Network and internet connections 3473 essay

The Internet is a network of networks that interconnects computers around the

world, supporting both business and residential users. In 1994, a multimedia

Internet application known as the World Wide Web became popular. The higher

bandwidth needs of this application have highlighted the limited Internet access

speeds available to residential users. Even at 28. 8 Kilobits per second

(Kbps)—the fastest residential access commonly available at the time of this

writing—the transfer of graphical images can be frustratingly slow. This

report examines two enhancements to existing residential communications

infrastructure: Integrated Services Digital Network (ISDN), and cable television

networks upgraded to pass bi-directional digital traffic (Cable Modems). It

analyzes the potential of each enhancement to deliver Internet access to

residential users. It validates the hypothesis that upgraded cable networks can

deliver residential Internet access more cost-effectively, while offering a

broader range of services. The research for this report consisted of case

studies of two commercial deployments of residential Internet access, each

introduced in the spring of 1994: · Continental Cablevision and Performance

Systems International (PSI) jointly developed PSICable, an Internet access

service deployed over upgraded cable plant in Cambridge, Massachusetts; ·

Internex, Inc. began selling Internet access over ISDN telephone circuits

available from Pacific Bell. Internex's customers are residences and small

businesses in the " Silicon Valley" area south of San Francisco,

California. 2. 0 The Internet When a home is connected to the Internet,

residential communications infrastructure serves as the " last mile" of

the connection between the home computer and the rest of the computers
on the

Internet. This section describes the Internet technology involved in that

connection. This section does not discuss other aspects of Internet
technology

in detail; that is well done elsewhere. Rather, it focuses on the services that

need to be provided for home computer users to connect to the Internet. 2. 1
ISDN

and upgraded cable networks will each provide different functionality (e. g.
type

and speed of access) and cost profiles for Internet connections. It might seem

simple enough to figure out which option can provide the needed level of service

for the least cost, and declare that option " better." A key problem

with this approach is that it is difficult to define exactly the needed level of

service for an Internet connection. The requirements depend on the applications

being run over the connection, but these applications are constantly changing.

As a result, so are the costs of meeting the applications' requirements. Until

about twenty years ago, human conversation was by far the dominant application

running on the telephone network. The network was consequently optimized to

provide the type and quality of service needed for conversation. Telephone

traffic engineers measured aggregate statistical conversational patterns and

sized telephone networks accordingly. Telephony's well-defined and stable

service requirements are reflected in the " 3-3-3" rule of thumb relied

on by traffic engineers: the average voice call lasts three minutes, the user

makes an average of three call attempts during the peak busy hour, and the call

travels over a bidirectional 3 KHz channel. In contrast, data communications are

far more difficult to characterize. Data transmissions are generated by computer

applications. Not only do existing applications change frequently (e. g. because

of software upgrades), but entirely new categories—such as Web browsers—come

into being quickly, adding different levels and patterns of load to existing

networks. Researchers can barely measure these patterns as quickly as they are

generated, let alone plan future network capacity based on them. The one

generalization that does emerge from studies of both local and wide- area data

traffic over the years is that computer traffic is bursty. It does not flow in

constant streams; rather, " the level of traffic varies widely over almost

any measurement time scale" (Fowler and Leland, 1991). Dynamic bandwidth

allocations are therefore preferred for data traffic, since static allocations

waste unused resources and limit the flexibility to absorb bursts of traffic.

This requirement addresses traffic patterns, but it says nothing about the

absolute level of load. How can we evaluate a system when we never know how much

capacity is enough? In the personal computing industry, this problem is solved

by defining " enough" to be " however much I can afford

today," and relying on continuous price-performance improvements in digital

technology to increase that level in the near future. Since both of the

infrastructure upgrade options rely heavily on digital technology, another

criteria for evaluation is the extent to which rapidly advancing technology can

be immediately reflected in improved service offerings. Cable networks satisfy

these evaluation criteria more effectively than telephone networks because:
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Coaxial cable is a higher quality transmission medium than twisted copper wire

pairs of the same length. Therefore, fewer wires, and consequently fewer pieces

of associated equipment, need to be installed and maintained to provide the same

level of aggregate bandwidth to a neighborhood. The result should be cost

savings and easier upgrades. · Cable's shared bandwidth approach is more

flexible at allocating any particular level of bandwidth among a group of

subscribers. Since it does not need to rely as much on forecasts of which

subscribers will sign up for the service, the cable architecture can adapt more

readily to the actual demand that materializes. · Telephony's dedication of

bandwidth to individual customers limits the peak (i. e. burst) data rate that

can be provided cost-effectively. In contrast, the dynamic sharing enabled by

cable's bus architecture can, if the statistical aggregation properties of

neighborhood traffic cooperate, give a customer access to a faster peak data

rate than the expected average data rate. 2. 2 Why focus on Internet access?

Internet access has several desirable properties as an application to consider

for exercising residential infrastructure. Internet technology is based on a

peer-to-peer model of communications. Internet usage encompasses a wide mix of

applications, including low- and high- bandwidth as well as asynchronous and

real-time communications. Different Internet applications may create varying

degrees of symmetrical (both to and from the home) and asymmetrical traffic

flows. Supporting all of these properties poses a challenge for existing

residential communications infrastructures. Internet access differs from the

future services modeled by other studies described below in that it is a real

application today, with growing demand. Aside from creating pragmatic interest

in the topic, this factor also makes it possible to perform case studies of real

deployments. Finally, the Internet's organization as an " Open Data

Network" (in the language of (Computer Science and Telecommunications Board

of the National Research Council, 1994)) makes it a service worthy of study from

a policy perspective. The Internet culture's expectation of interconnection and

cooperation among competing organizations may clash with the monopoly-oriented

cultures of traditional infrastructure organizations, exposing policy issues. In

addition, the Internet's status as a public data network may make Internet

access a service worth encouraging for the public good. Therefore, analysis of

costs to provide this service may provide useful input to future policy

debates.

3. 0 Technologies This chapter reviews the present state and technical evolution

of residential cable network infrastructure. It then discusses a topic not

covered much in the literature, namely, how this infrastructure can be used to

provide Internet access. It concludes with a qualitative evaluation of the

advantages and disadvantages of cable-based Internet access. While ISDN is

extensively described in the literature, its use as an Internet access medium is

less well-documented. This chapter briefly reviews local telephone network

technology, including ISDN and future evolutionary technologies. It concludes

with a qualitative evaluation of the advantages and disadvantages of ISDN-based

Internet access. 3. 1 Cable Technology Residential cable TV networks follow the

tree and branch architecture. In each community, a head end is installed to

receive satellite and traditional over-the-air broadcast television signals.

These signals are then carried to subscriber's homes over coaxial cable that

runs from the head end throughout the community Figure 3. 1: Coaxial cable

tree-and-branch topology To achieve geographical coverage of the community, the

cables emanating from the head end are split (or " branched") into

multiple cables. When the cable is physically split, a portion of the signal

power is split off to send down the branch. The signal content, however, is not

split: the same set of TV channels reach every subscriber in the community. The

network thus follows a logical bus architecture. With this architecture, all

channels reach every subscriber all the time, whether or not the subscriber's TV

is on. Just as an ordinary television includes a tuner to select the

over-the-air channel the viewer wishes to watch, the subscriber's cable

equipment includes a tuner to select among all the channels received over the

cable. 3. 1. 1. Technological evolution The development of fiber-optic

transmission technology has led cable network developers to shift from the

purely coaxial tree-and-branch architecture to an approach referred to as Hybrid

Fiber and Coax(HFC) networks. Transmission over fiber-optic cable has two main

advantages over coaxial cable: · A wider range of frequencies can be sent over

the fiber, increasing the bandwidth available for transmission; · Signals can

be transmitted greater distances without amplification. The main disadvantage of

fiber is that the optical components required to send and receive data over it

are expensive. Because lasers are still too expensive to deploy to each

subscriber, network developers have adopted an intermediate Fiber to the

Neighborhood (FTTN)approach. Figure 3. 3: Fiber to the Neighborhood (FTTN)

architecture Various locations along the existing cable are selected as sites

for neighborhood nodes. One or more fiber-optic cables are then run from the

head end to each neighborhood node. At the head end, the signal is converted

from electrical to optical form and transmitted via laser over the fiber. At the

neighborhood node, the signal is received via laser, converted back from optical

to electronic form, and transmitted to the subscriber over the neighborhood's

coaxial tree and branch network. FTTN has proved to be an appealing architecture

for telephone companies as well as cable operators. Not only Continental

Cablevision and Time Warner, but also Pacific Bell and Southern New England

Telephone have announced plans to build FTTN networks. Fiber to the neighborhood

is one stage in a longer-range evolution of the cable plant. These longer-term

changes are not necessary to provide Internet service today, but they might

affect aspects of how Internet service is provided in the future. 3. 2 ISDN

Technology Unlike cable TV networks, which were built to provide only local

redistribution of television programming, telephone networks provide
switched,

global connectivity: any telephone subscriber can call any other telephone

subscriber anywhere else in the world. A call placed from a home travels first

to the closest telephone company Central Office (CO) switch. The CO switch

routes the call to the destination subscriber, who may be served by the same
CO

switch, another CO switch in the same local area, or a CO switch reached
through

a long- distance network. Figure 4. 1: The telephone network The portion of
the

telephone network that connects the subscriber to the closest CO switch is

referred to as the local loop. Since all calls enter and exit the network via

the local loop, the nature of the local connection directly affects the type of

service a user gets from the global telephone network. With a separate pair
of

wires to serve each subscriber, the local telephone network follows a logical

star architecture. Since a Central Office typically serves thousands of

subscribers, it would be unwieldy to string wires individually to each home.

Instead, the wire pairs are aggregated into groups, the largest of which are

feeder cables. At intervals along the feeder portion of the loop, junction
boxes

are placed. In a junction box, wire pairs from feeder cables are spliced to
wire

pairs in distribution cables that run into neighborhoods. At each subscriber

location, a drop wire pair (or pairs, if the subscriber has more than one line)

is spliced into the distribution cable. Since distribution cables are either

buried or aerial, they are disruptive and expensive to change. Consequently,
a

distribution cable usually contains as many wire pairs as a neighborhood
might

ever need, in advance of actual demand. Implementation of ISDN is
hampered by

the irregularity of the local loop plant. Referring back to Figure 4. 3, it is

apparent that loops are of different lengths, depending on the subscriber's

distance from the Central Office. ISDN cannot be provided over loops with

loading coils or loops longer than 18, 000 feet (5. 5 km). 4. 0 Internet Access

This section will outline the contrasts of access via the cable plant with

respect to access via the local telephon network. 4. 1 Internet Access Via
Cable

The key question in providing residential Internet access is what kind of

network technology to use to connect the customer to the Internet For

residential Internet delivered over the cable plant, the answer is broadband
LAN

technology. This technology allows transmission of digital data over one or
more

of the 6 MHz channels of a CATV cable. Since video and audio signals can
also be

transmitted over other channels of the same cable, broadband LAN
technology can

co-exist with currently existing services. Bandwidth The speed of a cable LAN
is

described by the bit rate of the modems used to send data over it. As this

technology improves, cable LAN speeds may change, but at the time of this

writing, cable modems range in speed from 500 Kbps to 10 Mbps, or roughly 17 to

340 times the bit rate of the familiar 28. 8 Kbps telephone modem. This speed

represents the peak rate at which a subscriber can send and receive data, during

the periods of time when the medium is allocated to that subscriber. It does not

imply that every subscriber can transfer data at that rate simultaneously. The

effective average bandwidth seen by each subscriber depends on how busy the LAN

is. Therefore, a cable LAN will appear to provide a variable bandwidth

connection to the Internet Full-time connections Cable LAN bandwidth is

allocated dynamically to a subscriber only when he has traffic to send. When he

is not transferring traffic, he does not consume transmission resources.

Consequently, he can always be connected to the Internet Point of Presence

without requiring an expensive dedication of transmission resources. 4. 2

Internet Access Via Telephone Company In contrast to the shared-bus architecture

of a cable LAN, the telephone network requires the residential Internet provider

to maintain multiple connection ports in order to serve multiple customers

simultaneously. Thus, the residential Internet provider faces problems of

multiplexing and concentration of individual subscriber lines very similar to

those faced in telephone Central Offices. The point-to-point telephone network

gives the residential Internet provider an architecture to work with that is

fundamentally different from the cable plant. Instead of multiplexing the use of

LAN transmission bandwidth as it is needed, subscribers multiplex the use of

dedicated connections to the Internet provider over much longer time intervals.

As with ordinary phone calls, subscribers are allocated fixed amounts of

bandwidth for the duration of the connection. Each subscriber that succeeds in

becoming active (i. e. getting connected to the residential Internet provider

instead of getting a busy signal) is guaranteed a particular level of bandwidth

until hanging up the call. Bandwidth Although the predictability of this

connection-oriented approach is appealing, its major disadvantage is the limited

level of bandwidth that can be economically dedicated to each customer. At most,

an ISDN line can deliver 144 Kbps to a subscriber, roughly four times the

bandwidth available with POTS. This rate is both the average and the peak data

rate. A subscriber needing to burst data quickly, for example to transfer a

large file or engage in a video conference, may prefer a shared-bandwidth

architecture, such as a cable LAN, that allows a higher peak data rate for each

individual subscriber. A subscriber who needs a full-time connection requires a

dedicated port on a terminal server. This is an expensive waste of resources

when the subscriber is connected but not transferring data. 5. 0 Cost Cable-based

Internet access can provide the same average bandwidth and higher peak bandwidth

more economically than ISDN. For example, 500 Kbps Internet access over cable

can provide the same average bandwidth and four times the peak bandwidth of ISDN

access for less than half the cost per subscriber. In the technology reference

model of the case study, the 4 Mbps cable service is targeted at organizations.

According to recent benchmarks, the 4 Mbps cable service can provide the same

average bandwidth and thirty-two times the peak bandwidth of ISDN for only 20%

more cost per subscriber. When this reference model is altered to target 4 Mbps

service to individuals instead of organizations, 4 Mbps cable access costs 40%

less per subscriber than ISDN. The economy of the cable-based approach is most

evident when comparing the per-subscriber cost per bit of peak bandwidth: $0. 30

for Individual 4 Mbps, $0. 60 for Organizational 4 Mbps, and $2 for the 500 Kbps

cable services—versus close to $16 for ISDN. However, the potential

penetration of cable- based access is constrained in many cases (especially for

the 500 Kbps service) by limited upstream channel bandwidth. While the

penetration limits are quite sensitive to several of the input parameter

assumptions, the cost per subscriber is surprisingly less so. Because the models

break down the costs of each approach into their separate components, they also

provide insight into the match between what follows naturally from the

technology and how existing business entities are organized. For example, the

models show that subscriber equipment is the most significant component of

average cost. When subscribers are willing to pay for their own equipment, the

access provider's capital costs are low. This business model has been

successfully adopted by Internex, but it is foreign to the cable industry. As

the concluding chapter discusses, the resulting closed market structure for

cable subscriber equipment has not been as effective as the open market for ISDN

equipment at fostering the development of needed technology. In addition,

commercial development of both cable and ISDN Internet access has been hindered

by monopoly control of the needed infrastructure—whether manifest as high ISDN

tariffs or simple lack of interest from cable operators.