Maximizing Your Printing in an AS/400 World

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Printing has always been an important, fundamental operation in any IT system. It is important because in many cases what is printed represents the only communication between an organization and its customers. Printing has become much more important as it has evolved into the much greater role of creating, managing, and presenting digital information. What you can do with information on a piece of paper is limited. What you can do with the same information in fully electronic format is virtually unlimited.

At the same time, it is also important that printing is not something an organization spends a lot of time on. This means that printing should be a simple, integrated process that does not require a lot of extra management to get it done right. This has been the heritage of the AS/400, and there is no reason why today's network environment necessarily means that should change.

Maximizing printing in an AS/400 environment means that both elements described above are addressed. It means maximizing the transition from a printing-only model to a digital information model. It means minimizing the operational requirements in getting the print process done. The objective of this abstract is to introduce the facilities of advanced print and digital presentation on AS/400, and how they can used most effectively. The underlying architecture on AS/400 for the creation, management, and presentation of digital information is AFP (Advanced Function Presentation), and this will be the primary focus here.

This abstract represents a condensed version of a complete treatment on the subject, the *AS/400 Guide to Advanced Function Presentation and Print Services Facility (S544-5319)*. This guide can be accessed electronically at www.printers.ibm.com/as400 in the online manual section or ordered hardcopy.

Evolution or Revolution

Until recently, the AS/400 print model was designed to print AS/400 application data on mostly impact printers attached via twinax connections. The information being printed was generally line-oriented output, and most documents were only in final form when physically printed on a preprinted form. Certain "downstream" operations that were desirable on this data,

such as fax, archival, and electronic presentation, had to be done manually.

As the AS/400 has evolved to support new technologies, such as Java, network computing, TCP/IP, and e-business, the print model has been transformed into an integrated system to create, manage, and present digital information. Application output now spans the spectrum in complexity from simple text data to fully electronic pages utilizing electronic forms, multiple fonts, image, graphics, and barcode elements. Print management now includes the capabilities to print in a TCP/IP network environment to a wide range of printers while preserving established "mission-critical" operating characteristics. Finally, and most importantly, this fully digital information can flow automatically to fax, view, archive, retrieval, electronic distribution, and network "presentment" functions.

AS/400 Print Flow

Let's start at the beginning with a basic understanding of how digital output information is created and managed by the AS/400. Figure 1 shows a very conceptualized representation of the AS/400 print flow. In today's networked computing environment, client, network, and AS/400 applications create output to be managed by OS/400.

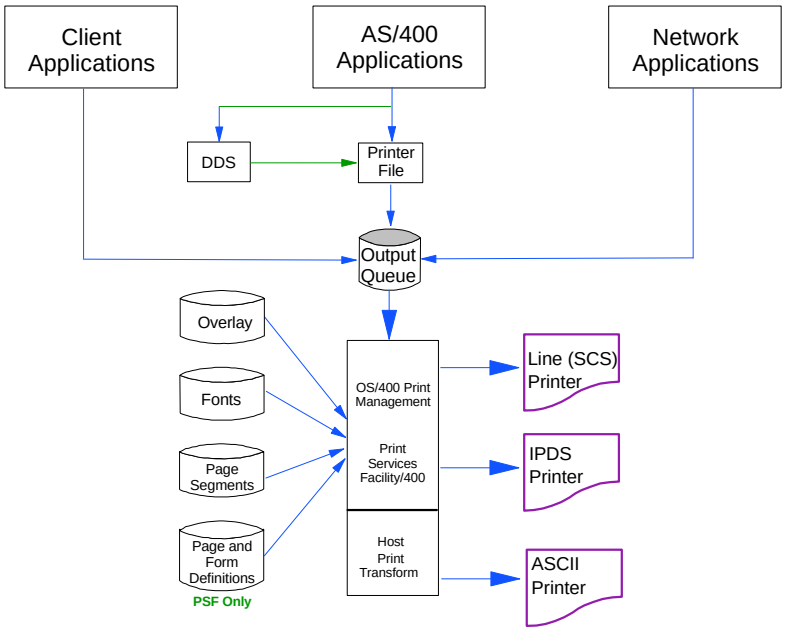

Figure 1. AS/400 Print Flow

Central to the AS/400 print subsystem is the **output queue**. This is the repository where client, network, and AS/400 print files flow through the system. The AS/400 supports three basic types of print files:

- SCS (SNA Character Set)
- AFP
- ASCII

SCS and AFP are native print datastreams to the AS/400. ASCII print files are handled transparently, meaning that the AS/400 does not understand the contents and simply passes the entire file to the printer. A wide range of functional options operate on output queues that let you manage and schedule the printing of print (spool) files and provide users full control of the printing process.

Application programs can reside on the client, the network, or the AS/400. Client and network applications can produce SCS or AFP print files by using the print drivers shipped with Client Access/400. Client and network applications can also generate standard ASCII formats (for example, PCL) and route those to AS/400 output queues. For AS/400 applications, output can be defined either within the application program (program-described) or external to the application program (externally-described). If the output is program-described, then the application program (RPG, COBOL, C) formats all of the data on the page one line at a time. Program-described output is normally SCS. With externally-described print applications, the page formatting is provided by Data Description Specifications (DDS). The application program simply passes records of data to DDS.

DDS determines how each field of every record from the application program is formatted on the page. DDS supports both SCS and AFP formatting. Fields can be individually placed on the page in any font or orientation. DDS keywords support all of the page formatting characteristics of AFP, including drawing lines and boxes, printing static or variable text in any font, printing data in bar codes, and selecting external resources such as overlays, page segments (images), and graphics. Some fields can be placed on the page as bar codes. DDS keywords enables lines and boxes to be drawn, as well as many sophisticated formatting options, such as the selection of AFP overlays. DDS also controls the use of external print resources. The resources may be downloadable fonts, overlays, or page segments (scanned images, such as logos or signatures).

The application program may or may not use DDS, but it always uses a **printer file**. Values specified in the printer file determine general characteristics of the entire print job, such as what printer the job will be

sent to, whether to print simplex or duplex, whether to print multiple pages per side, whether to add an overlay to every page, and so on. The printer file also supports page definitions and form definitions. These objects are subprograms that define how line-oriented application data can be reformatted in full electronic pages. This transformation is done dynamically as the print file is sent to the printer.

Let's now look at the printing side of the AS/400 print flow equation. As already indicated, the AS/400 supports three different kinds of print datastreams - SCS, AFP , and ASCII (there is also transform support for several image file formats - TIFF, BMP, and GIF). The application that controls printing is the print writer. Its job is to manage a spool file to a printer. The three print writers differ dramatically in how they accomplish this task.

Figure 1 shows the three print writers. The selection of the print driver by OS/400 is determined by the format of the print file and the datastream to be used by the target printer.

The base OS/400 print writer is responsible for printing SCS print files on SCS printers. It also invokes the other two print writers as required.

Printing to IPDS printers is managed by the second print writer, Print Services Facility/400 (PSF/400). PSF/400, a feature of OS/400, will handle both SCS and AFP print files when they are being printed on an IPDS printer. For AFP print files, PSF/400 performs the following functions:

1. The AFP datastream is transformed into IPDS (which is a printer-specific datastream).
2. Resources referenced by the print file, such as fonts, page segments, and overlays must be retrieved on the AS/400 and sent to the printer.
3. If page and form definitions are used (more on this later), PSF/400 must combine the line-oriented output of the application with these resources in order to assemble each AFP page.
4. The transformed (IPDS) file is sent to the printer. Because IPDS is a bi-directional data stream, PSF/400 manages a two-way dialog with the printer. Through this dialog, PSF/400 manages error recovery. If printer intervention is required during the printing of a job, PSF/400 resumes printing at the next page in the job so that no data is lost and the job does not have to be sent to the printer again.

The third print writer is Host Print Transform (HPT). HPT supports printing to ASCII printers. There are many different ASCII formats. PCL is the major page-oriented ASCII format. HPT will convert SCS and AFP print files to the appropriate ASCII datastream for a specific printer.

HPT uses a library of print drivers - called Workstation Customization Objects - that define the specific operation codes for each supported ASCII printer.

The OS/400 print writer and PSF/400 provide full print services to SCS and IPDS printers. Print management support for ASCII printers using Host Print Transform is much more limited.

An AFP Primer

Advanced Function Presentation (AFP) is the printing and presentation system that enables you to take full advantage of printing technology on the AS/400. AFP helps you combine the capabilities of high-function Intelligent Print Data Stream (IPDS) printers and print software to:

•Create state-of-the-art documents
•Exploit print formatting capabilities without changing application programs
•Replace traditional, labor-intensive print operations with a system-managed process
•Print with complete system management and full error recovery, whether the printer is system-attached via twinax or network-attached via TCP/IP.

Advanced Function Presentation can best be understood by describing its component parts:

•Document or page layout architecture
•Printer management architecture (IPDS, or Intelligent Printer Data Stream)
•Printing systems management architecture

As a document architecture, AFP is also known formally as MODCA-P, or Mixed Object Document Content Architecture - Presentation. As the name implies, AFP defines pages of output that mix all of the elements normally found in organizational documents - text in typographic fonts, electronic forms, graphics, image, lines, boxes, and bar codes. The AFP datastream is composed of architected, structured fields that implement each of these elements. This datastream is system and printer independent.

Figure 2 provides an illustration of an electronic document highlighting the key components, as follows:

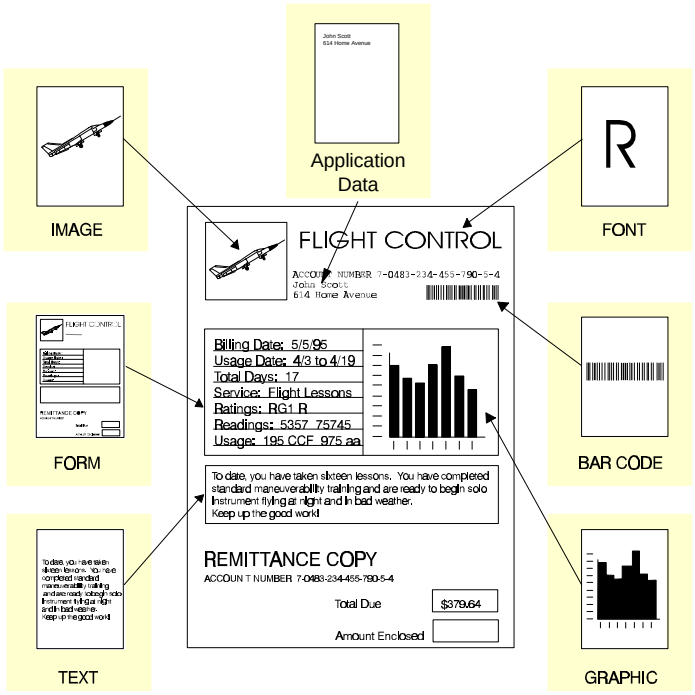

Figure 2. Electronic Document

AFP output can contain **text**, which is character data in the form of letters, numbers, punctuation marks, special characters, and signatures. Character data is printed using fonts. A font is a collection of graphic characters sharing the same type family, type style, type weight, and type size (for example, Helvetica Medium Bold 10-point). You can use any number and combination of different fonts on a page.

AFP output can contain **image** data, which is a series of static picture elements (called pels) arranged in rows and columns. Image data is created either by a scanning device or a program and is stored in a set of MO:DCA-P structured fields called a page segment. The image data can also be included within an overlay resource. Typical examples of image objects are company logos and electronic signatures.

AFP output can contain **graphics** data. Graphics data differs from image data in that it is dynamic. Graphics data is represented by a set of mathematical commands that draw a certain element. Graphics are used to represent data that varies by page in formats such as bar charts and pie charts.

Bar codes represent characters by sets of parallel bars of varying thickness and separation that can be read optically by transverse scanning. These codes can represent, for example, product numbers, part numbers, and zip

codes. Bar codes are designed to be read by a device called a bar code reader or scanner. Many different types of bar code arrangements, or symbologies, have been developed for specific applications. Some of the more common bar code symbologies are:

- Code 3 of 9
- Codabar
- Interleaved 2 of 5
- Code 128
- Universal Product Code (UPC)
- European Article Numbering (EAN)
- Postnet (Postal Bar Code)

All of the bar codes above are one-dimensional symbologies. This means the scanner cuts across the pattern of bars and spaces and reads (decodes) a string of characters. A recent innovation is two-dimensional (2D) bar codes such as UPS Maxicode. With these bar codes, the information is coded in both a horizontal and vertical pattern. 2D bar codes can represent far more data than a one-dimensional bar code. For example, a 2-inch by 2-inch Maxicode can contain up to 400 characters of data. This enables a small data file of information - in this case, postal code, country code, state, city and street address, service class, unique package ID, shipper ID, weight, and date of pickup - to be encoded on the package.

An **electronic form**, or overlay, is a collection of constant data stored as an AFP resource and primarily used in place of preprinted forms. An overlay can include some or all of the following elements, all of which are static:

- Vertical, horizontal, and diagonal rules
- Rules with different weights and thickness
- Boxes with and without shading
- Grids, arcs, and polygons
- Graphics or image, such as company logos
- Bar codes
- Text

Overlays facilitate complete electronic printing. They replace preprinted forms and the manual printing process. Electronic forms provide significant benefits over preprinted forms including:

- No forms inventory
- No obsolete forms
- Faster turnaround for new forms
- Less operator intervention

As a printer management architecture, AFP uses an interactive printer datastream called **IPDS** (Intelligent Printer Data Stream). This datastream is similar to the AFP datastream, but is built dynamically by PSF/400 specific to the destination printer in order to integrate with each printer's specific capabilities and command set, and to facilitate the interactive dialog between the AS/400 system (specifically, PSF/400) and the printer. AFP, SCS, and line data print files are transformed into IPDS prior to printing in order to support the bi-directional print dialog.

The two-way function of IPDS is a key component in AFP's system-managed printing process. This process includes document services, printer services, and print process management. Document services include identifying and automatically downloading externally referenced document resources such as overlays, images (page segments), and fonts to the IPDS printer. Printer services include monitoring printer resources and memory. Finally, the entire printing process is managed page by page to ensure each spooled file is printed completely and accurately. Error conditions at the printer are monitored and full error recovery is enabled at the AS/400 at the page level.

The system-managed printing process with IPDS takes on added significance in a network TCP/IP environment. Placing printers within the network and attaching them with an IP connection provides great flexiblity. However, TCP/IP print support is generally limited - essentially a one-way send of the print file. The AFP printing process and bi-directionality of IPDS provides a bridge across this type of connection. The result is the same application (ie. document capabilities) function and print management supported with twinax-attached printers. In addition, SCS print files are transformed into IPDS in order to be printed across an IP connection.

Creating AS/400 Print Applications

We have discussed the general print flow on AS/400. Let's take a closer look at the interfaces available to create fully electronic output. Application development for AFP output is supported with a wide range of interfaces, tools, and products. Integrated page definition support is provided by the following interfaces:

- AS/400 printer file
- DDS (data description specifications)
- Page and form definitions
- Advanced Print Utility (APU)
- AFP Toolbox APIs
- Third Party document design solutions

Printer File

As noted earlier, each AS/400 application creating output has an associated printer file. The printer file controls overall, or job level, print characteristics. Options, such as copies, page ranges, finishing, and multiple-up, can be specified. The printer file can also add electronic overlays to an existing application. For example, an invoice application that currently is printing on preprinted invoice forms can be migrated to fully electronic by converting the preprinted form to an electronic form and specifying that form name in the printer file.

Data Description Specifications (DDS)

With DDS, the application developer can precisely control all variable and static information on the page. Because variables can be passed from the application program to the external DDS printer file, each page can be composed "on-the-fly" with the layout directly determined from application data. DDS printer file support externalizes application output and extends it to full-page applications.

Figure 3 shows an example of how DDS is used within the printer file to define application output. The program builds the data fields to be printed and does a write to a DDS record format. The data fields are referenced within the record format. The printer file, through the DDS keywords, controls the position, orientation, font, and other characteristics for those fields. In addition, DDS provides access to all the elements--text, overlays, images, graphics, bar coding, lines, and boxes--that comprise complex electronic documents.

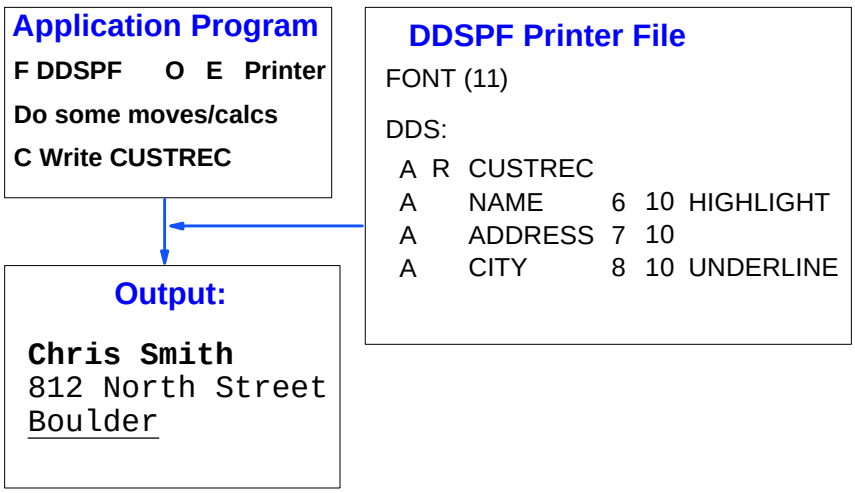

Figure 3. Data Description Specification (DDS) Concept

Advanced Print Utility

Advanced Print Utility (APU), a part of the AFP PrintSuite family of application enablers, is an end-user utility for transforming existing application output to advanced electronic documents. APU transforms

existing applications with line-mode output (using preprinted forms) to full-function electronic documents without changes to the "line of business" application program.

With APU, you can use data that produces multi-copy preprinted invoices as input to create electronic pages with customized copies.

APU, designed to build complex documents, has a simple end-user interface. Documents can include such elements as multiple page formats, multiple copies, and standard back overlays. APU provides application data remapping, enabling you to completely change the way the application data is printed. APU also provides output conditional processing, where data in the existing spooled output is used to determine document layout and flow.

Figure 4 shows the APU application flow. APU has a design phase and a production phase. During the design phase (which is done one time), a new electronic application is designed. This design process includes retrieving a sample spooled SCS file and displaying it for editing. The output of the design process is the APU print definition, which can define conditional logic, redefine data on the page, change fonts, and specify overlays, page segments, and bar codes.

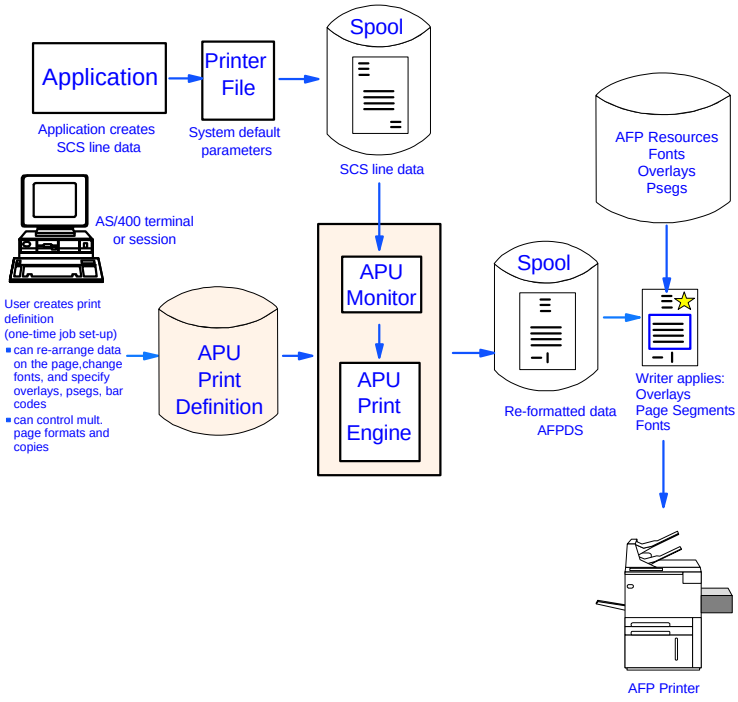

Figure 4. Application Flow with Advanced Print Utility (APU)

After the new design is ready, the APU Print Monitor is activated to put it into production. The monitor selects the target print file when it arrives in

a monitored output queue. It then follows a detailed "script" that you have designed that tells APU what to do with the target print file. Generally, the APU monitor retrieves an APU print definition, applies it to the target SCS spooled file, and places a new AFP print file in a specified output queue.

AFP Page and Form Definitions

When we look at DDS as an enabler for documents and reports, the integration of formatting with the application program is a significant advantage. It provides the application programmer with the capability to produce very customized output conditioned by the database and application data within the program.

However, there are environments where this tight integration is less desirable. It can make the task of coding application logic and output logic more complex because the logic is intertwined. Furthermore, the developer who works with the application programs may be different from the designer/developer that works with output formatting. There is a trade-off here: the customized output that DDS provides versus separation in the application development process.

New output formatting objects on the AS/400, page definitions and form definitions, provide a means to separate page formatting from the application program. These new objects, an industry standard in high-volume printing environments, were added to OS/400 with Version 3 Release 2 and Version 3 Release 7. The manner in which these formatting objects were implemented provides a dynamic method of transforming existing line-mode (SCS) print applications.

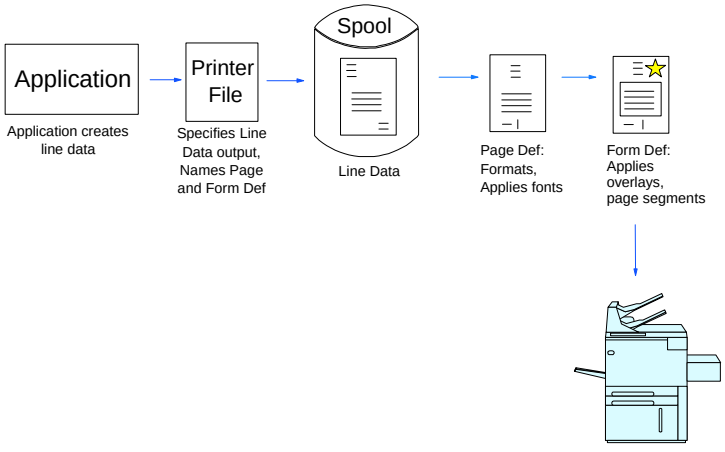

Figure 5. Application Flow with Page and Form Definitions

As illustrated in Figure 5, an SCS print application sends lines of output to the output queue.

With the simple reference of the page definition and form definition objects in the AS/400 printer file (and no changes to the application program), the output produced in the output queue is no longer SCS, but is AFP.

Page definitions and form definitions look and act like page formatting programs. They are developed in a source language (which can be front-ended with several different graphical tools) that defines how information is to be placed on the page. Figure 6 illustrates how page definitions and form definitions work. The page definition defines how data is placed on a logical page layout. Input print lines are read in, optionally parsed into individual fields, and placed on the page. Similar in structure to DDS, the page definition language enables you to place print lines or print fields anywhere on the page while controlling font, orientation, and color characteristics. Data can also be printed in a selected bar code symbologies.

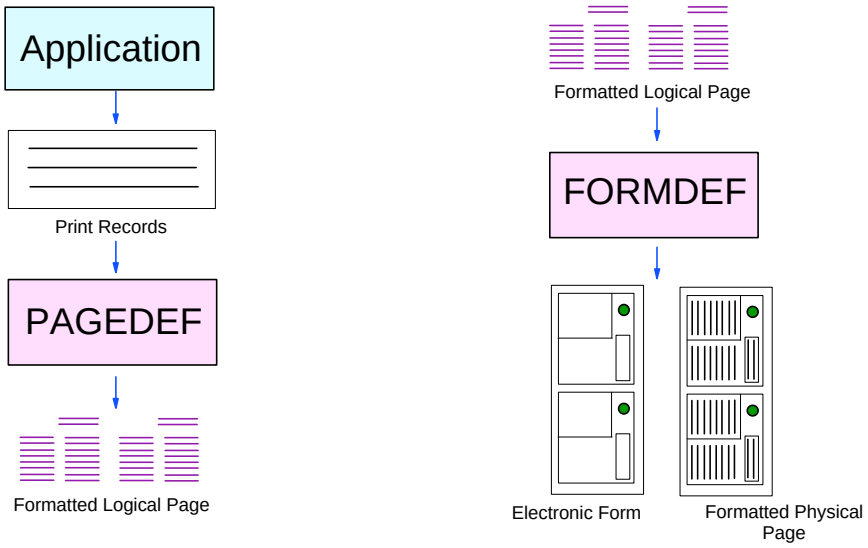

Figure 6. Function of Page and Form Definition Formatting Objects

The form definition controls how the logical page (defined with the page definition) is placed on the physical medium - the sheet of paper. Source statements within the form definition specify what drawer paper is selected from, what overlay(s) is placed on top of the logical page layout, whether duplexing is used, whether multiple logical pages should be placed on a single physical page, what copies are to be automatically created, and what

fields should be suppressed from which copy.

Other Design Interfaces
There are a number of additional products that intercept the output of existing AS/400 applications and reengineer it into fully digital AFP. Two examples are Custom Statement Formatter and DOC/1. These products are designed for applications such as statements and utility bills. They work in a similar fashion to APU. They would take an existing print file into a graphical design interface and redesign the pages. The new design would be stored as an object on the AS/400. A print engine would then monitor for the target print file, apply the design object, and create an AFP print file.

Beyond Printing

Once the entire page is created digitally by the AS/400, wide-ranging opportunities open up to operate on those pages. Printing is only one of many possible operations.

The **Client Access/400 AFP Viewer** provides the capability to resolve and view AFP documents graphically. It can also view other printed formats, such as SCS and ASCII, as well as a number of image file formats. Once viewed on the client, a document or image can be annotated, reprinted, or faxed from the client.

Facsimile Support for AS/400 provides comprehensive facilities to manage fax within your organization. It can handle inbound faxes; receiving, managing, viewing, and printing those documents. It can send any spooled information on your AS/400 outbound, including setting up and managing the transmission. Facsimile Support for AS/400 emulates an IPDS printers, so it actually invokes PSF/400 to build the outbound fax.

OnDemand for AS/400 is an archival/retrieval system. It can store documents and reports to disk, optical (COLD), or tape storage media. Both AFP and SCS print files can be archived by OnDemand. More importantly, OnDemand organizes and indexes application output. This function is essential in moving from the traditional print model - “print, then distribute” - to an electronic print model where output is produced, then immediately organized, indexed and stored electronically. This is a “distribute, then print” model. And, in this model, the printing is certainly optional.

For example, consider sales reports. Traditionally, they have been printed, then routed manually to the appropriate owner. Using the indexing and archival facilities of a system such as OnDemand, sales reports can be produced electronically and immediately stored for online access. Owners

can access the reports through PC clients or web browsers. They are able to first view the report and decide if all or a part of the report needs to be printed.

Other AS/400-based presentation solutions enable AS/400 print files to be e-mailed. An SCS print file, such as a report, or an AFP print file, such as a statement, can be attached to an e-mail and sent electronically. Still other presentation applications enable documents, such as bills or statements, to be presented directly to the web. These solutions convert the AFP document into HTML in order to take advantage of the interactive nature of HTML and provide for e-commerce applications such as interactive bill presentment and bill payment.

Summary

As you can see, the creation, management, and presentation of digital information represents a dramatic change from traditional printing. With Java, networking, and e-commerce, this area of AS/400 technology will continue to be a very dynamic one. What will remain the same is the need to have the right tools to create, manage, and present digital information. And, printing is not going to go away. Printing needs to complement these changes technically while retaining AS/400 integration and operational ease of use.

What can you do with Advanced Function Presentation

- Create your own forms in-house. This allows you to improve the flexibility and quality of your forms, avoid the expense of having someone create them for you, and avoid the inventory problems associated with preprinted forms (form obsolescence, storage, handling).
- Create your own bar codes. This allows you to automate your business processes, improve data entry accuracy and speed, and meet industry requirements for bar codes.
- Print line-mode data on page printers but also incorporate complex images and graphics such as graphs, charts, logos, and bar codes. This protects your investment in line-mode data and improves the quality and readability of your print output.
- Save time, paper, and unnecessary printing expenses by viewing your formatted output, with graphics and text merged, on a computer display *before* printing it or *instead* of printing it.
- Save paper and storage space by printing your system output with smaller fonts and by automatically printing more than one page of data on a single sheet.
- Include scanned images of transaction items such as canceled checks, delivery receipts, credit slips, and work orders in the statements you send to your customers. This can reduce billing inquiries and shorten your billing cycle by providing your customers with verification of their transactions. It can also save you time, expense, and postage by providing information electronically instead of manually.
- Print your office documents, letters, reports, and presentations but add different fonts, letterheads, logos, signatures, and graphics. This will improve the quality and appearance of your office documents.
- Convert any Adobe Type 1 fonts into fonts that can be used on AFP printers. You can select any fonts you need from over 1000 styles available in Adobe Type 1 format and use them with your AFP printers.
- Print postal permits and bar codes on your documents to convert them into mailers. This can save you the time and expense of filling envelopes and affixing stamps and perhaps can qualify your mail for cheaper postage rates.
- Change the format of printed output from your application programs without changing the application program itself. This will improve your programmers' productivity and use a single source of information for different purposes.
- Create pages containing images and graphics as well as text. This provides you with more flexibility in creating formats for your printed output.
- Create electronic documents that can be subsequently viewed, saved, faxed, reprinted, indexed, archived, and retrieved.
- Distribute documents and reports directly to Intranet or Internet customers.
- Print to network printers (i.e., TCP/IP-attached) with the same level of document function and print control that you have with system-attached, twinax printers.
- Scale up applications from desktop print volumes to production print volumes without changes to applications.

What are the Benefits of using AFP

Integration
The integration of application, development, and operational functions on AS/400 provides ease of use, productivity, and performance. AFP application development, among many enabling choices, uses high-level languages and Data Description Specifications (DDS), the same interface used in AS/400 application development. Managing AFP output uses printer files and output queues, and is an extension of AS/400 print management.

Efficiency
The AFP data stream is a highly structured, architected data stream that yields efficient, high-performance results. Many elements of the electronic document, such as overlays, bar codes, fonts, and image, are managed as separate objects. This means that the actual data stream from the output application is usually small.

Print Management
AFP is integrated into AS/400 print management and provides robust functionality. This functionality allows flexibility in managing and printing output files. And, more importantly, print management tracks the printing process to ensure that print jobs are printed accurately and completely. PSF/400, because of the two-way communication between the system and the printer, can manage down to the page level. AFP provides complete error recovery, guaranteeing the successful delivery of print to the printer.

Network Printing
Placing printers on the network enables a variety of systems and applications to use them. However, the standard print model for network printers is TCP/IP, and native TCP/IP support for print is very limited. AS/400 uses IPDS to manage network printers attached with TCP/IP, achieving the same level of print function and print management as twinax-attached printers.

Object Management
AS/400 is an object-oriented system, as is AFP. This allows applications to be broken up into objects (in the same manner as program, database, and display objects) and developed or managed separately. AFP extends this structure to electronic document elements such as overlays, fonts, and images. Such a structure facilitates a high-performance print process. It also enables the AS/400 system to easily control access to print applications, thus providing a security function.

Printer Integration
The integration of high-function printers with AFP output means that the printing process can be optimized to efficiently handle the support objects for an electronic document. For example, images are compressed to minimize storage and download time while IPDS printers are optimized to process this image, resolving and printing it at high rated speeds. Printing resources, such as fonts, overlays, and images are managed across job boundaries in printer memory, thus improving overall job throughput.

Scalable Applications
Documents and applications are scalable from low to very high print volumes. AFP is a page- and object-oriented architecture that enables performance tuning of print applications as the volumes increase. The actual printing architecture, based on IPDS, enables the AS/400 and the printer to cooperatively manage the printing process. In addition, IBM AS/400 printers scale up from desktop impact printers at 375 characters per second to production laser printing systems at over 1000 pages per minute.

Print Flexibility

AFP applications are part of a broader set of printing requirements for an AS/400 environment, where different print streams and different types of printers are commonplace. A number of tools facilitate the "any to any" printing of application output. AFP print can be routed to network or client-attached printers (using Host Print Transform). Network printing can be routed to AFP printers.

Integrated Application Output

Data Description Specifications (DDS) provides powerful, effective electronic documents, because it is integrated with the application program. This means that an individual customer’s document can be precisely tailored based on the data for that customer. For example, a customer invoice can be designed dynamically, with invoice segments and document elements dynamically placed based on the actual content of the customer transaction. This results in more readable, effective documents.

Application-Independent Electronic Documents

Where application integration of electronic output does not fit, you have many choices to format your electronic documents, independent of the application program. Advanced Print Utility (APU), page and form definitions, Print Format Utility (a module of Advanced Function Printing Utilities for AS/400 or AFP Utilities), and many third-party products provide this capability.