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Homes with Tails

WHAT IF YOU COULD OWN YOUR INTERNET CONNECTION?

By Derek Slater and Tim Wu*

Summary

America's communications infrastructure is stuck at a copper wall. For the vast majority of homes, copper wires remain the principal means of getting broadband services. The deployment of fiber optic connections to the home would enable exponentially faster connections, and few dispute that upgrading to more robust infrastructure is essential to America's economic growth.¹ However, the costs of such an upgrade are daunting for private sector firms and even for governments. These facts add up to a public policy challenge.

In this paper, we propose and describe a new way to encourage broadband deployment. Most proposals have focused on deployment as a problem for *firms* and for *government*. For firms, the question is how a company can justify investments in a fiber infrastructure without a "killer app" – a new and proven revenue source that is different from what is available from existing copper wires. For governments, the questions consider how they might build and operate their own networks, convince or pay existing carriers to do so, or encourage market entrants to arrive and save the day.

Our intuition is that an innovative model holds unrealized promise: household investments in fiber. Consumers may one day purchase and own fiber connections that run from their homes. They would then be able to connect to a variety of service providers, including today's Internet, television, and telephone services, as well as ultra-bandwidth intensive services of the future. Consumers would have the opportunity not only to get a fast broadband connection, but also benefit from greater competition and lower prices in the retail service market.

We call this property model "Homes with Tails," for the fiber would form part of the property right in the home. Key facets of our approach include:

1. A "condominium" model for fiber ownership, in which individual strands of fiber are sold to consumers, while maintenance and other collective needs are managed jointly.
2. Private firms and municipalities could consider selling fiber connections based on this model; and
3. Governments could consider using various mechanisms to support consumer purchases, including a tax credit to homeowners or renters who purchase a broadband connection.

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The idea of customer-owned fiber may seem odd, but it is important to remember that many items that consumers buy today would have seemed very strange not long ago. Until the personal computer, a computer was something that only large companies owned. For decades, telephones were available only for lease, not for purchase. Home fiber could be the next technology that moves into the realm of consumer property.

That said, the goal of this paper is rather limited: to outline what customer-owned fiber might look like and suggest why it is worth investigating further.² We do not suggest that this model is the panacea for broadband policy challenges; rather, it might serve as part of a broader solution.³ Furthermore, there are many empirical questions and obstacles to successful implementation that cannot be fully evaluated at this time. In particular, no market for consumer purchase of fiber currently exists, and there is a collective action problem in deploying a network of this sort. The only way to truly test this model's feasibility is to attempt to implement it. Below, we describe one trial that is already ongoing in Ottawa, Canada, and more experiments of this kind would provide important insights.

In the end, the intuition behind this paper is as old as property theory: that people will spend more on and value more that which they own.

I. Background

A. The Intuition

At a speech in February 2008, James Crowe, CEO of Level 3 Communications, presented a puzzle: why doesn't Moore's Law seem to work with bandwidth? Moore's Law holds that the capacity of digital devices tends to increase exponentially, doubling about every two years. And since 1965 or so, it has held. Processor speeds, said Crowe, have grown exponentially, and so have other digital indicators like hard drive storage; yet, the average speed of Internet connections to the home has grown more slowly. Why the difference?⁴

Crowe's question is extremely interesting. On the one hand, the point should not be exaggerated: mean consumer bandwidth has increased over the last 30 years. The 300 b/s modems of the early 1980s became the 56 kb/s of the 1990s, and finally the 1-3 mb/s connections at the beginning of the 2000s. But recently, speed increases have been relatively minor, and there are limits to how much more capacity can be wrenched from existing copper infrastructure, whether in telephone lines or the coaxial wires used by the cable industry.⁵

Our intuition is that the pattern of bandwidth growth may be related to how investment is structured. Processors, bundled with computers, are sold directly to consumers and businesses. Both businesses and individuals have the means, and the incentives, to buy faster computers over time. Consequently, investments are decentralized across the entire world of computer users. It is not unusual for a consumer or business to spend thousands of dollars every few years to buy new computers, which represent capital investments in the processor, monitor, and storage industries. Said differently, these industries are all beneficiaries of investments encouraged by the personal property system.

The computer processor industry also benefits from a diversity of buyers. The market for processor users includes both early adopters that have special demands, like scientists or graphic designers, and ordinary consumers. As researcher Tim Lee points out, "A lot of R&D costs have been borne by early adopters who pay relatively exorbitant prices for bleeding-edge hardware."⁶

This investment structure can be contrasted with broadband, where investments depend not on millions of consumers, but on a handful of companies. It is a centralized investment model. Incentives for providers to deploy new and faster connections have led to a fundamentally different pattern of investment – one that focuses on maximizing returns on existing infrastructure.

Generally speaking, the incentives for significant private infrastructure investments are relatively weak. Telephone and cable companies face quarter-to-quarter pressure to deliver high returns on any investment. Yet the required capital to deploy fiber to the home is massive, and such an investment takes a long time to recoup. Verizon's data regarding its FiOS fiber to the home deployment are instructive. Given customers' willingness to pay for services, the firm estimates that profitability in its fiber rollout depends on reaching a 35 – 40 percent subscriber take-up for triple play (voice, television, and Internet), and Verizon expects to reach that level in 2009, having begun deployment in 2004.⁷ While some believe Verizon's deployment strategy will give it a strong advantage in the market, others remain skeptical of FiOS' profitability even at a 40 percent take-up rate.⁸

What's more, carriers have mixed incentives because new deployments can endanger existing revenue streams. First, deploying a fiber to the home network undermines a provider's ability to continue to reap profits from its existing last-mile network. Second, applications and content offered over the Internet may compete with traditional revenue sources. For instance, faster access to online video services like Hulu can threaten the market for traditional cable television service.

This is not to say that carriers like Verizon, AT&T or Comcast have no reason to invest in broadband. Especially in the case of Verizon, considerable investments have been made. Nevertheless, there are structural reasons to suggest that there will be less investment in broadband connections than what is necessary to serve the national interest.

Here's another way to put the difference between bandwidth and processor speeds. One rarely hears the question, "how can we encourage Intel to deploy faster processors?" The reason is that Intel does not need to invest in the deployment of its processors. It simply makes them available for sale. In effect, millions of consumers – a crowd, as opposed to a small group – make the decisions to invest in processors. This is the difference between a decentralized, property-based investment model and a more centralized paradigm.

The deeper question is whether such a decentralized investment model is actually possible for broadband.

B. Shifting Boundaries of Consumer, Cooperative, and Centralized Control

Today it is assumed that broadband must be centrally owned and deployed. But the division between consumer property, community property, and what private firms provide as a service has a history of shifting.

Consider the telephone and telephone lines. In its very early history, homeowners and communities sometimes owned telephones and telephone lines. Un-served communities set up phone systems using their own wires. As Milton Mueller and David Gabel write, "instead of depending on regional or national markets... local independent telephone companies relied almost exclusively on local capital and local labor."⁹ To get service, consumers were often required to provide their own telephone lines running from their house to the main line, and help

in the physical work of stringing lines back to the switch. By relying on homeowners and farmers to provide much of the infrastructure themselves, the early rural telephone networks could get by with much less capital.

That model came to an end with the ascendancy of the Bell system in the 1910s and 1920s. Thereafter, and for most of the 20th century, the wires and even the physical telephone could not be owned, but rather were available for lease. That then changed again in the 1970s: with the FCC's *Carterfone* decision and its later *Computer Inquiries* orders, which effectively propeertized the telephone and most other network attachments. Beginning in the 1980s, the telephone and in-home wiring were, once again, something consumers could purchase and own.

In the history of electrification we see a similar story. Private firms were often unwilling to wire rural areas, believing that return on investment was insufficient. One answer was community-owned wires and electric utilities. In a "utility cooperative," or rural electric coop model, the members of a rural community created and funded an organization that then ran wires to homes and either purchased or generated electricity for the community. The model took off in the 1930s, and today utility cooperatives continue to serve more than 40 million Americans.¹⁰

Finally, the example of the personal computer is telling. Early computers were themselves once a form of shared property, used by numerous people and sometimes multiple firms at once, in the mainframe and supercomputer models. As Nicholas Carr writes in *The Big Switch*, "During the mainframe era... computers were institutional machines... [and] the rent on a typical IBM computer was about \$30,000 a month in the mid-1960sThat meant that the individual employees almost never had direct access to a computer."¹¹ The reason that we think of computers as individual or personal property is thanks to the invention of the idea of a "personal" computer, as pioneered by MITS, Apple Computer and others. The personal computer was partly based on improved technology and cost efficiencies. But it was also premised on a rethinking of what a "computer" could be.

In sum, who "owns" a utility or a product is something that has changed over the years. There should be no reason to assume that fiber deployment will always be a question of waiting for the phone or cable company to build and lease it.

C. Current Approaches to Broadband Deployment

As Robert Atkinson writes, "Broadband has become a 'motherhood and apple pie' issue; no one is against more of it."¹² The problem, however, is how to get more aggregate bandwidth in the nation without either wasting public money or destroying all private incentives to deploy.

Different approaches to broadband have been taken around the world, and we can recognize, roughly, three approaches.¹³ The first, typified by Korea and Japan, is to provide significant tax incentives and heavy public investment into the deployment of fiber, primarily by principal or national telecommunications firms such as Korea Telecom or NTT.

The European approach is more mixed, but tends to rely upon rules mandating competitor access to the facilities of the incumbent carriers, coupled with the hope that market entrants will stimulate demand for broadband. In recent years, European policymakers have taken more interest in creating a separation between the businesses that own the copper or fiber and those that run the networks.¹⁴

The American approach since the mid-1990s has been to minimize government involvement. Infrastructure deployment is essentially left to the private sector.

Each of the three approaches has costs and benefits. Japan’s and Korea’s approaches have reportedly achieved the greatest speeds and market penetration, yet there is a risk of government mismanagement and waste. The Europeans have also, generally, achieved high broadband penetration rates, but mostly over existing copper connections. The United States, finally, has benefited from the existence of a well-developed cable industry, which has meant more facility-level competition than in most other nations. The main problem with the American, hands-off approach is the prospect of underinvestment relative to what might be in the public interest. It is already clear that the United States is no longer a leader in broadband speeds or market penetration.¹⁵

The property rights approach suggested here is an alternative to all of these approaches and provides some unique advantages.

II. Property Rights in the Last-mile

What would customer ownership of a broadband connection look like in practice? Below, we detail its key aspects.

A. The Condominium Model for Fiber Ownership¹⁶

In our model, a fiber optic cable, as the home's “tail,” would, in law, become part of the home as a form of fixture.¹⁷ The consumer would own one or more strands of fiber, running from her home to a point of interconnection, known in telecom jargon as the “Point of Presence” (PoP), as shown below.¹⁸ The owner would then be in a position to lease Internet, television, or telephone services, and pay for management of any physical problems that might arise.

Significantly, a consumer would not run her own wholly separate fiber connection to the PoP. That would be costly and impractical. Instead, a trunk cable, containing hundreds of individual strands of fiber, needs to be run to an entire neighborhood in order to serve the many individual homes within it.¹⁹ The fiber / trunk architecture necessitates an ownership structure that is, at least in part, a mixture of individual and collective property.

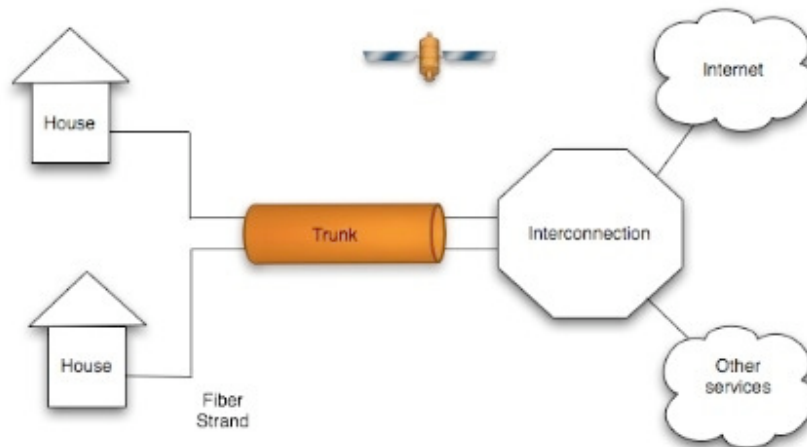


Figure 1. Condominium Fiber Model

Our proposed ownership structure is a condominium model.²⁰ In real estate, condominiums are designed to allow densely packed homes to be individually owned while the building and grounds are shared.²¹ Customer-owned fiber presents a similar class of problem, and may be addressed by a similar ownership structure.

As Black's Law dictionary defines it, a condominium is: "A single real-estate unit in a multi-unit development in which a person has both separate ownership of a unit and a common interest, along with the development's other owners, in the common areas." The unit owners share ownership of the hallways, elevators, heating ducts, and other common areas, and they pay recurring fees in order to finance maintenance of the building. The common areas are managed through a separate legal entity, the community association, consisting of all the unit owners and run by a board of directors.²²

In a fiber-condo, each homeowner would own separate strands of fiber, but the trunk that runs through the neighborhood would be collectively owned. After the fiber is installed, the community would contract with a professional management company to maintain it. This company would then charge each homeowner any necessary maintenance fees, similar to condominium maintenance fees.

For their construction, condominiums depend on the investments of unit owners to fund the entire building. Similarly, for last-mile fiber, building the trunk and related structures would ultimately be funded by the investment in the individual strands.

Condominiums were, at one time, seen as a relatively radical form of property ownership. Today, owning a condo is nothing special – the split between individual and collective ownership is taken for granted. Split ownership of fiber might similarly become normal.

B. Who Builds?

If consumers are the owners, who would act as the fiber provider, responsible for clearing rights of way, deployment, and maintenance? Various entities might build the network and then sell strands of fiber, including:

Carriers: The first possibility is carriers – existing or new wire information services providers, such as telephone companies. Along with selling services, a provider could start "don't lease, buy" programs that allow customers to buy fiber strands.

Municipalities: Local governments might also decide to become fiber providers along the lines described here. Over 40 municipalities around the United States, as well as many European cities, are already actively deploying fiber to the home.²³ Many provide retail services, some are wholesale-only, and some mix the two models. Selling fiber connections could provide a replacement for or supplement to these models.

For example, the UTOPIA fiber to the home network in Utah is moving toward a similar sort of business model, albeit without granting any actual property rights to consumers. Going forward, before UTOPIA runs fiber down a neighborhood's streets and offers wholesale access to service providers, it has to get a certain number of subscribers to commit to pay a "cooperative membership fee" – a lump sum investment separate from any monthly service revenue.²⁴

Fiber Construction Firms: Carriers and municipalities contract with specialized third-party construction firms in order to deploy fiber today. Businesses and universities also work with these construction companies to build their own networks. These construction firms could deploy fiber to homes themselves and sell off strands independently, providing whatever limited maintenance might be necessary.²⁵

Real Estate Developers: Real estate developers could arrange for customer ownership of fiber by building connections into new homes before they are sold. This might be especially practical for “planned communities,” housing communities setup along the same lines as a condominium complex.

An example of this model exists in the Issaquah Highlands development in Issaquah, Washington. Issaquah Highlands bills itself as an “urban village” that aims to recreate the feeling of a small town. Port Blakely, the developer, is running fiber to every home there. As its web site says:

Welcome to the Highlands Fiber Network.

As a resident of the Issaquah Highlands Community, your home is directly connected to a state-of-the-art Internet service. HFN is here to connect you to the rest of the world! You will experience the power of fiber optics, which will enable upload and download speeds faster than anything else you could buy for your home.

Every homeowner pays a \$250 hook-up fee and a monthly fee for Internet access. After Port Blakely has recovered its costs of deployment, the community association has the opportunity to take over control of the network.

Initially, a firm named Isomedia was selected through a bidding process to be the exclusive Internet service provider over the Highlands Fiber Network. While the homeowners cannot individually choose to connect their strands to other service providers, the community association has the option to open up bidding to new service providers in the future.²⁶

C. Interconnection, and Who Provides Services?

The final piece of this model is the point of interconnection. If the customer owns fiber, with whom can he or she connect? For ownership to make a major difference, consumers must be able to use their connection to access a multitude of differently priced services from a variety of service providers.

In an ideal scenario, customer-owned fiber would run from the home to an interconnection facility that is equally open to many service providers. Service providers would then be able to pay a fee to locate their networking equipment there and offer Internet, TV, voice, or other services, in direct competition with one another.²⁷

We call this sort of interconnection facility an Open PoP, and the idea is not particularly novel. For instance, Amsterdam’s CityNet fiber network allows multiple service providers to install their own equipment in each PoP and provides non-discriminatory access to these facilities. In a September 2006 interview, CityNet managing director Herman Wagter explains,

“In the switch house [central office] or interconnection point we provide for different racks for different operators, because on a line by line basis customers could sign up for different combinations of offerings.”²⁸

We anticipate that an Open PoP could operate similarly in a customer-owned fiber model. When a customer chooses to sign up with a particular service provider, the provider would connect the customer's fiber strands to its own equipment at the PoP. The service provider would also have to visit the customer's home and install some networking equipment there, just as Verizon has to when it installs FiOS service.²⁹

The key benefit of the Open PoP is that it lowers the barriers to entry for service providers and thus encourages competition in that market. Firms would be able to offer advanced Internet services, as well as new information services that are independent of the Internet. For example, say you and your spouse spend time apart every week. Providers of HD telepresence (fancy videoconferencing) might sell a service, independent of Internet connectivity that allows you to talk to and see each other in real time. As we explore further below, this sort of novel application could provide a significant attraction for consumers.

III. Costs and Benefits of the Model

A. How much will it cost per-customer?

It is impossible to precisely enumerate how much fiber would cost for a given individual. However, three factors are the most important: take-up, housing density, and whether fiber can be deployed aurally (e.g., on telephone poles) or must be run underground.³⁰

Take-up: Fiber to the home deployment faces high, fixed initial costs. For that reason the take-up rate can have a big impact on the per-customer cost. The cost of running a fiber trunk through a neighborhood is essentially the same regardless of how many people sign up to have individual strands run to their home. Put differently, once fiber has been run down your street and to your home, the marginal cost of running it past your neighbors' houses at the same time is relatively small. As such, the more people agree to pay for fiber to run through a given neighborhood, the more the total cost of passing homes is spread around, and the lower the per-customer cost becomes.

Housing density: It is also cheaper to deploy in a neighborhood where there is a high density of homes. If homeowners are spread out and thus more area must be covered, the cost of running fiber down each street will be higher on a per-customer basis.

Aerial versus underground: Generally, aerial construction is significantly cheaper than digging up the streets and running fiber underground. Consider one example: in 2007, the City of San Francisco commissioned a study of how much it would cost to connect every home in San Francisco with fiber, spanning 900 miles of streets. Assuming half aerial construction and half underground, the former amounted to \$41.9 million and the latter \$327 million.³¹

A range of other factors can also impact the total and per-customer costs. For instance, some businesses, universities, and other institutions already purchase their own fiber connections, and in some cases, different entities already cooperate to jointly buy and manage fiber. They might be willing to serve as "anchor tenants" in a deployment that also serves residential communities. As such, the cost to homeowners may be lower in such neighborhoods.

Verizon's data is again instructive. Verizon's average cost per-customer is around \$3000-4000 assuming a 40 percent take-up rate. At 20 percent, the cost is closer to \$7000. Verizon is focusing mainly on dense metropolitan and suburban areas, with a mixture of aerial and buried

fiber, and in close proximity to businesses.³² Less dense suburban and rural areas would be significantly more expensive.³³

In all cases, it is important to recognize that individual neighborhoods may have radically different costs. The variations might average out over a large-scale deployment like Verizon's; however, in a small-scale deployment, they can make a significant impact.

B. Utility of the Model for Fiber Providers and Service Providers

One of the chief challenges in fiber deployment today is the lack of a proven way to make additional money from selling services or, at least, capital investors' lack of confidence in such revenue streams. The prospect of gaining a 40 percent take-up rate for fiber-based services is daunting, yet often necessary to justify the investment. But if a fiber provider could get some level of consumer investment ahead of time, this would change the calculus.

Here's how it might work. Before running fiber into a neighborhood, carriers, municipalities, or other fiber providers might seek to get bandwidth-hungry early adopters to buy their own connection first. The early adopter is defined here as a consumer who has special reasons to pay for an advanced technology now, as opposed to waiting for the technology to come down in price. Just as consumers pay a premium to be the first person with an HDTV or an iPhone, consumers might pay a premium to be the first person with their own fiber connection. If 10 percent commit to pay \$3000 for the connection, then the fiber provider only needs 30 percent take-up in services; which makes the service-based business case that much better. In an ideal neighborhood, where per-customer costs are lower than Verizon's averages, it may be possible to fund the whole roll-out with a relatively small number of customers.

There are various ways consumers could commit to pay. They could pay with a lump sum upfront, or agree to an installment plan similar to home mortgages. A carrier could try to get consumers to sign up for a multi-year retail service plan commitment in exchange for rights to own the fiber after the service period ends. The experiment in Ottawa, Canada discussed below exemplifies just one innovative way that the cost might be spread out over a five-year period – by bundling it with electrical bills.

For independent Internet service providers and competing providers of other information services, customer ownership of fiber would have an obvious advantage. It would be far easier for them to enter the market, since they would only have to install equipment at the open PoP and the customer's home and would not have to incur the expense of deploying fiber themselves.

At the same time, one open question is whether lowering this barrier to entry is enough to attract multiple service providers into the market. Large incumbents, accustomed to owning their network, might resist giving up this control, and new entrants might still face significant barriers to competing against more established companies.

C. Will Consumers Bite?

Nothing in this model can work at all unless there are some reasons for consumers to want property rights in their fiber connections. Is there some “killer app” that might make consumers want a fiber connection?

While a challenge, we think the greatest short-term appeal will be to unique consumers, the “early adopters,” who for reasons practical or psychological need access to speeds or service not available to regular consumers.

In the long run, we believe consumers may be attracted to the possibility of greater competition and lower prices for retail services as well as access to services currently unavailable, like HD videoconferencing.

Early Adopters

During the 2008 election, CNN projected what it called a “hologram” of reporter Jessica Yellin into its New York City election center,³⁴ and, earlier this year, Australian phone company Telstra demoed much more advanced technology to allow its CTO to appear as a 3D-image and communicate with the audience in a room 460 miles away.³⁵ Those tasks took an enormous amount of bandwidth, far beyond anything available to consumers today. An interest in access to that kind of bandwidth – and the novel applications it enables – is what may motivate early adopters to buy fiber to the home.

When it comes to any plan to purchase connections, members of a neighborhood face a collective action problem. There are incentives to wait for others to deploy their own fiber first and become a ‘free rider,’ by waiting for the inevitable lower prices that will be based in part on the earlier deployments. However, in some cases, particular individuals’ demand for a good may be strong enough to overcome the problem.³⁶ That’s the role early adopters play in many technological markets.

Early adopters, by definition, have an interest in fiber optics that is unusual. Some people may have special needs for bandwidth; for instance, consider a film editor who needs to transfer massive files between his home, his office, and other locations. Others may have a particularly strong distaste for relying on telephone or cable companies for their Internet connections, and want the freedom from the incumbents that independent ownership might bring.

A third, and potentially important category, includes hobbyists who are interested in what they might do or invent with huge amounts of bandwidth. These are the kind of people who bought computers in the 1970s. Back then, hobbyists spent thousands of dollars on computers that were initially capable of very little. They then formed computer clubs to find out what they collectively might build.

Out of the computer clubs of the 1970s came Bill Gates, Steve Jobs, and many other future leaders of the computer industry. The same could happen with bandwidth clubs if buying fiber to the home becomes plausible. In the future, clubs of ultra-high bandwidth fiber owners might work together to develop their own applications. Imagine, for instance, a “Ten Gigabit club” – a network catering exclusively to hobbyists with 10-Gig or better connections.

Both service providers and clubs of this sort might develop services like extremely high-speed video conferencing, full size HD movie streaming, hologram projection communication, or primitive versions of the holodecks imagined on the Star Trek television shows.³⁷ The freedom to innovate and create services not yet imagined at all is probably the greatest attraction for early adopters.

Regular Consumers

As discussed at the outset, the things people buy are not always easy to predict and often change over time. While buying fiber might be expensive compared to the price of chewing gum, it is comparable or cheaper than many other home improvements. Renovating a washroom, fixing a roof, or buying patio furniture also costs thousands of dollars, in some cases tens of thousands. Yet homeowners consistently improve and add value to their homes in many ways.

To approach the question systematically, we might ask why a consumer *ever* buys, as opposed to renting.

One starting point is that consumers buy when rentals are simply not available. In areas that lack fiber networks today and where carriers are unlikely to serve, customers might want to take it upon themselves to acquire fiber connections. Just as farmers formed rural electric cooperatives, underserved homeowners in rural areas might want to pool resources to fund their own fiber network.

But in situations where a rental market does exist, why own items like skis, cars, or a home? For wealthy consumers, the price differential of purchasing a connection may be relatively trivial. Or it may just be a matter of preference or psychology: some people prefer to own.

More importantly, autonomy provides a major motivation. Ownership usually brings greater freedoms. You can paint butterflies on your own car but not a rental, and knock down walls in your own home. In the broadband context, customers would have a greater range of choices among information service providers.

For non-early adopters, we should also consider that consumers often purchase products because, over the life of the product, they expect that it will be far cheaper to do so. If you drive every day, renting a car for seven years would probably cost more than buying it.

Consumers might also save money in the broadband context. Consider a lease-to-own plan offered by a carrier. Consumers may be able to use the amount of money they already spend on Internet connections to fund eventual ownership of the fiber. Eventually, the consumers would be paying only for service (a corkage fee), and enjoying a discount for, in effect, “bringing their own pipe.” In addition, greater competition among service providers may lead to lower service prices.

The final reason that consumers might buy fiber has to do with what economists call the dynamic justification for property: the fact that the owner enjoys any appreciation in the property. If you buy land for \$75,000, improve it, and later sell it for \$1 million, you keep the difference. Fiber is akin to a type of home improvement or fixture, like a new kitchen, a patio, or oak floors – that is, an improvement that can contribute to the value of the home. A fiber connection could increase the resale value or rental value to a degree that could help justify the initial investment, particularly if the price of the investment is not huge. RVA & Associates, a market research firm that focuses on fiber networks, recently surveyed home buyers and developers and estimated that a fiber connection increases the value of a home by over \$4000.³⁸

Related to this last point is the fact that consumers sometimes purchase property because of government incentives of various kinds. The most obvious example of this comes from the American home mortgage deduction. Government might provide similar incentives for consumers to have a particular interest in purchasing fiber, as we will discuss more below.

IV. The Ottawa Experiment

The best way to test the practicalities of the model and assess the degree of consumer interest is to experiment with actual implementations. Currently, a 400-home customer owned network is being trialed in downtown Ottawa, Canada. Trunk fiber and splice points for the distribution of strands down individual streets have already been deployed.³⁹

The experiment is spearheaded by Bill St. Arnaud, Chief Research Officer at CANARIE, which is a nonprofit group devoted to advanced network research in Canada. He has been promoting the customer-owned network model for over a decade and is now attempting to demonstrate the general business case for it. To accomplish this task St. Arnaud came up with an inventive idea: selling fiber as part of a joint partnership between a specialized construction company named P2P Fiber and electricity resellers.

In Canada, electricity resellers purchase power from wholesale providers and sell directly to customers. To differentiate themselves, they offer packages that might, for example, put together electricity with cheap long distance telephone service.

St. Arnaud's idea was to sell cheap electricity and fiber together. The electric company sells the fiber connection along with its electricity contract, and collects payments over five years for it, through electricity charges of around two cents/kwh. St. Arnaud calls this approach "green broadband" because the surcharge also creates an incentive to reduce energy usage.

In order to test out this concept, St. Arnaud picked a neighborhood that makes deployment especially cost-effective. P2P Fiber estimates that 50 percent take-up will generate a per-customer cost of around \$1100. If only 10 percent sign up, a conservative estimate of the per-customer cost is \$2700.

In a survey of 100 homes, CANARIE found that 30 percent of customers were willing to sign up for this service. Interestingly, 10 percent said they would be more interested in purchasing fiber outright. The business plan is based on a 10 percent minimum homeowner take-up rate; that is, before they run fiber down a particular street, they need 10 percent of homes to sign up for the green broadband plan.

What can we learn from the Ottawa experiment? Obviously, the success or failure of it is not a good predictor of what consumers would do at different price points. However, it can help indicate whether consumers can understand and are interested in committing to pay for fiber. It can also indicate the usefulness of this bundling approach.

Interestingly, the biggest challenge so far has not been getting consumers to sign up, but rather getting service providers on board. Like the United States, the independent ISP market in Canada has drastically shrunk over the last half-decade. Despite an "open access" regime that allows independent ISPs to use incumbents' existing wires to provide broadband, the incumbent telephone and cable companies have the lion's share of the consumer market.

Due to stringent regulatory hurdles, independent ISPs in Canada have been largely unable to offer their consumers cable television, thus putting them at a competitive disadvantage vis-a-vis bundled services. Incumbents, on the other hand, sell cable TV bundled with Internet access, and it can be more expensive for a consumer to purchase these separately from different service providers. Finally, the incumbents enjoy the twin advantages of recognized branding and large marketing budgets.

In time, independent ISPs may begin to fill the market. Fiber's higher speeds may become a great enough incentive unto itself for customers to sign up despite the lack of cable TV, especially as online video services grow to be viewed as a substitute for traditional TV service. In addition, the market may be especially appealing to large, established incumbents from other areas of Canada that do not currently have a presence in Ottawa. For the moment though, this remains a substantial impediment to widespread adoption.

V. Government's Potential Role

We have so far simply described the model of customer-owned fiber as an idea that private groups and local governments should investigate. It is also possible that local or national government will want to stimulate investment through other means, such as a tax credit for consumers.

In the United States, the government sometimes uses the tax system in order to encourage investment in certain types of infrastructure. For example, the home mortgage deduction encourages Americans to buy residential real estate, and thereby subsidizes the building of infrastructure (homes). In recent years, Congress has also enacted more specific incentives for home improvement in ways perceived to be of general benefit. A leading example is the Energy Policy Act of 2005, which includes efforts to spur Americans to invest in energy efficient products and renewable sources of energy.⁴⁰

These particular tax credits share two interesting features. First, and crucially, this approach tries to incentivize the consumer as opposed to the industry in question. Although industry would benefit from more consumer spending, investment decisions are decentralized. Second, this approach is designed not just with the consumer in mind, but with economic spillovers, or externalities, as well. A home that relies on solar power, for example, saves money not just for the homeowner, but also decreases the costs imposed on others through pollution or the creation of greenhouse gases. Hence there are stronger justifications for a solar power tax credit than, say, a tax credit on the purchase of engagement diamonds.

The tax credit model may be a suitable model for encouraging broadband investment – provided, that is, that a market for purchasing last-mile connections develops. Consider, for example, a maximum \$1000 refundable tax credit for any homeowner who purchases property rights in a last-mile broadband connection. The credit would obviously encourage more purchases of such connections than we would expect to see otherwise.

This would represent a sizable government expenditure, especially if successful. But compared to other ways of supporting broadband connectivity, the tax credit model may prove highly efficient. First, as compared to a model that directly subsidizes service providers to deploy broadband services, the tax credit model has fewer enforcement problems. Subsidy programs create the potential for money to be collected without the industry actually taking the actions they were subsidized to do. Second, this tax credit would support local decision-making in the spending of government money. Consumers would be deciding to purchase last-mile connections based on their own needs, as opposed to the sense of a central planner.

This point should not be exaggerated. Fiber providers would still have to make certain commitments for the program to succeed at all. They would, for example, have to incur the initial costs of running trunk fiber past many homes that do not sign up, in order to reach the early adopters that do wish to purchase fiber connectivity. We simply offer the tax credit as a way to provide industry with a strong economic reason for providing this broadband service.

VI. Conclusion

Throughout this paper we have tried to be frank about the challenges and problems facing a consumer ownership model. In this conclusion we come back to two concerns that we suggested at the outset.

One objection might be that the fiber purchases we have described will primarily have meaning for the wealthy – homeowners for whom buying a last-mile connection is nothing compared to the price of high quality patio furniture.

The point is well taken. Our principal answer is that what we describe here is not an exclusive means of encouraging broadband deployment. It can be combined with programs that are specifically targeted to poor or underserved groups. In addition, if there are homeowners who have the money for this type of home improvement, it makes sense to take advantage of that fact.

A second, very reasonable objection is that the industry simply would not sell, or that consumers will not buy, last-mile broadband connections – the model is simply too strange. Our only answer to this point is that no paper can address that question by itself. This paper outlines how the customer ownership model could practically and technically function, and why it might be desirable and beneficial. But the feasibility can only be borne out through further study and experimentation.

At the same time, we do contend that there is no fundamental reason that last-mile broadband cannot be sold to customers. There are many industries that have gone from service only industries to selling a product only, or a combined product and service. “Homes with Tails” might seem strange now, but tomorrow may bring unforeseen changes.

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Endnotes

¹ See Daniel K. Correa, "Assessing Broadband in America: OECD and ITIF Broadband Rankings," The Information and Technology Foundation (April 2007), <http://www.itif.org/files/BroadbandRankings.pdf>.

² We also note that other writers and scholars have proposed similar ideas, see, e.g., Bill St. Arnaud, "Green Broadband – an alternative Ftth strategy," June 5, 2007, http://www.canarie.ca/canet4/library/customer/Green_Broadband.ppt; David Gabel & Milton Mueller, "Household Financing of the First 100 Feet?" in *The First Hundred Feet*, ed. Deborah Hurley & James Keller (Cambridge, MA: MIT Press, 1999); Eli Noam, "Beyond Net-Neutrality," *International Journal of Communication*, forthcoming (draft available at: [http://tprcweb.com/files/Beyond%20Net%20Neutrality%20Enduser%20Sovereignty%2014.08%20\(2\).doc](http://tprcweb.com/files/Beyond%20Net%20Neutrality%20Enduser%20Sovereignty%2014.08%20(2).doc)); Larry Lessig, "Fiber to the People," *Wired*, December 2003, <http://www.wired.com/wired/archive/11.12/view.html?pg=5>); Robert X. Cringely, "If we build it they will come," I. Cringely, *The Pulpit*, June 29, 2006, http://www.pbs.org/cringely/pulpit/2006/pulpit_20060629_000351.html); Brad Templeton, "The Glass Roots Movement," *Brad Ideas*, April 6, 2008, <http://ideas.4brad.com/glass-roots-movement>.

³ In addition, we have chosen only to focus on the deployment of last-mile fiber optic cable to the home. The reason is that the costs of deploying fiber are the most widely discussed, and that the potential speed of a fiber connection is, by current standards, beyond any relevant limit. The model might also be applicable to proposals for a wireless last-mile, though in such models the price of deployment of the last mile technology is not usually the main challenge.

⁴ Generally, as Tim Lee pointed out to us in an email, there is also an interesting difference between the smooth climb in processor speeds, and the jumps that characterize increases in bandwidth. There is reason to think that, were much of the public equipped with fiber to the home, we'd begin to see Moore's Law-like speed increases premised on the dropping prices of lasers. Technologies of data transmission have improved very quickly. For example, the price per port of Gigabit over fiber has dropped over the last decade. See, e.g., Brian Robinson, "Speedy price drop," *Federal Computer Week*, July 19, 2004, http://www.fcw.com/print/10_24/news/83538-1.html.

⁵ Telephone networks could be upgraded to VDSL, allowing the possibility of speeds of 50 mb/s downstream and 30 mb/s upstream, but this requires companies to build out fiber much closer to consumers and thus effectively shorten the local copper loop. Cable networks are looking to upgrade their networks to a new standard called DOCSIS 3.0, which promises greater bandwidth, possibly 160 mb/s downstream. However, this bandwidth will be shared among many customers, and is greatly limited in the upstream direction. In contrast, fiber to the home would make possible exponentially greater speeds in both directions. See Organization for Economic Development, "Developments in fibre technologies and investment," April 2008, <http://www.oecd.org/dataoecd/49/8/40390735.pdf>.

⁶ Email from Tim Lee, September 2008, on file with authors.

⁷ Verizon suggests it will reach this level of Internet penetration by 2010, and that FiOS will generate positive operating income beginning in 2009, see Verizon Communications, Inc., *Verizon FiOS Product Sheet* (May 2007), <http://newscenter.verizon.com/kit/nxtcomm/Product-sheet-FiOS-1Q07.pdf>. These take-up levels would be consistent with other estimates, see Anupam Banerjee and Marvin Sirbu, "Towards Technologically and Competitively Neutral Fiber to the Home (FTTH) Infrastructure," (2005), 23, in Carnegie Mellon University server, http://www.andrew.cmu.edu/user/sirbu/pubs/Banerjee_Sirbu.pdf (assuming ARPU per month to be \$130, the paper estimates that 35-40 percent penetration is necessary); FTTH Council, "Municipal Fiber to the Home Deployments: Next Generation Broadband as a Municipal Utility," (April 2008), 3, <http://www.ftthcouncil.org/documents/863222.pdf> (noting that a "typical FTTH business plan usually requir[es] a 30-40 percent take rate to 'break even' with payback periods.").

⁸ See Arshad Mohammed, "Verizon Lays it on the Line," *Washington Post*, Feb. 1, 2006, <http://www.washingtonpost.com/wp-dyn/content/article/2006/01/31/AR2006013101670.html>); Saul Hansell, "Verizon's FiOS: A Smart Bet or a Big Mistake?" *New York Times*, Aug. 18, 2008, <http://www.nytimes.com/2008/08/19/technology/19fios.html>); Saul Hansell, "A Bear Speaks: Why Verizon's Pricey FiOS Bet Won't Pay Off," *New York Times Bits Blog*, Aug. 19, 2008, <http://bits.blogs.nytimes.com/2008/08/19/a-bear-speaks-why-verizons-pricey-fios-bet-wont-pay-off/>; Mike Farrel, "Analyst: Economics of FiOS Rollout Make Little Sense for Verizon," *Multichannel News*, Jan. 21,

2008, <http://www.multichannel.com/article/CA6524100.html>.

⁹ See Gabel and Mueller, "Household Financing."

¹⁰ See National Rural Electric Cooperative Association About Us, "About Co-Ops," National Rural Electric Cooperative Association, <http://nreca.org/AboutUs/Co-op101.htm>; Laurence Malone, "Commonalities: The R.E.A. and High-Speed Rural Internet Access," 2001, in arXiv.org e-print archive, <http://arxiv.org/pdf/cs/0109064>.

¹¹ Nicolas Carr, *The Big Switch: Rewiring the World, from Edison to Google*, (W.W. Norton Company, 2008), 52.

¹² Robert Atkinson, "The Case for a National Broadband Policy," The Information and Technology and Innovation Foundation (June 2007), <http://www.itif.org/files/CaseForNationalBroadbandPolicy.pdf>.

¹³ See Correa, "Assessing Broadband," for descriptions of national approaches around the globe.

¹⁴ See Viviane Reding, Member of the European Commission responsible for Information Society and Media, "Better Regulation for a Single Market in Telecoms," (speech given at meeting of European Regulators Group, Oct. 11, 2007),

<http://europa.eu/rapid/pressReleasesAction.do?reference=SPEECH/07/624&format=HTML&aged=1>.

¹⁵ See Correa, "Assessing Broadband."

¹⁶ We credit Bill St. Arnaud for suggesting this idea to us.

¹⁷ Some may think it is strange to have home owners owning a wire or fiber that leaves the boundaries of the property. But it is not unheard of for private property to extend to public places – such as automobiles and airplanes, which move from private to public areas regularly.

¹⁸ This topology is called "home run" or "point to point" fiber, because the strands of fiber running from the PoP to the customer are dedicated to only that subscriber. In contrast, some topologies aggregate multiple customers' strands of fiber somewhere in the field, between the PoP and the customers. For a further discussion see Banerjee and Sirbu, "Towards Technologically and Competitively Neutral Fiber."

¹⁹ From this trunk, groups of strands are split off to run down individual streets ("laterals"), and then individual strands serve specific homes ("drops").

²⁰ As suggested by the utility cooperatives discussed earlier, another model is the coop model, but in this paper we focus on condominiums.

²¹ The first condominium law was Article 664 of the Code Napoleon of 1804, referenced in Roger A. Cunningham et al., *The Law of Property*, 2d. ed (West Pub. Co; Lawyer's ed edition, 1993), § 2.2, 34 n.26.

²² Center for Community Association Volunteers, "An Introduction to Community Association Living," Community Associations Institute (2006),

http://www.caionline.org/excerpts/community_association_living.pdf.

²³ See FTTH Council "Municipal Fiber to the Home"; Carol Wilson, "FTTH with European Flair," *Telephony Online*, Sept. 16, 2008, http://telephonyonline.com/ftp/news/telecom_ftth_european_flair/.

²⁴ See Grace Leong and Joe Pyrah, "The case for UTOPIA and iPROVO: double down or cut bait?" *Daily Herald*, April 21, 2008, <http://www.heraldextra.com/content/view/263223/18/>.

²⁵ Some examples of fiber building companies are Sunesys Corporation, www.sunesys.com; Black & Veatch, www.bvtelecom.com; Internetworking Atlantic Inc, www.Internetworking-atlantic.com; SRDP, <http://www.srdptele.com/en/>.

²⁶ Phone interview with Robert Black, general manager of the Highlands Fiber Network, Aug 6, 2008, and copy of Community Covenant on file with author. See also: <https://www.highlandsfibernetwork.com/customerservice.html>.

²⁷ Banerjee and Sirbu, "Towards Technologically and Competitively Neutral Fiber"; Columbia Telecommunication Corporation (CTC), "Fiber Optics for Government and Public Broadband: A Feasibility Study, Prepared for the City and County of San Francisco," Jan. 2007, http://www.sfgov.org/site/uploadedfiles/dtis/tech_connect/SFFiberFeasibility.pdf (provides useful taxonomies of different types of open access.) Here, we are imagining that different companies would be able to employ different data link layer technologies of their own choosing. Banerjee and Sirbu call this data link layer unbundling whereas the SF Fiber Study refers to this as physical layer open access.

²⁸ See Gordon Cook, "Financing Amsterdam's Huge FTTH Build," *The Cook Report on the Internet*, September 2006, http://www.broadbandproperties.com/2006issues/sep06issues/cook_sep.pdf. We also conducted an email interview with Herman Wagter, Managing Director of CityNet, in August 2008.

²⁹ This installation is considerably simpler if the user only subscribes to Internet and other data services, rather than a “triple play” that also includes traditional voice and television service. For a customer’s description of a Verizon FiOS install, see Dan Bricklin, “Installing Verizon’s FiOS fiber-optic Internet service to my house,” Dan Bricklin’s Web Site, Sept. 15, 2005, <http://www.bricklin.com/fiosinstall.htm> (discussing installation of the Optical Network Terminal). In more technical terms, each service provider would be responsible for providing its own customer premise equipment (CPE), which receives the light from the fiber and turns it into electrical signals. For instance, in order to provide Internet service, the CPE would turn the light pulses into Ethernet signals, and then you would connect your computer to the Ethernet port on your CPE. This hardware function is also referred to as the Optical Network Unit or Optical Network Terminal. See FTTH Council, “Fiber to Home Advantages of Optical Access,” 24, http://www.ftthcouncil.org/UserFiles/File/BBP_Apr08_FTTHPrimer.pdf.

³⁰ See Banerjee and Sirbu, “Towards Technologically and Competitively Neutral Fiber”; see CTC, “Fiber Optics for Government and Public Broadband,” 108-136.

³¹ CTC, “Fiber Optics for Government and Public Broadband,” 135.

³² See Verizon Communications Inc, “Verizon Communications, Inc. FiOS Briefing Session,” Sept. 27, 2006, <http://investor.verizon.com/news/20060927/20060927.pdf>; Mike Farrel, “Analyst: Economics of FiOS Rollout.

³³ See Banerjee and Sirbu, “Towards Technologically and Competitively Neutral Fiber” (comparing cost of urban, suburban, and rural areas) and CTC, “Fiber Optics for Government and Public Broadband,” (cost estimates involving San Francisco). A “home run” fiber topology may be more expensive than a network like Verizon’s, which uses less fiber and relies on Passive Optical Network splitters to aggregate fiber in the field. However, the exact premium for a home run network is somewhat contested, see Carol Wilson, “FTTH with European Flair,” (citing Yankee Group analyst Benoit Felten’s statement that “there is not a huge gap in costs”).

³⁴ See Chris Welch, “Beam me up, Wolf! CNN debuts election-night hologram,” *CNN.com*, Nov. 6, 2008, <http://www.cnn.com/2008/TECH/11/06/hologram.yellin/>.

³⁵ See Marguerite Reardon, “Beam me up, Telstra,” *News.com*, May 30, 2008, http://news.cnet.com/8301-10784_3-9955821-7.html?tag=mncol;txt.

³⁶ See Mancur Olson, *The Logic of Collective Action: Public Goods and the Theory of Groups* (Cambridge, MA: Harvard University Press, 1965).

³⁷ See John Markoff, “The Coming of the Holodeck,” *New York Times Bits Blog*, Apr. 11, 2008, <http://bits.blogs.nytimes.com/2008/04/11/the-coming-of-the-holodeck/>; W. Swartout et al., “Toward the Holodeck: Integrating Graphics, Sound, Character and Story,” in the *Proceedings of Fifth International Conference on Autonomous Agents*, (New York: ACM Press, 2001), 409-416.

³⁸ This statistic was cited in FTTH Council, “Fiber to Home Advantages of Optical Access.” It is true that a consumer could wait for a carrier to roll out fiber and the home would still increase in value. However, consumers might be eager to proactively buy connections in order to add this value to their homes.

³⁹ This description is based on several email and phone interviews with Bill St. Arnaud during June-August 2008, on file with authors. See also, Bill St. Arnaud, “Green Broadband – an alternative Ftth strategy,” June 5, 2007, http://www.canarie.ca/canet4/library/customer/Green_Broadband.ppt.

⁴⁰ *Energy Policy Act, 2005*, Public Law No. 109-58, 109th Cong., 1st Sess. (Aug. 8, 2005). The Act gives tax credits to anyone who invests in:

- Energy efficient home improvements (insulation, replacement windows, water heaters, and certain high efficiency heating and cooling equipment)
- Solar energy systems; and
- Fuel cells.