Keynote Address

Wij geven kennis

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The theme of this conference - *wij geven kennis* - captures perfectly both the Internet as a means of fostering and sharing knowledge, as well as the role of SURFnet as one of the Netherland's most valuable strategic assets today.

The value of the Internet and SURFnet are underscored by development occuring so quickly, that we get the surreal feeling of being networking observers watching our own evolution unfold before our eyes with each passing hour. I offer a few examples.

At the Supercomputer'94 Panel on the future of the Internet last Friday, all the panelists from very diverse backgrounds and positions were asked to succinctly speak to the future of the Internet.

The agreement on the directions of the Internet and the implications was really quite remarkable. The basic facts are fairly obvious - the network and its major applications are now growing at exponential rates. By the year 2000, present projections indicate that 187 million computers will be connected to an Internet constituting 4.1 million networks dispersed around the globe. World Wide Web traffic growth is so stunning that if it were to continue, in the year 1996 it will exceed the world's telephone traffic and by the year 2000, there would be 4000 PetaBytes of traffic - enough to fill 10,000 1.2 Gigabit/sec digital pipes!

Panelist Larry Smarr, Director of a leading supercomputing center - noted we don't have much experience living in such exponential worlds - particularly with a technology that is also dramatically altering how we and most of our institutions function. Others noted that humankind has never before enjoyed the benefit of an open electronic mesh of so many millions of information systems and people - and indeed it is people who are the Internet's most valuable resource. In fact, it's argued that currently, 80 percent of all the scientists who ever lived are now reachable on the Internet. The consensus of the panel was that the Internet was bringing about multiple profound changes that will ripple through global society.

Perhaps it was the scientific aspect that led UNESCO Director General Mayor a few weeks ago to circulate a Report prepared by Nobel laureate Joshua Lederberg and a team of eminent scientists who told UNESCO that the single most important action that could be taken to enhance science today was to assure that all scientists everywhere had effective Internet connectivity.

But it isn't just international science organizations that are realizing Internet's potential. Three weeks ago, UNCTAD held a world trade summit where the U.N. Secretary General called for Internet connectivity to enhance trade. Several weeks prior to that, the world's international organization of legislatures - the InterParliamentary Union - called for linking all the lawmakers of the world together through the Internet in a document known as the Tokyo Compact.

The Internet is also a paradigm change for opening up public institutions. The Japan Prime Minister

put up a WWW server in August - followed several weeks later by the USA White House's unveiling of a major Web portal to the entire federal government.

Indeed, the WWW has become so popular, that when the attendance at the second international Web conference in Chicago a month ago was limited by the building capacity to 1000 people, some people began selling their registrations for twice the price on the street outside the building. Scalping has come to the Internet showbusiness. Speaking of showbusiness, even the Rolling Stones last week did a MBONE multicast of their landmark concert from the VooDoo Lounge.

It's not surprising that the staid telecom and business carrier world is increasingly joining the Internet revolution. In August, Fujitsu announced it was leveraging its global Enterprise Internet backbone to offer worldwide access to the Internet. IBM four weeks ago announced a similar but more ambitious offering by bundling it's new OS/2 operating system with user-friendly access to IBM Internet service using its Advantis high speed backbone from up to 92 different countries; and just two days ago, MCI Communications Corporation on Monday announced the largest-scale suite of Internet services of any major carrier to date - something characterized by the press as the 600 pound gorilla jumping into the middle of the Internet business.

And then there is Microsoft's Bill Gates who promises to help reach that 187 million Internet host figure even sooner than December 1999 by bundling no-brainer Internet access with every new copy of Windows95.

It is all rather incredible - if not breathtaking. Having worked in almost every segment of the broadcast, telecommunications and information networking business in many different institutional and professional capacities, I frequently get jaded. But not in the Internet environment, for what is taking place is a dynamic so far beyond anything else, that it defies comparison.

Facets of Internet

These different experiences over the past few weeks symbolize what I call "facets of Internet." Internet is much more than just a new kind of network for transporting data. Rather it is 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 has profoundly transformed the way we conceptualize and create information infrastructure. The "old world" was oriented exclusively 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 and standards that no one quite understood or was able to effectively implement. 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 "facet 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, and for these reasons is becoming understood and is being embraced by national administrations.

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 science agencies, HEPnet, SURFnet, 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 stage 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 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 September, there were 440,000 allocated network addresses, 50,000 registered at the global Network Information Center. As of last week, there were about 43,000 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 Nov, IP traffic is being routed to networks in 90 different nations. It's known that the 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 or domains being registered. The developments here are quite amazing. Beginning about six months ago, commercial concerns in the USA and Canada began registering .com global domains at an increasing pace. As a result, there are now 27,000 registered .com domains versus about 2,000 .edu domains. .com registrations continue at a rate of around 3,000 per month. This has also begun to show on host counts, and there are now more .com hosts shown attached to the network than any other domain.

It's quite apparent that nearly every country is experiencing exponential Internet growth - with sharp upturns in growth within the past 12 months. In Europe, the number of connected networks in most of the larger countries is now about 1500.

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 attempting to measure potentially reachable machines. The results are generally released every three months. As of the end of October, the number of hosts was nearly 4 million and getting more steeply exponential with each passing quarter. The figures are also a bit on the low side, as the RIPE NCC consistently counts several percent more European hosts than Lottor does.

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 an estimated 170 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. It was 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. In short - "to give knowledge."

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. Almost all new open networking applications and products have 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. 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. 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 effectively 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 surprisingly, 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. But where is it taking us?

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. The next few years will surely witness a sizable fraction of the world’s computers linked together via the Internet.

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.

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. The announcement at the 2nd WWW conference a few weeks ago of Cybercash, Digicash, E-cash, First Virtual, and NetBill as low-overhead, secure forms of payment - represent giant steps toward dramatic scaling of Internet as a means for business transactions.

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. I know this is a special concern of the SURFnet community, but is seems highly unlikely there will be any diminishment of freely available information - indeed there will be more. As very inexpensive Internet access becomes available worldwide, we will continue to see bountiful information that is already producing needs for new services of information discovery and filtering.

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.

Here also, we will see major churn as almost every kind of provider imaginable competes for providing a variety of Internet services. The market is expanding so fast, there is undoubtedly room for most of them in the near future. Over time, they will be differentiated with some growing, others merging, and others going out of business.

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 to 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 worst 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 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.

I believe that Europe will play a major role in this development. The statistics indicate that the growth curves in most European countries are just as steep as anywhere else. Unfortunately, regulatory, policy, and pricing barriers have prevented those curves being a much larger magnitude. However, the good news is that many positive changes seem underway.

These matters will be a centerpiece of the G7 Information Society Conference at Brussels in late February, and you all can help by making sure your national government participants are sufficiently aware of your concerns.

In closing, let me comment that 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.

SURFnet has been playing a remark role not only in providing the underlying infrastructure, but also in educating and bringing about major cultural changes as well. "Wij geven kennis" is a motto for everyone to follow.

The Internet Society as the international organization for the Internet - working together with SURFnet - is dedicated to help make this happen.