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Internet Traffic Exchange and the Development of end-to-end International Telecommunication Competition

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Working Party on Telecommunication and Information Services Policies

INTERNET TRAFFIC EXCHANGE AND THE DEVELOPMENT OF END-TO-END INTERNATIONAL TELECOMMUNICATION COMPETITION

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FOREWORD

In December 2001 this report was presented to the Working Party on Telecommunications and Information Services Policy (TISP). It was recommended to be made public by the Committee for Information, Computer and Communications Policy (ICCP) in March 2002.

The report was prepared by Dr. Sam Paltridge of the OECD's Directorate for Science, Technology and Industry. It is published on the responsibility of the Secretary-General of the OECD.

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MAIN POINTS

Competition is increasing in Internet backbone markets, as a result of liberalisation, and the consequent ability of telecommunication carriers to provide infrastructure and services on an end-to-end basis. All major telecommunication carriers wanting to serve regional and global markets have put together their own networks in those areas. This has increased competitiveness for transit services. As a result, the price of transit services has decreased and the structure of such pricing has become more flexible for ISPs. Operators have also been able reduce transit costs by more extensive use of peering. The increasing use of peering is supported by evidence that indicates that the Internet is becoming less hierarchical. As a result there have been sharp decreases in the cost of Internet access for consumers and business users and, importantly, new pricing structures more favourable to Internet development.

In respect to Internet traffic exchange, this report concludes that the current arrangements provide the right incentives for developing backbone markets. Analysis indicates that different business models are being pursued in relation to Internet traffic exchange. Some incumbent carriers are building a high proportion of direct traffic exchange relationships with other carriers. By way of contrast, other incumbent carriers are pursuing a strategy of dealing only with a small number of other backbone networks. Commercial negotiations provide the flexibility for this to continue and for the market to decide the most efficient arrangements. The imposition of something external to that process runs the risk of fundamentally altering the incentives for commercial responses and solutions to any perceived problems. It may also strengthen existing distortions where monopoly power exists. The value brought by different networks to Internet traffic exchange needs to be given due recognition in any commercial negotiations. The best guarantee this will occur is to ensure there is sufficient competition in backbone markets.

Where assessments have been made, such as in the two largest points for international traffic exchange in United Kingdom and the United States, authorities have concluded there are competitive backbone markets. Other OECD countries have also indicated that they believe their markets are becoming more competitive. There is concern in some quarters that the current financial downturn in the sector will lead to industry consolidation. In this respect several authorities have recommended that regulators should investigate the adequacy of existing data to inform them on these issues. Continuing to share national experience, particularly in relation to the feasibility of such data collection, needs to be supported by OECD governments.

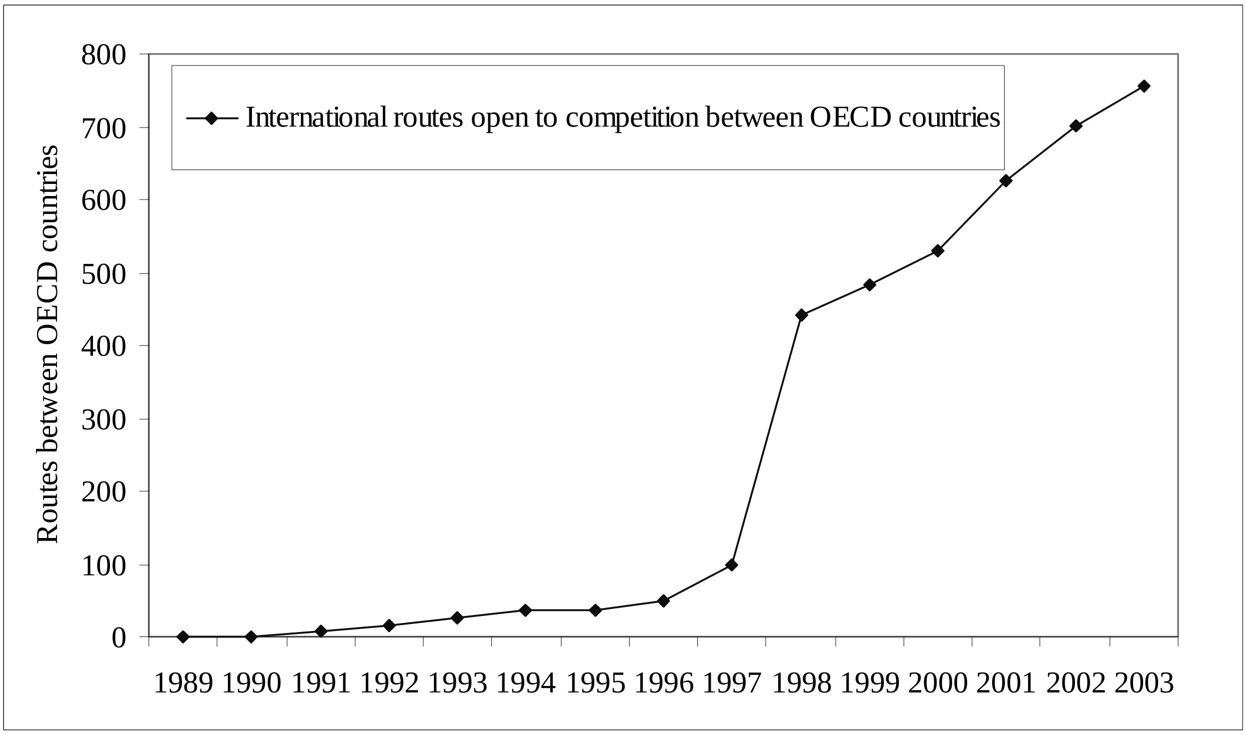
This report updates and extends previous analysis undertaken by the OECD on Internet traffic exchange.[1] In addition it builds on a workshop, held by the OECD, on Internet traffic exchange (Berlin, 2001) and series of previous workshops which considered this issue.

Introduction

The avoidance of monopoly rents and the need to ensure the continuity and quality of supply have, historically, been among the key drivers for the creation of new trade routes. In the field of telecommunications, for much of the past century, there has been little scope for achieving either of these goals. The avoidance of monopoly rents was unrealisable because most countries had legally mandated monopolies over the provision of telecommunication infrastructure. Even in those exceptional cases, where a country had opened its market to competition, monopolies continued to reign in corresponding countries. At the same time, monopolies made it difficult for one entity to guarantee service levels provided to its customers. This was because a single entity could not construct and manage their own end-to-end infrastructure across national borders.

Widespread liberalisation throughout the OECD area has fundamentally, albeit recently, changed this situation. By 2001 only four of the 30 OECD Member countries had monopolies over the provision of international telecommunication infrastructure – Hungary, Poland, Slovak Republic and Turkey. By the beginning of 2003 three of these countries will have liberalised their markets.[2] That being said, the transformation from monopoly markets is relatively recent. Some two thirds of OECD countries have liberalised their markets only since 1998. One way to conceptualise this change is to say that there are 870 possible international routes between OECD countries (*i.e.* 29 x 30). Prior to 1998 there were fewer than 100 routes that were open to competition. Just three years later 625 routes are open to competition (Figure 1).

Figure 1. Trends in international market liberalisation in the OECD area



Source: OECD.

In terms of Internet backbones this means that a growing number of telecommunication carriers can substitute services from other carriers (demand-side substitution), or as suppliers, can switch, or increase, production to supply the relevant products or services (supply-side substitution). For policy makers and regulators this is a very significant consideration. It means that the telecommunication market is becoming more like any other market. As long as there is sufficient competition, and markets remain open to new entry, commercially based arrangements for the carriage and exchange of traffic will continue to develop. Efficient traffic exchange and interconnection is vital between ISPs and it is important for governments to establish a competitive environment to realise this aim. Where there is insufficient competition or evidence of anti-competitive behaviour, regulators should be in a position to apply appropriate safeguards. For example, the new European regulatory framework, adopted in February 2002, will fully apply to the markets for Internet network services, including the provision of access to global Internet backbone networks.

In the European Union, an Internet service provider (ISP) may obtain the right of access to a local network access provider in order to connect end-users to the Internet backbone network of services and thus to offer global Internet connectivity, if this network access provider is deemed to possess significant market power for this particular access market. At the same time, regulatory interconnection obligations may apply to ISPs who are providers of Internet backbone network services regulatory interconnection obligations may apply to ISPs who are providers of Internet backbone network services if these ISPs are also deemed to possess significant market power in the market or markets for such services. However, it is very unlikely that the market for IP global connectivity (backbone) will be retained for ex-ante type regulation in the European Union, because this market is already regarded as effectively competitive. Local ISPs in the European Union market are therefore likely to have to continue to rely on commercial negotiations with the global Internet backbone network suppliers unless market bottlenecks or failure arise.

To date, the available evidence shows that, in liberalised markets, commercial responses and solutions in backbone markets are rapidly developing, and thriving, in relation to concerns raised by some incumbent carriers who were slower to react to changes taking place in the market. As infrastructure is developed for the new environment, the concerns of those carriers operating formerly along traditional lines has quickly receded. In addition the prices for connectivity for smaller ISPs, business users and retail users are declining. The OECD’s survey of dial-up prices has showed continuing falls in prices since it began in 1995.[3] Moreover where retail pricing is no longer dictated by backbone pricing (as was the case in some OECD countries when virtually all international infrastructure was owned by a single backbone provider) pricing for end users is also more flexible. Business users, such as Reuters, also report significant declines in the price of capacity on backbone routes.[4] In addition the price of transit for ISPs is reported to be declining.[5] At the same time ISPs have it within their own ability to reduce costs by measures such as peering at local IXPs. Notwithstanding this, regulators need to be vigilant in ensuring there is a strong competitive framework for Internet traffic exchange. This would be the case, for example, if in the current period of downturn there were to be a significant consolidation in the number of backbone players on particular international routes. In this respect several authorities have recommended that regulators should investigate the adequacy of existing data to inform them in respect to these issues. This would enable them to ensure that there is sufficient competition and to allow them to respond more rapidly in a very dynamic market.

Visualising the change in infrastructure in liberalised markets

Liberalisation has enabled telecommunication carriers to put together ‘end-to-end’ infrastructure on global and national routes. One of the easiest ways to visualise this change is to look at maps of global telecommunication networks (Annex 1). In the past, such maps showed international networks terminating at national borders. Even these representations somewhat overstepped the mark. In cases where international connections were put into place, between two countries, a theoretical mid-point existed. The capacity on both halves of this mid-point tended to be owned by different carriers (*i.e.* so called matching half circuits). In the new environment, however, telecommunication carriers can own capacity on an end-to-end basis. Moreover the ownership of international facilities does not terminate at national borders. Rather the networks continue, on a seamless basis, to form part of another country's backbone infrastructure.

The fundamental change in the possibilities for infrastructure ownership has coincided with a tremendous increase in demand for capacity to underpin the carriage of Internet traffic (Box 1). That being said this process happened in two stages – the monopoly phase and the liberalised phase. The first phase might be broadly categorised as being between 1993 and 1997. During this time the Internet was transformed from a largely academic network to a commercial network. This involved the ending of the so-called 'acceptable use' policy and, in 1995, the closure of NSFnet. It was a period typified by the emergence of commercial Internet Service Providers (ISPs) and their need to connect to backbone networks to provide services to their customers. But it was also a period in which nearly all the available infrastructure had been provisioned under the ownership structures which typified the monopoly phase. This raises the question of what this meant in practice for the way the Internet evolved.

Phase 1: The limitations of infrastructure developed by monopolies

The initial commercial Internet backbones emerged in the United States. Accordingly, the first ISPs in other countries needed to obtain capacity linking them to one or more of these backbone networks. In the majority of cases, ISPs did this from countries in which there were monopolies or where liberalisation was relatively recent. The latter point is very important because, in many countries, independent infrastructure had still not been constructed or been made commercially available. In practice ISPs purchased leased lines to connect them to major Internet exchange points (IXPs) in the United States.

The United States-centric nature of the Internet was reinforced by several factors. It was not just the case that the initial commercial backbones, and much of the initial content and services, were located in the United States. The least expensive way to exchange traffic on a global basis was to provision a link to the United States. This was because, as one of the first markets to liberalise, there was competitive pressure on the prices for international half circuits originating in the United States partly resulting in the Internet becoming United States-centric. Thus, by exchanging traffic in the United States, two foreign ISPs in different countries could minimise prices resulting in part from the monopoly rents extracted by their incumbent telecommunication carrier.

The initial United States-centric nature of the Internet did not, however, always ensure efficient networking. Traffic from networks in adjacent countries traversed inter-continental links because of the lack of connectivity between them. In these cases it was in the interest of all players to create domestic and regional IXPs so that foreign traffic did not need to traverse United States backbones. Much of the push for this came from ISPs determined to minimise their international costs but also to provide an improved level of service to customers. Liberalisation greatly assisted this process by reducing the cost to link to domestic and regional IXPs.

ISPs were not the only entities trying to avoid the high cost of international links and improve levels of service to customers. From around 1995 onwards, most telecommunication carriers began offering a full range of Internet services. This meant they had rapidly increasing demand for international capacity not only from ISPs but also from services provided to their own retail customers. Here it is necessary to recall that most of this infrastructure had been provisioned on the basis of monopoly ownership. In other words, the bulk of capacity available to service the needs of their own customers was owned only up to a theoretical mid-point. Telecommunication carriers around the world became, in effect, the customers of carriers with backbones in the United States. End users were, of course, still paying for the capacity but the flow of payments between carriers increasingly favoured those carriers with their own major backbone networks in the United States.

One reason for this imbalance was that carriers headquartered in the United States were among the first to build out new international infrastructure. Whereas these carriers could carry traffic on an end-to-end basis over their own infrastructure, other incumbent carriers were still purchasing foreign half circuits to meet burgeoning demand. It is important to note that the monopolies in question were on the foreign, rather than the United States, side of the link. A great deal of Internet activity is, of course, still centred in the United States and, in some cases, it may still be the least expensive point at which to exchange traffic. Traceroutes between major carriers in neighbouring countries, outside the United States, sometimes still reveal traffic exchanged via the United States. In November 2001, for example, a traceroute from Deutsche Telekom to France Telecom showed the traffic being exchanged in the United States (via BBN). This can even be true of carriers operating in the same country. For example, a traceroute from Concert in Belgium to Belgacom showed the traffic being exchanged in the United States (via Level3). The reasons for this are, however, different from what they were in the mid-1990s. There is no longer a lack of IXPs or other infrastructure deficiency reasons. In today's environment carriers from OECD countries exchange traffic solely based on commercial considerations, when commercial strategies dictate the exchange of traffic in the United States that still occurs.

Phase 2: Commercial responses and solutions evolve

While some incumbent telecommunication carriers urged government intervention to correct what they saw as an imbalance in payments for international links, others could see commercial responses and solutions. The process of finding commercial solutions brought about the second phase of the development of international Internet connectivity – roughly 1998 to 2001. During this time commercial actions emerged in response to the initial concerns raised by some incumbent telecommunication carriers. This process was boosted by the increasing impact of the 1996 Telecommunication Act, which encouraged new entry across all market segments in the United States. At the same time, widespread liberalisation across Europe, in 1998, opened these markets to the provision of end-to-end facilities. For carriers on both sides of the Atlantic liberalisation encouraged the provision of seamless services and enabled new options in putting together international facilities.

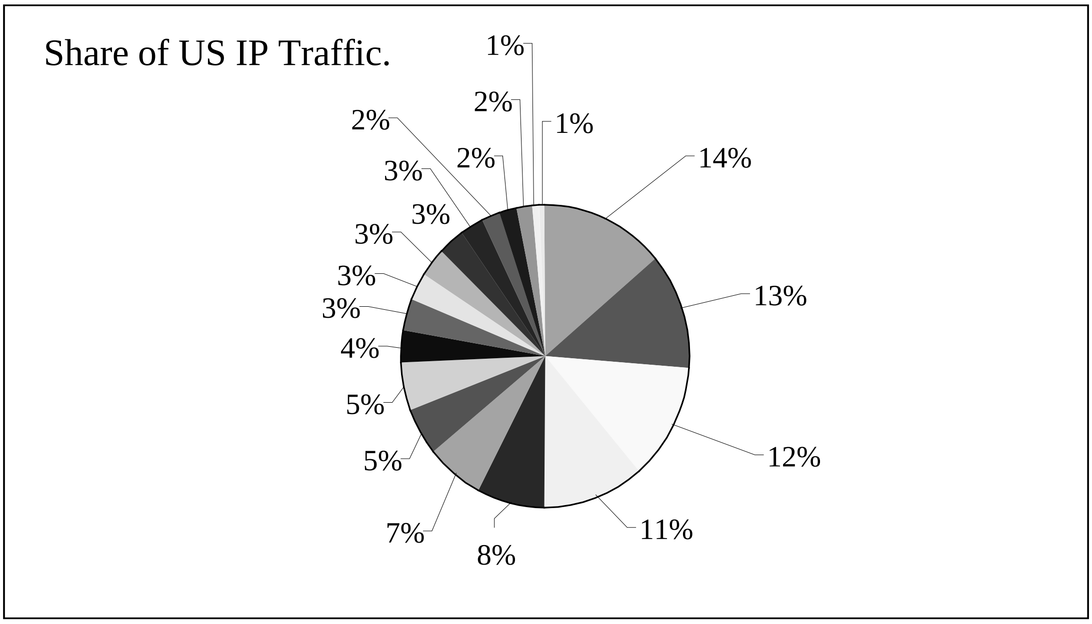
Following the 1996 Telecommunications Act, there was a huge increase in the amount of backbone capacity in the United States and on international routes to and from that country. This meant that foreign carriers had much greater flexibility and choice in striking commercial deals with carriers in the United States. Some of the new entrants include Level3, Williams Communications, Dynegy, Global Crossing and many more. While some questioned the competitiveness of the backbone market in the United States - when they had to purchase matching half circuits rather than having their own end-to-end infrastructure – the available evidence indicates that it has grown increasingly competitive.

In October 2001, the United States General Accounting Office (GAO) reported on the characteristics and competitiveness of the backbone market in the United States.[6] The GAO stated that the industry participants they interviewed regarded the backbone market as competitive. Significantly, they reported that companies that purchase backbone connectivity stated that the market had become more competitive in recent years. These companies said prices had fallen and purchasers' ability to negotiate better contract terms had improved. The GAO said that some ISPs believed their inability to peer with larger backbone networks put them at a competitive disadvantage. On the other hand, the report noted that rates for transit services were falling and that some ISPs preferred purchasing transit to peering with backbone providers.

The reason given by these ISPs was that they felt they received a higher quality of service with transit connections.

The GAO report noted that there are no official data available on backbone markets. One industry study, carried out with access to the largest 19 networks in the United States, concluded that the largest network only carried 14% of IP traffic in 2001.[7] These data suggest that the United States is the most competitive backbone market in the OECD area (Figure 2). Foreign telecommunication carriers operating backbones in the United States add to the level of competition.

Figure 2. IP traffic shares of the largest 19 networks in the United States



Source: Roberts et al. www.caspiannetworks.com

The pace of change generated by these developments has been remarkable. From 1998 onwards, foreign carriers have begun to put together backbone networks traversing the United States. Some of the first to act were Cable and Wireless, Telia and Teleglobe. Successively, a growing list of foreign telecommunication carriers have added their own backbone networks throughout the United States including France Telecom, NTT, Telecom Italia, Telefonica and Telstra. The major change, in terms of market structure, is that these carriers own this capacity on an end-to-end basis. They no longer need to purchase international half circuits originally provisioned in the monopolistic world of circuit-switched networks. At the same time they can carry traffic across their own backbone networks within the United States.

Telecommunication carriers have a range of new options available to avoid paying for the use of other networks. These include partnering with a carrier which is stronger in another region (*e.g.* KPN and Qwest; Telmex and Williams Communications), purchasing dark fibre (*e.g.* France Telecom and Level3), purchasing capacity and services (Deutsche Telekom and Metromedia Fibre Network - MFN) swapping capacity (*e.g.* Telia and Williams Communications) or purchasing a company (*e.g.* Teleglobe and Excel, NTT and Verio) or share of a company (*e.g.* Telstra and DynegyConnect). The foregoing is not exhaustive of the possibilities. Carriers may also purchase 'transit' services for their global requirements, in an increasingly competitive market, or agree to 'peer' and thereby exchange traffic without payment by either party. Port charges are the mechanism by which transit payments are made.

For their part, United States-based carriers have also been building out their networks on an end-to-end basis. For example Williams Communications has a backbone network in Australia and Worldcom has a backbone network in Japan. Indeed, most United States headquartered carriers now have networks throughout Europe and Asia. In the case of Williams the company has also partnered with Telmex to provide IP traffic exchange between their networks. Telmex has also taken a small stake in Williams Communications. At the same time the creation of new backbones across the United States is only part of the global networks being put together by carriers headquartered outside the United States. Telia or France Telecom's rollout of networks throughout Europe are just as important to their delivery of services as their backbones in the United States.

The result of this frenetic rollout of new infrastructure is that telecommunication carriers no longer necessarily need to be each other's customers for connectivity or the exchange of traffic. In many cases, of course, they do choose to purchase services from other carriers but this is no longer mandated by monopolies or the lack of infrastructure inherited from a monopoly environment. In turn, it means that carriers can strive to meet their goals of minimising payments to each other. Just as important, these developments place the carriers with global networks in a position to offer and guarantee greater levels of service to their customers.

Data on Internet traffic are less available for Europe than the United States. Some data are available for the United Kingdom – generally acknowledged to be the largest hub for Internet traffic outside the United States. In August 2001, Oftel reported that no operator appeared to have market power and that price levels do not indicate the presence of excessive profits.[8] One indicator Oftel used to reach these conclusions was that no one operator enjoyed a strong position in the market in terms of traffic volumes. Data were examined for six operators and Oftel noted that a further 15 players were providing backbone services. Oftel also noted that prices were falling for backbone services. When taken together with the available data for the United States, the evidence suggests a strongly competitive backbone market in the two leading centres of Internet traffic exchange. In smaller countries competition is also evident between backbone networks. In the Czech Republic, among the 22 largest Internet networks with large backbone networks, are a number of international operators. These include entities such as BT, Contactel, GTS, KPNQuest, RadioNet, Telenor, Telia and Tiscali.

Trends outside OECD area

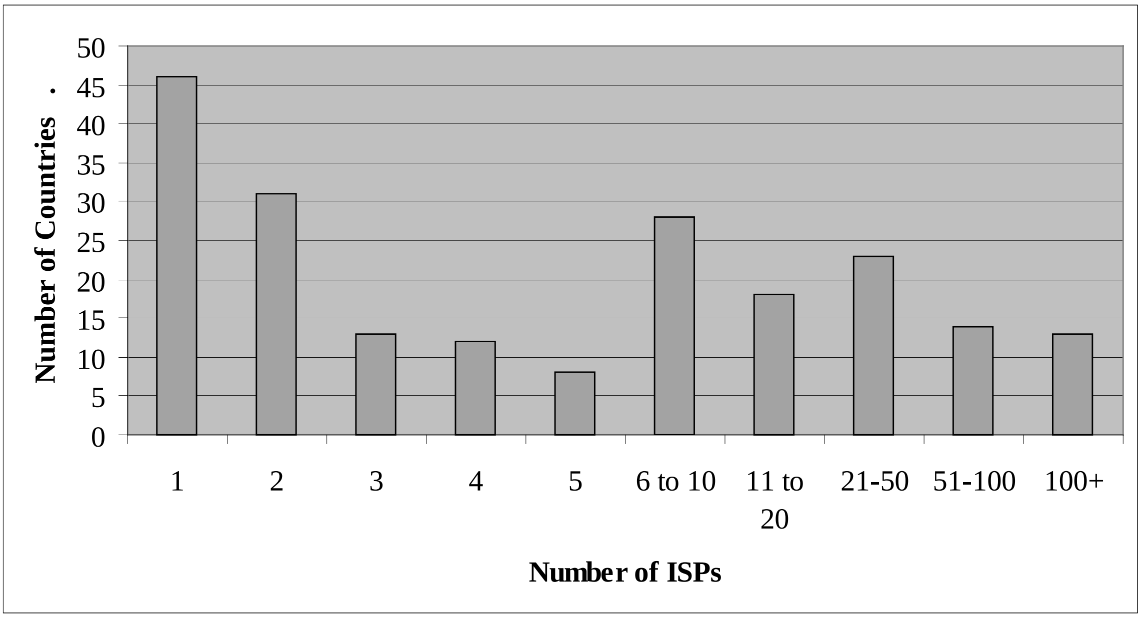
While the trends are clear, for telecommunication carriers in OECD countries, how will network owners in developing countries adapt to the new environment? Some may think, for example, that the strategies being employed by carriers in OECD countries may not be available to carriers in developing countries. On the other hand there is growing evidence to suggest that the same commercial responses and solutions can be put into place if markets are opened. The current barriers to developing countries taking advantage of the new possibilities to reduce international connectivity costs and encourage infrastructure development are the result of monopolies or the lack of infrastructure developed by carriers with monopolies in their home markets.

Where some degree of liberalisation has already occurred, developments are propitious. In February 2001, Dishnet, a leading ISP in India, contracted Tycom to construct an undersea cable to provide seamless connectivity between India, Singapore, Guam, Indonesia and the United States. On the other hand, in Kenya, the development of an IXP, for the exchange of domestic traffic, was blocked by the telecommunication regulator. This was based on a complaint, from the incumbent, that the new IXP somehow challenged its monopoly over the provision of infrastructure.

It is unlikely, of course, that carriers in developing countries will adopt exactly the same strategies as those in OECD countries. In most cases their priority should be to develop domestic infrastructure – a goal which is also being hampered by monopolies. This should not, however, be prejudged. Competitive forces, on routes where they are permitted to work, are already driving down the cost of owning international capacity. Based on current trends, it is relatively easy to imagine carriers in developing countries being able to own capacity on an end-to-end basis for those routes that are most important to their customers. At the same time the flexibility surrounding the acquisition of capacity is increasing. Some providers of international infrastructure already sell products allowing carriers to purchase a certain amount of capacity, which can then be allocated on different routes. This is radically different from the monopoly environment where leased lines or matching half circuits were available only from one point to another.

The barriers to developing countries taking advantage of the new environment are their monopolies. The creation of IXPs, for example, would create places where traffic aggregations would make it more attractive for global backbone networks to connect their infrastructure. This would increase the opportunities for peering and make the transit market more competitive. The same monopolies that once stopped this happening in OECD countries are now holding back the development of domestic and regional IXPs in developing countries. That being said, half the world's countries had less than five ISPs at the beginning of 2001 (Figure 3). Some 46 countries only had one ISP and more than 30 only had two ISPs. This is often because the incumbent telecommunication carrier has a monopoly over Internet access services or that their control over basic infrastructure has not encouraged independent ISPs to flourish. Accordingly, an even more fundamental step than establishing IXPs is to create conditions in which ISPs can develop and grow the overall market. These ISPs will then look for the best commercial arrangements for themselves and their customers.

Figure 3. Global distribution of ISPs



Source: OECD based on Netcraft.

In this context it is worth noting that half the countries in the world have gained their first Internet connection since the closure of NSFnet. In many cases, unlike OECD countries, the first connections were not provided by United States-headquartered carriers or even to backbones located in the United States. In fact the largest providers of connectivity, to those countries with less than five ISPs, are France Telecom, Cable and Wireless and Teleglobe. In some cases these carriers do provide direct connections between developing countries and their backbones in the United States. In other cases they provide intercontinental backbone connectivity which does not traverse the United States. Accordingly, not only is Internet connectivity becoming less United States-centric, but when traffic does traverse the United States, it may well be carried on backbones wholly owned by 'foreign' carriers.

While incumbents in developing countries may currently have limited flexibility in provisioning international connectivity – just as many OECD carriers did prior to the impact of liberalisation – the same solutions can be adopted. If markets are opened, commercial responses and solutions will certainly be adopted by new entrants, who have nothing to lose by way of extracting monopoly rents from the sale of international half circuits. In many cases, the companies served by the global backbones of companies such as Teleglobe and Interpackets in developing countries, are new ISP entrants. The more these markets can be developed, the greater the attractiveness for competition in provision of transit services and infrastructure.

Box 1. Trends in Internet growth

Internet subscribers

Between 1999 and 2000 the number of Internet subscribers in OECD countries grew 48% from 122 million to 180 million. The proportion of broadband subscribers is also increasing. At the end of 1999 only around 2.5% of Internet subscribers in OECD countries had a broadband connection. By 2000 this had increased to 7.8%. This trend continued in 2001 and in the first six months of the year the number of broadband subscribers increased from 14 million to 22 million.

Traffic

All the available evidence points toward continuing rapid growth in Internet traffic. In the United States, one study suggests that the growth rate for IP traffic in the six months prior to April 2001 was 300% on an annualised basis (*i.e.* 4x).[9] This study was based on data provided by the largest 19 backbone networks in that country. On the other hand, two experts in the field, based on the evidence they have available, suggest the annual growth rates may be more in the order of a factor of two (*i.e.* 2x).[10] In support of this they point to an annual growth rate for Genuity of 2.2x for the period 1998 to mid-2001.[11] They also cite a growth rate of 3x per year for AT&T but say this is ahead of industry averages.

The differences between 2x and 4x growth rates are extremely important for service suppliers and equipment manufacturers. If Internet traffic is growing toward the higher bound then new equipment will need to purchased and deployed to meet that demand. On the other hand growth at 2x will not necessitate this at the same pace. One thing that experts agree on is that the amount of Internet traffic continued to grow in the first half of 2001. While national indicators are not widely available, those that are indicate continuing growth in Internet traffic. In Australia, for example, the amount of data downloaded by users increased 16% in the June quarter of 2001.[12] Moreover, available indicators show that it is Internet traffic rather than voice traffic that continues to drive the expansion of capacity. In Hong Kong, for example, total international minutes of telecommunication traffic was 6.6% greater in June 2001 than September 2000. By way of contrast, the total activated international capacity, measured in Mbps, grew by 66% over the same period.[13] In Europe, the largest IXP (Linx) has reported that the amount of bandwidth connected to the exchange point trebled in the twelve months leading up to November 2001.[14]

Secure servers

By July 2001 there were more than 133 000 secure servers in the OECD area representing 94% of the global total. Between July 2000 and July 2001 the OECD total grew by 41%. Although there has been a downturn in the stock market valuation of some telecommunication and information technology companies on NASDAQ, following the so-called 'dot-com crash', the number of secure servers continues to grow in the United States (Figure 4).

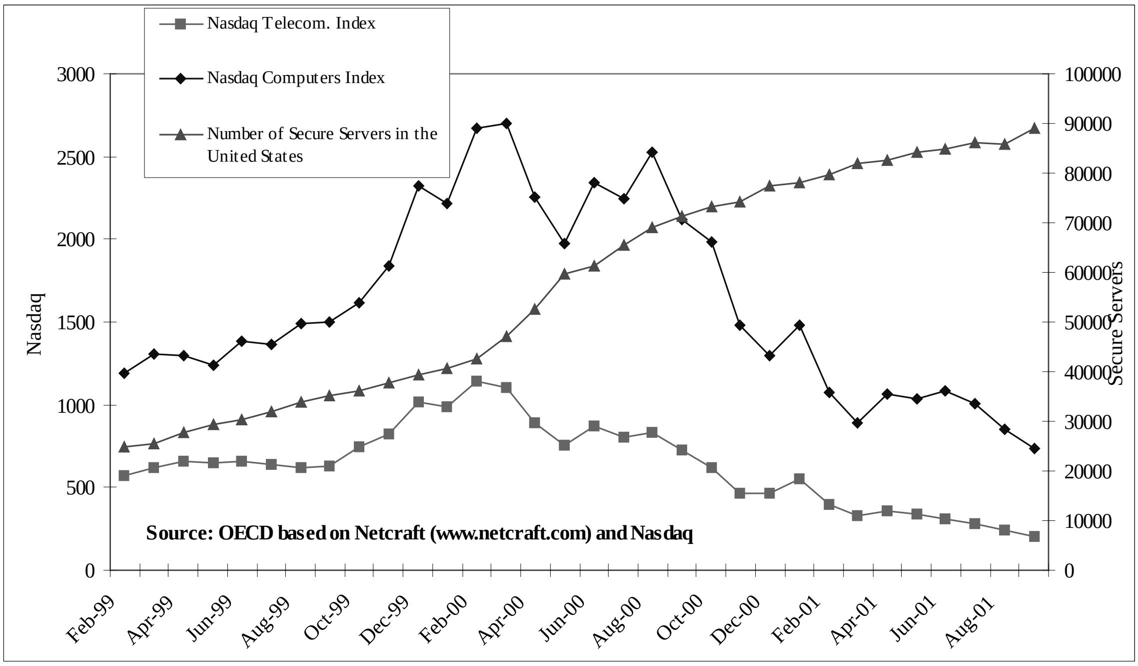
Internet hosts

Between July 2000 and July 2001 the number of Internet hosts in the world increased from 84 million to 117 million, of which 95.6% were in OECD countries, according to the survey undertaken by Telecordia's Netsizer.

Capital expenditure

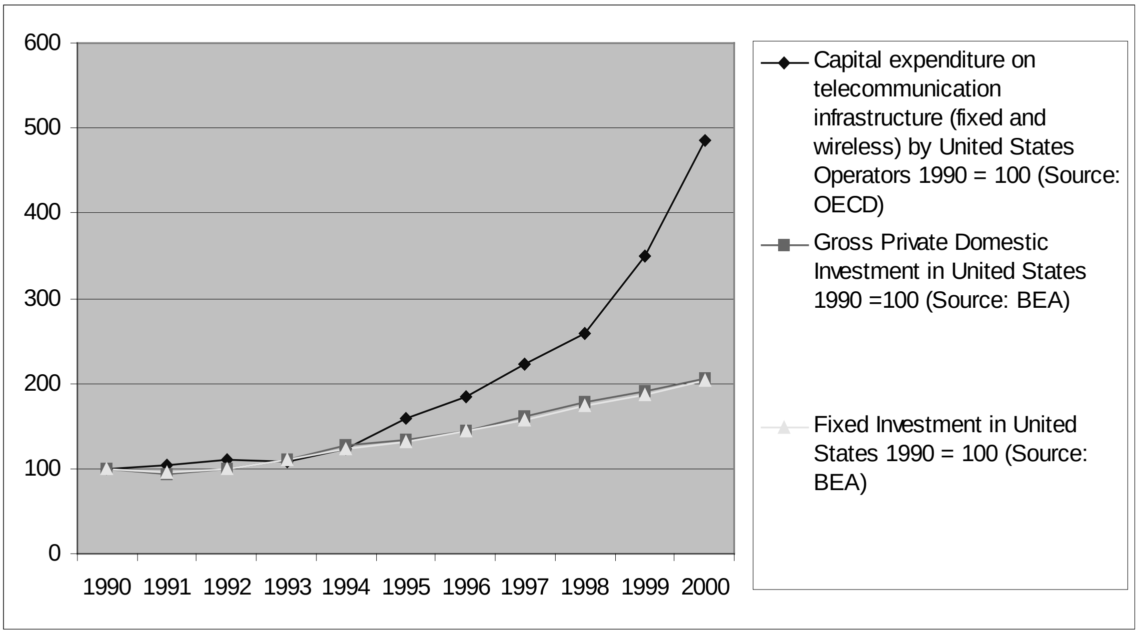
In recent years there has been a dramatic increase in levels of capital expenditure in the telecommunication sector. By the year 2000, levels of capital expenditure in the United States were running around five times the level that they were in 1995 (Figure 5). In the United States, levels of capital expenditure have slowed in the first half of 2001 compared to the second half of 2000. This being said, the first and second quarters of 2001 witnessed the fourth and fifth highest amounts of capital expenditure in the United States (Figure 6).

Figure 4. Nasdaq indexes and the growth of secure servers in the United States



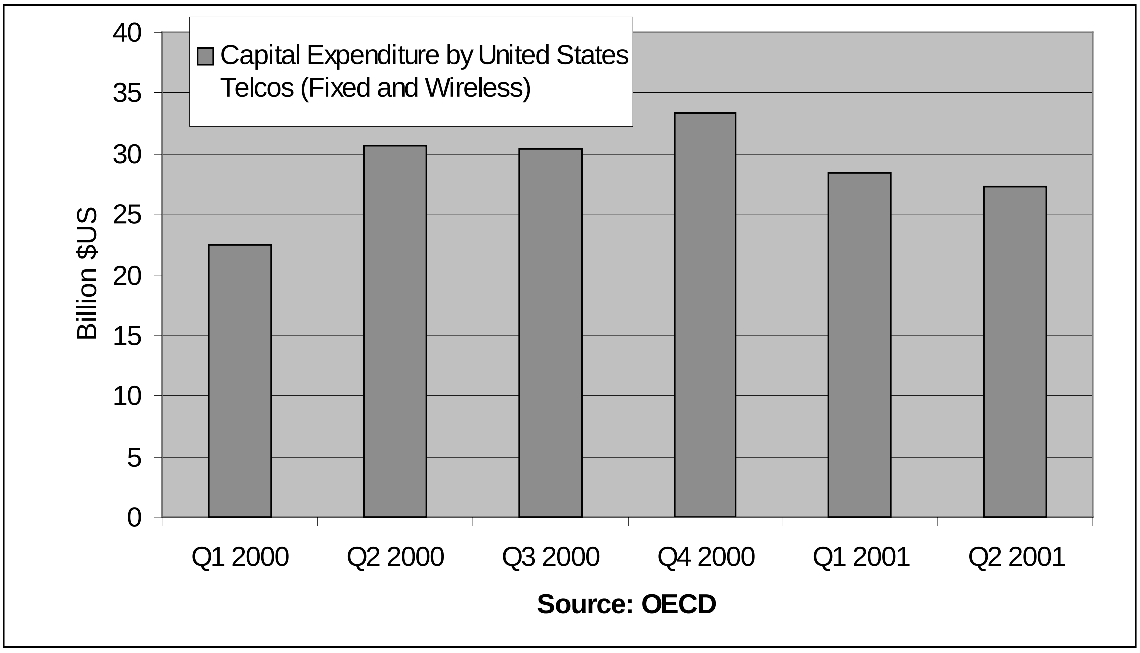
Source: OECD, Netcraft, Nasdaq.

Figure 5. Telecommunication investment trends in the United States



Source: OECD.

Figure 6. Quarterly investment in the telecommunications sector in the United States



Source: OECD.

Broadening backbones

Growth in broadband backbones is occurring at a very rapid pace. The fundamental premise for this development has been the liberalisation of telecommunication markets. As with any network development, there is inevitably a period from when regulatory reform is introduced to when services are available from new entrants. Simply put, whatever the pace of technological change, it still takes time to construct conduits and towers or lay cables.

It also takes time for companies with traditional business models to accept the realities of the new competitive environment and to change and adapt their strategies. In terms of international infrastructure some companies have clearly been ahead of others in reacting to liberalisation. In some cases this has involved building new international infrastructure or using other means to effect their strategic goals. In the new environment one of the primary strategic goals for telecommunication carriers in OECD countries is being able to provide end-to-end services.

In one sense, telecommunication carriers have always provided end-to-end services to their customers. The difference in a previous age was, of course, that end-to-end service provision meant joint provision by two monopolies. In the new environment a telecommunication carrier can provide services at both ends. If they cannot, they are at a competitive disadvantage against companies that will provide these services.

This is a profound change for traditional telecommunication carriers because it places the commercial arrangement for service provision in a totally new area. If a carrier cannot provide a service on an end-to-end basis, they need to put into place new commercial relationships with other companies to ensure they can meet the needs of users. The signs of this transformation are readily available. From the previous age, they involve the breakdown of the accounting rate system. In the new environment they involve the debates over new arrangements for Internet traffic exchange. These commercial arrangements involve new terms, such as ‘peering’ and ‘transit’, that are becoming increasing familiar to policy makers. What is less well acknowledged, however, is the way infrastructure is being developed by carriers to adjust to these new arrangements.

Peering and transit

In general terms, ‘peering’ is the agreement by two networks to exchange Internet traffic without payment. Peering is most common among networks of equivalent size and reach. In other words both networks agree to exchange traffic, without payment by either party, because there is an equivalent benefit. By way of contrast ‘transit’ involves the payment by one network to connect to another network and for its traffic to be carried by that network to third parties. Transit tends to be typified by networks of different size and reach. Peering can also exist between networks of different size for their own network traffic. However if one network, typically the larger, carries traffic to a third party then it may also charge for transit. The increasing publication, by ISPs, of their requirements for peering is welcome and assists in increasing transparency.

The new forms of traffic exchange create incentives for carriers to provision infrastructure accordingly. If a network wishes to be considered by another for peering it has an incentive to build or acquire equivalence. As such it needs to put together a network that will be attractive to other party. At the same time, by carrying traffic on an end-to-end basis, carriers can bypass other carriers who would otherwise charge transit payments. Moreover for some Internet content, by extending the reach of their network, carriers can improve the performance of their networks. They do this by moving closer to the most requested content or by seeking to host or mirror the popular content. The overall result of this activity is that “…there is less reliance on a small number of Tier 1 transit service providers and related financial arrangements."[15] This trend is likely to be furthered by the evolution of technology, which allows greater possibilities for small ISPs to exchange traffic directly.[16]

One outcome of the foregoing is that the Internet is becoming less hierarchical with a denser matrix of interconnected networks.[17] One indication of this is that the number of route entries and IP networks are rapidly growing. Yet, at the same time, the data show that there are fewer hops between networks. One reason for this is that each ISP has increased the use of multi-homing and lateral peering (or secondary peering).[18] In addition, it is reported that the cost of carriage (*i.e.* capacity) is declining faster than prices for transit. In other words, it is in the interest of each ISP to improve their financial position by increasing the number of peer connections and reducing their transit requirements.[19] In summary, the current commercial arrangements provide the right incentives for increasing infrastructure investment, efficiency and interconnectivity. By way of contrast, regulatory intervention could introduce distortions that would not achieve these goals – and provide incumbents with monopoly power with incentives to act against the development of the Internet. Nevertheless, it is necessary to bear in mind the role of government in promoting traffic exchange in an efficient manner through preventing major ISPs from abusing dominant power.

Building end-to-end networks

The impact of liberalisation on infrastructure provision has been significant. Following widespread liberalisation in Europe, in 1998, a tremendous amount of new backbone infrastructure has been put in place traversing the continent. New transatlantic cables have also come on stream dramatically increasing the availability of capacity on those routes and seamlessly connecting new backbone networks between Europe and North America.

It may be the case that the North American carriers were slightly faster to react. From 1998 onwards, carriers such as Worldcom, Teleglobe, Level3 and others strove to roll out pan European infrastructure as quickly as they could to provide end-to-end services. Telmex has also been actively expanding its international connectivity. In 1990, Telmex had no international submarine cable connections. By 2001, the company had put together some 35 international cable connections. For their part, European carriers were also striving to build pan-European backbone networks beyond their traditional termination at national borders. This involved both European flagship carriers, such as BT, Deutsche Telekom, France Telecom, and Telia, as well as new market entrants such as GTS with its Ebone network.

Although European carriers had to prioritise the construction of pan-European networks, as soon as these markets became open, they have been actively putting together North American backbone networks. References to the maps of newly created regional and global networks are available (Table 1) as are pictures in Annex 1. The network development plans of some of the leading payers are also available (Table 2).

Europe goes global

It is worth considering how telecommunication carriers are developing end-to-end networks that do not adhere to traditional borders. Towards the end of 1998, Telia gave a presentation on Internet traffic exchange to an industry conference. In the presentation they noted that a presence at North American Internet exchange points (IXPs) was expensive for them to utilise, even though North American bandwidth prices were considerably lower than Europe. Telia looked forward to factors that might change this situation. One such factor, with potential to change market conditions, was new regulation but Telia felt this was unlikely. A more likely solution for them was for European operators to enter North American markets. One tool they identified to do this was "capacity swapping" which they felt would decrease their transit payments and decrease the ‘dominance’ held by the, so called, Tier 1 carriers based in the United States. Although questions have been raised about whether the accounting treatment of ‘capacity swapping’ between telecommunication carriers has been appropriate, swapping has provided a significant means to rapidly expand services in markets where operators did not formerly own facilities.

Telia’s strategy to rapidly establish a high-quality and cost-effective international carrier network is readily understandable with that background in mind. From 1999 onwards the rapid expansion of Telia’s international network means that it can offer telephony, IP traffic, and network capacity in its own pan-European infrastructure. In addition, Telia is also one of the largest carriers of IP traffic over the Atlantic and one of the first European operators to begin doing business in the United States with a wholly owned network.

The way Telia put together its network in the United States was by swapping capacity on its pan-European network with network owners in the North America. This strategy gave these companies wholly owned networks in each other’s region. To complement this strategy Telia also acquired AGIS one of the pioneer ISP networks in the United States. Telia say that this acquisition gave them so-called ‘Tier 1’ status among backbone networks in the United States. There is also a great deal of capacity swapping at a more local level. An update on Telia’s activities for the first quarter of 2001 is available showing a mix of capacity swaps and sales (Table 3).

Cable and Wireless was probably even ahead of the Telia in reacting to the new environment. One reason for this was that the company’s diverse geographical holding gave it an incentive think about the creation of wholly owned end-to-end networks in advance of most other carriers. In 1998, Cable and Wireless purchased MCI's Internet business after competition authorities made its sale a condition of MCI's merger with WorldCom. The fact that it owned end-to-end facilities has meant that Cable and Wireless subsidiaries have often taken commercial positions, on Internet traffic exchange, that are different to those advocated by other carriers in those markets without end-to-end facilities.

Other European carriers have adopted strategies similar to Telia’s. For example, Telecom Italia has been active in swapping capacity with Teleglobe. In March 2001, the two companies signed a new agreement aimed at drawing upon the complementary nature of their respective international networks and services. Telecom Italia has initially focused on Latin America, Europe and the Mediterranean, while Teleglobe’s major activity is in the North American and Atlantic connectivity markets. One of Teleglobe’s first actions toward provisioning global end-to-end services was to acquire backbone infrastructure, in the United States, through the purchase of Excel Communications. Under the new agreement Telecom Italia is supplying Teleglobe with connections between a number of European cities. In return Telecom Italia is to acquire from Teleglobe transatlantic connectivity that will enable full integration of the Telecom Italia’s European IP network with North and South America.

In September 2000, France Telecom announced it would invest about USD 200 million to build the 28-city network and to provide high-quality, end-to-end services in North America via Global One.[20] This network will be connected to France Telecom's pan-European backbone network, opened in October 1999. The seamless, self-healing backbone, scheduled for completion by the end of 2001, will have up to 1.6 Tbps of capacity to support all types of traffic, including Internet, data, voice, and multimedia. This initiative provides France Telecom with fully-owned infrastructure in North America. Level 3 Communications is to provide the ‘dark fibre’ for that network. France Telecom will interconnect the North American backbone network with international submarine cables, linking North America with the rest of the world: Europe through the transatlantic cable ‘TAT-14’, South America through ‘Americas-II’ and ‘360americas’ submarine cables, and Asia through the Japan-US cable. France Telecom’s customers can expect to benefit from end-to-end connectivity world-wide.

By 2001, Telefonica was offering telecommunication services in nearly 50 countries and had its own facilities in 20 countries. The company had put together one of the largest international networks to support these operations, including undersea cable traversing the Atlantic and circling Latin America. The company's backbone networks can provide end-to-end seamless service between Europe and Latin America. Telefonica says its network carries 80% of the world's Spanish-language Internet content. In addition, in September 2001, Telefonica began operations in the United States and established a centre in Miami (Florida) to host content and to act as a hub for the exchange of traffic. The company said that the new centre "…would play a strategic role in Telefonica Data's consolidation of traffic from Spanish and Portuguese-speaking markets, to be exchanged with multiple carriers via peering agreements implemented in this facility."[21] The company also has a strategic alliance with AOL through which it provides network services to the main companies of AOL in markets within Latin America and Europe.[22]

Some European carriers have forged different strategies than the foregoing but toward the same goals. KPN's partnership with Qwest, to form KPN-Qwest is one example. BT's former partnership with AT&T, to form Concert, was another example. In both cases, KPN-Qwest and Concert, the companies had the ability to provision end-to-end services for customers. In other cases companies are agreeing to share the costs of network construction. The agreement between Level 3 and Colt Telecom is one example.

Asia-Pacific goes global

In the Asia-Pacific carriers were initially slower to react to the new environment. One factor is that new entrants, in the provision of undersea cables, prioritised the trans-Atlantic routes before constructing cables on the trans-Pacific routes. Notwithstanding this the same commercial forces are at work. An obvious case in point was NTT's purchase of Verio in 2000. Verio says it is the largest web hosting company in the world with a 'Tier 1' network. NTT's acquisition of the company gave it a network criss-crossing the United States.

More recently, in March 2001, Singapore Telecom (Singtel) and Belgacom agreed use of each other's international networks to bring end-to-end telecommunications services to their respective customers in Asia and Europe. The exchange of capacity on each other's international networks enables SingTel to expand its presence in Europe and Belgacom in Asia. The companies said that the new agreement "…would allow both parties to increase their respective share of the booming market for international transit and carrier services."[23]

Singtel has also been actively expanding its regional capabilities, with a strategy to establish a network of Internet Data Centres in major cities throughout Asia to provide seamless, end-to-end managed hosting services on a regional basis. In December 2000 the company announced it would invest USD 277 million, over an 18-month period, to expand its data hosting facilities in China, India, Indonesia, Japan, Malaysia, the Philippines, Korea, Taiwan and Thailand to add to those in Australia and Hong Kong. In addition, Singtel acquired Optus Communications in Australia, in March 2001, gaining an Australian backbone network. This adds to the company's shared ownership of the first overland cable linking China, Vietnam, Laos, Thailand, Malaysia and Singapore. The China-Southeast Asia Cable, spanning 7 000 kilometres across the six countries, commenced carrying commercial traffic in February 2001.

The other major transnational partnership emerging in the Asia Pacific region has been between Telstra and Pacific Century Cyber Works (Hong Kong Telecom). The joint venture, called Reach, combines the international infrastructure of Telstra Global Wholesale and PCCW-HKT. The first step in this strategy was to invest in the US-China cable, which entered service at the beginning of 2000. In addition, Telstra is investing in the Australia-Japan cable which will link to the US-China cable significantly increasing the available international capacity between Australia and the Asia Pacific in the third quarter of 2001. At the same time new entrants in the Australian market – Telecom New Zealand, Optus and Worldcom – launched the South-Cross undersea cable, in November 2000, dramatically increasing the amount of available capacity between Australia and North America.

Telstra has also been actively upgrading its trans-Pacific cable capacity and putting together a backbone network circling the United States. Telstra's partner, Dynegy, is a new entrant in the United States backbone market. DynegyCONNECT, Dynegy's North American subsidiary, is developing a nation-wide optically switched data network that will consist of approximately 16 000 route miles and 44 points of presence (POPs) by the fourth quarter of 2001. Level3 is providing Dynegy with the dark fibre to put together this network. Telstra is a 20% owner of DynegyCONNECT. The partnership also provides Dynegy with access to Telstra's Asia-Pacific network. The key to Telstra's involvement was gaining access to the fibre routes in the United States to provide end-to-end services to its customers.

Dynegy has also been active in Europe. Dynegy's European subsidiary, Dynegy Europe Communications (DEC), will be formed in the first part of 2001 following the acquisition of 'iaxis Limited', a privately held, London-based communications company. Upon completion of this purchase, DEC will acquire an 8 750 route-mile (14 000 kilometre) fibre optic network and have optical equipment and technology deployed at more than 30 co-location, data centres and hub sites throughout Europe.

Global traffic exchange relationships

International Internet traffic exchange occurs over a very diverse set of backbone networks with many thousands of transit and peering relationships. That being said incumbent telecommunication carriers are generally the largest players in backbone markets. Accordingly, it seems reasonable to assume that a relatively large proportion of international traffic is exchanged between these networks. This raises questions about how international Internet connectivity is evolving between the incumbent carriers. For example, do incumbents tend to exchange traffic directly or do they rely on other carriers to ensure connectivity with other incumbents? One way to test the number of direct exchange relationships between incumbents is to run a traceroute between two networks. If the traffic is exchanged, without recourse to a third network, then the two incumbents have a direct relationship. If, however, the traffic is passed through a third and sometimes fourth network, then the two incumbents do not have a direct relationship.

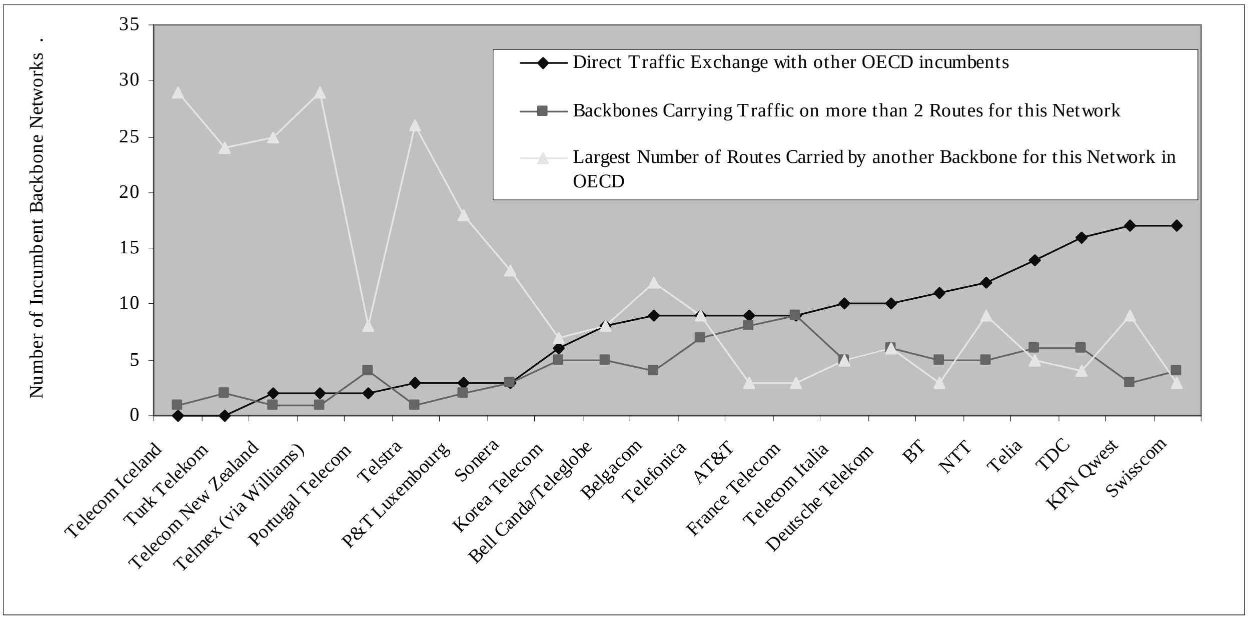
To see how many direct exchange relationships were in place traceroutes were run from the networks of 22 incumbent carriers to all other incumbents in OECD area.[24] The results showed a wide variety of approaches to traffic exchange (Figure 7). On the one hand carriers such as Swisscom, KPN-Qwest, TDC, Telia and NTT have a large number of direct exchange relationships with other carriers. Swisscom, for example, exchanged traffic directly with 17 of a possible 29 incumbent relationships. By way of contrast, Telecom Iceland did not exchange traffic directly with any incumbent. In this case all Telecom Iceland's traffic, with other incumbent carriers is carried by exchanging traffic with a single backbone network (Worldcom). Other carriers with relatively few direct exchange relationships with other incumbents were Turk Telekom, Telmex, Telecom New Zealand and Telstra. In the case of these carriers there was a distinct tendency for one exchange relationship to carry traffic between that network and most other incumbents. On the other hand Portugal Telecom had relatively few direct exchanges with other incumbents but exchanged traffic with a larger range of backbone carriers.

It is not possible to determine whether the relationships between incumbents are transit or peering arrangements from traceroutes. However it is interesting to see different strategies being applied. This is evident in terms of those carriers that have relatively few exchange relationships to those that have a much larger number. These data can also indicate which backbone networks are used to exchange traffic between incumbents (Figure 8). This chart shows the percentage of exchanges with the first backbone provider (*e.g.* Telstra to France Telecom exchanged via BBN (Genuity) counts as one exchange for BBN). At the same time, an exchange from Telstra to NTT is direct and therefore counts as one for NTT. The data reveal a rich tapestry of international exchange relationships between incumbents.

The data also indicate that Worldcom, Teleglobe, Global Crossing and Cable & Wireless are some of the backbone networks most frequently used for indirect traffic exchanges. That being said some of the proportions indicated are highly reliant on only a few relationships. For example, if Telecom Iceland's relationship with Worldcom was excluded the latter's backbone would show 7.4% instead of 11.6%. At the same time, if Telecom New Zealand's relationship with Global Crossing was excluded the latter's proportion of routes would halve. In addition if the eight carriers, for which no traceroute source was readily available, were included it is likely that the share of any individual backbone would also decrease. Accordingly, the share of routes for any particular international backbone network is not very large.

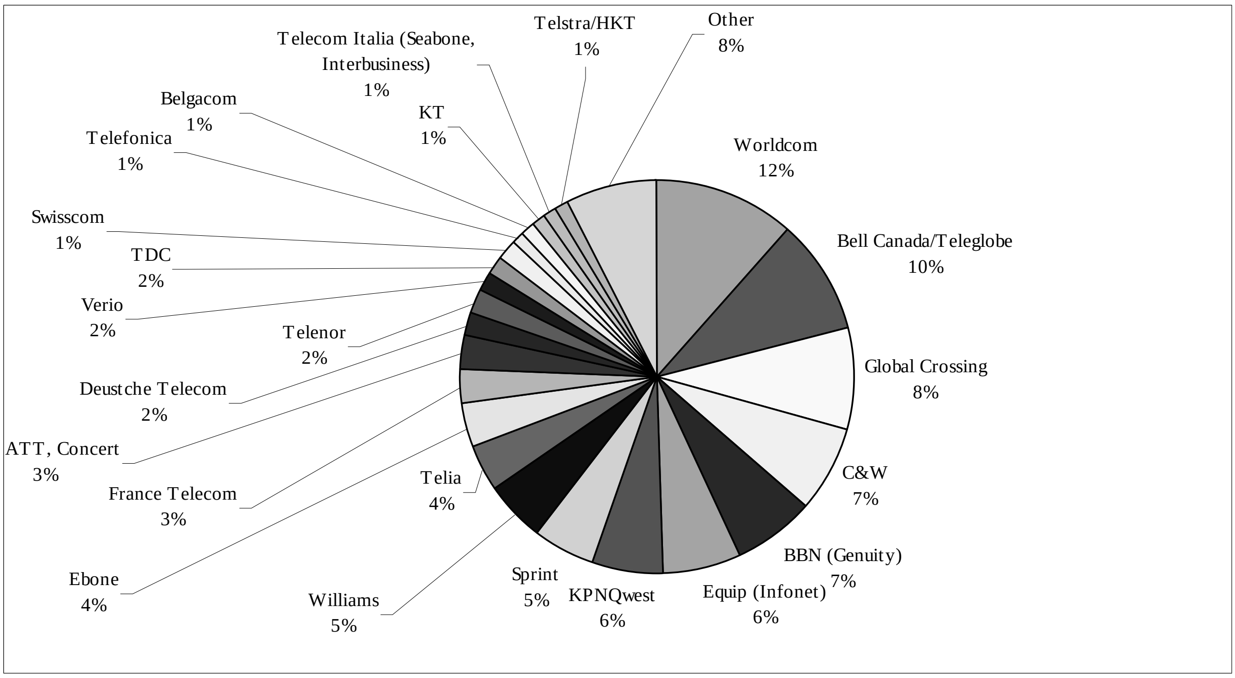
One conclusion it is possible to draw from the available data is that incumbents are far from reliant on any particular backbone network. A second conclusion is that if carriers have a relatively small or a relatively large number of direct exchange relationships, it is because they have found that these arrangements are in their best commercial interest. They would undoubtedly pursue the other strategy if it made more sense. Clearly, however, different commercial responses and solutions are being applied as the exchange of international Internet traffic evolves. The variety of different strategies provides a strong basis for viewing commercial negotiations as being the best way to manage traffic exchange relationships.

Figure 7. Traffic exchange relationships between incumbent telecommunication carriers



Source: OECD.

Figure 8. Backbone exchange routes between incumbent carriers in the OECD



Source: OECD.

Access to content

An issue sometimes raised in relation to the competitiveness of backbone markets is the bargaining power one network may have over another because it hosts popular content or provides connectivity to other entities hosting such content. This was one of the initial concerns expressed by some carriers outside the United States as the Internet first developed commercial aspects. The issue raised by some carriers was that if the most popular content and services were located in the United States, where they did not have backbone networks, then they had to connect to particular backbone networks to provide services to their customers. Accordingly, they said, some backbone networks in the United States had greater bargaining power in commercial negotiations. Several years later, it is worth reviewing how this situation has developed due to commercial responses to any perceived imbalance.

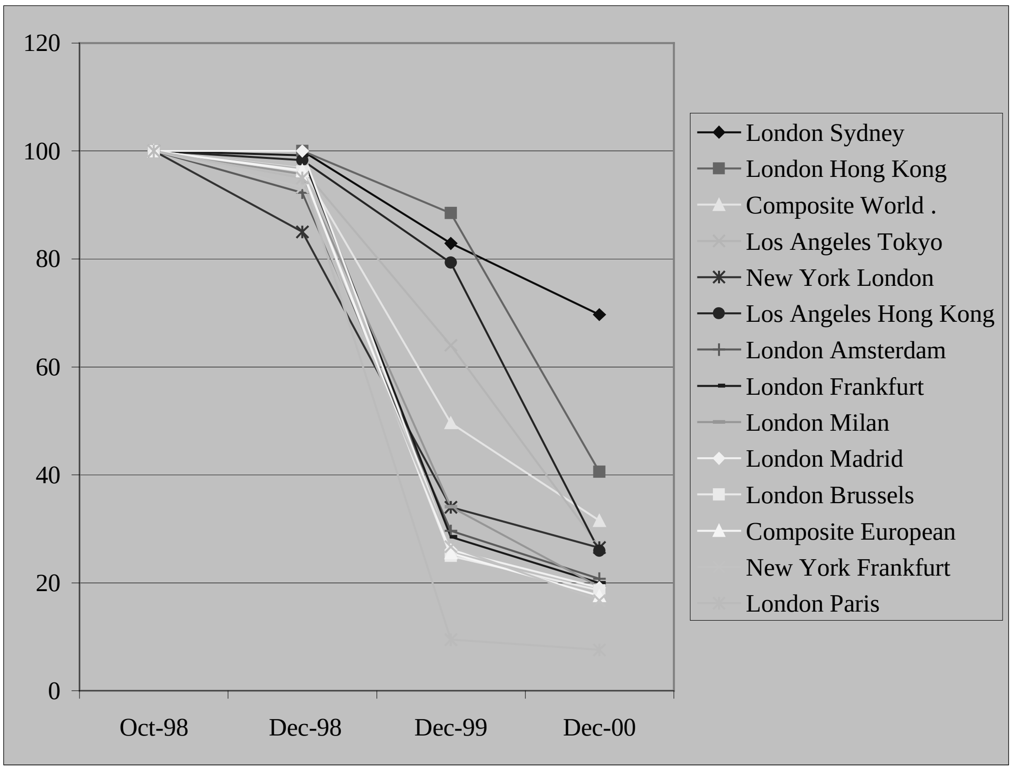
The ability of carriers in liberal markets to put together their own end-to-end networks has enabled them to provide connectivity direct to the most popular content. In the mid 1990s, for example, if a user in Australia, New Zealand or Korea wanted to access “Yahoo!” (www.yahoo.com), the traffic would have needed to be exchanged between network operators in those countries and backbone providers in the United States. In February 2002, traceroutes run from Telstra, Telecom New Zealand and KT (Korea Telecom) showed that they provided their own direct connectivity to “Yahoo!”. The traffic involved in these particular exchanges no longer needs to cross backbone networks owned by United States based operators.

Additional considerations may be involved where a backbone network also hosts content or is the owner of content. Before commenting on this, it is worth noting that nearly all incumbent telecommunication carriers are in the business of hosting content. In addition, many have entered into the business of content creation. In respect to web hosting, some of the largest companies are now owned by backbone operators. By way of example these include Exodus (recently purchased by Cable and Wireless), Digex (Worldcom) and Verio (NTT). Providing access to content may, of course, add to the attractiveness of purchasing transit or peering with a particular backbone provider. However it is necessary to note several other factors at work. One is that major content providers generally 'multi-home' (*i.e.* their hosting and carriage are provided by multiple entities). In, for example, the case of "Yahoo!" several backbone operators exchange traffic directly with Exodus (one of the providers that hosts "Yahoo!"). Yet at the same time the foregoing examples show it is also possible to exchange traffic directly with "Yahoo!" (*e.g.* Telstra, Telecom New Zealand and KT). One factor that needs to be noted is that it is in the interest of content providers to ensure widespread and efficient access to their products and services. For the same reason, carriers that are among the leaders in Internet content creation, such Telefonica (*e.g.* Terra-Lycos, Wired News, HotBot, Angelfire, Raging Bull, Quote.com and so forth), also 'multi-home' their content. As well as being in the web hosting business, Telefonica hosts 'Lycos' content at Exodus.

Global versus local: How end-to-end are the new networks?

In today's environment policy makers might consider the maxim "think global, act local" as worthy of consideration. Following widespread liberalisation the available evidence indicates that competition is developing on national and international routes. The benefits of a competitive backbone market are increasingly evident with falling prices for capacity and transit services on these routes. The Band-X Capacity Index provides one indicator of falling prices for capacity between major cities (Figure 9). This is a significant development for those policy makers considering the development of international telecommunications. The paradigm of 'one network – one country' has been replaced by a myriad of networks seamlessly operating at the national and international level. The operators of these networks enter into the best commercial arrangements for their requirements. They are free to build or buy with few barriers to entry.

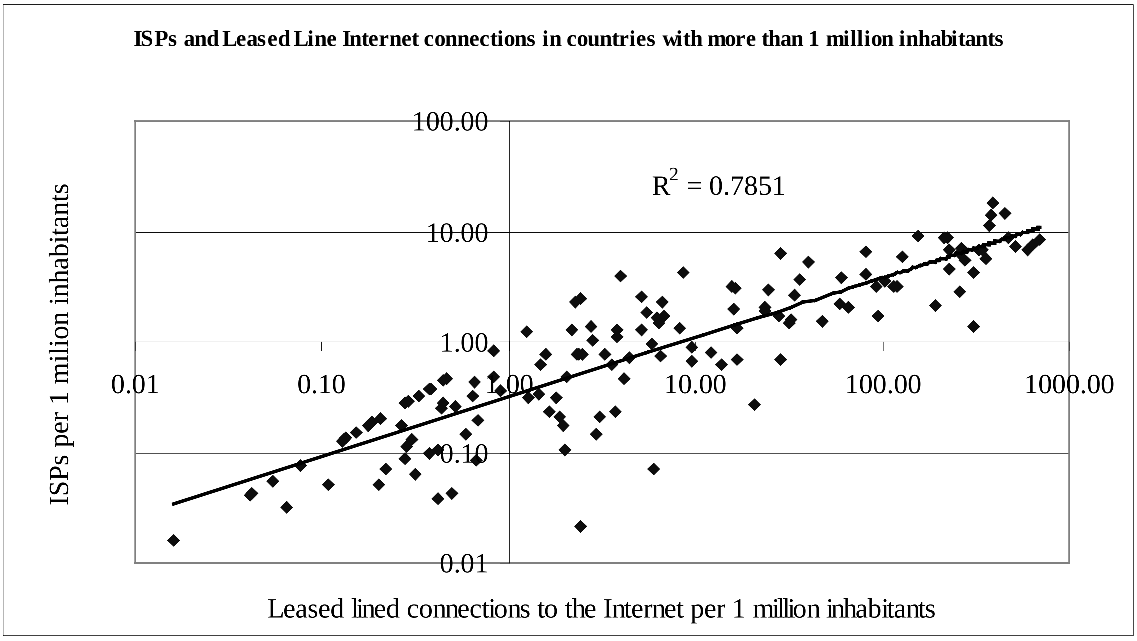
Figure 9. Band-X bandwidth price index (2 Mbit/s)



Source: Band-X (www.band-x.com).

By way of contrast it takes longer to develop local access infrastructure. This means that there is an ongoing need to be vigilant in terms of access to the infrastructure needed to make these networks fully end-to-end. For business users the key component needed to continue to develop their communication requirements are leased lines. Local leased lines, called tails in some countries, are the means by which business users and their service providers form connections to national and global backbone networks. In those countries where there is insufficient competition at the local level, the cost and provision times associated with local leased lines continue to be a major source of concern for new entrants and business users. One new entrant reports that the cost of tails typically accounts for 50-70% of the total cost of the services for their customers. In addition the available evidence indicates incumbents still accrue monopoly rents where there is insufficient competition. At the same time, delays in provisioning local leased lines are frequently reported to be of an unreasonable nature. The need for regulators to establish benchmarks for provisioning is increasingly critical as business seeks to use local leased lines for broadband access to their ISPs. The available evidence indicates, that on a global basis, there is a high correlation between the number of ISPs and the number of permanent leased line connections to the Internet (Figure 10).

Figure 10. ISPs and leased line connections to the Internet

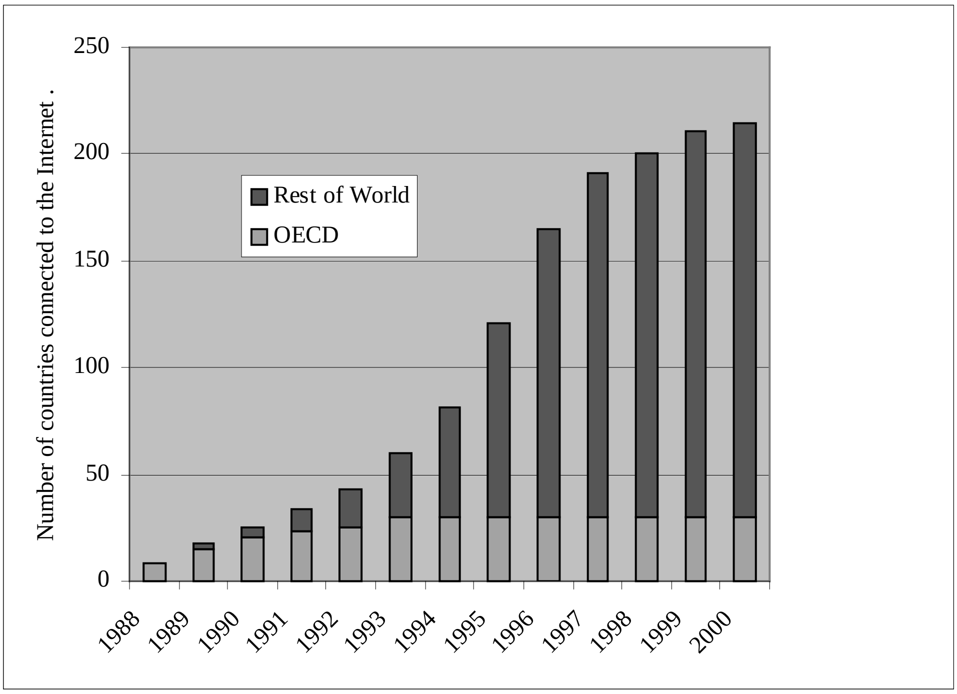


Source: OECD, Netcraft.

Global Internet connectivity

The origins of the Internet were in the United States and, as a result, the first international connections were to that country. The first countries to connect to the Internet were from among the developed world. All OECD countries had at least one connection to the Internet by 1993 (Figure 11). Accordingly, much of the connectivity between OECD countries occurred via these connections. Even domestic traffic in a country would flow over international links before being routed back to the appropriate network in the country concerned.

Figure 11. Countries with networks connected to the Internet



Source: OECD, ITU, NSRC.

As the Internet developed a greater number of public and private Internet exchange points (IXPs) were established outside the United States. In addition, liberalisation fostered greater connectivity between OECD countries. Accordingly, the growing number of IXPs meant that traffic could be exchanged on a regional basis rather than traversing transcontinental backbone networks. However, at this stage, the exchange of traffic between Europe and the Asia-Pacific region almost wholly transited via North American backbones.

One of the first arrangements to break this mould was between Singapore and Belgium. Due to Singtel's ownership share of Belgacom, the two companies were among the first to exchange traffic along routes traversing the Indian Ocean, Suez Canal and Mediterranean. Such arrangements are increasingly common. A traceroute from Singapore Telecom to France Telecom, in May 2001, showed the traffic being exchanged directly without recourse to transit from any other network. Unlike the Singapore Telecom and Belgacom example there is no shared ownership between France Telecom and Singapore Telecom. The traffic is exchanged directly because is advantageous to both companies.

This case is significant in its own right but can be developed further. If a user in Singapore wanted, for example, to access a website in Gabon or Nigeria, the traffic would also be exchanged over France Telecom's network. In these cases the traffic would traverse undersea cables between Singapore and France and then satellite connections between France and the two African countries. What the foregoing examples suggest is a growing matrix of international connectivity. Inter-continental traffic not traversing North American backbones is no longer exceptional. Moreover, in those cases where traffic still does traverse North American backbones it may never cross the network of carrier headquartered in the United States.

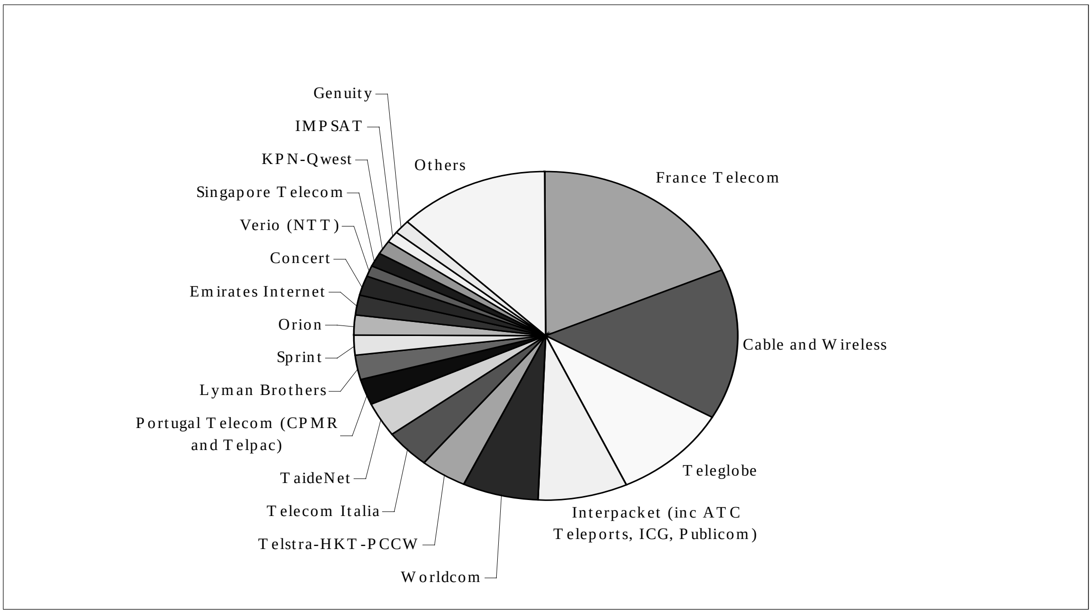
To test this hypothesis it is possible to examine the international connectivity of networks in countries with the least developed Internet markets. The methodology chosen was to take countries with fewer than five

ISPs providing leased line connections to the Internet. These data were provided by Netcraft's Internet leased line survey. One reason for setting the limit at five ISPs was to make analysis of the data manageable. For countries with a small number of ISPs it is relatively easy to see which networks advertise routes to ISPs, or networks with permanent Internet connections, in these countries. As the number of ISPs grows so to does the complexity of international connectivity. If routing information was not available, then traceroutes were run from widespread geographical locations to see which network provided final international hop to hosts located in the countries concerned. The methodology used may not capture all networks connected in the countries concerned but it should be robust enough to provide a good indication for the trends in international connectivity.

This approach covers networks in 110 of the 214 countries connected to the Internet at the end of 2000. There were no OECD countries falling into this category and the majority of countries, or territories, could be said to be have relatively small or low Internet development. The geographical mix of the countries, as might be expected, was extremely varied.

The results show that British, Canadian and French companies advertise the greatest number of routes to networks in countries with fewer than five ISPs (Figure 12). Leading the way was France Telecom, which provided connectivity to 29 networks in the 110 countries or territories at the end of 2000. A close second was Cable and Wireless connecting networks in 23 countries followed by Teleglobe connecting networks in 15 countries. It should be noted that around one-third of the countries had ISPs that were connected via more than one foreign backbone provider.

Figure 12. Providers of Internet connectivity in countries with fewer than five ISPs



Source: OECD, Netcraft.

A significant point coming out of this analysis was that networks, that might be said to be United States networks, had a relatively lower ranking than might have been expected. The two United States ISPs with the largest number of advertised routes were Interpacket and Worldcom. Interpacket, owned by Verestar (American Tower Corporation), is a satellite-based network specialising in the provision of Internet backbone connectivity. Worldcom is, of course, one of the largest and best known ISPs in the world. The contrast between the two companies is interesting. Interpacket is a relatively new entrant into international

Internet connectivity. On the other hand, some of the international routes advertised by Worldcom are to customers, such as universities or incumbent telecommunication carriers, who received there first Internet connections from Alternet and UUnet (*i.e.* two of the pioneering ISPs that now owned by Worldcom).

One conclusion that can be drawn from these data are that the backbone carriers connecting countries or territories, that are either small or have low rates of Internet development, are much more diverse than are perhaps commonly understood. Whereas the very first Internet connections were to NSFnet, in the United States, more than half the world's countries gained their first connection after the closure of this network in April 1995. In some cases the international connectivity arrangements, put into place by these networks, reflect the ownership of the incumbent telecommunication carriers. In other cases they reflect the fact that when networks in these countries introduced the first 'commercial' connections to the Internet they looked for providers with backbone networks in their region.

In this context it is useful to consider some examples of countries that connected to the Internet in the latter half of the 1990s. The Network Startup Resource Center (NSRC) records that Syria first connected to the Internet in May 1998.[25] This connection was between EUnet (now part of KPN-Qwest) and the Syrian Telecommunications Establishment via a satellite link between Damascus and Amsterdam. Subsequently, Telecom Italia also developed and advertised routes to the Syrian Telecommunications Establishment networks via its Seabone undersea cable network. A further route is advertised by Cyprus Telecom. Accordingly, many countries that have relatively recently gained their first Internet connections have not connected directly to backbones in the United States. Syria's international connectivity is provided by European networks. Carriers in more and more countries are taking advantage of the increase in regional connectivity to ensure a direct exchange of traffic. If a user in Tunisia, for example, accesses a website in Italy, the traffic can travel directly between both countries using an undersea cable, via Telecom Italia's Seabone network.

This does not mean that connections are always regional. Uganda, for example, has one of the most liberal telecommunication environments in Africa. ISPs in Uganda connect through a number of upstream ISPs to global networks. The networks of MTN Uganda, for example, are advertised by Teleglobe with international communications being routed over satellite from Laurentides in Canada. By way of contrast the networks of Starlight Communications, another Ugandan communications provider, are advertised by TaideNet in Norway, and once again connected via satellite.

It is no longer the case that all Internet routes lead to the United States. For those that do it is no longer the case that these backbones are owned by United States carriers. Consider, for example, the case of a user of an ISP in Japan, such as IIJ, accessing content located in the United States, hosted by the world's largest web hosting company (Verio). In this example all carriage of the traffic generated takes place over infrastructure owned by the Japanese companies IIJ and NTT.

The international connectivity of developing countries is sometimes to networks that traverse the United States. However because of the globalisation of networks, traffic may pass through the United States without ever crossing a network owned by a United States ISP. For example, a traceroute from an Internet host in Costa Rica to another in Yemen showed the traffic traversing the infrastructure of France Telecom and Teleglobe. The incumbent network in Costa Rica passed the traffic to France Telecom's network in the United States. After carrying the traffic to Paris, France Telecom handed the traffic to Teleglobe, in Germany, which in turn passed it to the Yemen International Telecommunications Company. In this example the traffic has passed through three countries between Costa Rica and Yemen. These are the United States, France and Germany. The exchange used the infrastructure of companies owned in France (France Telecom) and Canada (Teleglobe), not German or United States ISPs.

In some cases traffic between two countries traverses the United States but is handled by a single network. One example occurs when a user of Telefonica in Spain sends an e-mail to a user of Telefonica in Argentina. In that case Telefonica carriers the traffic on an end-to-end basis entirely over its own facilities. The traffic crosses United States territory but does not pass through the facilities of a United States carrier.

The challenge for developing countries is to take advantage of the new environment. The available evidence indicates that in the absence of vigorous competition between ISPs, monopoly incumbents will continue to seek to extract monopoly rents from their customers. By way of contrast liberalisation will have a number of benefits. First, if the stimulus to growth competition can provide to the use of the Internet in developing countries, this will in turn make these markets more attractive for players with global backbone networks. At the same time the available evidence indicates that new entrants seek commercial solutions to the changing world of Internet traffic exchange. In some cases they will choose to purchase transit services from competing regional and global players. In other cases they enter into commercial partnerships or put together their own infrastructure to connect major global IXPs where they have greater leverage to strike commercial deals. In all these cases the cost to provide international connectivity should be steeply declining and the benefits passed on to users. On the other hand, in the absence of reform, developing countries will not be able to take advantage of the new opportunities created by liberalisation in the OECD area or in developing their own domestic infrastructure (Box 2).

One case in point is that of Bangladesh, where the international telecommunication carrier (BTTB) said it could not establish an IXP, in 2001, because no funding was available from the government.[26] Although establishing an IXP would save BTTB money, and potentially lower costs for users and improve levels of service, the organisation does not have the flexibility to act in its own commercial interest if it has to look to the government to fund the establishment of an IXP. A traceroute between two ISPs in Bangladesh, undertaken in November 2001, showed the traffic travelled via Hong Kong, the United States and Canada (including two satellite hops). Without a domestic IXP it is actually better to host online content and services offshore rather than in Bangladesh. A recent UNCTAD study indicated that most Bangladesh sites are hosted in the United States.[27] At the same time, UNCTAD noted the potential for business in Bangladesh to earn foreign revenue via e-commerce in world markets (*e.g.* transcription of medical records) if Internet connectivity were improved. UNCTAD also noted that in some countries, the actions of the monopoly telecommunication carrier were indirectly opposed to developing Internet connectivity.[28]

A further barrier to the development of the Internet, in some countries, is the situation surrounding leased lines. In some developing countries business users cannot get leased lines because the monopoly telecommunication carrier does not provide that service. In other countries the high price of domestic leased lines makes it more economical for business to provide services and content offshore. This tendency was well documented in a case study of Thailand undertaken for the ITU. This study reported that of the leading 100 Thai Internet sites (in the Thai language) only 21% were hosted in Thailand.[29] By way of contrast 69% were hosted in the United States, 5% in Singapore and 5% in Europe. If these content were hosted domestically not only would it be more economical (in terms of international connectivity) but could also provide superior response times for users.

Box 2. Infrastructure development and the need for regulatory reform

The first country to establish an IXP in Africa, apart from South Africa, was a group of ISPs in Kenya. The Kenyan Internet Exchange Point (IXP) commenced operations in November 2000. The following month the Kenyan telecommunications regulator (CCK) ordered the closure of KPIX based on a complaint from Telkom Kenya, the monopoly telecommunication carrier. The details of this case demonstrate the need for regulatory reform if Internet traffic exchange is to proceed on an efficient basis.

According to the ITU's international regulatory database, Telkom Kenya has a monopoly over fixed network infrastructure (local, national, international and leased lines). The provision of ISP services is open to competition but the ISPs rely on the incumbent telecommunication carrier for their underlying infrastructure. In other words the key infrastructure needed to develop the Internet in that country is owned by the incumbent telecommunication carrier.

Until the establishment of KIXP all Internet traffic in Kenya was exchanged internationally. In other words, if a user on one Kenyan network requested information from a website hosted by another Kenyan ISP, the traffic may be exchanged, for example, in the United States. At the same time if a user of one Kenyan ISP sent an e-mail to a user on another Kenyan ISP network that traffic would also be exchanged in the United States. The ISPs that created KIXP say that these types of exchanges, between Kenyans, make up 80% of their total Internet traffic.

In this situation the reasons for ISPs in Kenya to create KIXP are clear and follow a development path established by all OECD countries. It is worth considering a couple of the more compelling reasons for creating an IXP. The first reason relates to quality of service. ISPs in Kenya use satellite circuits for international connections to upstream ISPs as there are no fibre optic connections to the outside world. Any satellite connection introduces latency, even in the circuit-switched environment. However, the international exchange of domestic Internet traffic involves two satellite hops and further latency. By way of contrast if Kenyan ISPs exchange traffic locally using fibre optic connections the latency can be considerably reduced. During the initial time KIXP was in operation the latency was been reduced, from an average 800 to 900 milliseconds previously, to 60 to 80 milliseconds (Figure 13).[30]

The second compelling reason for creating KIXP was the substantial savings it offered the Kenyan ISPs. The ISPs using KPIX published a comparison of the charges they incurred for international Internet traffic exchange versus domestic Internet traffic exchange (Figure 14). For a 64 kbit/s circuit the difference in price was USD 200 for a domestic leased line compared to USD 3375 for the same speed international link. For a 512 kbit/s circuit, the difference in price was USD 650 for the domestic circuits as against USD 9546 for the international circuit.

The high cost of accessing the Internet, as well as in obtaining a permanent connection with a view to the creation of local content and services, and low quality of network performance, are all factors mentioned as barriers to Internet growth in developing countries. In those countries with multiple ISPs, the use of IXPs is a very necessary part of Internet development. Unfortunately, the pace of liberalisation has not matched these development needs.

From the perspective of Kenyan ISPs and their customers, the efficiencies in traffic exchange and the financial economies for domestic traffic exchange are overwhelming. Moreover Kenyan ISPs say they originally approached Telkom Kenya to create an IXP but the carrier showed no interest.[31] In all probability this is a case of a monopolist seeking to extract monopoly rents, from the sale of international leased lines, for what would otherwise be a common sense step in Internet development.

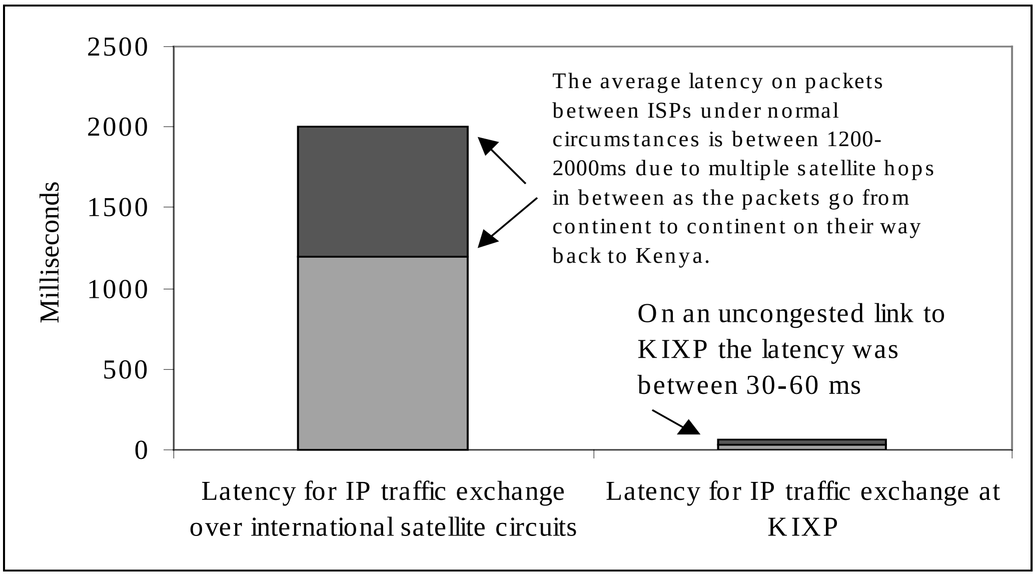
For their part the Kenyan ISPs argued that what they had created was in effect a closed user group which, under their interpretation, is legal under the Kenyan Communications Act. In addition they pointed out that the exchange of local traffic, at an IXP, in no way contravened Telkom Kenya's international monopoly, as all international traffic would still need to flow over international links provided by the monopolist.

Irrespective of the legal technicalities the wider implications are clear. A monopoly over the provision of telecommunication infrastructure is impeding Internet development. The case highlights the need for consideration of domestic reform at the same time as international Internet traffic exchange. The case is not unique to Kenya but has arisen here because it is one of the earliest examples of the creation of an IXP in Africa. Internet traffic exchange between ISPs and the monopoly telecommunications carrier was also controversial in South Africa when IXPs were established in that country.[32] In the case of Kenya, the telecommunication regulator finally issued a licence for KIXP to proceed, in October 2001, with a request that the incumbent partner ISPs in KIXP. In February 2002, after waiting several months for a decision from the incumbent, a group of Kenyan ISPs decided to go ahead alone and re-establish KIXP.

In Thailand, where two IXPs were in operation in 2001, it was suggested that the incumbent telecommunications carrier wanted to close the rival IXP prior to the market being liberalised.[33] Any move by incumbent telecommunication carriers to stop the creation of IXPs or to close established IXPs should be strongly resisted by regulatory authorities.

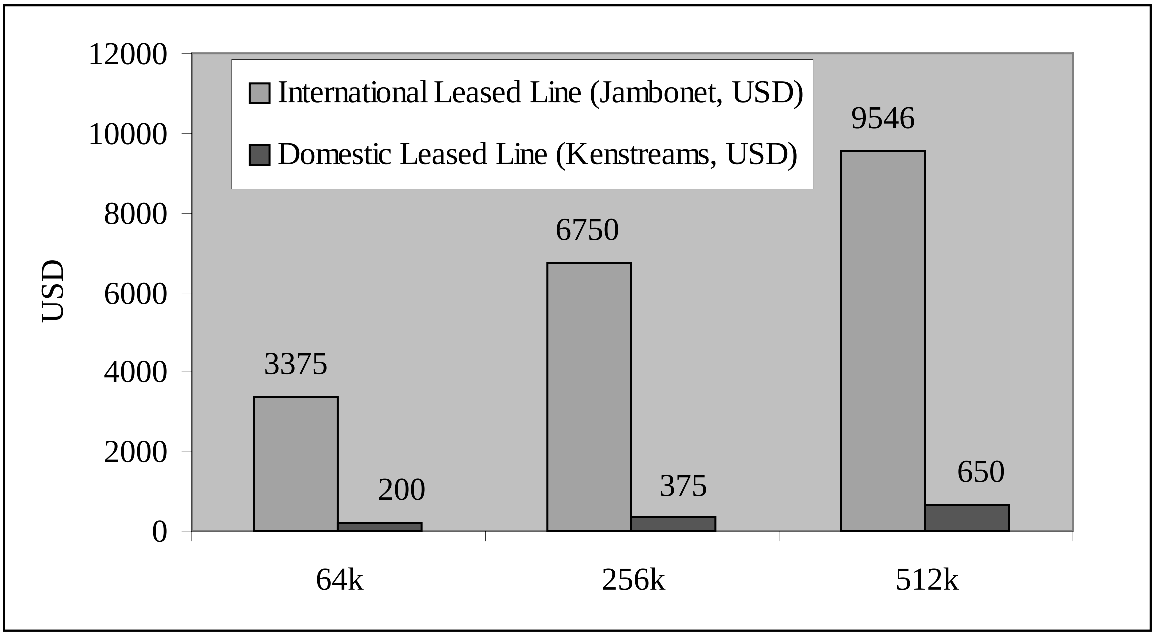
Propitiously, there are ongoing projects to set up IXPs in Uganda, Tanzania and Mozambique. The United Kingdom's Department of International Development (DFID) has made some funds available to each of the countries to accelerate the set up. Uganda is at an advanced stage and should be switching on by April 2002. Tanzania and Mozambique are still in the early stages.

Figure 13. Latency of Kenyan traffic with and without KIXP



Source: KIXP.

Figure 14. Price of Kenyan leased lines for Internet connectivity



Source: KIXP.

Table 1. Maps of global networks

Carrier	***Map Coverage***	***URL***
France Telecom	European backbone; Global Map and regional backbone, Undersea cables	http://www.francetelecom.fr/vanglais/who_we_are/international_ionlytrust_fd.html http://www.francetelecom.fr/vanglais/transverses/search_f.html http://www.marine.francetelecom.fr/english/frames/realisa/realisat/Index.htm
Global Crossing	Global network	http://www.globalcrossing.com/network.html?bc=Network
GTS	Ebone European backbone	http://www.ebone.com/ebone.nsf/FibreMapWeb.jpg
Genuity	Regional backbone maps	http://www.genuity.com/infrastructure/maps.htm
Flag	Undersea cables	http://www.flagtelecom.com/index_e1.htm
Internet Initiative Japan Inc (IIJ)	Asian and United States backbones	http://www.iij.ad.jp/network/index-e.html
Telia	Global map and regional backbone. Viking network and Telia.net	http://www.telia.net/carrier/
NTT (Verio)	Global map - US backbone and regional links	http://www.ntt.net/en/pages/network/index.html http://home.verio.net/company/technology/networkmapUSA.cfm?menu=yes
Telecom Italia	European and US East coast backbone	http://www.seabone.net/backbone.htm
Tycom	Global, Transpacific, TransAtlantic and European maps	http://www.tycomltd.com/global.html
Telefonica	European and Latin American Backbone	http://www.global.telefonica-data.com/ing/htm/mapared/f_mapared.htm http://www.e-mergia.com/map.htm
Cable and Wireless	Global and regional maps	http://www.cw.com/th_05.asp?ID=gn_01maps
KPN-Qwest	European backbone	http://www.eu.net/html/map.asp?sub_section_id=22
360Networks	Global backbone and regional backbone	http://www.360networks.com/Our_Networks.asp
Level3	Global backbone and regional infrastructure	http://www.level3.com/us/info/network/networkmap
Telstra (via Dynergy)	United States backbone network	http://www.dynegy.com/dynegy_com.nsf/framesets/POPs+Map
Williams Communications	Global Map and regional backbones	http://www.wilcom.com/network/map/index.html
Worldcom	Global Map and regional backbones	http://www.worldcom.com/about_the_company/fiber_network_maps/
Teleglobe	Global Map and regional backbones	http://www.teleglobe.com/en/our_network/system_map.asp

Source: OECD.

Table 2. Globalisation of selected telecommunication networks

Telecommunication carriers	***Network reach***
AT&T and BT	Concert was a 50%-50% venture between AT&T and British Telecommunications plc, Concert. Concert's frame relay network serves every major city in the United States and the United Kingdom, and extends to an additional 170 cities in 53 countries. Its high-speed IP backbone network spanned 21 cities in 17 countries. Although AT&T and BT have ended this partnership both companies will continue to pursue the development of international infrastructure to meet the requirements of their customers.
Cable and Wireless	Cable & Wireless' focus for future growth is on IP (Internet protocol) and data services and solutions for business customers. It is developing advanced IP networks and value-added services in the US, Europe and the Asia-Pacific region in support of this strategy. In December 2000, Cable & Wireless announced the second-phase completion of its USD 3.5 billion global Internet Protocol (IP) infrastructure build programme with a further 38 international nodes now in service across the US, Europe, and Asia Pacific. Already the largest IP infrastructure based on a single, fully meshed architecture, Cable & Wireless has said it will incorporate 84 international nodes into this infrastructure by the end of 2001. In the first half of 2001, the total number of fully operational nodes was 49. There were 23 nodes in the US; 24 nodes in 12 countries across Europe and two in Asia-Pacific. All nodes operate within the same autonomous system (AS3561) assigned to Cable & Wireless' IP infrastructure, to ensure seamless delivery around the globe. Phase three of the global IP infrastructure build programme, to be completed in 2001, is underway. In Europe and the US - connection to a further 30 nodes, including the integration of Cable & Wireless' acquired European IP businesses. Network capacity will grow to multiples of 9.6 Gbit/s (OC-192) on the pan European and US backbone. In Japan - connections to an additional node in Osaka plus a further four nodes are planned later in 2001 plus points-of-presence in 80 cities throughout all 47 prefectures.
Deutsche Telekom	In April 2001, Deutsche Telekom purchased two 2.5 Gbps wavelengths, with an option to buy two more, from Asia Global Crossing. Deutsche Telekom says it will have "seamless connectivity" between the United States and Asia. This follows the March 2001 launch of TAT-14 in which Deutsche Telekom was the fourth largest investor. TAT-14 increased Deutsche Telekom's trans-Atlantic IP capacity by a factor of five. In the United States, MFN is providing Deutsche Telekom with optical infrastructure, as well as operations, administration and maintenance services. The 20-year lease agreement will enable a further expansion of Deutsche Telekom's worldwide network platform that connects major cities in Europe, North America and Asia. MFN will connect Deutsche Telekom's backbone from New York to Washington, DC, and throughout the northern Virginia and New York City metro areas.

France Telecom	In Europe, France Telecom has developed the European Backbone Network, a backbone connecting 250 cities in 16 European countries. In September 2000, France Telecom announced plans to build a 15 000-mile transmission backbone network to connect 28 major cities in North America. This network will be connected to France Telecom's pan-European backbone network. France Telecom will interconnect the North American backbone network with international submarine cables, linking North America with the rest of the world: Europe through the transatlantic cable TAT-14, South America through Americas-II and 360americas submarine cables, and Asia through the Japan-US cable. France Telecom's customers can expect to benefit from end-to-end connectivity worldwide. In additon Equant acquired the data business of Global One from France Telecom in exchange for newly issued Equant shares. At the same time, France Telecom acquired the SITA Foundation's interest in Equant in exchange for existing France Telecom shares. Equant/Global One will have the world's most extensive and seamless network reaching key business centres in more than 220 countries and territories.
KPN and Qwest	KPNQwest is a facilities-based, pan-European provider of data-centric services based on Internet Protocol (IP). It is deploying a 20 000 km fibre-optic network connecting 50 cities throughout Europe and provides IP-based services. KPNQwest is one of the largest business ISPs in Europe with operations in 15 countries. The KPNQwest IP backbone offers 170 European peering relationships and connectivity to 70 US networks as well as with seamless extensions into Qwest's North American network.
Level3 and Colt	On 29 April 1999, Level 3 announced that it had finalised contracts relating to construction of Ring 1 of its European network in France, Belgium, the Netherlands, Germany and the United Kingdom. Ring 1, which is approximately 1,800 miles, connected Paris, Frankfurt, Amsterdam, Brussels and London. The network entered service in 2000. Ring 1 was part of the approximately 4,750 mile inter-city network. The European network was linked to the Level 3 North American inter-city network by the Level 3 transatlantic 1.28 Tbps cable system. On 4 May 1999, Level 3 and COLT Telecom Group plc ("COLT") announced an agreement to share costs for the construction of European networks. The agreement called for Level 3 to share construction costs of COLT's planned 1,600 mile inter-city German network linking Berlin, Cologne, Dusseldorf, Frankfurt, Hamburg, Munich and Stuttgart. In return, COLT was to share construction costs of Ring 1 of Level 3's planned European network. The Company has entered into transoceanic capacity agreements that will link Level 3's North American, European and Pacific Rim intercity networks. One agreement provides for Level 3's participation in the construction of an undersea cable system that connected Japan and the United States in 2000.

NTT	In September 2000 NTT completed the acquisition of Verio. Verio Inc. is the world's largest operator of Web sites for businesses and a leading provider of comprehensive Internet services, with an emphasis on serving the small and mid-sized business market. Verio supports its operations with national infrastructure and systems including a Tier One national network. NTT Com, in response to the continuing explosion of Internet and other traffic between Asia, Oceania and North America, is actively participating in the construction of global telecom infrastructure, including the China-U.S., Japan-U.S., AJC, APCN2, and TAT-14 cable networks. NTT Com is participating in the Asia-America Network (AAN) construction to rapidly develop IP business in North America, Japan, and Oceania, following its acquisition of U.S.-based Internet solution provider Verio, Inc. in September. At the same time, acquisition of AAN traffic volume will enable NTT Com to meet the increasing demand for Internet traffic among its customers. With the start of the AAN, NTT Com aims to providing reliable, user-friendly, competitively priced telecom services, as well as seamless network service, connecting Asia, Oceania, the United States and Europe.
Jazztel, Completel, Song Networks (Tele 1 Europe), Versatel Telecom	These companies are connecting their regional European networks via a common peering point in London. The combined networks have 15000 kilometres of fibre backbone and 6100 kilometres of local access networks. The network's coverage includes: Belgium, Finland, Denmark, Germany, France, the Netherlands, Norway, Spain, Portugal and Sweden.
Singapore Telecom and Belgacom	In March 2001, Singtel and Belgacom agreed to swap capacity on the pan-Asian and pan-European networks to provide each with enhanced capabilities in the other's region.
Telecom New Zealand	Telecom New Zealand is the largest shareholder in Southern Cross cable network. The company is owned by Telecom New Zealand (50%), Cable & Wireless Optus (40%) and Worldcom (10%). The Southern Cross cable lit up in November 2000, removing the bandwidth bottleneck between Australasia and the United States. Originally designed to deliver 120 gigabits per second (Gbit/s) of fully protected capacity, Southern Cross will now be upgraded to 240 Gbit/s during 2002, with the potential to increase total protected network capacity to 480 Gbit/s at a future date.
Sprint	In Oct. 2001, Sprint announced the completion of its high-speed, pan-European IP (Internet Protocol) network. Sprint says it is the first 10 Gbps (gigabit per second) trans-Atlantic IP backbone network connecting 11 cities across Europe. The 11 European cities comprising the network include London, Paris, Frankfurt, Munich, Brussels, Amsterdam, Hamburg, Copenhagen, Milan, Dublin and Stockholm. Since Feb. 2001, when Sprint announced plans to extend its global IP network in 2001 to 15 key global markets, 14 are now open for service. In addition the above Sydney, and Tokyo, Hong Kong. Singapore will be available for customer fulfilment by 15 Dec. 2001. By end 2003, Sprint's global network is expected to reach 35 cities in 19 countries.

Telecom Italia and Teleglobe	Telecom Italia and Teleglobe commenced working together with Sea-Bone, the Telecom Italia IP connectivity service that laid the foundations for Internet services between Italy and North America. In March 2001 the two companies signed a new agreement aimed at drawing upon the complementary nature of their respective international networks and services. Telecom Italia has initially focused on Latin America, Europe and the Mediterranean, while Teleglobe's major activity is in the North American and Atlantic connectivity markets. Under the new agreement Telecom Italia is supplying Teleglobe with connections between a number of European cities for an overall capacity in excess of 7.4Gbps. This includes a fibre optic ring with a 2.5 Gbps capacity connecting Milan with Greece, Turkey, Israel and Egypt; and a series of links between North and South America totalling 2.5 Gbps. Under the agreement, Telecom Italia is to acquire from Teleglobe a ring hosting transatlantic connectivity and IP transit services that will enable full integration of the Telecom Italia European IP network with North and South America.
Telekom Austria	Telekom Austria is part owned by Telecom Italia. The company also has a regional strategy. On 27 July 2001 the company put the first part of its European Jet Stream broadband network into operation. A 320Gbit/s broadband network now connects Vienna with Brno and Prague and Telekom Austria's first international fibre ring has been completed, expanding over 1 900 kilometers from Vienna to Frankfurt, via Prague, and back to Vienna via Munich. During the 1st quarter 2002 a second fibre ring connecting Vienna with Bratislava and Budapest and back will be put into operation. Further connections via Budapest to Zagreb and Ljubljana are planned for the near future.
TeleDanmark	In 2000 TDC Tele Danmark established TeamNet, a 6 000 kilometre long network of optical fibre cables that covers Norway, Sweden, Denmark and Germany and thus connects all major cities in Scandinavia and the six largest cities in Germany. With a planned expansion to Switzerland, TeamNet will increase its connect pan-European connectivity.
Telia and Williams	Telia is now building wholly owned networks in Europe and the United States. The Viking Network – Telia's international fibre optic carrier network – was further expanded during the year. In Europe, the fibre optic network's reach was extended from 4 070 to 13 000 kilometers, while ducts were extended from 1 900 to 5 300 kilometers. Several routes have been rolled out. Swaps with two American operators during 2000 gave Telia access to an 18 000-kilometre-long fibre network in the United States. The network is now being equipped with IP routers and wavelength capacity. The first route between New York and Miami was rolled out in early 2001. Once the entire network has been rolled out, the American portion of the network, which is integrated with the Europe network via the TAT 14 Atlantic cable, will cover 11 of the largest American cities, which account for 75 % of American long-distance traffic. Telia acquired all operating assets of the American Internet provider AGIS in spring 2000. The acquisition gave International Carrier Tier 1 status in the United States and access to an IP network, which is currently being integrated in stages with the Viking Network.

	In March 2000, Williams Communications entered into 20-year reciprocal buy/sell agreements with Telia pursuant to which Williams Communications will receive rights to use dark fibres on Telia's planned 28 000 mile fibre-optic network through Europe and significant additional capacity on the TAT-14 trans-Atlantic cable system. The Williams Communications IP network also offers global Internet reach to Mexico, South America, Australia and Asia. Williams is a 41% shareholder in PowerTel. PowerTel is building a long-haul network of nearly 2 000 miles linking major cities in eastern Australia. Telmex is a partner and small shareh older in Williams Communications.
Telefonica	Telefonica's subsidiary – Emergia – has constructed a 25 000 kilometre cable network linking key cities in Latin America. Emergia's goal is to be a leading broadband services provider throughout the major cities in Latin America and the United States, Emergia's network is seamless linked to Telefonica extensive Trans-Atlantic and Pan-European Infrastructure. Telefónica has its own Global IP Network managed entirely from one sole point (24/7) by the International Control Centre with the support of the various National Centres. Telefónica´s Network, reaches over 250 cities in 20 countries, managing 200 000 km of optical fibre cables, and 1 500 metropolitan rings, with connections to the most important traffic interchange nodes all over the world. It also has its own local networks in 14 countries in Europe and the Americas, which enable end-to-end Service Quality Commitments in both national and international contexts.
Telstra and Pacific Century Cyberworks/Hong Kong Telecom, Dynegy Connect	In February 2001, Telstra established an IP backbone joint venture with PCCW/HKT. The new company's assets include interests in more than 50 submarine cable systems and 22 points of presence (PoPs) in 14 countries. DynegyCONNECT, L.P., DGC's North American subsidiary, is developing the first nationwide optically switched data network that will consist of approximately 16,000 route miles and 44 POPs by the fourth quarter of 2001. This joint venture with Telstra Corporation Ltd., a 20% owner of DynegyCONNECT, L.P. ("Connect") provides us with access to its extensive Asia-Pacific network.
Worldcom	Apart from its United States network, MCI-WorldCom also provides switched voice, private line and/or value-added data services over its own facilities and leased facilities in the United Kingdom, Germany, France, the Netherlands, Sweden, Switzerland, Belgium, Italy, Ireland and other European countries. The company operates metropolitan digital fibre optic networks in London, Paris, Frankfurt, Hamburg, Dusseldorf, Amsterdam, Rotterdam, Stockholm, Brussels and Zurich. The Company also offers certain international services over leased facilities in certain Asian markets, including Australia, Japan, Hong Kong and Singapore. The Company was granted authority in the first quarter of 1998 to serve as a local and international facilities-based carrier in Australia and Japan. In Japan, the company is now classified as a Type I carrier and operates metropolitan digital fibre optic networks in Sydney and Tokyo.

Source: OECD.

Table 3. Telia international carrier signed contracts

	Signed contracts	***USD***
Storm	Fibre	121
GTS	Fibre	41
Tele 1 Europe	Fibre	28
LD Com	Ducts	4
Other (BT, France Telecom)	Fibre/Ducts	149
Other (Sprint, Telenor, KPN Qwest	..	50
Total IRU		394
360Networks	Fibre swap	95
Global Crossing	Ducts swap	58
Williams	Fibre swap	63
Colt	Ducts swap	34
Other Swaps (Nets, Infigate)	Fibre swap	155
Total Swaps		405

Source: Telia Interim Report, January-March 2001.

NOTES

1 This report builds on earlier OECD work in "Internet Traffic Exchange: Developments and Policy", March 1998, http://www.oecd.org/pdf/M000014000/M00014339.pdf.

2 Hungary liberalised at the beginning of 2002 while the Slovak Republic and Poland will fully liberalise at the beginning of 2003.

3 OECD, Communications Outlook 2001, Paris, 2001.

4 Philip Sayer, Presentation to Dubai 2002: OECD Global Conference on Telecommunications Policy for the Digital Economy by the Head of Vendor Relationships and Communications, Reuters Ltd. Reuters, January 2002.

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6 Ibid.

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11 Frederick Serr, "Network Traffic and Capacity", IMA Workshop on Large Scale Network Dynamics, 7 August 2001. http://www.ima.umn.edu/talks/workshops/8-6-7.2001/serr/serr.htm

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19 Huston, Berlin Presentation, Op.cit

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21 Telefonica, “Telefónica Data Begins U.S. Operations with a Combination of Multinational Hosting and Network Services”, News Release, 19 September 2001. http://www.telefonica-data.com/home_i.htm

22 Telefonica, “Telefónica DataCorp and América On-Line Conclude a Strategic Agreement”, News Release, December 2001. http://www.telefonica-data.com/home_i.htm

23 Singtel, “SingTel and Belgacom Sign MOU to Explore Opportunities in Asia & Europe”, Press Release, 22 March 2001, http://www.singtel.com/

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25 NSRC records are at: http://www.nsrc.org/networkstatus.html.

26 BTTB, “Report on the Tour of India by Delegation from BTTB”, 25 February 2001. http://www.bttb.net/

27 UNCTAD, “E-commerce and Development Report 2001”, www.unctad.org/en/pub/ps1ecdr01.en.htm

28 One example was the attempt by the Ethiopian telecommunication monopoly to close Internet cafes in that country.

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30 KIXP, “A First for Kenya”, 30 November 2000. http://www.kixp.net/pr_rel1.html

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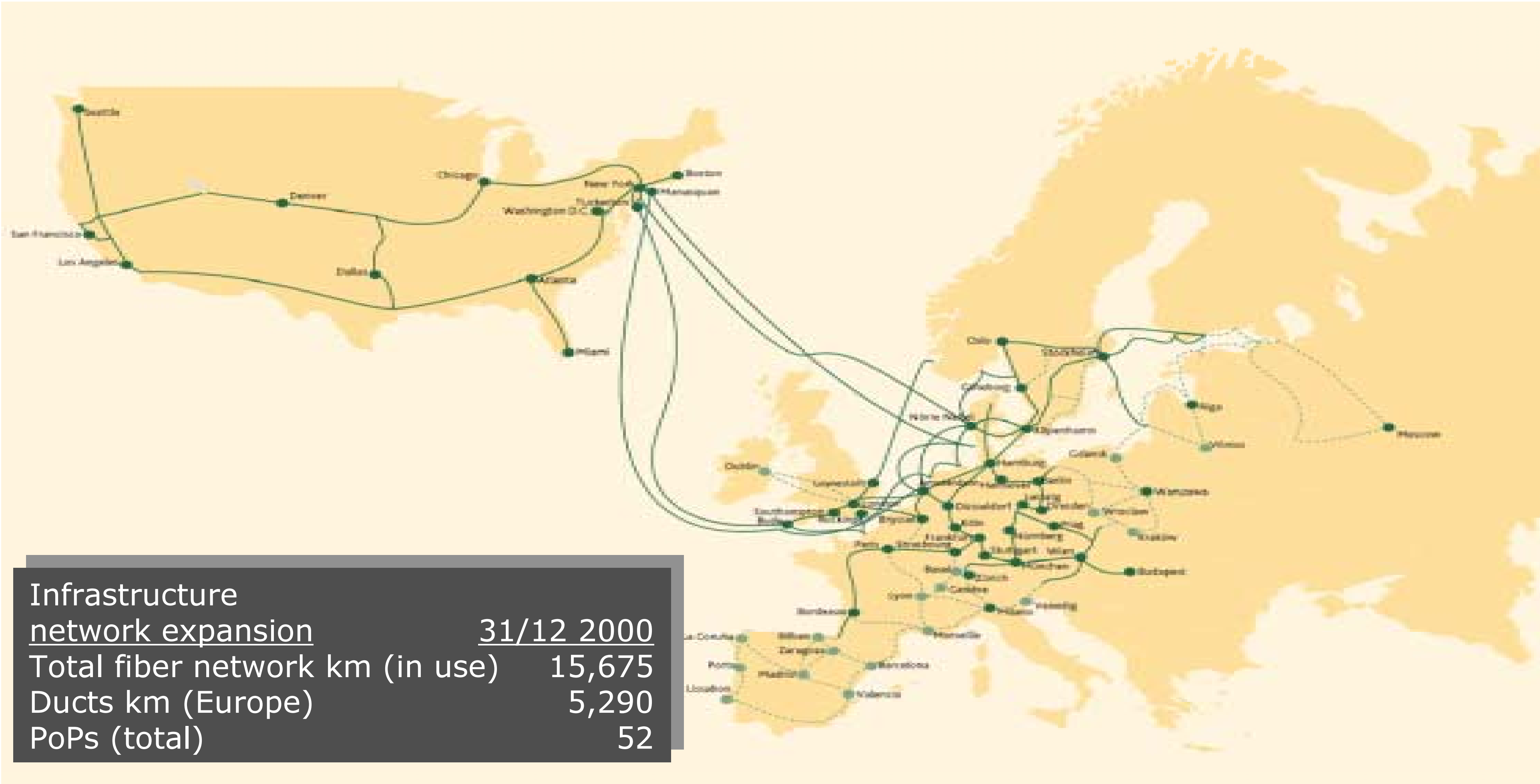
33 The issue was raised at an ITU workshop: “The Internet in South East Asia”, Bangkok, Thailand, 21-23 November 2001.

ANNEX

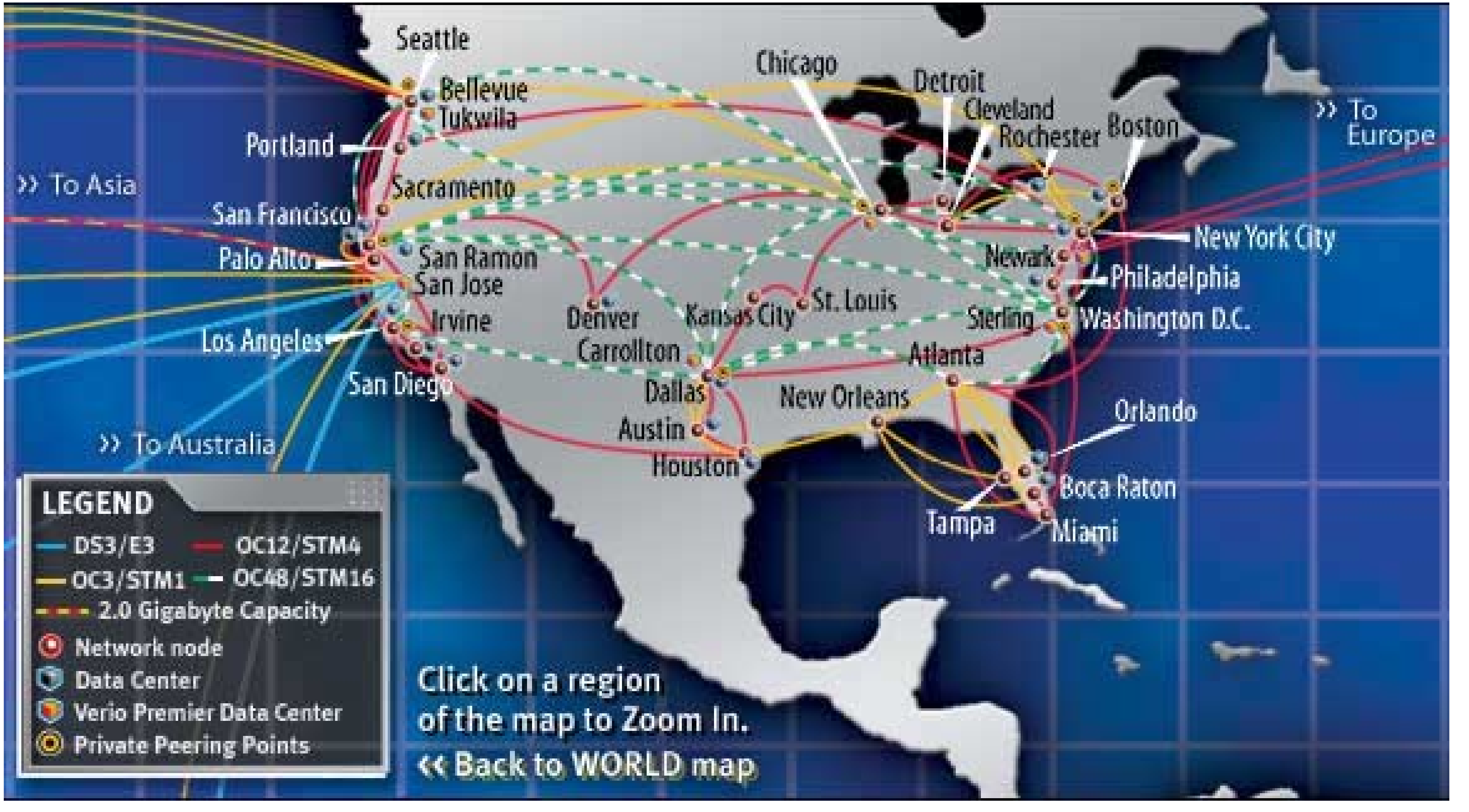
Map 1. France Telecom's US Backbone

Map 2. Telia's US and European Backbone



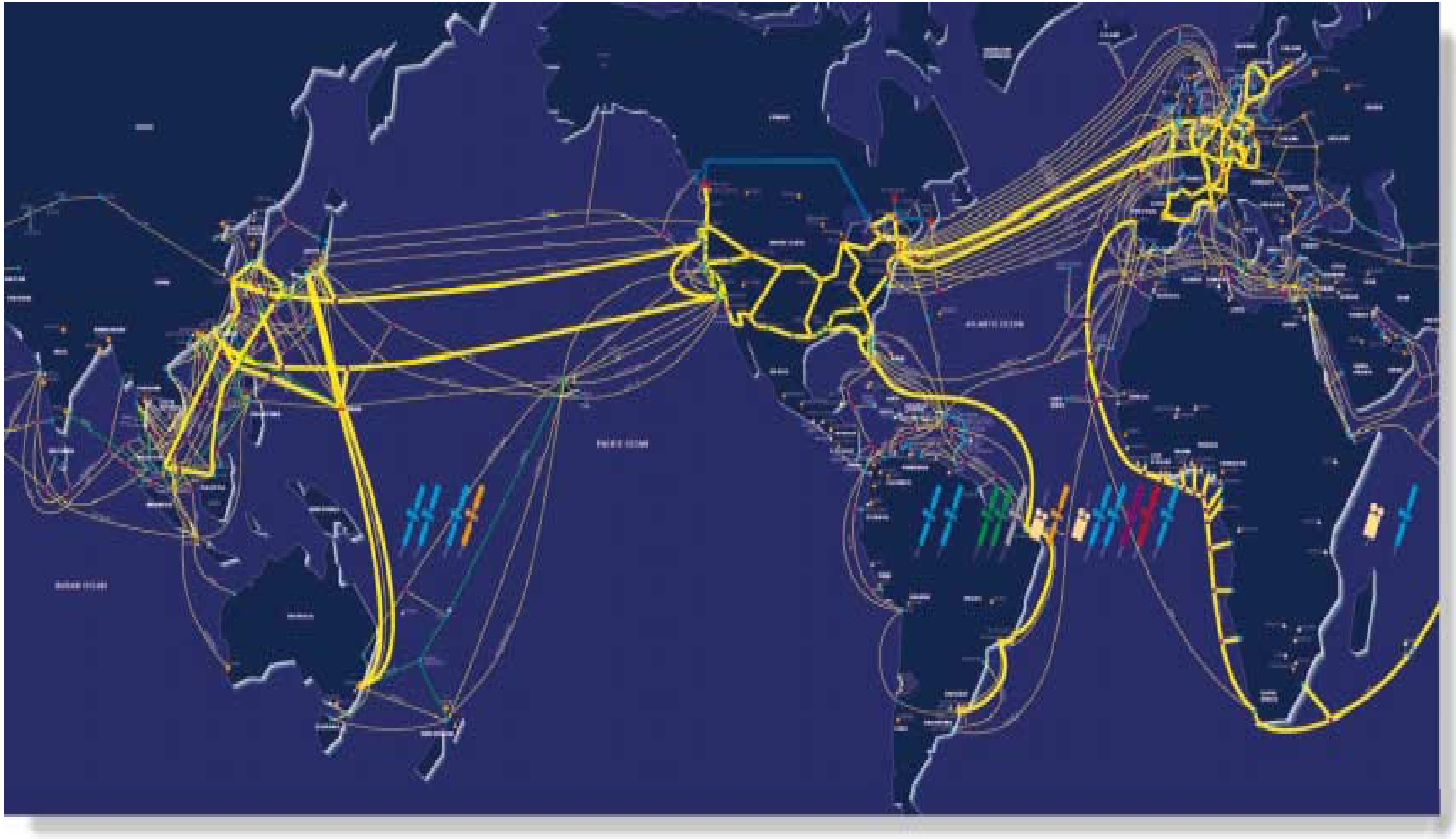
Map 3a. NTT's Global Backbone Network

Map 3b. NTT's United States Backbone Network



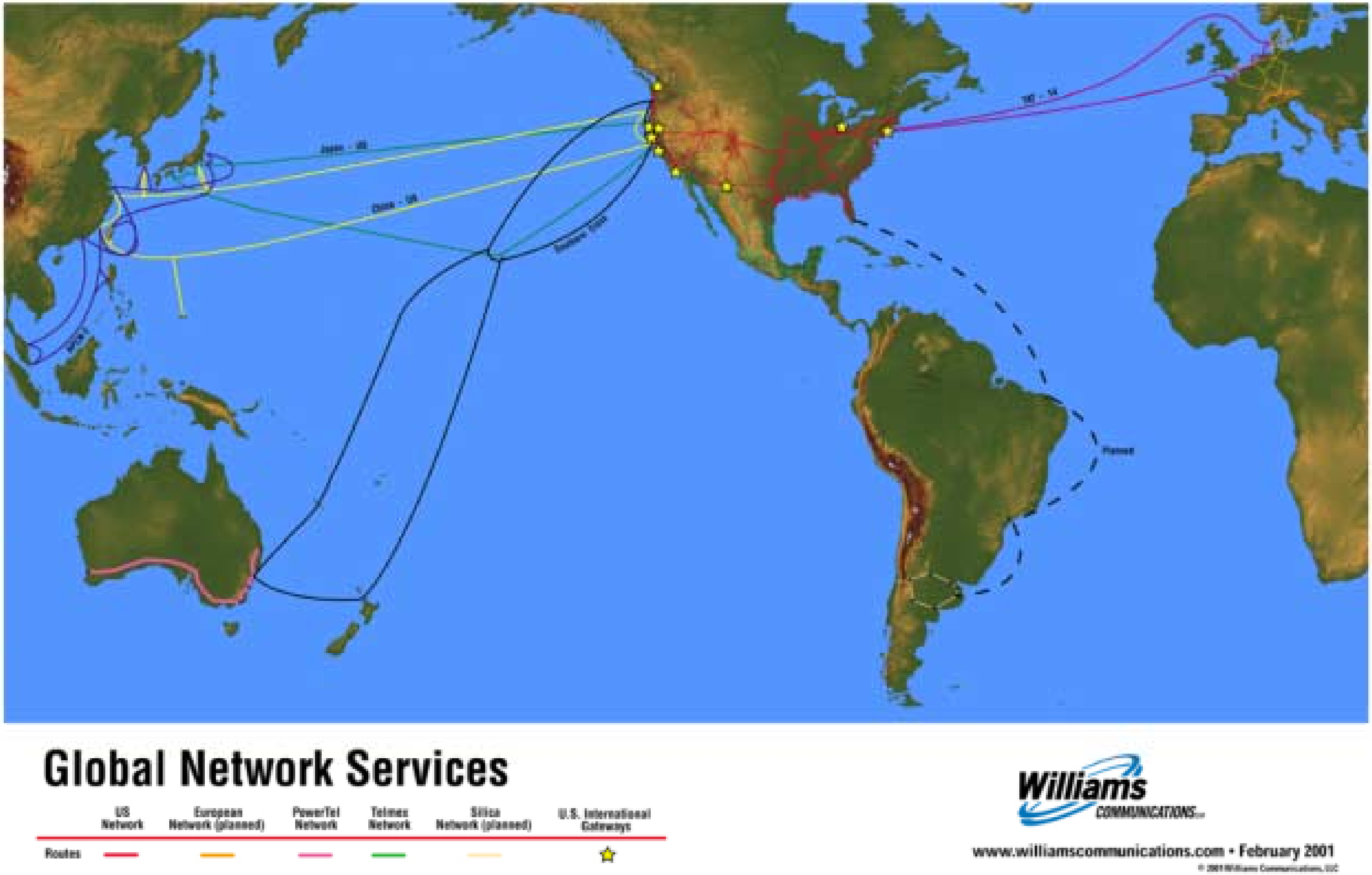
Map 4. Telstra and DynegyConnect's Backbone in US

Map 5. Teleglobe's Global Backbone

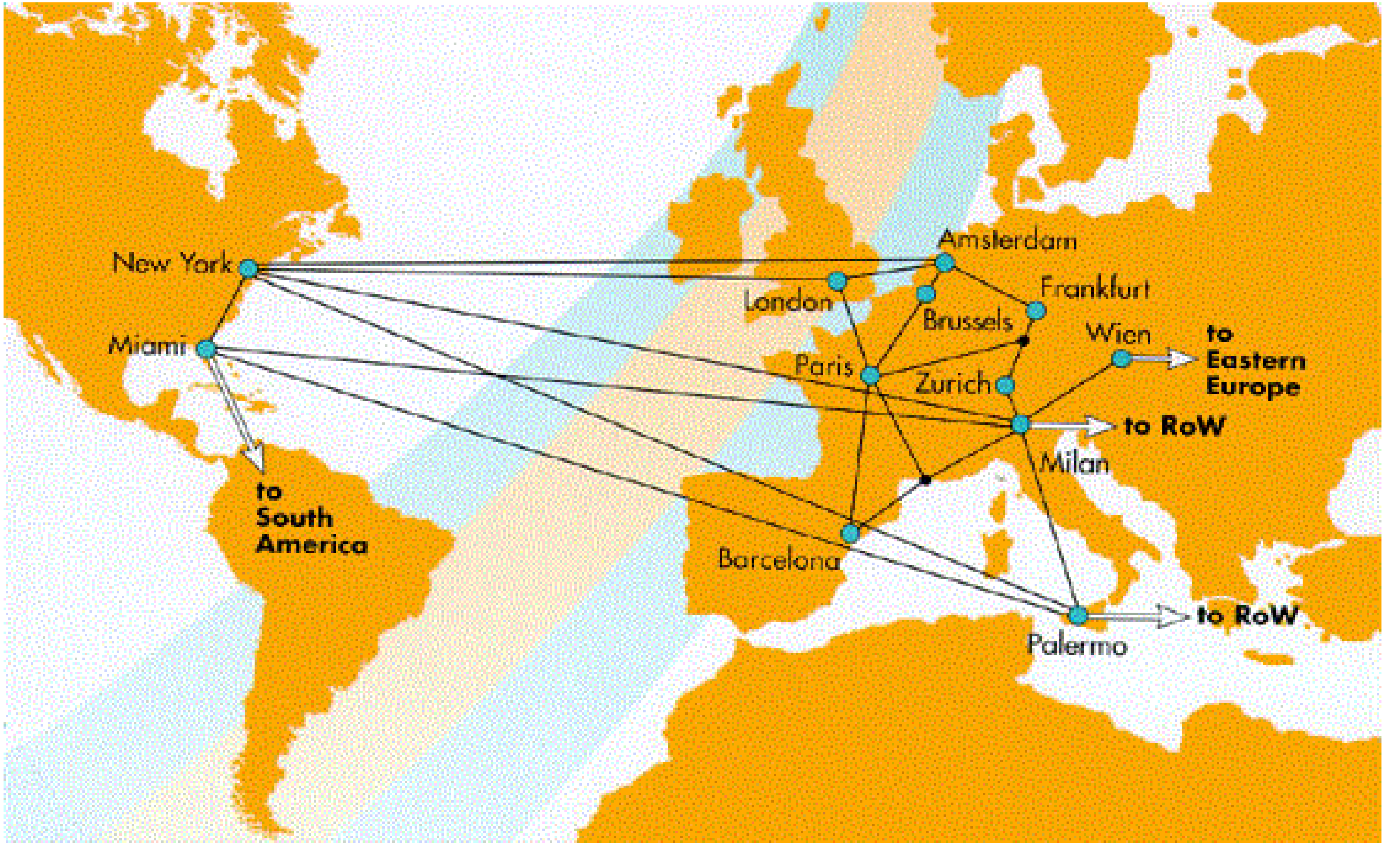


Map 6. Worldcom's Global Backbone

Map 7. Williams Communications Global Backbone



Map 8. Telecom Italia's SeaBone Backbone



Map 9. TyCom's Global Network (including Dishnet)

Map 10. Telefonica's Global Network