Broadband architectures, ISP Business Plans, and Open Access

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Background

Something suspiciously resembling a double standard exists in US regulation of broadband access carriers. Incumbent local exchange carriers—ILECs—are required to open their networks to competing service providers, while cable television companies are not. Where did Congress and the FCC get it right? In the telco case, where open access is required, and there is a nascent competitive market for telephony and DSL services, or in the case of cable data networks, where consumers usually have no choice but to buy their service from the cable company's affiliated ISP? Or is disparity the best policy?

ILECs are indignant at the double standard. They say, impose the same standards on both pipelines. Either place the same burden on our competitors, or, better yet, free us from open access requirements, too. Cable companies, for their part, deny that their behavior is anti-competitive. They feel they deserve to compete with the ILECs as best they can.

The FCC faces a dilemma. The Commission wants to promote investment, deployment, and market-driven outcomes. But any open access requirement will, to some degree, discourage investment in infrastructure. On the other hand, if the Commission sits on the sidelines while market concentration grows, it will become difficult to undo damage that could have been prevented by early intervention. The stakes are high. Should the broadband pipeline market succumb to concentration, the content and on-line commerce markets could follow. There are risks on either prong of the FCC's dilemma. FCC action or inaction could unwittingly undermine its goal of universal, competitive broadband local access.

For now, the FCC has chosen to sit back and watch. According to the FCC's Cable Services Bureau Chief Deborah Lathen,

> …The Commission has adopted a policy of vigilant restraint, refraining from mandating "open access" at this time, while closely monitoring for anticompetitive developments that may require intervention. Additionally, the Commission is also actively promoting the development of many broadband competitors—including wireless, satellite, cable, and telephone provider—by limiting regulatory burdens, by making more spectrum available, and by making spectrum use more flexible. Competition from multiple broadband providers is seen as the best way to prevent a monopoly by one provider.[1]

The FCC's ultimate hope is that multiple pipelines will make restrictions on any single pipeline unnecessary. In a market with two, or three, or perhaps more paths for broadband information into the home, facilities owners will presumably find it in their interest to provide non-discriminatory access to all content providers over their networks. At least that's the theory. But it assumes that *multiple* carriers will be in a position to compete for *each* customer's business. That may be the case in certain densely populated areas. But it may not be the case for most consumers.

The FCC is encouraged by the plans of AT&T and AOL / Time Warner to open their networks to alternate ISPs. The Commission takes these developments as a sign that intervention is not required. But they might also interpret the concessions as an effort to take the wind out of the sails of open access advocates. If not for the fear of Congress or the FCC imposing open access requirements, the industry would not have acted on its own.

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[1] Lathen [1999, 15].

Is there any cause for concern here? This paper reviews broadband architectures and ISP service profiles to show that open access is technically feasible and economically viable, even if implementation is not always trivial. The decisive factor is planning. If broadband networks are built with interconnection in mind, it will be easier to implement open access. Hence, I argue, the FCC should encourage the deployment of open-access-ready networks. Incentives that the FCC can offer at this stage to cable operators to design open access into their networks will have two benefits—they will lower the costs of implementing open access regulations should the FCC decide to act in the future. More significantly, if broadband network operators are encouraged to build open-access-ready networks, they will be better positioned to offer open access on their own, thereby eliminating the need for regulation.

Broadband Access Architectures

The problem of open access for broadband access networks depends in large part on where a subscriber's traffic first contends with other subscribers' traffic for network resources. There are three locations where contention can first occur:

1. at a carrier aggregation point remote from the subscriber's location (a telephone company central office or a cable company head-end,)
2. on the transmission medium, immediately upon leaving the subscriber's premises, or
3. at some point between the subscriber's location and the carrier's point of presence.

The point of first contention is critical to open access because contention means that the network operator must allocate network resources. Which users get what network resources, and when? The open access controversy revolves around this question: whose service provider is making the allocation of resources? Are both users the customers of the service provider making the resource allocation decision? Or is only one user a customer of the provider making the allocation decision, and one user a customer of an alternative ISP?

Or are both users the customers of different, alternative ISPs? If all users are customers of the same affiliated service provider, then they can expect the provider to manage network resources in a manner consistent with the service offering. But if any of the users are customers of ISPs not affiliated with the network operator, the alternative ISPs and the network operator will have to negotiate terms—for quality of service and allocation of costs—that govern how much of the network's resources a competitive ISP's customers may use.

The first possible location of contention—at the operator's point-of-presence—is characteristic of DSL service, the second is typical of cable data services, and the third is associated with special cases in the provision of DSL. The following sections describe these three possibilities, outlining how each architecture relates to the provisioning of open access services over broadband networks. We begin with the simpler DSL options, then proceed to the cable data option.

DSL Architectures

The standard DSL Architecture

Figure 1 illustrates a typical DSL architecture. If the DSL subscriber uses the ILEC's DSL service, the twisted pair enters the telco central office and passes through a line-splitter (if necessary) to isolate the voice and data slices of spectrum. Next, the signal enters the DSL Access Multiplexer (DSLAM.) On the other side of the DSLAM, the customer's data passes through the telco's data network, continuing on to the Internet. A CLEC customer's data takes a similar path through the CLEC's DSLAM and data network. The only difference between the two cases is that the CLEC customer's wiring takes a detour from the central office to the CLEC's equipment, which may be located either in a separate cage in the central office or in a nearby building.

It is easy to open DSL architectures to multiple ISPs. The twisted pair from the customer's premises to the DSLAM is dedicated to that customer. In this architecture, DSL providers maintain their own DSLAMs, and the Internet side of the DSLAM is connected to the ISP's own network.[2] Neither the ILEC or CLEC data networks carry traffic for customers of other ISPs. The independent wiring for each customer and the separate DSLAMs eliminate the fundamental open access problem: contention does not occur until customers' data is safely under the policy umbrella of their own ISPs.

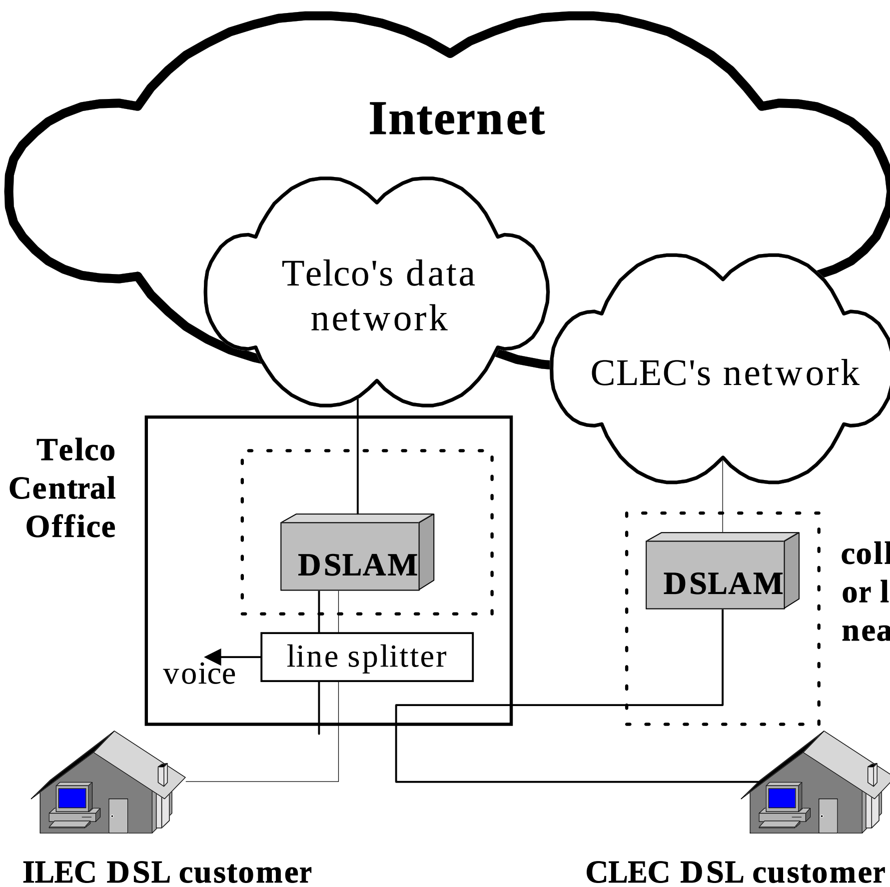

Figure 1. The Standard DSL architecture

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[2] In this simplified architecture, we ignore the possibility that multiple ISPs share the same DSLAM. The Internet side of the DSLAM might be on a switched ATM network, which would make it simple to direct data from customers to their respective ISPs.

Architecture for DSL over Digital Loop Carrier

In some areas, telephone companies economized on the use of copper in local loops by aggregating multiple subscriber lines near their subscribers and running a shared digital circuit to the central office. This technology is referred to as Digital Loop Carrier, or DLC. Figure 2 illustrates the DLC architecture. Since there is no dedicated copper pair from the subscriber to the central office, the open access technology is now more difficult to implement.

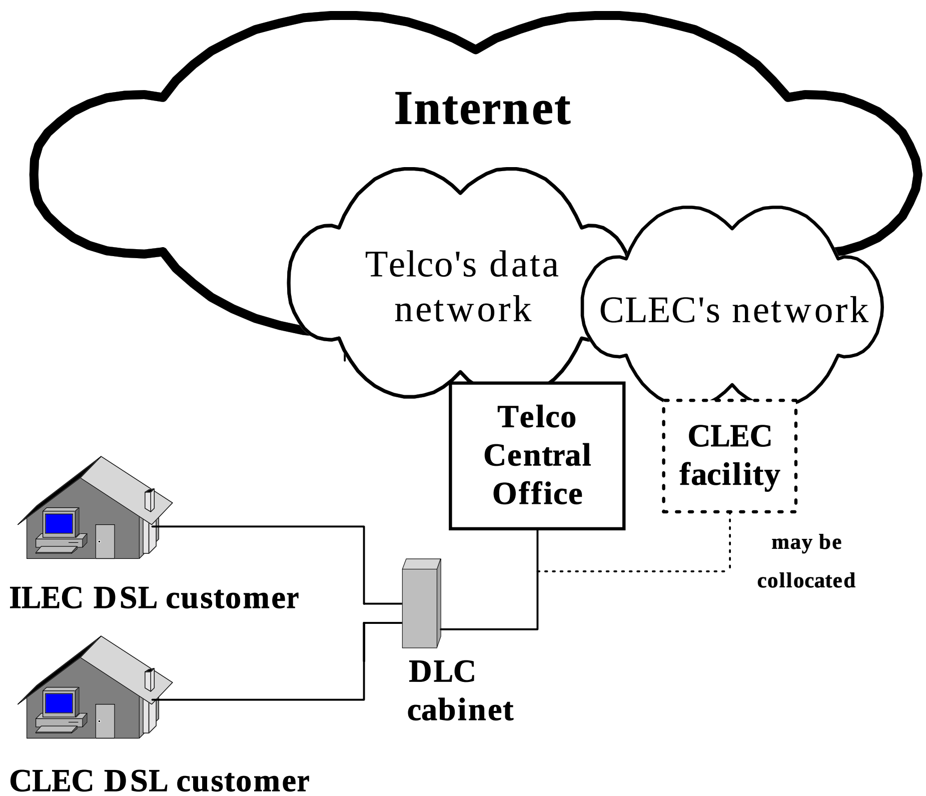

Figure 2. DSL with Digital Loop Carrier

The problem is rather low-tech: DLC equipment is installed in small, curbside metal cabinets. Space inside the cabinets is limited. To provide DSL service over the DLC system, the box must accommodate both the DLC equipment and a small DSLAM. The conventional open-access DSL model requires separate DSLAMs for each ISP, but because of limited space in the roadside cabinets, this is not likely to be an option for subscribers on DLC. If the mini-DSLAMs installed in the cabinets are designed with open access in mind, however, they can be equipped with multiple network interfaces to accommodate multiple ISPs. Data destined for a CLEC could be multiplexed onto the ILEC's data feed, or a new dedicated line could be pulled from the cabinet to the CLEC's facility.

Cable data architecture

The options for implementing open access for cable data networks depend on the medium access control standards used in the network. In the United States, the cable industry's Data-Over-Cable System Interface Specification (DOCSIS) is the overwhelmingly dominant standard. An alternative standard for cable modems was in development by the IEEE's 802.14 committee until March, 2000. The 802.14 committee was working on an Asynchronous Transfer Mode (ATM)-like standard that would have afforded a straightforward method of implementing open access. (If subscriber's packets were encapsulated in cells and switched through an ATM network, each subscriber's traffic could be sent directly to a network access point maintained by the appropriate ISP.) The American cable industry felt that the IEEE group was not converging rapidly enough on a standard, so it decided to pursue its own IP-based standard through the DOCSIS forum. The IEEE group withdrew its charter and disbanded because of lack of support by the cable industry.[3]

Cable operators have a variety of options in network architecture. DOCSIS does not dictate the structure of the data network—it is principally a physical and MAC layer specification. Two classes of cable data network architecture have been common: bridged and routed architectures. In a bridged architecture, the entire cable system is connected together via bridges (roughly speaking, dumb

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[3] On architectures for cable modem systems, see Maxwell [1999], Abe [2000] Azzam & Ransom [2000], and Robert Russell, chair of 802.14, personal communications.

routers that broadcast all incoming information on all output interfaces.) Simple bridged architectures were more common in the earliest deployments of cable data systems, but their limited scalability has led later system architects to opt for routed architectures. (Bridged systems do not isolate one segment of the network from another. Bridged networks cannot expand beyond a certain size, therefore, and they are more susceptible to disruption by rogue users or defective equipment.) Since a large and increasing share of new upgraded systems being deployed use the routed architecture, this section details the routed network option, only.

Figure 3 shows a simplified schematic of a routed cable data network. The cable modem in the subscriber's home sends information on the coax to a fiber node serving several hundred to several thousand homes. From the fiber node, a fiber optic cable carries information to the local cable head end. At the head end, a Cable Modem Terminal Server (CMTS) demodulates the upstream signals from users and forwards packets to a local router. From the router, the information passes through the cable operator's network and eventually on to the rest of the Internet. The figure illustrates that an alternate service provider, ISP-X, connects to the cable operator's ISP Manager.

Conventional routing algorithms are based on assumptions about the character of the traffic passing through the network. Open access policies violate these assumptions. For example, it is normally possible to assume that any packet with a destination address that lies outside the administrative domain of a network should be shown the way to the nearest exit from the network. However, customers of alternate ISPs would possess IP addresses that lie outside of the range administered by the cable company. Thus the normal assumption about how to handle packets with "foreign" destination addresses would no longer be valid. The packet would be expelled from the cable network, directed (according to the usual rules) to the ISP, which would route it back to the cable operator.

The loop would continue until the packet's time-to-live field expired, and no traffic would be delivered to the user.

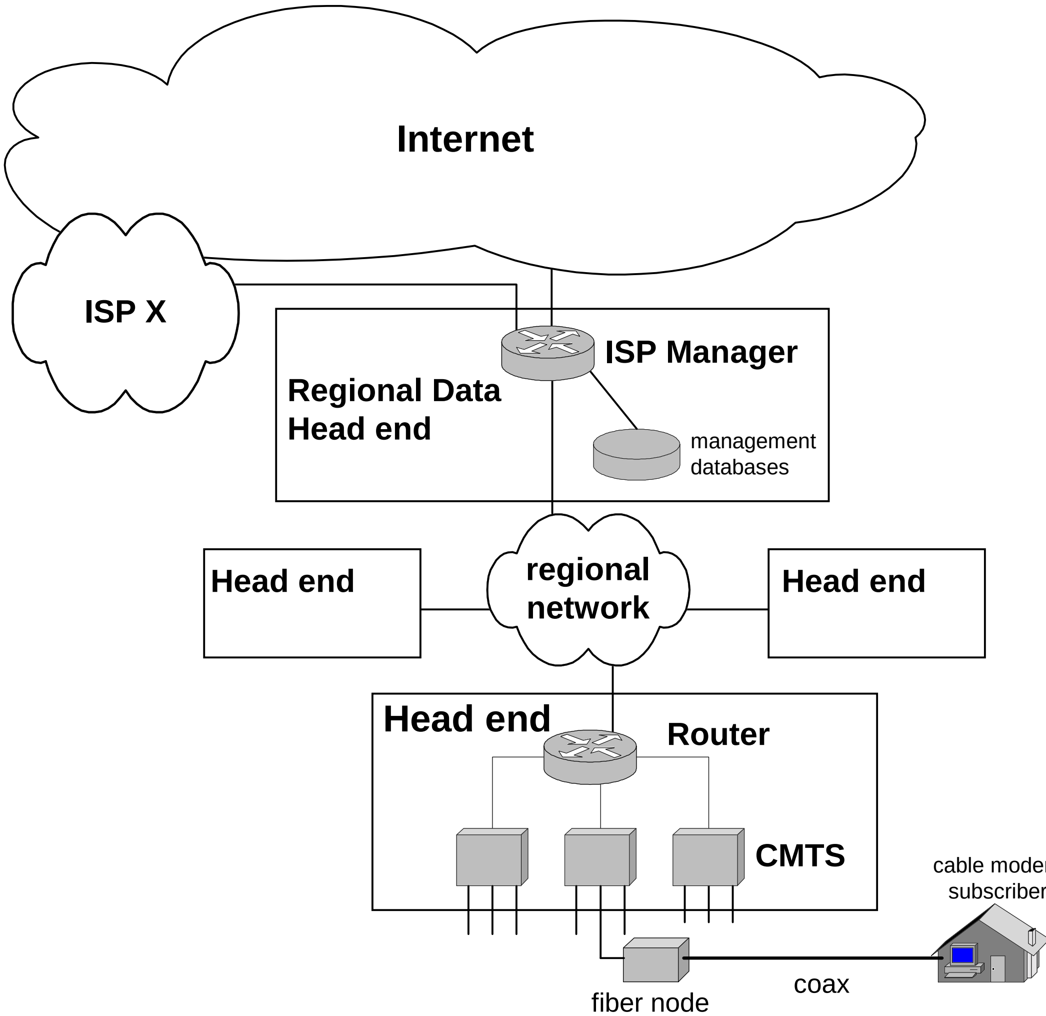

Figure 3. A cable broadband architecture

To successfully direct packets to customers of other ISPs located on their networks, cable operators would have to increase the size of their routing tables. The larger routing tables would include entries for individual customers of other ISPs (and *only* those customers of the other ISPs) currently accessing the Internet via the cable operator’s network. But keeping track of exactly which customers of other ISPs are located on a cable operator's network would be tedious work. It would require continuous updating of routing tables as computers went on- and off-line and changed their IP numbers. Such an approach would be impractical.

For outgoing packets, open access presents additional problems. In conventional routing schemes, packets are sent on a best path toward destination based solely on the destination address of the packet. Outgoing packets would be routed out of the cable network, regardless of which ISP's customers sent them. If alternate ISP customers are paying for premium handling of outgoing traffic, they will be unhappy that their traffic is being delivered as the cable company chooses. And the cable company might not be happy about forwarding traffic for other ISPs, unless it were being paid to do so.

There are several options for coaxing cable data networks to handle traffic for subscribers of other ISPs properly. The best choice will depend on the capabilities of the routers in the cable operator's data network. One set of options is available if the cable network's routers are capable of *policy routing* (or *policy-based routing*.) Under policy routing, routing decisions can be based on any number of criteria, including the packet's source address, the type of data carried by the packet, the time of day, the level of congestion on the network, and so forth. A network that uses policy routing and specially maintained routing tables could accommodate multiple ISPs. Outgoing traffic could be routed based on the source and destination addresses, with packets from customers of other ISPs being routed to the ISPs network; similarly, incoming traffic could be directed to the appropriate subscribers, despite their 'foreign' addresses.[4]

A much more manageable solution for implementing open access is *tunneling*. As the name implies, tunneling is an end-to-end operation. Depending on the type of tunneling used, the cable operator may not need to deploy any special equipment in the network. In tunneling, traffic for customers of alternate ISPs is

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[4] On routing and policy routing, see Huitema [2000].

encapsulated inside normal looking packets and transmitted across the cable network. From the outside of the tunnel, there is nothing peculiar about the behavior of the network. The encapsulating packets are handled according to the usual, shortest path, destination-address criteria.

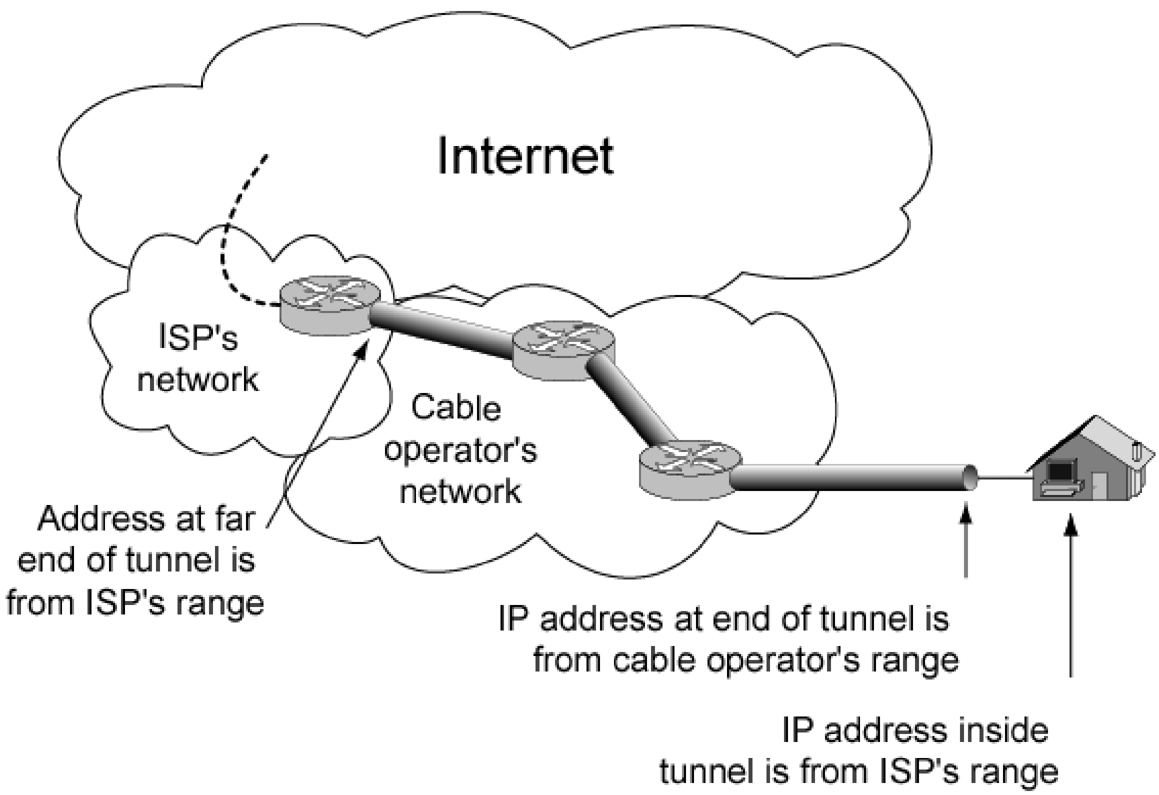

Figure 4. IP tunneling

Figure 4 shows a schematic of an IP tunnel for carrying traffic to the customer of an alternate ISP over a cable network. Inside the 'tunnel', packets to and from the customer are encapsulated in packets with source and destination addresses of the ISP's gateway and the 'outer' IP number of the user's computer. Inside the tunnel—in the encapsulated packet—are the real source and destination addresses and the payload data.

The options for managing tunnels include: Generic Routing Encapsulation (GRE), Layer 2 Tunneling Protocol (L2TP), and Multiprotocol Label Switching (MPLS.)

Generic Routing Encapsulation (GRE) is a tunneling protocol that can be used to forward a payload packet over an arbitrary delivery protocol. In the case of open access Internet service, both the payload and the delivery protocols are IP, and the purpose of the tunneling is to override the standard routing protocols. GRE requires special software in the client machine and in the router at the far end of the tunnel.[5]

Layer 2 Tunneling Protocol provides a point-to-point connection over a public network. L2TP simulates a layer 2 (data link) connection between two points by encapsulating layer 2 data in a tunnel constructed at layer 3, the network level. L2TP requires implementations for the client and end-point router, only. Windows 2000 includes an L2TP implementation.[6]

Multiprotocol Label Switching[7] (MPLS) is a method for, among other things, extending routing functionality on networks. Since MPLS networks switch traffic based on labels, rather than IP addresses, an arbitrary routing policy can be implemented in the rules for assigning and reacting to packet labels. For open access applications, the ability of MPLS to specify the handling of packets without regard to their IP destination or source addresses is a great advantage. MPLS would accomplish open access in much the same manner as IEEE 802.14 would have—by switching packets through the network to their destination, without relying solely on IP addresses.

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[5] See RFC1702, RFC 2784.
[6] See RFC2662 and Shea [2000].
[7] See RFC2547 and Davie & Rekhter [2000]

A specially designed IP stack could implement tunneling over conventional IP networks. The special IP stack would effectively tunnel the 'real' IP packets inside publicly visible IP packets. This solution is not as attractive as those that do not require replacing the standard IP stacks in client machines.

A note on costs

Most of the above methods of implementing open access require at most upgraded CMTS hardware and software upgrades for network infrastructure and client machines. A study of the capital cost of implementing open access by Tseng[2000] found that the incremental capital cost of implementing open access, under conservative assumptions, was no more than about $25 and perhaps less than $5.

Tseng emphasized that her model did not include the operational costs of managing a network with traffic for multiple ISPs. The more difficult aspect of open access will not be in hardware, but in network management. First generation CMTSs were designed with basic functionality in mind. The marketing literature for next-generation CMTSs, such as those now being offered by RiverDelta, RedBack and Cisco, highlight the ability of the equipment to handle traffic for multiple ISPs. RiverDelta's offering, notably, is reportedly able to allocate bandwidth dynamically on the cable network to groups of customers of various ISPs. RiverDelta's product can also manage traffic by application. Such functionality makes it possible for a cable operator to offer access to other ISPs without sacrificing the ability to manage the amount of bandwidth available to different classes of users and applications.

It should be noted that the advanced traffic management tools incorporated in the next-generation equipment provide exactly the same functionality that cable operators will have to deploy to insure the quality of service on their own networks. As the number of subscribers to cable data service grows, together with the appetite of consumers for bandwidth, cable operators will have to exercise finer-grained control over the traffic of individual users, groups of users, and individual applications. Consequently, it might not be fair to attribute the entire cost of improved network management to open access.

Before moving on to examine ISP service profiles, we note two additional methods suggested for implementing open access: spectrum unbundling and network address translation. Neither of these methods, however, appears to be seriously considered for wide-scale application for open access.

Perhaps the most obvious solution for providing open access over cable networks is to set aside spectrum for each ISP wishing to serve customers on the network. Unfortunately, cable operators have not reserved enough spectrum for data services on their systems to make spectrum unbundling feasible. Spectrum unbundling has become something of a straw-man proposal for opponents of "forced access," since most open access advocates appear to recognize the inefficiencies of spectrum unbundling.

Before we brush off spectrum unbundling, however, we should note that it would be a simple solution for the problem, if only spectrum for data were not in such short supply on cable systems. In the future, when fiber optics push out to the home and ease the spectrum bottleneck, one can imagine optical spectrum or lambda-unbundling for competitive service providers.

Though it is currently impractical, spectrum unbundling has a major advantage over all other open access architectures: it isolates the traffic of each ISP and allows each to manage the traffic of its own customers. The alternatives discussed above all create complicated network management problems for facilities owners and alternate ISPs.

Network Address Translation (NAT) resolves open access addressing dilemmas by using different IP addresses for intra- and inter-network communications. To the outside world, a subscriber has a globally valid IP address belonging to the subscriber's ISP; but inside the local network, the subscriber's machine operates with a locally valid IP address. A gateway at the edge of the cable company's network performs the translation of addresses in IP headers from the globally valid address to the locally valid address and back again. Unlike the tunneling protocols, however, NAT does not work well with recently developed Virtual Private Network (VPN) protocols. Neither does NAT accommodate security schemes that include verification of the source and destination addresses of packets.

Broadband Services: What does an ISP do for you?

To be clear about just what is unbundled by broadband open access policies, it helps to first list the key "service profile" that ISPs perform for their customers.[8] The “Internet Service” that an ISP provides is actually a bundle of services. The following enumeration of ISP services may seem very fine-grained, but as will be clear later, the details highlight the decisions that must be made when Internet access services are divided among facilities-based providers and non-facilities based providers.

ISP services fall into three general categories: (1) fundamental networking and internetworking, (2) applications, and (3) customer relations.

I. Fundamental Networking & Internetworking

- **IP number assignment**: All users of the Internet must be assigned an IP address, by an ISP or an organization's network administrator. An IP address identifies the user’s computer and gives remote systems information necessary to route data to the user’s machine. Typically, a consumer would have a unique IP address for a single on-line session. Users on local area networks may share IP addresses (if they are located behind a firewall or use

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[8] I use “service profile” in the sense described by Huston [1999].

network address translation,) or they may have IP addresses assigned on a long-term basis.

Consumers who connect to the Internet via a connection-oriented scheme, like PPP, are usually assigned an IP address upon establishing a connection. Customers who connect over a bridged or routed LAN typically obtain an IP address via the Dynamic Host Configuration Protocol (DHCP.) In either case, the ISP must manage the IP numbers it administers as well as the mechanisms for assigning IP addresses to users.

- **Directory Services:** The most commonly used directory service is the Domain Name Service (DNS,) which translates human-readable (or nearly human-readable) addresses like www.tprc.org into 32-bit binary IP addresses used by computers, like 10001101110100111100101100010101 (the address corresponding to www.tprc.org.) In the future, consumers will require simplified access to directory services required for telephony, conferencing, and other higher-level services marketed by ISPs.

  Also, if an ISP customer has registered a domain name, the ISP can perform the procedures necessary for maintaining information about the domain in the DNS hierarchy.

- **Outgoing packet routing and connectivity:** When a user transmits requests or data to a host computer, the ISP's network must direct the packet to the edge of its network and pass it to another provider that agrees to take traffic destined for the remote location. To forward packets to their destination optimally, the ISP must insure that its routers have up-to-date information about the best path to arbitrary points on the Internet.

  An ISP purchases or negotiates for services from other carriers on behalf of its customers. Lower-tier ISPs purchase transit on behalf of their customers from higher-tier ISPs; higher-tier ISPs provide transit, peering and interconnection services for their customers.

- **Incoming packet routing and connectivity**: Packets destined for a user from remote sites will be directed to the outside edge of the ISP's network. From there, the ISP is responsible for directing the packet to the user's computer.
- **Access:** All broadband access companies provide equipment at their end of the connection. They may also provide the customer premises equipment and the physical connection. Traditional dial-up ISPs and DSL providers using unbundled network elements supply only modem banks at the far end of the connection. Facilities based providers, such as ILECs, cable companies and wireless broadband companies, provide the physical medium.
- **Quality of Service & Network management**: ISPs typically make good-faith though nebulous promises about the quality of service their customers can expect. ISPs monitor the loads on their networks and servers and try to provision additional capacity as their customers' needs grow.

II. Application Services:

Application-level services offered by ISPs include the following:

- **Incoming mail services:** Email service is one of the most valued services delivered by an ISP. For individual consumers, incoming email services are typically provided by mail servers running the Post Office Protocol (POP) or the Internet Message Access Protocol (IMAP.) For both these protocols, the ISP must maintain a server to store email until customers retrieve it. For business customers, ISPs typically forward mail directly to a mail server maintained by the client, though some companies outsource maintenance of a mail server to their ISP. For both individual consumers and businesses, ISP mail servers must accept connections from outside mail servers and accept traffic addressed to customers of the ISP.
- **Outgoing mail services:** To send email, customers of an ISP must be able to connect to outgoing email servers, typically running the Simple Mail Transfer

Protocol (SMTP.) The ISP's mail servers accept mail from the user's machine, then forward mail to the destination email host.

- **Mail list services:** ISPs may offer customers mailing list services, including the ability to manage a mailing list.
- **Usenet news**: Most ISPs provide customers with access to news servers connected to Usenet news feeds using the Network News Transfer Protocol (NNTP.) In addition to the news feed, the ISP maintains a server from which customers can retrieve recent postings or make postings to Usenet.
- **Caching:** Content caching by ISPs could be considered a fundamental network service, since the decision to stage content closer to users is ultimately an engineering decision. But currently, caching is almost exclusively tied to one application: the web. In the future, other forms of content may be pushed near the edge of the network to hit the optimum mixture of cost and performance. Frequently requested web content that is cached locally at an ISPs minimizes traffic on the ISPs backbone connection and shortens the response time for web users. If managed properly, caching benefits both the ISP and the user.
- **Web hosting:** ISPs may provide web hosting or virtual web hosting services for customers.

III. Customer Relations

Finally, customer relations-level services offered by ISPs include:

- **Tech Support**: Customers expect their ISPs to provide help when they experience difficulty accessing online services.
- **Billing & Accounting**: With the exception of advertiser-supported Internet access, vendors of Internet access monitor and bill for their subscribers' use of resources.

- **Security & Confidentiality**: Technically, security can be implemented in the network infrastructure or by individual applications. ISPs maintain at least minimal levels of security, to prevent unauthorized users from accessing subscribers' email, and hacking users' web sites. ISPs may offer greater levels of security for customers engaged in e-commerce.

There are nearly countless possibilities for facilities- and non-facilities-based providers to divide the profile of services of interest to the ISP customer. Ultimately, service providers will choose a division of labor based on marketing decisions as well as details of the access network architecture.

Broadband Business Plans: Who does what?

If a cable company opens its network to competing ISPs, the ISP and the cable operator will be entering into a joint relationship with the ISP's customers. The ISP and the cable operator will be responsible for various elements of the service profile offered to subscribers. Exactly which services are to be performed by which party is for the ISP and the cable operator to determine. As illustrated in the following tables, there are dozens of decisions to be made about which company provides what services. (Table cells with more than one option indicate choices for providers and consumers to make.) Some of these decisions may be determined by technical constraints, but most are amenable to business analysis by the two parties, and should be resolved in favor of whoever can provide the most attractive solution.

First, consider the fundamental network and internetworking services:

I. Fundamental Networking & Internetworking Services	Who provides service: ISP or cable op?	comments:
IP number assignment	ISP ISP+cable	IP number must be from ISP's pool, but cable operator can issue number on behalf of ISP
Directory Services	ISP cable	Either ISP or cable op can provide directory services, but value of managing directories is likely to be
Outgoing packet routing and connectivity	ISP+cable cable	Either both must manage outgoing routing, or the ISP can outsource outgoing traffic to cable op. Outgoing traffic would then be sent directly out from cable 's network
Incoming packet routing and connectivity	ISP+cable	If the subscriber has an IP number from the ISP's pool, remote networks will forward packets to ISP. Both must be involved.
Access	cable	Only the cable company manages the physical connection.
Quality of Service & Network management	ISP+cable	Both the ISP and the cable op will be responsible for aspects of QoS.

Next, the application services provided to subscribers:

II. Application Services	Who provides service: ISP or cable op?	comments:
Incoming mail services	ISP	mail to the domain of the ISP will be handled by the ISP
Outgoing mail services	ISP cable	users may use outgoing mail servers of either ISP or cable op, if servers are configured appropriately
Mail list services	ISP third party	The ISP or a third party could offer mailing list services to subscribers
Usenet news	ISP third party	ISP could maintain news servers, or could outsource news services to cable operator or third party
Caching	ISP cable	ISPs could provide access to caches they maintain, or could outsource caching to cable op.
Web hosting	ISP third party	ISP or third party could host web sites.

Finally, the customer relations services:

III. Customer Relations	Who provides service: ISP or cable op?	comments:
Tech Support	ISP+cable	Both the ISP and the cable op would have to be involved in solving subscribers' problems
Billing & Accounting	ISP+cable	ISP would be responsible for billing; ISP and cable op would share responsibility for metering use and charges accrued by subscribers
Security & Confidentiality	ISP+cable	Both the ISP and the cable op could expose subscribers to security threats or could divulge private information.

The only service listed in the tables that must be performed by the cable operator is basic access. The only services that must be performed by the ISP are the issuance of an IP number (even if done through the cable ops hardware) and incoming mail queuing. There are many opportunities here for the cable operator to appropriate pieces of the value-added by alternative ISP. The cable operator could benefit both politically and financially through these open access arrangements. The cable operator earns points from regulators for opening up its network and earns money from competitive ISPs for performing services on their behalf.

Indeed, one competitive cable operator has announced that it will offer open access in its overbuild systems because open access looks like a money-making proposition. Colorado-based WideOpenWest hopes soon to be awarded franchises for cable systems in Denver and Boulder, Colorado. WideOpenWest will be building new cable plant, so it will not be limited by old cable data equipment.[9] It will be building open access into its systems from the start.

Integrators, SLAs & Verification

The simple who-does-what tables in the previous section included 8 services that could be offered by more than one provider. At a minimum, consumers might have to choose among at least 256 combinations of services and service providers. Such a menu would be daunting to industry experts. It would be even more intimidating to the average Internet user. What can be done to help subscribers decide what choices to make in broadband access? Eli Noam's [1994] suggestion that *integrators* step in to make technically complicated decisions for consumers in highly competitive markets seems to make sense here. Consumers would hire integrators to serve as agents to contract for the best service at the

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[9] Backover [2000].

best price and shield the consumer from the messy economic and technical details of how things get done.

In addition to finding the right product mix at the right price, integrators could also provide consumers with tools to assess the quality of the services that they are receiving. For example, one of the dangers of concentration in the broadband ISP market cited by open access proponents is that cable operators would preferentially cache content from affiliated content providers. An integrator monitoring the performance its customers get would be in a position to say whether the facility owner was playing games with connectivity.

There is a need here for an honest broker to represent the interests of the consumer. Consumers are, on average, poorly equipped to challenge the service that they receive from their communications providers. It is difficult and costly for consumers to aggregate their modest interests. Cable operators and their content affiliates, on the other hand, have very high incentives to cooperate. Their small number simplifies negotiations.

Moreover, differential caching and routing need not be blatant to be effective in steering consumers to preferred content. The subtle manipulation of the technical performance of the network can condition users to unconsciously avoid certain 'slower' web sites. A few extra milliseconds delay strategically inserted here and there, for example, can effectively shepherd users from one website to another. Given how impatient e-commerce customers are with slow web sites, it should not take much interference to effect a change in user behavior. The result would be the achievement in practice of a theoretical paradox first formulated by Yogi Berra: “Nobody goes to that site anymore. It’s too crowded.”

Since the strategic manipulation of network performance need not be flagrant to alter user behavior, it would be unwise to rely on human judgment to determine if some network administrators are favoring some content over other content on a network. Instead, an objective measure of the performance of the network is necessary. Monitoring the performance of the network would not only indicate if content discrimination is taking place, but it would also alert consumers when the performance of the network is below par. Depending on the specific problem a monitor might also be able to identify the source of the problem.

Integrators could install monitoring software on customers’ machines, measure the performance of the network, and aggregate the data across users to reveal any suspicious patterns. Consumers would not need to know—nor would they be interested in knowing—all the details measured by their integrators' network performance monitors. A simple thumbs-up or thumbs-down would indicate to the average consumer enough information about whether to get angry at the cable company, the ISP, or the kids down the street running Gnutella.

Conclusion:

In ruling against the city of Portland's open access requirements, the US 9th Circuit Court of Appeals has decided that "the transmission of Internet service to subscribers over cable broadband facilities is a telecommunications service under the Communications Act."[10]

Maybe cable companies really do see the Internet as just another piece of programming they offer to their subscribers, like a movie or a Bonanza rerun. But it is not the cable company that offers customers the content on the Internet—the publishers of the content that make it available. The Internet is just a medium for getting information from one point to another. The 9th Circuit was correct to characterize what cable companies do as a "telecommunications service," though cable companies also provide "information services," like conventional dial-up ISPs. In the Court's opinion:

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[10] AT&T, et. al. v. City of Portland, U.S. Court of Appeals, 9th Circuit, Appeal No. 99-35609, 6765.

> To the extent @Home is a conventional ISP, its activities are one of an information service. However, to the extent that @Home provides its subscribers Internet transmission over its cable broadband facility, it is providing a telecommunications service as defined in the Communications Act." [11]

The survey of ISP service profiles in this paper suggests that it may be no easier for the law to separate broadband access telecommunications services from broadband information services, as it is to separate a browser from an operating system.

To sell unbundled broadband access, facilities owners and reseller ISPs must untangle the mix of services that ISPs offer and decide who is responsible for providing which services and at what quality. The mechanisms for managing and insuring the quality of unbundled services, however, are not a high priority in the design of broadband networks. The natural inclination of facilities owners could be to build networks so hostile to open access that it would be prohibitively expensive ever to open them.

What measures can regulators take to encourage facilities owners from foreclosing open access through an engineering fait accompli? The FCC and Congress can continue to breathe over the shoulders of the cable industry. The results thus far have been good for open access, with agreements and test-beds in the works. The FCC could also formulate incentives for cable operators who construct open-access-ready networks. If cable operators build open-access-friendly networks, they may be more willing to let competition have a try on their networks. They might find that building walled gardens around proprietary content is not the best way to expand the broadband access market.

Much of the temptation to exclude other information providers has to do with a fixation on content. The mania for content may be self-defeating, however.

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[11] ibid. 6761.

Industry players are acting as though content is the only profitable market. Cable operators are jealously guarding their ability to control all forms of content flowing through their networks. Pure DSL players are making deals with content providers to try and increase the value they can present to their subscribers. But carriers and technology companies have tried to move into content before, without much success. One sure way to improve chances in the content market is to exclude the competition from the pipeline, but that may not be a wise long-term corporate strategy. It is certainly not in the public interest.

Besides, what's wrong with being a carrier? It might not be so bad being a carrier in a commodity bandwidth market, so long as the growth in consumption of bandwidth is fast enough. If the price elasticity of demand for bandwidth is significantly greater than one, and if demand grows exponentially, then carrier revenues will grow steadily, despite dropping prices for bandwidth.[12] If that is the case, a wise posture for a broadband access carrier might be to open up the network to any and all content creators, maximize the volume of traffic flowing over the access pipeline, and watch the revenues flow.

Finally, the numerous possibilities for combining services and service providers suggest that policy makers would benefit from a more complex analysis of broadband market structure. The economic and engineering linkages among the many services that make up broadband must be explored more thoroughly. Conclusions drawn by analyzing service markets in isolation will not resolve the larger policy issues driving the open access debate.

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[12] See Lanning, O'Donnell & Neuman [2000] for an elaboration of this argument.

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