Present & Future State of the Internet

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Abstract

The Internet is a vast "supernetwork" of public and private networks connecting thousands of organizations and an estimated 30 million individual users. 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; 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.

I. Introduction

One of the most basic continuing measurements of the size of the Internet is the number of host computers reachable. For more than ten years, the Internet has been measured almost every quarter by this method. This is a key value because one of the most fundamental capabilities of the Internet is to directly link virtually any kind of computer across almost any kind of telecommunication medium [18].

The latest measurement - sometimes referred to as "the Internet Walk" - shows 3.2 million reachable machines. This is an increase of 81 percent for the past year, and represents an even steeper than normal increase over the past six months. Indeed, 1 million new hosts were added during the first six months of 1994. Much of the increased growth is attributable to growth outside the world in more than 80 countries. These values are shown in the attached annex [16].

Table 1. (Hosts connected to the Internet during the last 4 quarters)

	July 94	Apr 94	Jan 94	Oct 93	Jul 93	Change (year)
Hosts	3,212,000	N/A	2,217,000	2,056,000	1,776,000	81%
Domains	46,000	N/A	30,000	28,000	26,000	77%

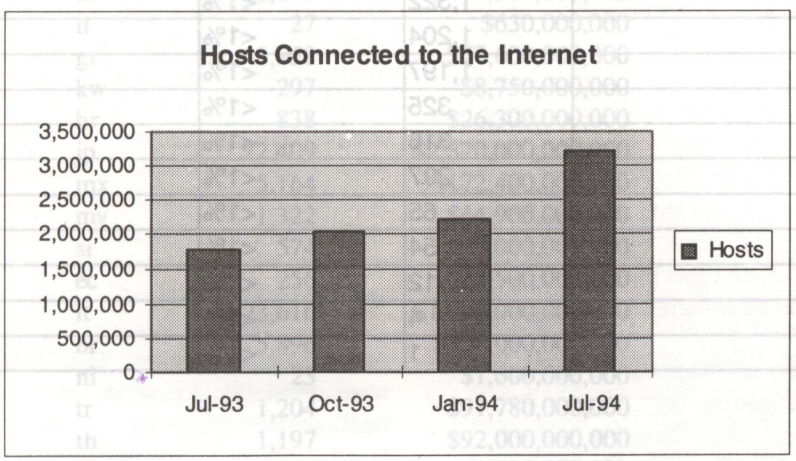

Table 2. Top 20 Internet users (worldwide)

Country	Hosts	%of Total	Change From Jan94
US-educational (higher)	856,234	27.00%	41.00%
US-commercial	774,735	24.00%	36.00%
US-government	169,248	5.00%	31.00%
United Kingdom	155,706	5.00%	37.00%
Germany	149,193	5.00%	51.00%
US-defense	130,176	4.00%	26.00%
Canada	127,516	4.00%	48.00%
Australia	127,514	4.00%	42.00%
Japan	72,409	2.00%	69.00%
France	71,899	2.00%	117.00%
US-non-profit organization	66,459	2.00%	31.00%
Netherlands	59,729	2.00%	43.00%
Sweden	53,294	2.00%	40.00%
Finland	49,598	2.00%	**
Switzerland	47,401	1.00%	24.00%
Norway	38,759	1.00%	22.00%
US-network operator	30,993	1.00%	146.00%
Italy	23,616	1.00%	38.00%
Spain	21,147	1.00%	79.00%
Austria	20,130	1.00%	30.00%

Table 3. Top 19 Internet users (Asia & Asia Pacific)

Country	Hosts	%of Total	Change From Jan94
Australia	127,514	4.00%	42.00%
Japan	72,409	2.00%	69.00%
New Zealand	14,830	<1%	157.00%
Korea	12,109	<1%	35.00%
Taiwan	10,314	<1%	29.00%
Hong Kong	9,141	<1%	60.00%
Singapore	4,014	<1%	45.00%
Russian Fed. (SU)	3,145	<1%	142.00%
Malaysia	1,322	<1%	204.00%
Turkey	1,204	<1%	140.00%
Thailand	1,197	<1%	334.00%
China	325	<1%	*
India	316	<1%	129.00%
Kuwait	297	<1%	115.00%
Philippines	65	<1%	*
Indonesia	54	<1%	*
Macau	12	<1%	*
Iran	4	<1%	0.00%
Saudi Arabia	1	<1%	*

Table 4. GNP/GDP Compared to Internet Hosts in July 1994 [19]

Top-Level Domain Name	Country Code	July 1994 Internet Hosts	GNP/GDP Total	GNP/Host Ratio
Iceland	is	3,268	$4,200,000,000	1.29
Finland	fi	49,598	$80,600,000,000	1.63
Norway	no	38,759	$72,900,000,000	1.88
Australia	au	127,514	$280,800,000,000	2.20
USA	var	2,044,791	$5,700,000,000,000	2.79
New Zealand	nz	14,830	$46,200,000,000	3.12
Sweden	se	53,294	$202,500,000,000	3.80
Canada	ca	127,516	$521,500,000,000	4.09
Netherlands	nl	59,729	$249,600,000,000	4.18
Czech Republic	cz	5,639	$25,600,000,000	4.54
Switzerland	ch	47,401	$238,050,000,000	5.02
U.K.	uk	155,706	$915,500,000,000	5.88
South Africa	za	15,595	$96,000,000,000	6.16
World Median	ww	3,212,000	$19,850,690,000,000	6.18
Israel	il	8,464	$56,400,000,000	6.66
Denmark	dk	12,107	$91,100,000,000	7.52
Austria	at	20,130	$164,100,000,000	8.15
Chile	cl	3,703	$30,500,000,000	8.24
Germany	de	149,193	$1,300,000,000,000	8.71
Slovak Republic	sk	868	$9,300,000,000	10.71
Singapore	sg	4,014	$43,200,000,000	10.76
Costa Rica	cr	544	$5,900,000,000	10.85
Hungary	hu	5,390	$60,100,000,000	11.15
Portugal	pt	4,518	$50,700,000,000	11.22
Ireland	ie	3,308	$39,200,000,000	11.85
R.o.W. Median (not USA)		1,180,387	$14,150,690,000,000	11.99
Belgium	be	12,107	$171,800,000,000	14.19
France	fr	71,899	$1,033,700,000,000	14.38
Taiwan	tw	10,314	$150,800,000,000	14.62
Luxembourg	lu	420	$7,830,000,000	18.64
Poland	pl	7,392	$162,700,000,000	22.01
South Korea	kr	12,109	$273,000,000,000	22.55
Spain	es	21,147	$487,500,000,000	23.05
Liechtenstein	li	27	$630,000,000	23.33
Greece	gr	2,958	$77,600,000,000	26.23
Kuwait	kw	297	$8,750,000,000	29.46
Croatia	hr	838	$26,300,000,000	31.38
Japan	jp	72,409	$2,370,000,000,000	32.73
Mexico	mx	5,164	$172,400,000,000	33.38
Malaysia	my	1,322	$44,900,000,000	33.96
Slovenia	si	574	$21,000,000,000	36.59
Ecuador	ec	256	$11,500,000,000	44.92
Italy	it	23,616	$1,090,000,000,000	46.16
Brazil	br	5,896	$358,000,000,000	60.72
Nicaragua	ni	23	$1,600,000,000	69.57
Turkey	tr	1,204	$91,780,000,000	76.23
Thailand	th	1,197	$92,000,000,000	76.86
Uruguay	uy	101	$9,100,000,000	90.10
Venezuela	ve	399	$52,300,000,000	131.08

Romania	ro	453	$71,900,000,000	158.72
Cyprus	cy	38	$6,100,000,000	160.53
Panama	pa	24	$5,000,000,000	208.33
Tunisia	tn	46	$10,900,000,000	236.96
Macau	mo	12	$3,100,000,000	258.33
Fiji	fj	5	$1,300,000,000	260.00
Colombia	co	144	$45,000,000,000	312.50
Argentina	ar	248	$101,200,000,000	408.06
Bulgaia	bg	79	$36,400,000,000	460.76
Peru	pe	42	$25,150,000,000	598.81
Philippines	ph	65	$47,000,000,000	723.08
Egypt	eg	52	$39,200,000,000	753.85
Ukraine	ua	339	$339,200,000,000	1,000.59
India	in	316	$328,000,000,000	1,037.97
China	cn	325	$452,000,000,000	1,390.77
Indonesia	id	54	$116,200,000,000	2,151.85
Russia	ru	322	$800,000,000,000	2,484.47
Algeria	dz	7	$54,000,000,000	7,714.29
Moldova	md	2	$16,900,000,000	8,450.00
Iran	ir	4	$90,000,000,000	22,500.00
Saudi Arabia	sa	1	$104,000,000,000	104,000.00
Yugoslavia	yu	1	$159,000,000,000	159,000.00
Czechoslovakia	cs	1,869	$0	0.00
Soviet Union	su	3,145	$0	0.00
Educational	edu	856,234		
Commercial	com	774,735		
Government	gov	169,248		
Military	mil	130,176		
Organization	org	66,459		
Networks	net	30,993		
US Int'l	us	16,556		
International	int	315		
Puerto Rico	pr	75		
Antarctica	aq	4		
Hong Kong	hk	9,141	n/a	
Estonia	ee	659	n/a	
Latvia	lv	180	n/a	
Lithuania	lt	53	n/a	

II. Information Infrastructure

The way we conceptualize and create information infrastructure has been profoundly changed during the last decade. The information infrastructure flowed "top-down" with plenty of abstractions that no one quite understood, under the aegis of never quite defined nor accepted concepts like ISDN, OSI, and next generation mainframes.

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, 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! [17].

III. The Internet Global Mesh

The Internet and internet technology has been growing and evolving constantly for the last 20 years. 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.

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 [17].

IV. The Size of the 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.

As of the end of May, there were 435760 allocated network addresses, 47846 registered at the global Network Information Center, and about 35000 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 July, IP traffic is being routed to networks in 83 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. 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 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.

V. Internet Development

Internet monopoly environments are invariably the worse kind - being antithetical to the very concept of what the Internet is all about. 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. A threshold condition is the freedom introduce and operate Internist 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.

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.

VI. Re-engineering of Business

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 surpassingly, 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.

VII. Internet 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.

VIII. Internet in Thailand

Since its inception in 1988, uses of the Internet has been growing rapidly in Thailand. The number of hosts connected directly to the Internet in Thailand has increased to 1,200 within five years. It is estimated that 400,000 users have currently access to the Internet in Thailand. Majority of these users use the Internet for research, education, and messaging to other users. Most host computers are currently utilized by academic institutions. The forerunner among these institutions is Assumption University with its well-known network AuNet currently serving the faculty and the student population of 17,000 users. Knowledge Service Center (KSC), a joint venture between Assumption University and KSC Telecom, is the leading Internet provider for personal and commercial use throughout Thailand. As the number of users grows, the demand for more user-friendly interface also increases. Currently all the users of AuNet use UNIX command mode to access the Internet resources. Work is underway to develop user-friendly interface software under Windows for users to access the Internet resources, such as Mail, FTP, Telnet, WAIS, and Mosaic for Windows.

Additional information about computerization in Thailand can be found in several publications by Charmonman and colleagues [1-15]. The development of Internet in Thailand has been discussed in greater detail in Charmonman [14] and the development of AuNet is fully presented by Charmonman [15].

IX. Internet Tools

There are many Internet tools which have helped development and wide-spread use of the Internet. These tools have enabled user with no computer background to use and access the vast amount of information available on various hosts on the network.

Internet users can find anything available on the Internet about computers in one central location. The Internet Computer Index (ICI), created by Proper Publishing, tells users everything that is known on the Internet about PCs, Macintoshes, and UNIX systems. Additional information is also available on ICI that isn't available anywhere else on the Internet. Further, ICI is supported by commercial sponsors who add up-to-date information about their products to the ICI service.

ICI uses the popular World Wide Web and Gopher systems to distribute its information. Using attractive, informative menus and hypertext, ICI gives up-to-date connections and pointers to the other freely-available information on the Internet. Anyone on the Internet, anywhere in the world, can access ICI 24 hours a day at no charge.

Using Gopher or World Wide Web client software, any user on the Internet, anywhere in the world, can get the most up-to-date information including pointers to all Usenet news groups, mailing lists, Gopher and World Wide Web servers, anonymous FTP sites, and other Internet-specific resources. In order to make searching easy, ICI is organized as hierarchical menus of information. For each type of computer system (PC, Macintosh, or Unix), there is a menu that lists the type of Internet resources that describe that system. Most people will be only interested in one of the three main areas, but other can easily traverse between the three through cross-links.

Users can search through Internet resources including:

* Usenet news groups
* mailing lists
* Gopher servers
* World Wide Web servers
* anonymous FTP sites
* frequently asked question files (FAQs)
* online publications
* commonly-downloaded files

Another Internet tool designed to post questions on what is something in the Net, how to find people, lists, information on WWW, SLIP, PPP, etc, is the HELP-NET -- a forum for learning and obtaining help on the Internet.

NCSA Mosaic is the most popular graphical browser for the Internet. More than two million copies of Mosaic are in use, and an additional 30,000 copies are being downloaded each month from the Internet. NCSA Mosaic was developed by the National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign. Mosaic gives users point-and-click access to the World Wide Web, an information retrieval system on the Internet with more than 3,000 graphical, multimedia databases of "hyperlinked" documents. The new University of Illinois - Spyglass agreement will create a broader, more practical distribution channel for commercial versions of NCSA Mosaic.

X. The Future

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

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.

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.

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.

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 dial-up, freephone dial-up, 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.

XI. Concluding Remarks

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 standards, 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 infrastructure 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 computer 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.

XII. References

1. Charmonman, S. Computer and Information Technology. United Nations Asian and Pacific Development Institute Seminar on Information for Development planning. Pataya, Thailand. January 1978.
2. Charmonman, S. State of Computer Technology in Thailand in 1980. Final Report of Unesco Regional Meeting of Computer Center Directors in Southeast Asia. Jakarta, Indonesia. October 20-24, 1980.
3. Charmonman, S. Informatics for Development in Thailand. ICID / Unesco Consultative Meeting Kuala Lumpur, Malaysia. October 1982.
4. Charmonman, S. Computer Hardware, Software and Peopleware-Selection and Maintenance for Library Applications. Proceedings of the Sixth Congress of Southeast Asian Librarians. Singapore. 30 May - 3 June, 1983.
5. Charmonman, S. Computers for Education in Thailand. Unesco-Asia Electronic Union Workshop in Computer-Assisted Instruction. Jakarta, Indonesia. October 1983.
6. Charmonman, S. Computer Laboratories in Thailand and their Needs. Final Report to USAID. August 1984.
7. Charmonman, S. and Sophonpanich, K. Transborder Data Flows in Thailand. Intergovernmental Bureau for Informatics World Conference on Transborder Data Flows. Rome, Italy. June 1984.
8. Charmonman, S. The Merger of Informatic and Telecommunication: Development and Prospects for the Future. Proceedings of the Joint Thai, IDRC, UNCTC, and IBI Asean Regional Seminar on Transborder Data Flow Impacts. 1987 Special Issue of ABAC Journal. 1987.
9. Charmonman, S. Telecommunications in Thailand. Presented to the Pacific Telecommunication Conference. Tokyo, Japan. October 1988.
10. Charmonman, S. Computer Educational Software in Thailand. Unesco Asia and Pacific Seminar in Educational Software Development, Evaluation and Dissemination. Tokyo, Japan. 12-22 September 1988.
11. Charmonman, S. and Pin-Ngern, O. Reasoning under Dynamic Knowledge Base with Application to Traffic Routing. Proceedings of the '93 Korea/Japan joint Conference on Expert Systems, Seoul, Korea, February 1993. pp.268-277.
12. Charmonman, S. and Chiraphadhakul, S. Computer Human Resource Planning for a Developing Country. Proceedings of the 1993 ACM SIGCPR Conference, St. Louis, Mo., USA, April 1993 ACM Press pp.370-378.
13. Charmonman, S. and Bijaisoradat, N. A Decision Support System for Nursing Care in Thailand. Proceedings of the 1993 Pan Pacific Conference on Information Systems, Taiwan, R.O.C., May 1993.
14. Charmonman, S. Internet Computer Access in Thailand. International Conference in globalization of Computers and Communications. Unesco, Bombay. 25-27 November 1993.
15. Charmonman, S. and Anaraki, F. An Internet Project for 100,000 users in Thailand. Inet 94 Conference, Prague, May 1994.
16. http://www.nw.com, Net Wizard World Wide Web.
17. Rutkowski, A. The Present and the Future of the Internet. Networld+Interop 94, Tokyo.
18. The measurement is described in the Internet document RFC 1296.
19. Internet hosts: Mark Lottor, Network Wizards, GNP figures: Groliers Encyclopedia, Ratios: EMMS.

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