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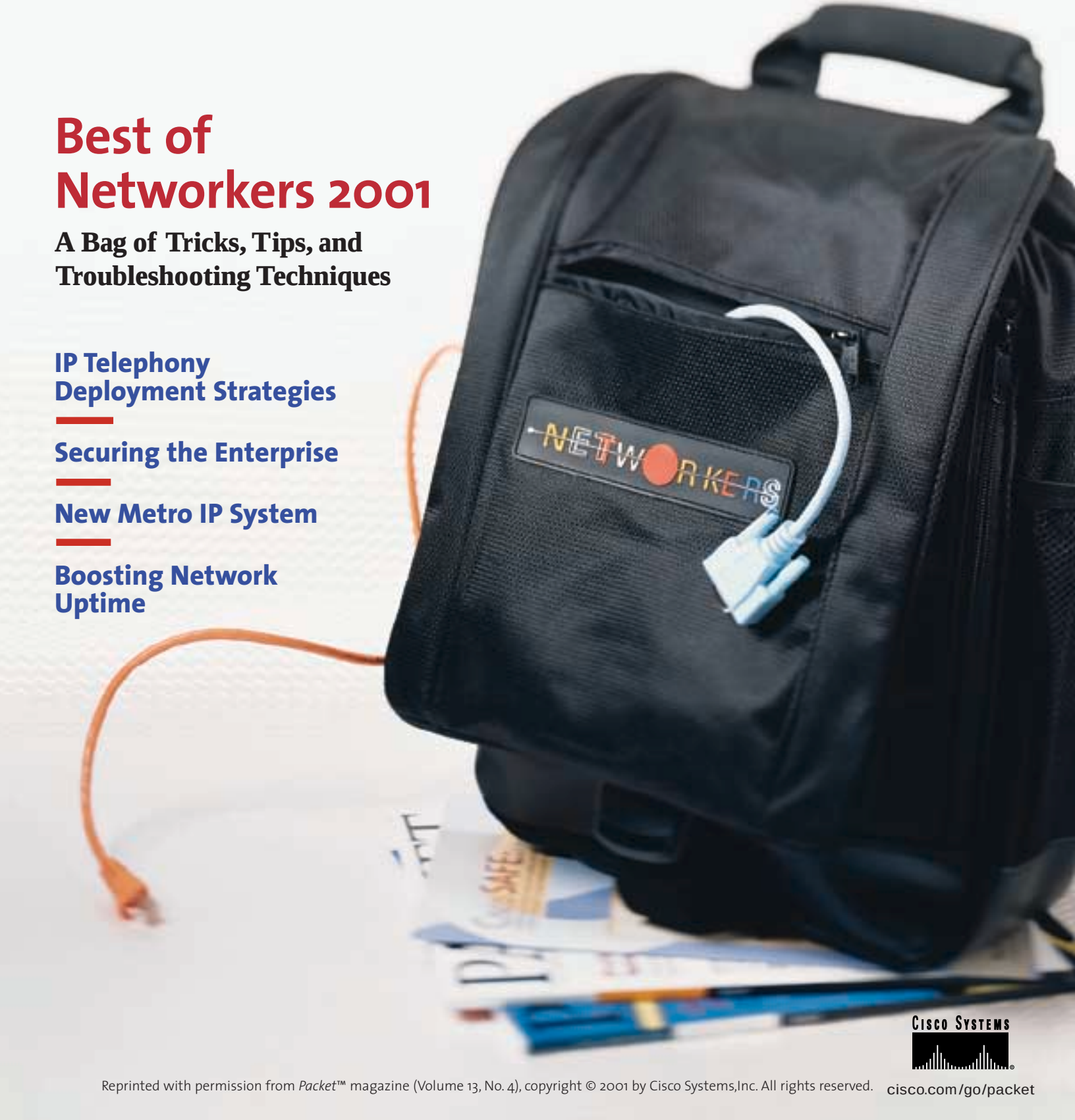

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UNIVERSITY OF HAWAII

Going the Distance

Cisco IP Multicast and QoS technologies enrich distance learning at the University of Hawaii.

BY DAVID BAUM

Distance learning isn't an option for the University of Hawaii. It's a *necessity*. The institution's unique geographic makeup—three university campuses, seven community college campuses, an employee training center, and five education centers distributed across six islands—make distance learning a prerequisite for both students and faculty.

Until this year, the University of Hawaii's distance learning network consisted of an analog system that could support only four classes simultaneously. Unfortunately, this network didn't have the capacity to adequately support all of the university's teaching and learning facilities, nor was it equipped to transmit IP-based applications. Today, however, network technologies from Cisco are enabling a fundamental shift in how learning is conducted and knowledge is exchanged at the university. At the heart of the interactive, multiservice solution are routers and switches that support end-to-end quality of service (QoS) and IP Multicast through Cisco IOS® Software.

"We wanted to be able to deliver video broadcasting for distance learning over the complete breadth of all our campuses," says David Lassner, Ph.D., director of information technology (IT) at the University of

Hawaii. "We selected a solution based on pure IP technologies. IP Multicast and QoS were the best way to help us reduce costs, increase flexibility, and minimize maintenance headaches."

Single Transmission, Multiple Benefits

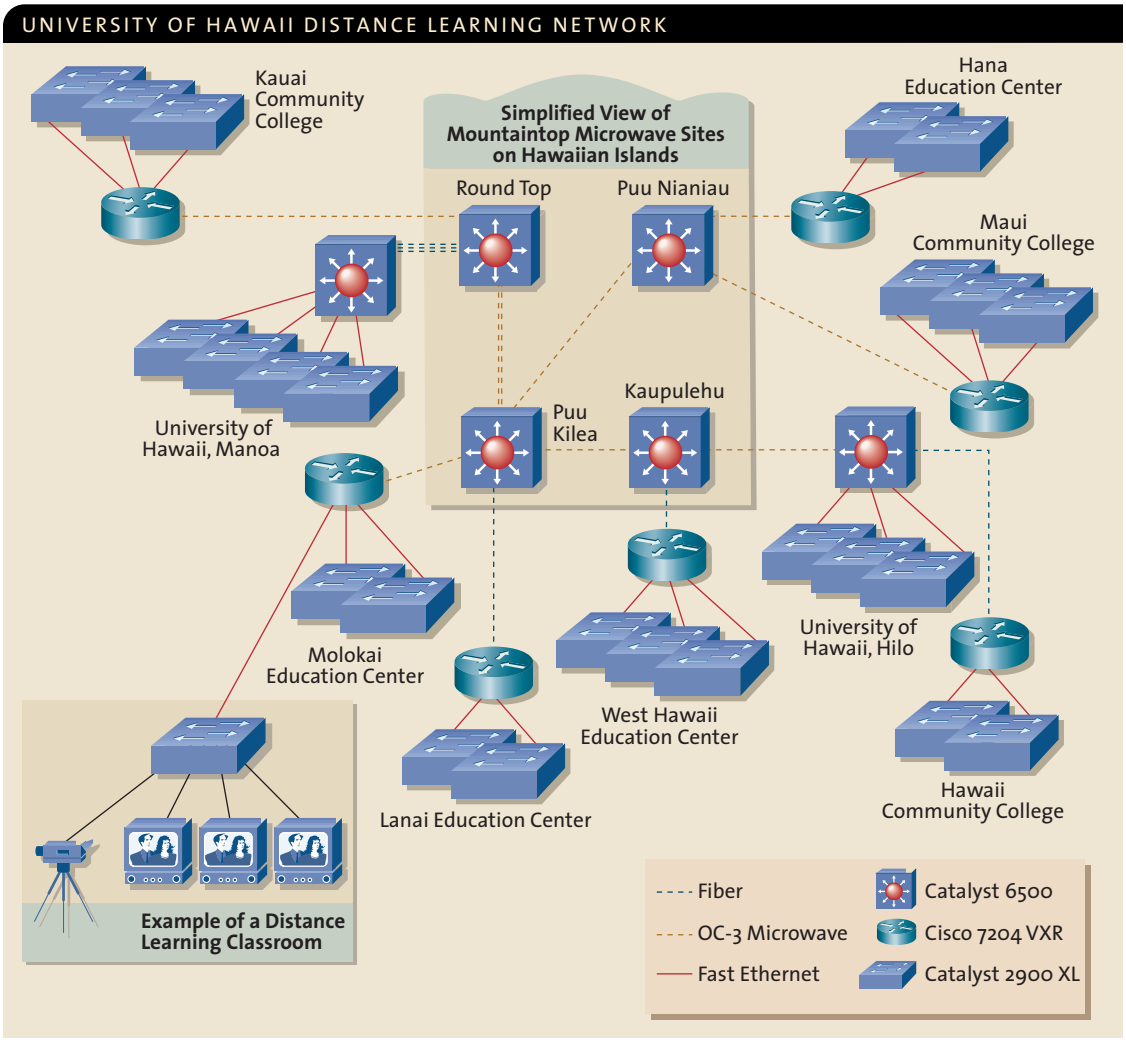
Lassner and his colleagues envisioned a packet-based network that would allow for multiple monitors in each classroom, allowing students to not only see the instructors but also to see and interact with their fellow students on other islands. Additionally, "quad-split" technology could enable up to four additional classrooms to be viewed on a single physical screen in cases where space inhibits multiple monitors in a classroom. With IP Multicast, information is sent to a targeted group of recipients via a single transmission. Video applications, for example, can send information to a group address, thus reaching only those individuals who want to receive it. Without multicasting, information must be either carried over the network multiple times or broadcast to everyone on the network.

"We designed one integrated network to support our interactive video as well as the university's burgeoning demands for other IP-based information and communication services," says Lassner. "Multicast lets us use scarce network capacity efficiently by sending only one copy of a broadband video stream on any path, even when it may be destined for seven other locations. QoS ensures that our audio and video traffic receive priority over less time-sensitive applications such as e-mail, file transfer, and general Web browsing."

Flexible, Nonblocking Video Architecture

The first step in making the integrated network a reality was to develop a WAN linking the university's campuses, community college campuses, and training and education centers on six islands. Fiber-optic infrastructure with OC-3 packet over SONET and Gigabit

ISLAND HOPPING: Using IP Multicast and QoS features in Catalyst 6500 and 2900 Series XL switches and Cisco 7200 Series routers, the University of Hawaii's new WAN efficiently routes data, voice, and video traffic for interactive distance learning and training across six islands. Cisco equipment terminates the point-to-point OC-3 for plentiful bandwidth.



"Our new multicast network not only provides students, faculty, and staff with greater distance learning and training opportunities, but it solves previous bandwidth limitation and scalability problems and provides for more efficient use of network servers, routers, and switches." —David Lassner, Ph.D., Director of IT, University of Hawaii

Ethernet was deployed to support intra-island connections, and OC-3 microwave was used for inter-island capacity. The biggest challenge, says Lassner, came with deploying the microwave transport facilities. The process required substantial planning, permitting, and construction—often involving remote mountaintop towers on each island.

To route data, voice, and video traffic across this very wide-area infrastructure, the university's IT team deployed several Cisco Catalyst® 6500 and 2900 Series XL switches and Cisco 7204 VXR routers (see figure). "The IP Multicast infrastructure ensures high bandwidth and low cost for two-way video transmission, while QoS ensures that all interactive classes use network capacity efficiently and effectively," adds Lassner. "By using real-time delivery and low-latency coding and decoding, we created a flexible solution to go between locations that have limited bandwidth. The nonblocking video architecture gives us tremendous advantage with flexible scheduling and the ability to grow on demand."

Twenty-five interactive video classrooms throughout the university were equipped with computers, cameras, microphones, monitors, visual presenters, and MPEG2 encoders/decoders. The multicast network receives and encodes television signals from a microwave dish located at the university's Oahu campus. Live classroom camera feeds are captured, switched, encoded, and streamed over the IP Multicast network. QoS capabilities inherent in the Cisco devices ensure high-quality video and low-latency interactive applications.

IP Multicast, Untrusted QoS Network

Within Cisco IOS Software, Protocol-Independent Multicasting (PIM) and Multicast Multilayer Switching (MMLS) enable multicast video transmissions. An architecture that allows the addition of IP Multicast routing on existing IP networks, PIM is used to discover multicast groups and build routes for each group. It works independently of unicast routing protocol and can be operated in dense or sparse modes. PIM dense mode (PIM-DM) is data-driven and resembles typical multicast routing protocols. PIM sparse mode (PIM-SM) tries to constrain data distribution so that a minimal number of routers in the network receives it. MMLS provides high-performance, hardware-based Layer 3 switching of IP Multicast traffic.

The University of Hawaii uses PIM-SM, which is optimized for internetworks with many data streams but relatively few LANs, according to Troy Nakagawa, a Cisco systems engineer in Honolulu. PIM-SM defines a rendezvous point that is then used as a registration point to facilitate proper packet routing. When a sender wants to transmit data, the first-hop router sends data to the rendezvous point. When a receiver wants to receive data, the last-hop router registers with the rendezvous point. "A data stream then can flow from the sender to the rendezvous point and to the receiver," explains Nakagawa. "Routers in the path optimize the path and automatically remove any unnecessary hops, even at the rendezvous point."

MMLS works as a packet-forwarding function, moving packets onto the connected Layer 3 switch whenever a supported path exists between a source and members of a multicast group. Packet flows are switched between IP subnets using advanced ASIC switching hardware, offloading processor-intensive multicast packet routing from network routers. Packets that don't have a supported path to reach their destinations are still forwarded by the routers.

Also, the university has an "untrusted" QoS network, says Nakagawa. If a student, for instance, tries to spoof the network by setting his or her own IP precedence bit or Differentiated Services Control Point (DSCP), traffic is reclassified at the edge before traversing the WAN links. If the WAN is congested, packets are queued using low-latency queuing that gives video traffic the fastest access to the WAN and guaranteed WAN service while other traffic shares the remaining bandwidth.

Spreading the Word

The University of Hawaii's interactive distance learning and training network is the largest, most extensive deployment of video over an industry-standard IP-based network using both LAN and WAN infrastructure.

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University of Hawaii, Continued from page 13

MPEG2 video at 3 to 5 Mbps is used, says Lassner—the same digital video compression technology used by cable, satellite, and wireless TV services but deployed over an IP network.

In addition to the university's flagship campus at Manoa, the system supports approximately 3000 University of Hawaii students at Hilo on the island of Hawaii and the smaller University of Hawaii-West campus on the leeward side of Oahu with about 700 students. Also benefiting from the network infrastructure are approximately 24,000 students and 1300 faculty in the university's community college system, which includes four campuses on Oahu and one campus on each of the islands of Maui, Kauai, and Hawaii. Additional education centers are located in remote areas of the state to enhance access to higher education in locations without a full-fledged campus nearby.

"The distance learning program supports undergraduate through Ph.D. students, including entry-level community college and all public post-secondary education in the state," says Lassner. "This makes it possible, for example, for an instructor who specializes in oceanography to teach a class composed of students from all the islands simultaneously."

About 2000 student enrollments per semester are conducted as interactive video courses, a number that will surely grow after the university's revamped distance learning network goes live later this year. In addition to opening up course offerings previously not available to students in some areas, the network will bolster videoconferencing for internal communications and expand the faculty's professional development opportunities (for example, ways to apply technology to improve their courses).

"By replacing the existing analog video network with an all-digital video-over-IP solution, the university has created an integrated data network for inter-island and intra-island communications that supports open industry standards," Lassner concludes. "Our new multicast network not only provides students, faculty, and staff with greater distance learning and training opportunities, but it solves previous bandwidth limitation and scalability problems and provides for more efficient use of network servers, routers, and switches."

And there's much more on the horizon for the University of Hawaii. Notes Lassner: "We're looking toward using the new multicast network for applications such as making video course playback available on demand for students who miss class or need the video for review, integrating digital video segments into Web-based instruction, and expanding course offerings beyond Hawaii to US mainland and Asia Pacific locations." ▲▲