Keynote Address

The Present and the Future of the Internet: Five faces

by Anthony-Michael Rutkowski
Executive Director
Internet Society

Seven weeks ago on the way to the Internet Society's annual international networking conference in Prague, I visited Geneva to meet with various international organization officials and give a seminar on Internet. It was envisioned as a small gathering for a few interested staff at one of my former employers, the telco world's International Telecommunication Union (ITU).

As it turned out, news of the subject had migrated about Geneva and the event became three separate sessions of nearly 300 people each in the largest conference room at the ITU. It attracted people from virtually every global organization in the city, including 30 different foreign missions and 6 ambassadors who came and participated actively. The Pakistani ambassador - who is also the chair of the UN Humanitarian Affairs Committee and provides his Internet address on his business card - addressed the audience stating that this was one of the most important things now occurring for developing countries. At the same time, the ITU itself announced that it had become the largest Internet access provider in Switzerland and its traffic was increasing at 20 percent per month.

The Society's own INET conference at Prague more than doubled over the past year and attracted 1200 people from 105 different nations. Billionaire Wall Street investor George Soros in his keynote address to the conference, called the Internet a critical component for the Open Society which was the basis for political and economic stability as well as organizational and individual success and self-fulfillment in the 21st century.

A few weeks ago, in reviewing the "metrics" of the Internet at the Society, we found that all measures of the network and its use continued to scale inexorably: ever more connected countries, gateways, networks, hosts, users, services and traffic. A network analyst recently noted that if one of those services - the World Wide Web - continues its traffic increase at present rates, it will exceed the world's digitized voice traffic in three years. We are now watching a global internetworking revolution scale in near real-time. Every thirty minutes, another network connects.

At the beginning of the month, the Washington Post carried the latest in a series of articles dealing with economic growth and contours of the "New Economy." Much of the new growth is coming from many thousands of small, fleet-footed new companies. At the same time, many of the old giants are being dramatically reshaped by young entrepreneurs who are in the vanguard of a productivity revolution that is reshaping the economy. "With the aid of new technology and new forms of corporate organization, they are finding ways to do things faster, better and cheaper, revitalizing entire industries and redefining the terms of economic competition at the same time."

On this Monday, the 30th Meeting of the Society's internet standards body - the IETF - began in Toronto. This body conducts its work almost continually on the Internet and physically gathers three times a year - typically bringing together more than 500 people at the meeting location and multicasting to more than 600 additional sites around the world. More than just developing standards, the IETF actually is a sophisticated technology transfer engine in which creative developers in academic, research, and business environments are joined in a kind of robust creative "soup" in which they imagine, write code, criticize, test, and very rapidly scale new information tools and services free from stifling formalities and positions.

And now here at Interop - Tokyo, we witness the event that more than any other has come to represent the rapidly growing one trillion Yen internetworking marketplace and the enormous networked Information Infrastructure that is now diffusing into businesses, governments, and homes around the world. Indeed, at Interop Las Vegas in May, Microsoft representatives said that PC

technology has diffused faster than any other form of electronic system, and at about the same time they announced that the next version of PC Windows would ship with the Internet Protocol.

Five Faces of Internet

These different experiences over the past few weeks symbolize what I call "five faces of Internet" and comprise the primary focus of my presentation today. Internet is much more than just a new kind of network for transporting data. Rather it is a broad "redefining paradigm" - in other words, a fundamental transformation that encompasses:

- building information infrastructure from the bottom-up;
- a robust global mesh for directly linking billions of computers and thousands of computer processes on whatever telecom and computer platforms that exist anywhere in the world;
- a means for open collaboration in the hyper development and evolution of new technologies and applications;
- transforming the structure, methods, and individual skills within enterprises, institutions, and professions of all kinds;
- a huge, rapidly growing market sector for internet-related products and services.

1. Bottom-up Information Infrastructure

The last decade had profoundly transformed the way we conceptualize and create information infrastructure. The "old world" was oriented around highly structured monoliths of the telco and early computer worlds that were planned and operated by big government and corporations. The basic plans flowed "top-down" from millions of hours of huge formal meetings and literal mountains of paper which purported to chart the future of information infrastructure for decades to come. They provided a plethora of abstractions that no one quite understood, under the aegis of never quite defined nor accepted concepts like ISDN, OSI, and next generation mainframes. Enormous directed monies were to flow into these projects pursued by national monoliths, and trickle-down information infrastructure would eventually settle into place.

There is no intent to denigrate these top-down efforts or the many people who were involved. Indeed, several years of my own career and those of many colleagues were invested in these efforts. However, top-down just did not happen as planned. Instead, a combination of VLSI, PCs, workstations, Local Area Networks, routers, and elegant user friendly software found an enormous marketplace that motivated individual initiative and investments. At the same time, long haul transport technology offered increasingly cheap bandwidth, and national governments allowed facilities-based competition among telecoms and deregulated value-added services. Under combined pressures from rapid technological change, competition, and affordable new systems, the world of information infrastructure began a speedy transformation.

At just the right time, robust TCP/IP technologies were available to serve as the universal intelligent interface among computers. As a result, enterprise networks, distributed network management and applications, and the global Internet became universally implemented. Massive bottom-up infrastructure happened, proliferated, and a new paradigm prevails.

This has been a remarkable decade-long learning experience about what information infrastructure is all about, and in nurturing its development. It's discovery time in cyberspace, and we are constantly learning about what works and what doesn't. This is not to say that all top-down activities are frivolous - no more than asserting that all bottom up activity will produce meaningful infrastructure. Similarly there is a lot more to information infrastructure than just the Internet.

This "face of the Internet" provides some invaluable models and lessons about key components of national and global information infrastructure and where we are heading in the future. The most prominent of these lessons is that bottom-up infrastructure succeeds most efficiently and spectacularly!

2. The Internet Global Mesh

Constant Evolution: Three Stages

The Internet and internet technology has been growing and evolving constantly since its inception in Vint Cerf's imagination and first

articulation more than 20 years ago on the back of an envelope in San Francisco. At the outset, it had multiple facets that addressed real needs: a means to share information system resources across multiple diverse platforms, a highly robust self-healing network that could operate across almost any medium to survive nuclear holocaust, and a way to bring together experts spread across the world in "collaboratories" to create, innovate, improve and produce in many different research areas.

It is now into the third stage of that evolution. The first stage was the early years under the aegis of the US DOD ARPA and the province of a relatively small closed community. Those people not only developed the technology, but the cooperative mechanisms and institutions that allowed it to scale and for further innovation to occur. The genius of it all can still be appreciated at major Internet meetings which typically bring together a significant cross-section of world's most highly motivated and innovative computer networking communities in every country.

Following DARPA's divestiture of the network and the technologies in the mid-80s, the second stage unfolded. It represented a period of major development by: 1) vendors for a growing enterprise internet market, 2) the USA National Science Foundation, NASA, and Dept of Energy and their counterparts in other countries who scaled the network to support open global academic and research activities, and 3) early innovators in the business sector who began providing public access services and using the capabilities. Interop itself was a key part of this second stage as it fostered massive investment in private open systems infrastructure.

The third stage is now unfolding as almost everyone, everywhere who provides, uses, promotes, or funds information systems and infrastructure becomes involved in the growth and use of the Internet, its technologies, and applications. If the first stage took us to 2000 hosts over the first ten years, and the second state scaled the connectivity from 2000 to 1 million over eight years, the third state of Internet growth is now marked by host counts that will likely proceed from 1 million to 100 million over the next five years. The growth of the attached networks is now publicly announced every three days, and we are literally watching it grow before our eyes.

Dimensioning Internet

The Internet is generally dimensioned two different ways. The core portion consists of the subset of registered internetworks that are known to have IP connectivity among themselves; while the larger Matrix Internet popularized by John Quarterman consists of the core Internet plus all the networks known to be connected to it by some lowest common denominator application like messaging.

The Core Internet and its metrics

As of the end of May, there were 435,760 allocated network addresses, 47,846 registered at the global Network Information Center, and about 35,000 known to have connectivity among themselves. For the last several years, the most widely used backbone network - the NSFNet - has provided a useful reference point for making consistent measurements.

Total networks increased at the rate of 160 percent last year; 183 percent outside the USA. As of 1 June, IP traffic is being routed to networks in 81 different nations. It's known that the European CERN backbone usually sees more reachable networks, and with the emergence of commercial public Internet backbones as well as the termination of NSFNet next year, the total number is likely to increase even faster.

Another major trend - in addition to globalization and the rapid increases - is revealed in analyzing the kinds of new networks attaching. Most are commercial in nature.

Specific focus on both the Asia-Pacific and European regions shows that about a year ago, the number of networks in most countries with significant GNPs began to scale significantly with about 1500 connected networks in each country. The trend seems unabated.

In addition to dimensioning the Internet in terms of networks, it is also possible to do so by computer hosts reachable. Since the earliest days of the Internet, Mark Lottor has been executing an Internet Walk script over several weeks to produce an actual list of every machine reachable. The results are generally released every three months. As of the end of December 1993, the number of hosts was 2.217 million. The count increased 69 percent over 1993. Lottor's hosts reachable dimension of the Internet is regarded as particularly significant because of

the Internet's most basic function is providing connectivity among machines. It is also used in estimating the number of Internet users based on a 10 to 1 ratio of users per host - realizing that this is an enormously variable ratio that encompasses everything from the PC on someone's desk to a gateway host supporting millions of users on some other network or commercial service.

Internet traffic is also highly important in understanding usage patterns among countries and among the hundreds of technologies employed as services on the Internet. Traffic on the largest backbones has been doubling every year and for 1994 seems likely to triple. Many smaller local backbones have experienced regular traffic increases of 20 percent per month. Outside the USA, many nations have experienced initial annual traffic increases measured in the thousands of percent.

At the individual service level, it's worth noting that files transfers account for largest amount of traffic (around 37 percent currently), with messaging totaling only around 18 percent. The most interesting new services from a metrics standpoint are the browsing variety like World Wide Web and Gopher. WWW in particular has grown spectacularly to account now for 6.1 percent of the entire NSFNet backbone traffic and growing at the unprecedented rate of 341,000 percent in 1993. New Web servers have been added at the rate of 12 per day over the past three months, and each can support many implementations. This currently amounts to almost a terabyte a month of Web traffic. If this growth pattern persists, some have calculated that in three years it will exceed the total world voice communication traffic.

The Matrix Internet

The core Internet's massive size, high performance, and open connectivity has proved a magnet to nearly every other kind of computer network. As a result, many other large and extensive networks have attached themselves to the core Internet's periphery. This includes networks based on specific platforms like BITNET, FidoNet, AppleLink, Minitel, and UUCP networks, as well as specific application networks for Email - for which there are numerous examples like X.400, AT&T mail, MCIMail, SprintMail, CompuServe, etc.

These peripheral networks create a larger Matrix Internet that currently reaches 154 countries, and provide many millions of people with lowest common denominator Email connectivity. In this capacity, the Internet is truly the world's universal electronic messaging backbone.

3. Open Collaboration and Development

Just as the Internet is technologically a virtual matrix among up to 4 billion computers and 64,000 process ports on each of those computers, so is it also a matrix among 20-30 million people who are directly or indirectly using those computers and processes. This is an enormously empowering capability that allows almost instant creation of workgroups, discussion groups, and audiences of all kinds. The capability transcends time zones, national and organizational boundaries, and in the near future even language. In its ultimate extrapolation, it is the ultimate open society where anyone, anywhere can provide or receive any information to anyone within seconds.

From its inception, the Internet was intended as more than just a computer network, but as a means of facilitating collaboration and development at great speed - sometimes described as technology transfer among disparate groups with different strengths like academics, industry researchers, and business entrepreneurs. This activity has taken two forms: 1) research and development of new distributed network techniques and applications, and 2) innumerable user populations employing the Internet and its technologies as tools to significantly enhance their specific professional activity or pursuit.

An entire new engineering and research discipline has been cut out of whole cloth - distributed autonomous networking - complete with its own development dynamics and methods. Mosaic, httpd, Gopher, Archie, Veronica, Collage, Eudora, POP, SMTP, Netfind, Knowbots, NFS, NNTP, VAT, and SNMP are examples of some of the more popular client-server products to come out of the Internet innovation "soup."

With amazing rapidity, ideas for a new application or service get vetted on a discussion group or at IETF "BOFs" and proceed through a standards working group. At the same time, the code is placed on a network server. In the process, innumerable users employ the code, grow the market, refine the code, and a large commercial

market emerges in a matter of months that is finely tailored to end user needs. Even commercial proprietary code is being distributed on the network to test and grow the marketplace - as is the case currently with 32-bit versions of Microsoft Windows operating system code being distributed concurrently with new versions of Mosaic. This process of developing running, standardized code through the Internet has been highly successful.

It is the more general user populations, however, who are embracing the tools in vast numbers across the planet. The enormity of the implications are just beginning to be understood. For example, it's asserted that 80 percent of all the scientists who ever lived are on the Internet today! And in each of these fields, the people "networked" constitute the majority of early adopters and innovators.

4. Transforming Enterprises, Institutions, and Professions

The effects of large-scale networking of enterprises, institutions, and people are now being realized. Certainly traditional barriers whether they are reporting hierarchies, institutions, country or geography are being obliterated. There is also a certain "compelling" effect that beyond a certain point promotes ever larger numbers of people to become networked. Not having an Internet mail address today has become a major liability in many businesses and professions.

The result has been to transform old institutions, create new network based enterprises, and bring about programmes to implement these transformations. The best known of the latter is the Clinton Administration's Reinventing Government initiative. However, on a smaller scale, efforts are now underway in Canada, Chile, Argentina, France, and Poland - as well as many international organizations.

Some major older corporations like IBM and Chrysler have embarked on well-known efforts to get Internet technologies introduced among their employees to purposely break down both internal and external barriers. In an increasingly competitive environment, lacking network connectivity and employees with skill sets to effective use the network tools, is a major liability that's quickly reflected in either diminishing market share or lost opportunities.

An entirely new and potentially massive new field is now emerging around the Internet and distributed networking. Getting connectivity is only one component. More significant (and perhaps more difficult) is obtaining and retraining people to effectively use these tools in many different enterprises. This daunting task involves not only equipment, but cultures and attitudes. And, it also pervades every office in a corporation or institution, from the CEO to the average staff member in every department.

Not suprisingly, there is a focus on developing these skills now at the elementary and secondary school levels so that children at an early age are able to comfortably use and create information on computers, to discover and make available networked information resources, and to collaborate seamlessly across networks with their peers. These are the survival skills of rapidly emerging global internetworked environment.

5. A Huge Market Sector

The estimated 20-30 million users on the Internet constitute an ideal market. The users are predominantly young, middle to upper class, well-educated, and highly motivated. As the number of Internet users grows another two orders of magnitude, these characteristics are likely to remain, in addition to becoming ever more global.

The Internet provides an exceptionally low cost mechanism for interacting with this audience. This interaction not only includes public relations and advertising, but testing of target audiences, sales, and customer support.

The principal major caveat concerns the strong traditions for propriety and privacy that rule out mass mailing or other intrusive techniques. Such misconduct or fraudulent behavior can also propagate very quickly.

The Future

These different facets of Internet will assure an exciting and constantly evolving future.

It seems meaningless to talk about "what's after the Internet" anymore than to talk about what's after the telephone. As long as we have computers speaking to other computers via distributed networks, we will have internets. Indeed, a hundred years from now, history may well record the emergence and

implementation of an Internet protocol as a profound turning point in the evolution of human communication - of much greater significance than the creation of the printing press.

No other form of human communication other than actual meetings allow people to actually interact with each other in a collaborative fashion in short time-scales. It is this capability of rapid, large scale, low-cost interaction of people and sharing of information that are unique Internet properties - which have profound implications across a broad spectrum of human activities.

Important Indicators

It's difficult to predict where all the different facets of the Internet are leading us. In the near-term, we can look at events currently underway to chart likely developments in the coming months.

Business on the net

Certainly the many initiatives using applied encryption technologies and dove-tailing with pre-existing EDI work, points to all kinds of business-related activity on the Internet. However, this is not likely to displace "free information" given the ever increasing use of the Internet by public institutions, for commercial public relations, or just the propensity of human beings to share their own information.

Ubiquity

Other major indicators include both the ubiquity of the access, as well as the ease of setup and use by ordinary people. Access involves the diversity of the media being employed (such as local dialup, freephone dialup, CATV LANs, N-ISDN, and VSATs), and the ever-expanding number of service providers - especially major carriers and local resellers. Resellers are especially important in this phase of internet evolution because of the frequent significant level of interaction with customers in using the technology. However, some of the newly emerging software for PC environments is so object oriented and self configuring that only minimal computer skills are required.

What Modulates Internet Development?

In the face of all these positive indicators, however, it is useful to consider what kinds of conditions result in the growth or stifling of internet developments. Over the past few years, some specific information on Internet diffusion has become evident.

Plainly, many external conditions modulate implementation and use. For example, available capital for investment is always a major factor with any new technology. Even with basic telephone systems, the correlation of telephone lines versus national GNP is almost a straight line. However, the diffusion of internet technologies, networks, and use require conditions that are really rather unique and go well beyond just capital investment to a host of factors that collectively are sometimes called "culture."

A threshold condition is the freedom introduce and operate Internets without significant governmental or institutional impediments. The Internet consists almost entirely of tens of thousands of private networks all constructed and operated by largely private initiative. The Internet functions very effectively on a global scale through a number of multilateral and bilateral agreements among backbone service providers and end-user networks.

The Internet is a creature of the unregulated, highly dynamic computer networking field - not the traditional regulated monopoly telecom environment. The Internet does best where the environments are subject to little or no regulation of any kind.

Internet monopoly environments are invariably the worse kind - being antithetical to the very concept of what the Internet is all about. Such environments are also contrary to the Annex on Telecommunications in the new General Agreement on Trade in Services (GATS) and the appended schedules of specific commitments by 96 signatory countries plus the European Union. These provisions elaborate on some of the desirable conditions needed for Internet fertility, namely access to markets and cost-oriented underlying transport circuits.

However, even in competitive environments, some regulatory authorities have a penchant for becoming involved in the operations of Internet providers - either reviewing business plans or operational agreements. Given the incredibly fast changing operational dynamics of the Internet scene, such intrusive regulation is inevitably stifling, as backbone providers increase in number and move from bilateral to multilateral arrangements among themselves

to lessen the complexities and enhance ubiquitous connectivity.

Other major diffusion factors include the cost of underlying transport bandwidth and the ability to acquire current-technology computers and software at low-cost. These factors go both to the national competitive conditions for basic telecom services and oversight of the pricing practices of dominant carriers.

Dominant carriers in most countries often attempt to charge prices for underlying circuit capacity that are orders of magnitude greater than the actual costs - principally in a misguided attempt to force customers to use the carrier's own value added networks and technologies, and to prevent competition. The great circuit price disparities between Europe and the USA, for example, prompted the European Nuclear Research Center (CERN) two years ago to publicly document these practices and plead for a change.

Because end user computers and peripheral hardware are such a fundamental component of Internet growth and development, national practices which heavily tax and restrict computer imports and use, also have a major adverse effect on Internet diffusion. Restrictions or taxes on the use of modems, for example, have widespread negative effects.

The Challenges and Promises

No electronic network mesh has consistently grown on the scale at the speed of the Internet. As a result, it has throughout its history been constantly challenged to develop new technologies, standards, and administrative techniques to provide greater bandwidth and additional services to more users through ever more complex architectures. However, each order of magnitude scaling becomes more difficult.

Problems associated with addressing and security seem largely transitory - with a combination of technology, new statndards, and administration providing effective solutions.

The next few years will likely witness nearly every computer in the world being potentially connected to an internet. This seems well within the realm of feasibility. However, what numbers are actually connected to the Internet or accessible - through the Internet and at what bandwidths or time periods - depends largely on the available underlying infra-structure and cost of service.

Bandwidth seems destined in the long-term to approach zero within and among most metropolitan areas of the world, but the increasing complexities of managing ever larger numbers of Internet networks is going to drive operation and maintenance costs up. The result for end users may mirror the com-puter world where the performance just keeps on increasing at relatively constant cost. In fact, the evolution of computers and computer networks is sure to proceed hand in hand. And collective innovative Internet genius will doubtlessly produce an endless stream of imaginative applications and tools.

It is at the human and institutional levels that major unknowns arise - but also offer the greatest promise. The autonomous, heterogeneous, flat model of the Internet seems intrinsically a good one. It will be constant discovery time in Cyberspace, but a world of shared minds that transcends the accidental boundaries of history, the distance of geography, the machinations of institutions, and the mischief of manipulation, is potentially one filled with discovery, fulfillment and fascination for all peoples - individually and collectively.

The Internet Society as the international organization for the Internet is dedicated to help make this happen.

›››šššš