

Regional Internet Exchanges Boost Regional Connectivity

Place Your Local Bets

Internet traffic flows due to a vast system of long-distance backbones and interconnections between Internet Service Providers of many kinds and sizes. Internet Exchange Points play an important role in establishing these interconnections and indeed create a world-wide web of connected computer systems and subsequent end-users. In this article the role of local exchange points appearing around the well-established large, often national ones, is examined.

From Raw Fibre to the Internet

On the back of the growth of broadband connections and data volumes of customers and business, wholesale bandwidth demand is on the rise. This subsector in the telecommunications industry was hit hard seven years ago, leaving a glut of unused fibre capacity across the world, literally a dark (fibre) area. The current upsurge in bandwidth demand is not only caused by the rise of end-user broadband connections but is also due to changing usage patterns. Most notable are the vast amounts of video traffic and large files criss-crossing the Internet. Raw bandwidth on various long, mid and metropolitan routes is key to accommodate the demand, and consequently the market activity for all sorts of bandwidth products is increasing. These are either 'long-term indefeasible rights of use' (IRUs), straight leases of dark fibre, wavelengths or sliced capacity of a wavelength – all variations are in demand. It is rumoured that long-haul fibre is becoming a scarcer commodity every day on selected routes, creating an opportunity to 'sweat assets' that were built years ago.

Raw bandwidth becomes a usable resource when it is converted to be part of the Internet. In this field, Internet Exchanges, or IXs for short, play an important role in offering

connections between network operators, with the IXs forming the corner-stone of weaving a more granular web, connecting servers and end-users to access each other and services anywhere in the world. Local and regional Internet exchanges are in the midst of these dynamics. Before explaining the values added by these exchanges, we first delve into the organization of Internet interconnections, i.e. Internet upstream, peering and transit.

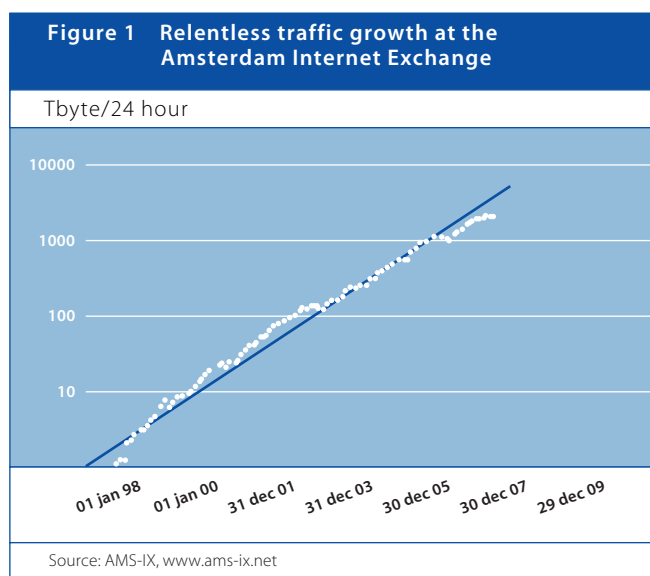
IP Peering

Today, more than one billion addresses on the Internet need to be interconnected. On the retail side of the chain, we find Internet service providers (ISPs) like telecom, cable, mobile, wireless and broadband operators. Most of these have their own access infrastructure to connect their customers, but some ISPs do not own an access network; they connect their customers through wholesale agreements with these access network owners. All these ISPs, either with or without access networks, have an autonomous system number (ASN), which is a unique identifier for their network. These identifiers play an important role in directing traffic close to its destination orderly, to deliver it ultimately to the individual IP addresses. Both the IP addresses and ASNs are globally administered by IANA (Internet Assigned Number Authority).

Interconnection between these autonomous systems (ASs) – the networks of ISPs – is arranged by bilateral agreements. These agreements are often based on peering, which is the exchange of traffic on equal terms, usually based on comparable traffic volumes and free of settlements.

To accommodate physical connections between the peering parties, Internet exchange points or IXPs were established for efficient interconnection, avoiding (a large amount) of bilateral links between ISPs. Peering partners meet each other in these technical hubs, which are often established on a national level and organized either as a commercial or a non-profit facility. In some cases the interconnection agreements extend beyond peering: one or both peering partners provide so-called upstream traffic to the wider Internet. This is called transit traffic and is depicted in Figure 2, together with peering and upstream traffic flow.

The traffic flow at these peering points has grown impressively and relentlessly, even during the Internet bubble burst. As apposed to the early days of Internet Exchanges in the 1990s, the traffic type has moved from 'pure' Internet traffic to a blend of traffic types, like video and voice over IP streams and even roaming traffic between mobile operators. Figure 1 shows a decade of traffic at one of the busiest IXPs, the Amsterdam Internet Exchange (AMS-IX). Whether it is London, Columbia or Hong Kong, most IXPs sustain the statement of impressive and relentless growth.



IXPs can be found all over the world in increasing amounts, in line with the spread of the Internet. In the early days, US-based IXPs (often referred to as network access points or NAPs at the time) ruled, and most Internet traffic was routed through the US. Europe caught up quickly in the second half of the 1990s and is now hosting a string of exchanges that is among the largest in the world (Amsterdam, Paris, Frankfurt and London).

This simple interpretation of the IXP concept suggests that the Internet is just a bunch of interconnected large IXPs. But reality shows a far more complex structure:

- By far not all traffic can be peered, because there is no IXP to which all ISPs in the world can connect. This leaves a significant amount of traffic for destinations that cannot be handed over within the IXP. This traffic is called upstream traffic. We will explain this in the next section.
- The IXP infrastructure is surprisingly varied. We see new IXPs appear on national, on regional and even on city levels. Still, many countries do not have a peering facility, whereas others have several. On the Internet, lists of global IXPs can be found that show the regional spread in detail.

IP Upstream Connections

Peering is about terminating traffic on a destination network or autonomous system. In theory, this would be enough, if all IXPs were interconnected and all ISPs were connected to an IXP. In the real world, however, we see so-called tier 1 ISPs that provide long-distance commercial upstream transmission services to ISPs, billed by reserved capacity (in Megabits per second). Just a few large players create this tier 1 level, and they are fully interconnected, making world-wide connectivity possible. Their service enables ISPs that connect end-users to provide world-wide connectivity with everyone else on the Internet, also outside their peering group, which is arranged through IXPs.

It was not long ago that several markets lacked peering facilities or a balanced peering market allowing all ISPs of any size to use the peering facility. ISPs that do not have access to peering have to upstream all their traffic to the tier 1 backbone provider. For example, until a few years ago, the largest ISP in Germany refused to peer traffic with other (smaller) German ISPs. All traffic exchange took place through tier 1 backbones, which often led to 'tromboning' traffic across the Atlantic. The same situation applied to Asia, but the appearance of more peering agreements and growth in granularity of tier 1 backbone connection points lead to more efficient routing.

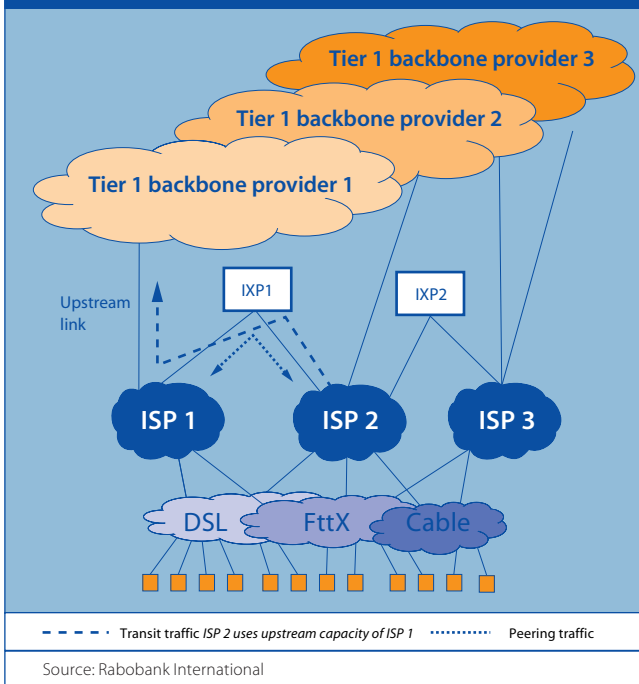
Taking IXP Infrastructure to the Next Level

An IXP infrastructure can be compared with an airport. The ISPs and tier 1s, represented by their unique ASN, are the airline carriers: they transport passengers and cargo. The IXP is the airport and accommodates the exchange on the ground of cargo and passengers, i.e. peering and transit. In this analogy, peering gives airlines the capability of exchanging clients. Transit agreements go beyond that point and can be compared with an airline alliance.

The airlines themselves land at a number of airports in the world. The same applies to the ASNs. The European Internet Exchange Association (www.euro-ix.org), which has more than 40 members, publishes a matrix showing how many of the connected service providers (ISPs) also have connections to other IXPs. The IXPs themselves have no interconnections.

Given the vast amount of traffic that is concentrated around IXPs, there is feverish business activity around them, such as server farms, data centres, applications services provisioning, collocation services and services that deliver access to tier 1 backbones. In general, the centre in which the IXP hosts its equipment is a meeting point of fibres, all in all creating a huge energy sink (see RaboCom, Spring 2007).

Figure 2 National and world-wide connectivity through IXPs and tier 1 backbones



If we take a closer look, we see that in fact many IXPs themselves consist of a number of very well-connected and redundant physical locations in different buildings within a city, each with redundant power backup for the sake of resilience and continuity of services. These connected locations can be compared with the different terminals of an airport. In some cases, these distributed points of presence of the IXP within or even spread over several cities are marketed as local 'market-places'. Good examples of these distributed exchanges spanning several cities are BBIX and JPIX, both Japanese IXPs. The NDIX is a Dutch-German example with a granular distribution across smaller cities. It is too early to tell if further distribution of IXPs is a trend, but at NDIX, the line of thinking and acting is to create a larger regional footprint.

Large and Small IXPs

What are the reasons to develop smaller regional, metro or city IXPs besides the big national and international ones? Taking a closer look at these reasons, as described below, one will notice the analogy with regional airports that feed main hubs (according to a hub-and-spoke structure).

Improving Regional Business Activity

Long ago, local businesses and municipalities acknowledged the appealing effects of having a regional airport in the vicinity. In the same way, they are very interested to see the appearance of a regional 'open market-place' for Internet and network services, a role that can be

fulfilled by a regional IXP. It lowers the barrier to entry for ISPs to kick-start a regional business, which in turn increases the choice of specialized service suppliers for customers. When this ecosystem of local service providers gains traction, regional IXPs benefit as well, because more activity means either more members, in case of a non-profit cooperative business model, or more customers, if the business is a commercial activity.

Niche ISPs Find Room to Operate

Regional and often smaller ISPs have lower traffic volumes and are generally not eligible for membership of a cooperation of IXPs that funded the large exchange points. Besides this imbalance of powers, regional ISPs usually face prohibitive costs to lease fibre capacity to bridge the distance from their region to the main hub. This makes the business case stronger for regional, hence traffic concentrating, IXPs.

Improved Regional Backhauling

A local IX has to be accompanied with a connection that backhauls the region into a main hub, likely one of the sites of the established, large IXP. This connection helps to lower the obstacle to delivering a variety of upstream IP service at the regional site, which enhances the position of the local market. This is even more important with the emergence of open-access networks as pursued in several fibre-to-the-home (FttH) and fibre-to-the-business (FttB) projects creating more demand for connectivity and bandwidth.

Regional Benefits

There is room for specialized regional IXPs that have a specific edge over national ones, either because of their location or because of other business chain differentiators. The distributed Dutch-German NDIX crosses national borders and helps to service businesses that want to extend their footprint in the regions of the eastern Netherlands and North Rhine-Westphalia. Another example of a regional IXP in the Netherlands is the recently founded Rotterdam-based R-IX that serves the port and international shipping business value chains.

The Long Shot

Over a longer time-scale a slow change in local/long-distance traffic patterns is discernible. For the sake of this argument we can overstate the situation as follows: voice conversations tend to be mostly local, with 80 per cent local traffic vs 20 per cent long-distance. Internet traffic has always been just the opposite with 20 per cent local vs 80 per cent long-distance. But the traffic flows of the Internet tend to grow towards the telephony distribution pattern due to higher local internet penetrations and a shift

from information access towards communication and P2P cooperation, which is local as well as global. This trend increases the demand for local/regional peering to avoid unnecessary upstream tromboning. One could say that, as flying between two cities of local importance became a niche carved out by budget airlines, connecting regional communication hubs is becoming interesting for ISPs.

Peering Dynamics

Increasing opportunities for peering might lead to churn of ISPs from one to the other IXP. Some ISPs will grow and move their peering to a larger IX, or they will find better deals (landing rights) for their peering and transit elsewhere. In practice, this is not an either/or decision for many ISPs; when the business grows, they usually connect to more IXPs to achieve efficient peering. The net result is comparable with further refinement of the well-known network effect, better described by a fractal hierarchy of IXPs, an ever more granular interconnected world closer to the end-users.

Conclusion

The prospect for regional IXPs is promising. First of all, they bring several advantages to regional economies and dynamics to ICT and the services industry. Additionally, the IXP infrastructure at large will be boosted beyond the current very large exchange. Therefore, regional IXPs are simply going to be a natural part of the Internet fabric.

However, not every region is the same, and the extension of the Internet fabric will grow organically, starting in areas with vibrant ICT, media and Internet activity. All players in these industries are interested in having an efficient and well-developed electronic market-place with plenty of bandwidth to be able to tap into the global Internet better. Under these circumstances there are many stakeholders making the case for creating an IXP by uniting to found a neutral and open cooperative exchange point. An alternative implementation can come from a commercial exchange operator who picks the opportunity.

The challenge is obvious in those areas where the industry and market forces are not so strong or even absent, which is often the case in less-developed countries. There is, however, no reason to believe that inhabitants of these areas or countries do not need a well-functioning link with the online world. Opening up these areas with a decent amount of bandwidth and services takes time, but well-organized public-private partnerships might help to clear the road and boost connectivity.

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