Customer-Owned IP Networks

Completing the IP Revolution Through Customer-Owned Networks

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Understanding Communications Systems

All communications systems can be understood as having three layers: the physical, the logical, and the content.

At any level, there may be singular or restricted ownership, or the resource may have many owners, or most important, it may have no owner at all. In some cases we can speak of a thing being a common resource.

This approach allows to see what is common and what is particular about any particular communications system. Here are a few examples.

	Hyde Park	Telephone	Internet	Broadcasting	Cable (carrying broadcasting)
Content	Free, unlicensed, expressed in public	Free, unlicensed, privately expressed	Free, unlicensed, **OR** for sale or rent, and protected as Intellectual Property	Licensed speech, protected by copyrights, and few speakers	Licensed speech, protected by copyrights, and few speakers
Logical	The English language (Common)	The SS7, owned by Bellcore	A common resource, TCP/IP, a standard	Heavily state regulated common resource (spectrum)	Privately held by cable owners , who own their codes (DOCSIS)
Physical	The park (common)	Local Monopolies, inherently few owners	Many thousands of networks, mostly privately held	Inherently few stations under private or public ownership	Privately held local monpolies

The two forms of communication which share a similar lack of ownership of the logical layer are the Internet and the English language. Both are acquired as a free resource. Neither may be appropriated by anyone: you cannot buy or sell TCP/IP or the grammar of the English language. The protocols upon which the Internet relies are standards established by the IETF (Internet Engineering Task Force). They have been given away, like the metric system. They might be changed in the future, but what has made the Net the Net has been the fact that the basic logic of how packets are designed and moved between computers is a common resource.

This lack of ownership has meant that no one has had to ask anyone's permission to innovate, with the result that for the past ten years or so we have seen tremendous unplanned product and service innovation. Many fishermen have fished in the ocean of TCP/IP, and prospered.

The Problem

Contemporary networks were designed in a pre-computer era on assumptions radically different from upon which the Internet is designed. As society tries to adapt to the needs of computer-to-computer communication, it faces two orders of problem:

- Problems inherent to the Internet
- Problems inherent to legacy systems

Problems inherent to the Internet include:

- *massive growth*: traffic has been doubling every 18 months but the capacity which has had to be installed to handle that growth has doubled every four months.

- *Poor scaling:* The number of linkages grows with the square of the nodes, which leads to the unwelcome possibility that the Net does not scale, or does not scale well- the N^2 problem.

- *the absence of settlements*: There is no known objective financial settlement model which is financially robust and technically feasible in the Internet. No system exists to measure the value of packets, and so permit settlements between carriers.

Problems inherent in the legacy systems include:

- The Internet is a *disruptive technology, in many respects*: it is the bargain basement of communications technologies; it reduces the cost of communication by orders of magnitude; it takes what used to be supplied and paid for as a service and turns it into an application.

- The end-to-end, peer-to-peer nature of the Internet removes control of both the logical layer and the content layer from its previous owners. The logical layer is given away, and the content may be too diffuse to control.
- By taking control of content away from large corporations, it devalues the content they previously held secure (Napster, Gnutella) guarded by intellectual property laws.

As a principle of good computer design, the Internet makes the minimum number of specifications of the lowest layers, the common elements of transport, so that the maximum flexibility can be obtained from the higher, applications layers. The Internet is not optimized for any one use, but is equally bad, or good, for all uses. This is its genius.

Legacy systems, all of which predate the computer, were perfected to serve one purpose. The service was integrated, rather than dissociated, with the transport of the signal.

For over a hundred years, the telephone system was perfected to carry voice signals through circuits and organized by a rigid internal protocol. The telephone system is perfect for its intended use, but highly inflexible and costly for computer-generated traffic. The telephone company owned both the physical infrastructure of communication and the logical system (the SS7) that moved the traffic.

The cable system was designed as a one-way delivery system of television broadcasting to the home. It mirrored the top-down, central command structure of television broadcasting, which was reinforced by elaborate property rights in the content itself. The owners owned the physical infrastructure, the logical system, and held exclusive rights in the use of the content

Neither system was designed to accommodate the principles of a peer-to-peer, end-to-end network. The technical incompatibilities between the needs of the Internet, one the one hand, and the needs of voice traffic and television transmission, on the other, are great enough, but there is a further incompatibility, which is legal. The owners of the cable and telephone systems enjoy rights and powers over their networks. In the case of telephone systems, which are common carriers, they have a right to compensation for the use of their facilities, but must in principle accord third parties access to their systems. Thus, after some initial difficulties, Internet service providers (ISPs) have been able to interconnect with telephone companies to reach customers.

In the case of cable television operators in the United States, the Courts have not recognized that cable operations are common carriers, and show signs that they are to be accorded the status of “the press”, meaning that they would have no duty to carry the signals of others. Thus as we pass from the narrowband system of telephony to the broadband system of cable television, the legal regime changes to one even more hostile to the end-to-end idea than the telephone system is. In Canada, broadband suppliers are required to afford access to third parties.

A New Kind of Network

The combination of technical incompatibilities, and the owners’ resistance to becoming open platforms for communication by third parties, has led innovators to consider establishing new kinds of network. In Canada, Sweden, the United States, and Holland, various entities are experimenting with new legal and commercial approaches to networks. The principal reason why these new models are being developed is the rapidly declining cost of the technologies employed.

These ownership structures allow the end user to have rights of use in a portion of the network. The customer may jointly own the network as a part of a condominium, or a neutral party, such as the municipality or local government, can install and maintain the network, while the users own shares in it. The patterns of ownership and rights of use may vary, but all such arrangements transfer power over the use of the network away from a centralized owner, and vest it with the users. This is revolutionary, in the same sense that the personal computer tore power away from the mainframe, and put it on everyone’s desk.

The technical advances upon which these networks rely are well known. Bandwidth capacity is doubling every four months, while computing power is doubling every 18 months. Dense wave division multiplexing (DWDM) allows for customers to own and control wavelengths. Ethernet is coming to be the accepted standard protocol for wide area and local networking, allowing networks to function without the costly underlying strata of SONET and its like.

Developments in protocols are also helping the transition to customer-owned networks. OBGP (Optical Border gateway Protocol) will allow customers to manage their own wavelength routing and extend their network domains. This will allow direct connection and peering with other network domains attached to the network cloud. Bill St Arnaud, head of special projects at Canarie Networks, says "OBGP is being developed to push control of network administration and peering into the hands of as many of the smaller players at the edge of the network as possible."

The development of customer-owned fiber networks, with gigabit and terabit capacity, will undermine the traditional carrier business model, which is built upon

- managed network services, and
- carrier-owned infrastructure.

The regulatory regime plays an essential role. People must be able to obtain carrier licences easily, and they need to be able to exercise rights to attach wires and cables to the poles and conduits of the incumbent carriers, for reasonable prices. The innovation here is principally legal and regulatory; the technology cannot be made to work if the regulatory barriers make it too expensive to try.

How the New Network is Designed

These networks have four characteristics that differ from legacy telephone and cable networks:

- Customers own and control their wavelengths, and may trade them with other like- minded customers.
- The network is an asset, not a service.
- Creativity is derived from the end users, not the network managers.
- The core of the network will not be optimally designed to minimize resource usage when end users have control; it will waste bandwidth.

Legal and Other Arrangements

The particular legal arrangements among owners of the rights of way, owners of the fiber, and the entrepreneur who organizes the project are as various as people can make them. There is no one plan or pattern.

Municipalities or other governments can build the fiber, assume the risk, and lease out the capacity as Indefeasible Rights of Use (IRUs). Or, tenants can band together and hire a private contractor, or the private contractor organizes the consortium.

In some cases, universities and research organizations can act as the "anchor" tenants. They have expertise in LAN (local area network) technology. Fiber is installed, owned and maintained by third party professional fiber contractors. Each institution gets its own set of fibers, at cost, on a twenty year IRU (Indefeasible Right of Use).

Engineering firms can organize a consortium, aided by a federal carrier licence, which gives them leverage with the incumbents, to join or be left out. The telcos and cable companies get their own strands of fiber for much cheaper than they would by building alone, so they join. High telecom prices (based on incumbent cost structures) make it profitable for institutions to take advantage of the offer made by the organizer of the condominium.

Each customer-owner lights their fibers using their own technology, Gigabit Ethernet, ATM, PBX.

The condominium model is a combination of private ownership (strands of glass or lightpaths) and public utility, through municipal or provincial participation in financing and rights of way. In some ways it resembles a public utility, like water, sewerage, roads and firefighting. The conduit may be public, but the lightpaths are privately owned. The analogy of private cars running on public roads might come close, but here the conduit can be owned by a municipality or by the condominium of users that paid for it. It can be thought of as facilities-based competition, fiber by fiber.

Market Drivers

The factors making possible these customer–owned networks are:

First - low cost. Up to 1000% reduction over current telecom prices. 6-12 month payback.
Second – The local area network (LAN) invades the wide area network(WAN) – no complex SONET or ATM is required in the network.
Third – The new arrangements enable new applications and services not possible with traditional telecom service providers. No managed services are provided by anyone.
Fourth – These arrangements allow access to new competitive low-cost telecom and IT companies at neutral meeting points.

Three Examples

Three examples of these developments are:

- Alberta's Supernet Initiative
- The Ottawa fiber condominium
- Quebec school board initiatives

The Supernet Initiative

Alberta's Supernet initiative is a scheme to unite all of Alberta's 420 communities and government buildings through a provincially-funded network of condominium-owned optical fiber. Private sector businesses will be able to lease capacity and connect to the system. The system guarantees the cost of bandwidth to all public sector institutions, currently at Cdn$500/month for 10 Mbps, Cdn$700/month for 100 Mbps. The network is a mix of fiber builds and existing supplier infrastructure (swap/buy/lease). All participants can buy (or swap) a share of the fiber (during the build or after) or lease bandwidth at competitive rates.

The total cost of this system is $C 193 million. The Alberta government will hold Indefeasible Rights of Use (IRUs) but will otherwise keep management of the system at arm's length from government operations. Prices charged to users are the costs of the system divided over the number of users.

Alberta:

Current situation	**Future Situation**
Residences	**Residences**
56 Kbps dial Internet ($85/Month) No high speed Internet	High speed DSL residential Internet at urban rates ($40/month)
Businesses	**Businesses**
Some T1 Facilities ($2000/Month average - rates distance sensitive) Some high speed business service on special setup arrangement	High speed business services available at competitive urban rates (eg $820/month - T1) Higher speeds at comparable rates, no distance sensitivity

The Ottawa Condominium

In Ottawa the consortium consists of 16 members from various sectors including businesses, hospitals, schools, universities, research institutes, operating from 26 sites. The network uses a point-to-point topology, joined by 144 fibre pairs. Costs have proven to be from C$11,000 to - $50,000 per site, for a total project cost $CDN 1.25 million. Cost per strand has been less than $.50 per strand per meter. 80% of the cable is aerial, 20% underground. Due to overwhelming response to the first build, planning for a second build is under way.

The network's costs do not increase much with scale or size. If the condominium fiber contractor were to double capacity of network (i.e.12 strands to each customer), the cost of project would only increase by 10%. A doubling of the number of participants would increase the cost by only 10% (plus cost of laterals for additional institutions). By doubling the number of participants average cost would be less than $20,000 per institution. Ultimately fiber costs could get as low as $1000 per institution if every building in the city was connected with fiber.

Ottawa condominium fiber network
Average total cost has been between C$7 and C$15 per meter as follows:

Engineering and Design:

- $1 - $3 per meter for engineering, design, supervision, splicing

Plus Installation:

- $7 to $10 per meter for install in existing conduit; or
- $3 to $6 per meter for install on existing poles

Plus Premise termination:

- Average $5k each

Plus cost of fiber:

- 15¢ per strand per meter for 36 strands or less
- 12¢ per strand per meter for 96 strands or less
- 10¢ per strand per meter 192 strands or less
- 5¢ per strand per meter over 192 strands

It has been found that annual maintenance and right of way cost is approximately 5% of the capital cost.

Quebec School Boards and other Local Government Initiatives

The government of Quebec has been active in encouraging its school boards and medical institutions to join in condominium fiber projects. Space does not allow for a discussion of the cost figures associated with these builds. However, very significant savings have been achieved, relative to the costs of conventional telephone and other associated services.

Putting together a Fiber Condominium Project

A fiber condominium project at this stage is a matter more of legal, financial and contractual organization that an advanced technical project.

1. A community consortium would put together a plan to fiber up all public sector buildings in their community. A community can be a province, a municipality, village, etc
2. The plan must make provision for a fiber splice box that terminates the fiber at the street side nearby each public sector building such as a school, hospital, or library. This box is called a “Node”.
3. The community must ensure that potential facilities exist nearby for private sector equipment to connect future home owners – a colocation facility. The colocation facility allows private sector interests to extend wireless, VDSL or HFC services to the neighbourhood around the school or public building.
4. Additional fibers are made available from the Supernode to all nodes such that competitive service providers can purchase fiber to the node at some future date.

The Role of Government

Governments can promote the policy of broadband Internet to the home by

- Subsidizing and encouraging early adoption by schools, universities and municipalities;
- Ensuring that the technology is open, cheap, and Internet-only;
- Regulating access conditions to ensure free and fair competition;
- Insisting that solutions address the “last mile”.

In order to convert and build massive infrastructure to new IP-based networks, governments need to:

- Set affordable prices for access to rights of ways, poles and ducts;
- Issue carrier licences easily;
- Make the legal regime for broadband the same as for narrowband – common carrier, rather than publisher; and
- Continuously define the nature of non-discriminatory access to networks, at all layers of the protocol stack, and intervene to promote it;
- Identify those areas which will need subsidies to be reached (do not subsidize carriers, but users)

It is not clear whether political centralization is a good or bad thing in this case. If cities and lower orders of government block these initiatives, uniform national regulation could help. On the other hand, subordinate or smaller units of government might provide many different solutions and avenues to experiment, such as in the fifty states of the United States.

It can be argued that Canada has accomplished the first three goals and secured an important benefit, common federal jurisdiction over networks.

- The CRTC has actively intervened to ensure access at affordable prices to incumbent carriers’ poles and ducts;
- It has established a regime friendly to facilities-based competition; obtaining a non-dominant carrier licence is easy;

- Telecom Decision 96-1 means that cable operators are common carriers when they offer to carry non-programming signals. The legal concepts in the Telecommunications and Broadcasting Acts ensured that when cable operators ceased to offer broadcasting, the default position was that they offered telecommunications services, and were subject to common carrier obligations; a**nd**
- The AGT and Guévremont cases have established one single federal jurisdiction over inter- and intra-provincial telecommunications. This could have been a disaster if the CRTC had made the wrong decisions, but a great benefit as it has made the right ones.

It remains to be seen whether the CRTC will continuously redefine the nature of non-discriminatory access to networks, as its understanding of the role of protocols grows. As to subsidizing users and not suppliers, we await the recommendations of the Task Force on Broadband Networks.

As to customer-owned IP networks, the incumbent carriers will do their best to create fear, uncertainty and doubt as to the wisdom of these arrangements. However, like the personal computer was in the 1980's, it is an idea whose time has come.

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