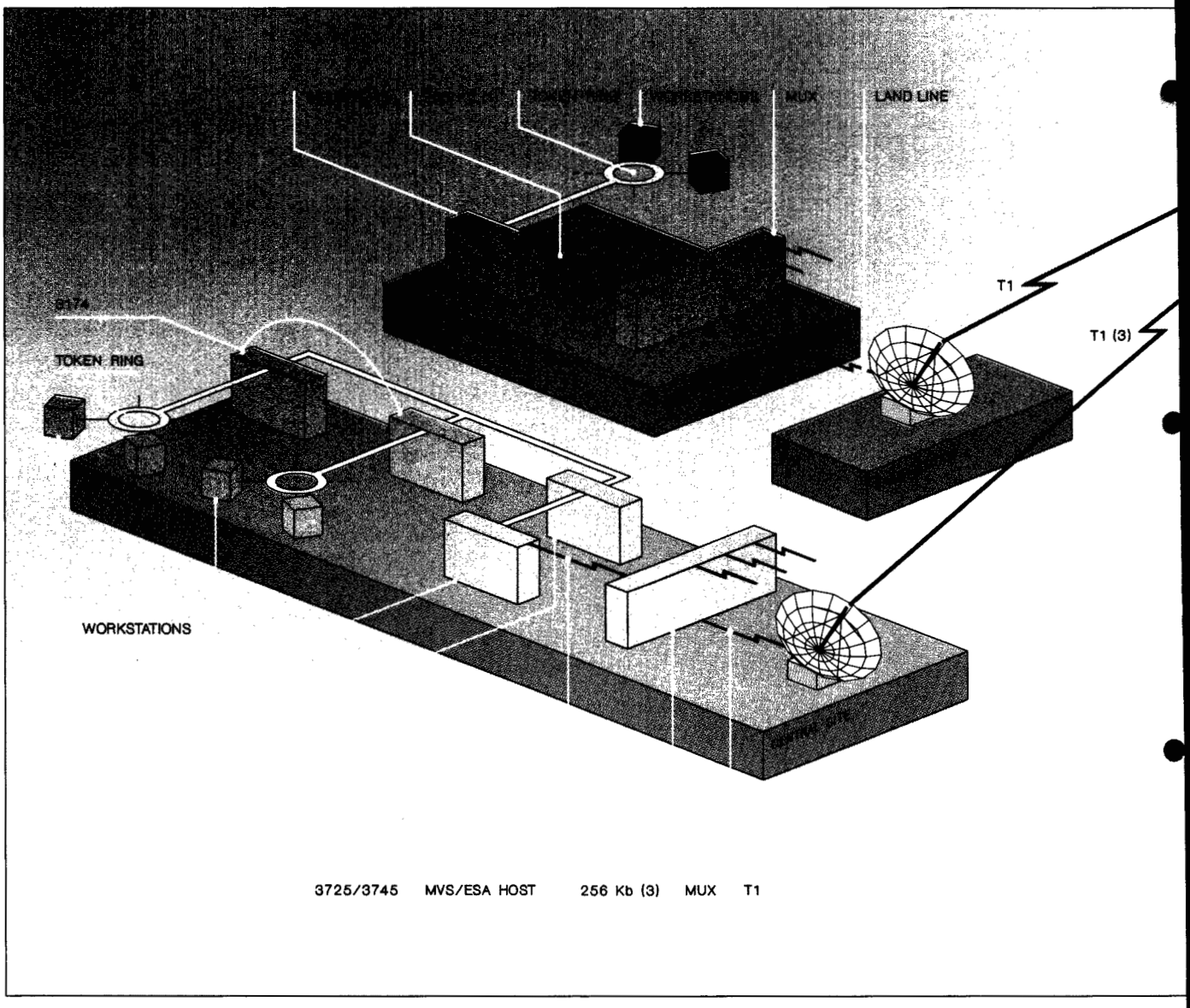
Communication subsystem components

Differences between MVS/ESA and AS/400 communications. The ImagePlus AS/400 system features direct attachment of the workstation token rings to the AS/400 host. Optical storage devices, driven by an IBM 5363 minicomputer, are also on a host-attached token ring in this system. The AS/400 Model B10 can support one directly-attached token ring; all of the larger models can accommodate two. In the MVS/ESA system, optical storage devices are driven by an IBM 8232 Optical Storage Controller, which is channel-attached to the ImagePlus host.

All work-flow command and control information between the workstations and the AS/400 flows over the token ring along with the image objects, with both observing the LU 6.2 protocol. Work-flow management communications in the MVS/ESA system are handled by a separate IBM 3270 (LU 2.0) link to the ImagePlus host.

In the ImagePlus MVS/ESA system, there are intermediate levels in the communication hierarchy. When the workstations and the ImagePlus host are in the same geographical location, the usual configuration for image communications has the workstation token rings connected to IBM 3174 Control Units which provide the communications gateway to the MVS/ESA host. Where workstations are remotely located, their token ring can be attached to a Token-Ring Interface Coupler on an IBM 3725 or IBM 3745 Communication Controller which serves as the communications gateway at the remote site. The remote 3725 or 3745 is connected to a host-attached 3725 or 3745 at the host site via a high-speed communications link. In either the local or remote configuration, there is a separate 3270 link

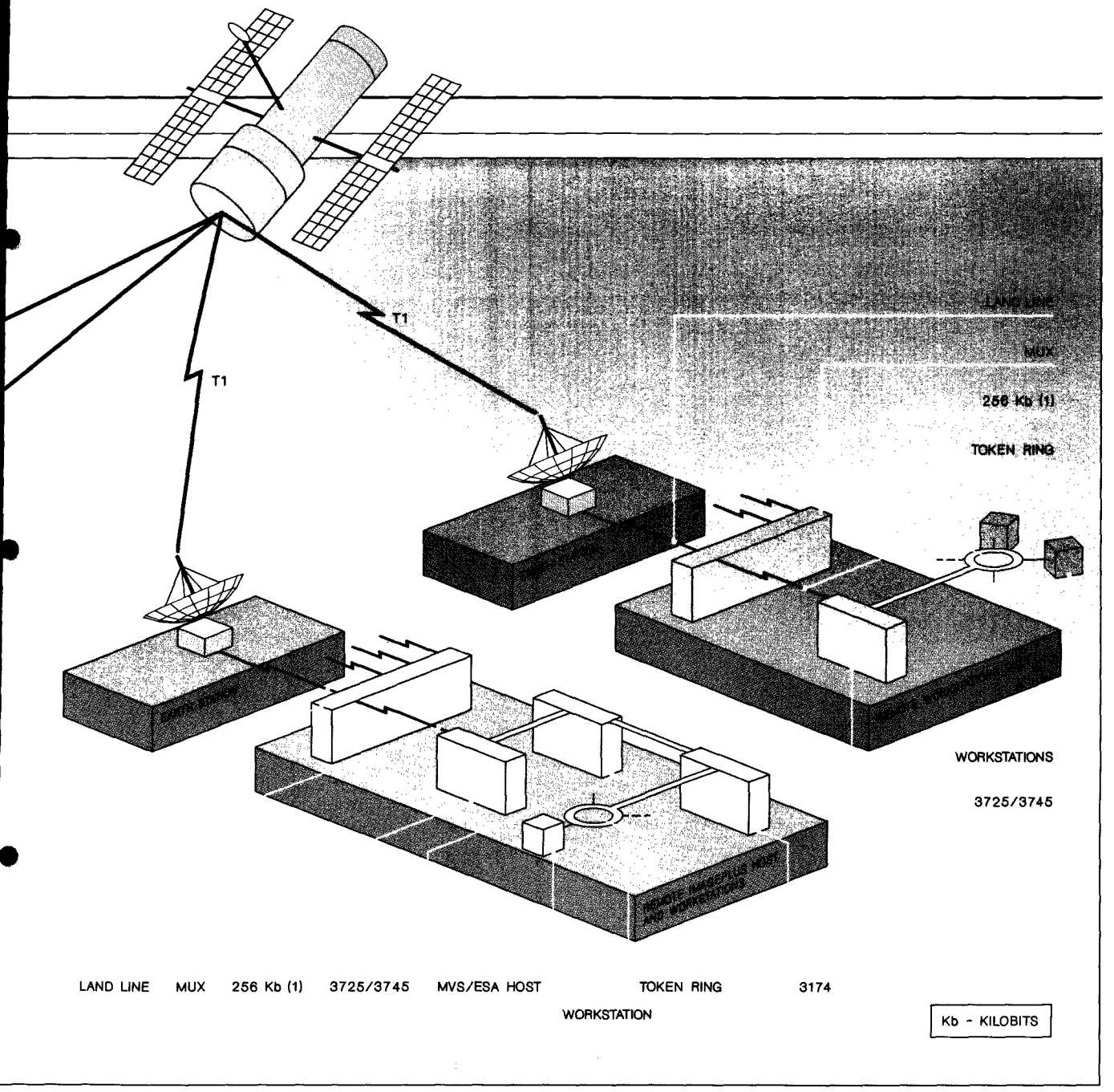
Figure 4 ImagePlus MVS/ESA example of distributed environment



to the host for work-flow management communications. ImagePlus MVS/ESA and AS/400 single-host configurations are shown in Figure 3.

ImagePlus MVS/ESA also supports the interconnection of image hosts at multiple locations for distributed processing environments. For large, geographically dispersed users, this mode of operation can be used in combination with the remotely attached workstations described in the preceding paragraph to form a network configuration such as the one depicted in Figure 4. Satellite links are often used to provide communications between the central site and the remote locations, with a T1 carrier (1544 kilobits per second) being multiplexed to provide the bandwidth needed for image transmission (256 kilobits per second, for example).

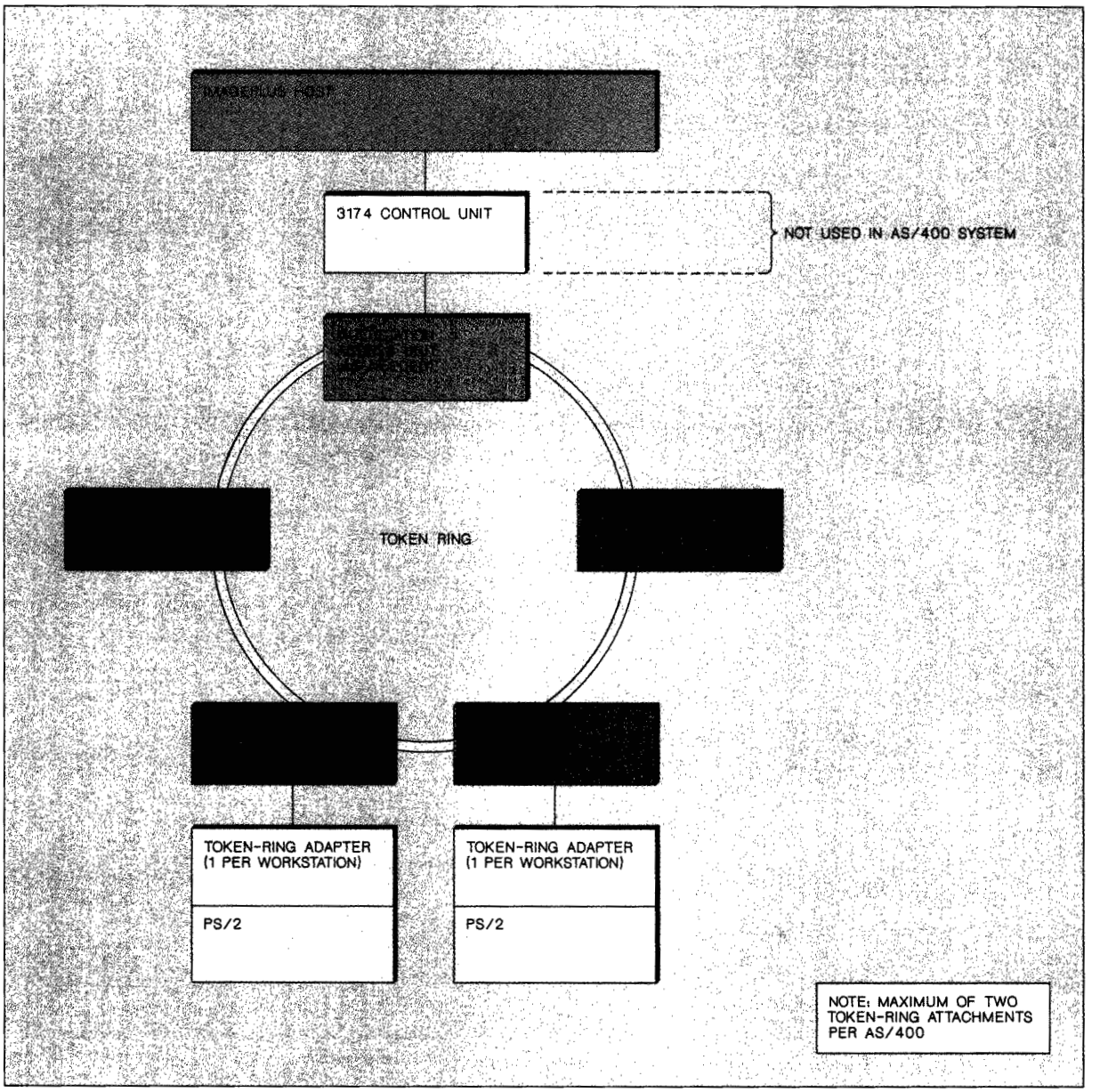
The following sections describe the components of the ImagePlus communication subsystem.



Token-Ring Network. IBM token rings were selected as the medium to connect the PS/2 image workstations to the ImagePlus system because of their high performance, cost-effectiveness, and flexibility. IBM's current token-ring products offer nominal data rates of 4 or 16 megabits per second (500 and 2000 kilobytes per second, respectively). Even allowing for an effective throughput rate somewhat below the nominal data rate, the 50 KB required to store the image of an average page at 200 ppi will transit the token ring in well under one second. All ImagePlus token-ring communications follow the LU 6.2 protocol.

As more workstations are added to the system, cost advantages will accrue to the user because of the token ring's ability to support more devices on a given ring-controller combination than could be handled with a comparable 3270-like terminal-controller arrangement.

Figure 5 ImagePlus communications—local area network



The characteristics of the token ring also afford the user an added dimension of flexibility when rearranging the workstation environment. Devices attached to the token ring can be disconnected, moved to another location on the ring, and reconnected without having to interrupt other users or redo the ring configuration parameters.

The PS/2 image workstations, each equipped with a Token-Ring Adapter Card, will be connected to IBM 8228 Multistation Access Units (MSAUs). Up to eight devices can be attached to each 8228. IBM 8218 Copper Repeaters or IBM 8219 Optical Fiber Repeaters can be used where necessary to expand the geographic coverage of a particular token ring beyond

the limits that can be served without repeaters. (See Figure 5.)

The allowable distance from the MSAU to the workstation is largely dependent on the user's choice of cabling medium—shielded twisted pair, such as IBM Cabling System Type 1 or Type 2 media, or telephone twisted pair (TTP), which is unshielded. IBM recommends TTP for use only with the 4-megabit per second token ring. A TTP-based token ring can accommodate the physical attachment of up to 72 terminals, while shielded twisted pair cabling can theoretically handle as many as 260 devices on a single ring.

In current ImagePlus MVS/ESA configurations, the limit per ring will be 64 (including the controller). This limit is due to a design decision to use four IBM 3174 Control Units on a host channel. A channel can support a maximum of 256 subchannel addresses, so 64 addresses will be available for each of the four control units.

The number of active, full-function workstations that can be supported by the ImagePlus AS/400 system is currently limited by the number of simultaneous sessions (100) that can be supported by the IBM 5363 minicomputer that drives the optical devices, not by the capacity of the token rings. A workstation must be in session with the 5363 minicomputer to store or retrieve objects from optical storage. Each AS/400 and batch job requiring optical access must also be in session with the 5363 minicomputer, so the number of workstations that can "access optical" at any one time is less than 100. This means that 100 or more workstations can be attached to the token ring(s), but they will not all be able to access optical at the same time. A likely scenario for this situation would be workstations used only on second shift, when some of the first-shift workstations are idle. One AS/400 installation has a total of 85 image workstations on two token rings and is planning to add 15 more. The actual number of workstations installed on a given token ring is also influenced by the usage profile and performance requirements.

3174 Control Unit. The IBM 3174 Control Unit provides the gateway from the workstation token rings to the ImagePlus MVS/ESA host at locations where a host has been installed. The 3174 Control Unit attaches directly to a host channel, providing the communications capacity needed to effectively move the large blocks of image data. Tests run using Version 1.0 of the 3174 microcode in a simulated image-processing environment yielded throughput rates in excess of 100 kilobytes (KB) per second using 1920-byte frames. For planning purposes, the authors used 100 KB per second to allow a margin of safety.

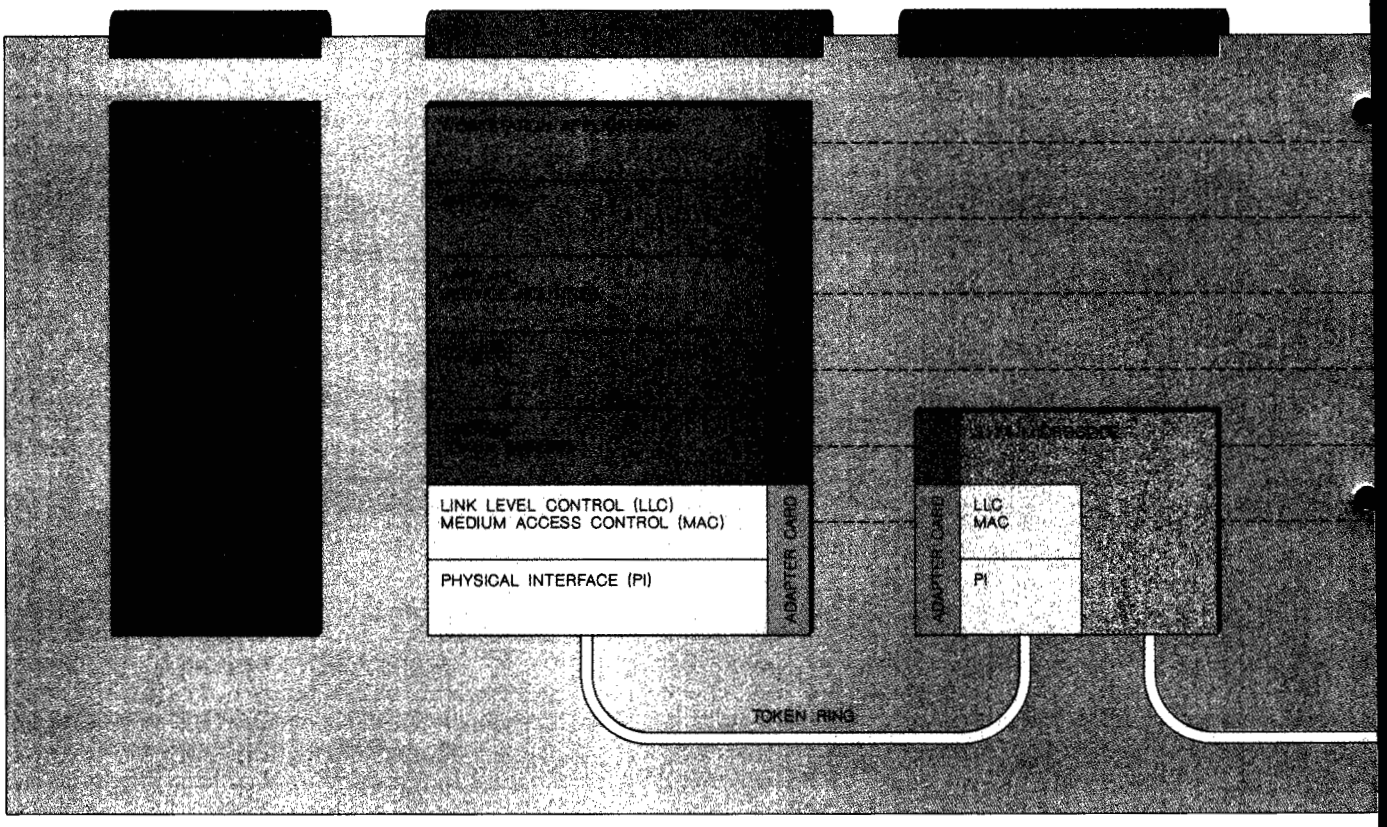
This paper describes the communications methodology for a system which was installed in early 1988.[1] Since that time, significant performance improvements have been made to the 3174 and its communication methods. Included in these enhancements are support for 4 kilobyte token-ring frame transfer, faster hardware within the IBM 3174 Control Unit, and significant improvements to the 3174 software. Taken together, a properly configured 3174 controller acting as a gateway from a token ring to a host channel now has a throughput capability of approximately 3.5 megabits per second (437.5 kilobytes per second).

The system architectures are based on standard IBM products.

3725 Communication Controller. IBM 3725 or 3745 Communication Controllers are used to expand ImagePlus MVS/ESA to remote locations. Each remote site will have a 3725 or 3745 controller linked to the central ImagePlus host through one or more high-speed data circuits (typically 256 kilobits per second). The remote sites may also be linked to each other to allow direct interlocation communication without having to go through the central site host.

Standard build and line macros will be used when the Network Control Program (NCP) is generated for each 3725 or 3745 controller. Currently, the NCP recognizes each token-ring workstation as a switched virtual circuit, even though a dedicated connection exists. As a result, NCP must "dial" each workstation when it wishes to communicate. This requirement affects the naming convention for the workstations in that their addresses must contain decimal characters only, since NCP cannot dial an address containing hex characters.

Figure 6 ImagePlus MVS/ESA system architecture



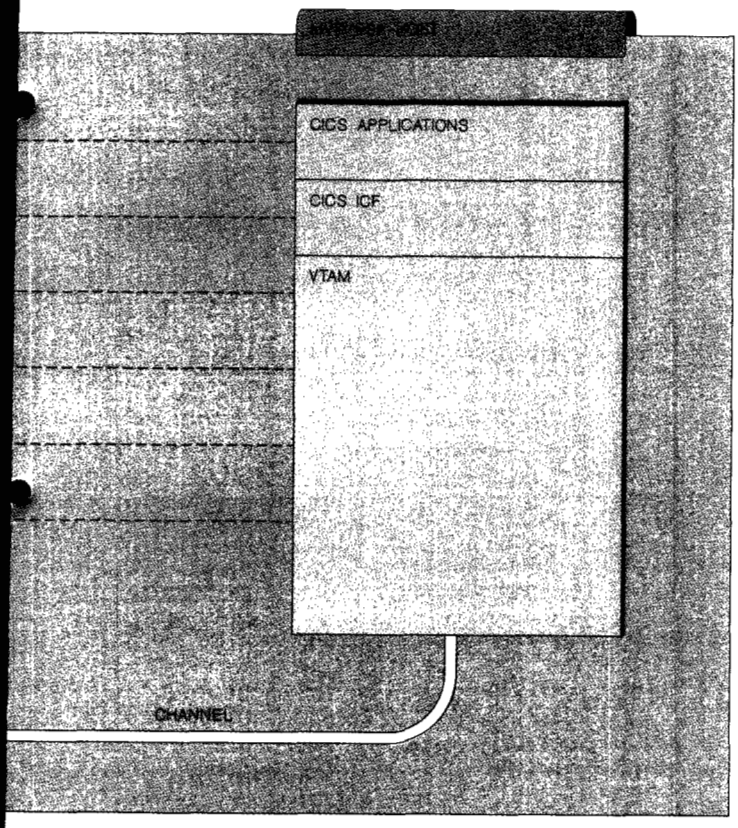
Software. The system architectures (Figures 6 and 7) of both the MVS/ESA and AS/400 ImagePlus systems are based on standard IBM products. Image-handling and work-flow applications both run under the OS/400® operating system in the AS/400. Image-handling runs as a Customer Information Control System (CICS) application under MVS/ESA in the large system, and work flow can be ordered as either a CICS or Information Management System (IMS) application.

Image host-to-workstation communication is handled by the Advanced Peer-to-Peer Networking (APPN) and PC Support software products in the AS/400, providing LU 6.2 connectivity across the Token-Ring Network. In the MVS/ESA system, the image host communicates with the workstations via LU 6.2 sessions through the Virtual Telecommunications Access Method (VTAM). The application programs in the PS/2 workstations are supported by standard IBM token-ring software, Advanced Program-to-Program Communications/Personal Computer (APPC/PC) and Disk Operating System (DOS) 4.0.

When 3725 or 3745 Communication Controllers are installed to support remote communications in the MVS/ESA system, each will run under NCP Version 4 Release 2 or higher, and will have LU 6.2 connectivity with the other locations.

Communications network management. The network management function for the ImagePlus systems is supported by a full range of IBM standard products. The MVS/ESA system uses the host-based NetView® product, supported by NetView/PC™ and the Token-Ring Network Manager, to monitor network status and collect performance data.

The Token-Ring Network Trace and Performance Program can be used by either system to gain insight into the utilization of the ring by all or a subset of the workstation population. The trace function enables application developers to analyze data on Token-Ring Networks, and facilitates the identification of data errors on production networks. The performance function presents a real-time window into ring



utilization to the operator and provides statistics on the traffic handled by different workstations on the ring. The information generated by this tool may be used to determine whether a requirement exists to split a single ring into two or more rings, or to redistribute some of the workstations to other rings.

Communication performance considerations. The current IBM token-ring architecture supports communication between devices on the ring, as well as through the token-ring gateway to the host. ImagePlus currently supports only workstation-to-host communications, so all traffic on the token ring passes through the 3174 Control Unit. It is therefore important that the communication network components be configured to ensure efficient handling of the large image objects.

Performance of the 3174 controller can be enhanced by selecting large data block sizes when configuring the ImagePlus system. In general, data throughput increases with increasing block sizes, with the curve flattening out around a block size of 4 KB, which is the maximum size supported by the 16-megabit token ring. This ring will support a data throughput rate approximately 30 percent higher than the 4-megabit token ring, which has a maximum block size of 2 KB. However, the 4-megabit ring can run on the less expensive unshielded twisted pair cabling, so a cost-versus-throughput evaluation may be needed to select the correct cabling medium.

Because of the large block sizes needed to maintain high throughput rates, it is recommended that ImagePlus run on its own VTAM, rather than share the user's production VTAM. In most cases, the production VTAM will be using buffer sizes of 300 bytes or less, which is appropriate for a 3270-oriented environment. To take advantage of the large block sizes needed to optimize the movement of image objects, the VTAM buffers should be set to around 2000 bytes (2 KB), which will dramatically increase the amount of host memory needed for buffer space, assuming the number of buffers for nonimage production is held relatively constant.

Without the larger VTAM buffer sizes, image throughput performance will be severely affected. The throughput rate with 1 KB buffers is one-half of what can be expected with the buffers set at 2 KB, and performance continues to drop off rapidly for buffer sizes below 1 KB.

Figure 8 depicts the maximum block size that can be used on the 4-megabit token ring. During throughput evaluations, pacing of 17 was found to be the most efficient factor. The pacing factor multiplied by the block size sets the CICS buffer sizes.

Pacing controls the flow of data through a communications network. This capability is needed because different network nodes can have different capacities for receiving, processing, and storing message data. Proper choice of pacing parameters for inbound and outbound traffic will reduce congestion that can result when a network node's processing and buffer storage capacities are exceeded.

Summary

The movement of image objects through a communications network requires careful planning and selection of system components and operating parameters. This paper has described how IBM standard products are used in the communications architecture needed to support the ImagePlus products and

Figure 7 ImagePlus AS/400 system architecture

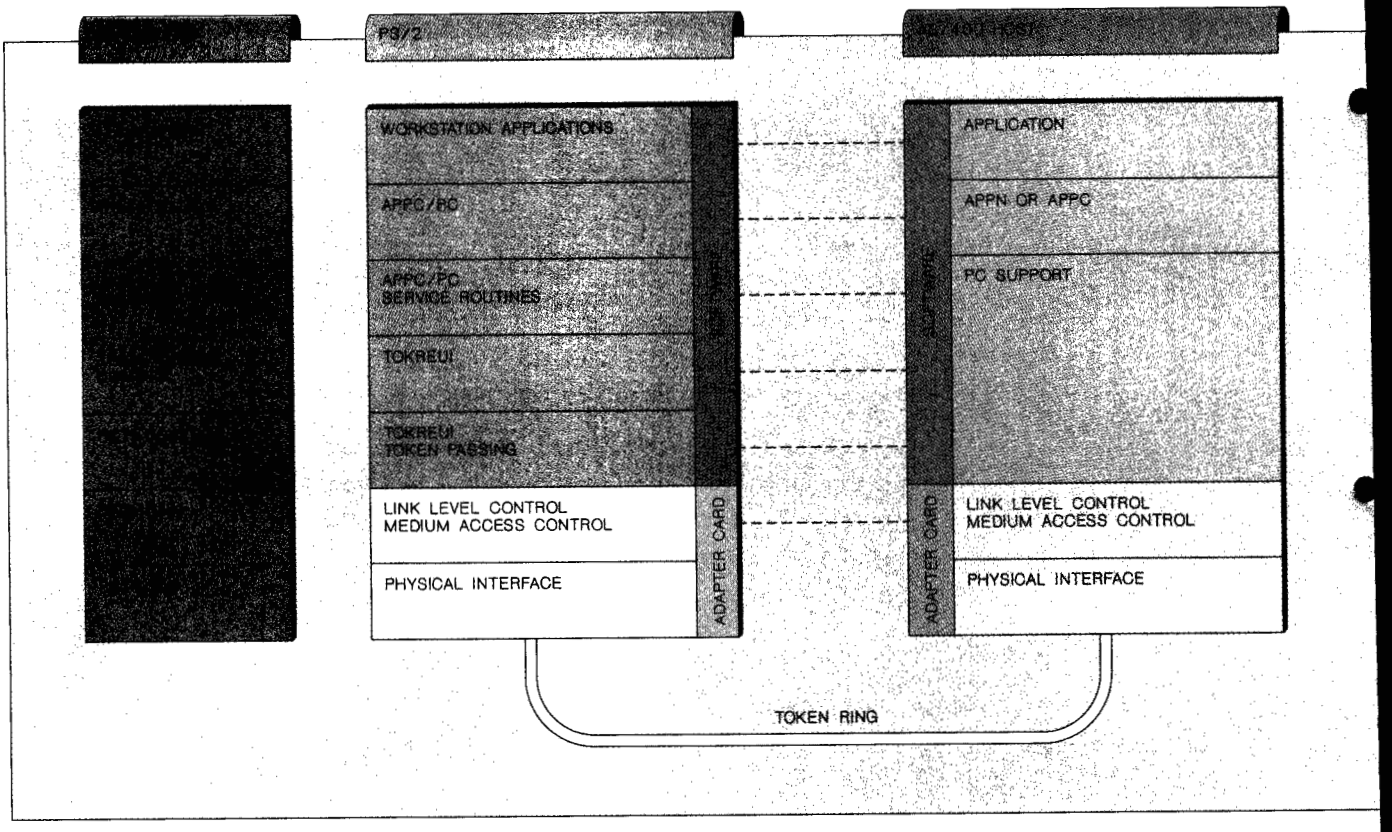
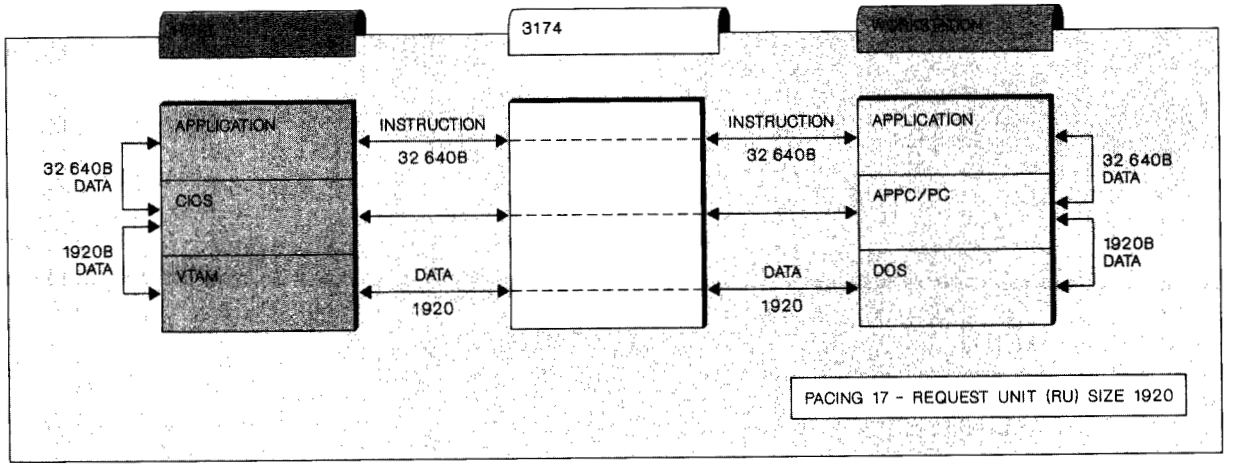


Figure 8 Four-megabit token-ring block sizes



has identified some of the important factors that should guide the network design process.

Effective implementation of ImagePlus in a user's data-processing complex will require tradeoff anal-

yses of performance, cost, and impact to the user's current operating environment.

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