Global Teamwork: Developing International ISDN Capabilities for the 5ESS® Switch

Gwan K. Lie

Thomas L. McRoberts

Jan Neuteboom

Robert E. Schleicher

Jeffrey D. Wiggs

Several geographically and culturally diverse partners within AT&T are working as a team to develop new capabilities for the 5ESS® switch in the international marketplace. Throughout this project, participants from organizations in AT&T Bell Laboratories in the United States and AT&T Network Systems International in The Netherlands and the United Kingdom have worked together using a common development process. This paper describes the global teamwork involved in the development of international Integrated Services Digital Network (ISDN) capabilities for the 5ESS switch.

Introduction

A global team of AT&T organizations working on the international switching project for the 5ESS switch has recently developed Integrated Services Digital Network (ISDN) capabilities for application throughout the world. (See Panel 1 for definitions of abbreviations, acronyms, and terms.) This is the first set of ISDN capabilities developed by AT&T to conform to both the standards of the European Telecommunications Standards Institute (ETSI) and the Blue Book recommendations of the International Telegraph and Telephone Consultative Committee (CCITT). Members of the AT&T international switching project began developing ETSI/CCITT ISDN capabilities in 1989. The first application of these capabilities on the 5ESS switch took place in The Netherlands in November 1991, and work is continuing to deploy these capabilities in other countries around the globe.

To enable AT&T to achieve a market share for the 5ESS switch in countries outside the U. S., the company conforms to the requirements of the governments of those countries, which typically stipulate that production and/or development facilities be local. For this reason, as well as for logistical advantages, the AT&T Network Systems International headquarters in Europe is located in Hilversum, The Netherlands. For the ETSI/CCITT ISDN project, the international development team included personnel from AT&T Network Systems International in The Netherlands and the United Kingdom, and

AT&T Bell Laboratories in the United States.

This paper describes the development process used by the ETSI/CCITT ISDN project and the global teamwork that made it succeed. The team members depicted in this paper are part of:

- Commercial and systems engineering groups in Naperville (Illinois), Holmdel (New Jersey), Hilversum and The Hague (The Netherlands), and Malmesbury (United Kingdom)
- Software development groups in Naperville, Hilversum, and Malmesbury
- Hardware development groups in Naperville and Huizen (The Netherlands)
- Verification groups in Naperville, Hilversum, and Malmesbury.

Although geographically and culturally diverse, these partners operated as a coordinated team throughout the project by following a common development process. From the beginning, each partner had a well-defined role within the project and took pride in the ownership of its part. At the same time, each partner brought unique strengths to the team, making the parts interdependent. This global teamwork became a key to the successful completion of the project.

A Global Development Process

New functions in the 5ESS switch are developed in several phases, as shown in Figure 1. In the international 5ESS switching project, a number of AT&T locations often share responsibility for each phase of development:

- Customer Requirements—The customer (network service provider) defines how the switching system will be configured, based on international standard agreements and country-specific exceptions.
- Specification—First, commercial and systems engineering groups and the customer agree on how the 5ESS switch will function in this particular application. Next, systems engineering, working with development groups, converts the customer requirements into a detailed feature list and generates a set of specification documents that define the detailed requirements for these features.
- Implementation—In the implementation phase, the specification documents are used to produce new software and hardware functionality. Software and hardware development groups prepare the design, code the software and/or assemble the hardware, and test each required feature.
- Verification—Following the implementation phase, verification groups test the software and hardware together to ensure that all customer requirements have been satisfied and that combinations of features interact properly with one another.
- Product Delivery—Once verified, the product is turned over to the customer for acceptance testing and is then ready to go into service.

The following sections detail how the global team carried out the core phases of this process—specification, implementation, and verification—during the ETSI/CCITT ISDN project.

Specification Phase. AT&T and PTT Telecom in The Netherlands have had a longstanding relationship, built during many previous local and toll switching projects. (A PTT [Postal, Telegraph & Telephone] is the national government agency responsible for combined postal, telegraph, and telephone services in many European countries.) Their cooperation on ISDN issues began long before PTT Telecom issued an ISDN specification. Joint working groups, including members of AT&T's commercial department in The Hague, systems engineers from Hilversum and Naperville, and PTT Telecom's technical experts, met on a regular basis to discuss ISDN issues.

When The Netherlands released its ISDN specification, AT&T's response was coordinated by the commercial department, with technical contributions from systems engineering in Hilversum, Malmesbury,

Holmdel, and Naperville. Much of this work was done using electronic mail and telephone, and the statement of compliance was completed at a joint meeting in Hilversum. A commercial technical team who best understood the customer (located primarily in The Netherlands and the United Kingdom) was well matched with a technical team who understood AT&T's previous ISDN implementation (located primarily in the United States).

As soon as AT&T and PTT Telecom agreed on the ISDN capabilities to be included in the initial release, systems engineering groups began working on the detailed requirements needed to adapt the 5ESS switch to provide ISDN. AT&T maintained contact with PTT Telecom throughout this phase, holding team meetings and exchanging written questions and answers regarding details of the requirements.

Internal AT&T requirements teams, led by systems engineers and supported by developers, were formed to detail the requirements. Although most team members were from different geographic locations, team leaders were chosen from the location that had the most experience with the function being documented. Teams were organized as follows:
- Basic call control, operations, administration, and maintenance (OA&M), and many supplementary services were documented in Naperville, where the ISDN capabilities for the U. S. market had been developed.
- Details of the layer 3 protocol (i.e., call control messages exchanged between the 5ESS switch and the ISDN customer premises equipment) were documented in Holmdel, where the ISDN protocol expertise resided.
- Using their knowledge of PTT Telecom and their ability to easily contact it, systems engineers in Hilversum

Figure 1. Global development phases.
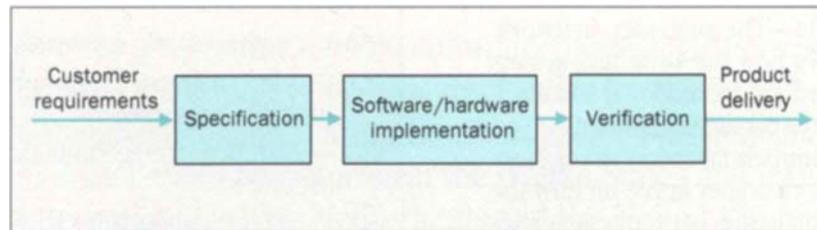
documented signaling interworking, charging, and supplementary services requirements specific to The Netherlands network.
- Engineers in Malmesbury who had experience with the ISDN interoffice signaling provided in The Netherlands documented the requirements for interworking between that signaling and the ISDN end-user to switch signaling.

The complexity of the ISDN capabilities being planned made it necessary for the requirements teams to maintain close contact during this interval, including telephone conference calls, electronic mail, and face-to-face meetings. One systems engineer was responsible for coordinating all teams, to ensure that every team member was kept informed of all customer questions, answers, and agreements reached. Regular status meetings over teleconference facilities at all locations made this interteam communication possible. The teams conducted a final review of each requirements document at a face-to-face meeting in Naperville.

Implementation Phase. This phase included both software and hardware implementation, as described in the next sections.

Software Implementation. During software implementation, feature specifications are translated into a set of internal design documents. These designs are then implemented in software to produce the required behavior. The ETSI/CCITT ISDN project accomplished this in five phases: feature design, module design, coding, module testing, and feature testing. A fundamental concept underlying these phases is the customer-supplier model, shown in Figure 2. The owner of any given phase was a customer of the previous phase and also a supplier for the next phase. For software implementation, these internal customer-supplier relationships were defined in terms of software features and modules. Each software feature defined in the specification phase represented a subset of the external customer's requirements. Software modules were defined at the start of the implementation phase to

encompass all affected areas of software; each module represented a logical unit of internal functionality.

Feature design, a high-level design phase, translated the feature requirements into a specification of the internal functionality required for each software module. Module design, a low-level design phase, transformed the functional specifications into specific changes to the software modules, each of which was then coded and tested. When the set of modules needed for a given feature had passed module testing, they were integrated to undergo feature testing.

Each software module was assigned an owner, as was each feature. The software module owner was responsible for implementing the software changes required for the module; the feature owner was responsible for the full operation of the feature. Because a software module typically provided functionality for more than one feature, and each feature typically needed functionality from more than one software module, multiple internal customer-supplier relationships were formed. Table I illustrates some specific relationships that existed on the ETSI/CCITT ISDN project. Subdividing the project into software modules effectively partitioned it among the global partners. This approach made it easy to detect redundancy and loopholes, because every software module was an indispensable part of the whole project. It also promoted teamwork and helped to build a close-knit community.

Two types of software modules were used prominently during the ETSI/CCITT ISDN project: those associated with basic calls and those associated with supplementary services. The former type was much less affected than the latter by the introduction of ETSI standards. The European partners were assigned supplementary services implementation to take advantage of their familiarity with ETSI standards; the U. S. partner was assigned the basic call. As soon as all tasks had been divided among the partners, the software was implemented. Figure 2 shows that a vital part of every phase of

Table I. Sample Relationship Between Features and Software Modules

Software Modules	Features	
	Basic Call (Naperville)	Call Forwarding (Hilversum)
Call setup (Naperville)	√	
Call control (Naperville)	√	√
Subscriber programming (Hilversum)		√
Charging (Malmesbury)	√	√

this process was the feedback loop from customer to supplier. For example, during feature design, the feature owner was responsible for producing a high-level design document that specified the functionality required from several software modules. While writing the document, the feature owner maintained informal contacts with each module owner through electronic mail, telephone conversations, and face-to-face meetings. When the design document was completed, the feature owner and all affected module owners held a formal review meeting. This feedback loop could continue to exist even after the feature design phase was completed, as more details were uncovered during module design and coding.

While the software implementation progressed from one phase to the next, the various customer-supplier relationships carried out by the global partners formed a strong network that held the parts together. Each participant had clear ownership of his or her part of the process, and each supplier had clear expectations from his or her customers. This structure, coupled with excellent teamwork and communication across all sites, led to the successful completion of all software features.

Hardware Implementation. The ETSI/CCITT ISDN project required the development of two new hardware elements: the U-interface line pack and the network termination unit. ISDN digital subscriber lines require a line interface pack within the 5ESS switch and a network termination (or NT1) at the customer's premises that provides the interface to the customer's ISDN set. The interface between the line pack in the switch and the NT1 is called the U-interface, which is defined by ETSI standards.

The U-interface line pack was developed in Naperville and the NT1 in Huizen. Both development organizations followed the same hardware development process to create the design information. They then transmitted the design information, which describes

assembly and test procedures for the product, to the hardware manufacturing facility. The hardware development process also produced hardware models that were used during software development and verification. To ensure quality, hardware development teams conducted design reviews, simulations, and hardware tests.

The line pack and NT1 development teams had a key advantage as they began this project. The two teams had already worked together to develop ISDN hardware for U. S. applications. This track record allowed the organizations to work closely from the start in an atmosphere of mutual trust and respect. Each organization participated in requirements reviews and design reviews for both the line pack and the NT1, working together to resolve issues and differences. Circuit simulations of the line pack and the NT1 were also tested together to ensure interoperability of the two designs. Finally, joint testing sessions verified that the final hardware designs worked properly together. This allowed the teams to verify the end-to-end integrity of the complete digital subscriber loop. The teams were also able to reduce development costs by reusing one circuit design to perform similar functions on both the line pack and the NT1.

Verification Phase. In this phase, the verification groups use the test laboratories for the 5ESS switch to ensure that the product works as defined in the specification and all new features interact correctly. The verification team also conducts testing to ensure that existing features still work properly. Naperville and Hilversum each had two laboratories available for testing; Malmesbury used these remotely over an intersite network.

Verification teams, formed at all three sites, focused primarily on the features developed at their respective locations. Half of the Hilversum-generated software was tested in Malmesbury to achieve a better balance of staff and resource usage. Because of the
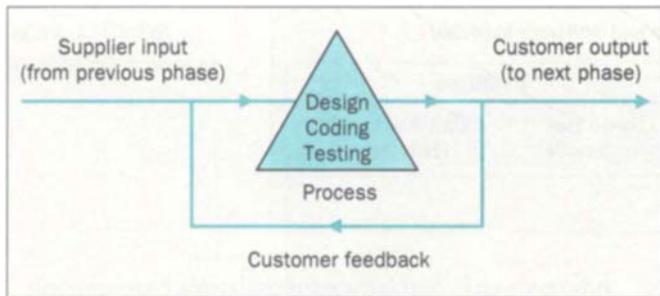
Figure 2. Customer-supplier relationship model.

remote testing capabilities and the time difference between the U. S. and Europe, verification teams were able to use the laboratories around the clock. For example, Malmesbury is six hours ahead of Naperville, so testers in Malmesbury could use Naperville's laboratories while their U. S. partners slept.

All faults discovered during the verification phase were recorded in problem reports, which were reviewed daily during a joint conference call meeting of all three sites. Each problem was assigned to the responsible development group, with the assignment based on the expertise required, the probable source of the error, and the availability of staff. Independent of where a fault was found, or which site corrected the problem, the solution was integrated into a common software/hardware product that was made available to all sites.

Overall Project Coordination

To coordinate many people from multiple sites, the ETSI/CCITT ISDN project was controlled by a project management team. This team, which had representatives from all sites, planned and tracked the entire project. Although this centralized mechanism enabled the team to control interdependencies and set priorities, the project was coordinated at all levels. Engineers and managers alike communicated regularly with their counterparts at other sites. By avoiding hierarchical lines of communication, the team members could quickly establish agreements and resolve problems.

The main methods of communication were electronic mail and telephone calls. Because of the difference in time zones (Hilversum is seven hours ahead of Naperville, for example), telephone communication was limited to the early morning business hours in the U. S. However, the time difference also increased the use of certain

resources. Computers and test laboratories, which could be accessed remotely, were used virtually around the clock. The turnaround time for exchanging technical information was also reduced. A question posed at the end of the day could be answered overnight on the other side of the ocean.

Maintaining face-to-face contact required a modest amount of travel between sites. Sometimes individuals traveled for a specific technical activity or meeting. Also, representatives throughout the project periodically gathered at one site to hold general planning meetings.

Conclusion

Throughout all phases of the development of international ISDN capabilities for the 5ESS switch, AT&T organizations in three countries worked effectively as one team pursuing common goals and following a common process. The respective roles of the team members complemented one another, taking advantage of different areas of expertise and entrusting one another with joint project ownership. The mutual respect and rapport that was cultivated during the ETSI/CCITT ISDN project built on similar successes from the past and will engender even greater cooperation in future projects. For all those involved in this project, global partnering has been a rewarding and positive experience, indeed, the best way to compete and succeed in the global marketplace.

Gwan K. Lie is a member of technical staff in the Application Features Department at AT&T Bell Laboratories in Naperville (Indian Hill), Illinois. He develops software and works on technical coordination and architecture for the 5ESS switch, its wireless applications, and Integrated Services Digital Network (ISDN). Mr. Lie received an M.S. in electrical engineering from Santa Clara University, California, and an M.S. in structural engineering from the University of Illinois, Urbana-Champaign. He joined AT&T in 1985.

Thomas L. McRoberts is a distinguished member of technical staff in the International Switching Systems Core Application and Product Management Department at AT&T Bell Laboratories in Naperville (Indian Hill), Illinois. After a number of years working on systems engineering for ISDN in international markets, he is currently working on product management for

switching systems in Mexico. Mr. McRoberts joined AT&T in 1973, after receiving a B.S., M.S., and Ph.D. in electrical engineering from Iowa State University, Ames.

Jan Neuteboom is a member of technical staff in the Call Processing and Support Development Department of AT&T Network Systems International in Hilversum, The Netherlands. He develops software and works on technical coordination and architecture of local/toll, Integrated Services Digital Network (ISDN), and wireless applications of the 5ESS switch. Mr. Neuteboom received an M.S. in experimental physics with mathematics and informatics from the University of Amsterdam, The Netherlands. He joined AT&T in 1985.

Robert E. Schleicher is a supervisor in the 5ESS Line and Trunk Development Department at AT&T Bell Laboratories in Naperville (Indian Hill), Illinois. He is responsible for developing ISDN and SONET interface hardware for the 5ESS switch. He is currently assigned to the Switching Cost Management Team. Mr. Schleicher received a B.S. and M.S. in electrical engineering from the University of Illinois, Urbana-Champaign. He joined AT&T in 1977.

Jeffrey D. Wiggs is a member of technical staff in the 5ESS Application Features Department at AT&T Bell Laboratories in Naperville (Indian Hill), Illinois. He develops switching systems software for international applications of the 5ESS switch. Mr. Wiggs received a B.S. in electrical engineering from Missouri University, Columbia, and an M.S. in computer science from Michigan University, Ann Arbor. He joined AT&T in 1979.