

The continuing evolution of Advanced Function Printing

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Advanced Function Printing™ (AFP™) has become one of the de facto printing standards. It is a broad architecture to support printing across an entire enterprise and encompasses IBM architectures as well as industry standards. AFP had its beginnings in the IBM System/370™ environment in 1984 and has since expanded to include midrange and local area network systems. Recently the capabilities of AFP have been extended beyond printing to include on-line viewing and management of presentation data. An overview of AFP capabilities was given in an earlier issue of the IBM Systems Journal. This paper traces the continuing evolution of AFP and its usage and how it is addressing the presentation requirements of businesses in the 1990s.

Communication is one of the foundations of civilization. For thousands of years humans have been recording their thoughts and ideas on various media to facilitate communication. Inventions such as the printing press and typewriter increased the volume and improved the quality of printed information. With the advent of computers and data processing it became possible to assimilate and process vast amounts of information. This information is of little value, however, unless it is communicated to people. Although dozens of mechanisms are used to interface computers to people, one of the most common is the printer.

Computer printing has evolved from a by-product of data processing to a critical function for many businesses. Because most early computer print-

ers were limited to simple text output, they could not disseminate information as effectively as a printing press. The introduction of computer-driven page printers has led to merging the benefits of high-quality printing with the power and flexibility of computers. Businesses now have exciting new options for increasing communication within their companies, with their customers, and with other companies. However, with this new power comes increased complexity and cost and the need to effectively manage printing in order for it to truly benefit the companies using it. Managing printing can be a daunting task today because of the myriad options available and the legacy of hardware and software that must be considered.

Evolution of IBM host printing

For many years the standard printer attached to computers was the impact printer. The impact printer was rugged and reliable and supported most applications available on systems. Impact printers could attach locally (e.g., via a System/370* channel interface) or remotely via communication lines. In most cases they supported text-based data streams such as the IBM 1403 or 3211. These were referred to as First Character

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Forms Control (FCFC) data streams because a control character in the first byte of each record controlled the position of each line on the page.

Host application programs formatted output for a specific type of impact printer and used row and column addressing to position lines and characters on the page. This formatting was common when printing on preprinted forms. Although this formatting was straightforward, it was imbedded within each application program, and moving to a different paper size or printer type meant changing the application. Studies have shown that many application-program changes are changes to the format of the output.

The need for high-quality output forced impact printers to become more sophisticated. New devices, such as 3270 or Systems Network Architecture (SNA) Character String (SCS) printers, offered the ability to select more options, such as additional font sizes and text color. As a result, applications generating output became more device-dependent. To help alleviate this situation, some systems and application environments provided external formatting or mapping services to isolate application programs from output-device dependencies. Application programs produced a device-independent form of text output and specified the name of an external object that mapped the data to a specific device. These maps were developed separately from the application program and were device-dependent. They specified how to map fields of data to an output device and allowed fonts, color, and other output attributes to be specified. They provided late-binding of the output to a particular device. Two popular Multiple Virtual Storage (MVS) subsystems provided this function for both printers and IBM 3270-type display terminals. The Customer Information Control System* (CICS*) provided an interface called Basic Mapping Services, or BMS, and the Information Management System (IMS) provided an interface called Message Formatting System, or MFS.

These external mapping services were a tremendous productivity boost to the alternative of applications formatting data for each impact printer. They were, however, limited to impact-printer technology and row and column addressing and did not support all-points-addressable (APA) printing technology.

With the advent of new printing technologies and APA page printers, companies immediately began to think of sophisticated applications to exploit these new capabilities. They saw an opportunity to use page printers to communicate more effectively and to become more competitive in their industries. The ability to use a wide array of fonts and to mix text on a page with image and graphics allowed traditional documents to be customized. For example, it was now possible to include a signature or corporate logo on printed pages as shown in Figure 1.

Page printers can also save money for businesses. Replacing preprinted forms with electronic forms can result in an immediate dollar savings for companies. Using electronic forms can reduce or eliminate the costs associated with purchasing and storing forms, managing forms during production runs, and throwing away unused forms. It also automates the labor-intensive process of changing printer forms.

For many companies, the printed document establishes their corporate image and differentiates them from other companies. They strive to produce the highest quality documents possible in a cost-effective way.

Generating output for page printers that takes advantage of their capabilities can be far more complicated than generating output for line printers. For example, with page printers it is possible to individually address every dot on the page. For a standard letter-size page at a resolution of 300 dots per inch, over eight million dots are directly addressable on the page. With page printers, usage of typographic fonts to make documents more readable is common. Most line printers do not support typographic fonts, so the width of each character is the same. With most line printers, the string "IIIIIIII" has the exact same width as the string "MMMMMMMM" when printed. With typographic fonts, this is not true. Every character of every font can potentially have a different width. Formatting, which was simple on line printers through row and column addressing, now became very complex because applications needed to understand font metrics (i.e., the widths of different characters).

Another significant difference between impact printers and page printers is how they process data. Impact printers generally accept a line at a

Figure 1 Complex document

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time from the host printer driver, and error recovery depends on this characteristic. It is possible to stop printing on a specific line and later restart on that line. Page printers, as their name indicates, process a page at a time. At high speeds (e.g., above 30 pages per minute), paper paths are long; i.e., there could be 5 to 15 feet of paper between the points at which the paper enters and exits the printer, thus complicating error recovery and repositioning. Early page printers had problems providing the same reliability and integrity as impact printers. Furthermore, not all print driver software was sophisticated enough to manage page printers properly.

As if all these conditions did not provide enough difficulties, there were no standards for early printers, and each page printer implementation defined its own data stream. Printers such as the IBM 3800-1, IBM 6670, and Xerox 9700 each implemented different data streams. Since many host applications were developed in-house by

companies, the lack of page printer standards became an application-development inhibitor. Application programs became more and more printer-dependent, and changing them to support new types of printers or new printer functions was costly.

Introduction to AFP

Advanced Function Printing* (AFP*) was initially designed based on customer requirements to address the page-printing issues just described. Specifically, it provides:

- A data stream architecture that isolates applications from printer dependencies
- A migration path for existing applications that allows them to exploit page printer functions such as electronic forms without being changed
- Reliability and integrity of impact printing
- Print driver software that can manage page printers, including the ability to determine what

fonts, forms, and other printing resources are required and to automatically download them into the printer if necessary

- A set of tools that allows new applications to easily access printer facilities
- A family of compatible printers, including those for both continuous-form and cut-sheet paper
- The ability to attach printers locally or remotely with no impact to the application
- External formatting of application output to reduce application changes required to change the look of the output

AFP capabilities and architecture were described previously by deBry and Platte¹ and by deBry, Platte, Berinato, and Marlin.²

AFP application architectures

AFP supports two types of application architectures. It provides a robust device-independent presentation data stream for building documents containing text, image, and graphics. The AFP presentation data stream, initially referred to as the Advanced Function Printing Data Stream (AFPDS),³ has been extended to support the Mixed Object Document Content Architecture for Presentation (MO:DCA-P*) functions. The rest of this paper uses MO:DCA-P to refer to the AFP presentation data stream.

The second type of application architecture supported by AFP is the native data streams of the local environment (e.g., 1403 line data in the System/370 environment). This architecture provides an important migration path for existing applications.

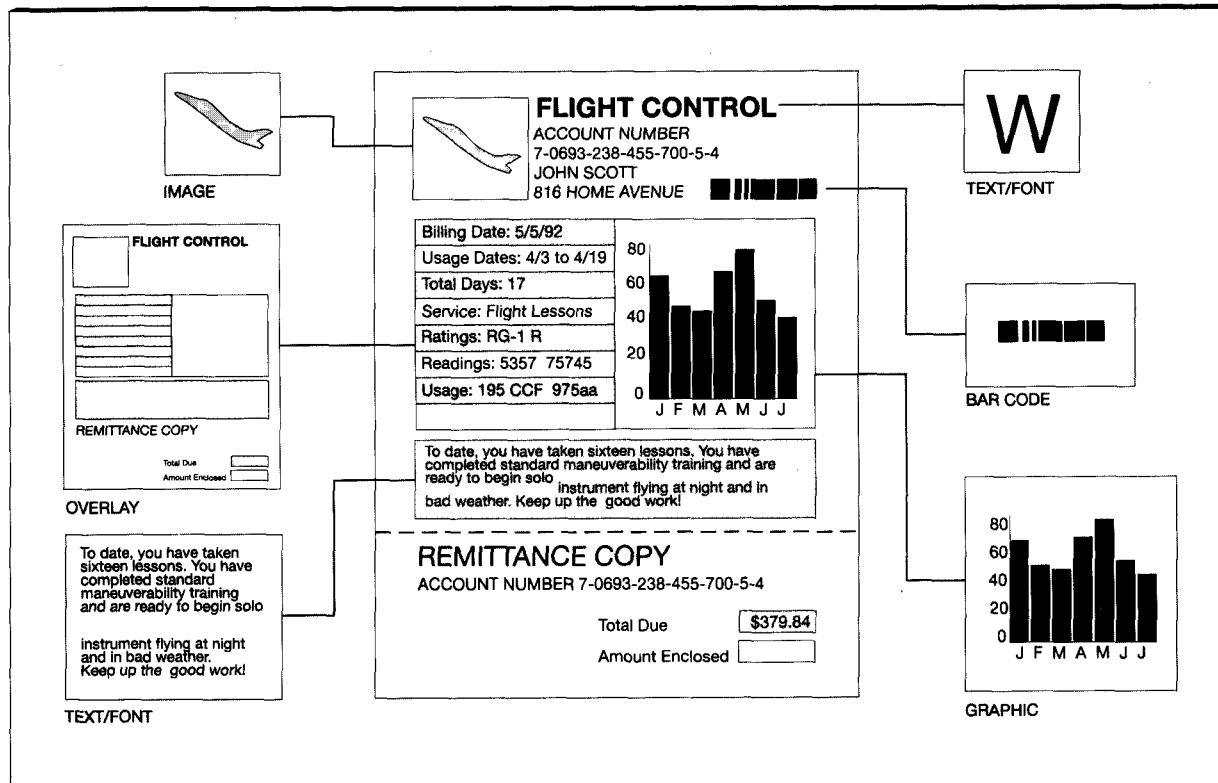
MO:DCA-P data stream. MO:DCA-P is a device-independent, object-based data stream comprising objects (referred to as object content architectures) of text, font, image, graphic, and bar code data. It is resolution-independent and supports color presentation. MO:DCA-P documents are structured into pages that are independent of one another. The specific functions supported within the architecture include:

- **Presentation Text Object Content Architecture (PTOCA)**⁴—The AFP presentation text object supports high-quality text printing. It allows presentation of text in different typefaces, code pages, and orientations and has an efficient

mechanism for specifying intercharacter spacing.

- **Font Object Content Architecture (FOCA)**⁵—The AFP font architecture supports definition of font typeface, style, size, weight, mapping of code points to graphic characters, and the metrics to control formatting. Initially the AFP font architecture was based on raster fonts to support high-speed printing. It has now been extended to support Adobe Systems Type 1**⁶ outline fonts. To provide a migration path to outline-font printers, AFP supplies a set of raster fonts, called the IBM Core Interchange fonts, that were generated from Adobe Systems Type 1 outlines. Usage of these fonts guarantees consistency between existing raster-font printers and outline-font printers. Additionally, through the Print Services Facility/2 (PSF/2) Type Transformer function, any Adobe Systems Type 1 font can be converted to an AFP raster font for use in nonoutline-font printers.
- **Image Object Content Architecture (IOCA)**⁷—The AFP image object supports both uncompressed and compressed device-independent image data. The resolution of the image data is not tied to a particular printer resolution and can be rescaled automatically by the printer. IOCA can also be rotated, sized, cropped, or trimmed as necessary on a page. The compression algorithms supported include International Telegraph and Telephone Consultative Committee (CCITT) Group 3⁸ (standard facsimile compression), CCITT Group 4⁸ (standard scanner compression), IBM Modified Modified Read (IBM MMR)⁹ used by IBM scanners, and Adaptive Bilevel Image Compression (ABIC)¹⁰ used by the High Performance Transaction System (HPTS).
- **Graphics Object Content Architecture (GOCA)**¹¹—The AFP graphics object provides a resolution-independent method of drawing lines, arcs, and curves and performing other graphic operations and can be rescaled automatically by the printer. GOCA can be rotated, sized, cropped, or trimmed as necessary on a page.
- **Bar Code Object Content Architecture (BCOCA)**¹²—The AFP bar code object provides high-level functions for building bar codes. It obviates the need for an application to understand the details of building bar codes. Many industry-standard bar codes such as the Universal Product Code (UPC), European Article Numbering (EAN) code, and the Materials Handling Institute (MHI) codes are supported.

Figure 2 Example MO:DCA-P page



- The MO:DCA-P data stream supports resource objects such as overlays, page segments, and form definitions. Overlays can be used to put fixed information on a page (e.g., as an electronic form or to include a piece of artwork in a document). They can contain any valid MO:DCA-P object (e.g., text, image, graphics, etc.). Page segments can be used to place an image or graphics object on a page and are typically used to place a signature or logo on a page. Form definitions define the physical characteristics of a form and can be used as an effective substitute for a multipart preprinted form. An example of a MO:DCA-P page is illustrated in Figure 2.

To facilitate producing the MO:DCA-P data stream, a new high-level programming interface is provided. The Advanced Function Printing Application Programming Interface, or AFP API,¹³ (also called the AFP Toolkit) provides applications in

the System/370 environment as an easy interface for building documents. It supports high-level formatting functions, such as text justification and tables, and relieves application programmers from having to understand font metrics and MO:DCA-P structured fields.

Applications producing the MO:DCA-P data stream are also available from a wide range of vendors. They include applications that provide an interactive interface for developing AFP resources such as overlays, page segments, and fonts as well as general business applications for many industries.

The MO:DCA-P data stream is supported via the AFP print subsystem, Print Services Facility (PSF), in the MVS, virtual machine (VM), Virtual Storage Extended (VSE), Operating System/2* (OS/2*), Advanced Interactive Executive* (AIX*),

and Operating System/400* (OS/400*)¹⁴ environments.

Native data streams. To provide compatibility with existing applications and to give them a migration path, AFP supports the native data streams in the operating system environments indicated below:

- In the MVS, VM, and VSE environments, PSF supports the 1403 and 3211 forms of line data.
- In the OS/400 environment, PSF supports SCS data as well as the existing application interfaces such as Data Description Specification (DDS).
- In the OS/2 environment, PSF supports the ASCII data stream at the Proprinter* and Quietwriter* levels, PostScript** Level 1, OS/2 Presentation Manager* (PM) applications through an OS/2 AFP device driver, and Microsoft Windows** 3 applications through a Windows AFP device driver.
- In the AIX/6000* environment, PSF supports the ASCII data stream at the Proprinter and Quietwriter levels, PostScript Level 1, and has a converter for troff and ditroff.

In the System/370 and OS/400¹⁵ environments, AFP allows applications that produce 1403 or 3211 data to take advantage of overlays, page segments, and typographic fonts without change. This is facilitated by the page definition object. The page definition specifies how the data are to be mapped on to the page. It allows text to be moved to different positions on the page, fonts to be changed, and a wealth of other capabilities such as conditional processing. The page definition provides what is called external formatting of application data. When combined with form definition, overlay, and page segment objects, it allows sophisticated pages to be produced by existing line data applications without any impact to those applications.

AFP device architectures

The AFP printer data stream is called the Intelligent Printer Data Stream* (IPDS*).¹⁶ IPDS is similar in structure and content to the MO:DCA-P data stream and supports the same object content architectures (e.g., graphics, image, text, and bar codes). However, it adds a bidirectional protocol that lets a print driver, such as PSF, manage the printer. The IPDS protocol allows PSF to:

- Query the capabilities of the printer. For example, PSF can query most hardware capabilities such as the number of input and output bins, the resolution of the printer, and whether or not the printer supports outline fonts.
- Query what fonts, overlays, and page segments are resident in the printer and download those that are missing or out of date.
- Provide page-level error recovery. IPDS defines errors that the printer can asynchronously return to PSF. For example, the printer can notify PSF that it is out of memory and cannot accept additional downloaded resources. PSF can then delete some resources so printing of the job can continue. IPDS also returns the last successfully stacked page, which is important for printers that buffer many pages or have long paper paths. If a printer error occurs, recovery is managed cooperatively between PSF and the printer, and printing will resume at the correct point in the document.

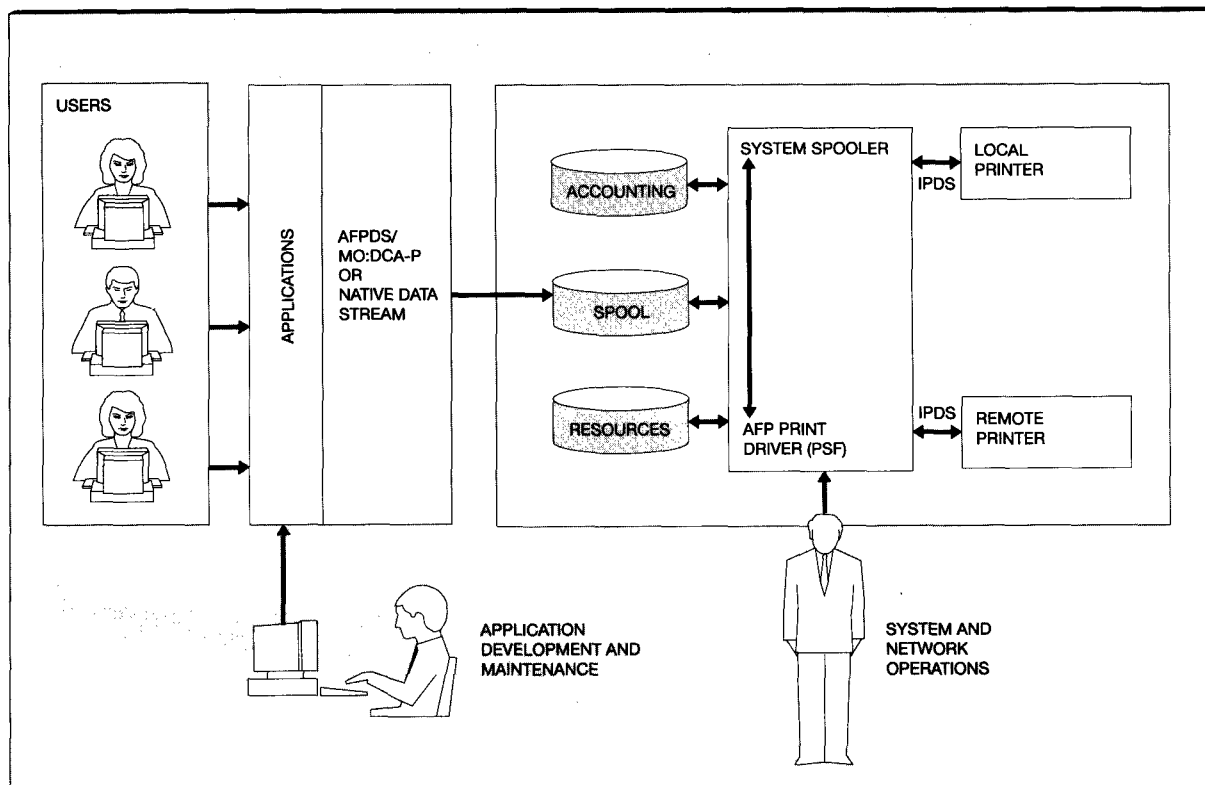
System-managed printing

One of the major design goals of AFP is to provide system management of printing. At the heart of AFP is PSF*, a print subsystem that manages the process of accessing application data and transforming the data to IPDS for the target printer. PSF automates many aspects of this process, including data stream transforms, resource access and management, error recovery, message routing, accounting, and other functions. Figure 3 illustrates the AFP system model.

PSF runs in six system environments: MVS, VM, VSE, OS/400, OS/2, and AIX. Although a large amount of PSF code is common across different environments, a lot of effort was invested to make sure that PSF functioned as an integral part of each operating environment. For example, PSF/MVS operates as a Job Entry Subsystem (JES) functional subsystem and supports the standard JES console commands for interfacing with the printer. The commands used to control a JES-driven printer are the same as those used to control a PSF-driven printer.

AFP is unusual among printing architectures because the software, hardware, and architecture were designed together at the same time. As a result, there is a great deal of synergy between PSF and the printer. Resource management, error recovery, and high performance are all possible

Figure 3 AFP system model



because they are accomplished via hardware and software cooperation.

AFP—providing a family of printers

Pennant, the IBM Printing Systems Company, produces a family of printers ranging from low-speed devices to very high-speed devices and including both continuous form as well as cut-sheet output. The current family of Pennant Systems IPDS page printers is shown in Table 1.

Many of the IPDS printers from Pennant Systems are based on a common control unit (CCU) design. To achieve a high degree of commonality among printer models, the same control unit hardware and microcode are used for different printer engines. The CCU design is flexible and extensible, allowing new printer capabilities to be added over time. For example, the original IBM 3900 printer did not have the ability to print compressed image and vector graphics. A new coprocessor card

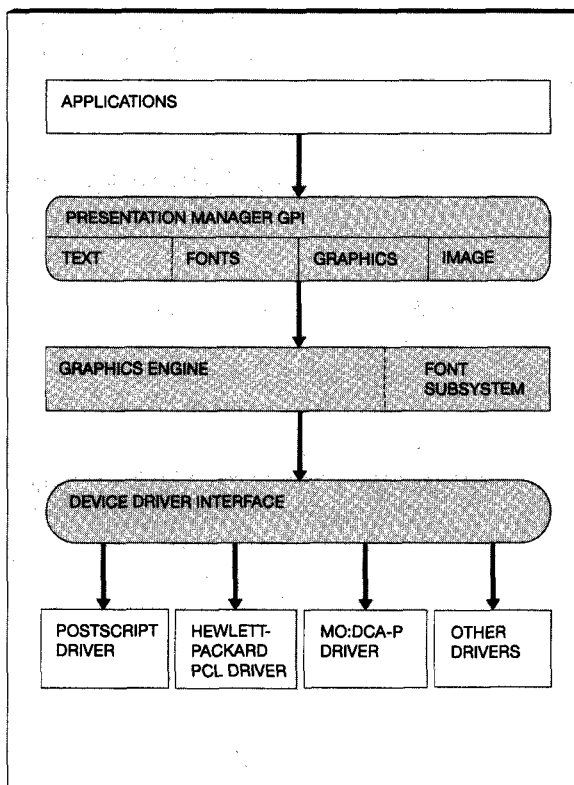
Table 1 Current family of Pennant Systems IPDS printers

Printer	Page Printers		
	Speed (impressions per minute, or IPM)	Paper Type	Paper Handling
IBM 4028	10	cut-sheet	
IBM 3912	12	cut-sheet	duplex
IBM 3916	16	cut-sheet	duplex
IBM 3930	30	cut-sheet	duplex
IBM 3935	35	cut-sheet	duplex
IBM 3825	58	cut-sheet	duplex
IBM 3828*	92	cut-sheet	duplex
IBM 3829	92	cut-sheet	duplex
IBM 3835	91	continuous form	
IBM 3900	229	continuous form	

*Magnetic Ink Character Recognition (MICR)

called the Advanced Function Image and Graphics (AFIG) feature was added to the CCU to provide this function across a range of printers.

Figure 4 OS/2 PM imaging model



The evolution of personal computer printing

Personal computer (PC) printing was not yet popular when AFP was initially designed. However, the evolution and problems of PC printing paralleled many of those in host environments for which AFP was developed. With the explosion of low-cost desktop PCs, personal printers such as the IBM and Epson dot-matrix printers became popular. These dot-matrix printers supported the IBM Proprinter¹⁷ or Epson ASCII print data stream and were capable of APA positioning of text and image data.

PC application vendors were responsible for supporting printers within their products. Initially this was not much of a problem because there were only a few forms of the ASCII data stream. As printer vendors added function to their products, they enhanced their printer data streams to support that function—creating many different printer data streams. In the late 1980s there were

more than 100 forms of the ASCII data stream. With the advent of page printers like the Hewlett-Packard LaserJet^{**}, printer data streams became much more complex and allowed use of typographic fonts, image, and graphics functions. Hewlett-Packard Printer Control Language (PCL^{**})¹⁸ and Adobe PostScript¹⁹ are examples of PC page printer data streams.

The multitude of different printers became a problem for both the application-software writers and the printer vendors. Since printer drivers were embedded within applications, new printer functions required support from application programs. Application-software writers were spending too much time writing printer drivers, taking time away from their business of application development. Popular applications such as WordPerfect^{**} and Lotus 1-2-3^{**} each had dozens of different printer drivers shipped. The printer vendors were frustrated because each time they introduced a new printer they had to convince software vendors to support its new features. Software-driver support was rarely available at the same time a new printer shipped, and if the volumes of the printer were not high enough, it was never available. The application-software writers had to be selective about which printers they could support.

To solve the problem of printer support, the PC operating system vendors built standard presentation interfaces into their systems. Apple Computer Inc. was the first to do so with their Quickdraw²⁰ interface on the Macintosh^{**} systems. IBM and Microsoft Corporation later developed OS/2²¹ and Windows²² with a similar model. The presentation interface provided a *common imaging model*, i.e., a single interface for displaying or printing graphics, text, and image independent of the presentation medium, be it a low-resolution display or high-resolution printer. Applications using this interface are isolated from display or printer dependencies. Support of a particular display or printer is provided through a device driver developed by the operating system or device vendor. These device drivers conform to a standard device driver interface (DDI) and are invoked by the system to render output on a specific device.

The OS/2 imaging model is depicted in Figure 4. Part of the OS/2 Presentation Manager (PM) API is the graphical programming interface (GPI). The GPI provides a robust set of text, graphics, and

image primitives that applications can use to generate output in a device-independent manner. Device drivers, which can be built by display and printer vendors, are invoked through a device driver interface (DDI) to render the output on their particular device. The flexibility of the DDI allows exploitation of sophisticated devices (e.g., ones that can directly process vector graphics) but can also support limited devices which may only be able to support image. The graphics engine will simulate those functions that cannot be directly handled by a device.

AFP software includes an OS/2 PM device driver that allows any OS/2 PM application to produce the MO:DCA-P data stream. A similar capability is also provided for the Microsoft Windows environment.

While solving one problem, this approach created other problems. The system vendors hoped that printer vendors would develop the device drivers. Unfortunately, printer vendors did not always understand software and struggled with the complexity of writing these drivers. This problem has largely been solved by tools facilitating device-driver development and joint development between printer vendors and system vendors. A second problem is performance; if the printer cannot handle the constructs that the API defined, it is forced to render the data as image. As faster desktop systems (e.g., Intel Corporation i486*-based systems) become common and the performance of printers improves, this problem will also be eliminated.

Local area network printing. Most early PC systems were stand-alone systems and were not networked. As a result, PC printer software and hardware were oriented toward personal printers that were attached to the local PC or workstation. Since applications could generate output much faster than the printers could print, spooling software was developed. Spooling software ran in the background and buffered print data so the application or user was free to do something else while the actual printing took place.

Local area network (LAN) hardware and software allows multiple PCs to be connected. By far, the most common reason people connect PCs is to share files or printers. Most of the common LAN networking software (e.g., Novell NetWare²³, IBM Lan Server,²⁴ etc.) ship print serving as a

standard part of the system. Often this print server software is based on personal workstation spoolers. It does a good job of spooling and scheduling jobs to a printer but it does not address

The most common reason people connect PCs is to share files or printers.

all of the requirements customers have for multiuser systems. In general, LAN print servers allow only printer data streams to be passed through to a printer. Management functions such as error recovery, accounting, font download, and data-stream transformations are lacking.

These limitations become more severe as departmental (i.e., higher-speed) printers are attached to servers and shared among users. For example, the Hewlett-Packard LaserJet III^{Si}, a common PC-attached departmental printer, can exemplify the difference between management requirements of departmental and personal printers. On a personal printer a paper jam is not a large problem because the user will see it and correct it immediately. On a departmental printer, a paper jam may take some time to be detected, at which point users' jobs will have been delayed. Other errors, such as the printer running out of memory or having the wrong font card, can result in lost or incorrectly printed jobs. The lack of management of PC-attached printers resulted from a lack of industry standard bidirectional printer protocols and print-server software.

As departmental printers become more commonplace and as their speed increases, there will be an increased need for management and integrity. AFP software supporting IPDS printers in the LAN environment solves this problem.

Movement to distributed environments

Today's computing environment is complex and heterogeneous. With low-cost PCs, workstations,

and networking technology commonly available, companies have built networks consisting of equipment and applications from many different vendors. It is common for companies to have a

The printing software in each environment typically supports different data streams and resources.

mixture of PCs and workstations from vendors such as IBM, Digital Equipment Corporation, Apple Computer, Inc., Hewlett-Packard Corporation, Sun Microsystems, Inc., and others. Connecting them via a network may require multiple network operating systems such as Novell NetWare, IBM LAN Server, and Transmission Control Protocol/Internet Protocol (TCP/IP). Those companies with host systems are connecting LANs to their host to provide access to corporate data and line-of-business applications. Connection to host systems requires support of additional networking protocols and data streams.

This heterogeneous environment poses a large print problem for companies. Because of the lack of interoperability between host and LAN printing, different islands of print capability have evolved. For example, a company may have printers dedicated to host production printing through JES, others dedicated to host transaction printing through CICS, and yet others dedicated to printing PC and workstation data. The result is frustration for users and increased printing costs. PC users are unable to print from their applications to host printers, and host applications are unable to access LAN printers.

In order to determine if distributed printing is possible in a heterogeneous environment, one must consider both nontechnical and technical issues.

Nontechnical issues. Different islands of printing may result in a lack of effective management and control of printing. The printing software in each environment typically supports different data

streams and resources. For example, a corporate logo or other artwork developed for host applications may not be usable by PC applications. This situation has led to multiple forms of the same artwork and a lack of a consistent corporate image for some companies.

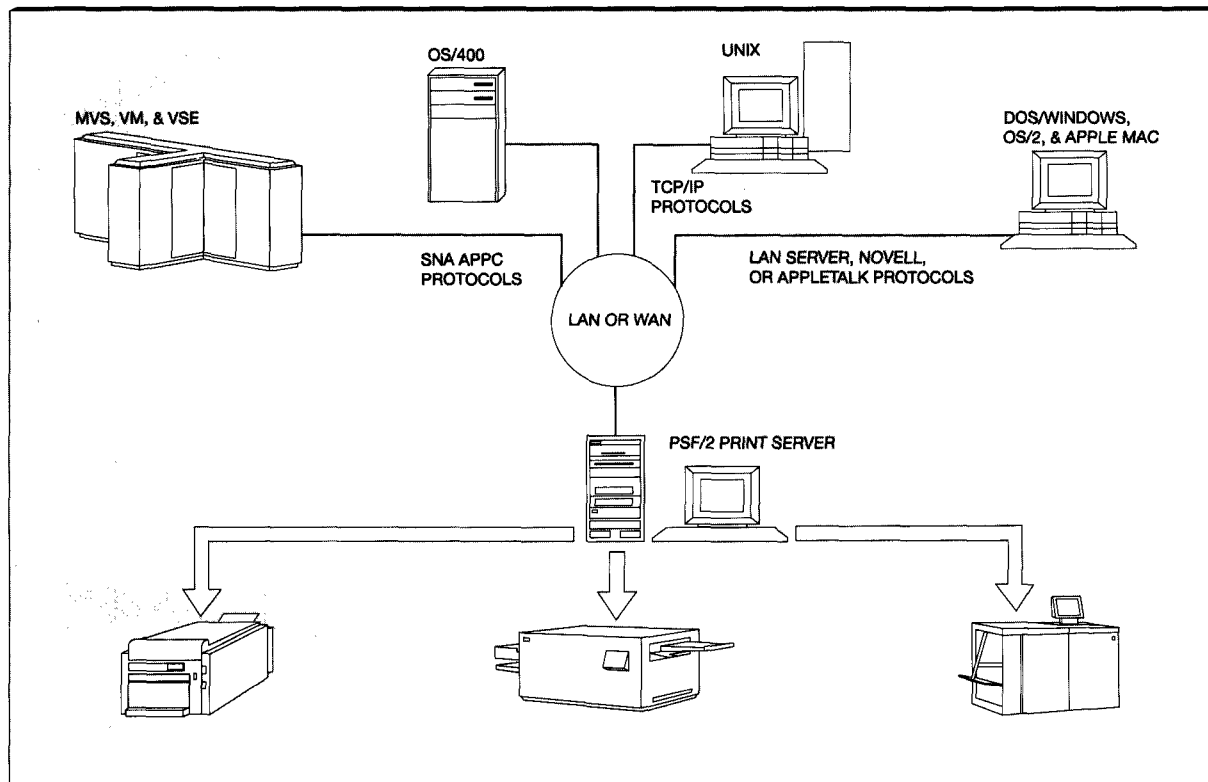
Different islands of printing also reduce productivity. End users need to understand which data stream is supported by which printer. For example, they may have a departmental printer located next to their office, but because it is set up to operate on a LAN, they are unable to print from their host database application. As a result they may have to print to a central host printer and wait several hours for their output.

Different islands of printing also increase costs. Printers dedicated to a specific application or environment may not be utilized fully. The cost per page of an under-utilized desktop printer may be as high as ten times that of a well-utilized departmental printer. Multiplied by thousands of printers across a company, this cost becomes significant.

Technical issues. Distributed printing software in operating systems today has evolved with the notion that only like operating systems need to be connected. Connecting unlike systems is much more complex and in some cases is impossible. For example, connecting two MVS systems for distributed printing is fairly easy. However, connecting an MVS system or Digital Equipment Corporation VAX** system to an OS/2 LAN Server for printing on a departmental printer is a challenge. Connecting unlike systems requires the following issues to be considered:

- Do the two systems support a common type of physical network connectivity? Token ring or Ethernet** are examples of physical connectivity.
- Do the two systems support a common networking protocol that provides distributed printing? TCP/IP, IBM LAN Server, and Novell NetWare are examples of networking protocols that support distributed print capability. Many non-IBM systems support forms of SNA connectivity but usually do not support distributed printing.
- Do the two systems support a common data stream? For example, OS/2 with Communications Manager* supports 3270 printer emula-

Figure 5 Print Services Facility/2



tion. This lets SCS and 3270 applications in MVS print on OS/2-attached printers. It does not, however, let JES or AFP applications print on OS/2-attached printers.

- If there is a solution to physical connectivity, networking protocols, and data streams, the final question is whether sufficient function is available in the protocols. For example, can you specify that the print job should be printed in duplex mode or that the paper should be pulled from the second input bin? Many existing distributed print protocols do not support the specification of such options.

AFP support for heterogeneous distributed environments

AFP is considered to be a de facto standard for high-function page printing in mainframe environments and is growing in use on Application System/400* (AS/400*) systems. The challenge of the 1990s, however, is outside of the traditional data

processing environments and is in the distributed environments. The set of AFP products and architectures has recently been expanded to support heterogeneous environments and address many of the PC printing issues discussed here.

Print Services Facility/2. The benefits and capabilities of AFP have been extended to the LAN environments through the Print Services Facility/2 (PSF/2) product (Figure 5). PSF/2 is a high-function AFP print server that runs under OS/2. Many of the PC- and LAN-printing issues discussed in this paper were considered when designing the PSF/2 product. Designed to be an *enterprise print server* that can connect and print from a wide range of systems, PSF/2 provides businesses with the ability to seamlessly share printers between host and LAN applications. In conjunction with the communications facilities of OS/2, it supports distributed printing from MVS, VM, VSE, and OS/400 host systems as well as LAN systems, including DOS, Windows, OS/2, AIX, and

many non-IBM systems. PSF/2 drives a wide range of printers from 4 impressions per minute (IPM) to 229 IPM and supports a number of different input data streams. It does this while preserving the management and integrity of AFP.

PSF/2 distributed print facility (DPF). PSF/2 supports distributed printing from host systems through an LU 6.2 client/server dialog between PSF on the MVS, VM, VSE, or OS/400 host system and PSF/2. By using PSF on the host systems as a client, PSF/2 can seamlessly support printing from host applications. In addition to downloading the data for the print job, the PSF host client automatically determines the fonts, overlays, and page segments required for the print job. If these resources do not exist on the server, or are out of date, they will be downloaded to PSF/2.

PSF/2 LAN distributed printing. PSF/2 relies on the robust communications facilities available for OS/2 to support printing from a wide range of PCs and workstations. The following LAN systems are supported:

- DOS, Windows, and OS/2 clients. They can be supported through IBM LAN Server or Novell NetWare protocols. Running IBM LAN Server on the PSF/2 system provides direct support for these systems. If Novell NetWare protocols are being used, the Novell NetWare OS/2 Requestor with RPRINTER is used to redirect print jobs from a NetWare server to the PSF/2 system.
- Apple Macintosh clients. They can be supported via the AppleTalk** support in IBM LAN Server 3.0 or via Novell NetWare.
- IBM AIX systems as well as other UNIX** and non-UNIX systems. They can be supported by running IBM TCP/IP on the PSF/2 system.

PSF/2 data streams. One of the major design goals of PSF/2 was to support the printing of a wide range of input data streams on all supported printers. PSF/2 does not limit the user to the input data stream supported by the printer but can automatically transform input data streams to the target printer data stream. This capability, combined with the wide range of systems to which PSF/2 can be connected, allows printers to be better utilized. With PSF/2 it is no longer difficult to print both host and PC data streams on a single printer. Input data streams and applications supported by PSF/2 include:

- MO:DCA-P
- PostScript Level 1
- Proprinter and Quietwriter ASCII
- MVS, VM, VSE, and OS/400 host applications—They are supported through the PSF/2 distributed print facility (DPF). Existing host data streams such as System/370 line data and OS/400 SCS data are supported through this facility.
- Microsoft Windows applications—They are supported through a Windows MO:DCA-P device driver. Through this driver, all Windows applications can generate MO:DCA-P. Windows applications are also supported through the Windows PostScript device driver.
- OS/2 applications—They are supported through an OS/2 PM MO:DCA-P device driver. Through this driver, all OS/2 PM applications can generate MO:DCA-P. OS/2 applications are also supported through the OS/2 PostScript device driver.

PSF/2 printers supported. PSF/2 supports the entire range of IPDS page printers provided by Penant Systems. Because of the wide usage of Hewlett-Packard PCL printers such as the LaserJet in the PC or LAN environment, PSF/2 provides full support for those devices. PSF/2 allows supported input data streams including MO:DCA-P and PostScript to be printed on Hewlett-Packard PCL-4 and PCL-5 compatible printers, including the IBM 4019, 4029, and 4039 page printers. PSF/2 also supports a range of printer attachments, including System/370 channel, coaxial, parallel, and LAN.

PSF/6000

PSF/6000 extends AFP capabilities to the IBM RISC System/6000* AIX environment. It provides new levels of printing function and performance not previously available in the UNIX environment. As with PSF implementations on other platforms, PSF/6000 works as an integral part of the system spooler. It supports standard operator commands for configuration and management and the common AIX print data streams. PSF/6000 can function as a stand-alone print driver or as a print server for TCP/IP networks. The range of performance available on the various RISC System/6000 models allows PSF/6000 to span a range of environments, from small LANs to high-end production environments.

As with PSF/2, PSF/6000 drives IPDS page printers and Hewlett-Packard-compatible printers such as the IBM 4019, 4029, and 4039. It supports printing

of the following input data streams: MO:DCA-P, PostScript, ditroff, and Proprinter and Quiet-writer ASCII.

Need for an enterprise presentation strategy

As businesses re-engineer to streamline work processes and become more productive, the focus in information systems has shifted from data processing, storage, and communication to information access and presentation. Information is a critical asset of every business, yet consultants estimate that most information used by businesses is not accessible on line. It is in file cabinets, desks, libraries, and other storage areas. Access to this information is inefficient and labor-intensive—as much as 25 percent of office workers' time is spent processing documents.²⁵ New technologies such as facsimile machines allow documents to be quickly disseminated among businesses and people. Unfortunately the inability to easily capture, index, and retrieve facsimile pages adds to the burden of unmanageable information.

Many businesses are implementing workflow-management or document-imaging systems that allow the capture and archiving of documents and provide on-line access to them. With continuing improvements in the price-performance of optical storage, many businesses have found optical storage to be less expensive than microfiche. The benefits in productivity and efficiency resulting from on-line access to data provide additional justification for moving to optical storage. Unfortunately most of today's archival solutions address a specific requirement such as computer output microfiche (COM) replacement or office-document imaging. Many companies want a solution that can address application capture of coded data as well as capture of noncoded data such as scanned forms, documents, and facsimile. In addition, they do not want the capture of coded data to be limited to 1403 line data or simple ASCII text.

AFP: addressing enterprise presentation requirements

AFP is well-positioned among presentation systems to provide the base architecture for storing, managing, and presenting information anywhere in the enterprise. The paginated, object-based structure of the MO:DCA-P data stream lends itself to interchange and viewing. MO:DCA-P is fast and easy to parse (i.e., it does not need to be inter-

preted) and clearly defines the beginning and end of pages and documents. Other common data streams do not enforce a page or document structure and are difficult to process efficiently. An-

The MO:DCA-P architecture has been extended to support indexing constructs.

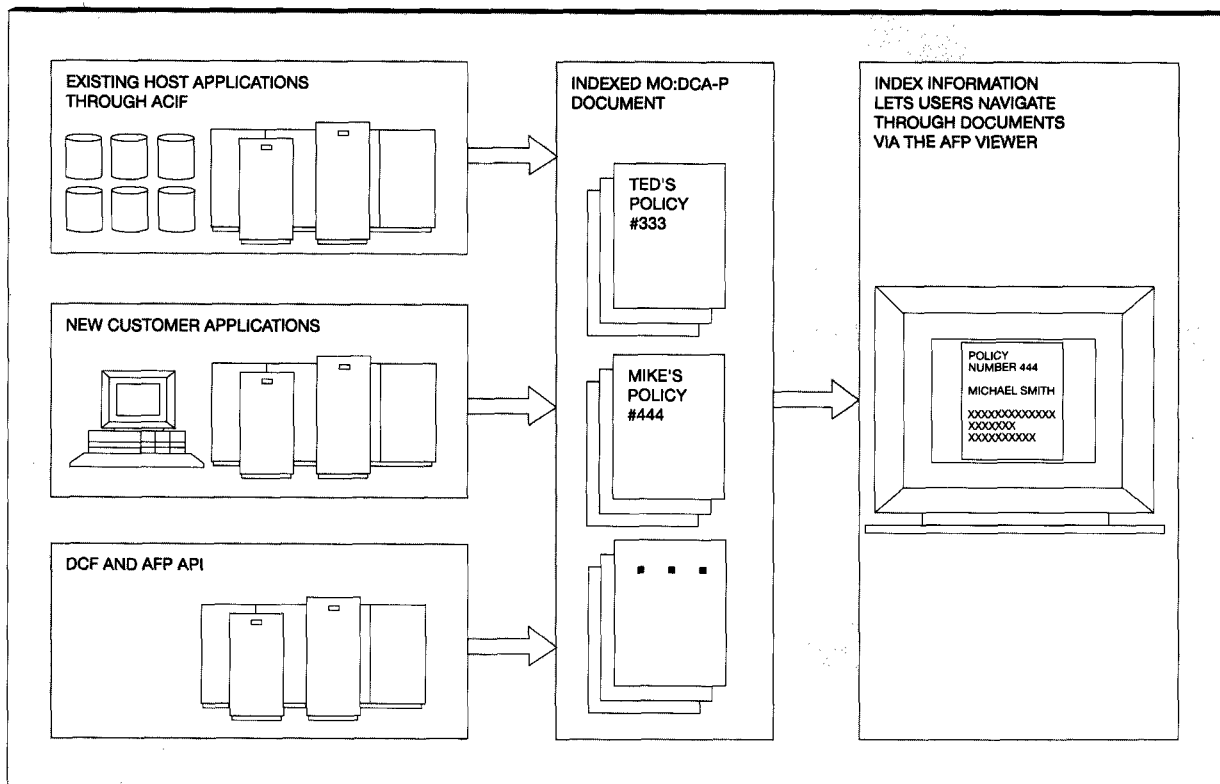
other important feature of MO:DCA-P is page independence. For example, in a 20-page document it is possible to efficiently locate and process (i.e., print or view) page 20 without having to process the data for pages 1 through 19.

The MO:DCA-P architecture has been extended to support indexing constructs. New MO:DCA-P data stream structures allow a user viewing a document to easily navigate within the document. These new MO:DCA-P structures allow applications to specify how documents are to be indexed. For example, an insurance application can specify that a document should be indexed by policy number, client name, and client zip code. Since each policy could be many pages, additional index information could indicate where different sections of a policy begin. Another example is an electronic publication. Index information could specify where chapters and sections within chapters begin. Users could directly access any point in a document based on a *table of contents* view of that document. Indexing of MO:DCA-P documents is flexible and is based on application-defined criteria. See deBry and Munger²⁶ for additional information on this subject.

Building indexed MO:DCA-P documents

The ability of businesses to easily build indexed MO:DCA-P documents (Figure 6) is a very important component of the AFP presentation strategy. Businesses have a large investment in existing applications which they must be able to leverage with this technology. The following tools allow indexed AFP documents to be easily built.

Figure 6 Applications generating indexed MO:DCA-P documents



AFP Conversion and Indexing Facility (ACIF). ACIF*²⁷ is a powerful tool for converting the output of System/370 host production applications into an indexed MO:DCA-P document. It will work with most existing host line-mode applications regardless of whether they are using AFP capabilities. ACIF processes three input sources:

- Index parameters that specify how the line data should be indexed. Since line data is repetitive in nature, ACIF can use conditional-logic specified in the index-parameter file to automatically generate indexed MO:DCA-P documents. For example, the index-parameter file could specify that the policy number is in column 30 on the top of the page for a new policy. ACIF then builds an index in the output MO:DCA-P file that can be used to directly access the beginning of a policy.
- The AFP resources that PSF would use to print the data. ACIF processes a page definition, form definition, overlays, fonts, and page segments

to build the MO:DCA-P output file exactly as PSF would process them at print time.

- The print data that can be line data, line data mixed with MO:DCA-P data stream structures (called mixed data), or MO:DCA-P documents. The indexing capabilities also work when processing MO:DCA-P data but are more limited since MO:DCA-P is not row- and column-oriented like line data.

The output of ACIF is a fully composed MO:DCA-P data stream containing all of the indexes. ACIF produces an external index file that can be used by other applications such as report distributed systems or document-management systems that have their own indexing scheme. ACIF also builds a file containing all of the resources (e.g., overlays, page segments, etc.) required by the document. When archiving documents it is important to keep the resources required so that the documents can be recreated exactly at a later time.

AFP API. The AFP API provides an interface to allow applications to build indexing information into documents. Applications building MO:DCA-P documents directly via the AFP API have a great deal of flexibility in specifying index information since they may have an understanding of what the data mean.

Document Composition Facility. The Document Composition Facility (DCF*) is an AFP application that supports document formatting and publishing. A powerful application that supports justification of text using typographic fonts, multiple columns, tables, headings, footnotes, imbedding of graphics, and many other formatting functions, DCF supports the use of a generalized markup language (GML) that allows the definition of hierarchical document structures (e.g., levels of headings, which, for example, could correspond to chapters, and sections within chapters).

DCF has been enhanced to support the building of indexed AFP documents. New formatting tags²⁸ support the specification of specific index information, allowing users a great deal of flexibility in indexing documents. In addition, documents that were built using GML need only to be reformatted via DCF to have index information automatically built. The resulting index will be much like a table of contents.

Viewing MO:DCA-P documents

The ability to view MO:DCA-P documents is a fundamental piece of the AFP presentation strategy. Combined with the ability to easily create indexed AFP documents, it provides a powerful presentation solution for many businesses. AFP viewing is implemented through the AFP Workbench* product.

The AFP Workbench (Figure 7) supports viewing the MO:DCA-P data stream and associated resources (e.g., overlays) and runs on workstation platforms.²⁹ In order for on-line viewing to be a productive tool, users must be able to do more than scroll backward and forward through a document. The AFP Workbench will use the MO:DCA-P indexing information to allow users to navigate through documents in a flexible, application-specific way. For example, when viewing an on-line book or article, the user is able to directly access a specific chapter, section, or figure. Another example, illustrated in Figure 7,

is the ability to navigate directly to a specific insurance policy. One of the benefits of using the MO:DCA-P presentation data stream for viewing is that the viewed page looks exactly³⁰ like the printed page. Fonts are rendered through Adobe Type Manager** (ATM) and are high quality. Even external resources such as overlays and page segments will be displayed correctly with the page data.

The AFP Workbench will provide open interfaces to allow it to function with other applications such as facsimile, scanning, document-management, and report-distribution systems that could exist on the workstation desktop. These applications will be able to interface to the AFP Workbench through dynamic data exchange (DDE) facilities.

Where AFP is headed

AFP today provides a powerful presentation solution for many businesses. It will continue to evolve and address new requirements. Two areas of focus will be distributed systems support and presentation enhancements through the AFP Workbench.

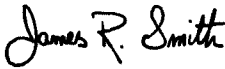
AFP Workbench directions. Over time additional applications will be added to the AFP Workbench. Some of these will be developed by Pennant Systems; others will be developed by independent software vendors and partners.

Scanning support. A future AFP Workbench component will support scanning of documents and converting them into MO:DCA-P. The capability to index these documents to facilitate retrieval will also be provided. Since MO:DCA-P directly supports the same compression algorithm (CCITT G.4) as scanners, the conversion from scanned data to MO:DCA-P is only a matter of adding MO:DCA-P header, trailer, and indexing information to the CCITT G.4 object.

Annotation support. The AFP Workbench will support annotation of documents. Users will be able to annotate documents with text, other documents, and scanned data.

Archival support. In the future, Pennant Systems will provide a high-performance client/server-based document archival system that integrates the AFP Workbench. This system will capture application-output as indexed MO:DCA-P files and

Figure 7 AFP Workbench Viewer

Viewer-INSURE.AFP	
File Edit View Search Options Help	
 Insurance Specialists	Disability Income Policy The Preferred Professional Insurance Specialists Company 100 Main Street Anycity Anystate 99999-9999
Insurance Specialists Company will pay the benefits provided in this Policy for loss due to injury or Sickness. We have issued this Policy to You in consideration of the payment of the premium and the statements made in Your application. Your application is part of Your Policy. Insured Lauren J. Baker Policy Number 434-9934300-22 05-15-89 Date of Issue	
NON-CANCELLABLE AND GUARANTEED CONTINUABLE TO AGE 65. NO CHANGE IN PREMIUM RATES. As long as the premium is paid on time, We cannot change Your Policy or its premium rate until the first premium due date after Your 65th birthday. RENEWAL OPTIONS AFTER YOU REACH AGE 65. SUBJECT TO CHANGE IN PREMIUM RATES. From age 65 to age 72, You may continue Your Policy for a Total Disability benefit with a limited benefit period while You are actively and regularly employed full time. This option is explained in PART 5. When You are no longer actively and regularly employed after the age of 65 or when You reach age 72, You may continue Your Policy for the rest of Your life. The benefits will be limited to a Hospital Confinement Indemnity. This benefit will take the place of all other benefits under the Policy. This option is explained in PART 6. YOUR RIGHT TO CANCEL. If You are not satisfied with Your Policy, You may cancel it. Return the Policy to Us or Our agent by midnight of the tenth day after the date You received it. If You return the Policy by mail, it must be properly addressed, postage prepaid, and postmarked no later than midnight of that tenth day. Our mailing address is 100 Main Street, Anycity, Anystate 99999-9999. Within ten days after We receive the Policy, We will refund any premium You have paid. The Policy will be considered to have never been issued. READ YOUR POLICY CAREFULLY. It is a legal contract between You and Us. Signed for Insurance Specialists Company	
 Secretary  President  Counter signed by:	

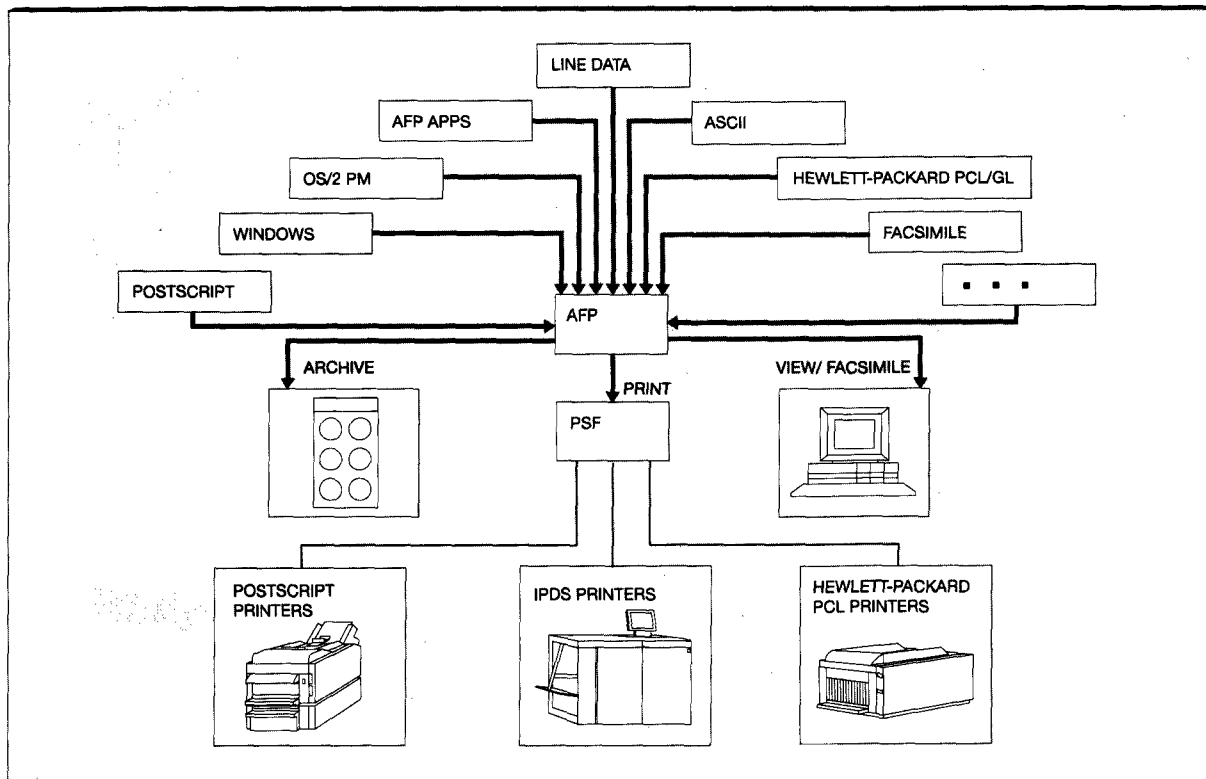
store it in LAN-attached optical jukeboxes. End users will be able to use the AFP Workbench to retrieve and view documents on their PCs. The combination of MO:DCA-P indexing and the object-based retrieval capabilities of the document archival system will provide businesses with a powerful facility for accessing information on line.

Multimedia. As multimedia support becomes common on PCs and workstations, businesses will take advantage of it for many applications. One of these applications is the annotation of docu-

ments. Extensions to the AFP Workbench will support adding audio or video annotation to MO:DCA-P documents. Although there are many potential uses of this technology, a practical one is a customer-service application. Imagine a service agent using the AFP Viewer to review a statement or bill on line. A phone conversation with the customer could be recorded and added to the statement or bill as an annotation.

Multimedia objects will also be supported directly within MO:DCA-P documents. MO:DCA-P documents, such as a parts catalog, will be able to

Figure 8 Future AFP presentation model



display full-color photographs as well as audio and video clips.

Distributed printing directions. Most of today's distributed-printing protocols are designed to address a homogeneous environment. For example, OS/2 LAN Server supports distributed printing between DOS and OS/2 clients and OS/2 servers. It does not define open standard interfaces to allow any vendor to plug in a client or server. OS/2 distributed printing also depends on other OS/2 facilities for interprocess communication, directory, etc. This problem is common among many distributed applications (e.g., file and database) and is not limited to print. As a result, companies are forced to exploit multiple networking protocols to achieve interoperability in a heterogeneous environment. Although these different networking protocols may all share the same physical attachment (e.g., Ethernet), they require separate management and administration, may require the user to log on

multiple times, and generally support different levels of function that are apparent to end users.

One of the crucial pieces necessary to solve this problem is a set of building blocks on which distributed applications can be built. Common directory services and transport-independent interprocess communication facilities (e.g., Remote Procedure Call) are two key building blocks. IBM and many other companies are supporting components of the Open Software Foundation Distributed Computing Environment (OSF DCE³¹) for these building blocks.

A key direction for distributed printing is the Palladium³² print system. Palladium is a client/server-based distributed printing system that supports the International Organization for Standardization (ISO) Document Printing Application (DPA) 10175 standard.³² This ISO standard defines the protocols and objects required to support dis-

tributed printing between systems. Initial work on Palladium began in 1988 at the Massachusetts Institute of Technology in the Athena** project. IBM, Digital Equipment Corporation, and Hewlett-Packard Corporation all participated in the initial design and development of the Palladium print system. In 1991 a Palladium prototype was submitted to the Open Software Foundation in response to the printing services portion of the Distributed Management Environment (DME) request for technology.

Palladium supports the ISO DPA 10175 standard protocols and objects and is built on top of OSF DCE services. It has the potential to provide a much higher level of distributed printing interoperability between vendors. In addition to specifying how to submit a print job with appropriate print options, Palladium gives end users an easy way of querying and managing their own print jobs in a local-remote transparent manner. Much of the benefit of Palladium will be in the simplification of print system management. Palladium support for a central directory of printers will reduce the time it takes to add new printers in large networks. It will support the ability to remotely manage print servers or to manage a network of print servers from a central PC or workstation.

Palladium will not replace the PSF/2 or PSF/6000 distributed print servers but will complement them. It will allow a larger number of systems to access the AFP capabilities provided by PSF/2 and PSF/6000 and will simplify the network management issues inherent with many existing distributed print protocols.

Summary

This paper traces the evolution of AFP in the ways in which it has evolved from a host-based printing architecture to an enterprise-wide presentation solution. New AFP products provide LAN solutions that can seamlessly integrate host and LAN printing and support on-line viewing and management of information. Figure 8 illustrates how the AFP framework can bring together multiple data streams and devices into a common solution for businesses.

*Trademark or registered trademark of International Business Machines Corporation.

**Trademark or registered trademark of Adobe Systems, Inc., Microsoft Corporation, Hewlett-Packard Corporation,

WordPerfect Corporation, Lotus Development Corporation, Apple Computer Inc., Novell, Inc., Intel Corporation, Digital Equipment Corporation, UNIX Systems Laboratories, Inc., Open Software Foundation, or Massachusetts Institute of Technology.

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Accepted for publication June 16, 1993.

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Reprint Order No. G321-5529.