

Porting DPPX from the IBM 8100 to the IBM ES/9370: Migration

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This paper explains the development of the migration process by which applications running on a network of DPPX/SP systems would migrate to a network of DPPX/370 systems. DPPX/SP is a centrally managed, distributed processing system designed to run on the IBM 8100 family of processors. DPPX/370 is the DPPX/SP system ported to the IBM ES/9370 family of processors. The paper outlines the strategies, the technical problems encountered and their solutions, customer participation, and testing. Finally, it provides recommendations on how the process might have been improved.

The migration of customer systems was a major concern in the porting of the Distributed Processing Programming Executive (DPPX) operating system from the IBM 8100 to the IBM ES/9370 hardware. Moving a computer system from one hardware architecture to another is a formidable task, requiring significant customer investment in training, planning, and execution of the technical changes.

A key concern of 8100 customers was the ability to use their existing DPPX System Product (DPPX/SP) applications and databases on the new ES/9370 hardware base. Further complicating the move was the existence of large networks of 8100s running DPPX/SP.

A primary goal was to make the migration from DPPX/SP to DPPX/370 as straightforward as possible

with a minimum of change to end-user commands and operator functions. This goal was essential to the success of the ported operating system. Migration to a new version of the operating system, rather than conversion to a new system, implied that the customers' existing skills and knowledge of DPPX would still be useful, minimizing the amount of training required.

The migration of existing system definitions, applications, and data also preserved the customers' substantial investment in a proven network configuration. This allowed the customers to avoid conversion to an entirely new hardware and software system with inherent costs in education, recoding of programs, and conversion of existing data.

Another major goal was to provide easy-to-use documentation of the migration process. This documentation is contained in References 1 and 2.

The migration information had the following purposes: It had to persuade the customer to migrate and therefore had to be presented as a task that was

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not overly difficult, it had to help customers plan their migration, and it had to provide actual migration procedures.

A secondary goal was to allow DPPX/SP and DPPX/370 systems to coexist in a mixed network. This was important because large networks consisting of one

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hundred or more DPPX/SP systems were in existence. This is a unique problem to distributed processing systems, where hundreds of systems can be in the network. Thus, a customer could migrate one system at a time, verifying the success of the migration, before making a commitment to migrate the entire network. References 3 and 4 give a general description of DPPX distributed processing systems.

Another established goal was to migrate a production system within a weekend. Although the actual time period is affected by many customer-dependent variables, this goal served as a focus for the migration committee to identify tasks that could be performed prior to the actual migration.

Migration was defined as replacing DPPX/SP systems on a one-for-one basis with DPPX/370 systems. If a customer chose to retain an 8100 to control communication devices not supported by DPPX/370, it was assumed that no applications would remain on the 8100.

On the other hand, if a customer was just adding an ES/9370 to an existing DPPX/SP network and was not migrating any data or applications from an 8100 to the new machine, this was considered a new installation, not a migration.

Strategy

Because of the diverse considerations that needed to be addressed in the migration, a committee was formed to analyze and define the migration process.

This committee was responsible for planning the migration documentation. It became apparent that some information was needed for the customers to plan the migration, whereas other information was needed only during the actual migration of the systems. Therefore, the documentation was split into a migration planning manual and a migration procedures manual.^{1,2}

The strategy for developing the migration information was to "divide and conquer." The job was divided into logical scenarios based on the typical customer environment. The scenarios described the overall migration of a customer's DPPX network. This strategy was further refined to migrate each DPPX system. The job was broken down further into migrating system parts, user-defined parts, and other considerations.

The migration committee consisted of approximately ten representatives from all groups in the DPPX development organization. These people had different technical expertise. The migration committee formed a wide knowledge base of the entire DPPX operating system. Of course there were some holes where no single member had technical expertise. Where DPPX technical expertise was lacking, it was identified, and a plan to obtain information outside the committee was formed.

Strengths and weaknesses of the strategy

The benefits of this strategy were twofold. (1) It allowed the parallel effort of many people involved in gathering the information. (2) It provoked an in-depth understanding of a limited part of the migration by each investigator.

There were also multiple benefits of the migration committee approach. The knowledge was shared among personnel from different groups, regular meetings permitted checkpointing and tracking of progress, and many conflicting ideas were resolved to provide a general solution.

The committee approach had a few weaknesses. Due to the rather large number of representatives in the migration committee meetings, much unproductive time was spent discussing conflicting opinions. Although a smaller migration committee may have been more productive with less discussion, many migration concerns may then not have been addressed.

The information gathering was done at the same time as program development. This resulted in conflicting demands on technical experts' time. The benefits of shared knowledge and early availability of migration information more than offset this weakness.

The people available to participate lacked a broad customer background. This weakness was offset by people who were very technically knowledgeable. Acquiring more customer knowledge from outside the migration committee was recognized as a problem that needed to be addressed.

Tasks

The migration committee decided to break down the large migration job to a task level. This allowed the work to be distributed and helped ensure that all possible items were handled.

The tasks evolved into a list of about a hundred work items. These work items were then distributed among the members of the migration committee. A standard format for documenting the information was developed, and the responsible committee members had the job of finding the correct technical person to document the task. They also had to gather a list of all the IBM customized DPPX/SP elements for the component being worked on. These customized elements were shipped with the DPPX/SP product and could be modified by the customer. Then the committee member had to present the findings to the rest of the committee to critique.

Once the task was documented, it was placed in a migration task file. This file was the source of information for the migration manuals which were written after all the task documentation was complete.^{1,2} Because the migration data placed in the task file were totally unorganized, the writers of the manuals encountered problems using the information.

The problems encountered. A number of problems were encountered. The most significant ones are discussed.

Organization of tasks. The biggest problem was the lack of organization of the migration tasks. Migration had numerous discrete tasks, but they did not fit together into a process the customer could follow. Not only was overall organization lacking, but each of the tasks contained planning and procedural sections that needed to be ordered chronologically.

Some tasks, such as ordering hardware, had to be done in advance. Other tasks, such as moving user data to the ES/9370, were done at the actual time of migration.

This problem was solved by dividing the tasks into planning tasks and procedural tasks. The planning tasks were those that could be done in advance before the customer installed the product. The procedural tasks were those the customer did at the actual time of migration. Tasks were further organized by subdividing by the type of user who would complete them. This organization provided the committee with hardware, data, and application migration tasks. This organization of tasks was then verified by iterative documentation reviews and testing.

Hierarchy of importance. It was not clear which tasks were important and would have to be done by all customers, and which were so obscure that no one would ever attempt them. This problem was solved through customer feedback during a joint study, described later, and system test of DPPX/370.

Audience definition. The migration committee was not sure who would be performing the tasks. Some very detailed task descriptions would be performed by an operator, whereas other tasks involved an in-depth knowledge of the most complex areas of the DPPX operating system. Some tasks required a hardware expert to perform them, others an application programmer.

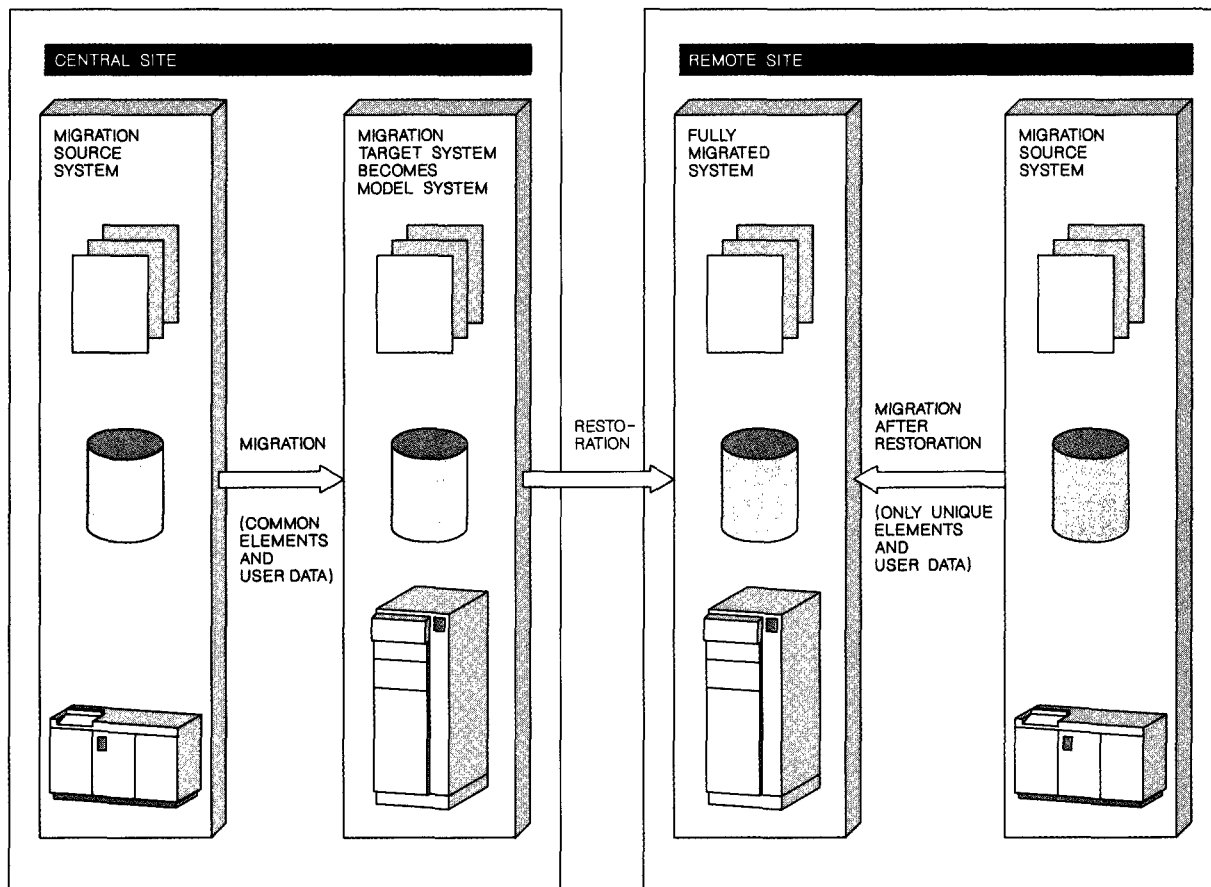
The tools that were being developed also reflected this problem. *Migrator*, the automated tool for migrating system elements and user data, was originally designed so that it could be used by someone at the operator level. The worksheets that were to be used by the person operating Migrator, however, required an in-depth knowledge of the system. Obviously, it was not known who would be using the migrator.

This problem was solved by getting to know who the migrating customers were. Findings were validated by conducting usability tests with the documentation and the code, using appropriate test subjects.

Network migration

DPPX is an operating system for centrally managed distributed processing. The characteristic environment of DPPX customers is a network with three types of systems.

Figure 1 Creation of a model system, restoration, and migration after restoration



1. An application development system, where customer applications are written and tested
2. A model production system, which contains application programs, data, and other items that are common to all the production systems in the network
3. Production systems, which are copies of the model system, customized for a particular production site (where end users execute the applications)

Scenarios were developed to describe the process for migrating a typical network, with actions depending on the type of system being migrated. Figure 1 shows the creation of a model system at the central site, the model system being dumped to tape, the system being restored at the remote site, and then the migration of unique data at the remote DPPX location.

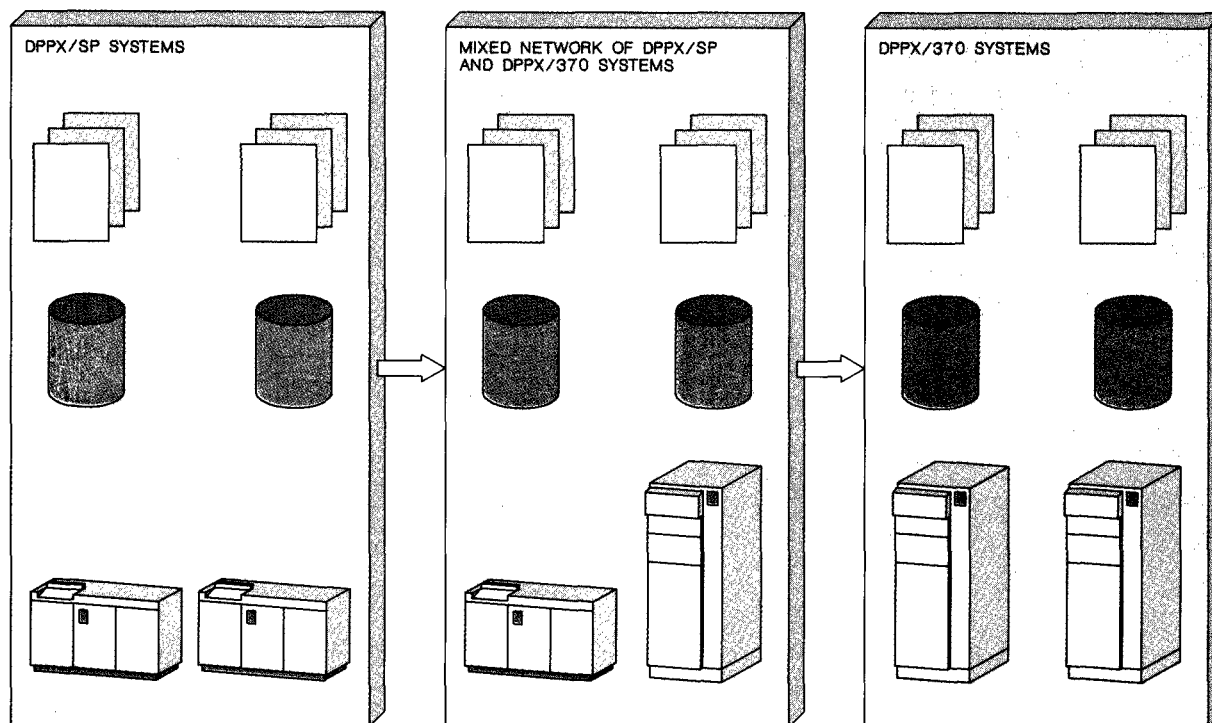
It was found that the migration of an entire network would be a gradual process. Figure 2 shows that over a time period of a few years some customers would have both DPPX/SP and DPPX/370 systems in the network.

Technical problems and solutions

Migrating 8100 hardware connections to ES/9370

The hardware supported by the 8100 could not be fully supported by the ES/9370 hardware. On the other hand, many communication connections supported by the 8100 hardware could be reconnected to the ES/9370 hardware with little or no hardware changes. Some minor differences between the 8100 and ES/9370

Figure 2 Network migration to DPPX/370



hardware required changes in cable lengths and hardware connectors.

8100 loop devices. The biggest problem for connectivity was migrating 8100 loop devices connected to the 8100 over to the ES/9370. The ES/9370 did not support the 8100 loop. Customers of the 8100 had hundreds of display terminals and hundreds of manufacturing terminals that could only be connected to the 8100 communication loop. The DPPX design department looked extensively for a method to support 8100 loop devices connected to the ES/9370.

One of the possible solutions investigated was a remote 8100 loop connected to a PC, where the PC was attached by Synchronous Data Link Control (SDLC) to the ES/9370. Since the final customer price for this hardware and software was too high to be useful for the customers, the final solution for 8100 loop support was to retain the 8100 to be used as a controller.

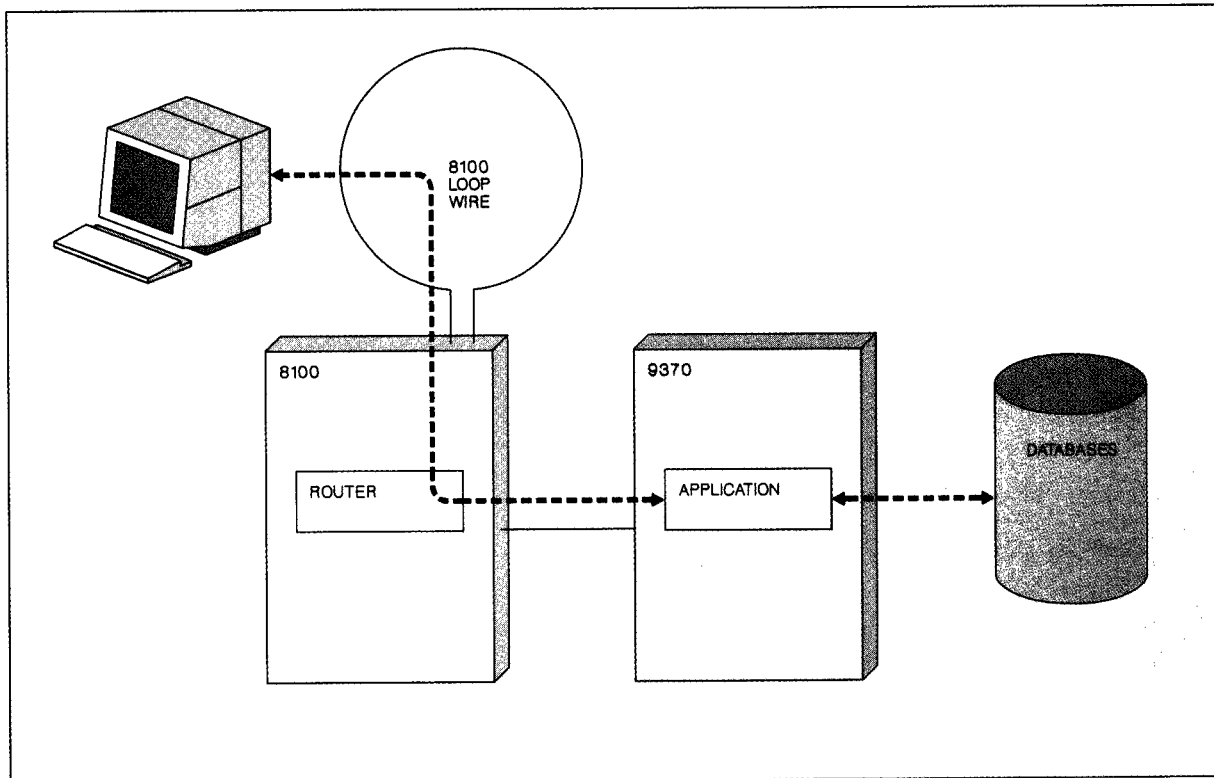
8100 retained as a controller to support 8100 loop devices. The ES/9370 supported a SDLC peer link, as shown in Figure 3. The 8100 and ES/9370 could be

peer-connected by this communication link with a data rate of 56 000 bits per second. Through the use of Router, which is software that is part of both DPPX/SP and DPPX/370, 8100 loop devices could communicate with DPPX/370 applications across the 8100 to ES/9370 peer link. No new code needed to be developed, since this was existing function currently supported by the router in both DPPX/SP and DPPX/370. Figure 3 shows a DPPX/370 application communicating with devices connected to the 8100 through the router.

Sample DPPX/370 configurations. When replacing an 8100 with an ES/9370, the customer could elect to keep the 8100 and use it as a controller. The following sample configurations show this option and other options available for hardware migration.

DPPX/SP configuration before migration. Figure 4 shows two DPPX/SP systems before migration. Both systems use an 8100 loop and have SDLC data links connected to a communication controller (3174 or 3274) or PC, where multiple display terminals can be connected to the communication controller. System B has manufacturing terminals (364x) and a display terminal (8775) connected to an 8100 loop.

Figure 3 Supporting 8100 loop-attached devices



DPPX/370 configuration after migration. Figure 5 shows the two systems after migration. DPPX/SP systems A and B are replaced with DPPX/370 systems. One of the 8100s is kept as a controller and is peer-connected to the DPPX/370 system B. All applications running on the DPPX/SP systems are moved to DPPX/370 systems A and B. The communication controllers and PCs that were connected to DPPX/SP system A's 8100 loops are replaced with communication controllers and PCs connected to a token ring. Devices attached to the old communication controllers are reconnected to the new controllers. System A's SDLC data links are moved from the 8100 to the ES/9370.

The devices connected to the communication controllers on system B are removed and reconnected to the DPPX/370 system B Work Station Controller (WSC). System B's loop wire remains connected to the 8100 retained to support the manufacturing terminals and loop-attached display terminals. Devices connected to the 8100 loop wire communicate with applications on DPPX/370 through the router software.

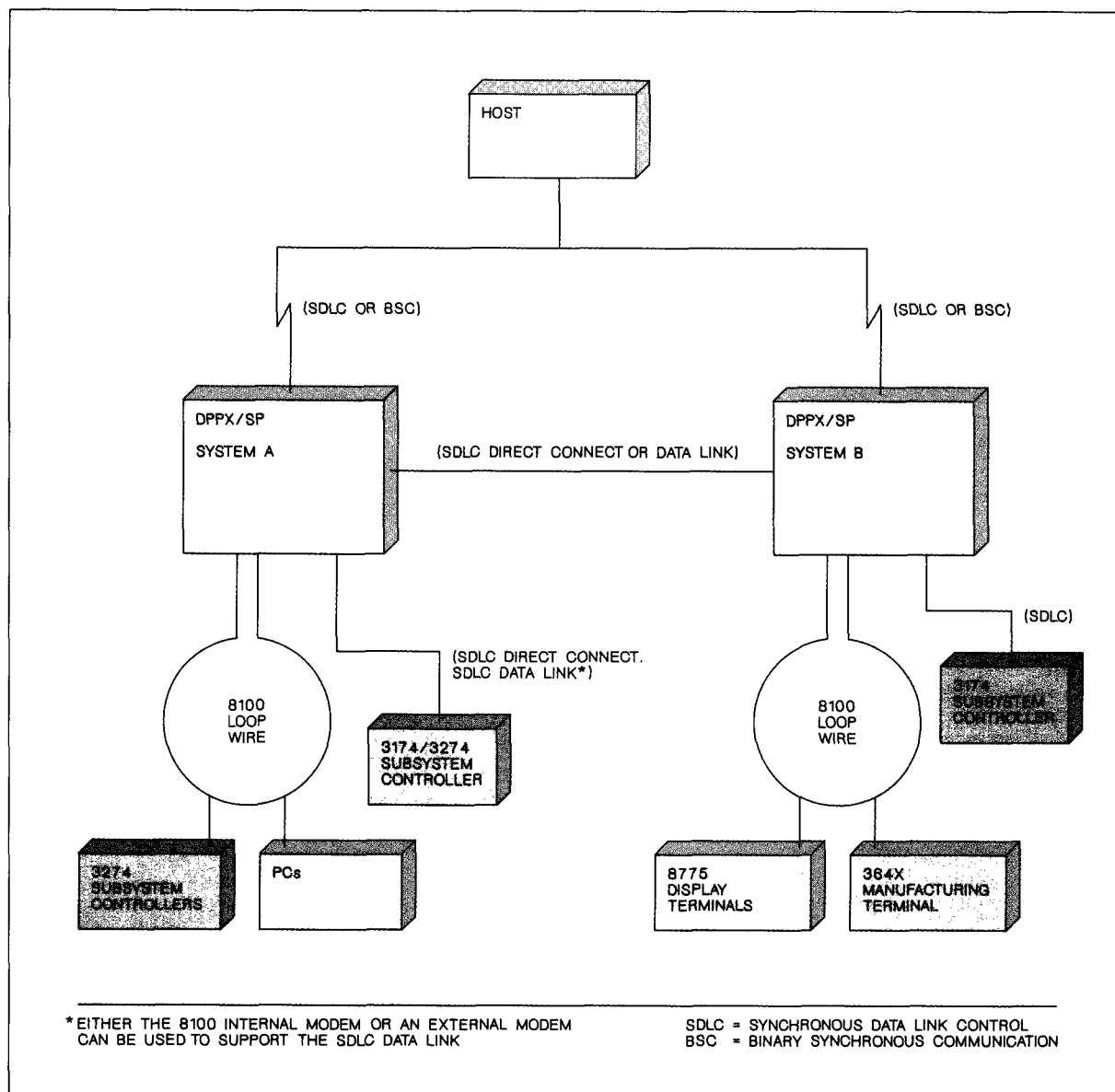
DPPX/370 configuration using token ring. Figure 6 shows another example of the same DPPX/SP systems in Figure 5 after migration to DPPX/370. In this example, the token ring peer-connects the ES/9370s and connects some of the controllers and PCs.

It is possible to upgrade the current PCs so that they can connect to a token ring. The customer would have to replace loop and SDLC communication controllers with models that support token ring. It was not necessary to rewire the devices attached to the controllers that could connect directly into the IBM token-ring controllers.

Other hardware migration concerns. Many other small hardware migration planning concerns were documented to make the migration document complete. Making the customer aware of even some of the smallest hardware concerns during the planning phase made the migration procedural phase go rapidly. Following is a list of some of the hardware migration concerns that were documented:

- If the 8100 would have to be in operation at the same time as the ES/9370 for some small migration

Figure 4 Two DPPX/SP systems before migrating to DPPX/370



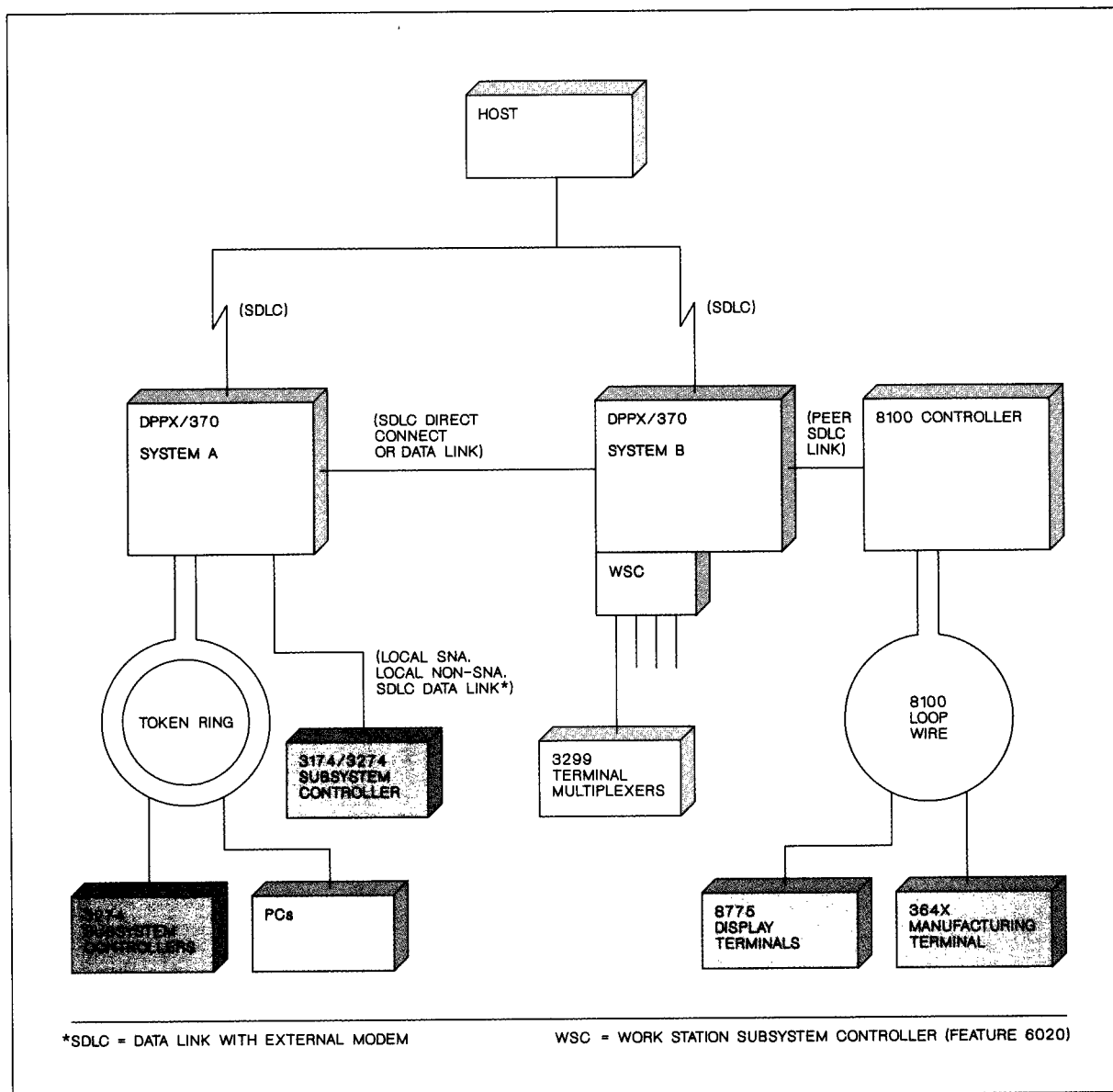
time period (for example, for two days on a week-end until migration could be completed), both electrical power and floor space would have to be made available to accommodate both the 8100 and ES/9370.

- Communication protocol differences and support were documented between the 8100 and ES/9370. In some cases, a modem to supply clocking was added to the communication line for ES/9370s.

- Cable differences were documented. Some of the ES/9370 cable lengths were shorter than those supported by the 8100.
- Sometimes the hardware that was required after migration would determine which data transmission method was chosen for migrating data.

Another hardware concern for customers who decided to retain the 8100 as a controller was the

Figure 5 Two DPPX/SP systems after migrating to DPPX/370

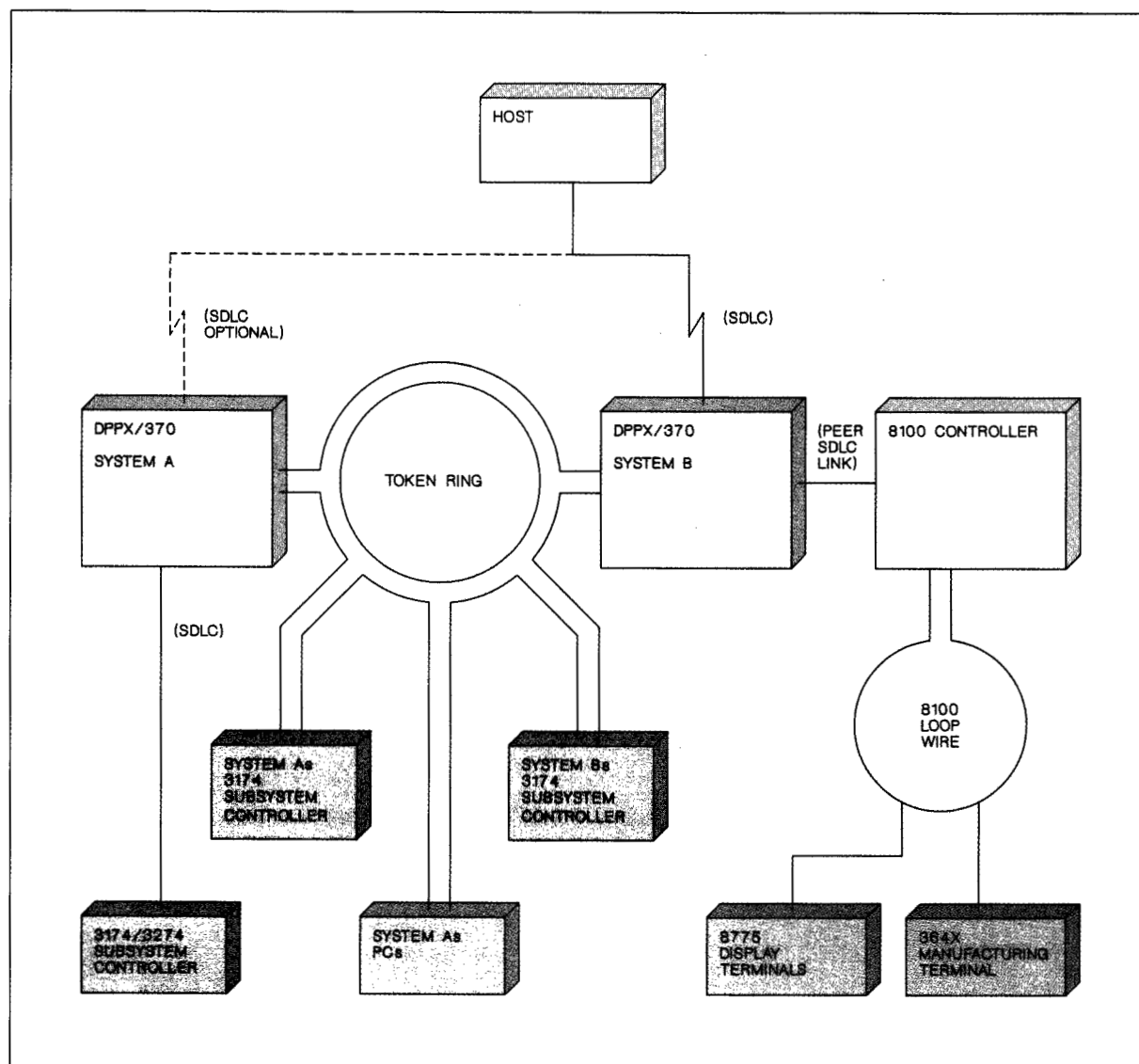


response time for 8100-connected devices communicating with applications running on the ES/9370 through the router. A program called the Performance Advisor was written that would run on a personal computer to assist the customer in planning the response time. Given various current 8100 conditions and response times, the Performance Advisor would determine what the response time would be using the 8100 as a controller.

Migrating data

To migrate data from the 8100 to the ES/9370, different data transmission methods were made available. The different methods had different hardware requirements and different performance rates. Below is a list of the data transmission methods from best to worst performance.

Figure 6 DPPX/370 network using token ring



1. Stand-alone DASD dump/restore (SADDR) used reel-to-reel tape to dump an entire DASD volume on the 8100 and then to restore this volume from tape to an ES/9370 DASD volume. Tape drives on both the 8100 and ES/9370 were required.
2. Peer Data Transfer (PDT) could be used to migrate data from an 8100 that was peer-connected to an ES/9370. This method was very convenient for systems where the 8100 was going to be retained and used as a controller to support 8100 communication devices that are no longer supported

by DPPX/370. This could be done over 56 000, 19 200, or 9600 bit-per-second communication lines.

3. Distributed Systems Executive (DSX) or NetView™ Distribution Manager (NetView DM) could be used to transport data from an 8100 to a large central site host System/370 and then back to an ES/9370 system. This was done over 9600 bit-per-second communication lines.

The migration tool, Migrator, which presented data

set selection screen panels, was designed to migrate data. It allowed the selection of 8100 data sets for migration. It made it easier to select data sets and provided the following functions:

- *Data set filtering.* Migrator filtered out IBM data sets that should not be migrated.
- *Customized data sets.* Migrator provided a list of IBM data sets that may have been used to customize DPPX/SP, which could be selected for migration in order to retain the same customization on DPPX/370.
- *Specific programs generated.* Migrator generated programs specific to the data transmission method selected. These programs would migrate the data selected when invoked on the DPPX/370 system.

Another very important requirement for data transmission was the ability to migrate all unique data at

DPPX/SP and DPPX/370 are highly distributed operating systems.

a production site within 30 hours—that is, within a weekend—so that users would not experience any down time.

DPPX/SP and DPPX/370 are highly distributed operating systems with usually one application development site and as many as a hundred production sites. All production sites usually run the same set of applications. Each production site is different only by its application data and communication devices. To migrate each production site, a model DPPX/370 system for all production systems would be built at the application development site. This model system, including the customized operating system, would be dumped to tape and then restored from tape on each production system's ES/9370 DASD. Then the production site unique application data could be migrated from the 8100 to the ES/9370 within this 30-hour window.

Migrating applications

Figure 7 summarizes the way each type of application is migrated to DPPX/370.

Migrating COBOL applications. Migrating COBOL applications proved to be the biggest effort in application migration. Considerations included:

- Source code incompatibilities between DPPX 8100 COBOL and DPPX/370 COBOL II
- Additional reserved words
- Whether the applications would exist in a mixed network of 8100s and 9370s
- Where the source would be kept
- What publications would be used
- Arithmetic precision
- Storage requirements

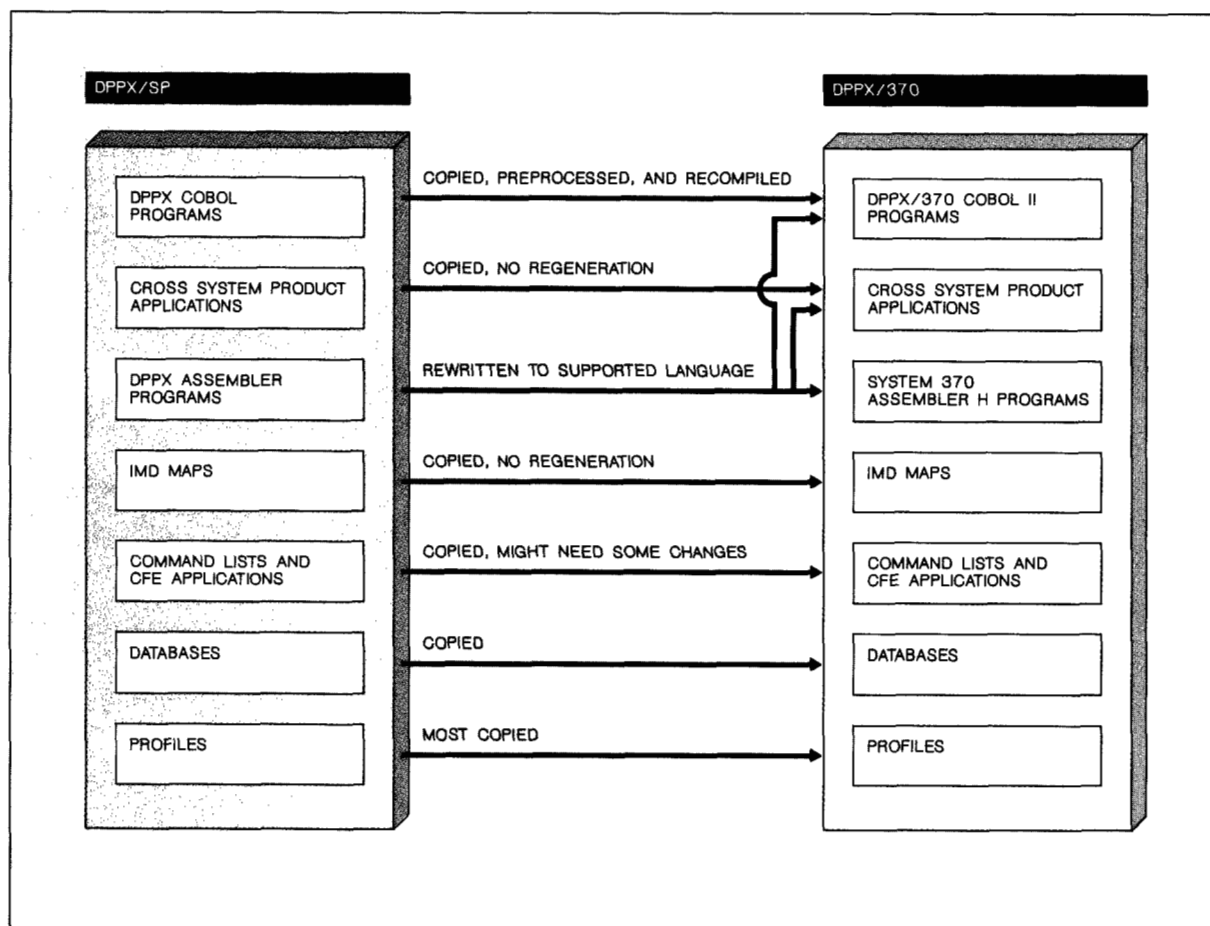
The preprocessor. There are two equivalent preprocessors, one for DPPX/370 and one for MVS. The choice of preprocessor depends on where the source will be compiled. The COBOL II preprocessor is a licensed program used to adjust 8100 DPPX COBOL source code for either COBOL II compilation.

The COBOL programs need to be run through the COBOL II preprocessor before recompiling them under COBOL II. The COBOL II preprocessor has two main functions: (1) It handles DPPX language incompatibilities by converting the statements (which run on the 8100) into acceptable COBOL II statements that will run on the DPPX/370 system. These conversions are necessary because of the differences between 8100 DPPX COBOL and COBOL II. (Some of the statements have different syntax requirements.) (2) It handles DPPX/370-unique I/O extensions not supported by COBOL II.

It was decided that DPPX/370 would support COBOL II, not DPPX 8100 COBOL. This decision made the COBOL programs meet the industry standard.

Customers had two main decisions to make in their migration. (1) Decide where to maintain the COBOL source. It could be kept on the DPPX/370 or at the host MVS system. During the network migration time, when operating a mixed network, the customer may have decided to keep source on DPPX/SP. (2) Decide which compiler to use—the DPPX/370 COBOL II compiler or the VS COBOL II, Release 1.2, compiler on MVS. This depended on where the customer was going to develop applications and maintain the source.

Figure 7 Overview of application migration



The migration process of COBOL compiler and applications. The customer needed to recompile the preprocessed COBOL applications before they could be used. They could be recompiled on MVS with the VS COBOL II, Release 1.2, compiler, or on DPPX/370 with the DPPX/370 COBOL II compiler.

Customers had to decide where they would *develop* their applications and where they were going to *maintain* their source. The answers to these questions decided which preprocessor and COBOL compiler the customer would use. Figure 8 shows the relationship between the compilers.

The following is an overview of how COBOL applications were migrated.

1. Preprocess on MVS or DPPX/370.

2. Compile on MVS or DPPX/370.
3. Link-edit the text deck on DPPX/370.
4. Run the program.

The assembler. DPPX assembler programs could not run on DPPX/370, since assembler language is directly associated with the architecture of the processor. The customer had to rewrite DPPX/SP assembler programs for DPPX/370 by using a language supported by DPPX/370 or by using Assembler H on MVS. DPPX macros for use with Assembler H were developed.

The customer had to decide which DPPX/SP assembler programs were required on DPPX/370 and then decide which language to use to rewrite those assembler programs. The customer also had to estimate the rewriting effort.

Data management

Figure 9 shows the different methods of data migration.

Catalog reformatting. In order to support larger DASD devices, the catalog structure changed in DPPX/370. Migrated catalogs needed to be reformatted before DPPX/370 would allow read/write access to the catalog. Read access to a DPPX/SP format catalog was allowed in order to permit the copying of data out of the catalog when the entire catalog was not needed.

Logical volumes. In order to move data from a DPPX/SP system residence volume to a DPPX/370 system residence volume, two disks with the same volume serial needed to be active at the same time. The logical volume function allowed the activation of the DPPX/SP system residence volume with a temporary name, allowing the copying of data from one disk to another.

Change in logical block size. Due to the change in the disk physical block size from 256 to 512 bytes, the default logical block size for data sets was changed to 512 bytes on DPPX/370. DPPX/370 maintained the external interfaces allowing 256-byte logical blocks. However, the system had to translate disk I/O requests into 512-byte requests, causing a performance degradation.

To help customers find data set definitions that should be reblocked, a tool was written to log those definitions that have the logical block length defaulted or specified as a nonmultiple of 512 bytes.

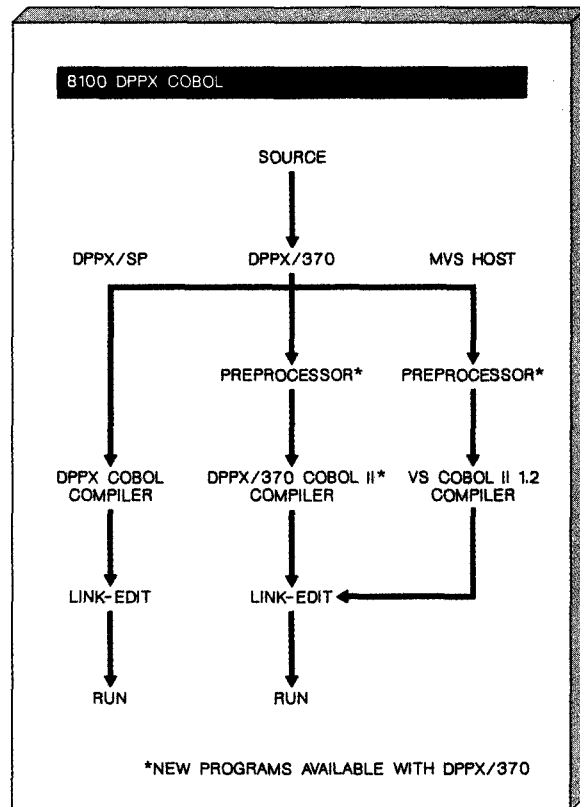
Multivolume user catalogs. DPPX/SP required that a user catalog reside entirely on one disk volume. Because the ES/9370 disks hold much more data than 8100 disks and the ES/9370 CPU is more powerful, the performance of the system was expected to be limited by the contention for disk I/O access.

To help alleviate this contention, multivolume user catalogs were designed to help balance the I/O accesses across multiple disk volumes. This is done by allowing the definition of catalogs (and thus large databases) spanning the data across more than one disk.

Migration tools

Some of the software tools used for migration were written to run on an 8100 under DPPX/SP Release 3

Figure 8 COBOL compiler processes

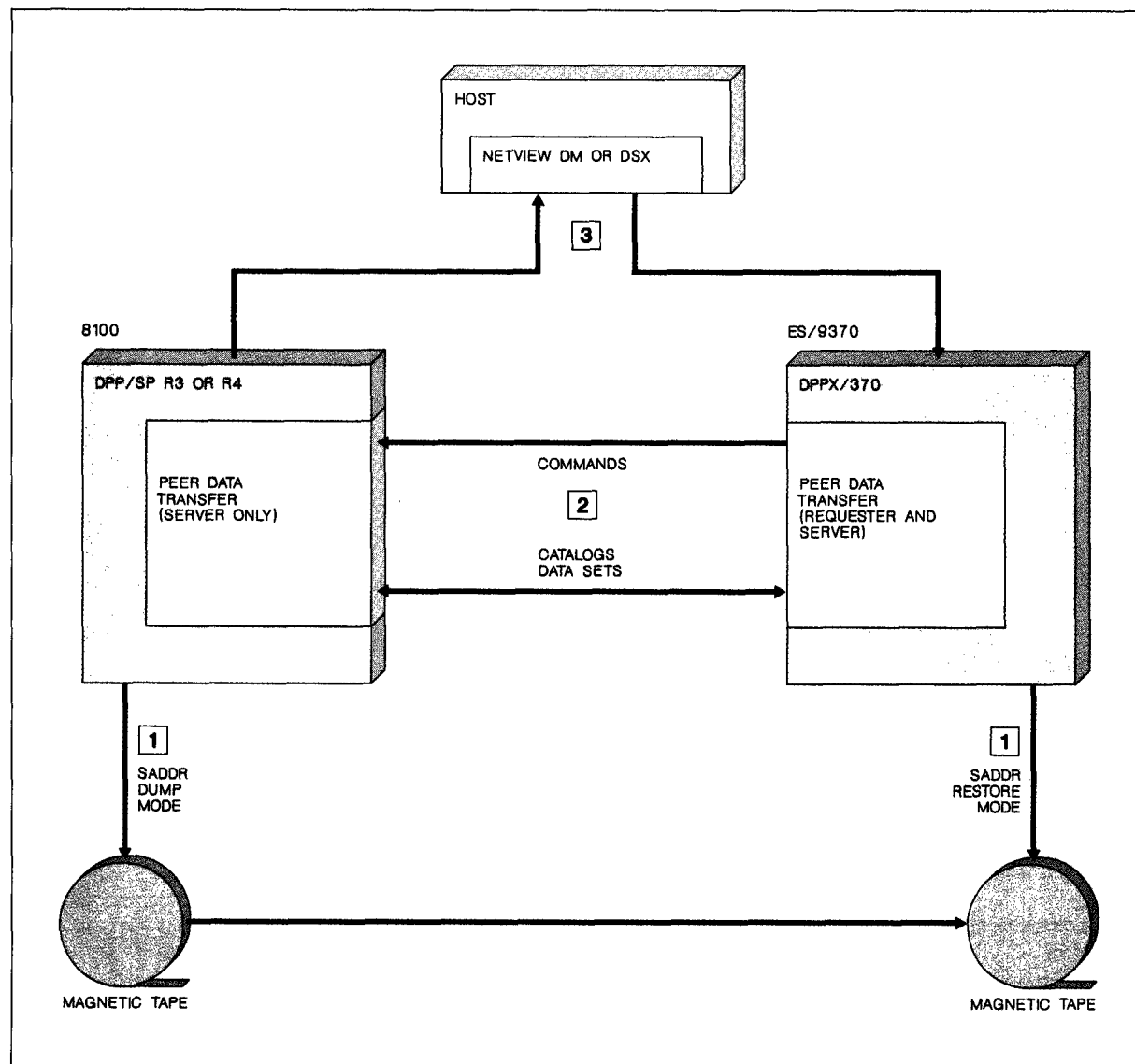


or Release 4. Other migration tools were shipped with DPPX/370 and run on an ES/9370 system.

The following is a list of the migration tools that were written to run on an 8100:

- The LIST.CONNECT command lists outstanding connections to disk data sets. This command is used to find 8100 data sets that were marked connected for output. Any data set marked connected for output could not be connected to, which would result in not being able to read the data set. Therefore these data sets could not be migrated.
- Migrator generates DPPX/370 commands that would be run on the DPPX/370 system to migrate data from DPPX/SP to DPPX/370. The user was presented lists of DPPX/SP systems data sets that may have been changed or customized by the customer. Data sets that had been modified could be selected for migration. Lists of user data sets could also be selected.

Figure 9 Data transmission methods supported by Migrator: (1) Stand-alone DASD dump/restore (SADDR); (2) Peer Data Transfer (PDT); (3) Distributed Systems Executive (DSX) or NetView Distribution Manager (NetView DM)



- Peer Data Transfer (PDT) provides commands that transfer data sets and catalogs from DPPX/SP to a DPPX/370 over a peer link between an 8100 and an ES/9370 system.

The following tools were shipped with the DPPX/370 system and run on the DPPX/370 system:

- The LIST.CONNECT command lists outstanding connections to disk data sets.
- The MIGRATE.DATA command runs commands generated by the migrator to migrate data from DPPX/SP to DPPX/370.
- Peer Data Transfer (PDT) provides commands to transfer data sets and catalogs from DPPX/SP to a DPPX/370 over a peer link between an 8100 and an ES/9370 system.
- Stand-alone DASD dump/restore (SADDR) lets the customer restore an 8100 SADDR-dumped DASD volume onto an ES/9370 DASD using magnetic tape

as the transfer medium. However DPPX/370 could then provide only read access to these data sets that were in catalogs with a DPPX/SP format. To obtain read/write access to the migrated data, either data sets had to be copied to another catalog that had been defined and created by DPPX/370 or the DPPX/SP formatted catalogs had to be converted to DPPX/370 format.

- The REDEFINE.CATALOG command provided the subcommand MIGRATE, which would convert volume catalogs and user catalogs that were migrated to an ES/9370 DASD by means of SADDR. The volume catalogs and user catalogs had to be converted from DPPX/SP format to DPPX/370 to enable read/write access to the data sets in the catalogs.

Managing a mixed network of 8100s and ES/9370s. ES/9370 systems can operate in a mixed network. The mixed network can consist of any mixture of ES/9370 systems and 8100 systems. Any of the two systems can use Distributed Systems Executive (DSX) or NetView Distribution Manager (NetView DM) to transmit data throughout the network.

8100 systems are typically multidropped from the host, often on lines containing other host-attached terminals. The ES/9370 system is attached to the host link either multidropped or through the IBM local area network token ring. An 8100 system can retain its own downstream networks. An 8100 can be peer-connected to an ES/9370 system.

Application development in a mixed network. The DPPX/SP application development process would have to be maintained as long as the customer was developing and maintaining DPPX/SP applications. The application development process would be needed for applying IBM service and for making updates to DPPX/SP applications on DPPX/SP.

The production test system in a mixed network. The DPPX/SP production test system would have to continue as the test system for both DPPX/SP IBM service and user application updates. The system would need to:

- Maintain IBM components: A DPPX/370 system would be required to install IBM DPPX/370 software maintenance. A DPPX/SP system to install IBM DPPX/SP software maintenance would also be required. Once the service is installed, the updates can be distributed to the other systems in the mixed network.

- Test and maintain user applications: As long as DPPX/SP applications had to be maintained, one DPPX/SP test system is required.

Customer participation

The difficulties that were encountered because of the uniqueness of the effort to migrate an operating system from one hardware to another may be summarized as follows:

- Documenting a process, not the code
- Inability to validate information until the process was completed
- Unsure of the process
- Lack of audience definition
- No expertise in key areas
- No clear idea of what the customer required

The joint study

The migration committee, though very knowledgeable about DPPX, was not as knowledgeable about customer usage of DPPX/SP systems. For this migration, it was necessary to obtain customer assistance to validate the proposed migration process.

During the joint study and customer meeting, it became apparent that most of the migration concerns of the migration committee were the same as those of the customer. It was also apparent that some concerns the migration committee thought would be enormous migration problems would not affect the customer at all.

An unfounded concern, for example, was the amount of time it would take a customer to migrate a network of DPPX/SP systems to DPPX/370. Originally it was thought that once a customer decided to migrate to DPPX/370, the migration of a large network of hundreds of DPPX/SP systems would be completed in approximately six months. Therefore, the customer would not have to be concerned with maintaining and updating DPPX/SP applications at the same time as DPPX/370 applications were enhanced. Also the customer application and test DPPX/SP systems could be removed once the last DPPX/SP 8100 system was migrated to DPPX/370. What was learned during the joint study, however, was that customers could not possibly migrate a complete network within six months. The migration committee assumed that application development would be suspended during migration in an effort to complete the migration as soon as possible. In fact, a cus-

tomer's requirement for application enhancements in the near future meant that application development work could not be suspended.

Two joint study customers agreed to receive code and documentation; six other joint study customers received just documentation.

Feedback from joint study customers. The customers in the joint study provided the migration committee with written critiques of the two migration manuals. These critiques included comments about errors, missing or extraneous information, specific requirements for a customer, or complaints about the migration.

The customers also provided feedback on code and documentation on a regular basis. This was due through a formal procedure identical to the way real problems raised during system test are dealt with by the DPPX development group. That is, problems were divided by category, assigned to a particular developer, answered, and closed. This provided a formal process for tracking problems arising during the joint study, many of which were specific to a particular customer. These were separated from other problems coming in.

The walkthroughs

Starting out. The migration committee decided to hold several migration walkthroughs. There were different ideas on what a walkthrough should be. These included:

- An inspection of the existing migration documentation
- A paper exercise using the existing documentation and a sample system
- Presentations by the various technical developers in the migration effort
- An exercise where the attendees actually migrate a system

All the different approaches had advantages and disadvantages. The present level of the system and of the documentation was a factor which needed to be considered.

The internal walkthrough. The internal walkthrough consisted of half-day sessions for one week attended by program developers and other technical experts. The format was a series of presentations on technical migration topics, with manuals distributed on the

first day of the walkthrough. It was expected that the attendees would read through the information during the week.

Getting the IBM systems engineers involved. It was decided to have some systems engineers (SEs) join the migration committee for a walkthrough. Each DPPX/SP customer is assigned at least one IBM SE who becomes very knowledgeable about the assigned customer system. SE input on the proposed migration process enhanced the knowledge of the migration committee concerning the customer requirements.

This walkthrough evolved into a question-and-answer session with the SEs forming a panel to represent their customer's point of view. The walkthrough provided source material, helped define the audience for migration, and provided customer migration scenarios.

Actual customers. Two months after the SE walkthrough, a walkthrough was held with the joint study customers who were to receive code. A week was devoted to each walkthrough and each presentation focused on the key concerns for each customer. The customer also provided the migration committee with early feedback on the drafts of the migration manuals.

Vended system test

Because of the lack of resources, lack of actual customer environments, and desire for customer feedback, DPPX/370 development managers decided to contract a customer to do the job of testing an actual customer migration. In order to simulate an actual customer migration as much as possible, this customer did not receive any formal education about DPPX/370 as did the joint study customers. This customer was provided migration manuals only.

What was learned

The migration committee did not have a clear view of what migrating customers wanted. Many thought that customers would find this the ideal time to recustomize their systems. The committee learned that the average customer just wanted to have the system exactly as it was before migration, with minimal disruption of normal day-to-day operations.

Another area of the committee's attention was the migration of customized IBM elements. It was thought that the customer would consider this criti-

cal to their migration effort. In reality, the major concern of most customers was the migration of their application programs, specifically the migration of their COBOL programs.

An area of dissension among the members of the committee was the length of migration. Some saw it as a quick one-for-one replacement; others saw it as a gradual process that would take years. In actuality, both were right. Some customers with a small number of 8100s installed would have a very short migration; other customers with a large number of 8100s installed or large number of applications would take years to migrate all the 8100s to ES/9370s.

The committee thought the person doing the actual migration would be an operator. The original draft of *DPPX/370 Migration: Procedures*² was written with this audience in mind. It turned out, however, after working with and talking with the customers, that the personnel responsible for this critical migration task would be very knowledgeable about DPPX and about the specific customer system being migrated.

Outcome of customer involvement

The early involvement of customers in the migration from DPPX/SP to DPPX/370 helped in the following ways:

- It provided source material.
- It defined who the migrating audience would be.
- It validated the completeness and usability of information in books.
- It defined the scope of information.
- It tested the code and documentation.
- It helped focus on key issues.
- It settled development disputes.

Testing migration

To test the migration, actual customer DPPX/SP applications were obtained with customer permission. The applications included the executable DPPX/SP modules, the databases, and the COBOL source code. Two of the customer applications were installed on 8100s in the DPPX development lab very early in the component test phase of DPPX/370.

The customer application systems were IPLed on the 8100. The first step was to recompile all the customer's 8100 COBOL source to determine if the source code would compile successfully on the 8100. After verifying that the source code could be compiled

successfully, the customer application was tested on the 8100 to verify that it could be executed.

COBOL source code was sent through the COBOL II preprocessor and then compiled under DPPX/370 COBOL II. Various errors were found in using the new DPPX/370 COBOL II compiler, and differences were found between the two compilers that required some minor changes to the application source code. These differences were then documented in the migration manuals.

After the differences were resolved and successful DPPX/370 COBOL II compilations obtained, the user data sets and modified DPPX system data sets were migrated from the 8100 to the ES/9370 system. The user application on the DPPX/370 system was tested for more differences between the compilers. These differences were either fixed in the COBOL preprocessor or COBOL II compiler. The application was now running on the DPPX/370. During this period, errors in DPPX/370 were found and corrected.

Different customer COBOL applications were written using different COBOL functions and programming styles. Each customer had a set of COBOL applications that stressed certain functions of the compiler more than other customer applications. After it was determined that each customer had different programming styles, a decision was made to recompile as much customer DPPX/SP COBOL source code as possible.

After finishing a basic migration for two customers, the next step was to test everything that was required for a customer to perform a migration. Testing an actual migration involved:

- Testing migration planning documentation
- Testing migration procedure documentation
- Testing such migration tools as SADDR and PDT, which migrated customer data

Testing the migration planning documentation was very difficult. It was given to non-IBM contractors to use during their migration testing. Also, DPPX/370 developers were assigned to migrate various customer applications using these manuals. Many comments were received from both sources. Verification of the planning document for completeness was heavily dependent on the customer responses to questions received in the very early part of the migration development phase.

To test the migration procedures document and migration tools, various groups were given the task of reading *DPPX/370 Migration: Procedures* and migrating a customer's DPPX/SP system to a DPPX/370 system. Since this was an iterative process of migrating and improving both the documentation and fixing errors in the tools, certain customer applications were migrated many times using different testing groups each time. Also, parts of the customer's DPPX/SP system were migrated using different data transmission methods.

After months of testing, improving the migration documentation, fixing migration tools, and then re-testing, the migration tests were almost complete. The duration of time to migrate data from the 8100 to an ES/9370 had to be obtained for each of the data transmission methods. The documentation for time to migrate data had to provide sufficient information to give a good performance comparison between the different data transmission methods and sufficient information to enable the customer to estimate about how long it would take to migrate their data.

Conclusions and recommendations

The use of a committee was necessary, due to the size of the effort and the information needed from many sources. The migration committee could focus on the problems of migration, while talking to many other people in order to gather technical information, understand customer requirements, and solve problems.

The migration work effort was done in parallel with the development and testing of DPPX/370. Also, the impact the migration committee had on development of the DPPX/370 product was minimal. Therefore, the migration work did not affect the scheduled general availability date of DPPX/370.

The division of the effort into major tasks, and the iterative breakdown of each task, allowed steady, measurable progress. Once the scope of a task was broken down to an understandable level, that piece could be researched and documented. This eventually was structured into documentation and tools that led the customer through a difficult problem in a straightforward manner.

The fundamental goal of a straightforward migration with minimal change to end-user and operator externals was maintained throughout the project. However, other goals changed over time. Some goals

changed due to customer feedback; others were changed due to the discovery of technical problems. The breadth of knowledge of the migration committee was essential for handling these changing goals.

While this approach was basically sound, some recommendations for possible improvements are listed below:

- Customers should be involved as early as possible. Feedback from customers can point out bad assumptions, key requirements, and areas for improvement.
- The migration work should be the key responsibility of the committee members. Although the importance of the project was recognized, other responsibilities were often given higher priority, causing undue delays.
- Hardware personnel should be involved. The lack of communication between the software and hardware organizations caused problems to be discovered late in the project schedule.

Had these recommendations been followed, a better quality set of information and tools would have been available at an earlier time.

The migration methodology used was a sound approach to the gathering and verification of vast amounts of information necessary to lead the DPPX/SP customers through a DPPX migration from an 8100 to ES/9370.

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