

Open Communication

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Abstract

In order to facilitate access for all to communication beyond the reach of the human voice, many of the traditional concepts and procedures of telecommunication networks should be revisited. The main technical systems used for such communication are based on infrastructures such as telephone networks and the Internet, including both wired and wireless links. Provision of such infrastructures is generally considered as a matter for telecommunication operators and public administrations to deal with. This has not always been the case and it is not true everywhere. Experiences from alternative ways to organize the deployment, management and operation of communication systems, including both infrastructure-full and infrastructure-less systems, should be disseminated and discussed.

Regarding infrastructure-less systems, we will in this presentation just point out and reference some examples of on-going work illustrating the concept of ad-hoc networking and its application to provide connectivity in rural areas lacking an infrastructure.

Regarding infrastructure-full systems, we will discuss experiences from pilot networks based on the concept of open exchange point-centric network topologies as opposed to the traditional operator-centric and draw conclusions related to regulation, competition and pricing. The components of such networks include operator-neutral access networks and distributed traffic exchange points to which service and content providers can connect servers directly and to which user communities and user agents can connect access points. Natural actors and user agents play important roles which facilitate the use of flexible economical models based on local opportunities rather than square national business models. The experiences include networks both in densely populated and rural areas, both in developed and developing countries. Strategies and role play for exploiting the concept to speed up the deployment of access networks will be discussed.

Infrastructure-less networks, Ad-hoc networking

Ad-hoc networking means that network nodes (user terminals or other nodes) that meet communicate directly with each other as soon as they are within the reach of each other.

One type of application is Daknet [*Pentland*], in which the infrastructure is replaced by a mobile server mounted on a vehicle, e.g. a bus. As the vehicle passes a village,

email and other asynchronous communication data is collected and delivered and when the vehicle reaches its home base, it is connected to the Internet.

A similar, but more complex, ad-hoc network is the SNC network used by the reindeer herding Saami nomads in the north of Scandinavia [*Doria*]. In this case, network nodes are mounted on vehicles like snow scooters which have no regular tours and meet more randomly when traveling around. Email and other asynchronous data is copied between the nodes and delivered to the Internet when possible. This model has also been discussed for interstellar networks in space.

Infrastructure-full networks

Internet has brought a shift of influence over the communication resources, including the infrastructure, from network providers to users and service providers. New actors have entered the market and there is a movement towards open systems, networks and communication. An exciting development is the emergence of open operator-neutral access networks i.e. local access networks that are available to anyone to connect and extend with new access points, facilitating organic growth, and to any Internet service providers to connect to provide transit to the Internet as a service. House-owners provide local area fiber networks to their tenants, with access points in private homes or office spaces of corporations. Public or private communities make wireless access points available even in public spaces. The local area networks are connected to access servers, sometimes colocated with Internet exchanges, providing a choice of upstream service providers. Content and service providers also connect directly to Internet exchanges providing colocation space. The traditional ISPs provide Internet transit. Users connect to local networks, possibly providing local services, with access servers allowing them to choose among upstream providers that can be reached directly from the access servers or via a transit network. How to best reach the points of presence of the upstream service providers may vary. The concept of autonomous systems is challenged. Who should pay whom may vary in different situations. Open access networks will create new opportunities and activate new actors.

We call this model Open.Net [*Pehrson*]. The beauty of the Open.Net model is that anyone can build an access network, based on very local economical opportunities. This creates an important flexibility which can bring access to areas where no traditional operator can see any business and also provide competition which can challenge local monopoly situations. Our hypothesis is that the open network concept will speed up the penetration of broadband access and that it is powerful enough to take the Internet technology to the next level, not only to a new generation global communication system, but also to a new dynasty with new key actors and new cultures.

Our research is focused on innovative technical solutions for scalable open access networks and traffic exchanges, security and privacy issues, and end-to-end quality of service issues ensuring dependable networks as well as innovative business models and a regulatory framework facilitating progress towards an open network access.

An important part of this research is to understand the value chain and its economical balance of revenues and risks, including identifying the actors, the roles and the

business models which could be regarded as the play itself. The actors include owners of real estate, operators of access points, access servers, colocation spaces, system manufacturers, service providers, users, etc. The main roles include ownership, operation and maintenance of the passive infrastructure, such as fiber trunks, networks in buildings, fiber hubs and closets with optical distribution frames, colocation spaces with redundancy and security, as well as the active infrastructure, including network elements such as routers, switches, modems. Besides the network, there is also servers, services and content and client terminals.

The business models are often very dependent on the local situation but there are some general aspects. Users pay the communication operator to be connected while content and service providers pay to reach the same users. Sometimes the communication operator manages to negotiate a share of the payment streams from the users to the content providers. The communication operators, in turn, pay to use the passive infrastructure and get Internet transit. The tariffs may be based on flat rates depending on QoS or be progressive depending on time, traffic volume and QoS.

Operator-centric networks

Traditionally, networks are service-specific, operator-centric and vertically integrated, as illustrated in Fig.1 below. The traditional telegraph, telephone and television networks are completely separate networks and the operator provides all levels of communication including the passive physical connection, the active communication links and network services as well as application services to its users. Operators exchange traffic via private peering between each other.

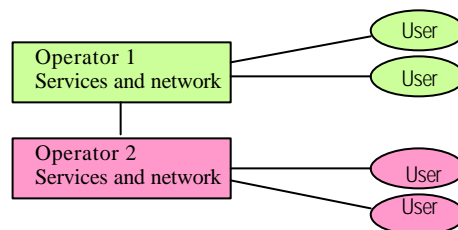


Fig 1 Operator-centric network topology

The economy of this model is introvert with little need for contact with end-users. The end-user terminals (e.g. telephones) represent a few percent of the total investment and the usage could be described accurately with mathematical-statistical models. The business models are mostly large-scale with little incentive for adaption to local opportunities. The operator-centric network topology reflects the history of networking having a national scope, requiring large investments and a specific competence. It is, however, a constraint on the road towards open networks and we will discuss below how the topology needs to change.

Open interfaces

In order to provide opportunities for more actors, competing or cooperating, to operate on all levels in the value chain, the interfaces between users, application services, network services, link services and different physical media have to be open. The digitalization, the integrated services data network standards, the intelligent network concept separating services and networks and the layered communication architecture illustrated in Fig.2 are all important steps towards the separation of the different levels of communication with open standardised interfaces

This separation has become more complete in the Internet technology which is based on a standardised data format for all kinds of user applications and application services, the Internet Protocol (IP). IP defines a data packet format common to all applications that can be sent over all sorts of links. The links can be wired (copper or fiber) or wireless (using any radio frequency band, including: hf, vhf, uhf or shf), terrestrial or satellite, depending on distance, capacity and cost requirements. IP, the Internet Protocol and its packet format, is a large step forward towards open networks. Instead of building separate networks for different services, the data from any service is put into a standard packet and shipped over any network.

The standardized levels of communication and protocols used for communication between peers on the different levels are shown in fig.2 below.

Email, web, remote connection, Mis, Voice, Video, Conferencing, shared workspaces		User applications
http, ftp, smtp, pop, imap, telnet, rtp, sip, afs, dns, ...		Application level
tcp/udp		End-to-end session
ip		Network level
ieee802.3 10Mbit/s-10Gbit/s	Pactor ax.25 ieee802.11 iee802.16 iee802.3	Link level
Cu fiber/wdm wireline	hf vhf uhf shf wireless	Physical level

Fig 2 Layered communication systems architecture

Systems for provision of traditional fixed telephony and Internet services are based on open standards and interfaces while systems for conventional mobile telephony networks are still closed and controlled by a few large systems manufacturers.

Open Spectrum

It is generally assumed that spectrum has to be controlled via licenses and monopolists rather than free competition to avoid chaos in the ether. Licensfree spectra such as the on allocated for the wifi technology has proven this wrong. Over a couple of years this technology has exploded and changed also other misconceptions rearding spectrum and wireless communication [Werbach]. By making more efficient use of the spectrum, we can remove the capacity constraints that limit current wireless

voice and data services. By opening up the ether for innovation, new networks, applications and services will be developed. Open spectrum technologies already provide low cost alternatives for broadband user access networks.

Open Networks

The availability of open standards and network components complying with these standards does not automatically lead to open networks. The way to build networks out of the network components, the network topology, also needs to be changed. The most important interfaces in an open network topology are

- open service-network interfaces, enabling any content or service provider to offer their services via any network
- open traffic exchange points, enabling operators of any size to exchange traffic with other operators on equal terms
- open user access networks, enabling users to select service operator, i.e. service-operator neutral access networks

In Fig.3 we illustrate an operator-centric network in which the elements promoting openness mentioned above are introduced; the services are separated from the networks, an exchange point (IX) has been introduced at which the network operators can exchange traffic, some access networks have been separated from the network operator and connected to an intermediary access server (AS) via which users can select what network service operator to use. Since several operators are present in the traffic exchange point, this is also a suitable point in the network for co-location of servers belonging to independent service operators.

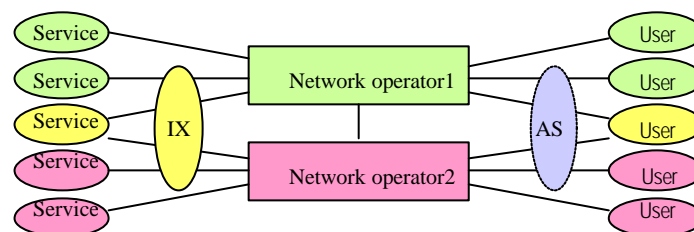


Fig 3 Open operator-centric topology

The open architecture and standards opens up for a number of new independent actors, e.g. service operators, exchange point operator, network operators, access network operators and access server operators. Among the challenges to enforce the openness is the fact that there are incumbent

Exchange point-centric networks

Fig.4 illustrates an open network topology, in which the multiple roles of the traditional operators have been distributed in a topology which facilitates for independent actors to get involved in different roles. We call this topology exchange point-centric since the exchange points constitute the natural meeting points between the user access networks, the service providers and the interregional connections.

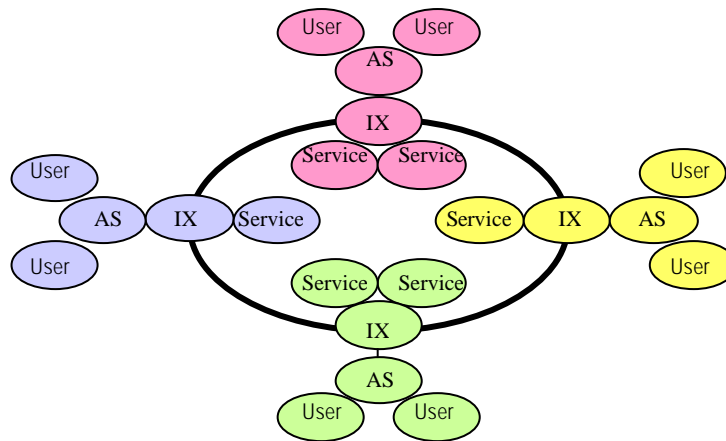


Fig 4 Exchange point-centric network topology

An Interesting discussion is if there are natural actors in the different parts of this topology. Starting from the user side, we will discuss user access networks, including access points and their connection to the access server, Internet exchange points, service and content provision and interconnection of traffic exchange points.

User access networks

User access can be wired or wireless. Wired access points are still in majority in apartment housing and office space where users are stationary while working or living, although the share of wireless access points are increasing also for stationary users since local mobility is supported and the cost of deployment can be lower. Wireless access points are more common in public spaces with mobile users. From a network point of view, there is little difference since the wireless access points are mostly connected to wired access points to reach the infrastructure. The wireless link just serves the first hop from the user.

Good candidates for natural owners of the passive infrastructure in the access network, the fiber or copper wires, are the real estate owners, whether the real estate consists of buildings or land. The operation of active links is, however, sometimes better outsourced to an access network operator, depending on the kind of environment at hand. The choice of partner when outsourcing should preferably be by an independent access network operator that does not compete with other operators to provide services., for several reasons, e.g.cost reduction by providing a shared infrastructure for all service providers, better competition and more freedom of choice for users,

Outsourcing to one specific service operator gives less support for competition, less user influence and less cost savings. It provides no drive towards a more horizontal, exchange-point centric architecture. The traditional operators will compete for buying the rights to the dense areas which are profitable, according to their own square and more narrow-scoped national business models, and leave the areas which are unprofitable, according to the same square business models, without access. The question still is: are there any areas at all that are dense enough to be profitable if you rely on a square, narrow-scoped national business model? At least not yet, it seems, since there are still too few users.

Shared infrastructure and independent access network operators

An experience from the open.net project is that the value of a shared infrastructure is high even in a densely populated area like Stockholm. The value is of course even higher the less user density there is. It is clearly a case of economy of scale, extremely sensitive to the number of users. If the access network is not shared, there is an extra cost for multiple connections, multiple access points and, perhaps worst of all, the extra work involved in negotiating and maintaining one contract for each access point operator at each access point site.

Independent access network operators is a better solution to this problem than regulation. The value proposition from such an operator is to offer the natural site owner support to put up operator-neutral access points and connect it to the closest point of presence where all operators can be connected. This concept also gives more power to the users and widens the scope of the business models. It is obvious that there is little motivation for

- a real estate owner to bother to allow more than one set of access points when there is a cheaper and simpler solution. especially if one operator offers a larger royalty, thereby reinforcing the traditional operator-centric model.
- an operator voluntarily provide transit for their competitors if they own the only last-mile connection to an end-user area

Moreover, service operators do not necessarily want to take on the contract work associated with establishing and maintaining hundreds, maybe thousands, agreements and access points, and to race with competitors to claim the profitable areas, if there are any.

Business models for access point operators

The reason for a real estate owner to provide accesspoints may vary, depending on the local economical prerequisites.

Our exploration of local economical models includes a number of different environments with different dynamics, such as:

- Private homes in apartment houses, condominiums and student housing areas. Besides commercial and private ISPs (e.g. school networks), the tenants can connect to commercial services, such as other ISPs, IPTV, VoIP and Video On Demand. The local networks are connected to access servers collocated with nodes in a distributed Internet Exchange point consisting of four nodes connected via a Gigabit Ethernet through Stockholm.
- Campus areas (corporate and academic): The IT-university in Kista provides wireless access to users on campus, including students, teachers and staff as well as collocated research institutes, companies and external visitors.
- Shopping mall: In the KistaGalleria project, a pilot wireless access network has been established in the Kista Center shopping mall. Work is in progress to explore

different business model in cooperation with the shops in the mall, the maintainers of the mall and the hotel in the mall.

- City centers: The city of Stockholm sponsors the establishment of an open access network in and around the City Hall, a central park and a central museum and library. Tourist information will be available in the local network. The city of Skellefteå in the north of Sweden extend their existing city network with operator-neutral access and the city of Nora has established an open wireless access throughout the city
- Arenas: The athletic associations encourage their members to help provide technical support for the organizers and the audience of athletic events, at arenas all over the country. Discussions are under way with arena owners that are interested in providing the infrastructure.
- Rural areas: The archipelago of Stockholm is a typical rural area with too few too distributed permanent inhabitants and too complex geography for any traditional operator to find any business there using traditional business models. In cooperation with the permanent residents, innovative business models that could make the network happen anyway are explored.
- Ubiquitous intranet access: One example of a project with this scope is a study of the impact on the work organization for social workers induced by ubiquitous mobile access to the Kista borough administration intranet.
- Developing countries: in the *MozambiqueOpen* and *MozambiqueIX* projects, a pilot access network and an Internet exchange point is established in Maputo in cooperation between UEM and KTH [*MozambiqueOpen*, *MozambiqueIX*]

Open traffic exchange points

The global network consist of a large number of interconnected independent networks. The topology of the global network is determined by the peering agreements between the operators and the routing policies of each operator. The tier 1 operators having global connections and points of presence define the root of a routing tree, the default free zone, from which there are routes to all parts of the network. Their customers, the tier 2 operators, have to pay to reach the default free zone and exchange traffic with other tier 2 operators, unless they can arrange a direct peering between themselves. Since such peering requires a direct link, it can only happen at locations where they both have a point of presence either via direct private links or via local traffic exchange points where several operators can connect.

A typical example of the benefits of a local traffic exchange point is a region with several local ISPs, a lot of local traffic and expensive external links. It does not make sense for ISPs to exchange local traffic on another continent as is the case for many African operators, due to the lack of local peering and local traffic exchange points. The Internet exchange point built in Maputo, Mozambique in 2002 [*MozambiqueIX*], cut the delay in local traffic a factor 1000 and unloaded all local traffic from the narrow satellite connections of the ISPs.

An open traffic exchange point is characterized by the rule that anyone can connect and decide what peering policy to announce subject to the restriction that the same peering policy has to apply for all others connected.

Conclusions

The most important conclusions from the Open.net projects are that the main bottlenecks still are the lack of ubiquitous access and the constraints to development induced by remaining monopolistic regulations and behaviour regarding the right to provide services, peering agreements, new operators' access to existing access networks and access to spectrum. The positive version of this is that if these constraints are removed, there are methods, systems, tools and entrepreneurial spirits that will increase the speed in the deployment of ubiquitous access enormously.

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