THE INTERNET - WHAT IS IT?


Defining the Internet is a bit like a conversation with Socrates. Just when industry pundits, commentators and other high muckety-mucks are lounging around the city square, feeling smug because we have all the answers, in wanders some shaggy, wild-haired “innocent” who starts asking all kinds of alarming questions.

What can we say to such basic inquiries as, “What is the Internet, anyway?” “How does it work?” or “How big is it?” After some hemming and hawing, most tech editors reach into their desks and start handing out the hemlock.

While most end-users don’t see themselves as having a philosophical bent like Socrates, they are seeking answers in their own right. Since our first Directory of Internet Service Providers, people keep asking the same deceptively simple questions. They vary in wording, but it always boils down to the same things, namely, “How do I get a good connection to the Internet?” and “How do I make money with it?”

Is the Internet a thing?

It’s safe to say that the Internet is not a static entity, but a complicated matrix of connections in a constant state of upgrade. Thousands upon thousands of players are making changes everyday. The Internet isn’t a single, monolithic network, either. It comprises an eclectic series of networks owned and/or operated by over 5,000 ISPs, nearly 50 backbone “Tier 1”, providers and an assortment of phone, cable and other communication companies. These many, many separate systems interconnect at some point, thus the “inter” in “Internet.”

IS THE INTERNET UNIFORM?

This is a legitimate question. At first blush, the answer is no. Connections vary, sometimes dramatically. All T-1 links are not created equal, all backbones are not created equal, and all Internet service providers are not created equal. Pricing and performance have little connection. It’s not as simple as shelling out the big bucks to get really good download speeds. Yet somehow, these dynamic, disparate sets of networks still glom together and work as a whole.

IS THE INTERNET REALLY THE BEST THING SINCE FIRE?
It is undoubtedly the best thing since Wonder Bread. If you believe the breathless commercials on TV, the Internet is a slick, futuristic gift created on high by the gods and given to the masses, Prometheus-style, to save all humankind.

This is where the rift between Internet hype and reality starts to creep into the picture. What’s lacking from this discussion are some working mental images of what the Internet is, how it works, and what its limitations are. One of the problems, of course, is that a great deal of its operation is logical rather than physical.

Physically, the Internet is a series of equipment rooms scattered across the globe with rack-mounted routers in them and few if any people nearby most of the time. They are connected with an array of “physical” leased telephone lines. That mental picture has little utility.

Picturing what is connected and where it is connected on the map is somewhat more useful. It is not perfectly accurate. All backbone maps are logical and symbolic simplifications of often extremely complex connections. But they can be useful. Overall, the Internet consists of technology so arcane and complex to the general public, even the high priests who maintain and build it resort to hieroglyphics and a glittering array of acronyms to define it. In schematic drawings, the Internet at-large is often depicted as a fluffy white cloud. A company’s connection plunges into the obscuring fog, emerging out the other end without a satisfying explanation of the pitfalls and slowdowns along the way.

So for further answers, it’s helpful to turn to the creation myth.

The original thirteen sites include:

- Merit - University of Michigan Computing Center in Ann Arbor Michigan.
- National Center for Atmospheric - Research in Boulder, Colorado
- Cornell Theory Center at Cornell - University in Ithaca, New York
- The National Center for Super-computing Applications (NCSA) at the University of Illinois, Urbana, Champaign
- The Pittsburgh Supercomputing Center in Pittsburgh
- San Diego Supercomputer Center at the University of California, San Diego
- Jon von Neumann Center at Princeton University
- BARRNet - Palo Alto, California
- MIDnet - Lincoln, Nebraska
- Westnet - Salt Lake City, Utah
- NorthWestNet - Seattle, Washington
- SESQUINET - Rice University, Houston, Texas
- SURANET - Georgia Tech, Atlanta, Georgia

IN THE BEGINNING

The Internet began with packet switching projects in the late 1960s, most notably the Advanced Research Project Agency’s ARPANET. During the ‘70s this network grew to support many organizations in the US Department of Defense and other government agencies. It also began to
support university and research organizations. The Transmission Control Protocol/Internet Protocol (TCP/IP) was developed as a packet protocol that would allow connections across a variety of physical mediums including satellite connections, wireless packet radio, telephone links, and so on. It was included in a popular release of the Berkeley Standard UNIX, which was freely distributed through the university community.

This was a loose development of technology, and in no clear sense a network of any kind.

In 1985, the National Science Foundation funded several national supercomputer centers. These included the Cornell Theory Center at Cornell University in Ithaca, New York; The National Center for Supercomputing Applications (NCSA) at the University of Illinois, Urbana, Champaign; The Pittsburgh Supercomputing Center in Pittsburgh; the San Diego Supercomputer Center at the University of California, San Diego; and the Jon von Neumann Center at Princeton University.

The NSF wanted to make the supercomputer centers available to the research community in universities across the nation. Many state and regional universities had already developed local and regional networks and some were even TCP/IP based. The National Science Foundation funded a 56 Kbps network linking the five original supercomputer centers, and offered to let any of the regional and university computer centers that could reach this network physically connect to it.

This was the “seed” of the Internet network as we know it today and the original reason to connect to it was to access supercomputer facilities remotely.

As universities linked to the NSF network to access the supercomputers, users discovered things such as electronic mail, file transfer, and newsgroups. The traffic on the network rose. In November 1987, the National Science Foundation awarded a contract to Merit Network, Inc. in partnership with IBM, MCI and the State of Michigan, to upgrade and operate the NSFNET backbone using 1.544 Mbps T-1 leased lines connecting six regional networks, the National Center for Atmospheric Research (NCAR) in Boulder, Colorado, the five existing supercomputer centers, and Merit at the Computer Center in the University of Michigan. No one had attempted a data networking project of this scale. The T-1 backbone was completed on July 1, 1988 - eight months after the award - linking thirteen sites and carrying 152 million data packets in its first month. Merit, IBM, and MCI also developed a state-of-the-art Network Operations Center at the Merit site in Ann Arbor, Michigan, and staffed it around the clock. The new NSFNet T-1 backbone started with 170 local area networks from the supercomputer centers and regional networks served. On July 24, 1988, the old 56 Kbps NSF network was shut off.

Two key points to remember: the NSFnet backbone was not the first network; its purpose was to LINK - interconnect - the growing “regional” networks setup by various university systems. In other words, from the beginning the Internet has been in a constant state of evolution and based upon network interconnection. From its genesis, the Internet developed a tension between cooperation and competition. The research goal was (and is) to make interconnection seamless. Yet each network and the technology overall is still evolving in the quest for the best network.
Throw a fiercely competitive marketplace into the mix and all sorts of complications arise. The result, of course, makes the “best” connection to the Internet an impossibility.

In January of 1989, the Merit/IBM/MCI team presented a plan to upgrade the network to higher speed using T-3 lines to handle the rapidly increasing network traffic. IBM developed the first router capable of handling T-3 speeds using their RS/6000 workstations running a subset of UNIX. These were eventually capable of routing 100,000 packets per second.

In September 1990, Merit, IBM and MCI spun off a new independent non-profit organization known as Advanced Network and Services, Inc. (ANS) to operate this NSFNET backbone and tackle the challenges of moving to 45 Mbps backbone speeds. IBM and MCI each contributed $4 million and ANS acted as subcontractor to Merit. The backbone was expanded to 16 sites and the final T-3 router was installed in November 1991. The 45 Mbps T-3 backbone connected about 3,500 networks.

This then was the National Science Foundation Network backbone. It reached such a critical mass of participation/population, that it became itself a thing to connect your private network to. The more smaller networks that connected to it, the more attractive it became. But the NSFNET backbone became the contested focal point of what the Internet would become.

The term “Internet” was first used in 1983 to describe this concept of interconnecting networks. And ten years later, THE Internet was largely defined as having connectivity to the NSFNET national backbone.

Naturally the commercial potential of the network of networks became apparent, which led to debate about the role of government in such matters. There was a great deal of discussion regarding the commercialization and privatization of the NSFNET backbone. The issues centered around whether the government should fund and operate a communications structure that competed with private companies such as MCI, AT&T, Sprint, and others. Meanwhile NSFNET traffic grew more and more commercial.

To address this issue, a number of private commercial backbone operators joined to establish a separate point for the exchange of Internet traffic. The Commercial Internet Exchange was formed and a router was set up in the Willtel equipment room in Santa Clara, California. In theory, the private companies were “connected” through this CIX router. Most traffic still transited over the NSFNET backbone, however. But it was an attempt to address the issues surrounding the balance between interconnection and commercial interests.

**THE NEW INTERNET**

In May, 1993, the National Science Foundation issued a solicitation for bids [NSF 93-52] that would radically alter the architecture of the Internet. The government agency was getting out of the backbone business. In its place, it designated a series of Network Access Points (NAPs). Similar to the CIX concept, NAPs were sites where private commercial backbone operators could “interconnect” much as they had using the NSFNET backbone. But rather than connecting to different points on an intermediary backbone, they would directly connect at a series of single
points. In this way, anyone could develop a national backbone for the connection of LANs, sell connectivity to it, and use the NAP as the physical point where they interconnected and exchanged traffic with all the other service providers. The NAPs would be based on a high-speed switch or LAN technology. No content or usage restrictions would be placed on traffic. The NAPs would serve to connect multiple providers, to allow the set of providers to suffice as a replacement for the current NSFNET service.

In February 1994, NSF announced that four NAPs would be built. One would be in San Francisco, under the operation of PacBell. The second was in Chicago, operated by Bellcore and Ameritech. The third would be in New York, operated by SprintLink. Sprint had already been coordinating international connections to the Internet for NSF. The New York NAP is actually in Pennsauken, New Jersey, across the river from Philadelphia. Metropolitan Fiber Systems received the award for the fourth NAP, MAE-East in Washington DC. Merit was awarded a contract as Routing Arbiter to maintain a database of information regarding the issues of interconnection. On April 30, 1995, the NSFNET backbone was essentially shut down, and the NAP architecture became the Internet.

**NAPs ARE A GOOD IDEA**

Currently, the heart of the Internet remains the four “official” network access points or NAPs in San Francisco, Chicago, Washington, DC, and Pennsauken. They establish the concept that interconnection is good, and that at least these four points, anyone can in theory interconnect with the rest of the Internet. This is a key concept. Private backbone operators are not inherently inclined to “share” customers by connecting them with someone else’s customers.

The desire of customers to be connected to THE Internet forces the commercial interests to deal with the subject of interconnection. The NSF set the interconnection standard in one sense by defining the Internet through its backbone and NAPs. But cautious of government intrusion, it left many questions unanswered.

Unfortunately, the NSF declined to address the concept of “peering.” While the NAPs provided a place of interconnection, anyone at a NAP can choose to interconnect with anyone else there, or for that matter, decline to connect.

Today, you can get a connection to the NAP, but it is quite an “old boys’ club” as to who will peer with whom. The issue at the heart of “peering” is the concept that in peering with you, a vendor is basically agreeing to allow your traffic to transit its backbone to get across country. Most of the backbone operators therefore will only peer with other operators that likewise have a presence at ALL of the NAPs and they are becoming increasingly selective about whom they peer with.

But once the resistance to interconnection is overcome through four official NAPs, the concept of interconnecting becomes increasingly attractive. Why should an e-mail message traveling from one office in Washington, DC, to another across the street have to transit through Chicago just because one of the correspondents uses Erols and the other uses Zeke’s General Store?
The more interconnections you have across the country - where physically convenient to cross connect - the more you can shortcut or shunt traffic and avoid bottlenecks. It also decreases total traffic on your network. This concept is called “hot potato routing” in that as a backbone, you should off-load packets destined for a site on another backbone at the nearest connection rather than hauling it across country and then delivering it. The destination site backbone should be responsible for cross country transit.

As it so happens, Metropolitan Fiber Systems, Inc. operates a series of Metropolitan Area Ethernet (MAE) systems in large metropolitan areas across the country. This is basically a fiber-optic data ring around the city where MFS can inexpensively connect companies and offices to this citywide network. MFS had been quite successful with this in Washington, DC, and its facilities made a natural point to interconnect private backbones. MAE-East, in Washington, DC, was creating interconnections on a significant scale before the four official NAPs were off the ground.

MFS operates MAEs in San Jose (MAE-West), Los Angeles (MAE-LA), Dallas (MAE-Dallas), and Chicago (MAE-Chicago). MFS has two in Washington DC, the existing 10 Mbps Ethernet MAE-East, and a higher speed 100 Mbps Ethernet usually termed MAE-East+. The two MAE-East NAPs and MAE-West are essentially defacto NAPs, with the other MAEs potentially serving as defacto NAPs. MFS has even gone so far as to redefine the MAE acronym as Metropolitan Area Exchanges rather than Metropolitan Area Ethernets. MFS has been redefined, as well, acquired in 1996 by UUNET, which was in turn acquired by WorldCom, which merged in 1998 with MCI.

Finally, there are two Federal Internet Exchange points: FIX-East at the University of Maryland in College Park, and FIX-WEST at the NASA Ames Research Center at Moffet Field between Sunnyvale and Mountain View, California. These FIXs largely exist to interconnect MILNET and NASA Science Net and some other federal government networks.

Since this represents a large population of federal workers, we don’t really have an Internet with them totally disconnected. So there has been some interconnection through Metropolitan Fiber Systems largely to these FIX locations, and a large volume of data traffic still goes through the FIX points. The aim was to decrease this by moving more of the Interconnect to the official NAPs as they became more operational and of course the MAEs.

The CIX router is still up in Santa Clara and it also has a router in Herndon, Virginia. While they still function, the CIX and FIX NAPs are more important as historical legacy NAPs than as current influences.

Currently there are eleven major interconnection points - four official NAPs, three historical NAPs (CIX, FIX-EAST, FIX-West), and four defacto NAPs (MAEs). Any national backbone operator that has a peer connection at one or more of these interconnects has some connectivity to the Internet. Most of the national service providers are connected to all four official NAPs and to most of the MAEs as well.
In some sense, this series of NAPs could be considered the “top” of the Internet, the heart of the Internet, or the sweet spot of interconnection. But more and more major network operators are looking at private peering points, and others are developing private NAPs and selling connectivity to those to get away from the public peering points. The NAPs have become the bottleneck of the Internet.

Most backbone operators are cross connecting with other backbones at virtually any location of convenience where they both have equipment rooms. There are several hundred of these “private” exchanges in operation at this point, and the concept of NAPs has very much become the heart of Internet topology.

More information on NAPs is available through the World Wide Web site associated with each NAP:

**SAN FRANCISCO NETWORK ACCESS POINT**  
Pacific Bell  
[http://www.pacbell.com/Products/NAP/](http://www.pacbell.com/Products/NAP/)

**CHICAGO NETWORK ACCESS POINT**  
Ameritech Advanced Data Services and Bellcorp  
[www.ameritech.com/products/data/nap](http://www.ameritech.com/products/data/nap)

**NEW YORK NETWORK ACCESS POINT**  
SprintLink Actually in Pennsauken New Jersey near Philadelphia  
[www.sprintlink.net](http://www.sprintlink.net)  
Metropolitan Area Ethernets (MAE)  

**CIX Commercial Internet Exchange**  
Santa Clara  
[http://www.cix.org](http://www.cix.org)

**FIX**  
Federal Internet Exchange  
[http://www.arc.nasa.gov/](http://www.arc.nasa.gov/)

**OVERSEAS**

Like hamburgers and jazz and syndicated television, the Internet comprises America’s last great (and occasionally questionable) 20th century gift to the rest of the world. In the early 90s, companies like Sprint and PSINet and MCI WorldCom took their new offerings overseas, bringing with them the methods for implementing and managing large-scale links between networks. They found many countries in Western Europe and the Pacific Rim already possessed their own popular networks waiting to be linked.
The French were particularly innovative with early widespread public networks. In the ‘80s, a two-way interactive data transmission system, Minitel, offered e-mail, basic chat at 75 baud (outgoing) over basic phone lines. The expensive, proprietary equipment needed to run Minitel was funded in part by the French government.

The main methodology for connecting Europe and North America is still terrestrial, or rather, oceanic. Transatlantic undersea cables (TATs) have been in existence since 1956 with TAT-1. TATs 1 through 5 (all of which are no longer in service, the last being TAT-5 which was retired in 1993) were owned by AT&T, and combinations of British, French, German and Spanish state-run phone companies. TATs 6 and 7 were for scientific use and both retired in 1994. Over a dozen other cables send phone messages and Internet packets zipping through the inky darkness of the Atlantic floor.

In the European Union, where national economies are often coordinated through a central ruling body, bandwidth, capacity and Internet protocols are often more standardized than in North America.

Like their North American counterparts, the colleges and research institutions in Western Europe had their own local area networks long before the Yanks arrived with their massive links. Public peering also took root through cooperation with the NSF and in research hot centers in London, Paris and Darmstadt, Germany. Peering, both public and private, has since spread to every continent except Antarctica.

**LEVELS OF ACCESS**

To form a rational image of the Internet, we can divide the topic into five categories or levels. These are arbitrary “levels” and many individual cases will overlap making the concept rather fuzzy. But it does give a point of view that is useful.

- **Level 1 - Interconnect Level - NAPS**
- **Level 2 - National Backbone Level**
- **Level 3 - Regional Networks**
- **Level 4 - Internet Service Providers**
- **Level 5 - Consumer and Business Market**
operators interconnect to establish the core concept of an Internet. Level two would be the national backbone operators, sometimes referred to as national service providers, and the network of networks spreads out from there.

The third level of the Internet is made up of regional networks and the companies that operate regional backbones. Typically, they operate backbones within a state or among several adjoining states much like the national backbone operators. They typically connect to a national backbone operator, or increasingly to SEVERAL national backbone operators to be on the Internet. Some do have a presence at a NAP - usually a single NAP - then they extend this network to smaller cities and towns in their areas. They connect businesses to those points with direct access connections and usually maintain dial-up terminal banks to offer 28.8-56 Kbps dial-up SLIP/PPP connections to consumers. In many cases, regional networks are much more extensive than national backbones, but on a smaller geographic scale.

The fourth level of the Internet would be the individual Internet service provider. These vary from small two- or three-person operations up to large outfits, such as those with more than 100,000 dial-up customers. But they don’t generally operate a backbone or even regional network. They lease connections to a national backbone provider, or a regional network operator. They might indeed offer service nationally, but using the POPs and backbone structure of their larger backbone operator associate. Several large providers, such as EarthLink and MindSpring, operate at this level. Generally, they operate an equipment room in a single area code, lease connections to a national backbone provider, and offer dial-up connections and leased connections to consumers and businesses in the local area. They tend to focus on customer service, configuration, and training and often offer lower prices.
The fifth level of the Internet is the consumer and business market. Each time a small office leases a line from its office to an Internet service provider’s point-of-presence, it has extended the Internet by that number of linear feet.

Many companies then setup dial-up ports at their offices for employees to connect from home or on the road and not only do they extend the Internet but the company becomes an ISP.

Deals are cut between operators at and across all levels of the Internet.

And there is a fear that somewhere in the Internet there is a single router that all of this hangs on such that one power hiccup and the entire network takes a tumble.

The point here is that there is an enormous amount of co-mingling of body fluids in the operation of an Internet. And there is a never-ending quest to have the largest, best, and most munificent network, made up entirely of the work and investment of somebody else, and offer it for sale to the public.

Further, the Internet service business is growing rapidly. Many of these organizations have gone through an initial public stock offering, or are in the process of doing so. Enormous quantities of cash are being invested in these companies, and they are adding personnel in groups of hundreds and thousands at a time. The number of knowledgeable Internet technicians and engineers available doesn’t approach the need. In attempting to assemble this data into some form of understandable information, we repeatedly encountered marketers and sales people who were enthusiastically and energetically ignorant and confused about their products, the network services they were selling, and just what an Internet was.

The point here is that you are likely to hear almost anything from an Internet connectivity sales representative. Some of it may be true. Some of it they may honestly believe to be true. In general, the signal to noise level is a little discouraging and you should take most assurances of quality, reliability, and service with a grain of salt.

That said, we did encounter other situations where the salesman at the field level was much more informed and competent than anyone at the management or public relations level.

<table>
<thead>
<tr>
<th>SOME INTERNATIONAL PEERING POINTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMS DC2 - Amsterdam, Netherlands</td>
</tr>
<tr>
<td>BNIX - Brussels, Belgium</td>
</tr>
<tr>
<td>CISP - Geneva, Switzerland</td>
</tr>
<tr>
<td>DGIX - Stockholm, Sweden</td>
</tr>
<tr>
<td>Ebone - Paris, France</td>
</tr>
<tr>
<td>FICIX - Helsinki, Finland</td>
</tr>
<tr>
<td>HKIK - Hong Kong, People’s Republic of China</td>
</tr>
<tr>
<td>INEX - Ireland Neutral Exchange - Dublin, Ireland</td>
</tr>
<tr>
<td>JINX - Johannesburg Internet Exchange - Johannesburg, South Africa</td>
</tr>
<tr>
<td>LIX - Santo Domingo</td>
</tr>
<tr>
<td>LNCC - PIR - Rio de Janeiro, Brazil</td>
</tr>
<tr>
<td>MIX Milan Internet Exchange - Milan, Italy</td>
</tr>
<tr>
<td>NZIX - Hamilton, New Zealand</td>
</tr>
<tr>
<td>SIX - Slovak Internet Exchange - Bratislava, Slovakia</td>
</tr>
<tr>
<td>SIX-ZH - Zürich, Switzerland</td>
</tr>
<tr>
<td>STIX - Singapore Telecom Internet Exchange - Singapore, Singapore</td>
</tr>
<tr>
<td>VIX - Vienna Internet eXchange - Vienna, Austria</td>
</tr>
</tbody>
</table>