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The *n*-Dimensional Superswitch

Larry Roberts has a next-gen router he says will kick Cisco's ass — oh yeah, and reinvent the Internet. Lawrence Roberts is not a patient man. But he's trying. He's leaning over a table in the San Jose headquarters of his new company, Caspian Networks. The building's exterior is standard fare — one more box [...]

LARRY ROBERTS HAS a next-gen router he says will kick Cisco's ass - oh yeah, and reinvent the Internet.

Lawrence Roberts is not a patient man. But he's trying. He's leaning over a table in the San Jose headquarters of his new company, Caspian Networks. The building's exterior is standard fare - one more box in a Silicon Valley office park - but this spartan corner nook is at the end of a curving yellow hallway lined with eerie purple lights. The shades are drawn, and the leathery, 63-year-old engineering legend is pointing out the shortcomings of the packet-switching architectures employed by his competitors - dullards like Cisco Systems, Juniper Networks, and Avici Systems. "They're using hypercube or hypertoroid topology, so they're limited to six dimensions, really - three up and three down," he explains. "I've been able to take more steps, to go into *n*-dimensional space."

His eyes bore into me from beneath a pair of bristling eyebrows, and soon he realizes that these terms are not ringing a bell, that *n*-dimensional space is not my natural habitat. So he switches gears. "Look. It's like you've got a bunch of dumb gorillas working on something," he says. "You can do it a lot faster and better if you get some smart people." It sounds like a crude and condescending remark, but for Roberts, it's a multidimensional metaphor. In a technical dimension, the gorillas symbolize the IP routers at the core of the world's long-haul optical data networks, while the smart people are Roberts' new creation, an intelligent "superswitch" that he insists will replace them. In a competitive dimension, his "gorillas" are also the core-routing heavyweights - Cisco and Juniper - while the smart people represent (surprise!) the engineers at Caspian.

More than three decades ago, while a researcher at MIT, Roberts began hatching the network designs that would evolve into the Internet. For the last three years, he's been holed up with what has become a cadre of 200-plus engineers nourished on a $140 million diet - provided by Paul Allen's Vulcan Ventures, WorldCom, Lucent, Merrill Lynch, and others - working on what he promises will be one of the biggest things since the birth of the Net. Now Roberts is just eight weeks from launch, when he'll announce a major backbone operator as a flagship customer. And while neither that company nor any other carrier - including WorldCom - would comment on Caspian's innovation prior to launch, Roberts has agreed to give *Wired* a sneak preview.

To the untrained eye, Caspian's product, the Apeiro, is a new kind of router. But Roberts says it's not a router at all, because where traditional routers are "dumb" - Roberts' shorthand for the fact that they don't differentiate between the kinds of bits running over a network - his "optical IP superswitch," as he calls it, is smart. It can identify packet types (voice, text, video, et cetera) and priorities, allowing it to determine one packet's relation to others, and expedite traffic in a way that's impossible today. For example, the Apeiro will recognize all portions of a videostream and label them as part of a greater whole so they can be more efficiently slotted and moved to their ultimate destination.

This may seem like a minor improvement, but Roberts says recognizing and prioritizing packets of data - coupled with the fact that racks of his devices can be stacked together to increase performance - will make the Apeiro as much as 1,000 times faster than typical core routers in use today. If those speed estimates prove out, Roberts says it will mean supercheap worldwide IP telephone calls clearer than those on the voice network. For people with high-speed Web access, it'll mean on-demand full-screen streaming of high-definition video. Even the dialup crowd will be able to pull up Web pages at least twice as fast.

Ultimately, Roberts says, the Apeiro will deliver an Internet that finally lives up to all the broadband hype - a platform that will dislodge every other entertainment and communications medium. "All entertainment is going to shift to the Web," he says. "You'll be able to get the programming you want, the way you want it." On the way, he promises, Caspian will reshape the routing landscape and put an end to the notion that the Net works best as a dumb network.

Of course, the fact that our Internet is dumb at all is mainly Roberts' doing. In 1967, while translating Leonard Kleinrock's theoretical work on packet switching into the Arpanet, he

have seen this dumb-core, smart-edge setup as the very essence of the Internet. But Roberts says that's not the case. "Cisco thinks the network *has* to be dumb because we used to say, 'Keep it dumb,'" he explains. "They're doing it in a clunky, old, expensive way."

As it turns out, Roberts and his cronies (Kleinrock, Vint Cerf, and Robert Kahn) simply wanted to make sure that they, not the telecommunications carriers, had control over the fledgling network. They designed it so the complex computing happened in the university computers they had access to. "We were afraid a smart switch would get in the way of our experiment," Roberts says.

With telecom analyst firm RHK estimating that the core-routing market will grow from $2 billion in 2000 to $12.5 billion in 2003, the sort of architecture shift Roberts is suggesting could mean a windfall for Caspian. But of course Cisco is not about to hand the game over to an entrepreneur - no matter how respected he may be. In fact, Cisco and company have suspected for some time that the surging volume and complexity of Net traffic call for more routing intelligence, and they've been designing switching fabrics of their own. The trade press has been eagerly anticipating the Caspian launch, but Cisco doesn't seem concerned. "Every 18 months or so, somebody comes along and says 'We're going to reinvent routing,'" says Rob Redford, the company's senior director of marketing. "Ipsilon Networks came in with an IP switching plan," he says, referring to a networking startup touted as a Cisco-killer before it was quietly acquired by Nokia in 1997. "That fizzled."

But if you listen to Roberts, the incumbents are doing little more than tweaking a fundamentally dumb design. He singles out Internetwork Operating System, the software running Cisco's routers, as an example. IOS, he charges, has evolved from a time when core-routing functions were much simpler, bulking up with layer upon layer of software to adapt to new demands. "You can't have a monolith like IOS running a 10-terabit switch," he says. "The only way to get where we're going is to start from scratch. And Cisco doesn't want to redo IOS."

The select few who have been party to the Apeiro's prelaunch blueprints say Caspian is about to redefine the way the Internet works. "What they're suggesting is revolutionary," gushes Matthew Carpenter, a VC with Salomon Smith Barney, which ponied up part of the $87 million financing round Caspian raised in December. "They take the issue of routing to a different level."

hooked together to process up to 5 terabits per second. Pluris, another newcomer, has a multirack system that will churn as much as 19 terabits per second. By contrast, Roberts says an Apeiro system - made up of scores of interconnected 7-foot racks filled with switching cards, each 23 inches deep, three-quarters of an inch wide, and 15 inches tall - can handle 160 terabits per second, with petabit capacity on the way. And the analyst community is backing him up. Says Muayyad Al-Chalabi, a director at research firm RHK, a rack of Apeiro switching systems "can get bigger throughput than anyone else - by an order of magnitude."

To make a fundamentally smart switching machine, Roberts had to scrap the routing blueprints. Beginning in the spring of 1998, he and a handful of engineers cranked out new designs for wiring, software, and chipsets. But between the Apeiro prototype and market success are any number of hurdles. For starters, Roberts' leap in functionality mandates a leap in complexity. Caspian has contracted IBM to manufacture the ASIC chips that will run the Apeiro, but that will be no easy task - even for IBM. The most advanced routing chips in use today can handle only three dimensions; Caspian's chips must maintain awareness of two dozen routing dimensions at once. Meanwhile, the software, which will run in a distributed manner - controlling each switching card separately to isolate failures even while functioning as a single entity - has several months of testing and debugging ahead.

__Dumb core, smart edge was the essence of the clunky, old, expensive Net. With Apeiro prioritizing packets, Roberts says, it will finally get smart. __

The reward for clearing these technological hurdles: Roberts gets to bring his baby into a crowded market to compete against the likes of Cisco, Juniper, Avici, and Pluris. And he'll have to do it without Grahame Rance, the 18-year Nortel veteran Roberts recruited as Caspian's CEO. In mid-March, Rance abruptly left Caspian to run electronics component maker SBS Technologies, causing some observers to ask, "Is there a problem they're not telling us about?"

Together it all seems daunting, but the good news for Roberts is that the exponential growth of Internet traffic over the last few years has made carriers like WorldCom, Sprint, and AT&T receptive to anyone who can help them handle the deluge. It's what allowed Juniper, which crashed the party in 1999 with a faster router, to promptly grab a third of Cisco's market share. And with Cisco's recent announcement that it will sack as many as 8,000 workers, the router monolith appears less intimidating than it once was. "In the days of single-digit growth,

tomorrow."

Wall Street's recent infatuation with optical networking has ensured that any company whose products come within a light-year of a fiber-optic cable touts itself as optical. But in reality, there are no true optical packet switches or routers on the market yet - at least not in the sense that engineers mean when they use the term. What many of the so-called optical networking companies actually do is optical circuit switching - connecting big pipes to other big pipes.

Caspian also identifies its wares as optical networking equipment, but - as with Cisco and Juniper - the company is optical only in the sense that its product sits adjacent to the optical backbone trunks, converts optical data into electronic form, decides where the packets should go, and converts them back into photons before moving them along. So, the real promise of Roberts' innovation has less to do with photonic optical switching - routing data as light without electrical intervention, which Roberts says is still many years away - than with advancing traditional routing to the next level. In short, Roberts wants to make packet routing as dependable as the switching that occurs in a voice network, until pure optical switching arrives.

"Our software is designed so it will run nonstop. That's never been done in a router," says Roberts. "When you're making a phone call and there's an outage, the system switches the call and you can't even tell anything happened. On the Internet, you get a 'server not available' message."

The idea of switching will make the carriers more comfortable, since the current system of routing is costing them a lot of money. The IP traffic explosion should have been a bonanza for the carriers, but it hasn't. Because the backbone routers can't differentiate between packets, they move all traffic as quickly as possible. As a result, carriers are unable to charge a premium for high-priority data like voice and video. What's more, today's core routers aren't smart enough to handle a port failure without shutting down, so carriers have to buy two core routers for every one they use - paying for twice as much equipment and capacity as they need.

They're also buying more often. Until a few years ago, a carrier would typically replace the core routers every 18 to 24 months - with a system from Cisco or Lucent full of OC-192 ports costing around $2 million. The IP boom has only accelerated that cycle. As a result, the chief

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