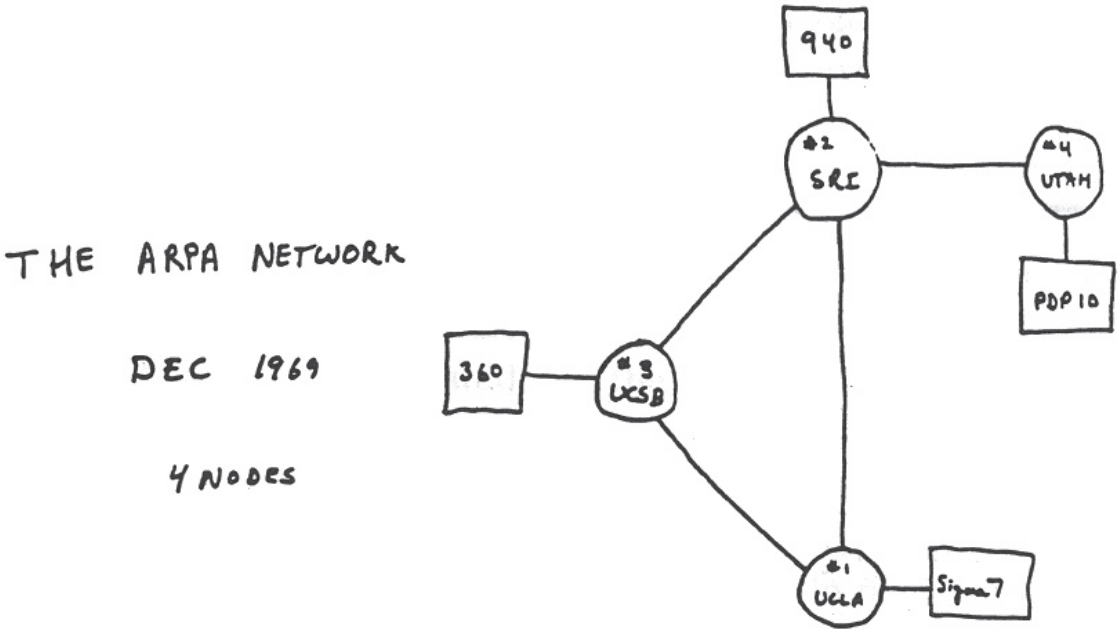

Figure 1. Sketch of the first ARPA network (predecessor of Internet), implemented in 1969 between four American universities.

The Internet – How big is it anyway?

A recent article in a quality newspaper had the title "Internet growth comes to a halt, but the Web is still growing". This title poses a few questions, the most interesting one being how to measure the size of the Internet. Since the Internet is not a centrally managed system this question is not easy to answer. One can only try to measure the actual size by looking at various parameters from the edges of the Internet. So, let us have a look at some of these parameters and try to draw conclusions.

The start of what we now know as the Internet can be traced back to December 1969 when a couple of universities in the USA connected their computers. Figure 1 gives the original network topology, and we can see that the size of the Internet was 4. Since those days the network has grown in size.

One of the early approaches to get a feeling of the size of the Internet has been to count the number of hosts connected to the net. In the early days of the net this was rather straightforward: almost all computers were directly connected to the Internet and they all had a unique Internet Protocol (IP) address and a unique domain name.

The Domain Name System (DNS) contains a distributed database coupling these addresses and names. In 1990 the late Eric Wassenaar of NIKHEF wrote the famous 'host' program that undertook a systematic walk through this database and counted the number of host entries.These counts have been done on a monthly basis for more than 10 years by NIKHEF and more recently by the RIPE NCC. Two numbers illustrate this:

2 October 1990	31,724
31 December 2005	14,981,314

A few comments on these results are appropriate.

In the first place these numbers refer to the geographical area of Europe, the Middle East and Central Asia. Secondly, while the first number gives a rather accurate description of the actual size of the Internet, the more recent number does not. This is caused by the fact that large numbers of computers nowadays are hidden by Network Address Translation (NAT) equipment and no longer appear in the DNS. One can think of compute farms or home equipment as examples. Finally, the total number of domain names in the global DNS today is about 80,000,000. Not all of them are active and contribute to the size of the Internet.

Let us now look at another parameter. The Internet is built by interconnecting networks owned and operated by Internet Service Providers (ISP). How many ISPs are there? This seems a rather easy question to answer: an ISP needs IP address blocks and the only way to get them is to join one of the 5 regional IP address registries. The combined membership of these registries today is about 10,000 ISPs. So, the Internet consists of about that number of networks, one might conclude.

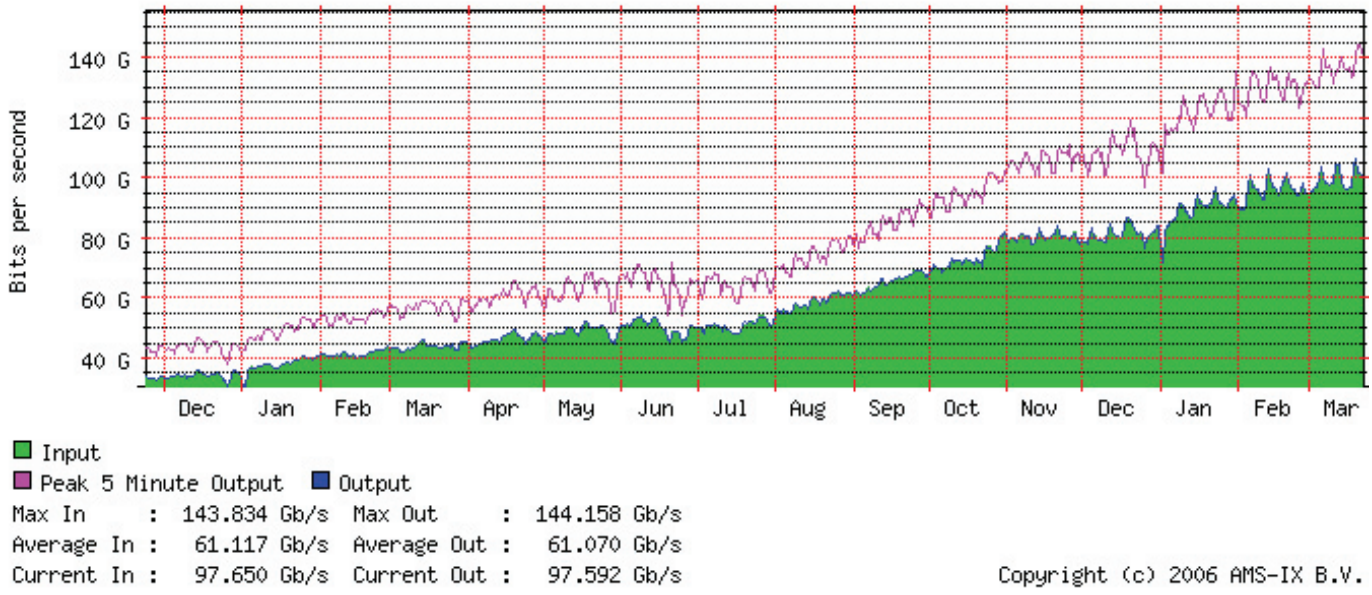

Figure 2. Data rates in 2004–2006 at the AMS-IX internet exchange point hosted by NIKHEF.

However, life is more complicated. Behind many of these ISPs reside other networks that do not deal directly with the regional registries, but do have their own networks. They just get their address blocks from upstream providers. To get an indication of how many of those exist we have to look at the routing system of the Internet. Routing on the Internet is again a distributed system. The basic principle is again simple: each network announces its existence to its neighbours, and the neighbours propagate this knowledge to their neighbours. After a while convergence takes place and a steady state is reached. If one now examines the routing tables, one can get a more complete picture of the interconnected networks.

The state of the global Internet routing table on 4 February 2006 tells us that 87,940 networks are announced by 21,423 ISPs. It is of interest to compare this with the global telephone system where there are less then 500 independent operators, highly regulated by the International Telecommunications Union (ITU) of the United Nations.

It is also of interest to note that the total announced IP address space amounts to 1,487,343,776 addresses. The equivalent number in the telephone system is approximately 1,000,000,000.

So, we have 21,423 ISPs that make up the global Internet by interconnecting their networks. There are various ways of doing this, the main ones being either direct connections or joining an Internet eXchange Point (IXP). An IXP is a neutral, common facility where several ISPs meet and connect their networks. The Amsterdam Internet Exchange (AMS- IX) is a good example of such an exchange point. The AMS-IX has currently 240 member networks and is one of the largest exchange points in the world. NIKHEF is home to about 100 of these ISPs and provides both AMS-IX connectivity and private interconnections. It is interesting to note that in 2005 more than 300 of these private interconnections were established at NIKHEF.

Let us now look at another parameter: traffic volume. How much traffic is there on the Internet? This question is easy to answer: nobody knows. However, we can have a look at various aspects of this question and come up with some interesting numbers.

In the first place traffic over the AMS-IX. Today the peak is at 140 Gbits/s, with the minimum value at 50 Gbits/s. The growth over 2005 was a factor 4. More details are shown in Fig. 2.

What is all this traffic? The major component today exists of peer-to-peer network traffic, in other words downloads of music and films. It is interesting to observe that many ISPs are trying to stop this traffic because their infrastructure cannot cope with the loads. ISPs can analyse the data content of IP packets and block e.g. BitTorrent packets. BitTorrent is a popular download mechanism. However, new versions of this application use encryption of their packets which circumvents ISP blocking of this

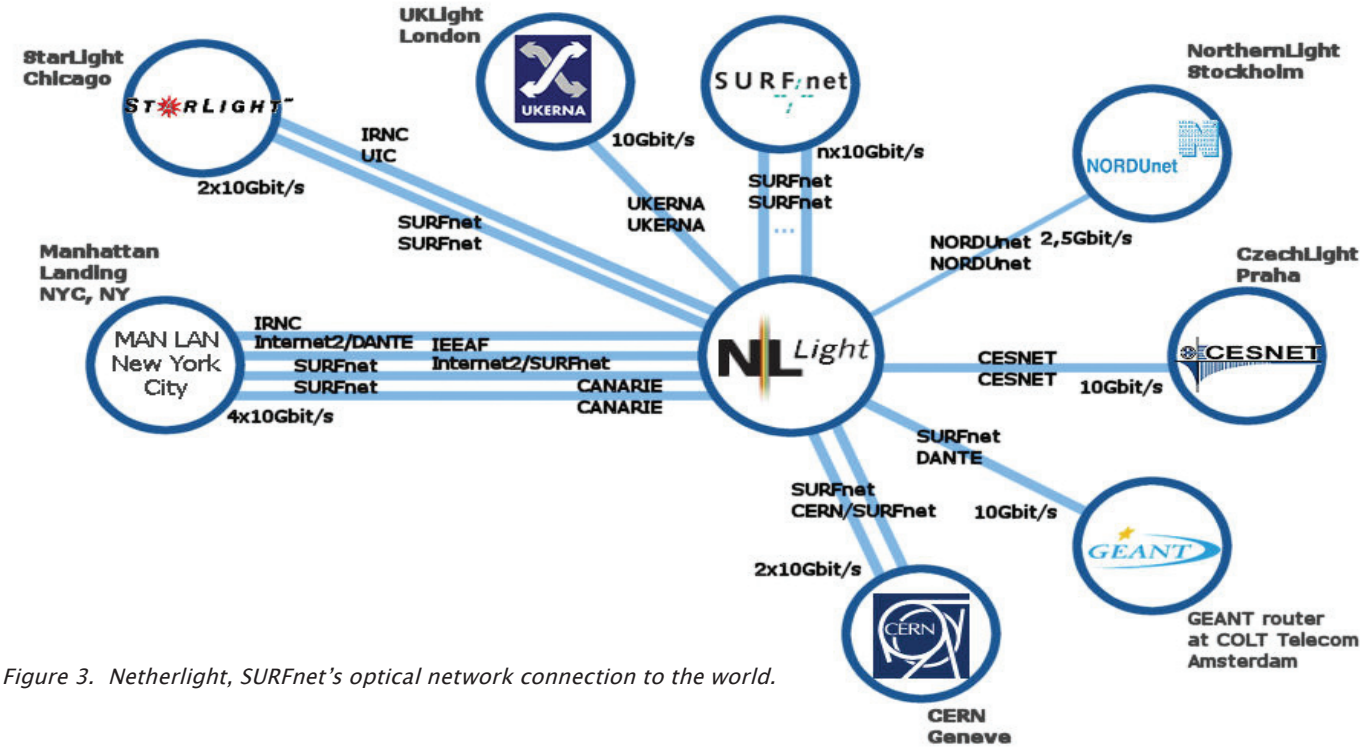

Figure 3. Netherlight, SURFnet's optical network connection to the world.

type of traffic. An interesting side effect is that law-enforcement agencies that do traffic sniffing suddenly find it impossible to analyse most of the Internet traffic. A blessing in disguise, according to some.

To transport all this traffic bandwidth is needed. So, how much bandwidth is there on the Internet? This varies dramatically. For example, it is not uncommon for a NIKHEF user to have 8 Mbits/s as a connection to the home. In Japan or Korea she could have 1 Gbits/s for the same price, whereas many African countries have less than 8 Mbits/s as total international connectivity. Pricing is even more divergent: 1 Mbits/s costs typically US$ 5 per month internationally, whereas in many African countries this will be US$ 15,000 per month. This is sometimes called the digital divide, but it is clearly more an economic divide. One of the roots of the African problem lies in the monopoly position of national telecommunication companies.

NIKHEF started international networking in the early 80's with 1200 bits/s connections. Today this has grown to a grand total of 30 Gbits/s thanks to the good works of SURFnet, our national academic and research network. SURFnet has built an optical network (see Fig. 3) that is the most advanced network of its kind in the world. NIKHEF is connected at 10 Gbits/s for general Internet connectivity. In addition to this SURFnet provides 10 Gbits/s to CERN in Geneva (Switzerland) and 10 Gbits/s via ESnet to Fermilab in Chicago (U.S.A.).

We started with the question of how big the Internet is. We have seen that this question is not straightforward to answer; therefore the real answer might well be: 42.

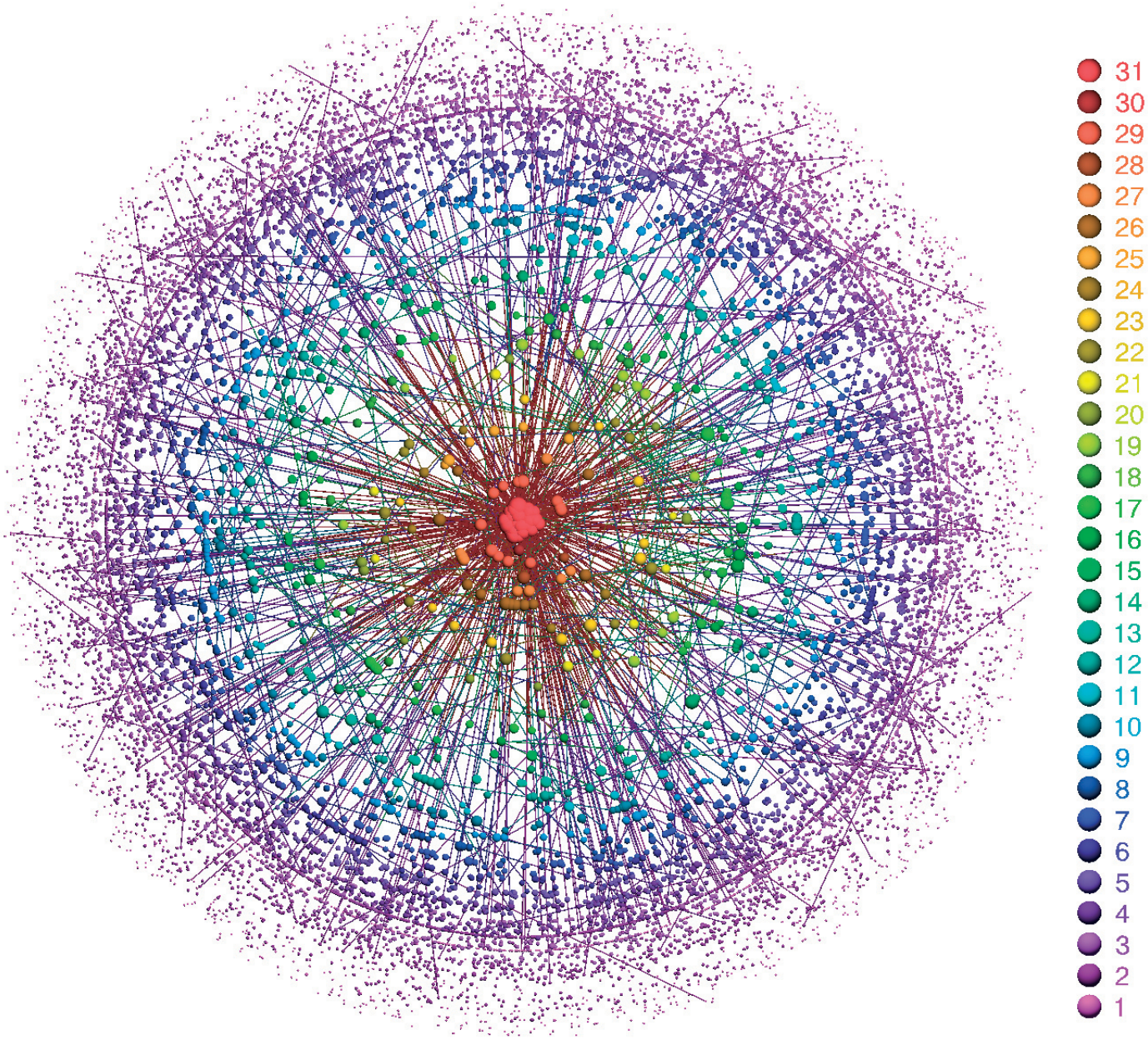

Figure 4. An IP-address map by DIMES (http://www.netdimes.org).