A VISION FOR THE INTERNET

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Since the beginnings of telecommunication technology 100 years ago, we have witnessed a number of major shifts in the application of communications technologies to the needs of our society and industry. In that process, we have seen the marriage of wireline and wireless technologies, of analog and digital technologies, of voice, data, video, image, fax, streaming media and graphics to create a computer-communications infrastructure that spans the globe and serves billions of people. The Internet is the current manifestation of these developments and has penetrated every structure of our society.

We are now in the midst of an accelerating groundswell in this field of computer communications in its most visible and useful sense—not simply the wires and networks, but also the infrastructure, middleware, applications, services, modes of use, and users of the technology.

On July 3, 1969, UCLA put out a press release[1] announcing the forthcoming birth of the Internet (known originally as the ARPANET) which would take place some months later that year. The opening sentence of that press release begins, ''UCLA will become the first station in a nationwide computer network . . .''. In the final paragraph of that press release, I am quoted as saying, ''As of now, computer networks are still in their infancy. But as they grow up and become more sophisticated, we will probably see the spread of 'computer utilities' which, like present electric and telephone utilities, will service individual homes and offices across the country''. The ''computer utilities'' comment foresaw the emergence of web-based IP services; the ''electric and telephone utilities'' comment foresaw the ability to plug in anywhere to an always on and ''invisible'' network; and the ''individual homes and offices'' comment predicted ubiquitous access. Basically, I articulated a vision of what the Internet would become. The part

1- Thomas Tugend, UCLA to be first station in nationwide computer network, UCLA Press Release, 3 July, 1969. http://www.lk.cs.ucla.edu/LK/Bib/REPORT/press.html.

I did not include in my vision 35 years ago was that my 98 year-old mother would be on the Internet today (and indeed, she is).

That vision for the Internet can be broken down into five elements:
1. The Internet technology will be everywhere.
2. It will be always accessible.
3. It will be always on.
4. Anyone will be able to plug in from any location with any device at any time.
5. It will be invisible.

The Internet almost got it right. Indeed, the first three elements have already come about. However, the Internet as we know it today has not yet achieved the last two elements of the vision, which are fundamental not only to enable completely new categories of networked services and applications, but also to match the ease of use and availability issues associated with truly consumer multimedia applications.

Why have these last two been lagging? Basically, the mistake regarding element 4 above—any device plugged in at any location at any time—was that the Internet's TCP/IP protocol assumed that end users, their devices, and their IP addresses would all be found in the same location and would all be tightly coupled. These were correct assumptions at the time since the mentality then was that of a deskbound model for computing platforms. However, it is no longer the case that we stay at our desks. Rather, we are nomads and we travel constantly from our office to our home, airplane, hotel, automobile, coffee shop, branch office, conference room, bedroom, etc. The fact is that end users do not always access the Internet from their fixed-location offices, do not always use the same device, and the IP address they use may not be one familiar to every subnetwork they encounter in their travels (indeed they may use different IP addresses in their travels). That is, the users are nomads, and the issues associated with nomadic computing were not anticipated by the network protocols that grew up in the Internet. Indeed, we have now entered the era of nomadic computing wherein the mobile or nomadic user seeks to be provided with trouble-free Internet access and service from any device, any place, at any time. The problem with element 5 — invisibility — is that the Internet is anything but invisible in the sense of being easy to use in ways that do not assault our human senses with irritating input and output interfaces. However, the rise of ad hoc networks, sensor networks, nomadic computing, embedded technologies, smart spaces, and ubiquitous access, enable cyberspace to move out into our physical world and open up new vistas. The concept of these technologies disappearing into the infrastructure (as has electricity) suggests some far-reaching capabilities in terms of how these disappeared technologies are organized into global systems that serve us and our information and decision-making needs in adaptive and dynamic ways.

In my current vision of the Internet future, I see users moving more into a mode of mobility wherein they access the net not only from their corporate desktop environment, but also ubiquitously at any time from wherever they happen to be with whatever device they have, in a seamless, secure, broadband fashion. I see small pervasive devices ubiquitously embedded in the physical world, providing the capabilities of actuators, sensors, logic, memory, processing, communicators, cameras, microphones, speakers, displays, RFID tags, etc. I see intelligent software agents deployed across the network whose function it is to mine data, act on that data, observe trends, carry out tasks dynamically and adapt to their environment. I see considerably more network traffic generated not so much by humans, but by these embedded devices and these intelligent software agents. I see large collections of self-organizing systems controlling vast fast networks. I see huge amounts of information flashing across networks instantaneously with this information undergoing enormous processing and informing the sophisticated decision support and control systems of our society. I see all these things and more as we move headlong into the 21st century. Indeed, I foresee that the Internet will essentially be an invisible global infrastructure serving as a global nervous system for the peoples and processes of this planet.

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