CHAPTER 1

Cisco and WAN Switching

Cisco has become a leader in the wide-area network (WAN) market that offers diversified next-generation technologies that are designed to meet the needs of a growing and more demanding customer base. How did Cisco achieve this leadership? Interviews with some of Cisco's top engineers and leaders, including Don Proctor, Vice President and General Manager of the Multiservice Switching Business Unit, and Morgan Littlewood, Senior Director within Cisco's Service Provider Line of Business, present an intimate picture of where Cisco has been, where it is today, and where it is going with WAN products and capabilities. This is a story that demonstrates the inner spirit and hard work of Cisco's employees and the determination to provide unprecedented value and opportunity to Cisco's customers.

A company known for its enterprise routers did not appear a likely candidate for investing in WAN switching products, but Cisco could see that customer needs, technology trends, and the customers themselves were rapidly changing. There was a strong emerging demand from larger enterprise customers and service providers for technologies that could seamlessly integrate routing, Frame Relay, ATM, and voice across a single network. Cisco responded to this demand by merging high-performance ATM switches with the intelligence and control of IP routing to develop the next-generation networking infrastructure. Cisco knew that this combined entity would deliver integrated, scalable multiservice network solutions to public carriers and enterprises. Cisco approached this challenge with the same vigor and experienced, forward-thinking strategies that made it the leader of router sales and deployment by first anticipating the need for networks to support multiple services such as cell relay, permanent virtual circuits (PVCs), switched virtual circuits (SVCs), Frame Relay, and local-area network (LAN) interconnectivity.

In 1990, the Frame Relay services market was kick-started by four major players: Cisco, StrataCom, DEC, and Northern Telecom (now Nortel), also known in the industry as "The Gang of Four." Around this time, Cisco developed the first Frame Relay router interface and

was interested in the ability of Frame Relay services to lower the cost of bandwidth for enterprise customers. With this interest in mind, Cisco led the development of the key technologies that allowed multiprotocol enterprise networks to leverage Frame Relay services to connect their LANs.

As the market for Frame Relay services grew, Cisco invested in a startup called Cascade that focused on lowering the cost of Frame Relay service delivery. Although Cisco had an equity investment in this company, it would eventually decide that a StrataCom acquisition would be a better fit for the Cisco product line. StrataCom had the highest-quality products and was based in San Jose. Most significantly, StrataCom had developed a full product line of enterprise and carrier switches that could seamlessly connect to Cisco routers. Many carriers and mission-critical enterprise networks, such as large banks, actively embraced this architecture.

Cisco's real entry into the WAN market started with the acquisition of StrataCom, Inc. on July 9, 1996. With this $4 billion acquisition, Cisco entered the ATM WAN switching and telco market and also brought together two of "The Gang of Four." A leading supplier of Asynchronous Transfer Mode (ATM), Frame Relay high-speed WAN switching equipment, and a key customer base, StrataCom and its products added value to Cisco's routing and LAN switching product line by allowing Cisco to leverage its expertise and vision across a broader technology base. The addition of WAN switching technologies facilitated Cisco's ability to provide customers with a superior network infrastructure for integrated data and voice environments, and to become the only vendor to offer end-to-end connectivity across public, private, and hybrid networks. In addition, it resulted in Cisco's first venture into the service provider line of businesses.

StrataCom was founded in January of 1986 as a spin-off of a failed startup called Packet Technologies that was ahead of its time with the implementation of interactive TV. Packet Technologies was made up of two lines of business: cable and interactive communication path development. When venture capital funding dried up, the engineers who had participated in the development of the interactive technologies started their own company and named it StrataCom.

In mid-1986, the Internetwork Packet Exchange (IPX) was the first product released by this new company. All traffic carried through the IPX used a fixed 24-byte packet size (to match the size of a T1 frame) and was given the proprietary name of FastPacket. StrataCom's fast packet technology was ATM-like and anticipated many of the features of the ATM standard. Eventually this resulted in a quick and easy implementation of ATM.

The original IPX was strictly a digital voice switch. This was an industry first and a revolutionary and pioneering concept designed to carry voice over FastPackets. The IPX accepted the voice stream in digital PCM (Pulse Code Modulation) format and then compressed it using Adaptive Differential Pulse Code Modulation (ADPCM) and Voice Activity Detection (VAD). This helped decrease costs to customers compared with traditional 64 K Time Division Multiplexing (TDM). An IPX network was established

and maintained by a novel and proprietary connection-oriented routing technology called AutoRoute that was designed to automatically select paths across a complex network.

It was difficult to convince companies to abandon the comfort of TDM and to embrace the revolutionary concept of FastPacket voice transport that the IPX provided. That the IPX could be relied upon to not only transport voice in digits but could also make better use of a company's T-1 line and save the customer money took some convincing, but with some persuasion, May Department Stores became StrataCom's first customer. Eventually, transportation companies including McDonalds trucking service and energy companies became customers as well, helping to build a broad customer base.

In the middle of 1987, the IPX became a 32-slot box and included some new diagnostics. The first major change to the IPX came in 1988, with data interfaces becoming an integral part of the IPX switch. It was no longer a strictly digital voice switch.

Many companies had separate voice and data devices, so the new IPX was an attractive alternative, with both services streamlined into one switch. The new IPX features served as an attempt to consolidate voice and data networks to create a single network. IPX would eventually succeed in becoming the first multiservice technology. But at this point, consolidating voice and data networks was the name of the game.

Another major change to the IPX came in 1989 with the addition of Data Frame Multiplexing (DFM). This new feature improved bandwidth efficiency by eliminating repetitive patterns (such as HDLC flags) within the incoming bit stream.

The IPX was originally designed with the North American standard T-1 (Trunk Level 1, a digital transmission link with a total signaling speed of 1.544 Mbps) for transmissions within the United States and Canada. However, by late 1990, the IPX contained the first international concept, the E-1, which operates outside of the United States and Canada at a total signaling rate of 2.048 Mbps.

The most significant improvement to the IPX came with the incorporation of Frame Relay capabilities. This was a new and emerging protocol, similar to X.25 PVC, but much faster and more efficient. The IPX was the first commercial release of a Frame Relay switch. The new Frame Relay capabilities became the third service (with voice and data) tied into the IPX box and helped get Frame Relay off the ground.

New voice cards, designed with an improved architecture and a greater number of voice ports were also introduced around this time, allowing older and less efficient cards to be phased out.

The next revolutionary change came with the introduction of ForeSight. This feature is a closed-loop relative-rate feedback mechanism designed to dynamically adjust network Frame Relay traffic to help utilize available bandwidth. Rate adjustments take place in supervisory FastPackets to allow for the optimization of bandwidth when network congestion occurs. Customers could use a dynamically adaptive rate-control mechanism to ensure that critical traffic could get through even under a heavy load. This was the only dynamic rate

control on a Frame Relay service. It was a major enhancement to the Frame Relay capability, with the focus on maximizing the efficiency of the E-1 or T-1 lines to the switches. This feature allowed very robust connectivity for all the routers on a Frame Relay network.

In the early 1990s, ATM was becoming a reasonably agreed-upon standard, and ATM platforms and interfaces were being created throughout the industry. As a result of this, StrataCom created a new switch called the BPX as the first dedicated ATM switch with T3, E3, and OC-3 interfaces. The BPX was rebranded by Cisco as the Cisco BPX 8600. It has become the most widely deployed ATM switch in the industry, with over 5000 nodes installed in networks throughout the world.

Then the IGX came along. This switch was designed as a replacement to the IPX. Its initial design focus concentrated on increasing the capacity of the old IPX 32 Mbps bus by increasing bus capacity to 1 Gbps. The first IGX had only voice, data, and Frame Relay features, but eventually ATM interfaces were incorporated into the IGX, creating a fully featured box.

A new product, AXIS, was designed to work as an access shelf on the BPX to allow efficient access at T1/E1 and slower speeds. The AXIS shelf supported Frame Relay, ATM, and circuit over an ATM backbone. The first member of the Cisco MGX family, the AXIS shelf was later rebranded as the Cisco MGX 8220.

The BPX originally used some proprietary ATM signaling, but as the ATM standards grew and became solidified over time, the BPX hardware had to be modified to accommodate changes in standards. The BXM card was designed to address this. It included the first carrier implementation of ABR traffic management.

The ultimate fruit of the StrataCom acquisition was the development of Multiprotocol Label Switching (MPLS), which is the industry's preferred method of delivering IP traffic over an ATM network. As IP and ATM come together, the idea is one of "route at the edge and switch at the core." With MPLS, switches are used at the core of the network, where they can utilize intelligent routing instructions, and where fast switching speeds are advantageous.

MPLS grew out of Tag Switching, which is a technique developed by Cisco for high-performance packet forwarding through a router, using labels or "tags" that are assigned to destination networks or hosts. By adding MPLS to the BPX 8600, Cisco created the industry's first WAN switch capable of the full suite of carrier data services. Frame Relay, ATM, and IP could be simultaneously supported on a common infrastructure.

Joining Forces

The bringing together of StrataCom and Cisco has ultimately proven to be a solid and rewarding marriage. However, one of the risks and challenges faced with any acquisition is to smoothly and successfully absorb the new company's staff. Merging an ATM company

with an IP company was challenging enough, and Cisco's short six-to-nine-month selling cycles put some initial strain on the StrataCom sales group. Mixing a small workforce with a large workforce, while blending and integrating the two cultures, required determined and experienced leadership. This leadership was eventually put to the test on April 13, 1998 with the meltdown of AT&T's Frame Relay network. This became a galvanizing event in Cisco's history.

AT&T's Frame Relay network consisted of Cisco's WAN switches, which formed the backbone network that carried 30 percent of the financial transaction traffic in the U.S. It was the most mission-critical public network of its time. The 22-hour meltdown happened while AT&T was upgrading the firmware on a BXM card during normal business hours. Ironically, the network's previous stability had enabled AT&T to become one of the first operators to upgrade network software without impacting customer traffic. The April 13 event became a positive turning point for Cisco because it emphasized the critical demand for high-availability data service by businesses. The service demand had grown beyond e-mail and basic Web surfing support, and with this, Cisco realized that availability had to become a core focus of the organization. From this event came many positive things, including the Reliability, Availability, and Serviceability (RAS) blueprint that was developed to help improve RAS networking standards.

Despite this major setback, a strong relationship with AT&T has been key to the ongoing development of the network that Cisco provides for AT&T's Frame Relay customers and the high availability since achieved in this switch network. Combined efforts and compromises on both sides helped develop a network that meets our joint customers' desire for high-availability services. Like a shuttle launch, we have focused on scrutiny of design for high availability and the development of even better tools with the help and cooperation of AT&T. Without question, this teamwork improved high-availability services. In July of 2000, AT&T reported a precedent-setting "five nines" performance on its market-leading Frame Relay network, which has been consistently performing above 99.999 percent reliability.

What Lies Ahead

With a sense of where Cisco has been, and an unprecedented history of product development serving as the basis of where the company is today, the next question to ask is where does Cisco see itself going as it continues to grow, diversify, and meet customer and industry needs for WAN switching products? A strong base of technologies and the brightest engineers in the business will help propel Cisco forward, as it envisions itself improving and building on its existing technologies to best meet the demands of its worldwide customers and breaking away from its competition. Cisco's history of WAN switching and its current position in the market are just the beginning. Cisco believes that tomorrow's worldwide multiservice networks will continue to demand the scalable, superior, and cost-effective solutions that have made its WAN product line a leader in the industry.

Thanks to the hard work of its employees, Cisco has succeeded in creating a diverse line of WAN products and capabilities that include the following:

- **MPLS VPN over ATM**—The MPLS VPN over ATM solution lets an enterprise or Internet service provider (ISP) connect its sites via a public network and enjoy the same security and service levels of high-growth IP Virtual Private Network (VPN) services that are provided by private networks. MPLS is an innovative method for forwarding packets through an existing ATM network with minimal up-front costs and a quick return on investment (ROI). By leveraging a customer's existing Frame Relay or ATM network, the MPLS VPN over ATM offers many business-class services over a common infrastructure that are highly scalable and very easy to manage. They also provide optimal routing and well-defined mechanisms for quality of service (QoS).
- **BPX 8600 series**—The BPX 8600 series is the most widely deployed IP+ATM carrier switch. It uses leading-edge MPLS technology to provide the industry's most cost-effective backbone infrastructure for broadband, IP, and broadband/narrowband service delivery. Cisco's BPX 8600 series lets service providers cost-effectively deliver ATM, Frame Relay, SNA, voice, and circuit emulation services while simultaneously adding emerging services such as voice over IP, IP-based VPNs, managed intranets, and premium Internet services.
- **MGX 8800 series**—The Cisco MGX 8850 wide-area IP+ATM multiservice switch allows the delivery of a complete portfolio of differentiated service offerings while scaling to OC-48C/STM-16 speeds. Its deployment flexibility provides the agility for service providers to be first to market with the services that customers demand and to deploy IP-enabled ATM networks up to OC-48c/STM-16 speeds.
- **Private Network to Network Interface (PNNI) networking**—PNNI capabilities are provided across the BPX and MGX product lines. PNNI is the utilization of a single physical transport infrastructure to simultaneously provide several network services with different characteristics and quality requirements. This multiservice switching product line was designed and developed specifically for robust multiservice networking for the service provider market. Multiservice switching products have key networking capabilities, including superior forwarding, control, and management functions that put this product family in a class ahead of the competition.
- **Cisco WAN Manager (CWM)**—CWM is a high-performance element and network management product for service provider networks. Cisco WAN Manager resides at the element and network management layer of the Telecommunications Management Network (TMN) model and integrates with other Cisco applications, such as Cisco Info Center and Cisco Provisioning Center. These provide higher-level applications, such as Service-Level Agreement (SLA) functions, provisioning, fault performance, and accounting management. CWM manages the Cisco BPX Service Expansion Shelf

(SES) and the entire IP+ATM multiservice switch product line. CWM allows network operators to easily monitor usage, quickly provision connections, efficiently detect faults, configure devices, and track network statistics.

- **TransPath**—The Cisco TransPath Multiservice (MS) System is an integrated, cost-effective solution for MPLS, Frame Relay, ATM, packet voice, and circuit emulation services that enable a broad range of carrier applications, including network-based IP VPNs, DSL backhaul, and mobile wireless transport. The Cisco TransPath MS leverages Cisco Multiservice IP+ATM WAN Switches and Ecosystem partnerships to offer service providers a pre-engineered, multiservice, carrier-class WAN solution including products, training, and implementation services. Cisco TransPath MS is designed to offer broadband access providers, mobile wireless providers, and carriers that want to rapidly deploy network-based IP VPNs a fully configurable solution that is cost-effective, highly reliable, and expandable to a range of services and port densities.