Design, test, and validation of the Application System/400 through early user involvement

by B. J. Pine II

The Application System/400™ (AS/400™) is the culmination of a development effort requiring seven million lines of code. Key challenges to its development were those of ensuring that the system had been designed correctly and thoroughly tested, that IBM Business Partners were ready for its introduction together with their applications, and that IBM marketing representatives and systems engineers were trained and knowledgeable on the system. This paper discusses how these challenges were met through the involvement of customers, Business Partners, vendors, and systems engineers in the development of the AS/400 system so as to positively affect its design and quality.

The Application System/400™ (AS/400™) was announced in June 1988 and was the product of a development effort centered in the IBM Rochester, Minnesota, Development Laboratory. The Application System/400 had to meet a host of growing needs. The first goal was to provide a system that combined the distinct operating system functions of the IBM System/36 and System/38 into one operating system architecture. The AS/400 system was also required to provide tight integration with IBM Personal Computers and the IBM Personal System/2®. The most important requirement was that the AS/400 had to provide what is essentially a new operating system that would be the base for Systems Application Architecture (SAA)[1] and allow the AS/400 system to meet customer requirements well into the 1990s.

The single integrated operating system to meet these requirements—Operating System/400™—was the product of the IBM Rochester Programming Center and comprised more than seven million lines of code. This code was derived from the System/38 and System/36, but much of it had to be brand new to provide such advanced function as SAA and to bring it all together into one cohesive unit. Key development challenges were those of making sure all seven million lines of code were designed correctly, that they met the requirements of System/36, System/38, and new customers, and were thoroughly tested.

A further challenge was provided by an industry that has grown up around the System/3X products, which are easy-to-use commercial systems. This is an industry with more than 300 000 installed IBM systems. This industry has developed thousands of System/3X applications, including more than 30 billion lines of RPG application code, and has thousands of Business Partners worldwide who provide application solutions and sell, install, and support

IBM midrange systems. Business Partners are non-IBM marketing personnel; these include IBM Agents (non-IBM sales representatives), Authorized Application Specialists, Authorized Industry Application Specialists, and Authorized Industry Remarketers (providers of turnkey systems).

To better meet the needs of this industry, we decided to involve customers, Business Partners, vendors, and IBM branch office people in the actual development of the AS/400 system. These groups would apply their special knowledge, experiences, and skills to the AS/400 development effort, while preparing themselves and their applications for its introduction. Whereas such groups formerly would have had limited involvement late in the product development cycle, this time their involvement was to be early enough to positively affect the system design and quality.

A comprehensive set of activities was created and implemented to make this happen, which we called "early external involvement" and divided into the following three phases:

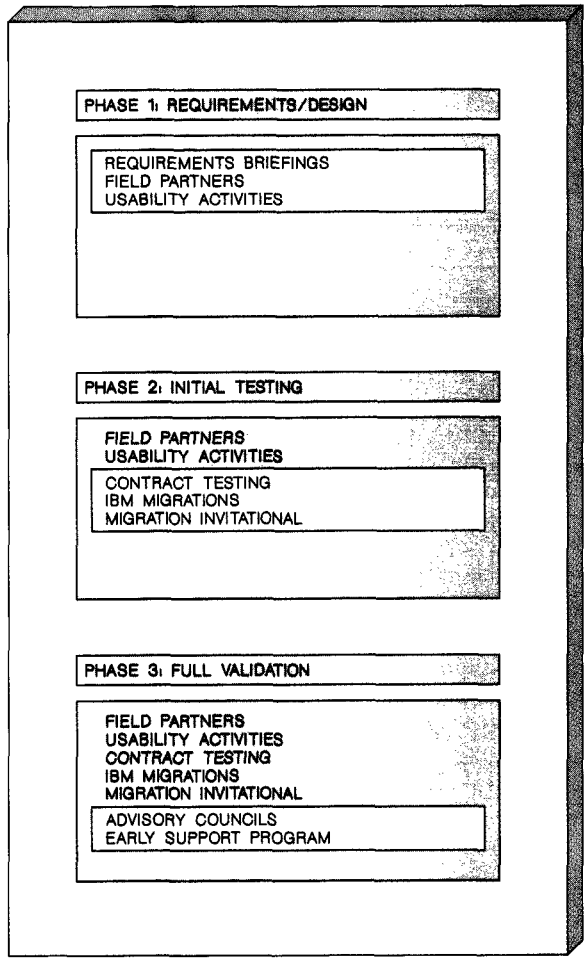
1. *Requirements and design.* Provide customer requirements and evaluate the design of the system.
2. *Initial testing.* Assess the system design and early implementation to ensure it meets the customer requirements.
3. *Full validation.* Validate the full system implementation and ensure that it provides a high level of quality.

Early external involvement activities

We first briefly describe the three phases of early external involvement and illustrate them in Figure 1.

Phase 1: Requirements and design. In the early stages of developing the Application System/400, we recognized that more information was needed about customers' requirements in a consolidated System/3X. Several requirements briefings were held with customers, Business Partners, and IBM marketing people, and the information gained was fed back into the internal requirements and design process. For example, several briefings in the third quarter of 1986 between software vendors and system developers allowed us to understand the typical content of mainstream System/36 applications. We also discovered that System/36 application programmers tended to wait to use new, advanced features until well after their release. These briefings helped the developers design the System/36 Environment that would run these applications on the AS/400 system.

Figure 1 *Phases and programs for design, test, and validation of the Application System/400 through early user involvement*



The development of any new system, including the AS/400, always involves choices among a universe of desirable functions that could be put into the system. One determinant is that of people available to design, code, and test the functions. Another, of course, is time. To help solve these problems, we brought in systems engineers from the field to help us winnow and focus on particular functions. These systems engineers came to the Rochester Development Laboratory on assignments ranging from a few days to more than a year and became our field partners.

Field partners made key contributions to the development of the AS/400 system in programming and testing numerous functions. For example, systems engineers programmed several system management functions to make it easier for System/36 users to understand and manage some of the advanced features of the new system. Systems engineers also found and designed applications that could test the new SAA Structured Query Language (SQL) database function, including System/370 SQL applications that were converted to the AS/400 system, as well as System/38 applications that were then enhanced with new SQL functions.

Field partners also wrote part of the on-line help text and many real-life examples for the hard-copy documentation. They were particularly helpful in applying their direct customer experience in reviewing the designs[2] of many of the AS/400 system features and advising the developers on how customers would use the features. Field partners proposed alternatives to make the AS/400 system more usable, with better function and higher performance. For example, very early in the development cycle a systems engineer reviewed the command layering design that would determine how users would navigate through the menu system. Based on this design review, significant changes were made to the command layering structure across the operating system.

Another area in which field partners were key to the success of the AS/400 was that of educating worldwide market support personnel. The Rochester Development Laboratory is required to provide education to those responsible to help set up the marketing plan for the system in each marketing group. These groups included headquarters staffs, application development centers, various support centers, translation centers, and education developers. For the AS/400, nine field partners took on this task. They worked with development personnel and with local market support personnel for IBM United States and for IBM World Trade Americas Group, IBM World Trade Asia/Pacific Group, and IBM World Trade Europe/Middle East/Africa to create the education materials. They then taught 28 courses to more than 1000 persons worldwide. Many of these courses were designed to teach the teachers, so that they then conducted their own classes for additional personnel at their home sites.

All told, several hundred systems engineers participated in the development of the AS/400 system. They not only made significant development contributions, but they also acquired an in-depth knowledge of the system. Thus they were ready to work with customers at the time of system announcement.

Within the IBM Rochester Development Laboratory is a Usability Center that has responsibility for maintaining and enhancing the ease-of-use characteristics of the systems. In the past, this area has often involved customers and systems engineers to some extent to verify the usability of new products. The ease-of-use requirements for the AS/400 system were far greater than any previous system, however, as the operating system had to provide a single, flexible interface that accommodates both System/36 and System/38 users, while at the same time meeting the new user-interface specifications of Systems Application Architecture.

The improved designs and their implementations were refined through iterative testing.

To meet these requirements, the involvement of external resources in usability activities was greatly expanded. It was not enough to verify the usability of the operating system once it was completed. Customers, Business Partners, and vendors, as well as IBM systems engineers, customer engineers, and marketing representatives, all became involved in the development of the interface designs.

First, the design directions were verified through formal surveys of a large number of customers. There were also round-table discussions with sets of customers and systems engineers on particular topics and walk-through reviews[2] of the interfaces before coding began. The improved designs and their implementations were refined through iterative testing involving more walk-throughs, as well as individual evaluations of prototypes by customers and systems engineers. Finally, the operating system interfaces were formally tested to certify their usability.

Almost 200 individuals from more than 50 companies and about 120 IBM branch office personnel came

to the Rochester Development Laboratory to participate in this process. As a result, the development programmers and members of the Usability Center made numerous changes in the operating system interfaces to better meet the ease-of-use needs of customers. Changes were made in menu structures, in the number of words on menus, in the words themselves, and in user navigation through menus. Also, new functions were developed to enhance the AS/400 system's ease-of-use and ease-of-learning characteristics.

System operations provide a good example of how external feedback aided in the usability process. The Usability Center assessed the requirements of novice users through formal end-user surveys and round-table discussions with customers. As a result, such system operations as save/restore and printing were given top priority. The AS/400 system had to be simple enough that a System/36 operator or a new operator could perform operation tasks successfully, even though the operator may have had limited experience with the variety of tasks available.

The Usability Center brought together a group of developers (including information developers), system testers, and its own usability staff members. These specialists determined the interface designs of a core set of system operator menus for the AS/400 system. These designs were then evaluated by operators employed by customers. Walk-throughs were conducted to review the design documentation and provide initial feedback on the usability of the designs. While this was occurring, the Usability Center was developing an early prototype of the system operator panels. Current System/36 operators were then brought in to perform typical operation tasks. Usability measurements were taken on user attitude, success rate, time to complete tasks, and number of requests for assistance. Developers were involved throughout these prototype evaluations to see first-hand the obstacles, frustrations, and successes that the operators experienced.

Responding to the walk-throughs and prototype evaluations, the Usability Center worked with the developers to redefine some of the difficult areas of the system, so that operators could successfully perform their tasks. For example, changes were made in the work management interface to allow the System/36 operators to work with system jobs more easily.

As the system operations interface developed, the prototype was replaced with real code. Customers were again invited in, this time to evaluate the real—and hopefully improved—interface. The tests showed that the interface had been improved, but that further improvement was desirable. The Usability Center continued to gather customer concerns. They discussed these concerns with the developers and assisted in further refining parts of the interface. Additional education was put into the system for operators on their specific tasks. This on-line tool, called *system delivered education*, allows operators and other end users to learn the system in their own way and at their own pace.

Following final changes to the interface, the Usability Center performed formal measurements of the AS/400 system operator interface and compared it with the System/36 and System/38. The AS/400 system operator interface was found to be at least as easy to learn as the other IBM systems. This provided the evidence that the system operator interface had reached its objective and would be acceptable to its customer set. We achieved this result and many other ease-of-use and ease-of-learning improvements through the early involvement of more than 300 external participants throughout the usability process.

Phase 2: Initial testing. One of the most difficult challenges in the AS/400 system development was the creation of a System/36 Environment which would provide the mechanics for executing thousands of available System/36 applications. This would involve the execution of billions of lines of code. The development organization charged with this mission knew that existing test scenarios were not adequate to test this large and varied environment, because they involved relatively straightforward test programs that would be comparatively easy to run. More robust applications would be needed to challenge the environment and its developers. Therefore, a vendor was contracted that owned several applications with the necessary characteristics. These applications were structured for ease of problem determination and well-behaved for repeatability, but they were sufficiently robust to test and challenge the System/36 Environment throughout the development cycle. We termed this test process contract testing.

We provided the vendor with a prototype system at a very early stage, and testing began with the very first software driver that ran the environment and continued through to the end of system test. As prototype systems were replaced by various hardware stages leading up to the final system, and as each

new milestone driver was integrated, the vendor would add the applications to the new system level and test as much of the system as the driver stability and level of function would allow. Over 1.5 million lines of application code were cycled through the System/36 Environment with this activity. As testing progressed, the vendor's application programmers worked very closely with the development organization to get the problems fixed and to improve the design of the environment through the insights gained from testing. Contract testing resulted not only in an improved System/36 Environment, but also in progress being made throughout the development cycle.

We decided to conduct an independent verification of the quality of the system before it would be shipped.

A second contract testing vendor activity was added later in the development cycle. The quality of the AS/400 system was so important and seven million lines of code was so large an operating system that ensuring that it was completely tested was crucial. Therefore, we decided to conduct an independent verification of the quality of the system before it would be shipped. An independent system test was contracted to a vendor with previous experience on System/3X products and on large-scale product testing. Overlapped with the internal system test function, this vendor tested more than 600 distinct system functions. Many problems were found and removed from the system by this process prior to shipment. With these fixes, the vendor was indeed able to verify independently the quality and usability of the AS/400 system.

To further test the AS/400 system's application environments, the Rochester Development Laboratory worked with application developers in the IBM Application Systems Division (ASD). In preparation for the AS/400 system, the Application Systems Division wanted to migrate and enhance their own System/3X industry applications (such as MAPICS for manufacturing, DMAS for distribution, and CMAS for construction). ASD's four million lines of application code—some of which were vended to third parties—were installed for well over 10 000 customers. Therefore, these applications provided an excellent test environment for a significant portion of the System/3X installed base.

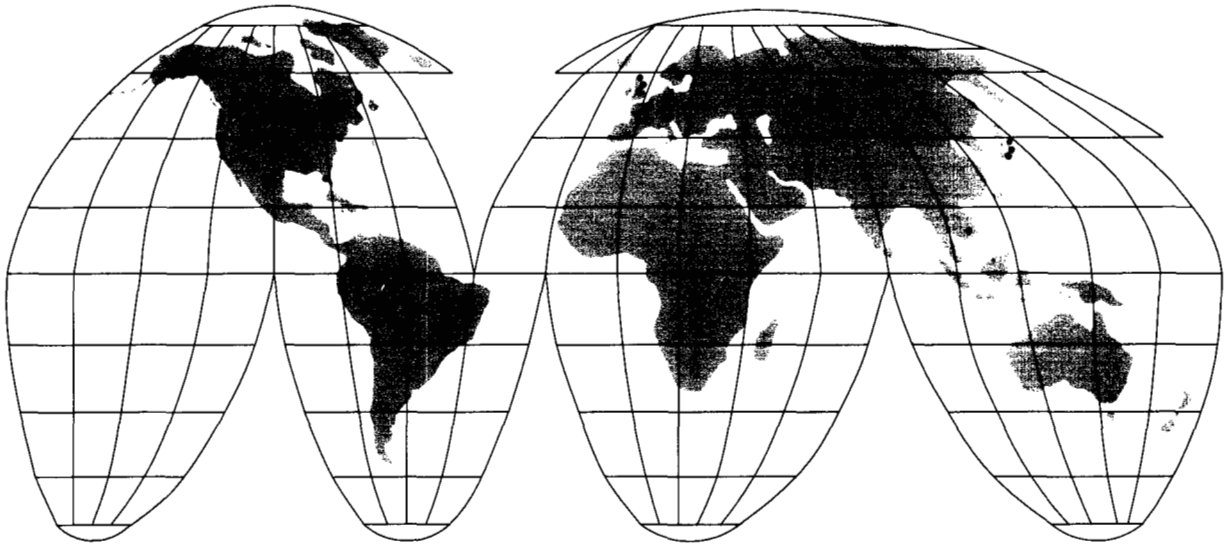
ASD used an automated testing system that simulated real users running their applications. This testing method not only allowed for regression testing of the migrated application versus the original, but also allowed for stress testing with multiple users all executing the applications. These advanced testing methods provided early identification of special problems that otherwise might not have been found. This migration method has proved so fruitful to IBM as a whole that it is being integrated into the system test phase of the development process for future releases.

Phase 3: Full validation. Most of the procedures we have been discussing provided feedback on specific low-level functions. We later added advisory councils to validate the overall strategy. Four distinct councils were run to gather the opinions of customers from the IBM United States and the IBM Europe/Middle East/Africa (EMEA) groups, as well as Industry Remarketers and Application Specialists (two types of IBM Business Partners). The advisory council participants spanned 22 industries and represented the interests of more than 4500 customers using 12 000 installed systems.

Beginning in the fourth quarter of 1987, the advisory councils reviewed strategy formulations and specific product plans, and they received demonstrations of early versions of the AS/400 system. The participants found specific areas that were in need of improvement, which included migration, PC support, office, total system packages, electronic customer support, and system usability. The changes made allowed the AS/400 system to more readily meet the needs of a wide range of customers worldwide.

The final validation of the AS/400 system prior to its general availability was performed by an early support program. Run by an entire department, this program's primary focus was to validate all facets of the AS/400 service and support structures. The early support program verified the readiness of the system code, the readiness of the marketing and servicing

Figure 2 Early support program sites



staffs, the quality of internal education, and the readiness of order entry, manufacturing (hardware and software), and delivery capabilities. The early support program also provided a great deal of feedback on function, quality, installability, serviceability, reliability, performance, usability, migration, and system information. This feedback provided a base for changes required in future releases.

The program accomplished this by shipping systems to a limited set of customers, using processes as close as possible to those that would be used at the time of general availability. With the software still in system test and the hardware just coming off prototype manufacturing lines, a small number of customers—beginning with internal IBM groups—began receiving their AS/400 systems almost five months before general availability. Two months later, just after public announcement, 90 systems had been shipped to 65 customers in 17 countries, all supported by the IBM worldwide service and support structures. (See Figure 2.)

These systems were tested by each customer and eventually put into full production mode. Each customer was surveyed every week to determine satisfaction levels in a wide variety of categories. This feedback was valuable and resulted in a number of important changes in marketing and service operations. The program also uncovered a number of system problems that we fixed prior to general availability. This support program differed from other IBM support programs in that it was run earlier in the development process (during system test) and involved many more customers than previous programs. These factors maximized the feedback that could be gained from such a program.

Migration invitational

The following items identified early in the development of the Application System/400 were critical to the eventual success of the system:

- The AS/400 system would have to combine the best features of the System/36 and System/38 for present users. The level of compatibility and ease of migration from these systems were therefore of prime importance, which called for additional testing beyond the normal development process requirements.
- IBM Business Partners must understand the product and be ready for its introduction. Their applications would have to be available almost immediately. Nowhere is this more important than for midrange systems.
- Systems engineers must be trained and be knowledgeable about the system and have a distinct affinity for it.

Achieving these critical success factors was a formidable task. The development and test organizations

were engaged in delivering the product on schedule. Full-scale compatibility testing that went much beyond that which was normal was out of the question if the resource and schedule requirements were to be met. Marketing was working closely with the Business Partners and would certainly do a good job in educating them, but that level of support had usually come some time after product announcement, with migrated applications many months or even years after that. Also, systems engineering education typically begins shortly before the announcement of a new system and would normally be offered to a limited number of systems engineers who would be responsible for educating the rest of the systems engineers.

A concept was developed to greatly influence all three of these critical factors with one program. This was to invite Business Partners to come to the development laboratory to test the migration and application environments of early versions of the AS/400 system in time to improve the system prior to its announcement and shipment. The motivation of these users would be to learn all about the system and migrate their applications to it. At the same time, their local systems engineers would accompany them to the development laboratory where other systems engineers would provide much of the support staffing. These resident systems engineers would also have the opportunity to learn about the system and prepare for its announcement. This innovative concept was called the migration invitational.

To implement this program, a Software Development Support Center (SDSC) was created. The SDSC is a set of facilities and a process for bringing IBM Business Partners and their systems engineers to the development laboratory for early application migration to the AS/400 system. It was not enough to simply have an adjunct facility work with the companies and then feed the data back to the development people. To achieve the goals, a real change to the development process had to be created that allowed direct interaction and feedback from the Business Partners and systems engineers to the developers and testers.

With all previous system announcements, the first feedback from external sources would come with the early support program. This would be so close to general availability time that any problems found or enhancements required (except straightforward bugs) could not be worked out until the next release or two. (This would be typically 9 to 24 months after the first product release.) With this change to the development process, a unique fast path from Business Partner to systems developer—from requirement to solution—was effected through the SDSC. The Rochester Programming Center could respond to feedback with fixes and significant enhancements within weeks—sometimes even days or minutes—that would be incorporated into the first release of the system. A full description of the AS/400 software development process and how early external involvement fit in is given in Reference 3.

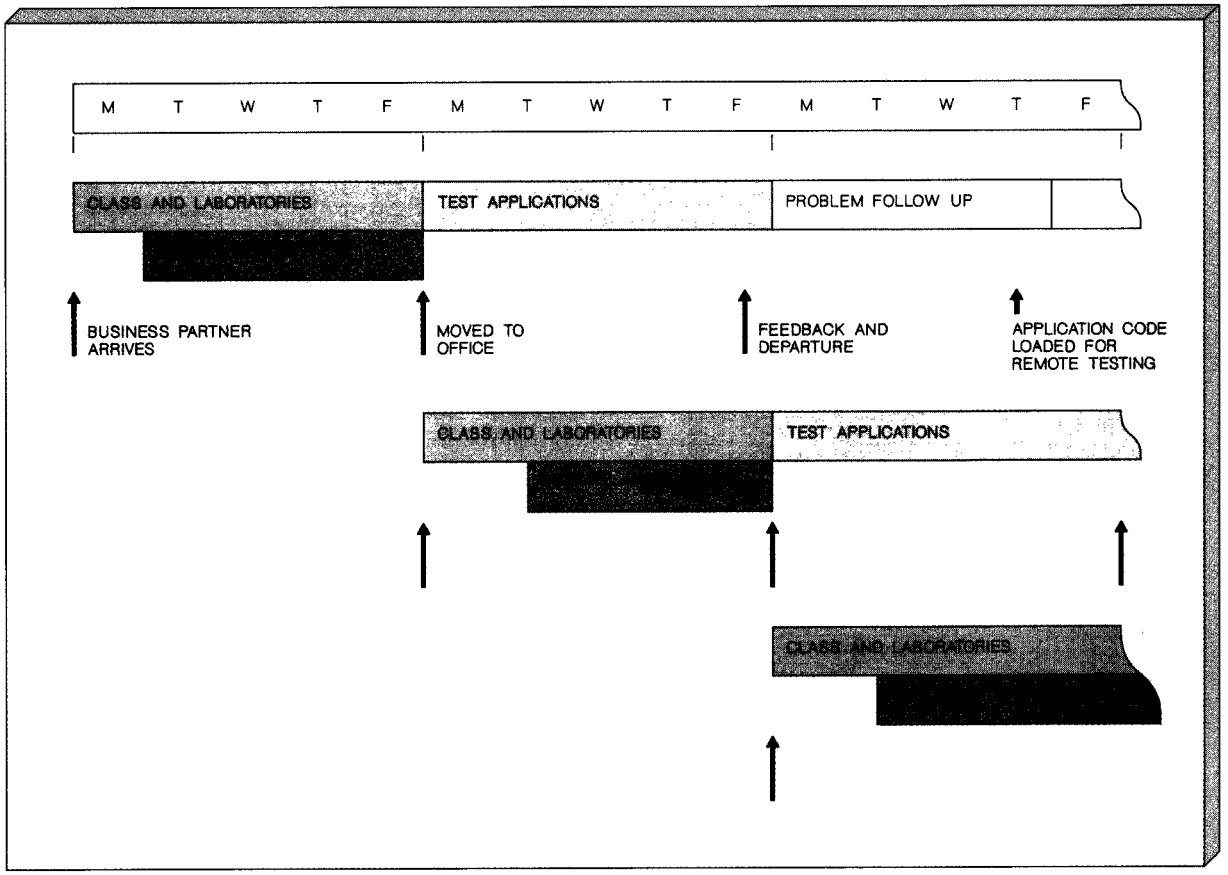
The SDSC began with pilot sessions from February to March 1987, a full year and a half before general availability of the AS/400 system. Three Business Partners came for the very first test of application migration from the System/36. In August 1987, input from the pilot was used to create the full migration processes.

At this time, a department was formed to create and implement the process for nominating, selecting, and inviting Business Partner participation. This department's activities included working with marketing personnel to select these partners, conducting one-day disclosure meetings to explain the program and formally invite the Business Partners, and establishing appropriate business agreements with the Business Partner who elected to participate in the program.

After this migration process was in operation for a few months, the tremendous potential for enhancing the AS/400's immediate success through a much larger portfolio of available applications was realized, and the objective was raised to 150–200 vendors. This required creating an innovative process that would allow many more Business Partners to migrate their applications than the one or two Partners per week that could then be handled.

The SDSC borrowed from established manufacturing assembly line concepts to create and implement an expanded migration process. (See Figure 3.) This process involved Business Partners (and a few customers) coming for two weeks at the SDSC. The first week was spent at one part of the facility in product education, hands-on tutorials, and application migration. The Partners then moved to another part of the facility for the second week, where they were assigned their own office to perform dedicated testing of their applications on the AS/400 system. At the end of this week, they returned to their own location, where they continued their application testing work through remote access to a system in the SDSC. The

Figure 3 Migration invitational process



remote access, secured and encrypted through new IBM technology, was provided for six more weeks. Help-desk support was also provided during this time to answer questions the Business Partners had and to feed any problems they encountered remotely into the development process.

As one group of Partners moved to the testing phase for the second week, another group was brought in for their first week's education phase. This created overlapping migration activity that greatly increased the number of Partners that could participate. Up to 12 Partners each week could be started in this process, yielding up to 24 Partners on site at any one time (which meant 50–60 persons altogether). In addition, nearly 100 companies had access to the remote systems at any one time.

This process was completed by offering to sell each Business Partner organization its own system at an early date, between announcement and general availability. This pilot program allowed the Business Partners to complete their application migration work, prepare their installation instructions and other documentation, and train their complete staffs.

In addition, many countries worldwide and geographic areas within IBM United States ran their own migration-center programs shortly before product announcement to educate other Business Partners on the migration process and to increase application availability. These programs were modeled after our migration program and were led by systems engineers whom we had trained. The pilot program was likewise extended beyond these participants. More than 600 systems were shipped to United States Business Partners and another 1200 systems were shipped to third parties worldwide to foster application development prior to general announcement.

Upon completion of any of these programs, Business Partner applications were submitted to the National Solution Center (NSC) in Atlanta, Georgia. The NSC followed up with each Partner to place their applications into the on-line SOLUTIONS database. This database is accessible to all marketing representatives and systems engineers, providing them with an easy method for finding the right application solutions for their customers.

More than 1000 applications were announced with the Application System/400 and over 2500 by general availability time.

Concluding remarks

Altogether, 175 Business Partners and customers participated in the migration invitational, 140 before announcement. As a result of all of the migration programs, more than 1000 applications were announced with the Application System/400 and over 2500 by general availability time.

Several hundred systems engineers accompanied the Business Partners to the Rochester Development Laboratory or were used to staff the Software Development Support Center (SDSC) on rotating internships and assignments. All of these systems engineers received valuable education and training on the system to give them the skills and experience they would need to market and support the AS/400 system.

The AS/400 system itself was greatly improved through this activity. The System/36 and System/38 Environments and the migration process were tested with more than 70 million lines of RPG and COBOL code, encompassing more than 200 000 programs and procedures. Numerous valid problems were found and fixed, and many areas of the system design were improved through the direct interaction with Business Partners and systems engineers. For example, the migration aids were enhanced to eliminate unnecessary flagging and to add flagging where it was most needed. A program from one Business Partner went from more than 1000 flagged lines of code down to the four lines that had to be examined in depth. These enhancements are now available to everyone using the migration aids.

As one further example, the AS/400 compilers were based on the System/38, with changes for the System/36 Environment made to match the System/36 specifications. Several Business Partners found that the System/36 compilers did not match their own specifications. The System/36 compilers allowed programmers to do many things that worked, but—according to the specifications—should not have compiled. Many changes were made to the compilers to maintain the highest degree of compatibility with the System/36. The only way these differences could have been found was through the testing of real applications.

Of course, not all of the differences between the System/36 and the AS/400 system could be resolved, because some involved very basic differences in the architectures of the two systems. For example, whereas the application programmer is responsible for data integrity on the System/36, the underlying architecture of the AS/400 system guarantees data integrity. This AS/400 feature could not be compromised, even for compatibility.

All of the improvements identified could be made directly into the first product release only because the development process itself was changed. Under the older development methodology, an enhancement would generally be made in the second or third release, or at best many months after the general announcement. In the new development process, a pipeline was created from the Business Partners into the development laboratory to allow the developers to fix problems immediately as they were encountered and to design solutions to requirements the Partners requested.

One other problem was addressed through this change in the development process. The frequent changing of development plans because of newly identified requirements and competing opinions was reduced because development personnel could go directly to a set of Business Partners and systems engineers who had the knowledge and skills to help with particular issues. The information gained in this direct manner allowed the laboratory to solidify

plans sooner and at a level much lower than the formal planning process could hope to achieve. In addition to the overall improvement in design, the migration process helped reduce the AS/400 system development time.

Early external involvement was key to the development and successful announcement of the Application System/400. Each of the programs allowed the development team to meet the challenges in ensuring that the system was designed correctly and was thoroughly and exhaustively tested. The end result of this effort is a system that represents the best of both the System/36 and System/38, while providing the initial implementation of Systems Application Architecture. The Business Partners and IBM field marketing personnel were prepared prior to the AS/400 announcement. More than 1000 applications were announced along with the system. Well over 2500 applications were ready by the time the system was generally available.

This happened because of innovative changes in the development process. Customers, Business Partners, vendors, and IBM field personnel all contributed to design, development, and testing of the system. They added over 100 person-years of effort to help ready the AS/400 system for its announcement and availability. These early external involvement concepts will continue and in some areas be extended for future AS/400 system releases. Other IBM development organizations are studying our methods and results with the view toward applying them to their own situations.

Acknowledgments

Early external involvement was a far-reaching set of programs within the IBM Rochester Development Laboratory. Thus it would be impossible to acknowledge everyone who contributed to its success. However, I want to cite a few individuals. Early external involvement was the invention of Susan Aldrich, a former systems engineer. Her concepts were supported within management by Don Kastella, Judy Kinsey, Don Van Ryn, and Dave Schleicher. Julie Ransom and Bob Haines played key roles in the migration invitational program. Bill Damerel and Dan Hattenberger developed and implemented the fast path business process.

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