Making the Internet Go Away

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Do not adjust your set. Do not click Reload. This issue’s Peer to Peer title is correct. I do want the Internet — as we know it today — to go away. And, for our industry’s sake, I want all of you in the data-networking-research, equipment-vendor, and service-provider communities to make it happen — soon.

Perhaps that’s a little over the top, but here’s a serious question for our communities: How do we turn today’s Internet into a mature and transparent communications infrastructure? Right now, we can do some really cool things on the Internet; with email, Web surfing, peer-to-peer collaborations, instant messaging, distance learning, business relationships, and data-set sharing for research, I’m only scratching the surface of an impressive list. But we achieve these activities at a cost: a very personal and irritating relationship with the technology behind the Internet. How many times do you have to suffer dial-in dropouts because Internet service providers (ISPs) can’t figure out the business cases for always-on broadband deployment? How often does the World Wide Web have to become the worldwide (unpredictable) wait? Where is the life-like, jitter-free video conferencing we once thought would be upon us by the end of the 1990s? Why do we still engineer and operate large sections of the Internet by the seats of our pants?

Don’t get me wrong. The Internet’s evolution is a great tribute to the work of thousands of engineers, experimental scientists, and visionary business people over the past 15 or more years. The fundamental move away from circuit switching and proprietary protocols let the Internet sprout and grow as a loosely coupled, packet-switching overlay on the robustly engineered telephone network. (Yes, the telephone network provided all those reliable fractional T1s, multimegabit leased lines, and Synchronous Optical Network/Synchronous Digital Hierarchy [SONET/SDH] optical circuits.)

If the proliferation of email and Web addresses on buses, billboards, and business cards is any indication, the Internet clearly has begun to pervade regular life. However, the underlying network infrastructure’s engineering is not a done deal. We’re still at the Model T Ford stage; society has started to see this telephoneless carriage’s potential and everyone wants one, but we’re still bouncing along with what amounts to a proof-of-concept technology. To phrase it another way, a grand engineering challenge worthy of everyone’s attention is staring us in the face: to move the Internet from an opaque (and often antagonistic) companion to a seamless, transparent partner in our daily lives.

A Driving Lesson

My proposal isn’t particularly novel. Consider the automotive industry. It’s been refining and evolving its products and processes since the horseless carriage first caught the public’s imagination. In the first few decades of the 1900s, users were simultaneously drivers and mechanics, largely sustained by their own wit, debugging expertise, and assistance from like-minded individuals in automobile clubs.

Automobile technology regularly intruded on the driving experience, turning most trips of any length into adventures in their own right. Long drives meant dust, smoke, smells, noise, and breakdowns. Nearly a century later, the modern automobile almost drives itself. We turn the key, point the wheel, and push the pedal. No expertise required. We take for granted smooth rides, air-conditioned comfort, cruise control, entertainment systems, GPS-powered navigation, and more. Today’s automobile is incomparably more robust, resilient, and predictable than its predecessors. Mechanics are specialists you see only as an exception or for preventative maintenance. The automobile is a central part of modern society, but its technology has become more transparent.

Perhaps counterintuitively, we will require more technology, not less, to make the Internet go away. The automobile is instructive on that, as well. Think about a modern car’s system-wide complexity compared to something from the 1920s or even the 1960s. It’s quite stunning. So what’s the key? How does an order-of-magnitude greater complexity produce a simple, easy-to-use tool integrated into modern life? The answer is engineering — for trans-
Transparency means that we generally don’t see it — that the Internet’s component technologies because so predictable, functional, and resilient that they drop below the threshold of our consciousness. I’m keen to see this happen because I want our world to have a ubiquitous, digital communications infrastructure that empowers people to connect and reconnect in ways limited only by their imaginations. A ubiquitous infrastructure must be invisible. Here’s how I believe we can face this grand challenge.

The Challenge

No matter what part of the research, development, or deployment arc you find yourself in, do not forget the consumer. The consumer experience is paramount. We’re talking about real people — all over the world. It’s a huge market, with a huge networking challenge. Don’t kid yourself into thinking regular people know how to install Linux or keep their Windows patches up-to-date. Regular people have more important things to do than fiddle with Web cams blocked by network address translation (NAT) boxes, wonder why their ISP connection keeps flaking out, or worry about whether someone is hacking their online banking experience. Regular people still have their VCR clocks blinking “12:00.”

Focusing on consumers means scaling the Internet way beyond what we have today — a real challenge. IP networking always has involved dynamic behavior at various timescales, from TCP’s windowed flow control to routing protocols’ dynamic reconvergence after topology changes. On small scales, these processes tend to converge to modestly predictable steady states in mostly acceptable time frames. Of course, the Internet isn’t small scale anymore. Most candid IP network engineers will confess that they really don’t understand much about the dynamic characteristics of the packet traffic sloshing around in their networks from one second to the next. They’re usually struggling to predict their networks’ detailed behavior next week, tomorrow, or in the next minute. And don’t even begin to ask

This will require a cross-disciplinary effort involving researchers, operators, and vendors. Refocusing our communities to jointly tackle the next phase in the Internet’s evolution will be a nontrivial task.

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Grand Themes

So, what should the new themes be for IP research, themes that excite researchers to get out of bed each morning? I suggest that the following broad areas are independent, overlapping, and crucial:

- broadband access,
- network resilience,
- seamless mobility, and
- saving the Internet from narrow-minded business models.

We can’t stop at proof-of-concept prototypes. We must address these themes with a target of hundreds of millions of active, dynamic, and demanding end hosts. (I also believe that we’re seeing diminishing returns in such currently popular topics as yet-another-tweak-to-TCP, QoS schemes that ignore market realities, and ranking ourselves by our forwarding paths’ speeds. But that’s another topic.)

We need ubiquitous broadband access. That means figuring out cheaper technologies (to minimize up-front and operational costs) and practical ways to offer meaningful tiered services to end users (to maximize return on investment). For example, there’s barely any agreement among ISPs on billing models. Some claim an “all you can eat” approach, and then quietly cap the heaviest users. Others offer flat rates up to a monthly byte cap, with either per-Mbyte incremental charges or a severe rate limit when you exceed the cap. Mapping billable units (usually Mbytes) to actual end users’ activities is a very difficult problem for which no ISP has yet found an adequate solution. This makes broadband costs difficult for regular consumers to understand and value. Unfortunately, without a predictable cost–value trade-off in consumers’ minds, it is difficult for ISPs to roll out premium-priced (high-revenue) IP access services. We need performance metrics that make sense to regular consumers while clearly differentiating between best-effort and tiered-access service. We also need to provide better characterization of emerging interactive and realtime application-traffic patterns. This is particularly important to help ISPs engineer their networks for the applications that are most likely to drive demand for higher-revenue, premium IP access services.

We know how to make fast routers, switches, and links. Now we must learn how to engineer a resilient IP network, one whose real-time performance degrades in graceful, predictable, and controllable ways in the face of internal system disturbances. Designing and planning such a network certainly will require accurate modeling and prediction tools, and it might involve new architectural principles. For example, we’ll need impulse-response models for large Border Gateway Protocol (BGP) clouds, end-to-end service degradation automonitoring and detection, studies of how TCP’s own dynamic behavior permutes end users’ perceptions of service degradation, analysis of how encryption and related security techniques can harden the network against deliberate attacks, and so on. The potential research topic list is extensive.

Seamless mobility makes this all the more difficult. I’m not talking about party tricks like small test beds of 100 nodes running Mobile IP, and I’m not thinking of just application-layer mobility. Instead, the ubiquitous Internet should let your IP identity transparently migrate as you move between physical network attachment points, wired and wireless access technologies, and ISPs — with accurate behind-the-scenes authentication and billing. You’re one of thousands of mobile nodes moving every second, on a network with millions of mobile nodes active at any one time. High-speed transitions are seamless, service quality remains high, and governments achieve their lawful interception needs without twisting the network’s architecture inside out behind the scenes. That’s no party trick.

Finally, we’re definitely past the point where our research community can ignore ISPs’ business needs. Anything we develop — tools, algorithms, models, or architectures — must recognize the need for ISPs to have viable business cases. When an ISP dies, creates walled gardens to lock in customers, or cannot see a business reason to play nice with its inter-domain neighbors, the network has failed. We must do what we can to minimize those network failure modes because they cut right across the stability of broadband access, network resilience, and mobility.

What Are You Doing?

The Internet’s next big success will occur when society thinks of it as a service rather than a technology. To make that success happen, we’re facing a grand engineering challenge involving researchers, operators, and vendors. We need to focus on the ultimate consumer experience as we instrument, measure, model, predict, reengineer, and manage a ubiquitous digital communications infrastructure. It will be complex, dynamic, and more than our current operational theories and practice can handle. So, what are you doing to help make today’s Internet go away?

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