MIT
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"Local Access to the Communications Infrastructure"*

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Massachusetts Institute of Technology

Tom Kalil: I want to talk about the Clinton Administration's views and visions with respect to the National Information Infrastructure (NII). The Administration is technology-neutral. We don't care whether the underlying technology that is used to move the bits is fiber, coax, twisted pair or wireless. But we do have a preference regarding the overall architecture and its capabilities. We would like to see an infrastructure that 1) supports many-to-many communications and a wide variety of applications; 2) has very low barriers to publishing; 3) has low barriers to entry by new network service providers; and 4) enables us to take advantage of the rapid technological change that is occurring in information technology.

There are three main questions regarding the NII. The first is whether the administration's goals are desirable. The second issue is whether market forces are sufficient to get us there. Firms are already working on the problem of how to deploy infrastructure that will support a wide range of profitable applications. The third question regarding the NII is how government and industry can partner to promote this architecture, whether you want to call it a Jeffersonian architecture or an Open Data Network. There are several ways that government, industry and academia can form a partnership which do not involve traditional government regulation — for example government sponsorship of R&D and of test beds.

Branko Gerovac: Local access is both a critical component, and a potential barrier, to achieving the kinds of promises, functions and applications that people have talking about for an information infrastructure — whether it is a community, national or global infrastructure. A large company or institution with sufficient funds can get full access to the Internet or any information service that is available. But individuals do not have many options. What we get into the home currently is through the telephone and cable, and the services are very limited. We can overlay a data modem on top of telephone, but we are restricted to relatively low bandwidth. So to get the kinds of services people are talking abut, we need to get past the current barriers to access. Improving access will affect small businesses in a positive way, and it will enhance individuals' lives in terms of their work, their lifestyles and their learning. However, when people talk about universal access, we must keep in mind that the costs for local access deployment are somewhere between $100 and $500 billion.

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* This is an edited summary, not a complete transcript of the speakers' remarks.

There are technical, economic and regulatory requirements for local access. One technical requirement is critical bandwidth steps, meaning bandwidth levels below which you cannot deliver a certain level of service and above which a whole bunch of services are opened up. There is some speculation that around three megabits per second could be a critical bandwidth step. A second requirement is bandwidth symmetry and asymmetry. Symmetry provides the low barrier for publishing that Tom Kalil talked about. Another technical issue is quality of services. Finally, what are going to be the pivotal standards? The recent NRC report suggested the notion of a bearer services as a key pivotal standard upon which the rest of the infrastructure could be built. Several traditional concepts have shown up repeatedly in architectural and communications design over the past few decades and are relevant in the context of local access. These are: 1) interoperability; 2) extensibility; 3) scalability; 4) cross-industry harmonization; 5) digital technology and 6) open architecture.

From a economic/business perspective, we want non-proprietary systems with barrier-free market entry. We want to see a transition from separate networking systems for telephone, television and computing to a situation of interaction. Non-partitioned networks will help to leverage consumer and business investments. In addition, we must make sure that the technology and equipment are easy to use, and that there is location independence and mobility. All these problems are being worked on. Finally, we must face business realities. I have yet to see a business plan that really makes money doing any of this. Until we have such a plan, venture capitalists will not go out and support the deployment of these kinds of networks in large numbers. A big question is who pays for the infrastructure upgrade. There has been a lot of discussion with Pac Bell that the upgrade should be paid for by the rate base of the telephone subscribers, but there are a lot to challenges to this idea.

In the policy area, tensions have built up between the desire to promote deregulation and competition, and the desire to promote broad national interests. As Tom Kalil mentioned, there are certain things that really are in the national interest, but they will in some cases run against interests in deregulation. Also on the policy side, we want to promote universal access but also maintain data integrity, individual privacy and security in the overall system and transmission.

David Fellows: The traditional technology used for wired cable television systems worked pretty well when we only had 30 channels of video and we were just a one-way bandwidth provider of video entertainment. But as we increased the number of channels, started looking towards reverse communications, and began facing real competition, it became clear that the traditional architecture had its limitations. Fortunately fiber optic technology showed up at about this time, in a format we could use. At Continental, we are using fiber in two different ways. First, we are running it out to the neighborhoods through different pocket of homes. Since there is not enough bandwidth for all 40,000 dwelling units in Cambridge to share, we have broken up the city into 21 different systems so we can target the bandwidth. We are also using fiber optics to tie isolated franchises together into regional networks. Fiber links greatly improve the end-of-line reliability and transmission quality. They also reduce maintenance demands and enhance the ability to widen the bandwidth. Having fiber replace the trunk also saves money, and it provides a network which is ready for other services. The first fiber architecture that was developed was fiber to the side of the home. Then came fiber to the curb, which allows cost-sharing among homes. Next the concept of hybrid fiber-coax (fiber to the serving area) was developed, which allows additional cost sharing among homes. Now telephone companies, having won the right to provide video dial-tone to the home, are caught in a dilemma between choosing fiber to the curb and fiber to the serving area, because they want the cost-savings of the latter but the individual targetability of the former.

There are many access pipes to the home. If the regulations allow it, pipes will be provided by both cable and telephone companies. We also face a lot of wireless competition, including cellular telephony and PCS. These may not be broadband but they are two-way. We also face competition from TV broadcast stations which have been allocated an extra six megahertz to allow a digital high-definition TV broadcast signal. There is also direct broadcast satellite, microwave, and wireless cable TV. So there are many alternatives. However, it is not

clear they can all survive unless the total pie grows to $3.5 trillion to support them all. As for Continental, we are busy putting fiber out to neighborhoods across the country. We are also doing some telecommuting experiments and we are doing telephony in Australia. We hope to apply these lessons to the U.S. when the regulations allow us to.

Robert Berger: When I started Internex in 1993, my original intention was not to be an Internet service provider but to offer tools and services for the Internet. What I quickly discovered is that most people cannot get at the Internet fast enough to utilize graphical user interfaces, rich text or imagery. So I went around asking Internet providers when they would be offering Internet access via ISDN. Nobody seemed to know what I was talking about until I found someone inside Pac Bell that knew about ISDN. Although it is a low speed Internet access technology compared to LANs and ATM, it is significantly faster than analog modems. But unlike other technologies it is inexpensive and can be used today.

In terms of the impact of the existing ISDN infrastructure on accessing the Internet, there are three key issues: 1) availability, 2) tariffs and 3) the technology. Regarding availability, most of the regional Bells have substantial ISDN deployment in their switches and are equipped to offer ISDN. The highest mark is 90% deployment in their central offices; this is for Bell Atlantic. Most of the RBOCs are in the 70% range. This means they are ready to offer ISDN, although they still have to worry about upgrading their switches. One of the breakthroughs that happened earlier this year is that Bellcore, the research arm for the phone companies, came up with the concept of "ISDN anywhere". This means that if the phone company does not have ISDN service at the switch you are talking to, they could bring it from the nearest switch. The main barrier is tariffs, not technology. Usage fees for ISDN are the largest impediment. These fees range from flat rates to 5 cents per minute, and the monthly fees range from $25 to $85 per month. What we are seeing is that if the usage fees are the same rate as voice, then people will consider using it. When fees are at the 5 cent per minute rate, people will not consider using it.

What are the advantages of ISDN? The biggest one is that it is four to 10 times faster than regular analog modems. This is still not anywhere near Ethernet speeds, but it crosses the barrier where you get between 56 to 128 kilobits per second of raw speed and you can start using things like Mosaic and Netscape. Another advantage is that ISDN has very fast call setup. With a modem it takes four to 10 seconds to dial, then 30 seconds to a minute for the modems to negotiate. With ISDN, it is all digital call set up and it can happen in less than one second. Even though the speed of ISDN is lower than a lot of the options of the future, ISDN has the advantage that it can be deployed rapidly with very little new infrastructure needed. ISDN has its limitations, however. It is still a dialup technology. To use it for Internet access, you still need some kind of local point-of-presence. The Internet provider must have a facility within a 12-mile radius of the customer. It is not a great solution for people who want to have servers on the Net. But it is excellent for people who want to go and surf the Net. The fast auto call setup and breakdown makes it look to the user like he is always connected. The downside is that only certain equipment will support this. ISDN can also be used to connect an entire LAN because it uses packet transport, which is useful if you have a small business. We are experimenting with a service for people who want to put up low volume servers, in which we would call the customers if there are packets waiting for them. This is a cost-effective alternative to a nailed-up connection or T1 line. To conclude, ISDN can be delivered now whereas a lot of the other technologies will require years of upgrading and deployment. Even though it does not deliver the performance of other servers, it gets people on the Net today so they can start using the many-to-many information structures. ISDN is also cost-effective. The costs are in line with customer expectations and I think the bandwidth will come along to fill out customer needs. ISDN is poised as the first practical on-ramp to the National Information Infrastructure.

Sharon Gillett: My talk compares two ways of providing Internet access to homes, through cable and ISDN systems. We can compare Internet access through cable and through ISDN on a number of dimensions. First is peak bandwidth. Cable offers 500 Kbps or 4 Mbps while ISDN offers only 128 Kbps. However, while cable has higher bandwidth, it is shared,

whereas with ISDN or any telephone-based approach, each individual gets his own bandwidth. It is hard to compare the two approaches without knowing how many people will be able to share the network. I made a very conservative assumption, which takes the mindset of the subscriber. I assumed that people want to do file transfers all the time at the maximum rate they could get with the alternative technology. So I assume that average bandwidth for both cable and ISDN is 120 Kbps. With ISDN, local performance will not vary unless there is some other bottleneck somewhere else on the Internet. But since cable is shared, local performance could vary depending on how many of your neighbors are using it at the same time. Connectivity is full-time for cable. But it is part-time for ISDN. If you want Internet over cable you have to live in Cambridge. Internet over ISDN is more widely available. In terms of limits to growth, the upstream channels are a definite limit on the cable side. On the other hand, ISDN is provided over existing copper pairs. There is a problem if everyone wants ISDN service in addition to their existing analog phone service, because there would not be enough pairs.

I built some models to estimate the costs of ISDN versus cable, based on case studies of PSI cable in Cambridge and Internex in California. I considered the subscriber universe to consist of people who already have a computer in their home — about 1/3 of the U.S. population. I found that the average cost of the 500 kilobit cable service was lower than the average cost of the ISDN service, even though the cable system provides a higher peak bandwidth. The average cost of the 4 Mbps cable service is slightly higher when targeted at organizations, but 40% lower than ISDN when targeted at individuals. However, the 500 Kbps cable service stops at a certain point. When you can only have four upstream channels you can't serve everyone because there is not enough bandwidth under the 120-kilobit assumption I made. Overall, then, I found that cable gives a higher peak bandwidth for less cost. There is a huge discrepancy between cable and ISDN on this measure. I also found that the cost of the equipment at each subscriber's house is a big portion of the total cost. But if subscriber equipment becomes cheaper, then it will be possible to provide both the 4 Mbps and the 500 Kbps cable service at a lower cost than the 128 Kbps ISDN service.

Even though cable may be cheaper, however, the ISDN system is available now, but you can't buy the cable systems I am talking about. It is necessary to consider the barriers to deployment of these advanced systems. In cable plants, the modem technology — which has been engineered for TV — is very immature. Another issue is that businesses do not really use cable while they do use ISDN. This allows the home market to bootstrap off the business side in ISDN but not in cable. And on the cable side, there is the limitation of closed access to channels. Entrepreneurs with good ideas like high-speed Internet access must go through the local cable company which owns the channels. On the ISDN side, which is governed by the common carriage model, this is not a problem. However, as Robert Berger mentioned, an important barrier to deployment on the ISDN is the existence of high tariffs in many states.

David Clark: An important point is that it will cost a lot of money to reach people's homes. We hear figures in the range of $50 or $100 billion. It doesn't make sense to blow that kind of money on a field of dreams. We do not know which services and applications will make money. There is no viable business plan, which is alarming. Another theme that I find contradictory is the idea the NII should be built through private enterprise, not government. But if there is no viable business plan, this is a contradiction. I also wonder if competition is the right model to implement the local loop. Maybe we should all agree that it is a natural monopoly, and we should bound the scope of that monopoly to the smallest piece that you can get your hands on, in other words to the end of the wire. The only reason I think people are so enthusiastic about competition is that nobody trusts the government. I also wonder if a different technological approach, such as wireless, would be appropriate to prove the existence of a market for services. Perhaps the government should fund and drive some new technology options. Given the societal objectives we have talked about, will wired cable or ISDN technology actually achieve these goals?

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Local Access to the Information Infrastructure

—

90% Done

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Bell Atlantic
Halts Plan for Video Services

NYT, April 26 1995, D1

"The Bell Atlantic Corporation called an abrupt halt to its scramble into television yesterday. Saying it wanted to rethink its strategy for upgrading its telephone network..."

Why Local Access ?

Local access is a critical component and potential barrier to achieving the promises of an Information Infrastructure, whether we're talking about Community, National, or Global Infrastructure.

Local Access Requirements
The New Agenda

Technical

- Critical Bandwidth Steps (and Latency Characteristics)
- Bandwidth Symmetry/Asymmetry
- Quality Of Service
  - negotiated transport characteristics
  - minimum service guaranties
  - negotiated graceful degradation
  - etc.
- Peer-to-peer verses Master-slave
- Pivotal Standards

Traditional Concepts

- Interoperability
- Extensibility
- Scalability
- Cross-Industry Harmonization
- Digital Technology
- Open Architecture

Business/Economics

- Barrier Free Market Entry
  /Non-Proprietary
- Telephone, Television, and Computing
  -> Content, Communications, and Interaction
- Economies Of Scale
  /Leverage Consumer Investments
  /Leverage Business Investments
  /Non-Partitioned
- Mass Market Attributes
  /Plug-n-Play
- Location Independence/Mobility
- Deployment Realities
  /Business Plan Realities
  /Who Pays for the Infrastructure Upgrade

Policy / Legislation / Regulation

- Deregulation vs National Interests
- Competitive / Non-Monopolistic
- Universal Access / Universal Service
- Integrity / Privacy / Security

10% Solution

90:10 Rule

90% Done – 90% To Go

Connecting Homes to the Internet: An Engineering Cost Model of Cable vs. ISDN

Sharon Eisner Gillett

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Telemedia, Networks & Systems Group,
MIT Laboratory for Computer Science

MIT COMMUNICATIONS FORUM, APRIL 27, 1995

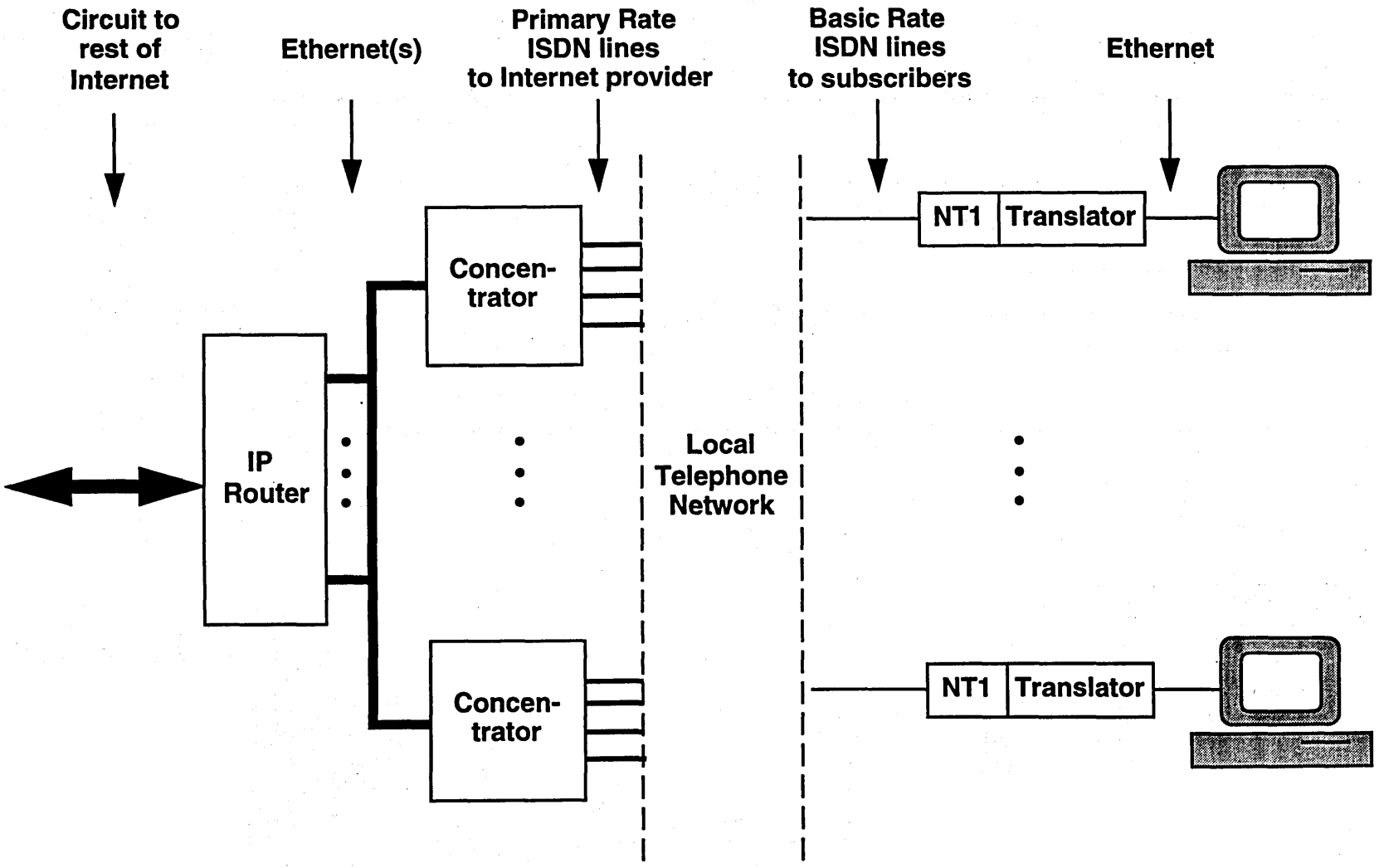
Why Internet?

- Good test for infrastructure
  - Wide mix of applications, including multimedia
  - Peer-to-peer architecture
- Open, non-proprietary network

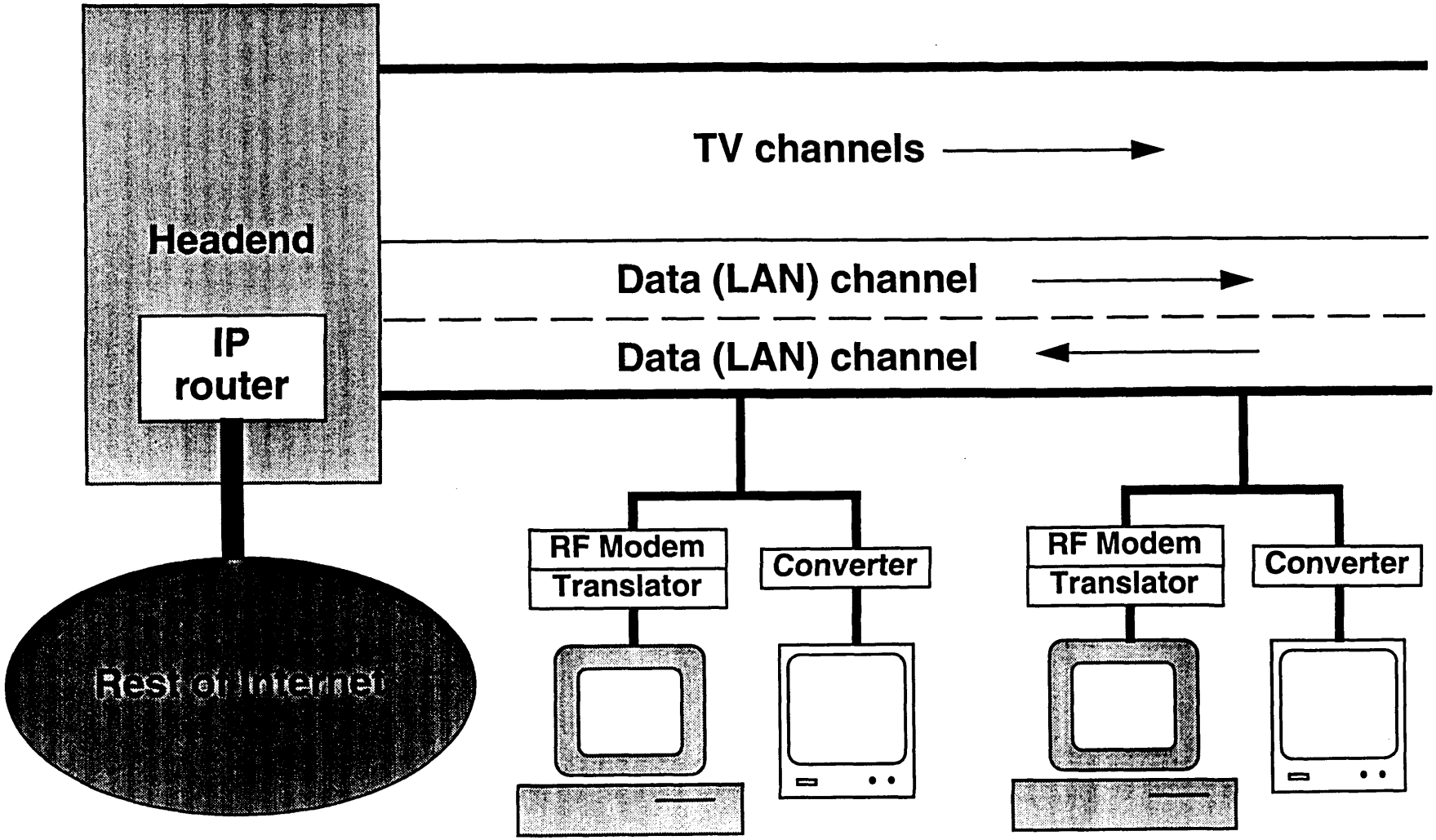
Why Homes?

- Hard infrastructure problem
- Reach:
  - consumers
  - citizens
  - my mother

Internet access via ISDN



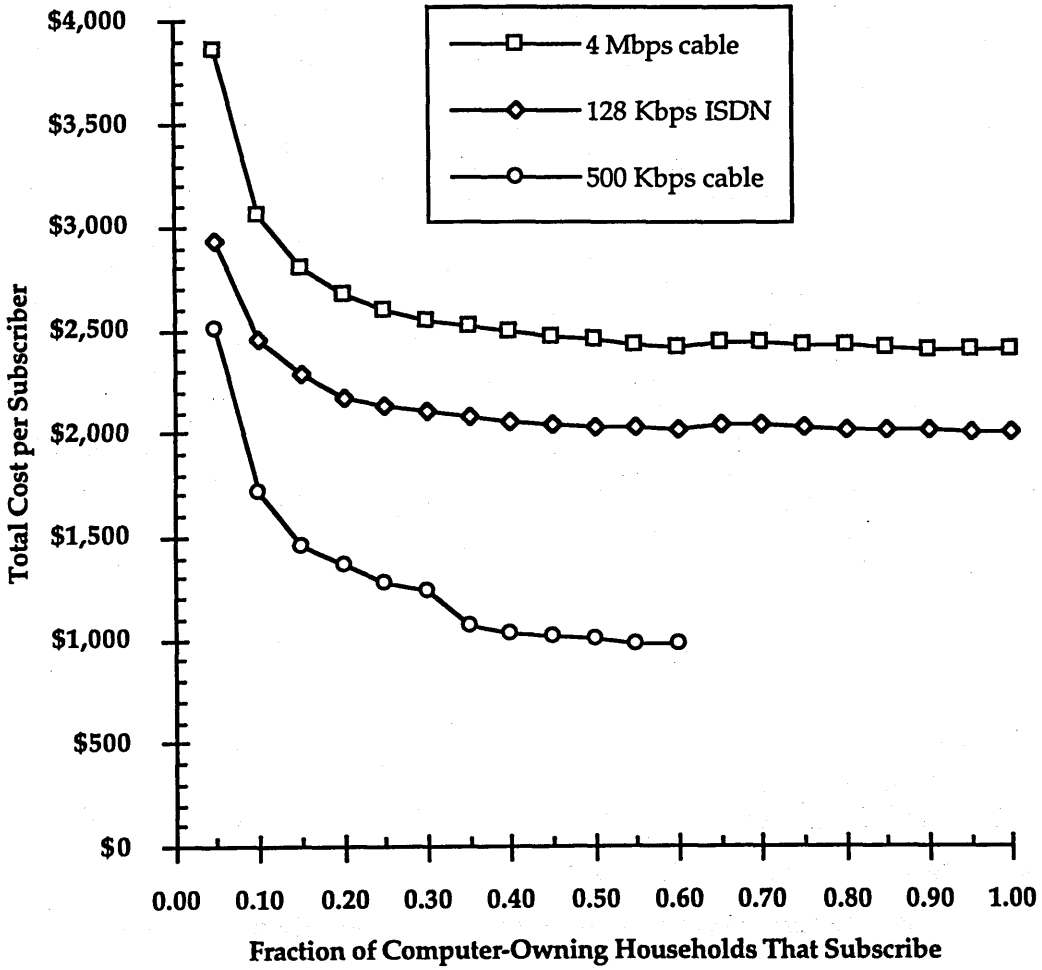
Internet access via cable



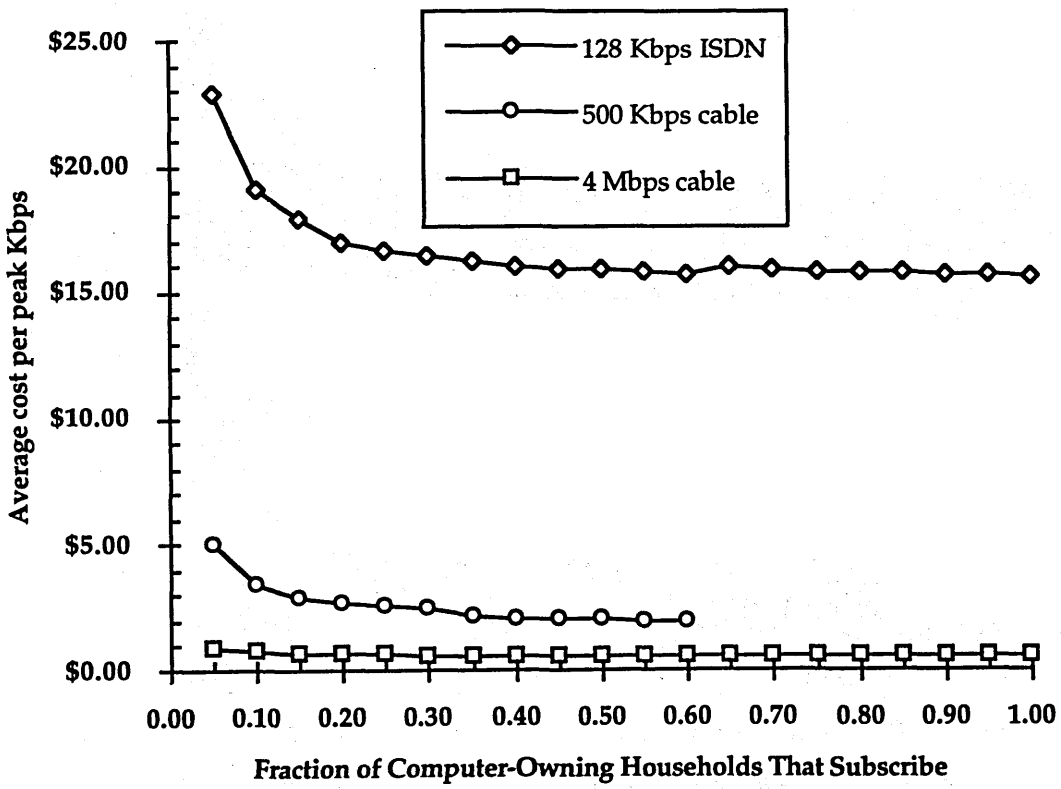
Comparison of approaches

	Cable	ISDN
Peak bandwidth	500 Kbps or 4 Mbps	128 Kbps
Average bandwidth	Assume 120 Kbps	120 Kbps
Perceived service	Variable	Local performance guaranteed
Connectivity	Full-time	Part-time
Availability	Cambridge, MA	Nationwide
Limits to growth	Upstream channels	$$

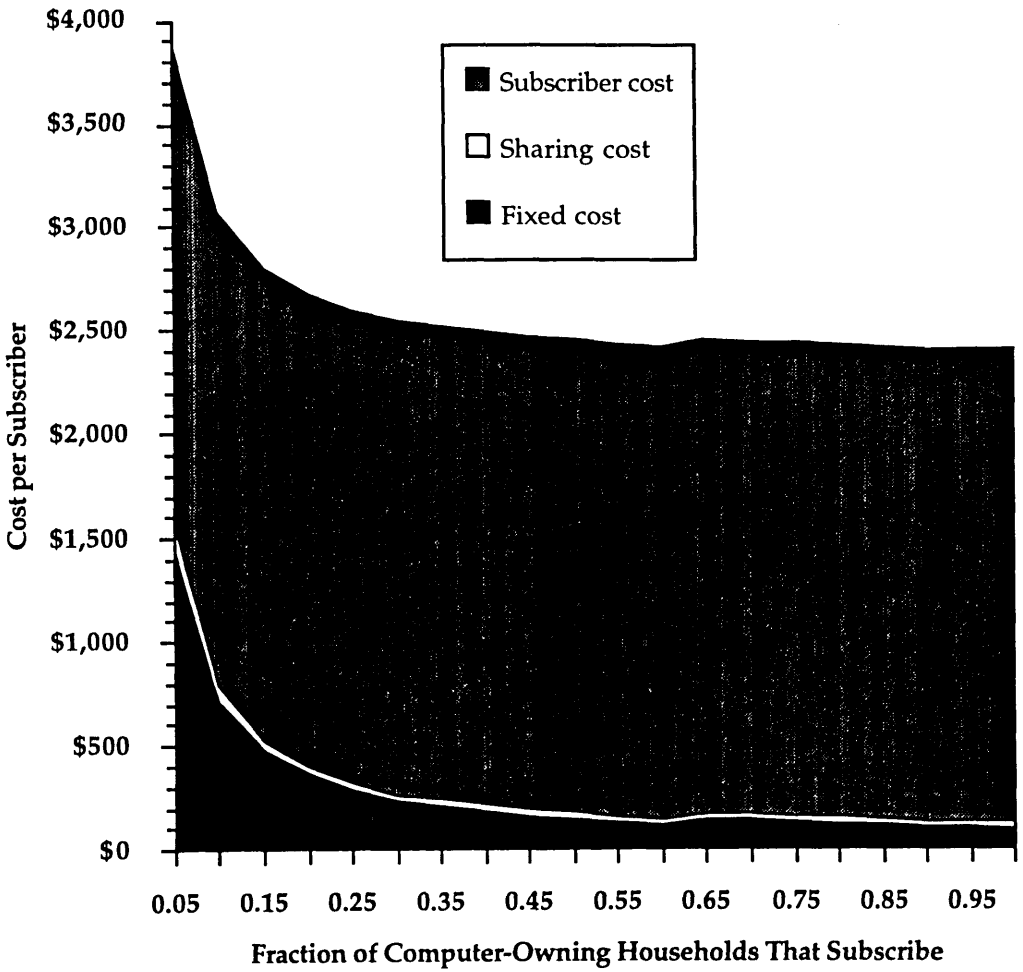
Results: Average cost



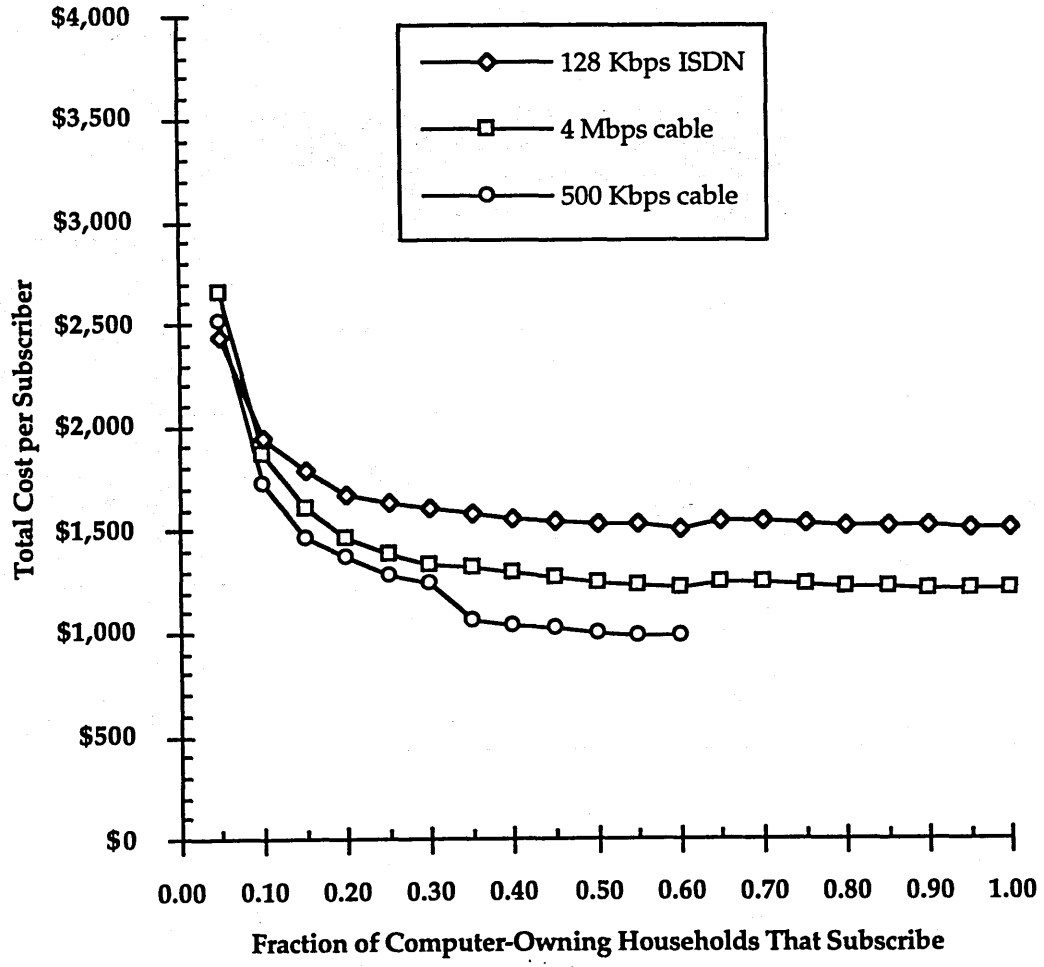
Cable: higher peak bandwidth for less cost



Subscriber cost dominates



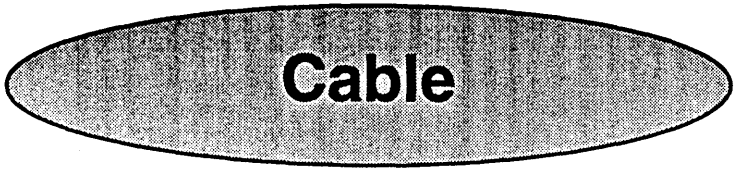
What if subscriber equipment gets less costly?



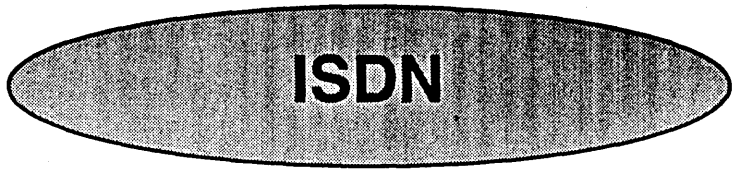
Capital cost to serve the U.S.
(in billions)

	Cable (500 Kbps)	Cable (4 Mbps)	ISDN (128 Kbps)
Infrastructure cost	$26	$23	$50
Subscriber cost	$78	$228 [$108]	$150
Total cost	$104	$251 [$131]	$200

Business and Policy Issues



- Immature modem technology
  - Plant engineered for TV
  - Chicken-and-egg equipment markets
- Closed access to channels



- Common carriage
  - Co-location?
- High tariffs in many states
- Will telephone companies offer Internet over ISDN?
  - Long-distance