Government Policy vs. the Fiber-to-the-Home Supply Chain

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Abstract

A policy for rapid deployment of fiber-to-the-home may be in direct conflict with the health of the transceiver component supplier industry. The interests of consumers, regulators, and even service providers are in conflict with the industry that provides a critical component necessary for the service. The industry needs to recognize this conflict and explore strategies to keep itself viable in light of these conflicts. A system dynamics model is used to explore the effects of government policy on the deployment of fiber-to-the-home as a broadband technology. Specifically this article investigates the effects of a policy for rapid broadband deployment on the component supplier that is farthest from the consumer in the supply chain.

Introduction

Fiber-to-the-home (FTTH) refers to the provisioning of narrowband and broadband services to residential customers over an optical cable rather than traditional copper wiring. Traditional telecommunications companies, such as the Regional Bell Operating Companies (RBOCs) of Verizon, Qwest, SBC, and BellSouth have an interest in fiber-to-the-home technology to help them compete with cable companies for the delivery of voice, video, and data service. Fiber-to-the-home technologies are especially of interest in areas that do not yet have broadband service and are out of reach of DSL (Digital Subscriber Line) service.

On March 26, 2004, President George W. Bush called for universal affordable access to broadband technology by 2007 (Keto, 2004). The system dynamics model presented here explores the effects of that mandate on the industry that supplies transceiver components for fiber-to-the-home. For the purposes of the model, the mandate means that all of the communities that do not yet have broadband will deploy it within three years. To explore the potential best case for high volume of transceiver components, the model assumes that all future broadband deployments are of fiber-to-the-home.

Technology Overview

An understanding of the technologies used to provide fiber-to-the-home service helps to illustrate where the transceiver suppliers fit into the picture. Fiber-to-the-home technologies fall into two categories: active and passive optical networks. Active optical networks have an active component (such as a switch or a router) between the central office and the end-user. These are point-to-point networks with switched traffic, as shown in Figure 1. This network is similar in architecture to traditional hubs and switches that run local area networks.

In an active network, fiber-to-the-home transceivers are located in the device at the customer premise (customer premise equipment or CPE), and in the customer facing side of the active switch. Thus for every additional active optical network customer, two transceivers are deployed.

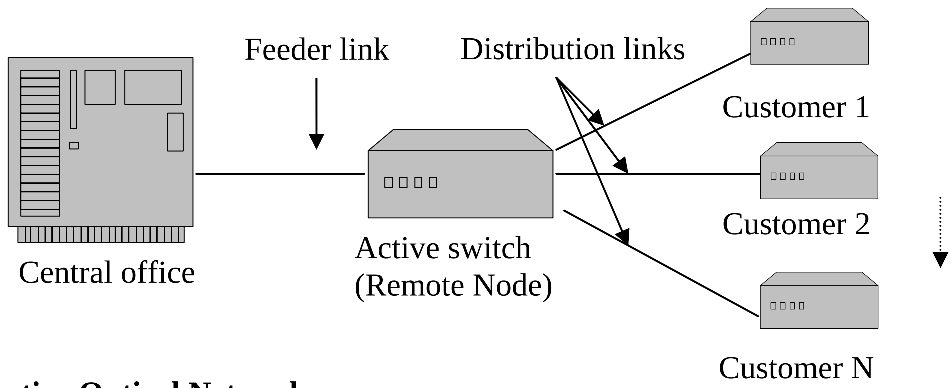

Figure 1: Active Optical Network

Passive optical networks (PONs), or passive star topologies, as shown in Figure 2, have no active components between the provider's central office and the subscriber. PONs are point-to-multipoint systems with all downstream traffic broadcast to all customers. The majority of fiber-to-the-home technologies being developed and deployed today are passive. In these networks, the fiber-to-the-home transceiver is located at the customer premise.

Currently, the transceiver devices being deployed in passive optical networks are different than those being deployed in active optical networks. In passive networks, there is also a high powered transceiver located in the central office. This device is sufficiently different in performance requirements from both the active transceiver and the passive customer premise transceiver that it is not included in the transceiver deployment rates discussed in the model. For a new customer on a passive optical network, one additional transceiver is deployed.

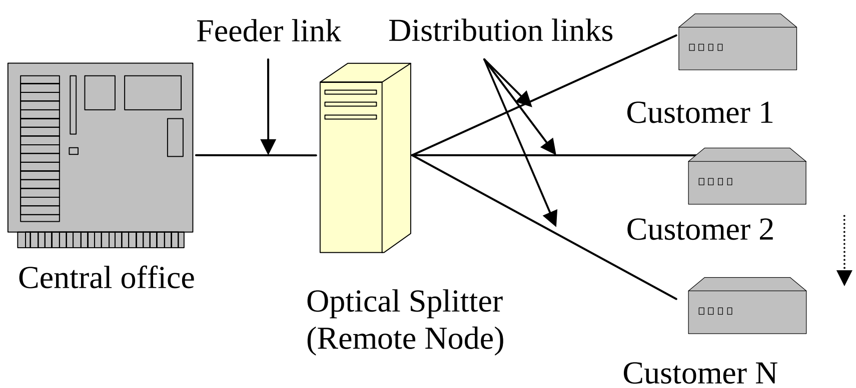

Figure 2: Passive Optical Network

High-Level Dynamics of Fiber-to-the-Home Deployment

Figure 3 shows a high-level overview of the dynamics governing fiber-to-the-home deployment. The text blocks represent variables associated with broadband and fiber-to-the-home adoption and deployment. The arrows between the variables represent causal links. As a variable increases or decreases, the variable that it is linked to changes in the same (+) or opposite (-) direction. For example, an increase in "available content and applications" results in an increase in "broadband customer base." Alternately, a decrease in "available content and applications" would result in a decrease in "broadband customer base." The green arrows represent dynamics that exist in the world today.

Currently, residential broadband subscribership is growing. Cable modem and DSL service are reaching more and more communities. The green loop entitled "content brings users" represents customers bringing more content to the network in the form of user-provided content and provider-based content (both commercial and non-commercial). Content in turn attracts more user interest.

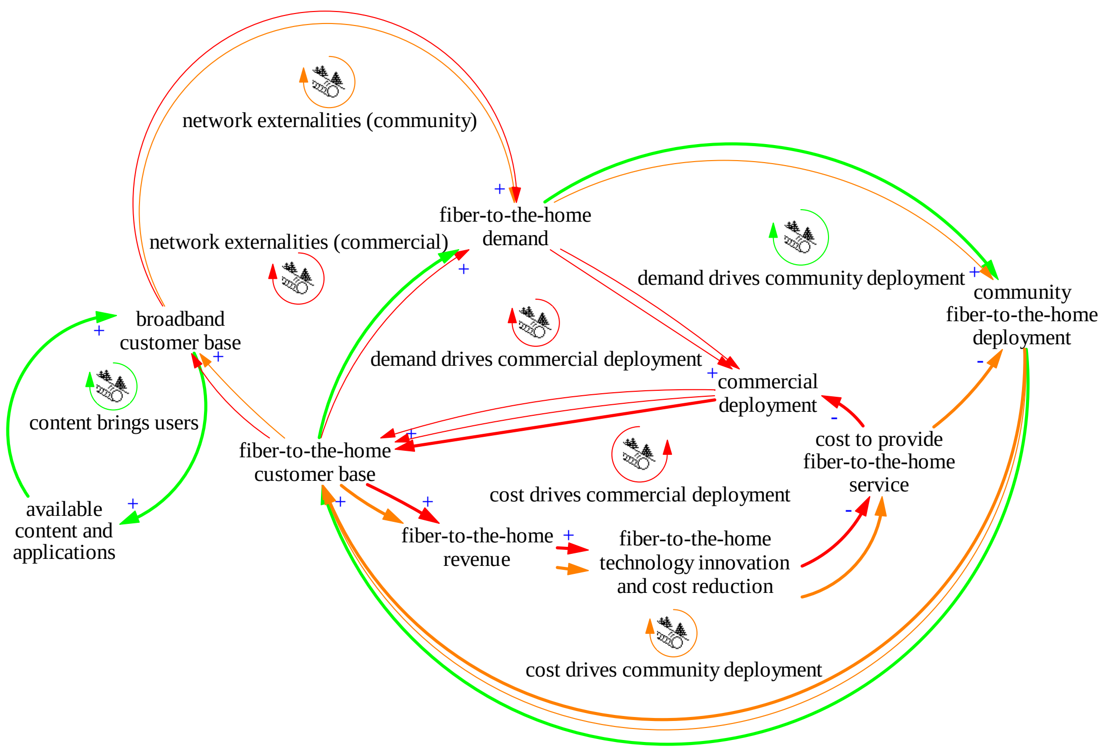

Figure 3: High level drivers for fiber-to-the-home and broadband deployment. Green represents effects that are active in the market today; orange the dynamics that are just beginning to emerge; and red represents hoped for dynamics.

However, not all areas are considered economically viable for broadband deployment. In many areas, the cable infrastructure is older and incapable of supporting cable modem service without complete replacement. Other communities are sufficiently spread out that DSL service cannot reach all residents, or the presence of loading coils and degrading copper wires makes service to those areas not viable.

The communities that do not have service are represented in the green loop labeled "demand drives community deployment." Communities without broadband service feel more pressure to acquire it as the number of communities with broadband increase. Those with municipally owned utilities or served by rural local exchange carriers that have been left behind by the latest wave of broadband deployment are beginning to look towards fiber-to-the-home as a solution for residential broadband service.

Fiber-to-the-home, like other telecommunications technologies, is subject to network effects. The more people that have fiber-to-the-home, the more interesting it is to others that do not yet have it. The same effect applies to broadband service overall, just as it does to narrowband services like telephones. This effect, shown in the orange loop labeled "network externalities (community)," is just starting to emerge in the market as broadband growth becomes more visible and communities perceive it as a key to economic success.

The other loop that is just beginning to emerge, and is of particular relevance to the transceiver market, is the orange loop labeled "cost drives community deployment." Cost reduction in the transceiver and electronics equipment market is making fiber-to-the-home more attainable to community deployments. These deployments in turn are producing additional volume for the industry and economies of scale which drives down cost.

It is hoped that the emerging orange cost reduction loop from municipal and rural deployments and the emerging demand loops will activate the currently dormant red loops of "cost drives commercial deployment" and "demand drives commercial deployment."

Overlying this already complex set of interconnections is government regulation at the federal, state, and local level. The interconnections between all the pieces of the broadband deployment puzzle are so complex that effects of policies are unknown before implementation and/or have unanticipated side effects. For example, TELRIC pricing, the FCC method for calculating wholesale rates for network elements, was intended to encourage competition. However, it appears to have discouraged infrastructure investment by both incumbents and new entrants.
The three year mandate expressed by President Bush included no details about how the policy would be achieved, so the model simply assumes that deployment happens to all communities that do not currently have broadband in the three years following the issuance of the mandate.

In a real world scenario this would be analogous to the government forcing the RBOCs to deploy broadband through some sort of incentive similar to the Universal Service Fund for telephony. Since the RBOCs are more heavily regulated than the cable companies, they are the logical choice for a government mandate. In most cases, the areas that do not already have broadband service are out of reach of traditional DSL, thus fiber-to-the-home would be the technology of choice. Assuming that all new deployments are of fiber-to-the-home serves as a somewhat extreme case test of the effects rapid universal access would have on the fiber-to-the-home supply chain.

Implementing the Mandate

The mandate is implemented in the model through the stock and flow mechanism shown in Figure 4. The model takes the number of potential communities and the mandated completion time and calculates how many communities need to deploy in a given timeframe to meet the mandate. The stock of "mandate deployed communities" is used to calculate broadband availability to households based on an average number of households in any given community.

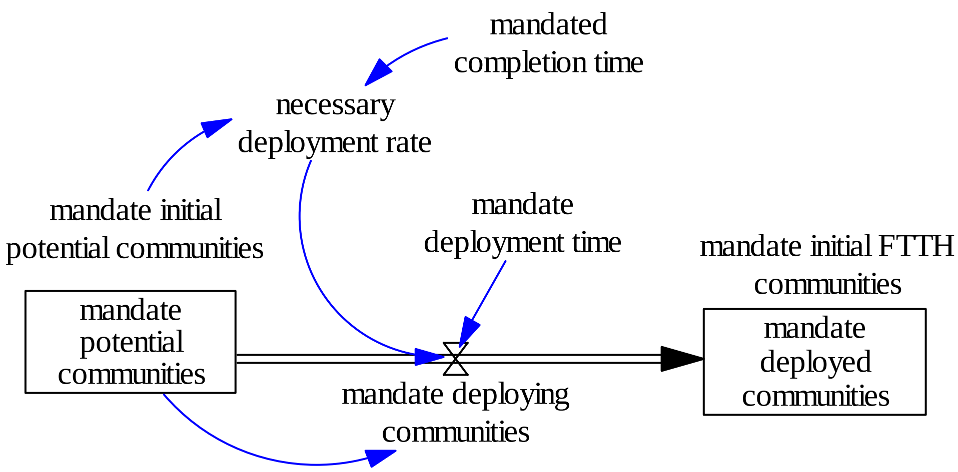

Figure 4: Mandate build stock and flow diagram.

The resulting broadband availability in the default run of the model is shown in Figure 5. The term "other" in the legend of the figure refers to pre-existing cable modem and DSL service in communities. Since the model assumes that all new builds are of fiber-to-the-home service, the availability of DSL and cable modem service to households does not change from its initial value. The initial values for the model come from summer 2004 data on communities that have cable modem (Warren Communications News Inc., 2004), DSL (broadbandreports.com, 2004; North American Numbering Plan Association, 2004), and fiber-to-the-home service, (Fiber-to-the-Home Council & Telecommunications Industry Association, 2004) and the number of subscribers to the services (Federal Communications Commission, 2004).

Figure 6 shows the causal diagram along with stocks and flows that converts broadband availability and potential customers to actual customers of broadband service. Households with broadband service available to them are placed in a stock of potential customers based on their willingness to pay the current price being charged for the service. Prices sensitivity was estimate based on the current average price of cable modem service in the Unites States (Warren Communications News Inc., 2004) and consumer price sensitivity information (Ainscough, 2003).

In order for households to actually adopt the service that is available, they need to be made aware of it. Two awareness mechanisms exist in the model: advertising, and word of mouth. The mechanism shown in the figure is adoption due to word of mouth. Customers that already have service interact with those that do not, and at some rate, convince the potential customers to acquire service. The conversion rates used in the model were calibrated from residential broadband data published by the Federal Communications Commission (Federal Communications Commission, 2004). The model assumes that new customers are more excited about their broadband service than customers that have had the service for a while, or customers that are returning to the service after having left it. So a new customer is more likely to attract an additional subscriber to the service then a customer that has had the service for a while.

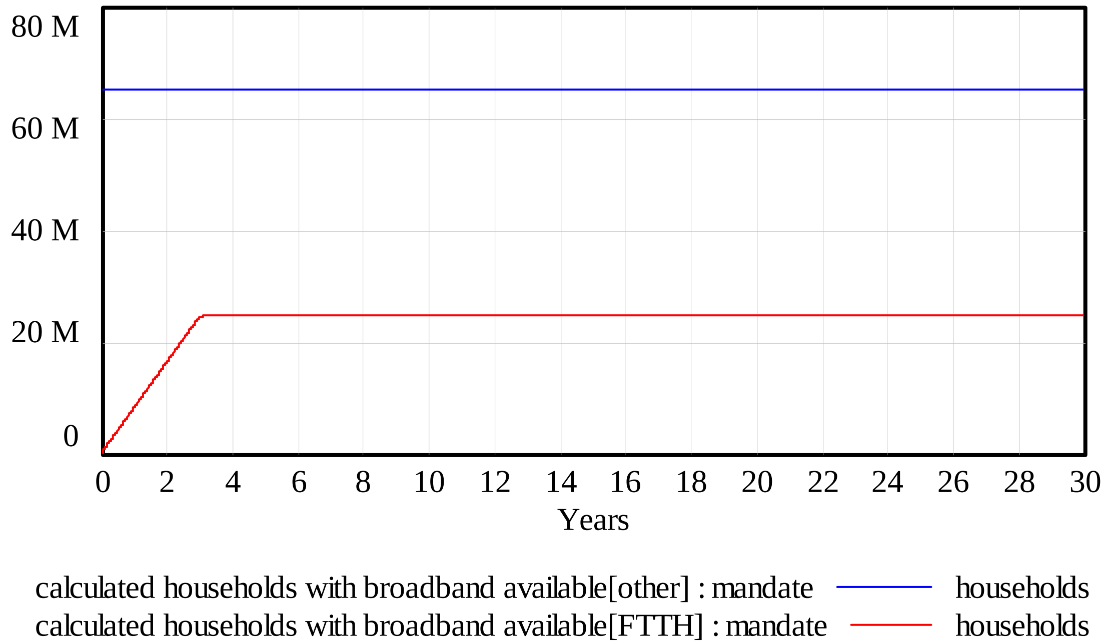

Figure 5: Community deployment rate under a three year mandate.

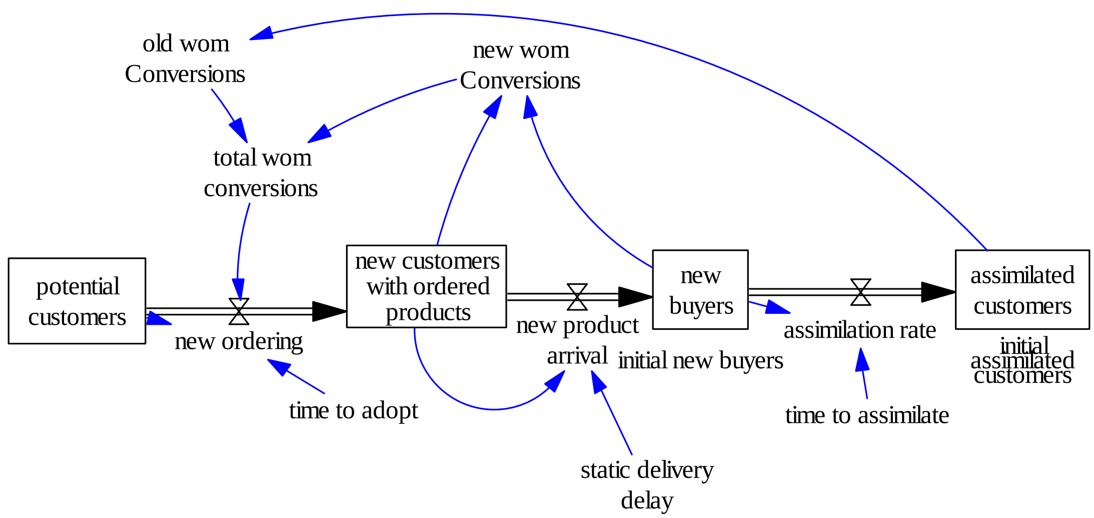

Figure 6: Customer broadband adoption.

Figure 7 shows the characteristic trend of the user adoption market for broadband. Initially, adoption is slow. Few people have broadband service, and even fewer have fiber-to-the-home service, so there is not a strong network effect, and marketing drives user adoption. The model assumes that the network effect that governs adoption is for all broadband, thus if a fiber-to-the-home customer interacts with a person that only has some other form of broadband available, that person is likely to adopt the broadband service available to them. As can be seen in the graph, once a critical number of users have signed up for service, adoption grows rapidly. The rate of adoption begins to slow once all communities have service available, and then reaches a limit.

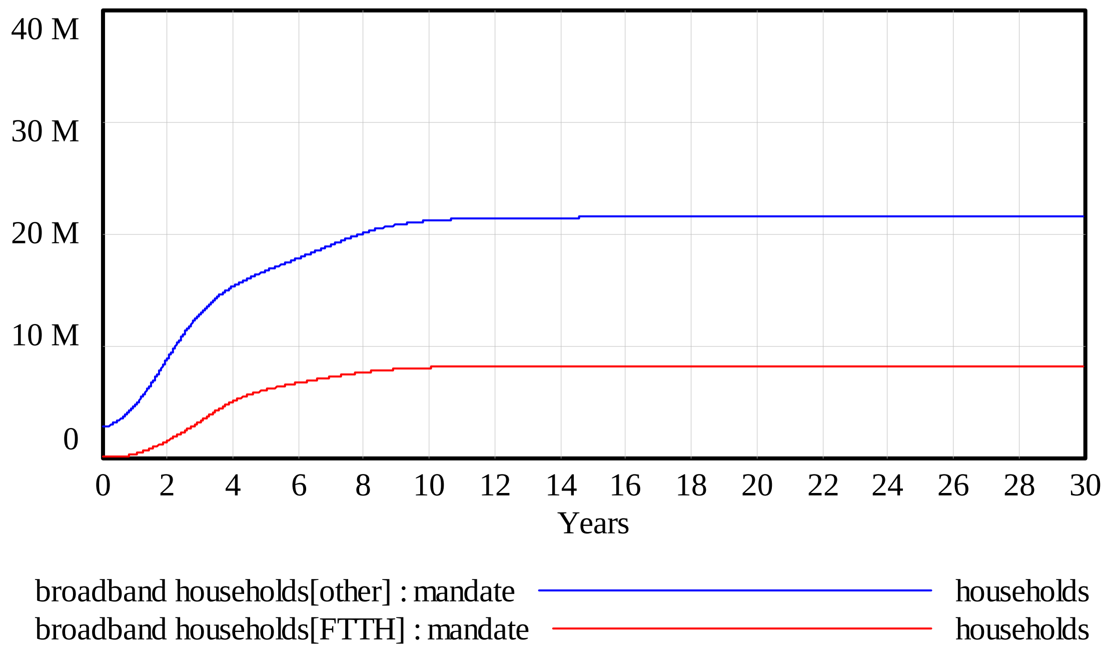

Figure 7: Consumer adoption trend for a three year deployment mandate.

Implications for the Transceiver Industry

Background research relating to the deployment of fiber-to-the-home and the state of the transceiver industry showed the following (Kelic, 2003):

- A large proliferation of standards for fiber-to-the-home transceivers;
- No clear convergence path or natural advantage for any one fiber-to-the-home technology;
- It is impossible to predict a 'winning' fiber-to-the-home technology and the direction of standards evolution; and
- It may be possible to standardize on one or two transceivers for both customer premise and remote terminal equipment.

These factors are translated into the following assumptions that are used in the model to go from customers as discussed in the prior section to the transceiver deployment rate:

- fiber-to-the-home deployments are 50% active and 50% passive;
- active deployments use the same type of transceiver at the remote terminal as at the customer premise;
- there is a five year equipment renewal rate;
- only one CPE is deployed per customer;
- the equipment being deployed has greater capacity than required for customers, so there is no driver for equipment replacement aside from equipment failure; and
- Standardized transceivers can be used at the customer premise for passive deployments and at both the customer premise and the remote terminal in active deployments.

Figure 8 and Figure 9 show how transceiver tracking is implemented in the model. The deployment rate of standardized transceivers is a simple sum of the transceivers in the remote terminals and those in the customer premise equipment. The deployment rate for active and passive transceivers is calculated using the percent active and percent passive deployment rates specified above.

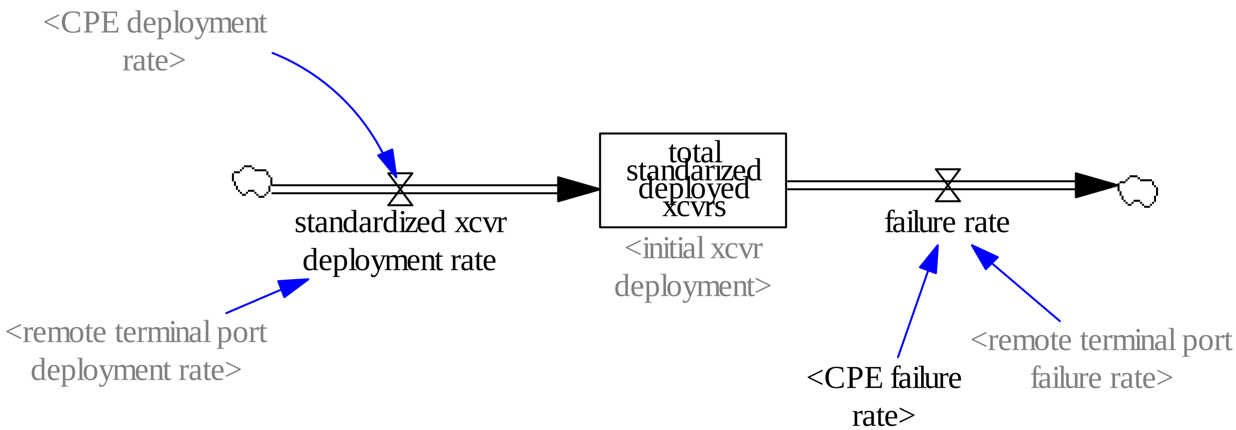

Figure 8: Standardized transceiver deployment rate.

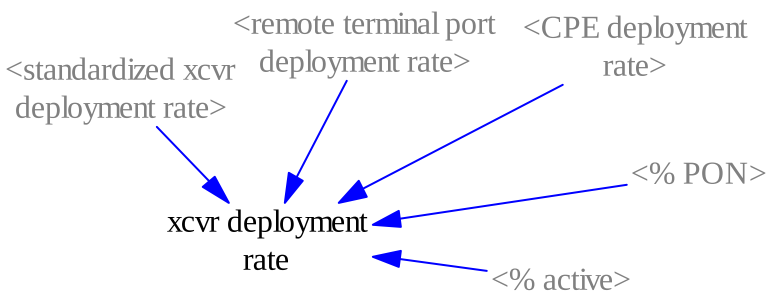

Figure 9: Transceiver deployment rate, all transceiver types.

The transceiver deployment graph that results from the market assumptions and the transceiver assumptions is shown in Figure 10. This graph shows that transceiver volume grows as deployment is happening, but then drops off to a replacement rate for equipment that fails. This effect is due to fiber-to-the-home deployments not requiring the leading edge in transceiver technology. Users are not demanding bandwidth anywhere near the capacity of the transceivers. This gives the carriers the ability to upgrade bandwidth by making changes in software without needing to replace equipment. The capacity of the equipment is much higher than current demand, and even near-future foreseen demand.

As shown in the figure, standardizing transceivers for fiber-to-the-home deployment sees a faster growth rate and a higher peak, and a similar decline to replacement rate. Standardizing a transceiver just for the fiber-to-the-home market is not enough to prevent the growth and decline. This sort of growth and decline can be devastating to an industry, since it requires the industry to build up capacity to meet demand, however that demand is not sustained. The excess capacity is likely to cause financial difficulties in the industry and individual companies to fail.

Since the rapid growth and decline comes about due to a fictitious policy that assumes that telecommunications carriers will be able to rapidly deploy fiber-to-the-home, it is necessary to explore the effects of a slower deployment rate on the transceiver industry. A slower deployment rate, while not in the consumer or regulator's interests, may help mitigate the growth and decline and also better reflect the constraints of an actual infrastructure build.

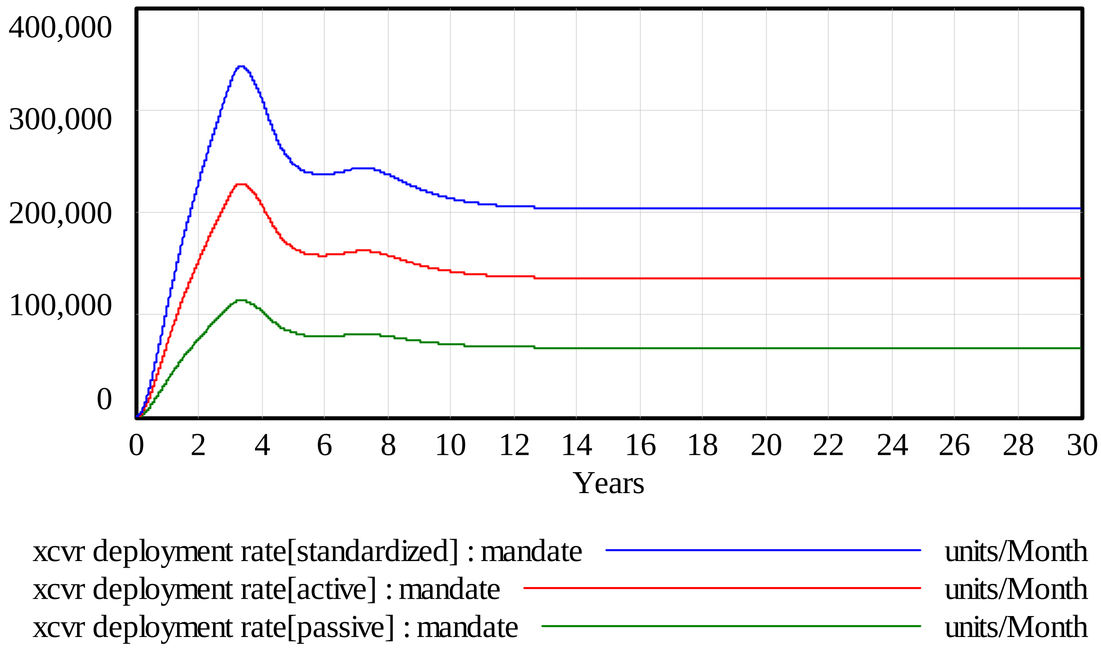

Figure 10: Deployment rates for standardized, active, and passive transceivers under a three year mandated deployment schedule.

Slowed Fiber-to-the-Home Deployment

If the deployment of fiber-to-the-home is slowed to a ten year deployment rate, still requiring that all of the communities that do not currently have broadband build fiber-to-the-home, the customer growth rate looks like that shown in Figure 11. As shown in the graph, it takes significantly longer for consumers in areas that do not already have broadband to adopt broadband technology. Delaying the deployment of broadband also causes adoption by people in the areas that already have it to slow slightly, since fewer customers causes the network effect to not be as strong.

The slower infrastructure build rate and adoption rate results in the transceiver deployment rate shown in Figure 12**.**

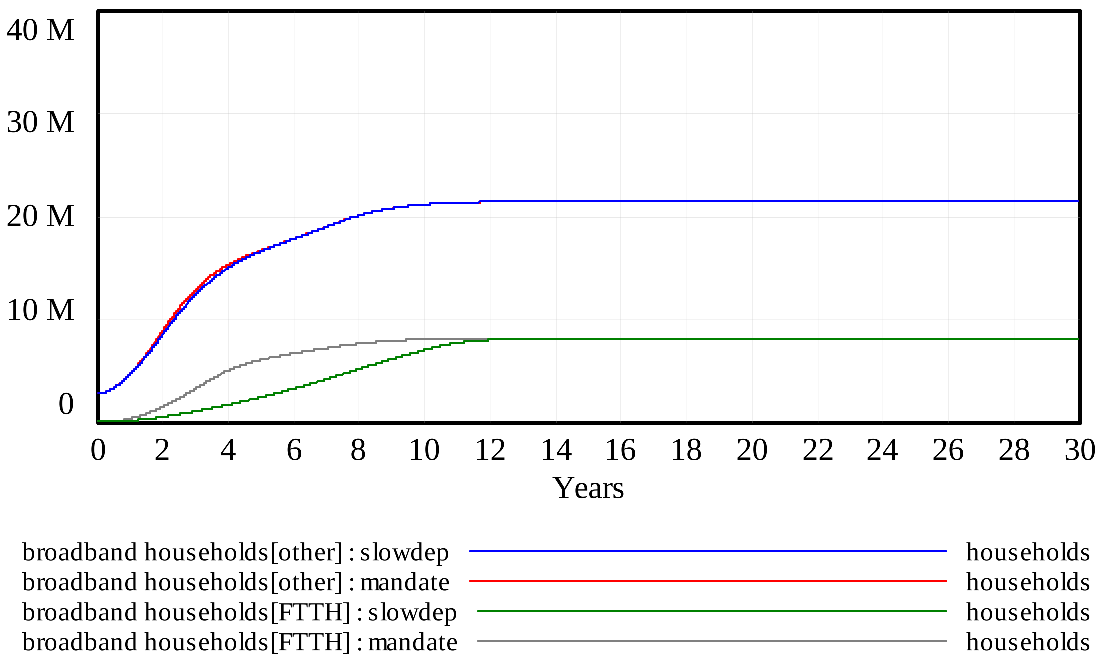

Figure 11: Customer Growth Rate Under a Three Year Versus Ten Year Deployment Schedule

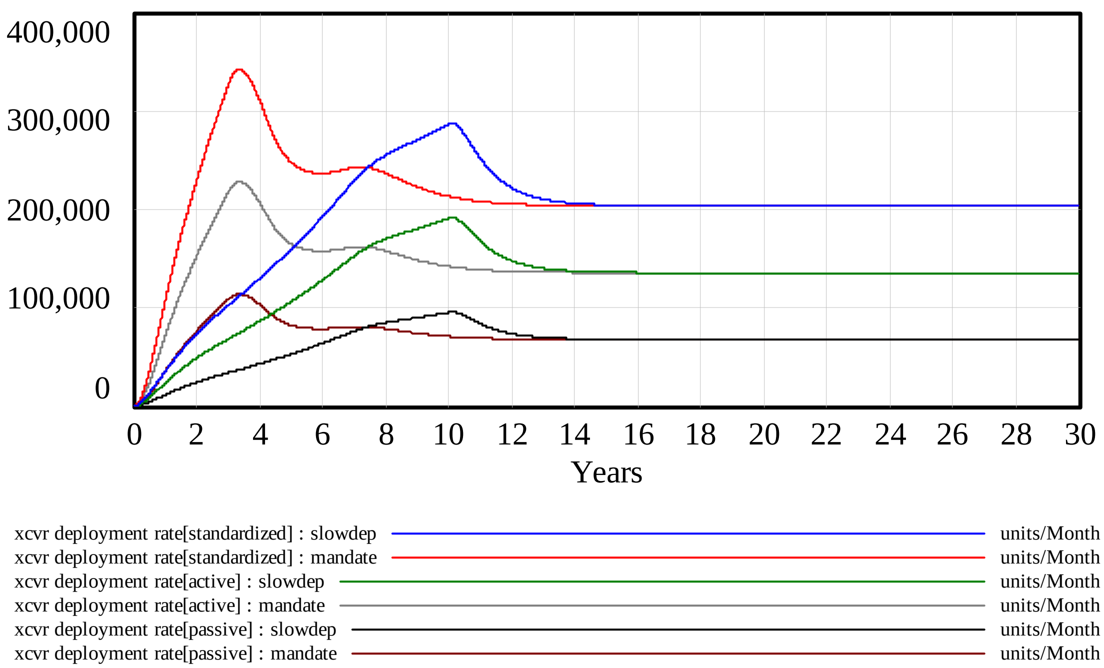

Figure 12: Transceiver Deployment Rate Under Ten Year Fiber-to-the-Home Deployment Schedule

As shown in the figure, slowing the deployment rate does make the peak less dramatic and also lengthens the build-up period before the peak. Slowing the deployment rate even further, to a twenty year infrastructure build time, results in the user adoption rate shown in Figure 13. The corresponding transceiver deployment graph is shown in Figure 14. Delaying the deployment completion time even further from ten years to twenty years drastically reduces the peak seen under the three year mandated deployment schedule.

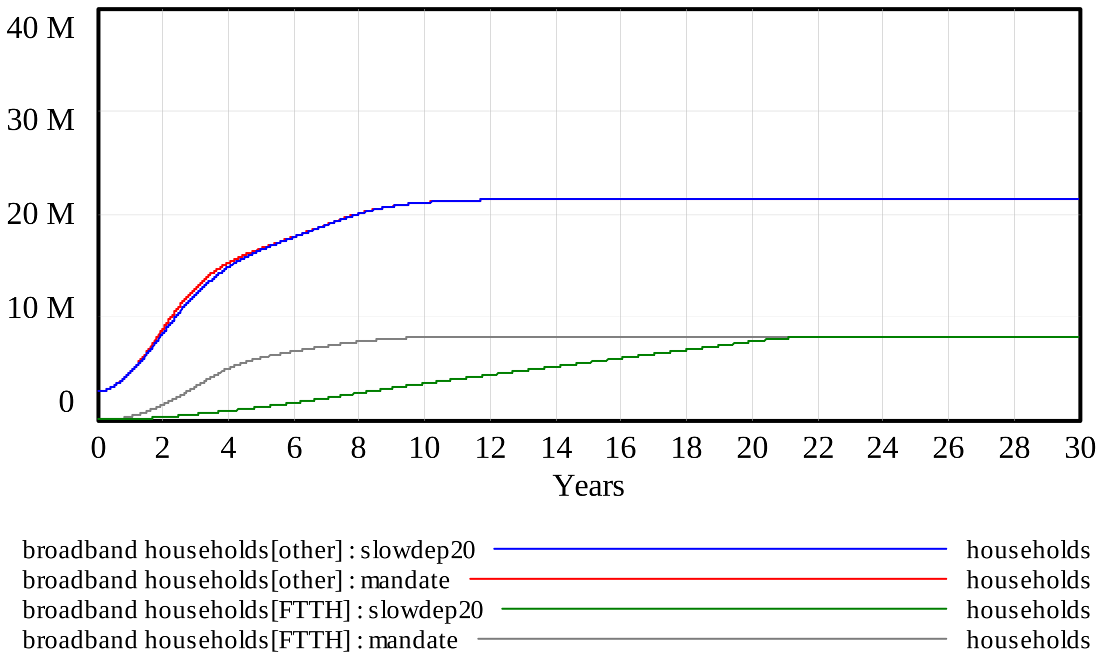

Figure 13: User Adoption Under a Twenty Year Deployment Timeframe.

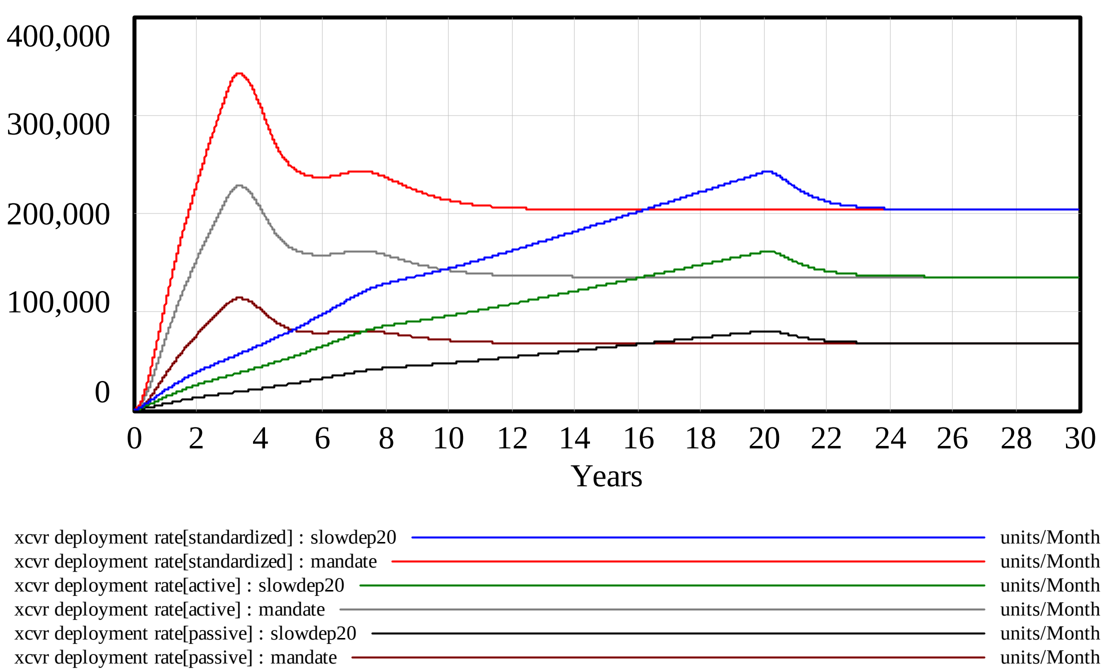

Figure 14: Transceiver Deployment Rate Under Twenty Year Fiber-to-the-Home Deployment Schedule

A slower deployment rate may be better for industry health in the short term because it delays the drop to a renewal rate and reduces that drop. However, it also results in much smaller overall production volumes for the industry and is far worse from a consumer perspective. Consumers have to wait much longer to be able to obtain broadband service, which is not in the interest of the consumer or of the policy makers.

Disposable Equipment and High Churn

Another potential way to prevent the ramp up and decline in transceiver deployment rate is a high customer turnover rate along with disposable customer premise equipment. If customer premise equipment cannot be redeployed by the service provider after a customer cancels service, that piece of equipment is disposed of. Any new customer additions or re-additions of former customers then require a new piece of customer premise equipment and a new transceiver.

Figure 15 illustrates how the discarding or redeployment of equipment is handled in the model. In the default runs of the model, the discard switch shown in the figure allows CPEs to be redeployed from customers that have left the service. When the switch is turned on, CPEs from customers canceling their service are discarded and not redeployed.

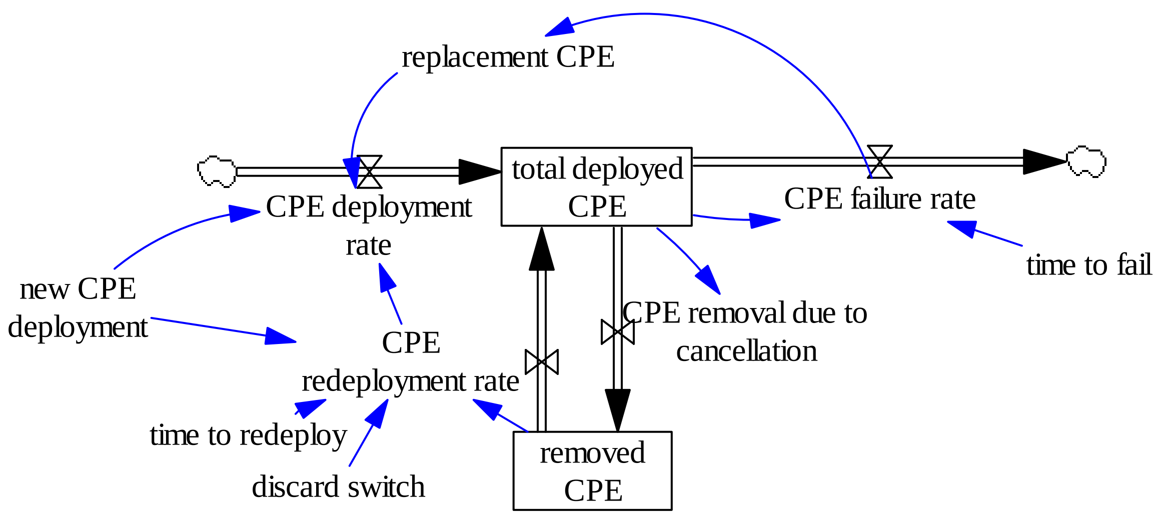

Figure 15: CPE redeployment and discard.

The results of disposable equipment under the original set of conditions for a three year mandated deployment schedule are shown in Figure 16. This deployment assumes a thirty-five percent churn rate (Credit Suisse First Boston Equity Research, 2003). The churn rate is the fraction of customers that leave the service provider annually. The default assumption is that fiber-to-the-home will have a churn rate similar to that of cable modem service since the characteristics of the installation are similar.

As seen in the chart, forcing service providers to discard customer equipment with a thirty-five percent customer turnover rate is extremely beneficial to the transceiver industry. The peak still happens, but since the customer turn over rate is fairly high, much of the deployed equipment gets discarded before it fails, so new equipment deployment overwhelms the replacement rate.

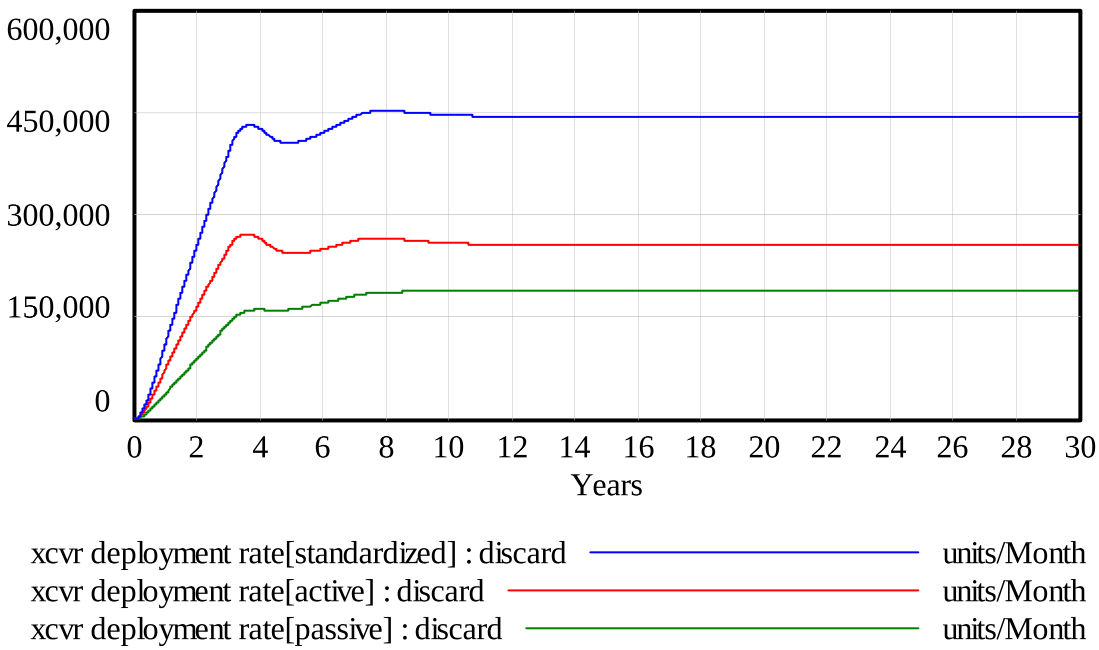

Figure 16: Transceiver Deployment Rate Assuming Disposable Customer Premise Equipment.

A high customer churn rate is costly to the service provider since there is a cost associated with acquiring each new customer. Service providers are investing significant effort into improving customer satisfaction to reduce the churn rate. The effect of a churn rate lowered to ten percent is shown in Figure 17. As can be seen in the chart, the interest of the service providers in lowering churn is in direct conflict with the interest of the transceiver industry in eliminating the growth and decline. Even with disposable equipment, the lower churn rate offsets the benefit gained by requiring that any returning customer get a new piece of customer premise equipment.

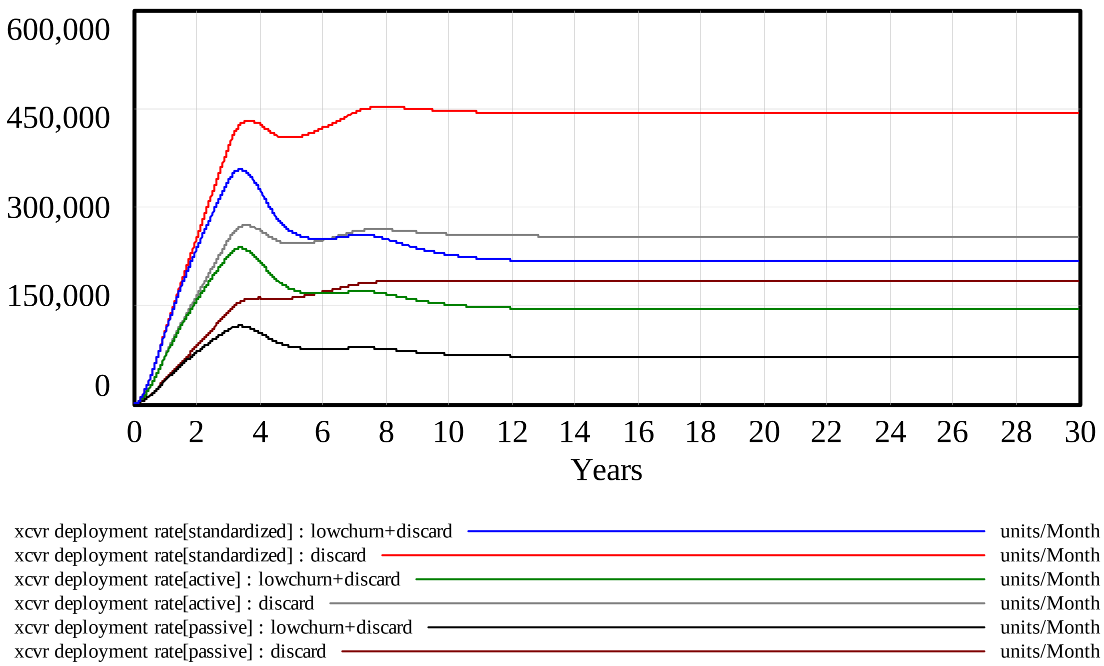

Figure 17: Transceiver Deployment Rate Assuming Disposable Customer Premise Equipment and a Ten Percent Churn Rate.

Summary

Government can have a devastating effect on the health of the transceiver industry. A government push for rapid deployment of fiber-to-the-home without an industry move towards standardization across product lines (telecommunications and storage, for example) could be devastating to industry health. This sort of push causes a rapid boom and bust cycle, with industry rapidly increasing capacity to meet demand and then left with a state of overcapacity after the deployments are finished.

Moderation in the rate of deployment would make the boom and bust cycle for fiber-to-the-home transceivers much less severe. However, slowed deployment is difficult for the transceiver industry to control. Increasing transceiver prices may slow fiber-to-the-home deployment; however it may also force service providers to a different technology, resulting in lower transceiver volume. Slowed deployment is not in the interest of consumers or regulators, since it delays the availability of broadband technology to the consumer.

Regulators at the federal, state, and local level have an interest in promoting telecommunications technology and ensuring that the technology becomes available to all consumers. When these regulators set policy they examine the problem from the perspective of the consumer and consumer choice. This results in policies that are designed to benefit consumers from a price and service perspective, and also to assist new entrants in providing competition in the market.

Rarely do telecommunications policies look beyond the consumer and the telecommunications companies to the effects on the remaining portions of the supply chain. The transceiver industry is at the opposite end of the supply chain from the consumer and thus subject to consequences of telecommunications regulation. Recent broadband policies have been designed to promote the rapid expansion of broadband services to the consumer and also to promote facilities-based competition. However, rapid deployment of broadband translates down the supply chain to a need for large production capacity that gets used in the initial network build, and then sits mostly idle used primarily to replace equipment that has failed.

The regulatory viewpoint of watching out for the good of the consumer is unlikely to change. The industry needs to explore ways to protect itself from the cyclical nature of the telecommunications industry and prevent situations of overcapacity and excess inventory.

The state of the transceiver technology makes it difficult for the industry to avoid a boom and bust cycle. Fiber-to-the-home deployments do not require the cutting edge in technology, especially at the customer premise. All of the existing standards deliver far more bandwidth than the consumer can currently use. The systems are designed so that providers can implement upgrades in bandwidth through software, without having to swap out components. For transceiver manufacturers this means that once initial deployment is passed the replacement driver will be equipment failure and replacement as opposed to technology upgrade, leaving excess capacity from the deployment ramp up.

In current broadband deployments, customer premise equipment has an expected life of five to seven years. This time frame is far shorter than the twenty-year standard for the industry's traditional telecommunications product line (transceivers in the backbone of the Internet), yet it is still too long to prevent overcapacity once networks are deployed. Service providers have reduced their reliability expectations for equipment deployed at the customer premise to be more in line with that of consumer electronics than with traditional telecommunications networking equipment.

Customer premise equipment that could not be redeployed in the event a customer left the service coupled with a high turnover rate of customers would help mitigate the fall to replacement shown in many of the transceiver deployment graphs. However, this could potentially be devastating for the telecommunications provider, since a high turnover rate means less cost recovery of the expenditure to acquire the customer and lower revenue. Equipment that could not be redeployed would also increase the cost to acquire any individual customer and the cost of the service as a whole. An option of equipment that is disposable is not entirely in the control of the transceiver manufacturer, since in many cases they do not manufacture the customer premise equipment itself, just the transceiver used in that equipment. Therefore such a transceiver industry policy would require the buy-in of all equipment manufacturers and telecommunications providers to be viable, and there is no incentive for cooperation on this particular issue. Customer turnover rates are also not in direct control of the transceiver industry; they depend on the ability of the provider to attract and retain customers.

Facilities-based competition with multiple providers building fiber-to-the-home networks would perhaps mitigate the boom and bust cycle. However, the networks are costly, and to date the majority of facilities-based competition has not been occurring in identical technologies. For example, broadband is currently provided over traditional phone networks (DSL), cable networks (cable modem service), and in some cases wireless networks.

Standardization across markets is one of the potential solutions that is under control of the transceiver industry and also good for industry health. A standard transceiver that can be used across markets would protect the industry from the cycles associated with telecommunications deployments and opens up the potential of appealing to additional markets. The transceiver industry needs to aggressively explore standardization across product lines to bring itself in line with the interests of the rest of the fiber-to-the-home supply chain and ensure its survival regardless of the direction that fiber-to-the-home deployment takes.

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