The Kingdom of Morocco is the most recent African country to enter cyberspace. Since the infrastructure necessary to establish Internet connectivity was simply nonexistent, connection was a monumental task. Major infrastructure complications and the fact that full Internet connectivity or Internet service providers (ISPs) did not exist anywhere in Morocco didn't help. There was also minimal telecommunications expertise within the country, and the university that elected to establish Internet connectivity had just broken ground outside a remote village in the Middle Atlas mountains. Al Akhawayn University in Ifrane (AUI) was inaugurated in January 1995. It is an institution of higher learning, based on the U.S. academic model. One of AUI's major goals is the advancement of science and technology to both local and international communities—Internet connectivity was a major factor in achieving this goal.

The university's plan for Internet connection was accomplished in four stages:

• Formation of an in-house computer network
• Implementation of a router to control traffic flows between the in-house system and the Internet
• Subscription of Internet service from an ISP
• The establishment of a dedicated circuit access to the ISP. AUI started from ground zero in meeting these requirements.

Although the remote physical location was problematic, designing the campus network before construction of the university proved advantageous. Cables could be laid or strung wherever they needed to be, there were no walls or constraints in regard to dependence upon existing equipment.

The accepted design for the AUI campus network consisted of an FDDI backbone, connecting administrative, academic, and dormitory building networks at a speed of 100M bps. These administrative, student, and housing networks are Ethernet LANs with a capacity of 10M bps running on either twisted pair wire or fiber-optic cable.

Computers are connected to a variety of Novell Netware servers for office software and disk and print sharing. They operate under both IPX/SPX and TCP/IP protocols. The Unix system (Sun Sparc Systems ranging from entry-level Sparc Classics to high-end Sparc 1000s) utilize the TCP/IP protocol, in-house system, and Internet connection.

Once the design of AUI's campus network was in place, the next step was to connect the campus backbone to an Internet hub. Interconnection between AUI and the Internet hub was done by a Cisco 2501 router. Some of the provisions AUI's network relies on include Ethernet interfaces, high-speed synchronous and asynchronous serial ports, and routing support for IP and IPX protocols.

In order to prevent or deter compromising internal network security, AUI has a single point of entry for the Internet. All data between the campus network and the Internet must pass through a firewall. Checkpoint Software Technologies, FireWall-1
On Site

is the primary firewall software utilized at AUI.

AUI wanted additional security and accounting in order to track the source and destination addresses of all traffic (email, WWW, ftp, telenet, gopher, and so forth) between the AUI network and the Internet. The router was able to count the number of bytes of traffic across the net, but was not able to provide the desired statistics. AUI also wanted to restrict traffic such as external finger, telenet, and other risky protocols from external sources, while allowing certain predefined services. Culture may have played a small role in the desire for extra security, but the primary reason was related to good business practice. Any entity with external network contact is foolish not to invest in firewalls and limited access software.

Since AUI considered becoming a service provider, it also needed a sophisticated means of compiling a complete billing report. In addition to source and destination IP addresses, AUI wanted to capture information such as duration of communication, number of kilobytes transferred, and top-level protocol (ftp, telenet) accessed. The company selected was able to enhance the FireWall-1 software to meet both security and billing needs of the university. AUI was one of the initial testbeds for this software, which the company is now producing as a standard product.

Subscription of Service

Morocco's geographic location on the northwest coast of Africa facilitated connections with European networks. Therefore, while the AUI campus was in the early stages of construction, RIPE (Résaux IP Européens), a voluntary organization consisting of European ISPs, was contacted. Among other things, RIPE promotes and coordinates the interconnection of IP networks within Europe and their links to other continents. When a potential Internet customer contacts RIPE, it, in turn, notifies all members of the request. By RIPE contacting all members on the service provider list simultaneously, each member has the same opportunity of obtaining the final contract.

After two requests (several months apart) from AUI, only one European service provider, the EU net Group, had responded. It was fortunate that the only responding ISP was also one of the best. Based in Amsterdam, the EU net Group consists of approximately 30 operating companies that provide Internet services to over 40 countries and over 100,000 major organizations. EU net also provides service to Egypt, Tunisia, and Algeria. EU net France, one of the major hubs, provides service to AUI. Once the provider was selected, the next step was the application for site registration. The Internet Assigned Numbers Authority (IANA) coordinates the global assignment of unique parameter values for Internet protocols. It maintains a registry of currently assigned unique values for such parameters as IP addresses and domain names. The RIPE NCC (Network Coordination Center) in Amsterdam acts as a clearing house for distributing IP numbers, registering DNS domains, and establishing IP routing policies for Europe, Africa, and the Middle East.

Each IP address is associated with a fixed hardware address, called a domain name. In the domain name AIAlkhawayn.ma, AIAlkhawayn is the second-level domain name, and .ma is the top-level domain (TLD), signifying the Kingdom of Morocco.

The last major requirement—a dedicated circuit to the ISPs—was the most difficult to meet. AUI is dependent upon three different telecommunications companies (on two continents) and a submarine cable service to provide leased-line service. A dedicated circuit had to be established from the Middle Atlas mountains in Morocco, across the Mediterranean Sea into Spain, and eventually linked with EU net France. The European side was not difficult, because the infrastructure already existed. As with most European countries, France Telecom had already created a link with Telefonica, Spain's national telecommunications network. Also, a submarine cable across the floor of the Mediterranean Sea had already been established between Tetouan, Morocco and Spain. However, leased-line access within Morocco was far more diffi-
The local ONPT (L’Office National des Postes et Télécommunications) owned pathways between Tetouan and Ifrane, but some portions of the pathways had no lines or switches. Therefore, the ONPT had to determine the best path between Tetouan and Ifrane, install 64Kbps lines and switches along the path, and test all connections.

Problems Encountered
Two major problems were encountered in the evolution to Internet connection: obtaining Internet connectivity and registering the domain name. As of June 1995, all Moroccan ONPT lines and switches were installed, connected to the France Telecom lines, and AUI Internet connectivity was ready to be tested. However, it took an additional two months to obtain the first Internet connection. The configuration recommended by ONPT did not work. The problem was finally resolved when AUI added two modems between its router and the ONPT connection.

Registering the domain name was even more exasperating. In most countries, with the notable exception of the U.S., the TLD is associated with the country of origin. All subsequent domain name acquirers within that country must follow that same hierarchy and retain the same TLD. Typically, the organization that establishes the TLD is responsible for registering all subsequent domains with RIPE NCC. When a university in Rabat, Morocco, established UUCP connectivity to provide intermittent email service, it was given the responsibility for managing all subsequent domains originating from the Kingdom of Morocco. Therefore, AUI contacted the university in Rabat, provided them with IP addresses, and requested that the AlAkhawayn.ma domain name be registered. This is usually a simple accounting procedure, accomplished in a matter of minutes. Unfortunately, months passed and the domain name was never registered. This required all communication between AUI and the Internet to occur at the IP address level. And, since some servers translated IP addresses to registered domain names (which we could not obtain) before allowing access, complete, unrestricted Internet access was not possible. A member of the Network Startup Resource Center (NSRC) heard our plight and graciously volunteered to register AUI under the NSRC.org domain until we could obtain official registration. AUI’s domain name was finally registered after numerous requests and pressure from RIPE NCC.

The first successful Internet transmission originated from AUI in August 1995. By January 1996, full Internet connectivity was finally available to all faculty, staff, and students. This was approximately one year behind schedule, but well worth the wait. Post-implementation analysis clearly demonstrates that AUI was highly successful in introducing Internet service to the Kingdom of Morocco. Given the dependencies of this system (an ISP located on a different continent, two leased-line providers, and a submarine cable), downtime has been very low, and decreasing each month. Faculty and graduate students who had Internet access for at least one complete semester were surveyed to determine usage and user satisfaction. A total of 124 surveys (38 faculty, 86 graduate students) were distributed. Eighty-seven surveys were returned (28 faculty, 59 graduate students), resulting in an overall response rate of 70%. Although most respondents (34% faculty, 78% graduate students) had no prior experience with Internet, they are heavily utilizing Internet services for business, academic, and personal reasons. And, over 80% of the respondents expect usage to increase. User satisfaction is also very high. Those of us who had used Internet facilities prior to AUI expressed the greatest level of satisfaction. It appears that the major reason for faculty or student dissatisfaction with any Internet service is directly related to their understanding of how the system works. Since the majority of students and faculty are still learning about the opportunities available to them by way of Internet, it is expected they’ll experience a steady increase in activity in all facilities.

Organizations in both public and private sectors throughout the Kingdom of Morocco have become increasingly aware of the advantages and capabilities provided by Internet connectivity. In the past year, over a dozen local ISPs have been established, and Moroccan businesses, governmental agencies, and universities are keeping them busy, making Internet connectivity throughout the country a reality, rather than a dream.

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