Residential Resale of Wireline Broadband via Wireless

by

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Abstract

The proliferation of Wireless Fidelity (Wi-Fi) and other wireless LAN technologies that take advantage of unlicensed spectrum in the radio frequencies offer a novel platform for extending broadband access and wireless services ubiquitously. After analyzing the availability and the regulation of unlicensed spectrum in Europe and America, this thesis explores the circumstances under which a wireline provider of broadband services (e.g., Digital Subscriber Line or cable modem) would find it advantageous to provide broadband services to a new customer via residential resale of wireline broadband services. That is, this thesis examines business, policy, and industry implications of residential subscribers setting up WiFi base stations to share their wireline broadband connections with neighbors. Moreover, this thesis assumes that appropriate mechanisms will exist to allow the residential resellers to charge for the services they provide, but that the upstream wireline carriers will not be able to separately monitor end-user and resold traffic. This thesis presents a cost model to evaluate the circumstances under which the acquisition of a new customer for the purpose of providing him broadband connectivity via broadband resale may be profitable for the wireline carrier.

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I do not want to forget my parents, my sisters Aurélie, Marine, Clémence, Héloïse, and my brother Guillaume, whose continual encouragements were so important to me.

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Chapter 1 Introduction

1.1 Context

1.1.1 Free wireless community networks

Wireless Local Area Network (WLAN) characterizes a new category of wireless technologies aimed at replacing wired Local Area Networks (LAN) such as Ethernet LANs in the enterprises and individual homes. They simply require to plug-in a WLAN Access-Point (AP) on any existing network - to be able to wirelessly access the LAN with any WLAN-enabled device. The most well-known WLAN technology as of this writing is IEEE 802.11, a.k.a. Wi-Fi (see section 2.2 for a complete description of WLANs).

The two primary expected benefits from wireless LAN over wired LANs (such as Ethernet) are 1) the increased convenience from connecting to the LAN from anywhere (for instance in a meeting room) – provided that one is in reach of a wireless access point; 2) the increased easiness of deploying a LAN[1]. However, besides facilitating the connection of the people who were previously connecting to the network via cables, WLAN devices also turned out to extend the reach of traditional wired networks and allow the connection to the network of people who previously were not supposed to connect. And notably, when combined with a traditional broadband connection to the Internet, WLAN devices enable users "from the outside" use this Internet connection.

Drawing on this capability, some individual subscribers to broadband Internet services decided to take advantage of their WLAN equipment to share their Internet connection with others – neighbors or passersby. Driven by altruism and a "community-sense", they were offering this wireless connectivity for free. In some urban areas, the number of such open-access WLAN access points increased so much that the "wireless-cells" (i.e. the wireless area covered by a given access point) started to overlap, creating de facto "free wireless wide area networks". The owners of these access points saw potentials to build citywide distributed networks of linked WLAN access points, owned and operated by individuals. They got organized into not-for-profit associations to promote and develop their networks.

[1] Rolling out a wired line implies to install and connect plugs at all the locations from which users may need to access the LAN, while rolling out a wireless LAN only implies to install and connect a few based stations across the building, which requires much less wiring.

Community groups across the nation and the globe[2] have banded together to promote the proliferation of free Wi-Fi networks, as explained by one of these associations in the following words: *"Freenetworks.org is a group of individuals and organizations that are committed to facing the social, political and technical issues that occur in the creation of these networks. We believe that through global communication and collaboration, we can work through these issues in a more efficient manner."*[3]

1.1.2 Lessons from wireless freenets

The ongoing development of freenets is meaningful to us for at least three reasons:

1. First, freenets represent a bottom-up telecommunications network. The resulting wireless network has no center, no manager, and grows organically from the addition of small wireless cells by individuals. These principles recall those of the Internet (a decentralized and distributed network, to which any computer could connect provided that it was abiding by certain rules[4]) applied to a "real-world" situation.

2. Second, in some areas where the density of freenets AP is very high (such as in San Francisco downtown) connection to the Internet via a freenet AP appears to be *a real alternative method* for accessing the Internet via a broadband connection.

3. Third, freenets prove that many individuals have the capability and the willingness to put themselves into setting up and managing an open WLAN access point, and share their bandwidth, even though it usually implies for them to benefit from a degraded maximum throughput. This point is particularly noticeable as the process is quite burdensome (they spend hours looking for help on message boards on the Internet, or sharing their experiences with novices), and as they do it totally for free.

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[2] As of 2001, there were already groups doing it in 12 U.S. cities, including three in Seattle and two in the San Francisco Bay Area; as well as at least six groups in five cities in Australia, at least one in Canada, as well as groups in France, Finland, Sweden and the UK (source: [Blackwell 2001]).

[3] See website http://www.freenetworks.org

[4] The major rules is the use of the Internet Protocol (IP). More information about the principles leading the initiators of the Internet can be found in [Saltzer 1984].

1.1.3 Freenets' shortcomings

In spite of the copious media attention they have benefited from, freenets still remain at the stage of an "interesting experience": their scope does not go beyond the center of only a few American cities and international capitals, and their current coverage footprints are still full of gaps.

The freenets' philosophy puts heavy burdens on the few altruistic persons who accept to make their own wireless AP and broadband connection available to strangers, neighbors or passersby. This burden is mainly twofold: 1) most freenets AP owners dedicate a lot of time to their involvement in the freenets movement (they spend hours learning how to best configure their AP, animating websites and discussion lists about freenets, building antennas…), and 2) they may suffer from a degraded connection's quality (in terms of maximal personal throughput) because they share it with others. Freenet node operators usually accept to support this burden by altruism[5].

Wireless freenets also suffer from another flaw: the freenets model necessarily imply the collaboration of a broadband carrier[6] to carry the traffic upstream from the freenet access points needs up to the Internet access point (called "point of presence", or POP). If freenet members are willing to provide this service for free, it may not be the same with those broadband carriers. And indeed broadband sharing is considered by most of the industry as theft, as expressed by Sarah Eder (a representative for AT&T Broadband): "This would be akin to stealing cable. When there are multiple users on a cable modem that we don't know about, that we're not assigning, we can't accurately manage bandwidth, and we can't give customers the service that they're paying for" ([Festa 2001]). This a priori opposition of the telecom industry against wireless freenet communities and broadband sharing may well jeopardize their development[7].

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[5] As Ken Caruso (a spokesman for the SeatlleWireless group) explains: *"[M]ost of it is philosophically motivated. You do it to provide access to the neighborhood because you're a community-oriented person and you believe this is the right way to the go."* (cited in [Blackwell 2001]).

[6] The carrier whose broadband services the freenet member had subscribed to.

[7] As explained by Alan Reiter (president of the Wireless Internet & Mobile Computing consultancy): "Voluntary organizations are going to spark action by large corporations. They're going to see this grassroots effort and try to crush it if they can make money by doing so" ([Festa 2001]).

1.1.4 Residential broadband resale

We hold a very pragmatic view on freenets. We regard this "magnanimous principle" as a major impediment against large deployment of freenets: if until now there have been a few hundreds of people accepting to incur these burdens *for free*, we do not believe that thousands or hundreds of thousands persons will be motivated enough by "philosophical principles" to accept the burden of creating and managing a freenet node. And even further, we believe that some of the current freenet nodes owners may soon be disenchanted by the burden they support while sharing for free their broadband connection to the Internet – especially as more users will access the Internet for free through their access point and broadband connection. Therefore we expect freenets as such will remain restricted to very few locations and does not have the potential of becoming a ubiquitous or even widespread alternative to commercial wireless and broadband networks that many freenet spokespersons claim they will be. If we agree that freenets showed the way to a potential cheap mode of accessing broadband[8], we also contend that freenets are not sustainable unless they evolve towards a more economic model, in which the players bearing the costs of providing services are being compensated by the persons benefiting from the services.

However, an evolution of the freenets model that would get rid this intrinsic impediments to freenets' deployments can be imagined, if broadband connection get resold rather than given away for free. This model called "broadband resale" can thus be understood as a maturation of the freenet model towards economics principles: its sustainability will be guarantied only if all the economic players (the managers of the WLAN nodes, the carrier transporting the traffic upstream…) taking part in the service provision chain can be compensated for their involvement. The broadband resale model could lead to a much greater availability of wireless broadband. Because of its flexibility (in the sense that anybody can easily become a local wireless internet service provider, by setting up an access point at low cost) access points should theoretically appear everywhere where demand for broadband is sufficient. To the extent that broadband resale would enable anybody on the street to use their Personal Digital Assistants (PDA) or their laptop and wirelessly access the Internet via a WLAN access point, broadband resale could be seen

[8] The "Bay Area Wireless Users Group" (BAWUG, one of the principal wireless communities in San Francisco) website notably mentions their members' understanding that wireless access can and has the potential to "significantly reduce the cost and increase the ease to share resources and access to the Intemet" (http://www.bawug.org).

as a main step towards ubiquitous wireless broadband and distributed connectivity, i.e. models where many sorts of devices (laptops, PDAs, watches…) could wirelessly dialog with each other[9].

1.2 Thesis' perspective

This thesis proposes an analysis of residential broadband resale (as described in section 1.1.4 above), i.e. a model considering residential customers of wireline broadband (in their homes) who decide to resell broadband thanks to wireless devices. Our framework assumes *distributed initiative*: it is some of the carrier's residential customers who will take the initiative to become resellers of broadband. This assumption comes from our perception of residential broadband resale as a maturation of wireless freenets (which were encouraging individual initiatives) towards economic principles. Analysis of other scenarios where the carrier would install contact some of his customers to ask whether they could stick some WLAN AP on their property to be able to provide wireless services in the surrounding area could be interesting extensions to this thesis.

We will restrict the scope of our analysis to the resale of broadband *by* residential users *to* residential users. In other words, we will only consider the form of broadband resale that could serve as an original method for connecting households to the Internet at broadband speeds – and as a potential substitute to other fixed broadband solutions such as DSL, Cable and MMDS. We should note here that there exist other potential uses of residential broadband resale. Notably, residential broadband resale as a whole also includes resale of broadband connectivity to mobile or nomadic users (such as passersby in the area who want to check their emails)[10] – a subcategory that we will ignore in this thesis.

This analysis of residential broadband resale will adopt the perspective of a carrier providing wireline broadband services to residential customers[11]. Our decision to adopt this particular perspective comes from our perception that wireless freenets will be impeded in their development by the opposition from the telecom industry (see paragraph 1.1.3 above), and that the proposed model of residential broadband

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[9] See [Clark and Wroclawski 2000] and [Faratin 2002] for an exemplary model of distributed connectivity.

[10] The characteristics of *mobile* broadband resale are different from the *residential* broadband resale ones. Notably, the relationship between the end-user and the reseller are necessarily very short with mobile broadband resale, which needs to impact the reseller's pricings and the billing mechanism.

[11] As we will explain later, we will sometimes restrict our analysis to the perspective of a carrier providing *Digital Subscriber Line (DSL)* services.

resale will be able to thrive only if the broadband carriers find interests in this model – and this thesis proposes to analyze the conditions under which they will. As we will see, these players are concerned with residential broadband resale on two counts: first, they represent an indispensable link in the value chain of residential broadband resale [12]; and second, if broadband resale were to take off, this new proposition for accessing the Internet would compete with their wireline broadband business.

For most of the thesis (i.e. from 0 to Chapter 4), we will consider that this carrier provides broadband services via *wireline* technologies, i.e. either via Cable or Asymmetrical Digital Subscriber Line (ADSL). This assumption is not restrictive, if one considers that today these two broadband technologies dominate the market for residential broadband access: Cable and ADSL together represent more than 92% of the broadband subscribers in the US[13]. Given that Chapter 5 is a quantitative analysis in which we needed to be very specific about the technology used by the carrier to provide broadband services: we chose to assume that the carrier is an ADSL provider. The reason for choosing to take the perspective of an ADSL provider over a Cable provider is that ADSL providers have a cost structure less favorable than Cable provider, and therefore we expect residential broadband resale to represent a greater opportunity for DSL providers than for Cable providers[14]. Then this assumption will be relaxed, as most the analysis in 0 (that proposes a qualitative analysis of the impacts of broadband resale at a macro-level) is applicable to the two wireline broadband technologies, cable modem and DSL.

1.3 Research approach

Our analysis of residential broadband resale will follow a two-step approach. First, we will try to estimate what would be the profitability for the broadband carrier of an individual customer of residential broadband resale, if this service was launched. It implies thoroughly assessing the incremental costs that

[12] The traffic from broadband resale will take the wireline broadband connection that these carriers provide to the resellers.

[13] In 2002 the U.S. counts about 11 million of cable modem subscribers and 6 million of DSL subscribers, out of a total of 19 millions broadband subscribers (Source: [Davis 2002]). Alternative technologies such as MMDS and satellite broadband are penalized either by technical shortcomings (e.g. latency for satellite) or unfavorable cost structures preventing to provide these services at competitive prices.

[14] DSL providers notably need to engage in greater upfront incremental capital expenditure costs foe serving an additional customer (see [McKinsey 2001, p.70]). Since the users of broadband resale services have the advantage of requiring small upfront incremental capital expenditures (see section 5.2) the potential gains of promoting broadband resale are likely to be greater for a DSL provider than for a Cable provider.

each additional resale user would generate for the carrier. Acknowledging the intrinsic difficulty of forecasting the revenues that the carrier will be able to draw from resale users, our analysis of revenues will be succinct and qualitative. Nevertheless, our analysis will enable us to identify the circumstances under which a DSL carrier will find advantageous to acquire and provide broadband resale services to a new customer.

Then, after assessing the intrinsic potential profitability of each individual resale users, we will address the bigger picture of residential broadband resale, on a qualitative level. For doing so, we will identify the major transformations that residential broadband resale will apply to the structure of the carrier's customer base, and try to assess the extent of these transformations as well as their main determinants.

1.4 Related work

Several categories of research works appears to be of great relevance to our study. First, the cost structure of wireline broadband technologies (DSL and Cable) have been analyzed already[15], and this thesis will partially draw on some of these cost models' data and results. However, one must be very careful that the situation analyzed in these models is different from the situation we propose to study: most of these models analyze the incremental costs of adding capabilities of broadband provision to pre-existing incumbent telecommunication plants (the telephone plant in the case of ADSL, and the cable TV plant in the case of cable broadband); on the contrary, we will assume that such capabilities for the carrier provisioning broadband already exist (and the corresponding sunk expenditures for plant upgrade already incurred), and we are concerned with the incremental (from this initial situation) costs – upfront and recurring – of serving an additional customer (via wireline or resale).

Then, the various analyses of WLAN technologies and their impacts on the telecommunications terrain are very insightful. In this category, two bodies appear of particular interest to us: analysis of the wireless community networks phenomenon (but these analysis were either newspaper articles destined to laypersons, or technical articles from those community websites destined to new community members),

[15] See [Gillett 1995] for a comparative cost modeling of Cable and ISDN (a precursor of ADSL technologies); [Fryxell] for an analysis of the forward looking capital costs for constructing a broadband access network (based on DSL and Cable architectures) capable of offering integrated internet access and voice services; and [McKinsey 2001, pp.68-81] for an analysis of the incremental capital and ongoing costs for providing broadband via DSL and cable.

and analysis of business models and value chains based on WLAN technologies[16]. In a sense, this thesis is located at the crossing between these two subcategories, and will draw upon both of them.

1.5 Thesis' Assumptions

This section describes the principal assumptions that will frame our vision in the course of this thesis.

1.5.1 Designations

In the rest of the thesis, we will refer to the different stakeholders in a consistent manner, with the following terms:

- The **carrier** is the company providing wireline broadband services in the considered area, and whose perspective we adopt in our analysis[17].
- The **wireline users** are the customers who officially subscribed to the carrier's traditional wireline broadband services (DSL or Cable).
- The **resellers** constitute a subset of the wireline users; they engaged into resale, and make use of wireless LAN technologies to sell their personal wireline broadband (DSL or Cable) connection with some of their neighbors.
- The **resale users** are the "buyers" of resold broadband services supplied by the resellers. There is always a reseller as a proxy between them and the carrier (as explained in section 1.2 above, only *residential* customers of residential broadband resale are considered, i.e. we do not consider resale of wireless services to mobile passersby).

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[16] See [Rubin 2002] for an analysis of the potential of WiFi to build new business models; [Keene 2002] for a presentation of a value chain for "hot spot" services; [Redman 2002] for an analysis of the business models for wireless broadband service providers making use of WLAN technologies.

[17] Therefore any subjective judgment expressed in this thesis (such as "preferable", "better"…) must be understood from the carrier's perspective.

1.5.2 Assumptions related to the carrier

- *The carrier is either an Incumbent Local Exchange Carrier (ILEC), or a large cable broadband and TV provider*. Besides their legacy business (providing analog voice services or providing TV programs), these companies are supposed to have engaged into providing wireline broadband services (via DSL and Cable modem respectively for the ILEC and the cable company). For the sake of simplicity, we will assume that these companies have (in their initial states) no other telecommunication activities besides their legacy and wireline broadband activities[18].

- *We consider an urban residential area*; this assumption is partly motivated by the range limitations of current generations of WLAN equipments, which makes broadband resale more likely to thrive in dense areas.

- *The carrier is already providing wireline broadband services in this area* (i.e. the carrier already incurred the costs of expanding its "DSL reachability" if it is an ILEC, and the carrier already upgraded its cable TV plant to make it suitable for two-ways communications if it is a cable provider).

- *In this area, competition from other companies on the broadband market can be ignored.* This simplifying assumption is made to keep the thesis within reasonable bounds, allowing the use of static models rather than dynamic ones. It is particularly necessary in Chapter 4 (the review of economic literature related to broadband resale). However, the existence of competition will be implicitly acknowledged in our discussion of the strategic benefits from broadband resale, in section 6.3. In the cost model, the existence of competition is also implicit in our consideration of the customers' churn rates.

- *The carrier's pricing model is based on "peak-bandwidth tiered pricings"*, i.e. we assume that it proposes a choice of combination peak bandwidth / flat-rate monthly fee. This assumption is consistent with the pricings used by most DSL providers as of this writing[19].

[18] Notably, we assume that the carrier provides no wireless services such as MMDS, or mobile telephony.

[19] Example: $40 per month for a 512 Kbps connection, $60 per month for a 1.5 Mpbs connection (cf. Appendix I).

- *The carrier has the capacity to discourage residential broadband resale*. In other words, if the carrier was coming to the conclusion that broadband resale is harmful to him, we assume that it will be able to discourage all but the most determined customers from doing it (via specific clauses in the subscription contracts signed by their customers, or via threats from legal actions). This assumption is consistent with our previously stated conception that the telecoms industry has the power to impede the development of wireless freenets (cf. [Festa 2001]).

- *The carrier has no direct relationship with the resale end-users*[20]*, and therefore can get information about them only via the intermediary of the resellers*. This assumption comes from our vision of broadband resale evolving from the current wireless freenets – for which the carrier has no knowledge of which customers became reseller, and who are the end-users.

1.5.3 Assumptions related to the end-users

- *A base of customers for the carrier's DSL wireline broadband services is already established.* We consider that all these customers have the following characteristics: early-adopters of broadband, with high-valuation for connection speeds, small price elasticity.

- *There is still some outstanding unmet demand for broadband services.* We further assume that this demand remains unmet for now because of its lower valuation for connection speed and its lower willingness to pay for broadband services[21].

1.5.4 Assumptions related to the resellers

- *Resellers are a subcategory of the carrier's wireline customers*, which means that 1) they have direct relationships with the carrier, 2) they pay a monthly flat-rate fee to the carrier, and the actual amount depend on the "peak connection speed" the reseller has subscribed to.

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[20] Notably, the carrier is supposed to not know the name, traffic volume generated, banking information… of the resale users (unless the resellers accept to provide such information to the carrier). This assumption follows from our vision of broadband resale networks as an evolution of the current freenets.

[21] This assumption is supported by many analysis of the latent demand for broadband. See section 2.1.1, as well as [Yankee Tiered Pricing], [Laszlo 2002], and [McKinsey 2001].

- *Resellers are former users of wireline broadband services who then engaged into broadband resale.* As stated in section 1.2 above, we assume that the resellers take the initiative of engaging into resale, in a way similar to owners of access points who decide to become part of a wireless freenet[22].

- *Beside their resale activity, the resellers use their connection also for their personal needs of Internet access.* In a sense, they can be assimilated as being one resale users for their resold services they offer[23].

- *As part of their resale activity, the resellers take upon themselves at least these two functions: Customer Management* (password attribution, maximum bandwidth allowed, handling of authorized MAC addresses…), and *Billing* (choice of pricing model, metering of traffic, automatic negotiation and striking of transaction, recording of past transactions…) of resale users.

- *No assumption is made relative to the actual management of these functions (and of the relationship reseller / resale users).* Notably, we do not want to make any precise assumption about the pricing model used by resellers to charge the end-users (it will be chosen locally by the resellers), nor the used "payment procedure" (informal hand-to-hand payments, totally automated payments via credit card number, via online systems such as Paypal…). By that we acknowledge that it can greatly vary from reseller to reseller.

- *The resellers are driven by two objectives: maximizing their profits from resale, and experiencing a sufficiently good broadband connection for their own use.*

1.6 Preview of key conclusions

The key findings of this thesis are:

1. Resold broadband will be a good very different from traditional wireline broadband, and will appeal to different customers. Wireless resale users will be characterized by lower valuation for

[22] See section 1.1 for more details about wireless freenets.

[23] Regarding the resellers as resale users of their own shared DSL line is relevant since they will probably also use their connection via WLAN technologies, and since they will experience the same (as a first approximation) degraded quality of service as the other resale users on this shared line.

connection speed, lower willingness to pay for broadband connection, and higher churn. See sections 4.4 (page 9) and 5.4.3 (page 117) for an explanation of this conclusion.

2. Acquiring and providing service to an addition resale user will require much lower upfront expenditures by the carrier, and will generate much lower recurring operating costs. If servicing resale users appears to be cheaper than servicing wireline users, it will probably be offset by lower revenues. This conclusion is developed in Chapter 5 (page 82).

3. Framing adequate relationships with the resellers will be crucial for the carrier, since its ability to capture revenues from the resale users depends thereof. Based on the assumptions of the cost model developed in this thesis, acquiring a resale user will generate positive incremental cash flows for the carrier if it can secure more than $7 of monthly revenues from resale users. If these revenues were greater than $19 per month, then acquiring a resale user would have more value than acquiring a wireline user. See section 5.4 (page 112) for the analysis of the cost model's results.

4. Broadband resale is expected to have three major macro effects on the carrier's customer base: direct cannibalization of existing wireline users; indirect cannibalization of prospective users a priori interested in wireline services; and expansion of the customer base by appealing to users who were otherwise not interested in broadband. This conclusion is discussed in greater details in section 6.2 (page 124).

Chapter 2 Broadband resale enabling technologies

This chapter provides information about the technologies enabling residential broadband resale: traditional residential broadband technologies and wireless LAN technologies. This overview will support our analyses of residential broadband resale in the following chapters, by understanding the possibilities of broadband resale as well as the technical constraints hanging over it. The first section in this chapter will focus on traditional broadband technologies, while the second section will present the emerging wireless LAN technologies (with a special attention given to IEEE 802.11, since it is almost the only technology available on the market as of this writing[24]) and their capabilities. Finally, a third section will show how these two technologies get combined together, and what are the elements necessary for a wireline customer to start reselling wireline broadband via wireless.

2.1 Residential broadband technology

In order to understand how broadband can be resold thanks to wireless technologies, we first need to get a sense of how in the first place the resellers get this broadband connection that they will resell. This is the object of this section, which will particularly describe the two most prominent residential broadband technologies: Asymmetric Digital Subscriber Line (ADSL) and Cable modem.

2.1.1 Broadband market overview

2.1.1.a <u>Broadband technologies</u>

In spite of the concerns frequently expressed about the penetration of broadband in the U.S. population, its growth has been steady in spite of the recent economic downturn. As expressed in a recent article published in the Wall Street Journal: *"Today, more than 15 million American households have broadband*

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[24] As we will describe, some groups are working on alternative technologies, but they accumulate delays and disappointments. The example of HomeRF, a set of technological specifications once thought to compete with IEEE 802.11 is significant to this extent: *"The group was formed in 1998 and some of its key member companies included Proxim, Siemens, Motorola and Compaq Computer. However, the growing popularity and industry support for 802.11b helped to drive the evolution of the 802.11 specifications and lower the cost of products that were faster than HomeRF"* ([Shim 2003]).

connections through cable modems or Digital Subscriber Lines, known as DSL, offered by telephone companies. With new households signing up at a rate of 100,000 a week, the total should climb to more than 20 million by the end of the year [2003], or nearly 19% of the 107 million U.S. households" ([Grant 2003]). This quote is concerned only two broadband technologies: cable model and Digital Subscriber Lines, even though alternative broadband platforms also exist (such as Direct Broadcast Satellite – DBS, or Multi-channel Multipoint Distribution Service – MMDS). The reason comes from the observation that the penetration of these alternative technologies is still very low: satellite and MMDS still represent less than 5% of the broadband market, and can still be characterized as "wild cards, with enormous potential but significant hurdles"[25].

This observation also explains why we stated (in section1.2 above) that this whole thesis assumes that the carrier is providing broadband services via a wireline technology, i.e. via DSL or cable modem[26]. For this reason, this section about residential broadband technologies will also restrict its focus to these two prominent wireline technologies. We will give a special attention to the ADSL technology in order to support the cost model presented in Chapter 5[27]. Nevertheless, since most of the thesis (apart from the cost model) considers that the carrier may also be a cable provider, we will also describe (though more briefly) the cable modem technology in this section. It will notably help us understand the extent to which these two technologies are similar, and thus the extent to which cable modem resale and DSL resale via wireless can be analyzed together.

2.1.1.b Industry prospects

the residential broadband industry is entering a new phase, where the hurdle holding back broadband deployment is finally shifting from supply to demand[28]. In other words, the most important question to prospective customers is changing from "can I get broadband?" to "do I want broadband?" In this context, pricing becomes a core element impacting the penetration of broadband (especially for residential

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[25] See [Yankee Broadband, p.6-8].

[26] In the rest of this thesis, the terms "broadband" or "broadband market" will specifically refer to these two technologies.

[27] As was explained in section 1.2, the cost model will make the assumption that that the carrier is an ADSL provider.

[28] 50% of U.S. households are DSL-enabled and 65% are Cable-modem-enabled, and these rates are expected to rise to 70% and 80% respectively by 2006 (Source: [Davis 2002]).

customers)[29]. The question of price is made even more acute now that providers are deemed to be running out of early adopters that they can easily upsell: most classic early adopters have already acquired broadband at this point, and new strategies and messages will be required to entice increasingly mainstream dial-up users to broadband ([Laszlo 2002, p.2]).

2.1.2 Access networks' architectures

In the "last mile" (the part of the network located between the carrier's building and the customers' houses), DSL and cable modems systems rely on different network topologies: DSL is based on a star topology (the carrier's Central Office is directly connected to each customer's house by a dedicated pair of copper wires) whereas the cable modem architecture uses a bus topology. This section provides a brief presentation of these two architectures and their main elements. Note that we do not aim at presenting all the possible variations on these designs that can be found on the field.

2.1.2.a Asymmetric Digital Subscriber Line (ADSL) access network [30]

As already expressed, Digital Subscriber Line (DSL) technologies (and, in particular Asymmetric DSL, on which we will focus in this thesis because it is the most widespread instance of DSL) enables to carry digital signals over the legacy PSTN plant at broadband speeds[31].

As described in [ADSL Forum], two elements terminate the ADSL line at both ends, and engage in physical-layer negotiations and transmissions between the home and the carrier's CO: 1) at the customer premise, the line is terminated by a Remote ADSL Transceiver Unit (ATU-R); the ATU-R is integrated in a network termination unit, usually known as an ADSL modem; it is installed inside the premise, and connects to terminal equipment in the home usually using Ethernet or Wireless LAN connections[32]; and 2) at the carrier's Central Office, the DSL line is terminated by a Central Office Transceiver Unit (ATU-C). The ATU-Cs are housed in a Digital Subscriber Line Access Multiplexer (DSLAM).

---

[29] Dial-up consumers have always regarded broadband pricing as a key disincentive, and the slowing economy only exacerbates their reluctance to switch to broadband. 72% of online households that don't have broadband yet cite the price as one of the main deterrents of broadband ([Gramaglia 2002]).

[30] This section draws on [Abe 2000, pp165-209] and [Fryxell].

[31] It does so by increasing the usable spectrum in copper loops from 4 KHz to about 1.1 MHz.

[32] Note that only one ATU-R is required per DSL line even though multiple computers within a home may be connected through it.

The role of the DSLAM is to statistically concentrate the typically bursty individual traffic streams into high-bandwidth upstream links (usually Fast Ethernet or ATM trunks, which then carry the data to an Internet Point of Presence). One DSLAM may house hundreds of ATU-Cs..The top of Figure 1 shows how these elements connect together in this simple ADSL architecture.

The distance between the carrier's CO and the customer house is a crucial element in provisioning of ADSL services. Because the signals attenuate as they travel long distance through copper loops, the customer's ATU-R may not be able to demodulate and decode the transmitted signal if his house is too distant from the central office. For remote locations, modulation techniques more robust to signal attenuation and deformation need to be used – but this translates into lower available peak bandwidths[33].

This problem may be alleviated by creating Remote Terminals (RTs) to serve customers that otherwise could not receive DSL services because of their too long distance from the CO[34]. RTs avoid having copper wires going all the way from the customer premises to the CO, and the signal being degraded by attenuation. As seen on the bottom of Figure 1, the RTs are connected to the CO via fiber cable, while the customer premises are connected to the RTs via copper pairs. In this architecture, the DSLAMs and the ATU-Cs are located in the RTs.

The ILECs are currently deploying such infrastructures in order to expand their DSL "addressability" (i.e. the proportion of their customers to whom they are able to provide DSL services)[35]. Thanks to these investments (and to technology improvements) the average addressability of ILECs in the U.S. increased from 44% of the households in 1999 to 64% in 2001 ([McKinsey 2001, p.8]). The ILECs keep on progressively increasing their addressability, neighborhood by neighborhood.

---

[33] The highest data rates (6.144 Mbps downstream) can only be achieved for loops up to 9,000 feet. Over this distance (and up to 18,000 feet), the downstream speed is reduced to 1.5 Mbps. Loops longer than 18,000 feet are generally not eligible for ADSL service (though other lower speed xDSL services may be feasible) – see [Fryxell].

[34] Remote terminals are sometimes used for economic considerations, even if the loops' lengths would have permitted to provide DSL services over them.

[35] See for instance [Pronto 2000] for a description of SBC's deploying such architectures.

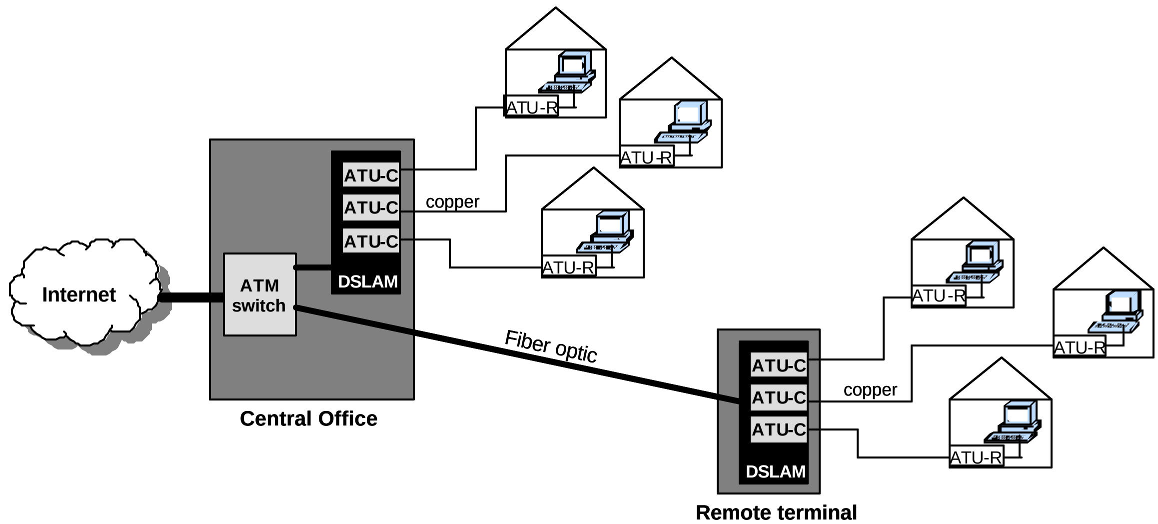

Figure 1: Architecture for the ADSL-based access network[36]

The cost model in Chapter 5 will be concerned (among other things) with the incremental costs of adding a wireline customer. Given this architecture of the DSL access network, for each[37] added customer these incremental costs correspond to: a) the allocation of a DSLAM slot, b) the purchase of a line card, c) the testing and conditioning (if required) of the copper loop linking the customer premise to the carrier's building (CO or RT), d) the (manual) connection of the loop to the line card, and e) the installation of the ATU-R (embedded in the DSL modem) at the customer premise.

We should note that if a customer is *addressable*, providing DSL services to him will imply similar "incremental process" (and incremental costs), no matter whether he is connected directly to the CO or via a remote terminal; the question of whether making him addressable in the first place has required null[38] or large expenditures (if addressability expansion was required) is of no relevance for the forward looking analysis that we propose, because they are sunk costs.

[36] Source: [Fryxell]. Note that only the elements dedicated to broadband provisioning have been represented. Other elements (voice switch, POTS splitter, connection to the PSTN…) are left out of the figure, even though they are also located at the CO and used to provide analog voice services.

[37] As explained in footnote 169 (page 92) some ILECs allocate less line cards than there are customers; however, these practices concern mostly the low costs ILECs, and we will not consider them in this thesis.

[38] If he lives close to the CO, to which he is connected via a good quality copper line.

2.1.2.b Cable access network

This section presents the architecture of cable modem networks. It will then be used in the next section where the DSL and the Cable modem architectures are compared together.

The cable modem architecture relies on the legacy plant designed (and installed progressively since the 1950s) to carry TV programs to the subscribers. In this architecture, the carrier's *head end* receives the TV programs (possibly from different sources and upstream access technologies, such as satellite or over-the-air broadcast), and brings the signal to its customers over a coaxial cable that run from the carrier's head end to the served neighborhood, where branches (also coaxial cables) are split off into multiple cables to bring the service into the subscribers' homes, following a *branch and tree* topology (see [Gillett 1995, p.35]). Because all the customers in a given neighborhood are connected to the same coaxial, this architecture is said to be *shared*: each subscriber is reached by the whole signal, and his personal modem has to select the channel of interests to him.

Since the early 1990s cable companies are upgrading this legacy cable infrastructure to what is known as Hybrid Fiber and Coax (HFC) networks, in order to be able to provide broadband data services over it. The principles of this upgrade are similar to the principles behind the addressability expansion performed by the ILECs; here as well, the main objective of the upgrade is to alleviate attenuation effects. Cable optics connects the carrier's head-end to "optical nodes" located in the served neighborhoods. From these nodes, coaxial cables extend the network to the customer premises. By shortening the distance must be traveled by the signal over cable, this architecture enables larger spectrum utilization. In the carrier's head end, the main element relative to Internet access is called the Cable Modem Termination System (CMTS). The CMTS and the cable modems at the customers' premises appropriate a portion of the usable spectrum in the cable plant to create data channels. The CMTS is a router interconnecting the downstream cable modem networks to an upstream connection heading to the Internet. As explained in [Fryxell, p.7], the CMTS and the customers' cable modems "appropriate a portion[39] of the usable RF spectrum in the cable plant to create a pair of digital channels for data transmission". Figure 2 below illustrates a typical HFC architecture.

[39] For the downstream communications, a 6 MHz channel is usually appropriated by the broadband devices, and enables a peak bandwidth of 27 Mbps.

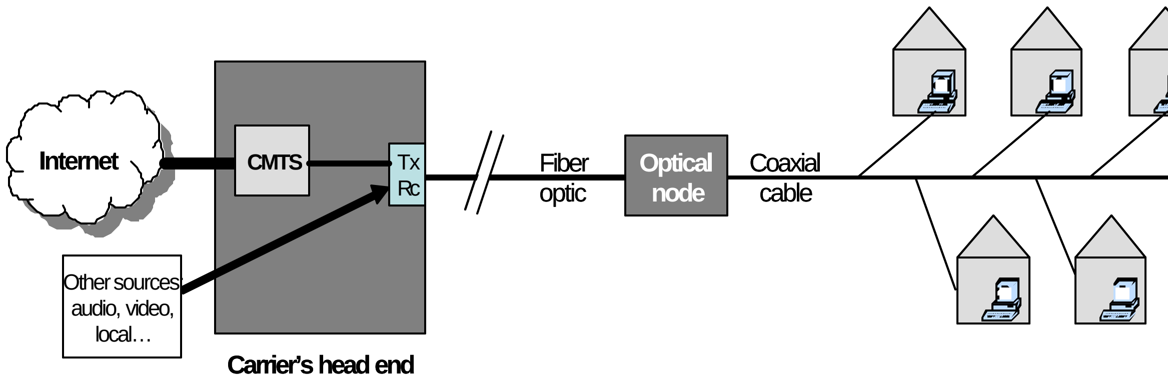

Figure 2: Simplified architecture of an HFC network

Even if we will not enter into the detailed steps implied by the addition of an additional customer, it is easy to understand that they will involve smaller costs. Because of the shared nature of the HFC network, for each customer addition: 1) less additional equipment needs to be inserted in the existing architecture; and 2) no loop conditioning will be required, since the customers all use the same shared coaxial cable[40]. For this reason, the upfront network expenditures necessary for providing broadband services to a new customer are much smaller with cable modem than with ADSL[41].

2.1.3 Comparison of DSL and Cable modem

The two preceding sections will support our comparison of the ADSL and cable modem access networks in this section.

2.1.3.a <u>Different cost structures</u>

The first lesson (that was pointed out at the end of section 2.1.2.b just above) is that ADSL and cable modem fundamentally differ in their respective architectures. While on the last mile ADSL relies on dedicated[42] copper loops, cable modem relies on a coaxial bus shared by all the customers in a given

[40] Note that the drops linking each customer to the coaxial cable are "dedicated", but they do not require conditioning.

[41] McKinsey estimated in 2001 these costs (excluding the marketing costs of customer acquisition) to be of $343 per subscriber for cable modem against $667 for ADSL ([McKinsey 2001, p.70]).

[42] Note that "dedicated" only refers to the physical lines linking the customer premises to the carrier's DSLAM, and not to the ADLS architecture as a whole, which also correspond to a shared architecture, upstream to the DSLAM.

neighborhood. These differences translate into different incremental cost structures for servicing additional customers – to the advantage of cable modem networks[41]. Broadband resale can be regarded as a way to share (against compensation) a wireline broadband connection and the fixed costs associated to it. Since we showed that these fixed upfront costs are higher with ADSL than with cable modem, we expect the potential benefits of broadband resale to be greater for ADSL providers than for cable modem providers – and this is the reason why we decided to focus our cost model (in Chapter 5) on ADSL (as stated in section 1.2 above).

2.1.3.b Similar experience for the customers

However, notwithstanding these fundamental differences in their underlying architectures (which translate into different cost structures), these two technologies look quite similar from the "outside", i.e. from the customers' perspective.

Table 1 below shows the performances of ADSL and Cable access networks. This table shows that very different maximum burst speeds are available to the users depending on the technology they use, because of the intrinsic architecture differences.

	(A)DSL	**Cable**
Maximum burst speed downstream	1.5Mbps[43]	27 Mbps[44]
Maximum burst speed upstream	610 Kbps	10 Mbps
Typical speed available downstream	384-640 Kbps	500 Kbps-1 Mbps
Typical speed available upstream	256-384 Kbps	256-500 Kbps

Table 1: Performance metrics across broadband technologies[45]

Nevertheless for most Internet applications the maximum burst speed rate is not the most relevant metrics accounting for the quality of the customer's online experience: for instance if a customer can send data for only 10 ms every second (because the shared medium is occupied by other users the rest of the time),

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[43] For very short loops, the downstream rate may be higher (up to 6.144 Mbps) – see the specifications in the ADSL PHY recommendations (ANSI T1.413 issue 2 and ITU G.922.1).

[44] Achieved by using a QAM-64 modulation on a 6 MHz channel.

[45] Source: [McKinsey 2001, p.37].

this user's online experience will not be good in spite of the 27 Mbps peak bandwidth available to him. Therefore a more relevant metric is the average bandwidth available to each the user. For cable modem, it will be determined mostly by the "node size", i.e. the number of homes connected to a given node's shared coaxial network[46], while for a DSL connection it will be determined mostly by the bandwidth provisioned by the carrier upstream to the DSLAM: the carriers do not provision enough bandwidth upstream to the DSLAM to be in a position of serving all their customers at the same time[47]. At some times (during the "busy period" of the day, when many customers are connected) this under-provision will translate into congestion at the DLSAM level, and the actual average bandwidth available to the end users in practice will be lower than the peak bandwidth that can "physically" be provided by the DSL connection.

As Table 1 shows it, in actual practice the average bandwidth available to the users appears to be in comparable ranges for both technologies (in spite of a slight advantage to the cable technology). Therefore the users' online experience is comparable with both technologies, as well as their potentials in a broadband resale context.

The preceding descriptions of the ADSL access network (in section 2.1.2.a) and of the Cable modem access network (in section 2.1.2.b) also show how similar these two technologies are in terms of the devices to be installed at the customer premise: in both cases, the incoming link (copper wire, or coaxial drop) simply needs to be connected to a modem, itself connected to the user's computer (for the simplest designs).

To sum up, we showed two points: 1) Both wireline broadband technologies have intrinsic large differences, which translate into different costs structures. Because of these differences, we expect broadband resale to be more attractive to DSL provider than to cable provider, which justifies our choice of focusing on DSL in Chapter 5's cost model. 2) Notwithstanding these intrinsic differences, both technologies seem very similar from the users' perspective. This observation explains why we are entitled to treat both wireline technologies together in our qualitative analysis of wireline broadband resale – what is done in Chapter 4 and Chapter 5.

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[46] It is usually in the range between 150 and 250 homes per node (see [McKinsey 2001, p.38]).

[47] Because this upstream bandwidth is costly to the carrier (see section 5.2.3.a).

2.2 *Wireless LANs*

This section will provide industry and technical background about wireless LAN technologies – in particular IEEE 802.11 given the predominance of this family of standards on the WLAN market as of this writing.

2.2.1 WLAN market overview

A wireless LAN (WLAN) is a data transmission system designed to provide network access between computing devices by using radio waves rather than a cable infrastructure. The spectrum used by WLAN devices is unlicensed – a range of frequencies where anybody can emit without requesting any special authorization from the Federal Communication Commission (FCC), provided that the device was certified and complies with a set of 'correctness' rules.

The IEEE 802.11 family of standards predominates over the WLAN market. In 2001, almost 9 millions units of the IEEE 802.11 family were sold worldwide, which represents a unit shipment growth over 2000 of nearly 150 percent. Gartner analysts forecast that these shipments will continue to grow at a compound annual growth rate (CAGR) of 42 percent from 2001 to 2007 ([Rolfe 2002]). Other WLAN standards initially though to compete with the IEEE 802.11 standards also exist, but they are losing industry support. For instance HomeRF, a group aimed at developing a competing standard cheaper than 802.11b, disbanded at the beginning of 2003. As explained in [Shim 2003]: *"the growing popularity and industry support for 802.11b helped to drive the evolution of the 802.11 specifications and lower the cost of products that were faster than HomeRF"*. Another technology once expected to compete with IEEE 802.11 was the High Performance Radio LAN (HiperLan and HiperLan2) standard developed in Europe. However the prospects for this technology are also very dark. As explained by Lynn Lucas, director of marketing for Proxim (a wireless network equipment maker): *"More than five years after ETSI published the standard, and major European wireless makers announced they were busy at work on product, there isn't one HiperLan2-based device"* (cited in [Charny 2002b]). Even Ericsson that initially was one of the leaders of the HiperLan movement has pulled out of the effort in 2001, thereby "signaling its demise before products came to the market in any serious way"[48]. As an Ericsso spokesman explained: *"We see the market as moving to 802.11a. Our focus is on 802.11a now"* (cited in [Judge 2001]). As a

[48] In [Judge 2001].

consequence, the IEEE 802.11 family of standards appears to be the only credible WLAN technologies available on the market[49], and this thesis will focus on this family.

2.2.2 IEEE 802.11[50]

This section will describe the main technical characteristics of the IEEE 802.11 family of standards, in order to provide an idea of how they can be used in the broadband resale context.

2.2.2.a Spectrum ranges

Two ranges of frequencies are available for use by wireless LANs: 2.4GHz and 5GHz (see Table 2 below for a comparison between these two bands). The regulations concerning these two bands are analyzed in details in Chapter 3.

	2.4 GHz	**5 GHz**
Advantages	• Cheaper equipment costs • Better ability to propagate (notably goes inside buildings) • Greater coverage areas (due to better propagation of signals)	• Less prone to interferences from other appliances (cordless phones, microwave ovens…) • More spectrum available (enabling greater number of channels) • Less problems caused by delay spread or multipath reflection effects[51]
Limitations	• Limited available spectrum • Multiple sources of interferences: Bluetooth, 802.11, amateur video/radio broadcasting, microwaves, cordless phones…	• Smaller ranges (because shorter wavelength makes propagation more difficult[52]) • Technologies less mature and therefore more expensive

Table 2: Comparison of unlicensed spectrum across 2.4 GHz and 5 GHz[53]

[49] Note however that in some rare cases the Bluetooth technology may also play a role alongside WLAN technologies in providing internet access. For example a company called *Netario* launched the first public access hot spot using Bluetooth technology in Manchester, England, and BT also indicated that Bluetooth would be used in his hot-spots when needed (source: [Deighton 2002]).

[50] This section draws on [3Com].

[51] See [Hansen 2002].

[52] See [Hansen 2002]. Also, [Rappaport 1996] states that as an electromagnetic wavelength grows shorter (i.e., higher frequency), the path loss of that wave increases according to a square law relationship (see also footnote 54).

[53] Source: [Kahn 2002].

2.2.2.b A multitude of standards

	802.11	802.11b	802.11a	802.11g (proposed)
Modulation Scheme	DSSS	DSSS	OFDM	OFDM CCK
Theoretical Link Rates	1 or 2 Mbps	1, 2, 5.5, 11 Mbps	6, 9, 12, 18, 24, 36, 48, 54 Mbps	6, 9, 12, 18, 24, 36, 48, 54 Mbps
Actual Link Rates	1 Mbps	6 Mbps	33 Mbps	Pending ratification of the standard
Frequency Band	2.4 GHz	2.4 GHz	5.2 GHz; 5.8 GHz	2.4 GHz
Typical Range	150ft (46m) indoors 300ft(92m) outdoors	100ft (30m) indoor 200ft (60m) outdoor	Limited to 15-25ft (4.5-8m)[54]	Pending ratification of the standard
Typical Number of Clients Supported per Access Points	Theoretically: up to 256 Depending on usage pattern, 20-30 users are recommended for optimal performance	Theoretically: up to 256 Depending on usage pattern, 20-30 users are recommended for optimal performance	Theoretically: up to 1024	Theoretically: up to 256 Depending on usage pattern, 20-30 users are recommended for optimal performance
Transmit Power	Up to 100 mW	Up to 100 mW 30 mW most common	Up to 100 mW 30 mW most common	Up to 100 mW 30 mW most common
Strengths		- Mature - Meets today's requirements for wireless	- Faster data rates - Less interferences - 32-bit bus architecture	- Compatible with 802.11b and 802.11a - Increases data rates
Limitations	- Slow - No longer widely used	- Half duplex - Prone to interference - WEP security breaches[55]	- Consumes more power - Shorter range - Not accepted on worldwide basis - Not backward compatible to 802.11b - Immature	- Standard not ratified - No products on the market before 2004 - No Wi-Fi certification process announced

Table 3: The 802.11 standards[56]

[54] Gartner estimates (see [Hiller 2002]). [Mobilian 2001, p.8] identifies various potential 5 GHz path loss models showing decreased ranges compared to 2.4 GHz solutions of 45%, 50% and 75%.

[55] Security is expected to be improved with the next standards (802.11a and 802.11g) – see [Charny 2002c].

[56] Source: [Hiller 2002].

The IEEE 802.11 standard was proposed by the IEEE in 1997. As seen above on Table 3, there are several variations of this standard, all of which are based on the same principles and underlying core technology: 802.11, 802.11b, 802.11a, 802.11g. The 802.11 is the first standard and is only found in legacy installations. The 802.11b is the dominant standard as of this writing, and offers 11 Mbps data rates in the 2.4GHz band. But manufacturers are today pushing a new standard: 802.11a. It functions in the 5GHz band, and has three main advantages over 802.11b: better security features (a characteristic particularly appealing for enterprises), data rates up to 5 times greater (54 Mpbs), and the ability to handle more users at once (see [Charny 2002c]). However, this new standard is not backward compatible with 802.11b. And finally, a fourth standard is in preparation: 802.11g, working in the 2.4GHz band, and expected to offer the advantages of 802.11a (security, greater speeds), while being backward compatible with 802.11b devices (see [Charny 2002c]).

2.2.2.c Core technological principles

Like all other IEEE 802 standards (notably the Ethernet standard), the 802.11 standards[57] focus on the lower two levels of the well-known ISO model: the physical layer and the data link layer (see Figure 3). Any protocol (including TCP/IP), LAN application, or network operating system will run on an 802.11-compliant WLAN as easily as they run over Ethernet ([3Com]).

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[57] See the reference document [IEEE 802.11].

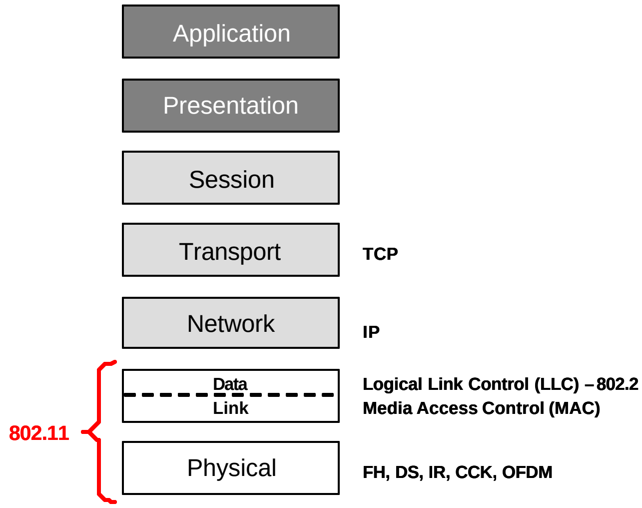

Figure 3: 802.11 and the ISO model[58]

2.2.2.d Architecture

802.11 defines two pieces of equipment: 1) a wireless station, which is usually a PC equipped with a wireless network interface card (NIC), and 2) an access point (AP)[59], which acts as a bridge between the wireless and wired worlds. The access point acts as the base station for the wireless network, aggregating access for multiple wireless stations onto the wired network. The range of access points is usually inversely proportional to speed: as the distance between AP and wireless client increases, the speeds decrease and vice versa.

2.2.2.e Robustness to interferences

At the physical layer, the 802.11 standards use spread spectrum techniques. This transmission technique has much greater immunity to interference and noise compared to conventional radio transmission techniques – and allows several users to use the same frequency at the same time. Its principle is to take a narrow band signal and spread it over a broader portion of the radio frequency band, in a predefined method.

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[58] Source: [3Com].

[59] An access point usually consists of a radio, a wired network interface (e.g., 802.3), and bridging software conforming to the 802.1d bridging standard ([3Com, p.4]).

There are two basic methods to performing the spreading:

1. Frequency Hopping spreads the signal by "hopping" the narrow band signal as a function of time: the sender and receiver agree on a hopping pattern, and data is sent over a sequence of subchannels. Each conversation within the 802.11 network occurs over a different hopping pattern, and the patterns are designed to minimize the chance of two senders using the same subchannel simultaneously.

2. Direct sequence spreads the signal via a technique called "chipping". Each bit of user data is converted into a series of redundant bit patterns called "chips." The inherent redundancy of each chip combined with spreading the signal across the 22 MHz channel provides for a form of error checking and correction; even if part of the signal is damaged, it can still be recovered in many cases, minimizing the need for retransmissions.

Thanks to the use of spread spectrum techniques, communications may happen even over parts of the spectrum where other spread spectrum communications are currently taking place. These techniques have been shaped so that these concurrent communications "bother" each other the least.

2.2.2.f Association between AP and clients[60]

The 802.11 Media Access Control (MAC) layer is responsible for how a client associates with an access point. When an 802.11 client enters the range of one or more APs, it chooses an access point to associate with, based on signal strength and observed packet error rates. Once accepted by the access point, the client tunes to the radio channel to which the access point is set. Periodically it surveys all 802.11 channels in order to assess whether a different access point would provide it with better performance characteristics. If it determines that this is the case, it *reassociates* with the new access point, tuning to the radio channel to which that access point is set[61].

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[60] Draws on [3Com].

[61] Reassociation usually occurs because the wireless station has physically moved away from the original access point, causing the signal to weaken. In other cases, reassociation occurs due to a change in radio characteristics in the building, or due simply to high network traffic on the original access point. In the latter case this function is known as "load balancing," since its primary function is to distribute the total WLAN load most efficiently across the available wireless infrastructure.

2.2.2.g Trade-off between range and throughput

WLAN throughput depends on several factors, including the number of users, microcell range, interference, multipath propagation, standards support, and hardware type. Gartner estimates indoor and outdoor ranges to be 100 ft (30 m) and 200 ft (60m), respectively, for 802.11b (at the highest bit rate) ([Hiller 2002]).

To support very noisy environments as well as extended range, 802.11b WLANs use *dynamic rate shifting*, allowing data rates to be automatically adjusted to compensate for the changing nature of the radio channel. When devices move beyond the optimal range for 11 Mbps operation, or if substantial interference is present, 802.11b devices will transmit at lower speeds, falling back to 5.5, 2, and 1 Mbps[62]: *there is a constant trade-off between range and throughput*. Thanks to these lower bit rates, the range of 802.11b can extend greatly: it gets close to 130-150 ft. at 5.5 Mbps, and 250-350 ft. at 2 Mbps (source: [3Com]). Rate shifting is a physical layer mechanism transparent to the user and the upper layers of the protocol stack.

2.2.2.h Limited number of users per AP

The 802.11 MAC layer has been designed to support multiple users connected to the same AP (and therefore using the same channels), by having the sender sense the medium before accessing it. The protocol is known as *Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA)*, and is very similar in concept to the Ethernet protocol[63]. Theoretically, this protocol is capable to handle 256 users per access point for the 802.11, 802.11b and 802.11g standards (in the 2.4 GHz band), and 1024 users for 802.11a (in the 5 GHz band). However, such high numbers of users trying to concurrently communicate with the AP is likely to overwhelm the AP. Gartner recommends 20 to 30 users per AP for optimal performance (depending on the usage pattern).

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[62] Likewise, if the device moves back within the range of a higher-speed transmission, the connection will automatically speed up again.

[63] See [3Com] for a detailed description of CSMA/CA.

2.3 Integration of Broadband and WLAN

Residential resale of wireline broadband via wireless is made possible thanks to the combination of wireline residential broadband and of wireless LAN devices. This section describes how these technologies get combined, and what functions need to be fulfilled by the reseller's network for him to successfully engage into broadband resale.

2.3.1 The reseller's local network

Figure 4 below shows a typical configuration of a reseller's home network. As we see, it comprises: 1) the broadband modem (either DSL or Cable modem); 2) a router; 3) a personal LAN (typically over an Ethernet bus)[64]; 4) an access point[65]; 5) an authentication server; 6) a DHCP server; and 7) a firewall.

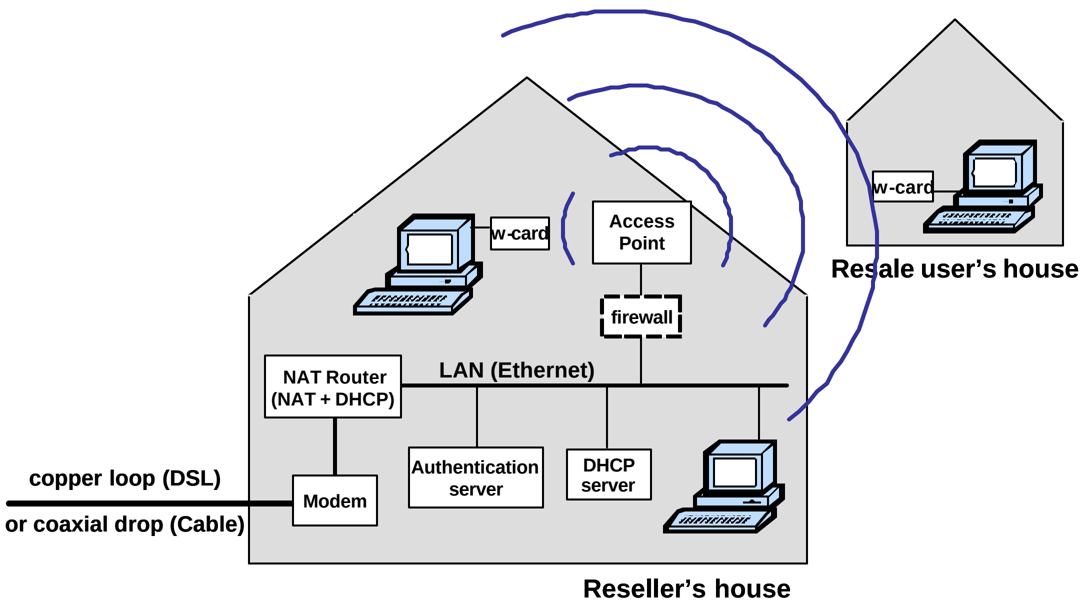

Figure 4: Typical integration of broadband and wireless LAN

[64] Note that we describe here the different functionalities that need to be fulfilled. In actual practice, all the functions may be integrated in one device (say in the AP), in which case there will be no "physical LAN" in the reseller's house.

[65] Let us recall that (as seen in section 2.2.2.c) wireless access points based on IEEE 802.11 technologies are meant to seamlessly expand the classical wired (Ethernet) LANs in a way totally transparent to the applications making use of the local network. In other words, in the simplest configuration, the resale users will find themselves like belonging to the reseller's local network.

Some network elements represented on Figure 4 (such as the access point or the broadband modem) have already been presented in the preceding sections of this chapter. Some other elements however are seen for the first time, and the rest of this section will describe each of them. However, one must be careful to the fact that not all these functions necessarily correspond to an actual independent hardware device connected to the network.[66]

2.3.2 The Dynamic Host Configuration Protocol (DHCP) server

DHCP[67] is a protocol designed for addressing dynamic IP addresses to devices on a network. It keeps attributes and keeps track of the IP addresses used on the reseller's local network, and thereby greatly simplifies the reseller's network management tasks. When a (known) resale user associates with the reseller's AP, the DHCP server assigns automatically an IP address to it – therefore exempting the reseller and the resale user from doing this assignation manually. The assigned IP address is said to be dynamic, because the server chooses it accordingly to predefined criteria (such as the range of IP addresses to choose from), and by being careful that no other devices on the network is already using this particular IP address.

2.3.3 The Network Address Translation router

Usually, broadband providers attribute only on IP address to each of their subscribers, notably because of the scarcity of IP addresses. It means 1) that from the carrier's point of view as well as from any computer connected to the Internet, all the traffic taking one customer's broadband line will always display the same origin IP address (in the IP packets' headers), and 2) that if two (or more) computers at the customer's premise need to access the Internet at the same time, they will have to share this single IP address.

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[66] Each box on Figure 4 represents a particular *function* that needs to be provided by one element on the local network. However, several functions can be implemented either in software or in hardware. Also, it is very frequent that one single hardware device can fulfill several functions (e.g. it is frequent that the access point, the DHCP server, and the NAP router are all merged together).

[67] The base protocol is documented in [RFC 2131] and [RFC 2132].

Installing a network address translation[68] (NAT) router[69] on a residential home network (at the interface between the customer's local network and the carrier's wide-area network) is a simple solution that enables several computers to share the same IP address.

NAT routers act as an agent between a public network (typically the Internet) and a local network, and enable an entire group of computers (on the private network) to share a single IP address visible from the public network (i.e. the IP address provided by the carrier to the reseller). In a sense, the NAT router can be said to collapse all the resale users' IP addressed (that were attributed to them via the reseller's DHCP server, and are internal to the reseller's local network) into the single external IP address. This use of network address translation for sharing a single IP address among several computers is also known as port address translation (PAT) because of its working. All the outbound packets see their "origin IP address" translated by the router to the reseller's IP address combined with a port number different for each resale user. In other words, the NAT router makes these packets look like they were emitted by a particular application (identified by its port number) running on the reseller's computer. For inbound traffic, the NAT router only needs to look at the destination port of this packet (to figure out which resale user it is destined to), and then put the corresponding private IP address in the header before it enters into the reseller's local network.

We should note that because of the resellers using NAT devices, the carrier will have no way to distinguish between the primary traffic from the reseller (and his family) and the traffic from resale users.

2.3.4 The firewall

If the reseller is not careful in configuring his network, any wireless-enabled user in the neighborhood will have the possibility to associate with the reseller's access point, and benefit from his broadband connection. In such a situation, the reseller would appear similar to a freenet base owner. However, this situation would be problematic to at least three counts: 1) reselling broadband implies that the reseller has the capability to refuse the resold service (broadband connectivity) to some users – typically the ones who

[68] Network Address Translation principles are described in [RFC 1631].

[69] The general definition of a router is: "a device, or in some cases, software in a computer, determines the next network point to which a packet should be forwarded toward its destination. The router is connected to at least two networks and decides which way to send each information packet based on its current understanding of the state of the networks it is connected to." (definition from SearchNetworking.com: http://searchnetworking.techtarget.com/sDefinition/0,,sid7_gci212924,00.html)

do not pay; 2) once they are associated with the reseller's AP, wireless users a priori have a full access to the reseller's LAN, and ill-intentioned users may try to take advantage of it[70]; and 3) as we saw in section 2.3.2 above, from the exterior all the resale users will appear under the reseller's IP address; therefore, if some wireless users engage into unlawful activities on the Internet, the reseller may be held responsible for them.

For all these reasons, the access of the resale users to the network need to be controlled, and this can be done by installing a firewall device between the AP and the rest of the LAN. The firewall is a device (hardware or software) designed to prevent unauthorized access to a private network. It examines all the IP packets trying to enter into the private network (the reseller's LAN) and block those that do not meet some specified security criteria. For the sake of security, the reseller will have to configure his firewall so that it blocks all the incoming traffic from unknown users.

2.3.5 The authentication server

This function is likely to be performed by a dedicated server (possibly a software running on the reseller's computer). Its task will be 1) to authenticate the resale users associating with the access point; 2) check whether an account exist in the resale users database, and check this user's registered status; and 3) either allow access to the user, by automatically changing the firewall's configuration (see section 2.3.4 above), or ensure that the firewall is configured to block the traffic from this user[71].

2.3.6 Conclusion

This section provided a brief overview of the different elements that should be part of the reseller's local network. After reading it, some users may have the feeling that each reseller will have to engage into large expenditures to purchase so many devices. However, one should keep in mind that 1) many devices currently available on the market can fulfill several of the described functions; and 2) many of these

[70] For instance by stealing files on the reseller's computer, or stealing passwords.

[71] Note that many firewalls can be remotely reconfigured via other network devices, for instance by using Simple Network Management Protocol (SNMP).

functions can be implemented in software -- and may therefore in the future rely on contributions from the open source community[72].

[72] A good example of it is provided by NoCatAuth, a software managing authentication functions initially developed by NoCat.org (see http://www.nocat.org), a wireless freenet community, and available under GPL license. See [Flickenger 2001] for more details about this software.

Chapter 3 Policy and regulatory overview

This chapter presents policy and regulatory challenges confronting our model of residential broadband resale. The most acute challenge relates to the availability of sufficient unlicensed spectrum for the reseller's and end-user's wireless LAN devices to transmit data at high-speeds. In the first section of this chapter we will study such availability in the U.S. and in Europe and show that it is not always guaranteed.

However, the question of sufficient availability of unlicensed spectrum on the long-run cannot be addressed by a static overview of current regulations. Spectrum is a shared resource, and therefore its availability for each user depends on the number of other users competing for this resource. One of the main policy challenges that residential broadband resale will face on the medium and long run (were this model to take off) therefore relates to dealing with congestion problems, and these issues will be addressed in the second section of this chapter.

3.1 Availability of unlicensed spectrum

Through IEEE 802.11b, wireless LAN products are becoming mainstream and meeting wide acceptance in the market (see section 2.2.1). This success was achieved via the following virtuous circle due to learning curve effects: running down the learning curve enables to cut the manufacturing costs, and therefore to reduce the products' prices, and thereby increase the volumes of sales, and hence run down further the experience curve[73]. The growing popularity and industry support for 802.11b helped to drive the evolution of the 802.11 specifications and lower the cost of products (see [Shim 2003]). Such a virtuous process may not have been possible if unlicensed spectrum had not been widely available in many countries around the world, and should be taken as an example for future development of wireless technologies in other unlicensed bands.

[73] See [Anastassopoulos 2000].

3.1.1 Availability of unlicensed spectrum in the U.S.

3.1.1.a The Industrial Scientific and Medical (ISM) Bands

In 1985, the Federal Communications Commission (FCC)[74] issued rules permitting "intentional radiators" to use of the "Industrial Scientific and Medical" (ISM) bands (902-928, 2400-2483.5, 5725-5850 MHz) at power levels up to one Watt without end-user licenses. Originally these bands had been reserved for unwanted, but unavoidable emissions from industrial and other processes, but they also supported a few (often military) communication users.

Availability of these bands has stimulated enthusiasm and innovation. Provided that the device abides to certain "correctness rules" defined by the FCC (the so-called "part 15" rules described below, defined so as to enable the cohabitation of devices on this spectrum range), there is almost a complete absence of user restrictions - no registration procedure, no qualification of end users, no restrictions as to where the products can be used. The absence of spectrum license fees also contributes to the economic attractiveness of these products.

3.1.1.b Regulation of unlicensed spectrum in the U.S. (FCC Part 15)[75]

In the U.S. parts of both the 2.4 GHz band (used by the IEEE 802.11b standard) and the 5 GHz band (used by the IEEE 802.11a standard) are available for unlicensed use by any wireless-LAN device, as long as it complies with the FCC rules stated in the FCC Part 15[76]. Therefore there is no legal hurdle to the use of recent wireless-LAN technologies such as IEEE 802.11a and 802.11b in the U.S. As we will see in section 3.1.2, the situation is very different in most large European countries.

The ISM bands are unlicensed spectrum. This is not to say that it is unregulated spectrum, since the FCC allows anybody to make use (intentionally or not) of this spectrum, only to the extent that his emissions comply with a precise set of rules aimed at ensuring that other users will not be impeded from concurrently using the same range of frequency because of these emissions. These rules are specified in

[74] The FCC was created by the Communications Act of 1934, and charged with the duty to regulate "as public interest, convenience or necessity" requires within certain spectrum-defining areas, and to make decisions about how to best use the spectrum in the public interest ([Lessig 2001]).

[75] This section draws on [Gubish 1999].

[76] See [FCC Part 15].

the FCC Part 15, whose scope and legal provisions specify that it "regulates intentional, unintentional and incidental radiators operated without an individual license. Operation or marketing of intentional or unintentional radiators without complying with Part 15 technical and administrative rules is a violation of the Communications Act of 1934."

The FCC established Part 15 in 1975, “in order to prevent interference to the reception of radio and TV broadcasts, and to protect other sensitive radio services such as aircraft navigation and emergency beacons”[77]. It regulates devices that generate radio frequencies unintentionally as well as low power radio transmitters. Part 15 affects varied devices, such as TV sets, radios, computers, remote controls, paging receivers, commercial networking systems, cable TV boxes, and electronic toys. As new electronic devices were introduced on the market over the years, the FCC simply added new regulations to Part 15 rules in order to control the potential interferences from the new product types. In 1989 the rules were rewritten, consolidating all these added parts.

In order to be approved by the FCC, devices making use of unlicensed spectrum have to comply to the rules included in Part 15. They precisely specify the maximum power transmitted in the band (1 Watt), as well as the out of band emissions (to not pollute adjacent bands). These rules also specify that Spread Spectrum techniques have to be used (either Direct Sequence or Frequency Hopping), to facilitate the peaceful cohabitation of different systems on the same spectrum ranges.

3.1.2 Availability of unlicensed spectrum in Europe

In order to illustrate the difficulties of coming to homogenous regulations across the world (or at least continents), this section will look at the current (and prospects of) regulatory situation in Europe.

3.1.2.a European terrain less favorable to WLAN devices

Disharmony and, in some cases, uncertainty surrounding the use of unlicensed 2.4GHz spectrum has contributed to Europe's current backwardness behind the U.S. and Asia as regards deployment of hot-spot WLAN access[78].

[77] In [Gubish 1999].

[78] See [Marsden 2002].

First, the European regulatory environment for telecommunications is still in the aftermath of the multibillion dollars 3G spectrum auctions[79] that took place in the summer 2000, shortly after the dot-com bubble started to deflate – whose impact impacts on the European biggest telecom companies then turned out disastrous[80]. Perceiving wireless LAN technologies and public hot-spots as potential threats[81] to the committed-to 3G mobile systems, European governments then showed very little enthusiasm in leveling out the regulatory field to facilitate the adoption of WLAN products in Europe[82].

But above all, Europe lacks a pan-European regulation of 2.4GHz or 5GHz bands, leading individual countries to implement different requirements (see Table 4), as will be explained below for the two technologies 802.11b and 802.11a.

3.1.2.b <u>IEEE 802.11b expected to finally take-off</u>

On the industry side, delays to commercial General Packet Radio Service (GPRS) launches and expected delays in commercial third-generation (3G) service rollout led many mobile operators in Europe to take a different view of wireless LAN technologies and hot-spots; many of them are now planning for hot-spot access services and solutions, in a strategic attempt to forestall new entrants from taking revenue shares away from 2.5G and 3G services. Gartner predicts that 70 percent of Europe's mobile operators will offer some form of WLAN service in 2003 ([Chapman 2002]), which will fuel the demand for WLAN products in Europe.

In parallel to this mindset evolution, most European countries have recently adapted (or are in the process of adapting) their national regulations to enable the use of these wireless LAN technologies in the 2.4GHz band on their national territories. Like in the United States, this spectrum is both free to use and free of any government regulations in most European countries; most Nordic countries, Germany, Holland and

[79] The spending frenzy on licenses through high-cost auctions and investment-heavy "beauty contests" led to more than US$120 billion being spent on 3G licenses in Europe; in the U.K., as much as $595 per person have been spent on licenses by the mobile operators (source: [Hart 2002]).

[80] The fees paid for 3G licenses stalled the industry and led to many operators being left with large debt burdens. These debts have in turn affected the operators' ability to invest in new networks and to continue expanding into other countries.

[81] Even today hotspots seem to be seen by certain as an alternative to traditional cellular services; for instance, BT, the only large incumbent having no stake in 3G systems, is also the only one having committed to deploying public hot-spots.

[82] *"Mobile operators' initial response to the threat WLANs pose to their 3G service revenue was to support regulations limiting the commercial use of the 2.4GHz and 5GHz bands that WLANs use."* ([Chapman 2002]).

(most recently) the United Kingdom are now having more and more wireless networks in place. As summarized by Gartner in [Deighton 2002], "the regulatory barriers to delivering 'hot-spot' public access in Europe using 2.4GHz band products will disappear by 2004. (…) Europe is trailing North America in corporate WLAN adoption and laptop market size, but as WLAN and Bluetooth[83] prices fall and volumes grow, this will change dramatically through 2004" (see section 3.1.2.d below for detailed information about particular European countries).

3.1.2.c More complex regulatory environment in the 5GHz band[84]

If the regulation for the 2.4 GHz band in Europe was eventually leveled out, paving the way for a large (though delayed) deployment of 802.11b products, the regulatory situation for the more recent WLAN version 802.11a (working in the 5GHz band) remains much more confused, as is shown in this paragraph.

In Europe, for many years, operating in the 5 GHz range was either limited or forbidden in most nations: as explained in [Charny 2002b], "the North Atlantic Treaty Organization interceded when companies like Germany's Siemens, Philips Electronics and Ericsson began rumbling about making 5GHz wireless LAN equipment. NATO used parts of the spectrum for radar and satellite operated in the same areas."

The main European standards body (European Telecommunications Standards Institute – ETSI) created a standard for wireless LANs to use in the 5GHz spectrum: HiperLan2[85]. But more than five years after ETSI published the standard, there isn't one HiperLan2-based device on the market. ETSI later modified its own rules, saying the equipment doesn't have to be based on the HiperLan2 standard, and added two new requirements[86]:

1. The equipment has to be able to "sense" when radar or other types of broadcasts are in the spectrum, and avoid them. The technique is known as Dynamic Frequency Selection (DFS), and is not necessary on 802.11a devices in the U.S.

[83] In Europe, Bluetooth is expected to be used in some hot-spots (see section 2.2.1).
[84] This section is based on [Charny 2002b].
[85] See section 2.2.1 page 9 for information about the prospects for HiperLAN standards.
[86] See [Charny 2002b].

2. 802.11a-based equipments are required to use Transmit Power Control (TPC). This technique reduces a radio signal's power depending on how close a wireless client is to the AP[87].

Manufacturers are now rolling these features into their chipsets in order to be allowed to supply 802.11a products in Europe. However, after meeting ETSI certification requirements, 802.11a makers still have to next meet the varying requirements of the government telecommunication regulatory agencies in every European country. Generally, these countries are all letting 802.11a broadcast in the 5.15GHz to 5.35GHZ range and the 5.47GHz to 5.725GHz range. But a few countries excluded some areas from those two ranges, or designed some channels within the spectrum as off-limits because they were being used for military radar or satellite transmission (see [Charny 2002b]). As a consequence of these local specificities, a subscriber might not be able to roam from a hot spot in one country to a hot spot in another[88].

3.1.2.d <u>Overview of the current European regulation per country</u>

Following the preceding overview of the general situation in Europe, the paragraph will give details about the state of the regulation in the five biggest European countries, as of December 2002. The results are summarized in Table 4 below, followed by some more detailed explanations concerning the particular situations in France and the U.K.

[87] As explained in [Charny 2002b]): "Usually, the Ethernet card and access point are 'shouting at each other,' with signals going full blast no matter how close they are together."

[88] The consequence of this complex regulatory field is stated by Intel spokesman Tom Potts: "Theoretically, if you took a card from U.S. to Europe, it would work but it may well be illegal. There is a good chance that if you buy our 802.11a equipment in the U.K., then take it to another country and turn it on, you might be violating the law." (quoted in [Charny 2002b]).

Country	2.4GHz Band (used by 802.11b)	5GHz Band (used by 802.11a)[89]
Germany	Private use, free of license	Not permitted
	Public use, requires license	
	Limited to 100mW	
France	Bandwidth 2400 to 2483.5MHz limited to 10mW inside buildings. No license required	No license required
	Bandwidth 2446.5 to 2483.5MHz limited to 100mW inside buildings. No license required	
	Use limited to 2.5mW outside buildings. License required from ART	
Spain	No license required	Not permitted
	Limited to 100mW	
U.K.	Private use, free of license	Not permitted (expected to be permitted with special license)
	Public use no longer requires a license since 31 July 2002	
	Limited to 100mW	
Italy	Permitted with individual license (general authorization expected soon)	Permitted inside buildings
	Limited to 100mW	

Table 4: Wireless LAN Radio Frequency Regulation in Europe[90]

France[91]

The telecommunications regulating body[92] claims to be aware that there is a strong desire to be able to offer high-speed Internet access in hot-spots such as train stations, airports and hotels, and is working to make the regulation on WLAN networks more flexible. However, the military still uses part of the 2.4GHz band, and therefore the 5GHz band is likely to be used in the hot-spots arena before the 2.4GHz band.

U.K.

[89] All uses of the 5GHz band in Europe requires dynamic frequency selection and transmit power control features, which are not included in the 802.11a standard. As a result, 802.11a equipment may not be used in Europe (see section 3.1.2.c).

[90] Source: [Deighton 2002].

[91] These two paragraphs about France and the U.K. draw on [Deighton 2002].

[92] Named *Agence de Régulation des Télécommunications* (ART) ; see http://www.art-telecom.fr

In the U.K. a specific regulation was preventing the commercial use of wireless LAN technologies. In May 2002, British Telecom (BT) announced plans for the deployment of hot spots around the United Kingdom, and is expected to have 400 hot spots in coffee shops, hotels and airports by June 2003, and 4,000 by 2005. This bold move by BT correctly anticipated that the *Radio communications Agency* (RA) would free the spectrum. On 10 June 2002, the U.K. e-Commerce minister announced that provision of public services in the 2.4GHz band would no longer need to be licensed from 31 July 2002.

3.2 Congestion[93]

Even in the U.S. where unlicensed spectrum is available in the 2.4GHz and 5GHz ranges, our vision of residential broadband resale may still suffer from a lack available spectrum, if too many users (from broadband resale or from other uses) in the same area also try to use the same portion of unlicensed spectrum. Congestion will be the result of interferences between different emissions in the same range of spectrum which impair each other. For a resale user trying to access wirelessly the Internet via a reseller's 802.11b AP (working in the 2.4GHz band), spectrum congestion may typically come from the following sources:

- Other resale users trying to connect to the same reseller's AP (and therefore in the same spectrum range). As seen in section 2.2.2.h, an AP based on the 802.11, 802.11b or (to-come) 802.11g standards can theoretically handle 256 users at the same time. But Gartner estimates that for optimal performance not more than 20 or 30 users should use a same station concurrently[94]. Some resellers may sometimes be tempted (by the lure of profit) to try providing resold broadband to too many users (more than this recommended optimal range), which may overwhelm his AP and result in a much degraded bandwidth available to each of these users.

- Potentially other APs running in the area (for broadband resale, hot-spots, individual usage…), and using either the same or an adjacent[95] channel.

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[93] Note that in this regulatory chapter, "congestion" refers to "wireless congestion", i.e. the difficulty to make use of unlicensed spectrum if too many other users compete for the same resource. It is distinct (and can add up to) the congestion occurring in the reseller's DSL modem or in the carrier's DSLAM (described in section 5.2.3.a).

[94] Source: [Hiller 2002]).

[95] Among the 11 channels in 802.11b, only three are totally independent (see [Hiller 2002]).

- Other wireless telecommunication devices that use the same range of unlicensed spectrum (e.g. Bluetooth), or home appliances emitting in the same range (either purposely like cordless phones or unintentionally like microwave ovens).

The intensity of the three first cited sources of congestion directly relates to the number of users of wireless devices (such as WLAN and Bluetooth products). Therefore, a direct consequence from the strong expected growth of WLAN devices[96] is the rapidly growing risk of congestion in the unlicensed bands of the spectrum. In densely-populated areas, many users are experiencing congestion already[97]. Of course, IEEE 802.11b modulation schemes (based on spread spectrum techniques, as described in section 2.2.2.e) have been chosen precisely for their robustness to interference, while the data link layer CSMA/CA protocol was precisely designed to provide “a way of sharing access to the air” ([3Com]). If these techniques and protocols proved good enough until now in alleviating congestion occurring between a few users, actions must be taken on the longer run in order to ensure the scalability of systems based on unlicensed spectrum. The uncertainty resulting from the possibility of congestion may impede the deployment of initiatives such as broadband resale. Below are three methods that regulatory and standard bodies will consider to alleviate the risks of congestion on the medium term.

1. Licensing some spectrum to the carrier.

The use of unlicensed spectrum is actually not a necessity in our proposition for residential broadband resale. It could be imagined that in the future, the carriers willing to propose resold broadband services to their customers could buy exclusive licenses for some channels of spectrum, which would then be dedicated only to the users of this carrier (resellers and resale users), thereby reducing the number of users in this range of spectrum.[98]

2. Making more spectrum unlicensed.

[96] Worldwide shipments of WLAN equipment will grow at a compound annual growth rate (CAGR) of 42 percent through 2007 ([Rolfe 2002]).

[97] For example, evidences of users experiencing congestion are given in [Jesdanun 2002]: *“In a high-tech community in Cary, N.C., Chuck Musciano wasn't getting the promised high Internet speeds with his wireless devices. He soon realized that half his neighbors had wireless networks as well — all using Wi-Fi, or 802.11b, the most popular wireless protocol. ‘Because of the houses being close enough together, all of the wireless networks were overlapping with each other,’ Musciano said.”*

[98] This model would of course not be realistic in the short term, because currently the available devices function only on very specific ranges of only-unlicensed spectrum. But the wireless devices in the future are expected to be more flexible (notably through the use of software radio).

The FCC could add additional spectrum bands to the pool of unlicensed spectrum. Industries and organizations would then work out new standards relying on this spectrum, and launch to the market new devices that do not interfere with the other WLAN devices already present. If this non-interference between incumbent and new devices is the reason why such a strategy would alleviate the congestion issues, it will also be the source of significant "migration costs"[99] if the new technologies are not backward compatible with the older ones. Considering the residential broadband resale model base on such a new technology, the upfront costs of providing the service would be much higher: 1) all the interested resale users would have to buy a WLAN card specific for this technology (while with 802.11 technologies, we assumed in our model that the resale users were all owning 802.11-enabled devices already); 2) like with any other new technology, the hardware (AP and card) prices would be much greater.

3. Developing new technical solutions

There is room for further improving the efficiency of spectrum utilization. Improvements can come from better modulation schemes (based on wideband technologies), better allocation of channels among the APs in a given area (the AP could negotiate with each other from time to time, and distribute the channels among themselves according to an optimal algorithm)[100], better cooperation between the distributed nodes in a network[101])... However, even if future technological evolutions enable more users to concurrently use a given range of spectrum in a same location, this solution alone may not be sufficient if congestion problems are too severe, in which case it should be combined with the other described solutions.

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[99] These issues described in this paragraph are actually the same encountered by 802.11a; these migration costs are even advanced by Apple as a reason to not develop any 802.11a device: "*'802.11a makes no sense--no sense at all', Joswiak (an Apple Vice President) said. 'There's no conceivable (802.11)a market.' A growth in use of 802.11a technology would also create a problem in deciding how to cater to the millions of devices already using the 802.11b standard, raising the question of whether to build two different networks, Joswiak said.*" ([Charny 2003b]).

[100] Mobile carriers use complex "paving" and channel allocations algorithms when they roll out services in a given area. Adaptations of these algorithms could for instance be included in the specifications for future WLAN standards.

[101] David Reed points to the research of Tim Shepard ([Shepard 1995]) and others demonstrating that a wireless network could be structured so that an increase in the number of users actually increases total capacity[101]. Reed argues that the capacity of a free space radio network is not fixed, but instead is an increasing function of the density of user terminals in that space: the more nodes there are on the network, the closer these nodes are; the closer they are, the weaker the signal connecting these nodes must be; the weaker the signal, the more signals there can be. A network of wireless nodes could expand spectrum capacity as the number of nodes increases.

3.3 Conclusion

We saw in this section that mainly for regulatory reasons, the U.S. represent a good terrain for the use of WLAN devices, and thus for experimenting our model of residential broadband resale in the short run. On its side, Europe lags behind the U.S. as regards adoption of these technologies, because of their lack of transnational regulatory authority. However, we also saw in section 3.2 above that on the medium and long run congestion is likely to hurdle the development of WLAN networks and hence of broadband resale services, and we gave an overview of some possible solutions to alleviate this foreseen threat.

There are other regulatory questions relative to broadband resale, which generate uncertainties that could harmfully dampen the carrier's enthusiasm and impede the development of broadband resale. Notably, regulatory agencies will have to statute about the legality of broadband resale. This question would relate to two traditions: 1) the common carriage legacy, which forbids denying access to customers who are otherwise similar, usually by putting constraints on (or forbidding) price discrimination. This tradition would tend to prevent residential broadband resale practices. And 2) specialized rules. Notably, ILECs are required by the Telecommunications Act of 1996 to allow "Total Service Resale" by Competitive Local Exchange Carriers (CLECs) for all services – a reading which may find broadband resale legal. Then, the FCC will need to clarify the status of residential resellers, to be sure that these not subject to other resale requirements/rules.

Chapter 4 Related economic literature

This thesis introduces an original vision of what could possibly become a new mainstream architecture enabling broadband connection to the Internet. However this new architecture would imply that some providers of traditional wireline broadband services (such as DSL and Cable) partner with some of their customers for the sake of providing services to others: were they to endorse residential broadband resale, carriers would have to accept this inclusion of the resellers in the value chain between them and the end-users, to whom some crucial functions (such as customer management) would be delegated. This chapter describes three bodies of literature useful for supporting our analysis of this new model of broadband services provisioning.

In the first section, we will describe some results from the economic research on industrial organization in general, and issues of vertical control in particular. This body of literature proved very helpful to address the implications that the fragmented provision chain (constituted from the upstream carrier and its pool of resellers) could have on the carrier. One characteristic of broadband resale is that it needs the involvement of a player (the carrier) that is already offering broadband services to his residential customers. One of the most stringent issues raised by broadband resale will therefore relate to its impacts on the existing business of the carrier, and the risks of cannibalization. Sections 4.2 and 4.3 describe two pieces of the economic literature that help us understand the impact of broadband resale on the carrier's existing wireline broadband business: section 4.2 describes literature about quality discrimination, i.e. the potential benefits and risks for a company of providing several similar products that vary only on the quality dimension; and section 3 will finally discuss the economic literature about resale markets for durable goods. Although "broadband" is not a durable good, this literature body provides a useful framework for understanding certain aspects of the resale of a wireline broadband connection by resellers.

4.1 Vertical control[102]

The theory of vertical control issues in industrial organizations provides insights for understanding how residential resale will impact wireline broadband providers. Comparing the broadband resale scenario

[102] This section about vertical control draws on [Tirole 1988, Chapter 4].

with the scenario of wireline broadband distribution appears to be similar to comparing a disaggregated distribution structure with a vertically integrated structure (see Figure 5 below). Literature about vertical control abstracts from the issues of transaction costs, incomplete contracts, and ownership, and focuses on the factors that create an incentive for one or the other structure. Therefore, general literature about what the borders of a corporation should be, and what are the general risks, benefits and economic consequences of relying on an external distribution network is presented in this section.

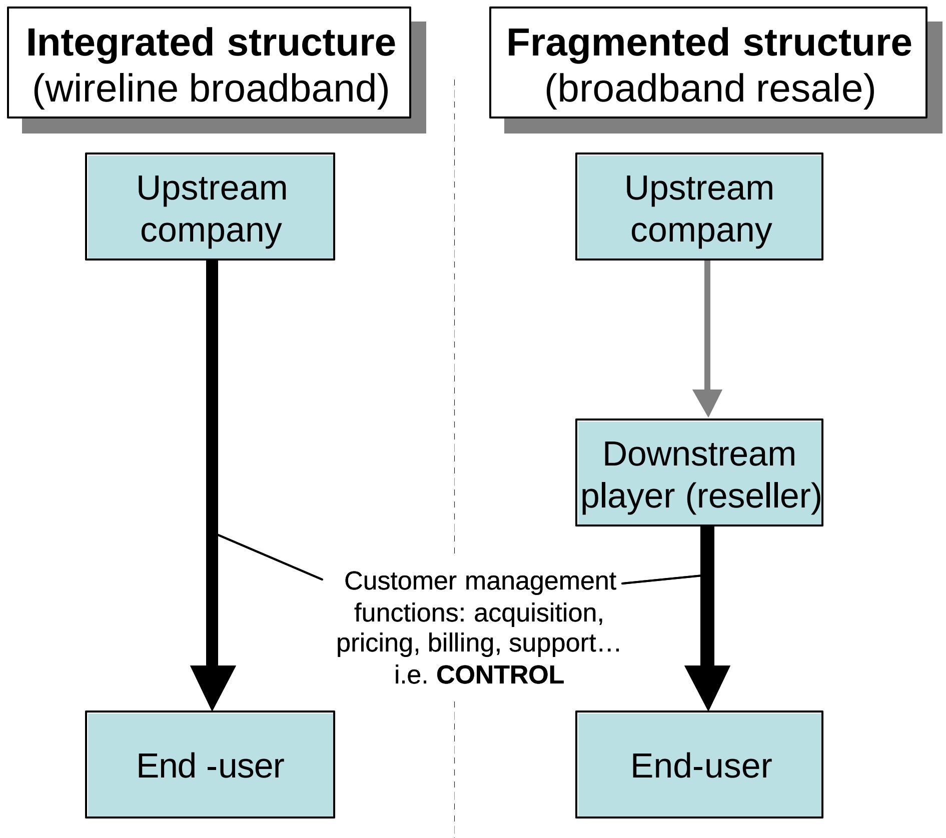

Figure 5: Integrated and fragmented stuctures

4.1.1.a Framework presentation

The literature on vertical integration studies the *relationships* between an "upstream firm" possessing monopoly power in an intermediate good market, and the users of that good, the "downstream firms" (here "firm" must be understood to refer to the individual resellers). These downstream players serve as a proxy between the upstream monopolist and the final users. General examples of these intermediary-level players include manufacturing or service companies using an intermediate input, wholesalers, and retailers. This fragmented structure is usually compared to a benchmark: the *"vertically integrated* *structure"*[103]. The vertically integrated benchmark is particularly useful because it demonstrates which decisions the upstream monopolist would like the downstream firm to make concerning matters he cannot directly control.

Relying on independent retailers may be appealing for the upstream company if it increases its efficiency. Consumers may be heterogeneous, and having a network of retailers located at different points in geographical or quality space enables the upstream company to better appropriate consumer surplus[104]. If these efficiency gains more than compensate for the loss of control, a disintegrated structure will be preferable.

The downstream firms often increase the value of the good or service provided by the vertical structure, by providing services that make the manufacturer's good more attractive to consumers. The most typical examples of such value-added retail services are consumer credit, elaborate premises, excess sales help to keep waiting lines short, free delivery, technical support, or pre-sale information. We will gather all these value-added services under the designation "promotional effort" or "services".

4.1.1.b <u>Control issues</u>

Literature on vertical control focuses on the balance of power between the upstream and the downstream players. Because downstream decisions (for instance about promotional efforts) will eventually affect the consumers' demand for the good, the upstream monopolist's profits will be affected by these decisions. For this reason, the upstream firm has an incentive to exert some control on downstream operations. Control will appear to be a central issue in the analysis, given that the upstream and the downstream players' interests are not always aligned. Also, the final repartition of the vertical structure's benefits between the upstream and the downstream players will also be determined by the balance of power between them.

A carrier will not support broadband resale if it implies foregoing too much control over the downstream resellers' behavior and if the lack of such control implies that net profits will be smaller. On the contrary,

[103] Following [Tirole 1988, p.170], we will say that the upstream firm is vertically integrated if it controls (directly or indirectly) all the decisions made by the vertical structure. And the "vertically integrated profit" is the maximum aggregate (manufacturer's plus retailer's) profit that the vertical structure can obtain – that is, the aggregate profit that the structure would get if all the decision variables were costless to observe, verify, and specify in the contract.

[104] See [Tirole 1988, p. 184], [Dixit 1983], and [Mathewson 1984 and 1986] for spatial models.

if the upstream player manages to sufficiently influence the downstream players' decisions to the best of his own interests (for instance by realigning their interests using adequate incentives schemes), adopting a vertically disintegrated structure may increase the structure's overall efficiency and prove valuable.

As in the rest of the thesis, this chapter also assumes that the upstream company is a monopolist. However, no unique assumption is made about the downstream players, since no definite answer can be given to the question "in the framework of broadband resale, will resellers benefit from monopoly power?" Arguments for both answers can be given, and the reality is likely to depend on local conditions and context. On the one hand, it is sure that no reseller can be regarded as a full monopolist, for at least two reasons: 1) this reseller will necessarily have to sustain the competition from at least one "product": the wireline broadband services provided by the upstream carrier itself; and 2) the fact that every subscriber to wireline broadband services can quite easily setup a wireless AP and engage into broadband resale is a factor that greatly limits the potentials for market power accruing to broadband resellers; it means that downstream the end-users should benefit from relatively competitive prices from the resellers, and that upstream the monopolist carrier will have the possibility to easily substitute a reseller to another, in a given neighborhood[105]. And on the other hand, one can argue that wireline and resold services are different enough so that they cannot be too strong substitutes (see section 4.4.2 below for a detailed comparaison of resold and wireline broadband goods)[106]. Another argument for low competition between resellers comes from the technically limited ranges of WLAN devices[107]: because of it, many resellers are likely to benefit from some market power on the local market surrounding them. As a result, we see that no definite answer can be given as to resellers will be in monopolist situations or not, and that the actual answer is very likely to depend on local market conditions. For this reason, we will investigate separately both cases in the rest of this section.

[105] This possibility can be seen as favoring the upstream carrier in the balance of power between it and the downstream resellers. However, in real environments, this will be partially offset by the reseller's possibility to cancel his broadband subscription and subscribe to the wireline broadband services of a competitor.

[106] The two products will differ along such characteristics as price, peak bandwidth, required commitment…

[107] See section *2.2.2.g-Trade-off between range and throughput.*

The type of relationships existing between the different downstream retailers[108] – i.e. the extent of competition among them – will impact their decisions (be they about pricing, marketing efforts, level of good transformation…) and thus the whole structure (see Figure 6).

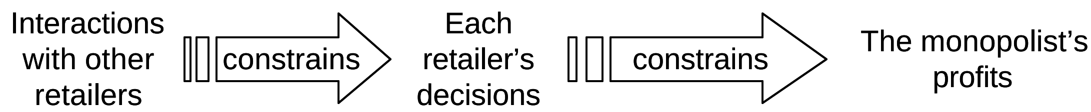

Figure 6: Impact of the downstream market structure on the upstream players

The rest of this section will show that the need for control by the upstream firm on the downstream firm is traced to the existence of externalities between downstream firms and the upstream firm (when the downstream retailers are monopolist), or among downstream firms themselves (when they are competitive). Table 5 summarizes the characteristics of these externalities.

Externality	Vertical	Horizontal
Illustrated by	Double marginalization Moral Hazard	Free-riding
Concerns	Final price Level of promotional services	Level of promotional services
Origins from relations with	Upstream manufacturer	Other retailers
Resellers need to be	Monopolist	Competitive
Harmful for	Manufacturer, end-users	Manufacturer, end-users
Can be alleviated by	RPM, two-part tariffs	RPM, exclusive territories

Table 5: Comparison of the vertical and horizontal externalities[109]

4.1.1.c <u>If the retailers are monopolist</u>

Vertical externalities[110]

[108] For the sake of simplicity, players in the intermediary level will be described as "retailers" in the rest of this section about vertical control. However the analysis is very general, and applies to any other kind of intermediary player between the upstream monopolist and the final end users (e.g. manufacturers of intermediary goods, wholesalers…).

[109] Source: [Tirole 1988, Chapter 4].

[110] Draws on [Tirole 1988, pp. 173-181].

In this paragraph about vertical externalities, the downstream retailers are assumed to be monopolists. We will assume that the upstream monopolist charges his goods via a linear pricing. Thanks to market power he will be able to charge a price premium above its marginal costs. This price will be considered by the monopolist retailer as the marginal cost for this intermediary good. He will make its pricing, promotional and product-transformation decisions accordingly to this supported price.

Any decision made by a retailer that increases his demand for the intermediate good by one unit generates an incremental profit for the upstream firm. However the retailer, who maximizes his own profit, does not take the upstream manufacturer's incremental profit into account, and therefore tends to make decisions that lead to too a low consumption of intermediate good. Figure 7 shows two illustrations of vertical externality, where a suboptimal situation results from suboptimal choices of price and level of promotional service by the downstream retailers.

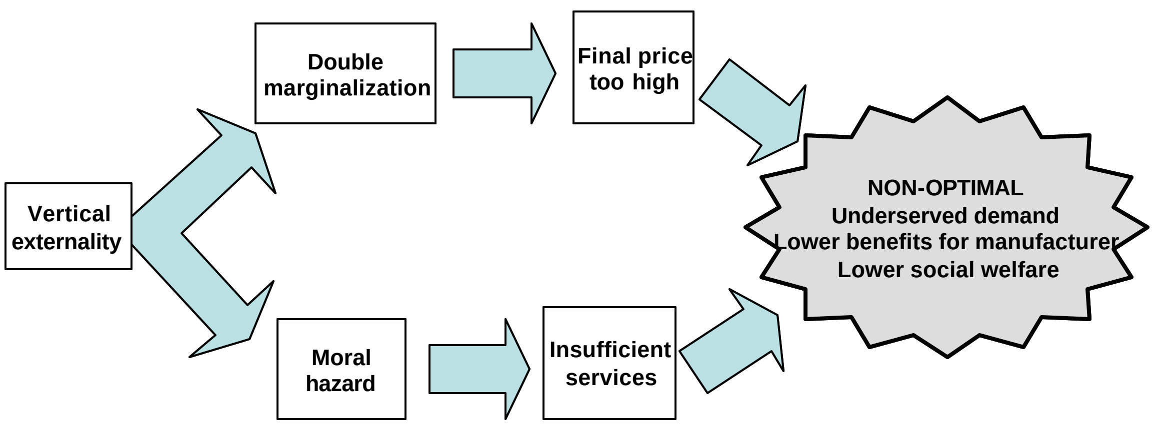

Figure 7: Two harmful effects of vertical externality

This problem comes from the fact that the retail's cost for the good differs from the vertical structure's, and results in an aggregated profit for the manufacturer and the retailers lower than the vertically integrated profit. Let us look deeper into the two phenomena depicted on Figure 7:

1. **Double Marginalization.** If we further[111] assume that 1) the retailer's only decision is the retail price and 2) the manufacturer sets its price first, and the retailer chooses the consumer price second, then the vertical externality leads to what is known as the "double marginalization" effect

[111] On top of our assumption that the manufacturer and the retailer are monopolists.

(first described in [Spengler 1950]): as a monopolist, the manufacturer charges to the retailers an extra markup over and above its marginal costs. This price becomes the retailers' marginal cost to which they add-up their own mark-up (since they are assumed monopolist). Because of these two successive mark-ups, the retail price is higher in the decentralized structure than in the integrated one, resulting in a lower overall level of consumption, and the vertical structure's marginal costs is not equal to the marginal revenues captured from the end-users (sub-optimal profits for the structure). Under these assumptions, vertical integration therefore appears to be economically preferable for both the manufacturer and the consumers[112].

2. **Downstream Moral Hazard.** To the extent that promotional efforts (the value-added transformations or services provided by the downstream retailers) positively affect the demand for the good, the upstream firm wants to encourage the retailers to supply more of it. But, in the same way as the retailers do not take into account the accrued profits for the manufacturer when they increase their sales' level thanks to increased promotional efforts, they will neither take into consideration the positive impact of their promotional efforts on the manufacturer. Thus for any retail price, the retailer provides too few promotional services, as compared to the promotional efforts that would be provided by a vertically integrated structure.

Securing against vertical externalities

As we have just seen, a vertically integrated structure is economically more efficient than a fragmented one when the downstream firms (the retailers) are monopolist, because of vertical externality effects. On their side, the consumers would also be better off under vertical integration because they would face a lower price (not subjected to double marginalization), and welfare would thus unambiguously increase by the elimination of this vertical externality (see [Tirole 1988, p. 177]).

The upstream firm can however secure itself against vertical externality by making the retailers the *residual claimants*[113], i.e. to ensure that at the margin the retailer captures any extra profit of the vertical structure. It would make him internalize the vertical structure's objectives, and thus lead him to make the decisions that yield the greatest profits. There exist several mechanisms that the upstream firm can use to

[112] As expressed by Jean Tirole in [Tirole 1988, p.175]: *"What is worse than a monopoly? A chain of monopolies."*
[113] See [Tirole 1988, p.36].

make the retailers the residual claimants. We describe two of them: the franchise fee and the resale-price maintenance.

1. **Franchise fee.** By using a two-part tariff, the manufacturer can realize the integrated profit without integration. He will charge a price equal to his marginal costs. That way, the downstream unit has the same marginal costs as the entire vertical structure, and her personally optimized solution will also be optimal for the vertical structure: there is no externality. The manufacturer can then appropriate the retailer's profit by imposing a franchise fee equal to the vertical structure's profit (provided that all the resellers are homogeneous). This method aligns the incentives of the upstream and downstream players together (in terms of pricing, promotional effort, and input choices)[114].

2. **Resale-price maintenance.** The upstream manufacturer can sell the intermediate good at a price equal to his marginal cost plus the monopole markup, and then impose resale-price maintenance at this price (i.e. include covenants in the contracts which force the retailers to sell the product at a given price). In that situation the retailers make a zero profit, and the vertical structure's aggregated profit (which is equal to the manufacturer profit) equals the centralized profit.

In the case of broadband resale, this thesis assumes that the carrier keeps on using flat rate pricings (actually tiered pricings, where the value of the monthly flat-rate fee depends on the peak bandwidth available with the connection), as most of them do today. Such pricing schemes are examples of two-part tariffs, with the variable cost (the extra cost per megabyte of traffic) equal to zero (the marginal cost per extra megabyte of traffic is very low for the carrier – though above zero[115]). If the resellers keep on being subjected to such pricing schemes (which we assume – see section 1.5), then these resellers are de facto in the situation of *residual claimants* (see discussion about this point in section 4.1.1.f below).

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[114] However, franchise fees have drawbacks in uncertain environment with risk-averse retailers: because they claim all the uncertain residual profits, while having to pay the predetermined fixed fee, they may feel that they bear too much risk; in that case, a reduction in the franchise fee, together with an increase in the wholesale price above marginal cost, gives the retailer some insurance that she called for ([Tirole 1988, p. 176]).

[115] See section *5.2.3.a-Costs of transport*.

4.1.1.d If retailers are competitive[116]

Benefits from competition among retailers

While in the previous section we were assuming that the retailers were monopolist, we will now make the opposite assumption and presume that the downstream fringe of retailers is competitive.

The vertical externality issue disappears with the competitive supply of retailers, because competition forces them to sell at their marginal cost. As a result, no price distortion will be introduced on top of the upstream monopolist's markup, as was the case with double marginalization. In such a situation, vertical integration is not preferable to vertical disintegration, since the vertical profit is the same in both cases. Finally, a competitive retail level will also benefit the upstream firm by giving him accrued bargaining power for choosing the terms of the contract with the retailers: in other words, competition may *"discipline the retailers"* (as expressed in [Tirole 1988, p.184]).

Horizontal externality and free-riding[117]

If competitive retail results in an optimal eventual pricing to the end-users, we will nevertheless see that it often leads to non-optimal levels of promotional services (notably pre-sale information) provided by the retailers, because the retailers exert a horizontal externality on each other.

If retailers are competitive, consumers will buy from the retailer who offers them the best package of price and services. Then retailers will offer consumers their most preferred price and services package subject to the condition that the retailers not lose money. Modeling this behavior[118] shows that such a competition amongst retailers introduces a bias in the choice of services. While the integrated structure would equalize the cost of a unit increase in promotional services with the marginal revenue accruing from the resulting increase in demand, competition among retailers equalizes it with the marginal consumer surplus from these improved promotional services. From the existence of this bias, the competitive retailers may tend to provide too few or too many services[119]. This is another type of

[116] See [Caillaud 1986].

[117] This section draws on [Tirole 1988, pp.182-185].

[118] See [Tirole 1988, p.182] and [Caillaud 1986].

[119] The welfare analysis of vertical integration when retailers are competitive can be shown to be ambiguous: provision of services under retail competition is socially optimal given the wholesale price; however, the wholesale

externality exerted by the fringe of downstream retailers (through them competing) on the upstream manufacturer, given that they do not offer the level of promotional services he would prefer.

More generally the horizontal externality gives rise to a public good problem: *retailers free-ride on one another*, and the public good (the information provided to the consumers) is undersupplied (see [Telser 1960]). Since a retailer who incurs the cost of providing the information must charge a higher price than a retailer who does not provide the information, consumers have an incentive to visit the first retailer to obtain information, and then go and buy the good from the second one.

In our context of broadband resale, free-riding may happen to be a particularly acute problem for the carrier if it leads some resellers to provide insufficient "value-added services" to resale-users. For instance, if the carrier decides to market broadband resale services under its own brand name, and if some resellers happen to be sloppy and unable to provide satisfactory services to the resale users (because of the free-riding problem, or other reasons such as the reseller having low technical skills or low availability), then these resellers will take the edge of the carrier's reputation, and may eventually hurt all its other businesses on the long run. It corresponds to a major risk of providing broadband resale.

Restraints to competition can alleviate horizontal externality. To encourage an adequate provision of services by retailers, competition among them must be reduced or eliminated. The manufacturer must give the retailers a property right on their services by protecting them against unfair competition. Competition reducing restraints such as RPM, or the grant of exclusive territories[120] to the retailers (in order to limit competition by dividing the final market among the retailers), are adequate solutions to serve that purpose. In spite of their negative impact on the retailers' pricings, "*such restraints are generally welfare-enhancing because they allow the retailers to supply valuable information to the consumers*" ([Tirole 1988, p.183]).

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price is the monopolist's choice and may exceed the wholesale price (fictitious – actually the internal transfer price) under vertical integration.

[120] "Territories" can be understood both in a spatial and market-segmentation sense.

4.1.1.e Conclusions

We saw in this section that the upstream manufacturer needs to balance the potential strategic and commercial advantages of relying on an independent retail network, against the loss of control and economic inefficiencies resulting thereof. We also saw that, no matter of whether the resellers are monopolist or competitive, the upstream carrier needs to intervene on the downstream resale level to ensure that his profits levels will be optimal. The objective and means of the intervention – to alleviate horizontal or vertical externality effects – will nevertheless depend on the initial type of relationship existing among the resellers. These two possibilities are summarized in Table 6 below. The following section will then try to make a reasoned assessment of the most likely type of relationship that will take place among the resellers of broadband services.

	Competitive resellers	**Non-competitive resellers**
Type of externality	Horizontal externality	Vertical externality
Effect	- Price to end-users not optimally setup (but less distortion) - Promotional services are underprovided (free-riding)	Price to end-users is too high (double marginalization)
Repartition of value	The upstream carrier captures all the vertical value – but it is suboptimal	The upstream carrier has to share vertical value with the resellers – and its value is suboptimal
Challenges for the carrier	Limiting competition between resellers	Making the resellers the residual claimants
Possible solution	RPM, exclusive territories	RPM, two-part tariff

Table 6: Challenges to upstream firm from vertical and horizontal externalities

4.1.1.f Foreseen relationships between the resellers of broadband

We have identified several elements pushing towards showing either that great competition will take place among resellers of broadband, or to the contrary that resellers of broadband will be able to benefit from monopoly power. They are summarized in Table 7 below:

Indications for LOW competition among resellers	**Indications for HIGH competition among resellers**
- *Each geographical market is very localized and small (due to limited range of WLAN technologies). Hence distant resellers do not compete on the same market.* - *For each resale user, one particular reseller will have a great competitive advantage on his potential competitors → competing resellers will segment the market.* - Each reseller has a limited capacity of supply: he cannot serve too many users without becoming uncompetitive	- Competition of broadband resale with wireline broadband - Low barriers to entry at the resale level: virtually any user of wireline broadband can start doing resale and compete with existing resellers

Table 7: Indications for the expected level of competition at resale level

As seen from this table, we have identified several factors that we expect to limit the intensity of competition between the resellers of broadband services. Two of them are expected to be of major importance:

1. First, the whole market for broadband resale is actually fragmented into a multitude of independent small markets, because of the limited range of WLAN technologies[121]. Because each reseller can provide resale services only to the users living close to him[122], he cannot compete with other resellers on more distant markets – and inversely cannot expect too much competition from resellers distant from more than 200 ft.

2. This reasoning can even be pushed further: for each user interested by wireless resale, there will be one reseller that will be in a better position to provide resale services to this user; the most obvious reason for this would be that he lives closer from this user (because of *dynamic rate shifting*, the data rate decreases as the distance between the reseller and the resale user increases – see section 2.2.2.g), but other technical reasons could explain that: if their wireless antennas are

[121] For the most pervasive WLAN technology, 802.11b, indoor and outdoor ranges are 100 ft (30 m) and 200 ft (60m) respectively ([Rolfe 2002], as a result of restrictive regulation on emission power.

[122] Note that we assume only residential broadband resale provided to fixed users (as a potential substitute to wireline connection – see section 1.2), and therefore we do not consider any roaming user. Because of this assumption, each user has a limited choice of possible resellers.

> from the same manufacturer (which usually result in higher performances[123]), if the reseller's antenna is better oriented… Such a reseller would benefit from a great competitive advantage against other resellers to serve this particular user, and this competitive advantage will give him some market power.

Because of these two elements, for a given set of resellers and interested customers, we expect an equilibrium to take place, where the market for residential broadband resale will be geographically segmented. Each reseller will benefit from an individual market (whose size will nevertheless depend on the competitive environment: the more competitors, the smaller each reseller's personal market) on which he will benefit from some market power.

Conclusion

As shown in Table 7, we also expect some factors to push towards a competitive environment between the resellers. However, we regard them as much less compelling, and therefore *we expect the net effect of all these factors to lead to a mostly uncompetitive environment, where each reseller would benefit form market power in his own local market* – whose size will however depend on the competitive conditions. Therefore, there should be a tangible risk that resellers engage in double marginalization, thereby negatively hurting the carrier's profits. However, given our assumption that resellers will still be subjected to tiered pricing by the carrier, the amount they will pay each month will be constant no matter how many resale users they serve. In other words, the resellers will naturally be the *residual claimants* for the revenues from resale: since they are the ones in direct contact with the end-users, the resellers will be in a "natural" position to capture most of the revenues from resale users – and therefore they will internalize the profits of the vertical structure, and adapt their efforts to maximize these profits[124] – an

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[123] As stated by QualityLogic (a company making test software and tools): *"The immaturity of the wireless networking market has led to a situation common to new, evolving technologies where manufactures are pumping out new products as quickly as possible to gain market share. This leads to "interpretation" of the protocol specifications by each manufacturer, as no one has yet gained market ascendance and thereby become the "gold standard" against which other protocol implementations are measured. The common result is that interoperability problems crop up, and reliable operation comes only from exclusive use of one manufacturer's product."* (http://www.qualitylogic.com/mobile_test/testing_802-11b.html)

[124] Note however that because resale generates indirect costs to the carrier that the resellers will not take into account (especially the costs of transport), the resellers may "see" more profits from broadband resale for the vertical structure than there actually is, which could lead them to "oversupply" broadband resale (i.e. to acquire too many resale users). However, the congestion that will occur if the reseller acquires too many resale users will make the

optimal solution for the vertical structure. Therefore the pricings currently used by the carriers are therefore suitable to make the resellers the residual claimants, and alleviate potential issues of vertical externalities.

If the vertically integrated profits for the structure "carrier + reseller" may be close from optimal thanks to the near residual-claimancy of the resellers, the question of how the carrier can afterwards appropriate some of these revenues captured by the reseller remains. As explained in section 1.5.2, we will not try to figure out how the carrier can best shape his relationship with the resellers (and design appropriate mechanisms) to capture his share of these revenues. However, these mechanisms should be careful not to annihilate the residual-claimancy of the resellers (and for instance be of a nature close from a franchise-fee, as advocated in section 4.1.1.c above about franchise fees).

In short, we expect the technological limitations of wireless technologies to prevent the occurrence of horizontal externalities, while the current pricings setup by the carrier should secure from vertical externalities issues.

4.2 Quality discrimination

While the previous section was concerned with the impact of broadband resale on the industry structure and the balance of power between the carrier and the resellers, this section (and the following one) will address the interests and risks for the carrier of offering broadband resale, a service that could compete with their traditional wireline offers.

Roughly, it can be said that the producer price-discriminates when two units of the same good or service are sold at different prices, either to the same consumer or to different consumers. There is no price discrimination if differences in prices between consumers exactly reflect differences in the costs of serving these consumers (this amounts to considering the net cost of serving a consumer)[125].

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resellers "internalize" the cost of transport borne by the carriers because of broadband resale, and therefore our claim that the resellers are close from being residual claimants can be maintained.

[125] Definition taken from [Tirole 1988, p.133].

The possibility of price discrimination is linked to the possibility of arbitrage. It is conventional to distinguish between two types of arbitrage. The first type of arbitrage is associated with the transferability of the commodity. It is clear that if the transaction (arbitrage) costs between two consumers are low, any attempt to sell a given good to two consumers at different prices runs into the problem that the low-price consumer buys the good to resell it to the high price one. The second type of arbitrage is associated with the transferability of demand between different packages or bundles offered to the consumers. Here there is no physical transfer of good between consumers: the consumer simply chooses between the different options offered.

It is customary to distinguish three types of price discrimination (see [Pigou 1920]):

- **First-degree price discrimination** is perfect price discrimination, when the producer succeeds in capturing the entire consumer surplus. It is unlikely in practice either because of arbitrage or because of incomplete information about individual preferences.

- **Second-degree price discrimination** is the situation when the producer extracts consumer surplus by using self-selecting devices, even though he has incomplete information about individual preferences. In the rest of this section we will particularly focus on this type of price-discrimination since most broadband carriers engaged in it (see [Gramaglia 2002]).

- **Third-degree price discrimination** occurs when the producer can observe some signal that is related to the consumer's preferences (e.g. age, occupation, location) and use this signal to price discriminate.

4.2.1 Second-degree quality discrimination[126]

A monopolist can also discriminate among consumers with different tastes for quality (or service) by offering an array of qualities[127]. Typical examples of such practices are the different ticket classes offered by railroads or airlines companies.

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[126] This section draws on [Tirole 1988, pp. 142-152].

[127] Quality discrimination about which we are concerned is very similar to quantity discrimination. A simple relabeling of variables is sufficient to go from one to the other, and therefore both types of discrimination are identical at a formal level (see [Maskin 1984]).

With second-degree quality discrimination, we assume that the monopolist knows how consumers' preferences for quality are distributed within a group (via marketing studies), but does not know each consumer's preferences. If the tastes of consumers for quality differ, the producer generally wants to target a specific package for each consumer. He will therefore offer a menu of qualities to choose from. In doing so he must, however, take into account the possibility of *personal arbitrage*, i.e. the possibility that a consumer to whom the manufacturer targeted a given quality package may decide to choose a package that was originally directed to another consumer. This introduces *self-selection* or *incentive-compatibility constraints*.

More precisely, the biggest threat faced by producers engaging into second-degree price-quality discrimination is personal arbitrage by higher-end customers: when consumers with high valuation for quality end up choosing the cheap bundles directed to consumers with lower-valuation for quality. To relax this personal arbitrage constraint, the monopolist offers a relatively low quality to the consumers who do not value quality much. Because higher-valuation consumers suffer more from a reduction in quality than low-valuation consumers, this relaxes the personal arbitrage constraint. Hence the monopolist reduces the quality offered to the low demand consumers so that the high-valuation consumers will be less tempted to consume the low-valuation consumers' bundle (see [Mussa 1978] and [O'Keefe 1981]).

An early example of a monopolist using lower quality goods as market segmentation techniques was given in [Dupuit 1849] with a discussion of the French railroad tariffs for passenger traffic:

> *"It is not because of the few thousand francs which would have to be spent to put a roof over the third class carriage or to upholster the third class seats that some company or other has open carriages with wooden benches…. What the company is trying to do is prevent the passengers who can pay the second class fare from traveling third-class; it hits the poor, not because it wants to hurt them, but to frighten the rich…"*

Sometimes the quality-variable does not refer to the good itself, but to some disamenity associated with the purchase of the good. For instance, consumers usually do not like to travel to faraway stores, to bargain at length, or to buy from stores with few services. Or they incur a cost searching for the lowest price for a given good. In more general terms, the purchased good is tied to another good (a "bad" one) which represents the time spent (or more generally, the disamenities incurred) in obtaining the good. If the consumers with the highest willingness to pay for the good (which the firm tries to determine) are also the ones with the highest distaste for the bad, the firm may offer a high (low) price for the good associated with a low (high) consumption of the bad. Again, the high consumption of the bad for a low price for the good is meant to prevent the high demand consumers from exercising personal arbitrage ([Tirole 1988, p.151])[128].

These lessons from the economic literature about quality discrimination will be relevant provided that one can consider wireline and resold broadband as two similar goods, varying only on the price and quality dimensions. Section 4.4 below will discuss the validity of his contention.

4.3 Resale markets for durable goods

In this section, we will present the major elements of literature about resale markets and their impacts on the primary supplier of the good. As we will see in this section, this literature usually deals with resale markets for durable goods, such as books, machines, or cars. Since the good "broadband" has features very different from the ones of a durable good, we will have to be very careful in applying these results to the envisioned broadband resale model. These issues are discussed in greater details in section 4.4 below).

4.3.1 Conventional wisdom and empirical evidences

Logically, the existence of markets for used goods is thought to affect the incentives of manufacturers of new goods for two reasons: 1) buyers of new goods can sell the depreciated good; and 2), buyers of a new good have the option of purchasing a substitute ([see Hendel 1999]).

The conventional wisdom is that a secondary market should be limiting profits of the monopolist in the primary market. And at first the reason sounds definitive: since the goods traded on the resale market are similar to the products traded on the primary market (they are usually identical, but of different "vintages"), they will be substitutes for the goods sold by the manufacturer on the primary market, and therefore hurt its profits. This notion seems to be widely spread in the industry, as shown by the observable behaviors of many companies. The most frequently cited example relates to the publishing industry, which is suspected of editing frequent re-edition of their books with the only aim of decreasing

[128] [Salop 1977] shows that discrimination through price dispersion may be a good strategy for a monopolist when consumers differ in search cost. [Chiang 1982] proposes a similar type of analysis, but relates to discrimination through waiting times.

the perceived value of the used books on secondhand markets[129]. Examples are also available on different markets: for instance Waldman argues that companies as diverse as United Shoe in the market for shoe machinery, Xerox in the market for copiers, and IBM in the market for computers, have been using lease-only policies for their products for the very goal of eliminating the associated markets for secondhand goods[130].

4.3.2 Overview of existing literature[131]

A close scrutiny of the existing academic literature shows that economists do not necessarily agree with the conventional wisdom presented above – the debate about whether the existence of a secondary market is harmful or not for the manufacturer is actually still open. The answers provided by the different contributors to this debate appear to be very sensitive to their assumptions (about what determines the goods depreciation and durability, demand homogeneity, possibility of scrappage…). Below a quick overview of these major contributions is provided:

- [Swan 1972] presents a model of a durable good market with exogenous durability[132] to prove that the profits of a monopoly seller coincide with the profits of a monopoly renter of durables. This so-called "Swan Independence Result" implies that *the existence of a secondary market does not limit profits of a monopoly seller*, because the initial selling price of a durable good necessarily reflects the price at which the good will change hands in the secondhand market in the future.

- [Rust 1986] proposes a model with endogenous durability (the lifetime distribution for durable goods is determined by the level of scrappage[133], in turn determined by equating supply and demand for all vintages of durables). He analyzes the manufacturer's choice of optimal durability

[129] Other publishers are even more innovative, and try to sell "instant destruction" books by including answer pages to be torn out and handed in to the instructor ([Miller 1974]).

[130] See [Waldman 1997].

[131] This section partially draws on [Hendel 1999].

[132] i.e. durability is inalterable once fixed at date of manufacture; this is typically the case with goods of the lightbulb variety (i.e. the good gives the same service until it dies), or for which additional units of services can restore their quality after depreciation (i.e. quantity and quality are perfect substitutes).

[133] Scrappage corresponds to the possibility for the users to eventually resell their used good for a fixed price, no matter of its quality at that time.

and price as the solution to a Stackelberg game between the monopolist and the consumers. His results by and large support the "conventional wisdom", and show that *endogenous scrappage provides consumers with a substitution possibility which limits the profits of a monopolist seller*[134].

- Using a two-period model with exogenous durability, [Waldman 1997] shows that preference heterogeneity can overturn Swan's result, because of substitutability across different vintages. A corollary is that *monopoly profitability is maximized by the elimination of the secondhand market, as long as the valuation on quality of the low-valuation group of consumers is sufficiently small.*[135] Therefore, according to Waldman, the existence of a secondhand market *per se* reduces monopoly profitability.

- [Hendel 1999] is a general analysis of secondary markets, based on realistic and not very restrictive assumptions (endogenous durability, heterogeneous demand) and therefore leads to the most general conclusions. The authors simply acknowledge that the presence of markets for used goods affects the incentives of carriers for two reasons: 1) buyers of new goods can sell the depreciated good; and 2) buyers of a new good have the option of purchasing a susbstitute (the old good). Therefore they frame the overall impact of resale markets as a tradeoff between an increase of the new good's primary value, and substitution effects from used goods.

4.3.3 Increased discrimination capabilities

[Hendel 1999] is one of the most recent contributions to the question, and proves particularly insightful. According to the authors, a monopolist firm facing heterogeneous demand can take advantage of a secondary market as a tool for extracting more surplus from their consumers. This effect directly follows from the fact that *"The marginal type purchasing the new good when markets are closed is lower than*

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[134] Nevertheless his results confirm Swan's contention that a secondary market per se imposes no limitation on the profits of a monopolist, since the constraint on monopoly profits is a result of substitution possibilities created by endogenous scrappage (which can occur with or without the existence of a secondary market).

[135] *"If this low-valuation group has a sufficiently low valuation for the monopolist's output, the revenues decrease for new units due to the availability of old units will be larger than the revenue generated by the sale of those old units. In such a case, the monopolist has an incentive to eliminate the secondhand market, that is behaves in a fashion such that old units of output are unavailable for consumption by both high- and low-valuation consumers."* ([Waldman 97]).

when markets are open. Used markets facilitate segmentation of demand in such a way that the new good is consumed by quality sensitive consumers, while the used good goes to consumers who are less sensitive to quality." ([Hendel 1999]).

Because they know that they will be able to later resell the used good on the secondary market, the high-valuation customers will be willing to pay a higher price for the first good. In other words, the existence of the secondhand market results in lower elasticities of demand for high-valuation consumers[136]. Even though consumers buying used durables directly reduce demand for new products (as they are consuming substitutes), indirectly they increase demand from other consumers who anticipate a positive resale price, and this induced effect dominates (see [Anderson 1994]).

The economics of secondhand markets therefore strongly relate to the literature on discrimination based on product quality (presented in section 4.2 above). However, discrimination via secondhand markets differs from "traditional" quality discrimination on at least two points:

1. The "used" goods cannot be produced directly, but must come from "new" goods that have been depreciated. Hence the product spectrum and prices must be computed in such a way that they are consistent with both consumer preferences and depreciation (see [Konishi 2000, p.4]).

2. The monopolist has less control on the features (price, quality) of the lower-quality goods with resale markets than with classical price discrimination on quality. However, this difference can be mitigated if the manufacturer manages to influence the resale market – and indirectly the characteristics of the goods traded there, as explained in the next paragraph.

4.3.4 Control of resale markets

Nevertheless there are several implementation difficulties for a monopolist desiring to benefit from the discrimination capabilities of the resale market. The monopolist firm needs to be able to control (or at least influence) the conditions prevailing on the secondhand market (most typically the price and quality of goods sold) – otherwise the monopolist will suffer from cannibalization of its primary market – as it

[136] This point was already expressed in [Miller 1974]: *"It is sometimes said that the initial price captures that the present value captures the subsequent value of all subsequent transactions so that used items in fact do not compete with new ones. The buyer of a newly produced diamond pays a price consistent with what the diamond can be sold for to others including members of later generations"*.

occurs with classical discrimination when the characteristics of the various goods are not sufficiently different. The monopolist will have to use some influence levers to institute conditions on the secondhand market that may be compatible with price discrimination on quality. These control levers are:

- **Control of the goods' durability**: The monopolist can affect the quality of the goods sold on the secondary market by choosing the durability of the goods he sells. By reducing built-in durability the monopolist ensures that used assets are worse substitutes for new assets[137].

- **Control of the transaction costs**: If there are positive transaction costs on the secondary market (e.g. the search for replacement goods is costly to the end users), consumers may hold their durables over multiple periods to economize on transaction costs. [Sandfort 1999] shows that as transaction costs increase, the market for high quality used goods close, since all owners of these durables prefer to hold the durable to a more degraded state rather than trade it and incur the transaction cost[138].

- **Control of maintenance**: For many goods, maintenance complements durability, since consumers can extend the useful life of a product and increase its quality by maintaining the good – thereby making it a better substitute for the new goods on the primary market. Thus the monopolist sometimes benefits from limiting maintenance[139].

4.3.5 Conclusion

In this section about resale markets for durables, we saw that the upstream monopolist could sometimes benefit from the existence of a second-hand market, and indirectly use it to achieve a form of second-degree price discrimination: secondhand markets can enable the monopolist to effectively extract high

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137 An example of such control was given in paragraph 4.3.1: book publishers control the durability of their books by choosing the frequency of book re-edition. In some other cases, durability can be chosen by technical means (e.g. lightbulbs).

138 An illustrative influence of the transaction costs on secondary markets was provided by some car manufacturers that instituted a policy that seems designed to facilitate transactions in the used market. Notably, Infiniti and Lexus certify "pre-owned" vehicles and extend warranty coverage to used cars ([Hendel 1999]).

139 A possible way of influencing the costs of maintenance is to void warranty coverage if the product is maintained differently from some prespecified standard. A second way is to charge a higher price for complementary products unless the consumer uses the maintenance policy offered by the manufacturer.

surplus from high-valuation consumers while at the same time also servicing those with lower valuation for quality via the secondary market.

All of the literature described in this chapter relates to durable goods, which *a priori* have little in common with broadband connectivity. The next section aims at investigating the similarities and differences between the broadband good and durable goods, in order to figure out how the insights from the literature about resale markets for durable goods can support our analysis of broadband resale.

4.4 Nature of the resold "broadband good"

Until now we have frequently used the expression "broadband resale", and have explained what we were meaning by "resale". However, the nature of "broadband" has not been defined yet – notably because there is no obvious definition. To support this analysis, we will first look at what features of broadband are most valued by consumers (demand side), and then focus on how the broadband good is priced by the carrier (supply side).

On the demand side, it appears that a very large majority of broadband subscribers identify high access speeds as the most appealing attribute of broadband service, as shown on Figure 8 – the next most valued attributes are the "always-on" feature, and the possibility to use the phone while being connected to the Internet[140]. Therefore, it appears that the consumers mostly think of "high speed connection" when they hear about broadband.

[140] This analysis performed by McKinsey is confirmed by other analysis. For instance, The Yankee Group's 2001 Technologically Advanced Family Survey shows that 51% of broadband households cite faster connectivity as the leading reason being subscription to high-speed Internet ([Gramaglia 2002]).

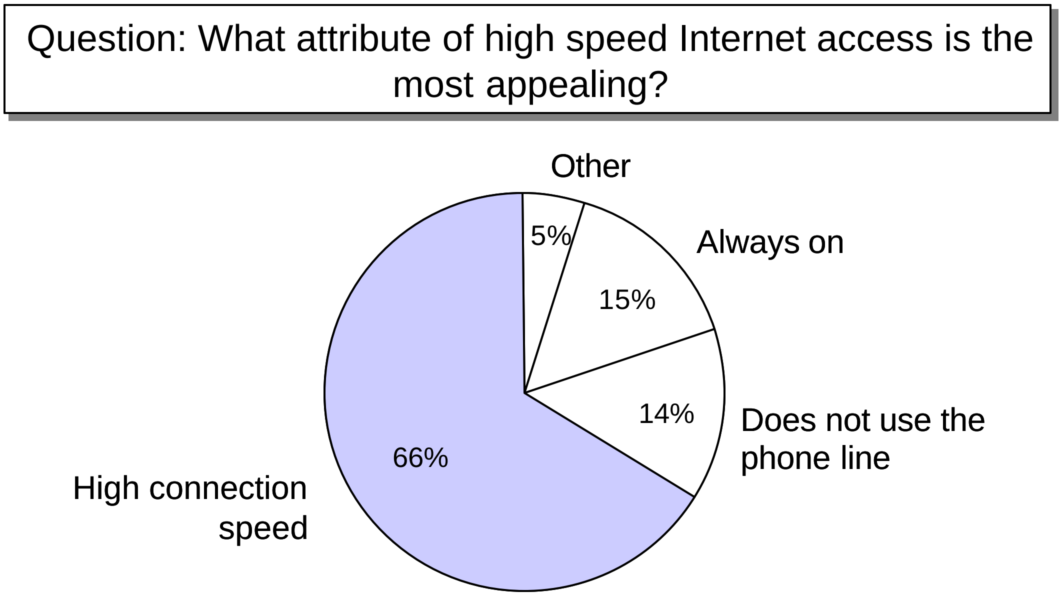

Figure 8: Drivers of broadband demand among existing users [141]

On the supply side, we can look at how the carriers price the broadband good, in order to figure out how the carriers "regard" the service they supply. As described in the overview of the DSL industry in section 2.1.1 (as well as in Appendix I), a large majority of carriers currently offer tiered pricings, i.e. different combinations of connection speed and price. For example a typical offering would be made up of a solution for $50 with peak download speed of 768 Kbps, and a solution for $60 with peak download speed of 1.5 Mbps[142]. Therefore, most carriers seem to agree about the idea that what differentiates a "good-quality" service from a "bad-quality[143]" service is the connection speed[144]. This fact is probably induced in part by the way they are themselves charged for their upstream links by backbone carriers: broadband carriers are charged according to the peak bandwidth they need (refer to Section 5.2.3.a about the costs of transport), which reflect the cost structure of the upstream providers (their marginal cost for

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[141] source: [McKinsey 2001, p.29].

[142] These values correspond to Verizon's offering in the Boston area as of September 2002 (cf. Appendix I).

[143] Note that we still give to "quality" the sense it had in the economic literature about price discrimination. Therefore it refers to "any valued attribute", and hence especially to the connection speed. It does not refer to the technical notion of Quality of Service (QoS).

as a subjective name referring to the most valued attributes "quality".

[144] Note that other factors can also drive this choice of pricing, including "marketing reasons": it could be that carrier prices for his average consumer, and that the behavior of this average consumer calls for such a pricing scheme.

carrying traffic when there is no congestion is very low, while the cost of carrying traffic during congested hours is much more expensive, since it theoretically implies to engage into large capital expenditures to increase the plant capacity).

Therefore, it seems that the peak bandwidth of the connection is both the characteristic that the consumers of the "broadband good" value the most, and a major driver of the upstream costs on supply side. From this analysis, we will assume that the good "broadband" under our scrutiny should not be assumed to be a "megabyte of traffic", but should rather be considered as "a *megabyte per second* of broadband connection".

4.4.1 Characteristics of the good "broadband"

Now that we identified "broadband" as being essentially a megabyte per second of connectivity, we will identify and describe its main characteristics: "broadband" is an experience good, of zero-durability, which is sharable but non-transferable. All these characteristics are illustrated in Table 8 and below.

Good characteristic	Comments
Experience good	- Users need to get informed about it - Users need to test it - Adoption process is difficult and costly
Non-durable	- Consumption cannot be delayed
Sharable	- One user can have other persons benefit from it while still benefiting of it - When the good is shared by several users, each of them benefit from a good of degraded-quality
Non-transferable	- The good is associated with a given geographical location, from which it cannot be moved away - Corollary: the good cannot be purchased at a location different from the place where it will be "consumed"

Table 8: Main characteristics of the good "broadband"

4.4.1.a Experience good

Broadband is an experience good[145], i.e. a good whose quality (any valued attribute) cannot be fully determined before it is purchased (as first described in [Nelson 1970]). Typical examples of experience goods are computer software, motion pictures, and most foods. Even if in practice, there are a number of sources of product-specific information (advertising, reputation, third-party evaluation, signals such as warranties, word-of-mouth information – see [Shapiro 1983]), information about the product is usually bundled with the product itself and the most important source of information about the product is often actual experience with it. As a consequence, the demand curve shifts over time as buyers learn about the product, as McKinsey analysts express it about broadband ([McKinsey 2001, p.24]): "*We believe that the most important near-term implication is that consumers do not fully understand the relative [as compared to narrowband dialup] value proposition of broadband (…). In fact we believe that the hypothetical demand curve (…) can easily be shifted up to support greater penetration at current prices based solely on improved marketing and promotional efforts.*"

4.4.1.b Non-durable good

Contrary to a durable good, a high speed connection cannot be stored in order to be used later. For instance, if I go on vacation for one week during which I will not be able to actually benefit from my DSL subscription at home, I will not be able to "postpone" the consumption of the week of connectivity to a later time by canceling my subscription for one week. I will therefore not have the possibility to "delay" my consumption of this good to later period when I know I will be at home. Broadband is an "immediate consumption good", a feature that makes a great difference with the commodity goods usually traded on traditional secondary markets and analyzed in the economic literature.

4.4.1.c Sharable good

The broadband good can easily be shared amongst different users. We will illustrate this point by comparing a broadband connection with a paying-for[146] cable TV channel. Subscription to a particular TV channel is also an experience good that can be shared amongst several users, in the sense that one

[145] As opposed to a 'search good', for which the features are all known in advance, and the only remaining relevant discriminatory dimension is therefore its price.

[146] This feature is necessary only to make the comparison with broadband subscriptions more accurate.

subscription to the channel is usually sufficient for a whole family, even though different people plan to use it. Sharing the good entails some disagreements (for instance, the impossibility of watching concurrently to different channels in the same family, or the disturbing noise made by other TV watchers), and therefore the good's quality perceived by each user decreases when it is shared with more people. Nevertheless the decrease in the good's quality is usually slow, in the sense that "half a TV channel subscription" (a TV channel shared among two persons) has almost as much value to each user as a personal subscription to the TV channel would have.

A broadband connection is very analogous to a paying-for cable TV channel. Among the several characteristics making up the broadband good (see Figure 8), we can say that the "always-on" and the "no use of the phone line" features are perfectly sharable among different users, while the "high speed connection" feature is sharable at some costs – since sharing the connection (with other family members) will imply degradations of speed at some times (for instance when one family member wants to use streaming videos at the same as another member downloads large files) – and no disagreement at other times. Since the most important attribute of a broadband connection as been shown to be its speed, this example clearly shows that the average quality of broadband perceived by one user degrades when the good is shared amongst more people. Nevertheless, similar to the TV example, the value that one person draws from her broadband link will not be cut by half as soon as she starts sharing it with her roommate. In other words, the total benefits that can be drawn from a broadband connection is not fixed: the aggregated utilities drawn by three people sharing one connection will be higher than the utility that one single user could draw from it if she were alone.

4.4.1.d <u>Non-transferable good</u>

Contrary to a durable good, the "broadband" good is hardly movable, since it is linked to a phone line, itself linked to a particular location. This obvious statement has deep consequences: a broadband connection cannot be lent for a short period of time by a subscriber to a friend of her. Nor can she buy her broadband connection during her vacation in South Korea, where DSL subscriptions are notoriously much cheaper than in the U.S.[147]. This characteristic will notably have consequences on the market's competitive structure.

[147] The monthly subscription averages 23.73 USD in South Korea, versus 49.96 USD in the U.S. ([Wachovia 2002]).

4.4.2 Resold vs. wireline broadband

Considering the characteristics of the broadband good identified above, the next crucial point to evaluate is how the resold good compares to the new good. More precisely, we need to figure out whether resold broadband can be considered as a sort of "used" broadband.

We need to assess the level of substitutability between the goods available on the primary and the secondary markets – i.e. between the wireline broadband connection and the wireless resale connection. The more substitutable they will be, and the least benefits the carrier will be able to draw from resale, because the resale products will be very attractive to its wireline users, and cannibalization effects will be great. To the contrary, a large gap between these two products would make them target different subcategories of demand, and therefore to discriminate. Table 9 shows the main differences between wireline and resold broadband.

	Initial good: Wireline broadband	**Resold good: Wireless resold broadband**
Last transmission medium	Wire (DSL)	Wireless
Pricing	Tiered pricing (flat rate monthly fee, whose amount depends on the connection speed)	Depends on resellers' choices(can be a monthly fee, variable pricing, micro-transactions…)
Price level	High (of the order of $40/mo)	Assumed lower because 1) lower quality[148], and 2) lower costs (most fixed costs are shared)
Long-term commitment	Usually required by the carriers[149]	Unlikely (but at the discretion of resellers)
Peak available bandwidth	High (the value depends on the plan subscribed to)	Lower if too many resale users (shared connection)
Uncertainty about connection's speed	Low (quality varies with the time of day, but is quite predictable)	High (may depend on interferences, other users' consumption patterns, reseller's skills…)
Service perenniality	Guaranteed (with large incumbent providers)	Not certain

Table 9: Comparison of wireline and resold broadband

[148] Refer to the discussion in 4.4.1.c.

[149] However, some recent promotional offers do not require any long-term commitment anymore: e.g. Verizon's current offer enables the users to leave when they want, provided that they send their DSL modem back to the carrier if they stayed less than one year (source: www.verizon.com).

Table 9 can be summarized as follows: *the resold broadband service product supplied by the resellers is of overall lower quality than the wireline broadband product provided by the upstream carrier*[150] *– and this lower quality will need to be offset by lower prices for resold broadband*. From this angle at least, the resale market for broadband is similar to the traditional resale markets for durable goods: since it is of lower quality than wireline broadband, resold broadband can be assimilated to a degraded – or "used" – version of the original wireline good.

Some will probably argue that the resellers provide "additional services" (see Section 4.1.1.a) that will add to the value of resold broadband. And it is true that broadband resellers will 1) provide a wireless service, while the carrier provides only wireline services, and 2) provide marketing and customer support value. However, we explained before (see 1.5 about this thesis' assumptions) that we would not consider the "wireless feature" as an advantage of resold broadband over traditional wireline broadband. The reason is that WLAN devices are becoming cheap[151] mainstream technologies, and therefore users valuing wireless connection can benefit from it by purchasing a WLAN Access Point[152]. In other words, classical wireline broadband can easily be turned into wireless broadband – and wireless capabilities are not specific to broadband resale. As for the second remark, it is true that resellers will take upon them some of the marketing and customer support roles. If it means a lot for the carrier in terms of costs reductions, we do not expect it to radically change the users' experience: given that marketing and customer support services are already provided in the world of wireline broadband[153].

Therefore, we regard resold broadband as a sort of degraded wireline broadband. Its will appeal to some customers on condition that it is provided for a lower price than traditional wireline broadband connections. From this angle, a parallel seems possible between the resale market for broadband and

[150] Note that this statement relates only to the residential use of broadband resale as an alternative to wireline broadband – the subject of this thesis. As explained in the introductory chapters, other uses of broadband resale (by nomadic users for instance) can be imagined, and for which the wireless characteristics of resold broadband make it much more valuable to the users than wireline broadband.

[151] According to Gartner analysts, *"by the end of 2007, the average selling price for a wireless LAN adapter will fall to less than $30, as economies of scale and competition drive down prices"* (in [Rolfe 2002]).

[152] We can reasonably assume that the customers subscribing to broadband connections are likely to be among the most prone to value the benefits of wireless and WLAN technologies.

[153] Here we implicitly assume that the end-users value the support provided by the broadband carrier as similar and the support provided by the resellers. It may not be true for all resellers (some of them will provide outstanding customer support, while others will provide very poor customer support), but we regard this assumption as reasonable "in average".

resale markets for durables: in both cases, the goods traded on the secondhand markets will be of worse quality than the ones traded on the primary market, and at a cheaper price. Besides, wireline and resold broadband are partial substitutes for each other, as are new and used durable goods, to an extent that depends on the difference between the two goods in terms of price and quality. These similarities[154] allow us to use the analysis of secondary markets for durables as a support for our analyzing of broadband resale.

Finally, our literature review confirms the intuitive idea that the more control the carrier will be able to exert over the resellers, the better off it will be. This issue about control of the upstream company over the downstream players (retailers, or consumers selling their used products) is pervasive in both the vertical disintegration and the resale frameworks. The extent to which the upstream carrier will be able to control the resellers is hard to figure out a priori, since it will depend on actual implementations of the carrier's strategy. For example, if the carrier merely allows resale, the actual resellers are likely to hide, and the carrier will therefore have almost no control on them. To the contrary, if the carrier openly announces and shows that he really is in favor of resale, he may enter into real partnerships with the resellers, and by that have more influence on the conditions prevailing in the market for resold broadband.

[154] These similarities should not mask the important differences remaining between the broadband resale market and markets for used durables, and notably: 1) the impact of time (that conditions the degradation of durables, while this notion is absent from broadband resale), and 2) the relationship between the new good and the used good (while one new durable will eventually become one used durable, this relationship does not hold with broadband resale, in the sense that one wireline broadband connection can be used to resell *several* degraded broadband connections to resale users).

Chapter 5 Cost model of residential resale

5.1 Introduction and overview

5.1.1 Purpose of cost model

In the rest of the thesis, our objective is to identify the effects of broadband resale on the carrier. The metric that we use to assess whether broadband resale is advantageous or not is naturally the carrier's profits: if an action (endorsing broadband resale, acquiring an additional resale user…) end up increasing the carrier's profits, it will be considered as desirable, otherwise the action will be regarded as harmful.

Some effects of broadband resale on the carrier can be reasonably estimated, while others are more speculative. More specifically, the analysis of the costs that resale users will make weigh on the carrier can be performed rigorously, based on existing data about the costs faced by broadband carriers. It is the object of the current chapter, and will enable us to find out what are the conditions – on the revenues captured by the carrier from resale users – which make the acquisition of a resale user desirable for the carrier. However, some other impacts of broadband resale – impacts concerning mostly a macro-level – can only be identified at this point, since they are much more difficult to quantify[155]. Next chapter (Chapter 6) presents these different effects, as well as their main determinants.

The current chapter proposes a quantitative analysis of the incremental costs expected to be incurred by the carrier during the process of acquiring and providing broadband service to a resale user, and will compare them to the incremental costs of acquiring and serving an additional wireline user (see Figure 9 below for a representation of the two options compared). We focus on costs and will not model revenues directly (as explained in 5.4.3 below), by lack of reliable data on which formulate our revenue model. Of course, knowing the revenues that the carrier can expect from resale users would be ideal since it would permit us to calculate precisely the incremental profit from acquiring a resale user, and thereby to figure out whether such acquisitions are desirable to the carrier or not. Consideration of the costs alone, however, remains useful since it establishes the minimal floor for incremental revenues from resale users

[155] For obvious reasons, notably the fact that broadband resale has not occurred yet; therefore, any analysis related to the expected demand for this new type of broadband services is therefore speculative by nature.

that must be anticipated by the carrier for the acquisition of a new resale user to be profitable. Also, for some given anticipated revenues from wireline and resale types of users, our cost analysis will tell how best to add the next increment of customers – via direct sales of DSL lines or via extension via resale.

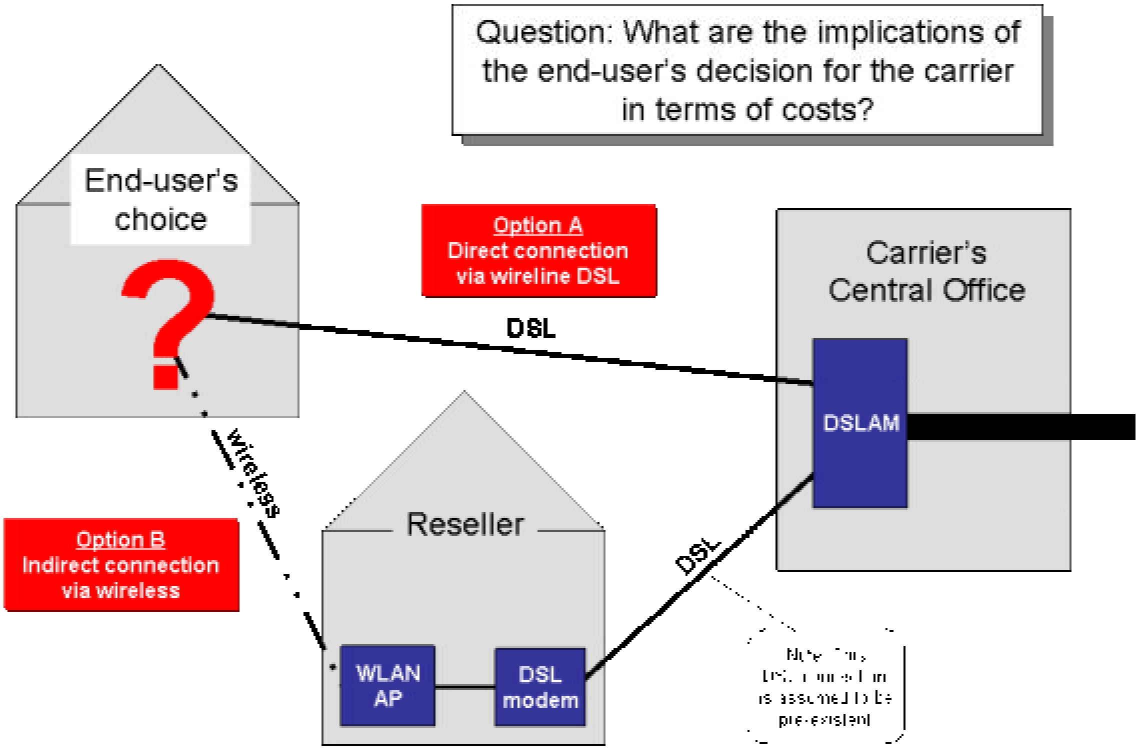

Figure 9: Perspective of the cost model

This chapter is organized as follows: the next section provides a detailed analysis of the incremental costs (falling to the carrier) of providing broadband services to an additional wireline user and to an additional resale user. Analyzing the costs of a service that does not yet exist is uncertain by nature, and relies on several assumptions that we will explain. It will be based on empirical data from other cost-models and simulation where reliable data is lacking. The following section (section 5.3) then discusses and provides a range of estimates for the foreseen average churn rate of resale users. Finally this chapter's last section (section 5.4) combines the results from the two preceding sections, and analyzes the profitability of the acquisition of resale users as the parameter giving the monthly revenues captured by the carrier from a resale user varies.

As we will see, this chapter relies on financial concepts to assess the incremental costs of acquiring an additional user. Notably, the schedule of the costs over time matters, because of the time-value of money.

In other words, the earlier the revenues (and the later the costs), the better it is. This impact of time is included by discounting the distant (in time) cash-flows with a constant discount rate, which relates to the firm's opportunity cost of capital[156].

5.1.2 Specific assumptions for the cost model

All the assumptions presented in section 1.5 still hold in this chapter. However, we need to be even more specific in order to be able to carry out a cost analysis. For this reason, we will further restrict the scope of our study.

First, while the carrier was only supposed to be a wireline broadband carrier until now (i.e. either an ILEC providing DSL broadband services, or a cable TV company also providing cable modem services), the cost model in this chapter will be restricted to the situations where the carrier is providing broadband services via DSL technologies. As we already explained in the section stating this thesis' perspective (section 1.2) is that we expect broadband resale to be more attractive to DSL providers than for cable providers because of their respective cost structures (see section 2.1.3).

Additionally we assume that the ILEC is of a size comparable to Verizon, i.e. serves about 30 millions of customers. A direct consequence of this assumption is that we will assume that this ILEC benefits from bargaining power that will enable him to obtain substantial rebates from its suppliers. We will assume that the rebates obtained by this ILEC from suppliers of hardware equipments (companies such as Alcatel or Cisco) amount in average 30% off listed prices.

This chapter also assumes that the cost of the wireless cards (which give wireless capabilities to the end-users, and enable them to wirelessly associate with the resellers' access points) is not an incremental cost falling to the carrier, and therefore will not be included in this cost modeling. Several reasons support this assumption: 1) these devices are becoming mainstream, and are expected to soon become ubiquitous[157] and be automatically provided as standard features with computers[158]; and 2) given our assumption that

156 See [Brealey Myers] for more details about these financial concepts.

157 The development of WLAN technologies is for instance strongly supported by Intel, who announced in October that its Communications Fund planned to invest $150 million in wireless start-ups to help accelerate the acceptance of 802.11. Intel is taking minority stakes--less than 20 percent--in companies, typically investing between $1 million to $10 million (source: [Shim 2002]).

158 Citing Tony Bonadero, director of marketing for Dell's Latitude notebook line: "Next year, we see (wireless) becoming a standard offering" (cited in [Spooner 2002]). Indeed Dell will include the 802.11b and 802.11a wireless

the carrier has no direct relationship with the resale users (see section 1.5.2), and given the expected high churn rate of resale users (see section 5.3 below), we do not regard as credible the possibility that the carrier may want to subsidize the purchase of such wireless cards[159].

As will be explained in footnote 165 on page 88, we assume that acquiring and servicing an additional resale or wireline customer does not generate any incremental overhead costs (which include the rent, utilities, insurance, taxes, as well as the cost of supervisory personnel).

And finally, this model accounts for a factor crucial in determining the profitability of telecommunication services providers: the churn (or turnover) of the customers. Section 5.3 will be dedicated to its analysis. Because of churn we need to make a distinction between two types of customer addition: 1) the ***gross** customer additions* accounts for all the acquisitions of new customers by the ILEC; and 2) the ***net** customer additions* only accounts for the acquisition of new customers that make the size of the customer base increase, i.e. the acquisitions that are not offset by the concurrent departure of a customer (because of churn). Simply put, the net additions correspond to the gross additions minus the churn. As we will see below, some costs are driven by the net additions of customers, while other costs are driven by the gross additions. In this model, we are of course interested in the costs per *gross customer addition*; whether this addition happens concurrently or not with the departure of another customer is not a pertinent element *in se*. However, some of the costs that we can assess will relate to net customer additions, and therefore we will have to be careful to "convert" these costs into costs per *gross customer addition*.

Our last assumption relates to the lifetime of electronic equipments (such as DSLAMs or line cards). Because they are subject to very rapid obsolescence because of the rapid pace of innovation, we assume

formats as standard features in all of its Latitude notebooks released in 2003. Dell is predicting that wireless will soon become almost as ubiquitous as networking technologies such as Ethernet ([Spooner 2002]).

[159] In our vision, each particular reseller is responsible for handling his relationship with the resale users. Notably, the resellers are free to choose the wireless technology that will connect them to the end-users (as for this writing, the resellers could for instance decide to set-up an 802.11a or an 802.11b access point; this choice is not neutral, given that these two technologies are not compatible with each other).

that equipment must be amortized over a five years. This value corresponds to the five-year period over which these elements can be depreciated according to legal tax schedules[160].

5.1.3 Scope of analysis

Plant upgrade

Similar to the qualitative discussion presented in Chapter 5, the ILEC is supposed to have already upgraded its plant (in the neighborhood under consideration) in order to make it suitable for DSL technologies. These plant upgrade expenditures did not necessarily concern all the locations: one important benefit of the DSL technology is that it can sometimes be deployed as a relatively easy and highly variable capital overlay to existing PSTN (Public Switched Telephone Network) copper plants. As explained in [McKinsey 2001, p.40], no plant upgrade costs will even be required in the easiest cases,[161] and only an incremental variable investment per central office and new customer is required. For the other cases, however, upgrading a legacy PSTN plant to make it suitable for providing DSL services requires the creation of remote terminals to serve lines that currently cannot carry DSL either because of loop length or non-DSL-compliant last generation remote terminals.[162]

Given our assumptions that these capital expenditures have already been engaged by the carrier for the considered area, and given the fact that such expenditures cannot be recovered (even in the case where the carrier would stop providing DSL services in a given area), they are "sunk" and thus should not intervene in any of the carrier's strategic decisions – which should be concerned only with series of future cash-flows. For this reason, these costs will not be accounted for in our model.

Costs of Access Points (APs)

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[160] [IRS946 pp.29-31] shows that all "computers and peripheral equipment" and "high technology telephone station equipment" (as well as most other high-technology equipments) have a 5-year recovery period.

[161] The DSL upgrade is the easiest in the following legacy environment: where the copper loops are short (i.e. less than 12,000-15,000 feet from the central office), "clean" (i.e. no legacy electronics such as load coils or bridged taps will deform the digital signals), and "naked" (i.e., the connection between the central office and the customer location is 100% copper and does not imply any remote terminal) – source: [McKinsey 2001, p.40].

[162] For a typical footprint, McKinsey estimates that 30% of the locations require addressability upgrade, which costs around $250 per upgraded location – source: [McKinsey 2001, p.69].

The costs of purchasing a wireless access point can also be regarded as costs of "plant upgrade" necessary before being able to provide broadband resale services. However, like the costs of "plant upgrade", these costs will not be regarded as incremental costs for the carrier, for two principal reasons. First, as already stated, these costs need to be engaged by the reseller *prior* to any acquisition of resale user; and once the reseller has purchased and installed his access point, the acquisition of an additional resale user will not generate any more cost related to the access point; therefore this cost does not qualify as an *incremental* cost. Second, our model assumes *distributed initiative*. It means (as explained in section 1.2) that it is the resellers who take the initiative to become resellers[163]; drawing on this first assumption, we can further assume that the costs falling to the carrier will be close to zero (since these resellers will take upon themselves most of the costs implied by the decision of becoming resellers[164]).

Considered costs

Table 10 presents the different categories of incremental costs implied with acquiring and servicing new customers, and that will be accounted for in the model:

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[163] As opposed to the carrier contacting some customers and asking them to install a wireless LAN so that neighbors can connect to it.

[164] Moreover, the customers who are the most prone to become resellers are likely to be the ones already owning a wireless access point (either of their personal usage, or because they had gotten committed into a wireless freenet), i.e. the ones for which the cost of becoming a reseller is the lowest.

Type of cost	Categories	Comments
CAPEX Customer Addition	• Loop conditioning • Line Card • DSLAM	• Costs incurred for net adds only • Thus not influenced by high churn rate
OPEX Customer Addition	• Marketing and acquisition • CPE • Provisioning (cross connection, testing, installation)	• One-time costs • Incurred for each gross add • Increases (on a per customer basis) when churn rate higher
Ongoing OPEX[165]	• Transport • Maintenance • Customer Service	• Incurred on a regular basis • Transport costs determined by average consumption of bandwidth at peak time. • Maintenance and customer service costs determined by the number of lines on service.

Table 10: Incremental costs for adding up a new customer via DSL

As can be seen on Table 10, the incremental costs implied for servicing an additional customer via DSL can be sorted into three categories:

1. ***Incremental Capital Expenditures (CAPEX) of Customer Addition* –** These one-time upfront expenditures represent the investment that the carrier needs to engage when he wants to serve an additional user. They mostly represent hardware equipments bought and installed at the central office in order to increase the capacity to serve a new user. Even if the customer leaves after a few months, the capital acquired thanks to these costs remains and can then be reused for servicing other customers. In other words, these costs are engaged only for each *net customer addition*.

2. ***Incremental Operating Expenditures (OPEX) of Customer Addition*** - These one-time upfront expenditures are also incurred upfront when an additional customer is acquired by the carrier, but contrary to the "CAPEX of customer addition" they do not translate into any tangible goods (such

[165] Note that a particular category of ongoing operating expenses has been excluded from the scope of this model: the overhead costs, which include the rent, utilities, insurance, taxes, as well as the cost of supervisory personnel. These ongoing operating expenses are *mostly* fixed costs – and our cost model will consider them as entirely fixed costs (as stated in section 5.1.2). This simplifying assumption amounts to assume that the addition of new customers hardly changes anything to the total amount of these costs, and has only the effect of sharing a given amount of these costs among more customers. In other words, we assume that the incremental overhead costs are nul, and therefore this category gets ignore in our model.

as hardware equipment[166]), and are therefore sunk as soon as they are engaged. For this reason these costs need to be engaged for each *gross customer addition*, no matter whether this addition happens concurrently to the leaving of another customer (because of churn). The churn rate will be a major determinant for these costs (assuming that at the equilibrium the number of customers for the carrier remains constant, each customer departure needs to be offset by the acquisition of another customer that will generate additional *incremental OPEX of customer addition*).

3. ***Ongoing Operating Expenditures (OPEX) -*** These expenditures are incurred on an ongoing basis to provide the broadband service to the customers.

5.2 Estimation of costs

For each cost category, we will provide 1) a documented estimate of the incremental cost for adding up a wireline user to the customer base, 2) an assessment of how the cost would translate for resale users at the minimum, and 3) an assessment of how the cost would translate for resale users at the maximum. These two bounds should not be understood as values for different scenarios. To the contrary, they relate to the same scenario (that we sometimes call the "optimal strategy" followed by the carrier). They account for the uncertainty intrinsic to a prospective analysis such as this cost modeling of resale users; wide apart bounds will tell that we did not deem the available data were sufficient for us to make a more precise assumption, while close bounds tell that we are confident about our estimates of the costs. Because these bounds correspond to uncertainty and not to scenarios, regarding all the lower bounds of the ranges for costs will give us the smallest incremental costs of adding and servicing a resale user that we regard as plausible. Adding up all the higher bounds will give the highest total costs that we regard as plausible.

If the cost analysis of wireline users can often be precisely performed as there is plenty of information publicly available, the same cannot be said of the costs generated by resale users, mostly because of the prospective nature of the exercise. In order to account for the uncertainty implied by this analysis, we will often provide a range of possible values rather than a single value.

[166] We are including the Customer Premise Equipment (CPE) into these expenditures (as was done in [McKinsey 2001]), because we assume that the customers eventually own this device, even if the carrier initially paid for it. This question will be discussed in greater details later.

Table 11 and Table 12 below summarize our estimates of the incremental costs implied by the acquisition and provision of broadband services to an additional wireline and an additional resale user. Note that the costs presented in these two tables are not directly comparable, since the upfront costs are incurred only once (before starting to provide service to the customer), whereas the operating costs in Table 12 are incurred every month, and result from the "normal" provision of service to these users. In the subsequent analysis of these results (in section 5.4), we will often refer to the costs in the "average scenario". These costs are simply estimated as the middle of the proposed range. The section following these two tables explains the cost elements and the derivation of their monetary value.

Upfront costs of customer addition (one-time costs)		Wireline	Resale		
			average	min	max
CAPEX	*DSLAM slot*	$80.0	$0.0	$0.0	$0.0
	Line Card	$200.0	$0.0	$0.0	$0.0
OPEX	*Marketing and acquisition*	$125.0	$42.5	$25.0	$60.0
	Provisioning	$120.0	$20.0	$10.0	$30.0
	Customer Premise Equipment	$150.0	$0.0	$0.0	$0.0
		$675	**$63**	**$35**	**$90**

Table 11: Summary of the one-time upfront costs of customer addition

Recurring Operating costs ($ / month)		Wireline	Resale		
			average	min	max
OPEX	*Transport*	$4.0	$2.2	$0.8	$3.6
	Customer Support	$8.0	$2.8	$1.6	$4.0
	Maintenance	$5.0	$0.0	$0.0	$0.0
		$17.0	**$5.0**	**$2.4**	**$7.6**

Table 12: Summary of the recurring operating costs ($/month)

5.2.1 CAPEX costs of customer addition

5.2.1.a DSL Access Multiplexers (DSLAM)

Modularity

The DSLAM is the central element for providing DSL services to a neighborhood, and one of its main cost elements. As described in the technical section about DSL (section 2.1.2.a), a DSLAM can be thought of as a device that consists of multiple ATU-Cs (ADSL Transmission Unit – Central Office, that can be though of as DSL modems) in a single chassis, and offering a dedicated point-to-point connection from the customer's location to the central office. The DSLAMs are configured to accept these multiple

DSL connections and consolidate them into a high-speed data link for access to Internet backbone of an upstream service provider.

The ATU-C is embedded in a line card in the DSLAM. DSLAMs, which can support the aggregation of hundreds of DSL connections, can also be linked together in the central office to provide for a higher density in larger populated central office locations. This modularity allows service providers to build and deploy DSLAMs for the individual requirements of each central office location[167].

Price

DSLAMs can be purchased in many sizes, with versions ranging from four ports to several hundreds of ports. Because the cost for manufacturing a DSLAM consists of a fixed part (relative to those elements in the DSLAM that do not need to be duplicated as the number of port increases) and an incremental cost for each additional port, the average cost per port decreases with bigger DSLAMs. This factor, combined with others (such as increased bargaining power for bigger customers) explains that the average price per DSLAM port is very sensitive to the size of the contract. As of this writing, DSLAMs are priced as follows (these are only ranges, since uncertainties and vagueness about the detailed sales conditions relative to training, installation, delivery, parts, special interfaces and other factors make exact comparisons impossible) [168]:

- $60 to $80 per port corresponds to the world's lowest prices, and are occasionally reached in contested bids for contracts over a million ports. Samsung gave that price to Chunghwa in Taiwan, and the prices negotiated by Yahoo!BB are estimated to be in the same range (see [Burstein 2002]).

- Prices in the range between $75 and $95 per port are typical in large contracts (for clients of the size of France Telecom).

- Lower volume buyers can obtain prices between $100 and $150 per port.

Model

[167] This paragraph draws on [Worms 2001a].

[168] Source: [Burstein 2002].

Only large-scale DSLAMs (i.e. with a number of ports in the order of 240) are assumed used in the ILEC's central office. Since our model takes the perspective of a large ILEC, we will assume a cost per DSLAM port equal to $80. As seen just above, this price corresponds to the lower end of the range of prices faced by a carrier like France Telecom. We should note that this price is incurred only for each ***net customer addition***. In other words, the DSLAM port attributed to a customer will not be lost when this customer will decide to churn. If the DSLAM did not reach the end of its lifetime, it can be reused.

Resale users

Given that resale users will have their traffic carried over a reseller's DSL line, no additional costs of DSLAM are required when a new resale user is acquired. From this point of view, resale would enable to share elements in the DSL architecture that are now dedicated.

	Wireline	Resale		Comment
		Min	Max	
DSLAM slot	$80	$0	$0	• These costs are incurred only for net adds • Thus will be smaller for gross adds • Evolution: will decrease as the acquired customers will replace churning customers

5.2.1.b Line Cards

The line card embeds the ATU-C (ADSL Transmission Unit – Central Office) that will dialog with the customer's DSL modem. It needs to be inserted into a free DSLAM slot and connected to the newly-acquired customer before this customer can be activated and broadband service can be provided to him. We assume that the carrier installs one line card per subscriber – even though some carriers sometimes install less line cards than there are customers to serve[169].

Searches on the Internet[170] return products priced around $250 per port[171], a value particularly stable across manufacturers. Given that our model takes the perspective of a large ILEC and our assumption that

[169] As explained in [McKinsey 2001], DSL usually requires dedicated line cards for each DSL subscriber. However, some low costs carriers sometimes install less line cards than there are customers – on the basis that the probability of all the customers connecting at the same time is unlikely: *"US West probably saves about $200 in network equipment by not dedicating a line card to each user, the precise amount being based upon the (undisclosed) oversubscription ratio."* ([DSL Prime]). However we will stick to the conservative assumption that the carrier installs one line card per customer.

[170] For instance on http://shopper.cnet.com

it can get an average 30% discount off list prices, the incremental price paid by the carrier for the line card comes close to $200 per card[172].

Again, and similar to what concerned DSLAM ports, one line card is required only for each *net* customer addition. In other words, if the lifetime of a line card is not over when a given customer leaves (because of churn), then the line card can be reused to serve another newly acquired customer. Therefore, the actual incremental cost per gross customer addition will be smaller htan $200 (see section 5.4.1 below to see how it impacts the results).

Resale users

Just as in the case of DSLAM slots, resale users' traffic will take the reseller's line, and therefore no additional line card purchase is necessary when a new resale user is acquired.

	Wireline	Resale		Comment
		Min	Max	
Line Card	$200	$0	$0	• These costs are incurred only for net adds • Cost for gross adds will be lower, especially in the future as the acquired customers will replace churning customers

5.2.2 OPEX costs of customer addition

5.2.2.a <u>Marketing and acquisition</u>

Customer acquisition costs are the marketing and advertising expenses needed to turn a prospective customer into an actual customer subscribing to the broadband service (see [Hamblen 2000]).

As is explained in chapter 2.1.1 the expansion of broadband services now becomes less hindered by a lack of available solutions (because the footprint of each technology is expanding) than by a lack of

[171] e.g. the Cisco 6015 Series Line Card is listed at a price of $237 per card.
[172] This value is consistent with the value provided in [DSL Prime], as well as [McKinsey 2001].

understanding[173] of the broadband value by potential customers: the issue shifted from supply to demand. While the first acquirers of broadband were technology-savvy users easy to convince, carriers will now have to deploy more effort to further expand their base of customers.

Since broadband is an experience good (see section 4.4.1.a), marketing and acquisition efforts are key to fuel the growth of the carrier's customer bases. Acquisition costs will typically come down to the two following major categories:

- The "push methods", which include the classical advertising channels (in written press, on TV or on the Internet) used to increase the customer's awareness of the product, as well as more targeted methods such as phone selling… In order to keep the costs low, advertising efforts need to be narrowly targeted, and should emphasize either a usage pattern or a consumer segment[174].

- The "pull methods", which consist of promotional offers or pricings[175] . For instance, in October 2001 Verizon introduced a promotional price of $29.95 for the first three months of DSL subscription, i.e. a discount of $20. Such move belongs to Verizon's customer acquisition strategy, and increases the acquisition costs by $60 per acquired customer (for the concerned plans).

Acquisition Costs

McKinsey evaluates the marketing and acquisition costs to be $125 per gross customer addition ([McKinsey 2001])., and this value is expected to rise in the next years because of a tougher competition between broadband solutions providers. We will use this value in our model, since it is the only monetary estimate of the acquisition costs faced by a DSL provider that we found. We can however note that this value compares well with the acquisition costs of cable TV, estimated at $150 per acquired customer[176],

[173] 59% of total dial-up customers still remain unclear on the price point at which they would subscribe to broadband services ([Gramaglia 2002]).

[174] For example, broadband ISP Speakeasy identifies four consumer segments – classic, gamers, system administrators, and home office workers – and targets different plans at each.

– see http://www.speakeasy.net/main.php?page=res_dsl

[175] For instance, in October 2001 Verizon introduced a promotional price of $29.95 for the first three months of DSL subscription, i.e. a discount of $20 – which increases the costs of acquisition by $60.

[176] See [Seibel 2002].

but remain much lower than the acquisition costs of many other companies in the telecommunications industry[177].

Resale users

This section discusses the question as to whether the carrier has to pay out more or less to acquire a resale user than to acquire a wireline user – this comparison will of course assume that in both cases (acquiring a resale user and acquiring a wireline user) the carrier uses the most effective – and cost efficient – methods available to him.

Acquiring a resale user is likely to involve a process very different from acquiring a wireline user. An example of possible process that can be used to acquire resale user may be as follows: the reseller first engages all the costs for acquiring a customer (one of these costs will be the time he dedicates to convincing his neighbors of the interest of broadband resale), and then gets compensated for (all or) part of them by the carrier when it leads to effective acquisitions of customers. Of course, this is only an example, and the optimal acquisition solutions may be more complex (it may for instance imply classical marketing techniques combined with work by the reseller *in the field*).

We expect the costs falling to the carrier for acquiring a resale user to be significantly lower than the corresponding costs for acquiring a wireline user, for the two following reasons: 1) The acquisition of resale users is very likely to give an important role to the resellers (as detailed in Table 13), and we regard this factor as *efficiency-enhancing*. The resellers have indeed a good *a priori* knowledge (acquaintances, knowledge of demographic data, income levels…) of the market they will target, since it is their very close neighborhood. This knowledge entails a great marketing value[178], and we expect it to increase the efficiency of the marketing methods deployed by the vertical structure (carrier and reseller), and therefore to decrease the marketing costs of acquisition. And 2) the marketing and acquisition costs will be shared between the carrier and the resellers – and the final cost eventually falling to the carrier should therefore be reduced, compared to the cost of acquiring a wireline user (when the carrier needs to take on all the acquisition costs).

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[177] For instance, in the mobile phone industry acquisition costs are much higher: $315 for Sprint PCS (for 4Q2001), $430 for Nextel (for 2Q2001), $335 for VoiceStream (for 1Q2001). In the Satellite TV industry, DirectTV announced a $550 acquisition cost per subscriber for 2001 (source: [Seibel 2002]).

[178] Since it enables to narrowly tailor the offer (in terms of quality and pricing notably) to match the local demand.

	Acquisition of wireline customer	Acquisition of resale customer
Acquiring agent	• Carrier	• Carrier + Reseller
Acquisition channels	• Large-scale advertising • Promotions, rebates	• Narrowly-tailored methods by the resellers acquaintances, door-to-door selling, signs on the street • Possibly large-scale advertising (depending on carrier's strategy)
Origin of acquisition costs to the carrier	• Cost of channel (TV, magazine ads) • Marketing department • Foregone revenues from promotions	• Incentive and compensation directed to the resellers (to encourage and compensate their efforts in marketing broadband resale services) • Possibly traditional marketing costs (depending on optimal strategy)
Cost per subscriber	• $125 to carrier	• Between $25 and $60 to carrier

Table 13: Differences between the acquisition processes for wireline and resale users

Assessing quantitatively 1) how more efficient acquisition processes will be for resale users than for wireline users, and 2) what share of the costs will fall to the carrier in the optimally[179] designed acquisition process is a speculative process subject to high uncertainty, that prevents us from giving a precise monetary value for the marketing costs of acquiring a resale user. Accounting for the discussion above (which tells us that these costs should be much lower for a resale user than for a wireline user), we will use in our model acquisition costs for resale users comprised in a range between 20% and 50% of the acquisition costs currently faced by DSL carriers to acquire wireline users – i.e. a value comprised between $25 and $60 per gross acquisition of resale user[180].

	Wireline	Resale		Comment
		Min	Max	
Customer acquisition	$125	$25	$60	• These costs are incurred for each gross add • These costs come on top of the costs supported by the reseller

[179] A crucial optimality issue relates to the optimal level of incentives / compensations that the carrier should promise to the carrier in order to encourage them in acquiring resale users.

[180] Note that these values are assumed to be the costs falling to the carrier, on top of the costs supported by the reseller.

5.2.2.b <u>Provisioning</u>

Provisioning refers to the end-to-end process of adding a customer—beginning with the customer's call to request service and ending with the service running. The main elements of the provisioning costs are the following:

- ***Loop testing,*** to assess the necessity of loop conditioning.

- ***Loop conditioning[181],*** necessary (when needed) to remove problematic loop electronics like load coils and bridged taps that block DSL signals on the loop. Conditioning is performed progressively on the plant, as an <u>optional</u> step in the provisioning process.

- ***Cross-connection***, a series of manual and automated steps necessary to configure the DSLAM and other core elements in the ILEC's Central Office, including the loop-by-loop changeover. This step is particularly labor-intensive.

- ***Installation,*** i.e. all the steps required at the customer premise to attach the customer to the broadband network and initiate service. The Holy Grail in the residential market has always been self-installation, since profitability improves when customers do the work. ILECs now achieve good self-installation rates with standard ADSL by simply studying customer behavior in trial settings, creating better instructions and automatic configuration software, and using simple in-line filters on the home's phones to eliminate the need for physical splitters[182].

Costs

According to McKinsey estimates ([McKinsey 2001, p.71]), in a typical area loop conditioning may be required for about 10% of the locations, and the costs per loop amount to $600[183]. Therefore, the average cost per loop of conditioning is $60. Testing and cross-connection amount to a $13 cost per loop, while

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[181] Note that loop conditioning correspond to an upgrade of the carrier's outside plant. As such, it could be considered as a capital expenditure. However, while capital expenditures usually need to be incurred only for each net add, loop conditioning expenditures need to be incurred for each gross add, since each loop is usable for only one location. For this reason, in this model we have classified the costs of loop conditioning as an upfront operating cost, like the rest of the provisioning expenses.

[182] To encourage customers to do it themselves, ILECs have used a wide range of tactics ranging from charging customers up to $200 for technician installs to promoting DSL through retail and computer manufacturer channels (source: [McKinsey 2001]).

[183] They estimate the conditioning to require 12 hour of work by a technician, and a cost per hour of $50.

installation amounts to an average $47 per loop[184]. Adding up the costs of all these elements we come up with an estimate of $120 for the cost of provisioning per gross wireline customer addition.

Resale

Given our assumption that resale users have no direct relationship with the carrier, the provisioning process will be very different for resale users. It will consist mostly of installation and testing – this latter element gaining importance in a wireless context. The reseller will most likely handle the provisioning process, by 1) installing and configuring the WLAN receptor antenna at the resale user's location, 2) configure his own Access Point so as to allow association with the end-user's WLAN receptor, 3) update his customer care softwares and databases (notably the software or database used to handle billing).

All the process will be more or less tedious (and hence costly) to the reseller depending on his skills, on the set of tools available to him to handle these functions, and on the resale user's ability to handle alone some of the required steps. We are here concerned by the costs of provisioning averaged over the population of resale users. We assess that in average it takes the reseller between one hour (when the end-user is skillful enough to handle most of the process over the phone, and possesses efficient resale management tools) and three hours (when the resellers need to go back and forth between his house and the end-user's) to completely configure and setup the system. Valuing the reseller's time at $20 per hour[185], our monetary estimates of the total provisioning costs is between $20 and $60 per resale-customer addition.

We now have a range of estimates for the provisioning costs incurred by the reseller. Similar to the acquisition costs, they will then be shared between the carrier and the reseller. Again, speculating about what the carriers will regard as the optimal solution is subject to great uncertainties. In our model, we will assume that the carrier equitably shares these costs with the resellers, and therefore that the incremental provisioning costs falling to the carrier when an additional resale user is acquired are in the range between $10 and $30 per gross acquisition. Note that we do not make any restrictive assumption about how the

[184] This estimate assumes that already 75% try the self-installation process. As even more customers go through self-installation, installation costs should drop further ([McKinsey 2001, p.71]).

[185] This valuation is lower than the hourly cost to the carrier of the technicians doing the conditioning work ($50). The reason is that on the one hand we are considering the cost of an hour of technician work to the carrier (which includes tax expenses, social security contribution…) while on the other hand we are concerned with the reseller's valuation of his own time. This difference is justified if one considers that the carrier can find ways to *indirectly* compensate the reseller, for instance by lowering his DSL subscription price.

carrier will engage these costs. A simple possibility may be that the carrier compensates the reseller afterwards for the time he dedicated to provisioning service to the resale user.

	Wireline	Resale		Comment
		Min	Max	
Provisioning	$120	$10	$30	• These costs are incurred for each gross add

5.2.2.c Customer Premise Equipment (CPE)

In the case of ADSL technology, the CPE corresponds to the subscriber's DSL modem. The CPE (at the customer's location) and the associated line card (at the ILEC's Central Office) engage in physical layer negotiations and transmissions.

Carriers can follow varied policies as regards their subscriber's DSL modem. Usually, if the subscriber accepts to commit to a sufficiently long time contract[186], the carrier pays for the CPE. However, even if the carrier contributed to financing (all or part of) the DSL modem, it usually belongs (or ends up belonging) to the subscriber (notably for obvious reasons of high inventory handling costs if old modems were to be returned to the carrier). As a consequence, the costs related to purchasing the DSL modem need to be incurred for each gross addition of customers – because most leaving customers take their DSL modem with them.

Cost

A DSL modem typically costs $200[187]. Given our assumption (see section 5.1.2 above) that the ILEC benefits from a 30% rebate off listed prices, and assuming that the carrier takes upon itself all this cost (as is usually the case), the DSL modem will cost around $140 to the carrier for each gross addition of wireline customer. Adding up $10 to account for the additional elements usually provided with the DSL modem to the customer (including the splitters, cables, installation software CD…) it comes up to a cost of $150 per gross customer addition. We will use this value for our cost model[188].

[186] This is for instance the case with Verizon's offers, as soon as the subscribers stay more than 12 months (details of their offer at http://www22.verizon.com/ForHomeDSL/channels/dsl/forhomedsl.asp).

[187] A search on http://shopper.cnet.com shows that the cheapest modems can be acquired for about $200. For example, a "Hotwire Reach DSL Modem 10BT 110V" (manufacterd by Paradyne Corp.) sells for a price comprised between $180 and $218, depending on the resellers.

[188] This cost relates well the estimate of $162 per gross customer addition, used in [McKinsey 2001, p.70].

Resale

Resale users do not need any DSL modem (since their traffic is handled by the reseller's modem). However, they need a WLAN receiver antenna[189] to be able to connect their computer to the reseller's wireless access point. We explained in section 5.1.2 above (concerning the additional assumptions specific to the cost modeling) that we do not consider the costs of these wireless cards as incremental costs falling to the carrier.

However, one of our assumptions is that WLAN technologies will very soon become ubiquitous (see section 1.5 about our general assumptions), so that all potential end-users will already own computers (or other types of devices) which are "wireless-enabled". In other words, we expect wireless cards to soon become standard devices as are Ethernet cards today. For this reason, we assume no incremental costs for the wireless CPE. Moreover, it would make very little sense for the carrier to subsidize these wireless devices, given our assumption that the carrier has no direct contact with the resale users.

	Wireline	Resale		Comment
		Min	Max	
CPE	$150	$0	$0	

5.2.3 OPEX recurring costs

5.2.3.a <u>Costs of transport</u>

Once the broadband carrier has aggregated the traffic from all his customers (at the DSLAM level), he needs to carry it upstream to the Internet. For this, the carrier will usually contract with one of the few long-haul carriers in the U.S. (such as Worldcom/UUnet, Sprint, Cable&Wireless, Equant). This long-haul carrier will take care of carrying the traffic from the broadband carrier's different Central Office locations, to an entry point into the Internet network: a Point of Presence (POP)[190].

The broadband carrier is usually charged depending upon the size of the pipeline linking its different COs to the POP. Even if actual pricing schemes may take complex forms, they usually roughly amount to

[189] They currently sell for about $90, and this price is forecasted to fall to less than $30 by 2007, as economies of scale and competition drive down prices (source: [Rolfe 2002]).

[190] To be more precise, the ILECs usually do their own interoffice transport (see [Fryxell, p.9] for more information about interoffice networks). Then this aggregated traffic is given to the upstream Internet carrier.

pricing depending on the peak traffic received from the COs by the long-haul carrier. Many contracts also stipulate a series of clauses specifying the guarantied quality of service in terms of latency, availability of service, setup-time, and the compensations the broadband carrier will receive in case these clauses are not fulfilled (these caveats are known as Service Level Agreements). For the purpose of our cost modeling, we cannot fully account for the complexity of these contracts between the broadband carriers and their upstream backhaul providers. In our modeling, we will assume that the complex pricing schemes described above are in the end tantamount to a fixed cost per peak megabyte per second.

Transport costs for wireline user

The price per peak megabyte per second for long-haul communications has been decreasing fast in the last two years, due to excesses of bandwidths in the US (see [Smetannikov 2002]), and backbone carriers have lowered prices beyond levels imaginable just a year ago. For example, very low cost operators like Cogent have even plans charging $30 per Mbps (with volume commitments) and “brand name” service providers can sell connections for about $55 per Mbps. These price drops also affect higher-speed pipes: an OC-3 pipe that would have been priced at $125 per Mbps two years ago now goes for $40 to $80 per Mbps[191] ([Smetannikov 2002]). For the sake of robustness, we will use the higher end of this range (i.e. $80 per peak Mbps) as input for our cost model.

In order to evaluate how these costs translate on a per user basis, we need to evaluate the ratio between the upstream pipeline provisioned by the carrier and the number of customers using this pipeline on the downstream side. This information is not publicly available, and we have to estimate it.

For doing so, we will consider a very simple framework, with homogeneous users, and the parameters described in Table 14. We should however note that there is uncertainty in these numbers.

Item	Value	Comments and sources
Busy hour ratio (% users active at peak)	50%	[Dutta-Roy 1999]
Bandwidth/user	100 kbps	Estimate of residential consumption in [McKnight 2001]

Table 14: Value of parameters used to evaluate the costs of transport per user

[191] This evolution is partially due to the new competition from companies that have emerged from (or are still in) Chapter 11.

Note that the bandwidth per user is an average value, and does not imply that the needed throughput is constant; at some times of the busy period, a given user will generate some higher throughput bursts, while at other times it will not generate any traffic – the assumed value of 100 kbps is an average over the duration of the peak period. Given that the traffic of hundreds of DSL consumers is aggregated at the DSLAM level, the variations will be leveled out (because of the statistical law of large numbers), and our analysis does not need to take this variability of individual traffic patterns into account.

Average needs for bandwidth per customer		100	Kbps
x Probability that one consumer is connected at peak time		50%	
= Average needs for bandwidth per consumer during peak time		**50**	Kbps
x Monthly cost per kilobit per second for the upstream link ($80/Mbps)	$	0.08	
= Average monthly cost of transport per customer	**$**	**4.00**	

Using this simple framework, we find that at current low market prices for bandwidth, the operating costs of transport are $4 per month and per user. This value is substantially lower than the value of $7 per user per month estimated in [McKinsey 2001] one-and-a-half year ago, and the deviation can be explained by the recent sharp declines of the costs of bandwidth.

Transport costs for resale users

In order to assess how transport costs translate for resale users, we will first assume that resale users have the same average peak needs for bandwidth as wireline users, and qualitatively discuss the effects determining the transport costs for resale users in this particular situation. Subsequently we will then relax this assumption, and describe how we quantitatively came up to a range of estimates for the transport costs generated by resale users.

As we saw in the previous section, the average[192] needs for bandwidth at peak time for a connected wireline user is of the order of 100 Kbps. Given that a DSL connection typically permits peak download speeds of 400 Kbps[193], we see that the last mile link is usually not used at its highest capacity. For this reason, we could say that given these values, the DSL link could theoretically support 4 average users at

[192] This value corresponds to their average needs during a several-minutes period.

[193] This assumed value belongs to the range for the “typical speed available downstream” estimated by McKinsey (see section 2.1.3.b and [McKinsey 2001, p.37] for more details). Note that it accounts for “average congestion” occurring at the DSLAM at peak time.

any peak period (either wireline or resale user, given the holding assumption that they have similar traffic patterns).

Given our estimate that each user connects at only 50% of the busy periods (see Table 14 above), one may be tempted to conclude that in average under the described conditions, one DSL line can support 8 users without any difficulty. This is false however, because it is unlikely that *exactly* 4 of these 8 users are connected at each busy period: there may be some peak periods where only 3 users get online, and other peak periods where as many as 5 users try to get online[194]. In the latter situation, the average peak demand will amount to 700 Kbps, and congestion will occur at the level of the DSL modem, since it is above the 500 Kbps of available bandwidth[195]. We see in this simple example that if the reseller provides service to 10 resale users, congestion will occur each time 6, 7 … or 10 users try to connect at the same time (i.e. congestion will occur in 38% of the times, as can be calculated with the binomial law). Each time congestion happens, the link's capacity (400 Kbps under our hypothesis) will be shared among the number of users who tried to connect.

Congestion appearing at the level of the carrier's DSL modem is very important for assessing the costs of transport generated by the resale users. The reason is that when congestion occurs, some traffic is clipped at the level of the reseller's DSL modem, and therefore does not translate into upstream traffic. In other word, none of the "congested" traffic (i.e. the traffic clipped because of congestion) will generate costs for the carrier.

The principle of our model to analyze the cost of transport generated by resale users is actually perfectly illustrated by the example describe two paragraphs before. We basically applied the same reasoning to several sets of assumptions concerning the demand of resale users for average peak bandwidth. Our model takes the parameters presented in Table 15 as inputs.

[194] The probabilities are given by a binomial law. For instance, the probability of having exactly 4 persons out of 8 connecting is 27%. The probability of having 3 persons is 22%, while the probability of having 7 persons is 3%.

[195] This effect comes from the fact that in the broadband resale model, the traffic from relatively small numbers of users is aggregated by the wireless access point (and sent to the DSL modem). Because of the law of large numbers, no such statistical phenomenon happens with larger aggregation. For instance, if a DSLAM aggregates the traffic of 300 users, and each user needs in average 50 Kbps per busy period (same assumptions as above), the carrier should provision 1500 Mbps (not more) of upstream bandwidth for these users.

Item	Value	Comments and sources
Busy hour ratio for wireline & resale user (% users active at peak)	50%	[Dutta-Roy 1999]
Average need of peak bandwidth per user for wireline users	100 Kbps	Estimate of residential consumption in [McKnight 2001]
Average need of peak bandwidth per user for resale users	20% – 100% of the needs of wireline users	Broadband resale is expected to appeal to users with a lower valuation for connection speed (see section 4.4.2), and therefore we expect them to need less bandwidth (otherwise they would subscribe to higher quality and more expensive wireline broadband)
DSL line peak bandwidth	400 Kbps	See footnote 193 on page 102
Number of resale users served per reseller	8 resale users per served per reseller	See explanations in Table 16 below. Note that our model implies that at any peak period only 50% of these users are online (4 resale users). Note that by assuming such a low number or resale users is a robust assumption, and ensures that we will not overestimate the effects of congestion.
Cost of upstream bandwidth	$0.08 per Kbps	See discussion in beginning of section 5.2.3.a

Table 15: Assumptions holding for modeling the transport costs for resale user

Table 16 below shows the reasoning and the assumptions that were used to estimate the number of resale users per reseller. Note that we assumed a 10% penetration rate of the resold broadband services in the neighborhood of each reseller.

Item	Value	Comments and sources
Density in the area	25000 inhabitant per square kilometer	This value is typical of dense areas such as Boston, New York City, San Francisco, Chicago[196].
Range of AP (802.11b)	45 meters	Typical range for communications at 11 Mbps (See section 2.2.2.g).
Nb persons per households	2	Assumed
Nb households in reach of each AP	79	Calculated with above inputs
Average %age of households subscribing to resale broadband	10%	Hypothesis
<u>RESULT:</u> **Average number of resale users served per reseller**	***8 resale users served per reseller***	Note that at a given peak time, our model assumes that only 50% of these users are connected *in average*, i.e. 4 users (see Table 15). This value is much lower than the "maximum recommended" number of wireless users per AP (20-30 users – see section 2.2.2.h)

[196] See http://www.demographia.com/db-hyperdense.htm

Table 16: Estimation of the number of resale users per reseller

Our model calculates the available bandwidth per resale user for several values of these users' needs of average peak bandwidth. As shown and explained in Table 15 above, we will consider needs going from 20 Kbps (if resale users happen to be "light" users with low needs for bandwidth) to 100 Kbps (if resale users have needs identical to the needs of wireline users). Given our analysis of resold broadband described in section 4.4.2, we do not consider plausible that resale users have higher needs for average peak bandwidth than wireline users, hence the upper considered limit of 100 Kbps.

The results of our model are shown on Figure 10 below.

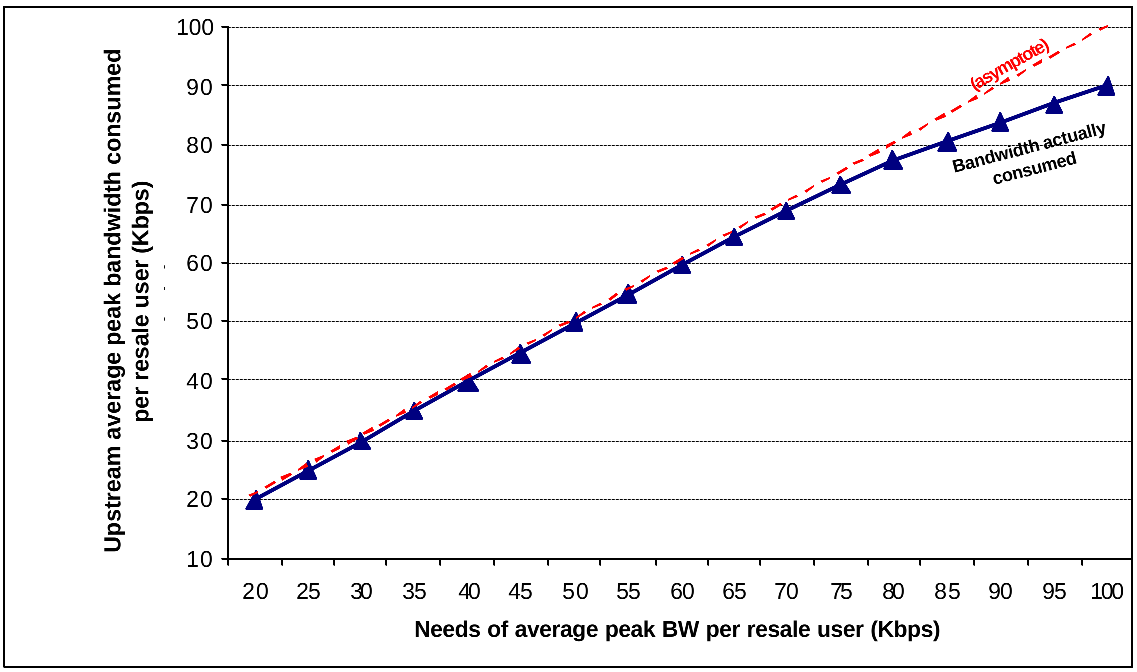

Figure 10: Outputs of our modeling of upstream bandwidth consumed by resale users[197]

This graph is interesting to two counts:

[197] Note that these values correspond to the users' needs for average peak bandwidth *when they connect*. In other words, it does not account for the fact that each user connects at only 50% of the peak times. This factor will need to be taken into account when it comes to the costs.

1. It shows that if the resale users appear to have low needs for average peak bandwidths, then they will be able to benefit from as much bandwidth as they want, because the reseller's DSL line is sufficient to carry the traffic of the 8 users served by the resellers.

2. If the demand of resale users for bandwidth increases a lot (and comes closer to the demand of wireline users for bandwidth), then congestion starts appearing at the level of the reseller's DSL modem, as he average aggregated needs for bandwidth come closer from the available bandwidth[198]. Because of this congestion, all the "expectations" of resale users in terms of average bandwidth at peak periods do not translate into traffic arriving at the carrier's DSLAM (and hence do not translate into costs for the carrier).

To sum up, it turns out from our modeling that if we assume that the resale users have needs for bandwidth comprised between 20% and 100% of the needs of a wireline user, then (under our assumptions[199]) they will generate traffic comprise between 20% and 91% as much traffic as an average wireline user[200]. The reason is that for resale users having great needs for bandwidth, congestion will occur on the reseller's DSL line, and some traffic from resale will be clipped at that level. Therefore, this traffic will not totally translate into upstream traffic, nor into costs to the carrier. Our final assumptions about the cost of transport are shown in the following table:

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[198] One can note on the figure that congestion starts occurring *before* the average aggregated needs (from the average four people connected at each peak time) become greater than the link's capacity (here 400 Kbps). This comes from the statistical effect mentioned before.

[199] We should mention that we have been careful not to underestimate the cost of transport for traffic from resale users, by choosing robust assumptions. Notably, our assumption of 8 resale users (which translate into 4 resale users at each peak period, in average) served by each reseller is voluntarily low. If the resellers serve more resale users, then much more congestion will occur at the DSL modem's level, and the costs of transport from each resale user will be lower.

[200] Note that these values may be underestimated because of the overhead of contention algorithms (for instance, 100 Kbps of bandwidth shared between two users will probably give *less* than 50 Kbps of traffic to each of them, because of this overhead), that we did not account for.

	Wireline	Resale		Comment
		Min	Max	
Transport	$4 per month	$0.8 per month	$3.64 per month	• These low costs assume that the carrier pays $80 per Mbps on the upstream link • They assume that resale users have equal or lower needs for bandwidth than wireline users • Because of congestion at the level of the DSL modem, some traffic from resale users is clipped and therefore does not translate into costs for the carrier • We assessed this congestion at 9% (cf model above), i.e. 9% of the traffic emitted by the resale users will be clipped because of congestion, if resale users have same traffic pattern as wireline users

5.2.3.b Customer support

Customer support is an area of increasing strategic value for broadband carriers. Technical support creates customer satisfaction and loyalty, and its quality therefore impacts the churn rate of the carrier's customers – one of the main determinants of the carrier's profitability.

The best customer or technical support consists of real-time conversations between end-users and knowledgeable representatives for the reseller or vendor, and the availability of such representatives without long waits. Technical support may also be available via e-mail, a solution that may be much more cost-efficient.

Cost for wireline users

Because technical support is very labor intensive, it is extremely expensive to provide to the clientele. For this reason, most carriers encourage technical support through the more inexpensive channels of e-mail and instant messaging technologies. Since technician and operators' wages correspond to by far the largest cost category in call center, these costs can be said to be variable, and we do not expect great economies of scale to appear (basically, twice as many customers imply twice as many calls received and therefore twice as many operators to handle these costs).

In a survey of the costs of customer support (launched by supportindustry.com[201] and Help Desk 2000), the average cost per call appeared to be around $25 for 75% of the support organizations they surveyed. The analysts also expected this cost to fall to $18 per call within three years as a result of e-support technologies[202]. Assuming that wireline customers resort in average four times per year to the carrier's customer services, the costs per customer will amount to $100 per customer per year, or around $8 per customer per month[203].

Cost for resale users

Resale users may induce costs of customer support in two ways:

- **Direct:** they will first generate costs if they call the customer support hotline themselves, and ask for help – provided that the carrier accepts to provide support to resale users (see discussion below).

- **Indirect:** They will also generate indirect costs of customer support via the reseller. Indeed, since the resellers will be faced with more technical issues than classical wireline customers (how to connect the DSL modem to the access point, how to configure it…), they are likely to resort more often to the carrier's hotline than traditional wireline customers. These costs were induced by resale, and will therefore be attributed to resale users – even though it is the reseller (a wireline user) who calls the hotline.

Just as we expect the resellers to help the carrier to acquire resale users by enabling to establish more efficient processes and by bearing some of the costs, we expect the resellers to lower the overall burden of customer support for the carrier: because they live very close to the resale users (and therefore know well the "local conditions", which could for instance influence the quality of transmissions), and because they have performed themselves the provisioning process for these users (the configuration of their computer), we expect the resellers to be able to provide more efficient support to the resale users. In a sense, the possibility to use the reseller as customer support agent more efficient than other agents will lower the overall costs of providing customer support to the end-users. Then, the reseller will take on a part of this cost, while another part will fall to the carrier (again, we will not try to figure out what the optimal

[201] http://www.supportindustry.com

[202] Results cited in *Call Center Management Review*, November 2000 (see http://www.ccmreview.com).

[203] This estimate agrees well the value of $8 per customer per month used in [McKinsey 2001, p.70].

repartition is), and therefore the cost to the carrier of customer support will be much smaller with resale users than with wireline users.

Precisely assessing the extent of how these costs will be reduced is a very speculative exercise. Rather than entering into a questionable attempt to model these costs, we acknowledge the high uncertainty hanging over the value of these costs, and will provide a large range of estimates. As we emphasized, the presence of a reseller between the carrier and the resale end-users has similar effects with the costs of customer support and the costs of customer acquisition (see section 5.2.2.a above). For this reason, we assume that the costs for resale users will relate to the costs for wireline user in a similar way, i.e. that the cost of customer support for resale users will be comprised between 20% and 50% of these costs for wireline users. Therefore, our model's input concerning customer support will be the range between $1.6 and $4 per resale user and per month.

	Wireline	Resale		Comment
		Min	Max	
Customer support	$8 per month	$1.6 per month	$4 per month	

5.2.3.c <u>Maintenance</u>

DSL providers face significant traffic engineering and troubleshooting challenges. Repairs in the Central Office or on the outside plants (notably after bad weather conditions) are estimated to amount to $5 per customer and per month in 2001 ([McKinsey 2001, p.71]).

These maintenance costs are determined by the total number of DSL lines in use. Again because the traffic of resale users is carried over the DSL line of a reseller, broadband resale will not translate into higher maintenance costs for the carrier, and therefore the incremental maintenance cost for resale users is zero.

	Wireline	Resale		Comment
		Min	Max	
Maintenance	$5 per month	$0 per month	$0 per month	

5.3 Estimate of churn rate

5.3.1.a Importance of low customer churn

For a carrier, churn is a crucial parameter: by giving the average lifetime of the customers (higher churn rate meaning shorter lifetime), the churn rate tells how fast the carrier needs to recoup his fixed upfront costs if he wants to be profitable.

Customers of wireline broadband may churn for many reasons, for instance if they find the service too expensive, the quality of customer service too bad, or if they move house[204]. The carriers need to thoroughly investigate the reasons for their customers churn and address them very quick, given how crucial a low churn rate is for their profitability. Reducing the churn – or increasing the customer's "stickiness" – is often achievable via very classical means. For instance, reducing prices, increasing the quality of customer services, or increasing the quality of the service provided may be moves efficiently reducing the customer's churn – but they are often costly.

5.3.1.b Estimates for wireline users

McKinsey estimates that the churn rate was around 1.7% per month in 2001 for wireline users in the broadband industry. This value is much smaller than the churn rates of customers of wireless services (the churn rate is 3.08% for ATT Wireless users, 3.83% for VoiceStream users, and 2.58% for Sprint users – see [Entner 2002]), because the broadband market is still less competitive than the mobile phone market (in terms of number of competitors, and of the marketing efforts they deploy)[205].

[204] No public survey about the causes for churn in the wireline broadband industry was found. However, Gartner Dataquest provides an insightful analysis of the churn in the mobile telecom industry ([Hart 2002]).

[205] However, as competition increases in the next years on the broadband market, McKinsey expects the churn rate to rise to 2.2% by 2005 (in other words, the estimated average customer life is expected to drop from around 5 years to 3.5 years by 2005) – source: [McKinsey 2001, p.77].

5.3.1.c Estimates for resale users

Before being able to come up with an estimate of the expected churn rate of resale users, we need to better precise what we the notion of churn entails. Because if its meaning was obvious in the case of wireline users, it becomes much more intricate when applied to resale users. A resale user may put an end to his relationship with his reseller principally in three situations:

1. The resale user switches to another reseller (assumed to be linked to the same carrier, since we do not consider several broadband providers engaging into resale). Given that we take the perspective of the carrier, we will not consider the first situation as churn; this perspective implies that the switching costs are negligible (for instance because the resale user will have learnt form his first resale experience how to configure his computer), and that after switching the customer "goes on" with his customer life. In other words, we would consider this switching of reseller in the middle of the resale user's customer life as having very negligible impacts from the carrier's perspective.

2. The resale user switches to wireline services provided by the same carrier (see section 6.2.3 below for more details). This may be a lucky event for the carrier, if wireline users are more profitable than resale user, and therefore we do not want to consider this event as churn. We actually contend that our quantitative modeling does not account for that kind of conversion (even though it is described in section 6.2.3). If an extension to our model were to be built and account for these conversions, for each resale user "converted" to wireline broadband the model should consider both the incremental revenues from this conversion (i.e. the profits from wireline users) as well as the incremental opportunity cost from this conversion (i.e. the foregone cash-flows from the resale user).

3. The resale user cuts off any kind of relationship (direct and indirect) with the carrier. This situation is the only one that we will consider as churn in our further discussions and analysis. It will for instance happen when the resale user moves house to another region, or when he decides to switch back to dialup connection. This category is the most similar one to what "churn" means when applied to wireline users.

To estimate a range of values for the churn rate (defined as in point 3 above) that we consider as the most plausible, we will rely on the following observations: 1) the resale users have a lower interest for broadband (this contention comes from the fact that we expect resold broadband to be cheap and low-quality alternative to wireline broadband; therefore) than wireline users; 2) because the resellers do not have the same requirements as broadband carriers to recoup large upfront investment, we do not expect the resellers to make every possible effort to keep the churn rate of their resale users as low as the churn rates displayed by wireline users; 3) it may happen that the resale users are *forced* to churn, for instance if the resellers decides to stop providing broadband resale, or simply to churn.

For these three reasons, we expect the churn rate of resale users to be greater than the churn rate of wireline users. In the modeling, we will consider a churn rate of resale users comprised between 1.7% (the churn rate for wireline users) and 3.4% per month (twice the churn rate of wireline users), in order to account for the uncertainty about these parameter.

5.4 Analysis of results

This section is divided into two parts: the first part aims at reprocessing the cost estimates from section 5.2 above so as to enable their comparison. Then, the second part will compute the net present value of acquiring a wireline and a resale user, interpret the results and analyze their sensitivity to the principal parameters.

5.4.1 Processing of the costs

Section 5.2 above provides us with three different categories of costs that are not comparable together: some cost categories are incurred once for the *net* additions of customer only (the CAPEX costs of customer addition); some other cost categories are incurred once for each *gross* customer addition (the OPEX costs of customer addition); and a third category of costs is incurred on a regular and recurring basis, every month, for all the customers (the OPEX recurring costs).

As we already explained in section 5.1.1 about the chapter's perspective, we are interested with the costs per *gross* acquisition of customer, i.e. the cost that *each* added customer will generate for the carrier *in average* (some of these additions will generate more expenditures by the carrier than others, notably the ones which result in a net increase of the size of the customer base, because they require the carrier to purchase and dedicate to them a new DSLAM slot and a new line card; however, nothing intrinsically distinguishes these more expensive net additions from the other cheaper additions).

The OPEX costs of customer addition do not need to be reprocessed since they are already expressed as costs "per gross customer addition".

The CAPEX costs of customer addition do need to be transformed from a “per net addition” to a “per gross addition” basis. The process is simple, and will be illustrated with the example of line cards. We already saw in section 5.1.2 above (concerning the additional assumptions holding for this chapter) that we expect electronic equipments to have a 5-year lifetime. We also saw (in section 5.3 that wireline users have a churn rate equal to 1.7% per month, which is equivalent to say that in average the wireline customers stay 59 months – or 4.9 years – before churning. Therefore it appears that each line card purchased will in average be used to provide service to one customer[206].

As for the recurring OPEX costs, they also need to be reprocessed. The reason is that these costs are incurred on a recurring basis every month over the customer’s lifetime, and as such cannot be directly compared to one-time costs happening at time zero. We need to discount all these costs back to time zero (see [Brealey Myers 2000] for details about discounting methods), to account for the fact that costs distant in the future are less “harmful” than costs occurring upfront. And similarly, revenues occurring early are worth more than identical revenues occurring in the far future, because of the time-value of money (basically, if I have $1 earlier I will be able to invest it and therefore to get more than $1 later). In order to account for it, we need to calculate the net present value of the future cash-flows. The discount-rate (or cost of capital) we use will be 10%[207]. Discounting the recurring costs generated by the customers back to the present time enables to come up with the Present Value (PV) of these recurring costs – a figure that is comparable (and can be added) to the upfront costs per gross add. Note that these recurring costs are discounted over the customer’s lifetime, inferred from our estimates of the churn rate – hence the great importance of this factor, discussed in section 5.3.

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[206] Note however that this is an average value. For customers churning after only two years, these equipments will be reused for other customers. To the contrary, our model assumes that those equipments will need to be changed during the lifetime of the customers who stay more than 5 years.

[207] Discount rate used by McKinsey in [McKinsey 2001].

PV of Costs per gross customer addition		Wireline user	Resale user average	Resale user min	Resale user max
	Customer addition				
CAPEX	*DSLAM slot*	$78.4	$0.0	$0.0	$0.0
	Line Card	$196.1	$0.0	$0.0	$0.0
OPEX	*Marketing and acquisition*	$125.0	$42.5	$25.0	$60.0
	Provisioning	$120.0	$20.0	$10.0	$30.0
	Customer Premise Equipment	$150.0	$0.0	$0.0	$0.0
	Ongoing				
OPEX	*Transport*	$187.2	$74.5	$26.8	$122.2
	Customer Support	$374.5	$94.0	$53.7	$134.2
	Maintenance	$234.0	$0.0	$0.0	$0.0
	TOTAL	**$1,465**	**$231**	**$116**	**$346**

	Wireline user	Resale user
Monthly Churn rate used	1.7%	2.6%
Yearly churn rate	20%	31%
Average customer life (years)	4.9	3.3

Table 17: Present value of different cost categories for a wireline and a resale user

Table 17 just above shows how the costs of Table 11 and Table 12 translate when they are reprocessed as explained above. All the costs of Table 17 are comparable – they correspond to upfront costs per gross customer addition – and therefore can be added together. The column called "average" corresponds to our medium estimates of the incremental costs generated by the resale users. They are simply calculated as the middle of the uncertainty ranges assessed for each cost category in the preceding sections.

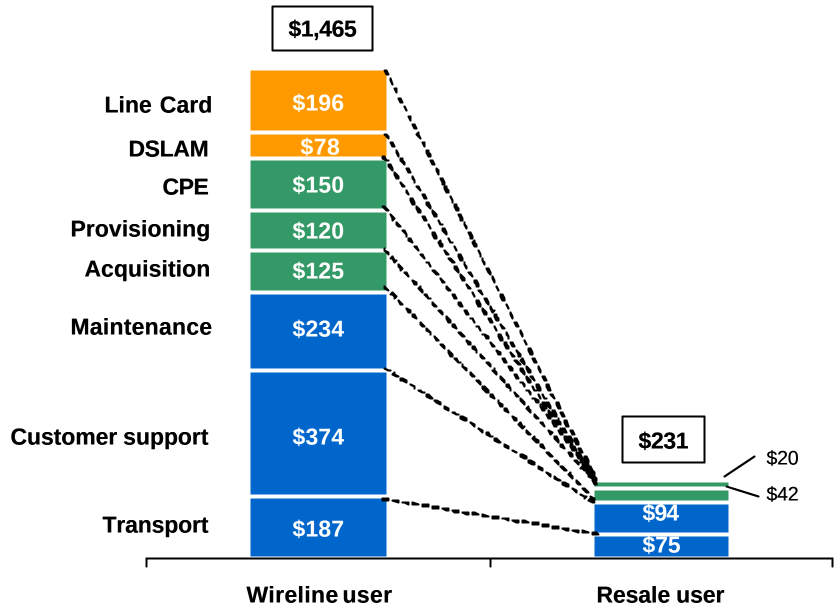

Figure 11: Present value of incremental costs to the carrier for addition of a wireline user and a resale user[208]

Figure 11 just above is a graphical representation of the results (for the resale user, our average estimates have been represented). Table 17 and Figure 11 show well how much wireline and resale users differ in terms of costs to the carrier: the present value of the costs generated by a wireline users is comprise between 4 and 12 times the present value of the costs generated by a resale user (6 times in the average scenario). Therefore, this analysis confirms our previous perception that resale users would represent a category of "low-cost users". Even if it is true that the carrier will probably be able to capture less value from each resale user than from each wireline user (see our discussion in section 5.4.3 below), these first results tend to indicate that only small revenues captured from resale users would be sufficient to make a resale user attractive.

5.4.2 Sensitivity analysis to the costs of transport

We saw from last section that one of the major incremental costs categories for the resale user consists in the costs of transport. In this section, we will analyze the sensitivity of the overalls cost of a resale user

[208] For the resale user, the average estimates (from Table 17) were used, as well as an assumed churn rate of 2.6% per month.

(the present value of the cost series) to the average peak bandwidth expected by the resale users when they are online (i.e. in 50% of the peak periods). All the assumptions presented in section 5.2.3.a still hold for this sensitivity analysis.

We will use the average estimates as our "base scenario" for this sensitivity analysis. In this base estimate, each resale users is expected to be in need of 60 Kbps average bandwidth when they are connected at peak periods. As was shown on Figure 10 (page 105), these needs will not generate congestion and translate into a "consumption" of 60 Kbps upstream bandwidth. Accounting for the fact that resale users gets online only for half of the peak periods, each resale user will generate 30 Kbps per peak period in average, which amounts to an average cost of $2.4 per month.

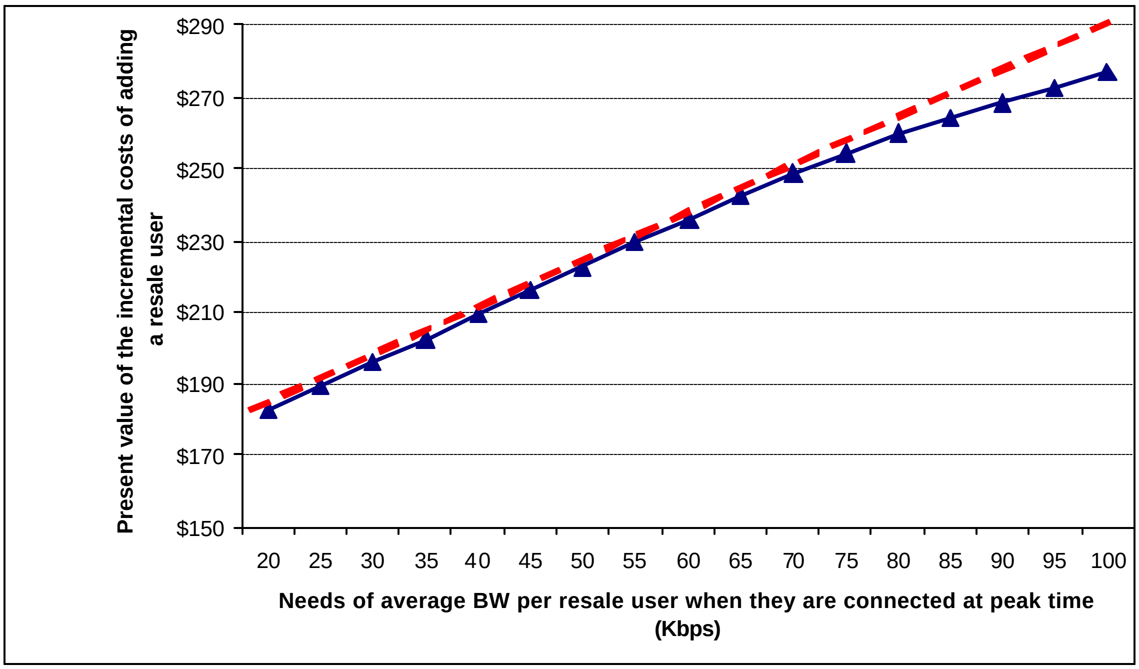

Figure 12: Sensitivity of the PV of incremental costs to the needs for peak average bandwidth of the resale users

Figure 12 above shows the results of our sensitivity analysis. It shows that if resale users are by nature small consumers of bandwidth and need only 20 Kbps of peak average bandwidth, then the discounted incremental costs for adding a resale user are as low as $180. From that point, these discounted incremental costs will first increase linearly as the needs of resale users for bandwidth increase. However, when these needs increase too much (i.e. above needs of 70 Kbps), congestion will appear at the level of the reseller's DSL line, and the resale users will not be able to benefit from as much bandwidth as they wanted to. From that point on, we see on Figure 12 that the linear relationship between the present value of the total costs and the needs of resale users for bandwidth ends, because of congestion appearing. If resale users have exactly the same demand for bandwidth than wireline users, then each resale user will generate a present value of costs equal to $275.

Even if we expect the resale users to have needs for bandwidth *at most* equal to the needs of traditional wireline users, we will end this sensitivity analysis by a look at what happens if we broaden the range of variations for the needs of resale users to values higher than the typical needs of a wireline user. As shown on Figure 13 below, the incremental costs incurred by the carrier become almost independent from the needs for bandwidth of resale users – when these needs become too high.

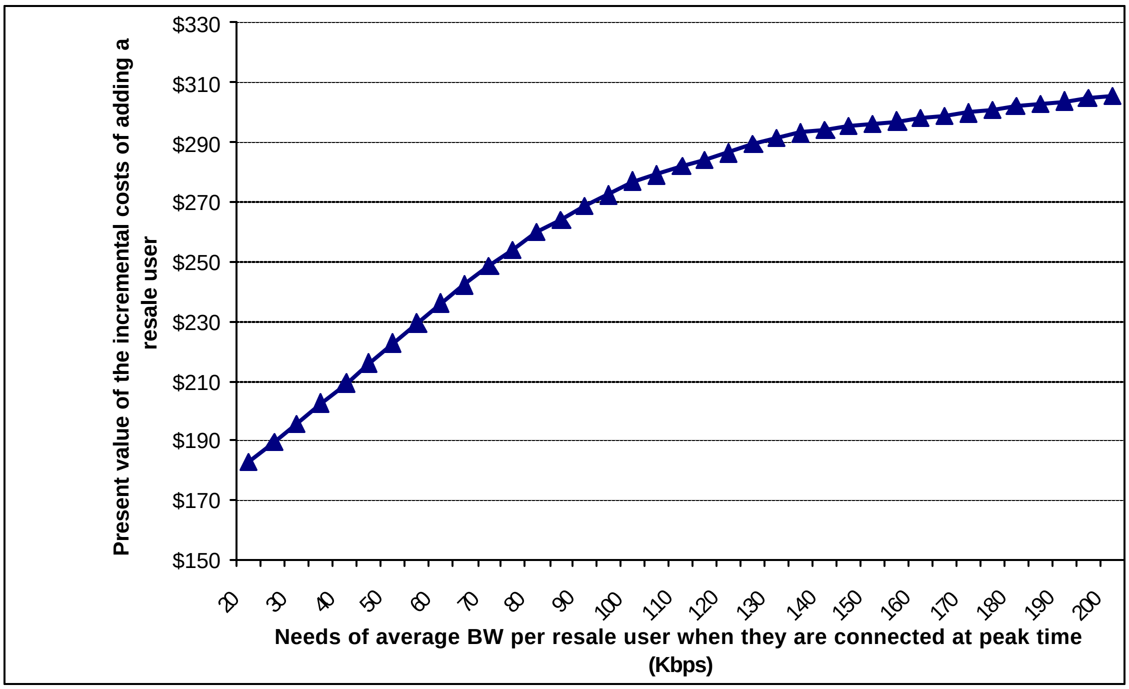

Figure 13: Sensitivity of the PV of incremental costs to the needs for peak average bandwidth of the resale users (expanded variation range)

5.4.3 Average monthly revenue from resale users

Until now, Chapter 5 focused on analyzing the incremental costs that the acquisition and servicing of a resale user will imply for the carrier. As we saw, it is possible to investigate these costs in details, by relying on data about the structure of costs born by the DSL carrier when it acquires a new wireline user.

However, such a quantitative analysis is not possible on the revenues side, and we will therefore consider a very large range of "possible" revenues in our break-even analysis.

5.4.3.a <u>Sources of revenues from broadband resale</u>

If the carrier had no possibilities to get extra revenues from broadband resale in order to offset the costs we identified, then the question of whether broadband resale is interesting for the carrier would have an immediate answer. However, this section will detailed a few scenarios showing that broadband resale represent a potential source of new revenues for the carrier.

A first observation is that even if the carrier does not follow any specific "optimal" strategy to increase its revenues from resale, it will still see incremental revenues as indirect consequences from broadband resale, since broadband resale is likely to increase the profitability of most resellers' DSL line.

Indirect benefits from resale

We showed in section 5.2.3.a above about the cost of transport that in some cases (whose frequency depends on the average number of resale users served by each reseller and the traffic pattern of these resellers) congestion will occur at the level of the carrier's DSL modem. The reseller (and her family members) will suffer from this congestion on two counts at least: first, this congestion will degrade her own online experience; and second, the congestion will irritate the resale users, leading some of them to stop using resold broadband and paying the reseller for this service. Given that on the other hand broadband resale will increase the reseller's income, one can reasonably expect many resellers to "reinvest" a part of their incremental incomes from resale into "boosting" their DSL connection – by subscribing to higher-end DSL packages with greater promised peak bandwidth. As a result, in average the carrier will charge higher[209] monthly subscription fees to the resellers than to their other traditional wireline consumers. Providing higher-speed connections to the resellers will translate into incremental costs (notably the necessity to provision more upstream bandwidth for these users), but the increase in costs remains lower than the increase of revenues (wich may be around $10 per month, as shown in Appendix I). Therefore the return on investment (ROI) of the capital engaged in the resellers' lines will

[209] As shown in Appendix I, carriers typically charge $50 per month for a promised 768 Kbps peak download speed, and $60 for a claimed peak download speed of 1.5Mbps.

get increased, since greater ongoing cash-flows (recurring revenues minus recurring costs) will be generated without the need for the carrier to engage additional capital expenditures.

Besides increasing the resellers' willingness to pay for their DSL connection, broadband resale is also likely to reduce the churn of the resellers, because their resale activity "amplifies" their switching costs. For instance, if churning implies foregoing any connection during the intermediary time, some resale users may be irritated and leave the reseller. The expected reduced churn of resellers is also tantamount to an increase in their profitability, since it gives more time to the carrier to recoup the initial upfront capital investments.

Direct revenues

These indirect revenues to the carrier from broadband resale may be complemented by more active strategies deployed by the carriers to appropriate more revenues from resale. Given that the resellers are the only ones in direct relationship with the resale users, in the first place they will capture all the revenues from resale. Therefore the carrier will need to reinforce the links between the carrier and the resellers. There is a whole range of possible strategies for that purpose. For instance, one tack for the carrier would be to invest in technology development (such as tools of traffic pattern analysis) that will give them a better idea of who is doing resale, and then use that knowledge to appropriate somehow more revenues. Another tack could consist in offering "partnerships" (under the form of technical support, lower DSL subscription fees, cheap leasing of access points…) to the resellers, in exchange for a form of revenue splitting. The carrier will yet need to be careful to propose fair mechanisms that leave enough revenues to the resellers as incentives and compensations for acquiring and servicing the resale users[210].

This thesis assumes the existence of an "optimal" strategy for the carrier to eventually appropriate more revenues from the resale users. However, acknowledging the wide range of possibilities, it does not make specific assumption about its actual characteristics and implementation. As the rest of section 5.4.3 will show, some the revenues that this optimal strategy will bring to the carrier are constrained.

[210] See section 4.1 about vertical control.

5.4.3.b Determinants of revenues

We explained in section 4.4.2-*Resold vs. wireline broadband* that we expect resold broadband to be perceived by the end-users as a product of lower quality than wireline broadband. For this reason, we believe that resold broadband will appeal to users with lower valuation for bandwidth, and a lower willingness to pay for their broadband connection.

As a consequence, we expect that the users of resold broadband will not be willing to pay as high a fee per month as what wireline broadband users are currently paying to broadband carriers for their broadband connection[211]. The integrated revenues from resale of the vertical structure “carrier + reseller” will therefore be lower than what the carrier usually gets from wireline users[212]. Assessing quantitatively how much resale users are likely to be willing to pay for resold services is however almost impossible. It would require us to make restrictive assumptions about the shape of the demand curve from resale users. Because we regard such an exercise as questionable by nature, we prefer not to make any quantitative estimate of the value that resale users may accept to pay each month for the service.

5.4.3.c Influence of resellers

In the preceding section, we explained that we expect the revenues accruing to the vertical structure “resale user + reseller” to be lower than $40. Whatever the actual value is (for instance: $30 per month), the carrier will in no case be able to capture all of it because of the presence of the resellers. Not only the resellers make the appropriation of revenues more difficult to the carrier (by hindering the carrier to establish direct relationships with the resale users) on a practical level, but also they *must* be compensated (by keeping a share of the revenues from resale) for the crucial role they play in the resale value-chain.

5.4.3.d Conclusion on revenues

The discussion in this section led us to the following conclusions: 1) the revenues to the carrier from resale are necessarily positive, because of indirect mechanisms described in section 5.4.3.a; 2) the revenues capture by the vertical structure “carrier + reseller” will smaller than $40, because of the resale

[211] Between $40 and $60, depending on the speed of the connection (see Appendix I).

[212] However, these lower revenues are matched by lower costs, and therefore do not imply that resale users are necessarily less profitable than wireline users.

users' expected smaller willingness to pay for broadband connectivity; 3) the carrier will in the end be able to capture a share of these revenues, because the resellers will necessarily keep some of them.

Because the characteristics of the "optimal strategy" followed by the carriers are unknown, as well as the précised characteristics of the demand for resold services, we will not propose any estimates for the monthly revenues that the carrier may expect to capture from the resale users. Rather, we will acknowledge the high uncertainty concerning these revenues by keeping this parameter variable, in the range between $0 and $40.

5.4.4 Break-even analysis

The purpose of this section is to find out how much monthly revenue the carrier needs to secure from resale users to find them profitable – i.e. to prefer acquiring a resale user rather than acquiring no user. This analysis will be based on our average estimates of costs, defined as the middle of the ranges of estimates.

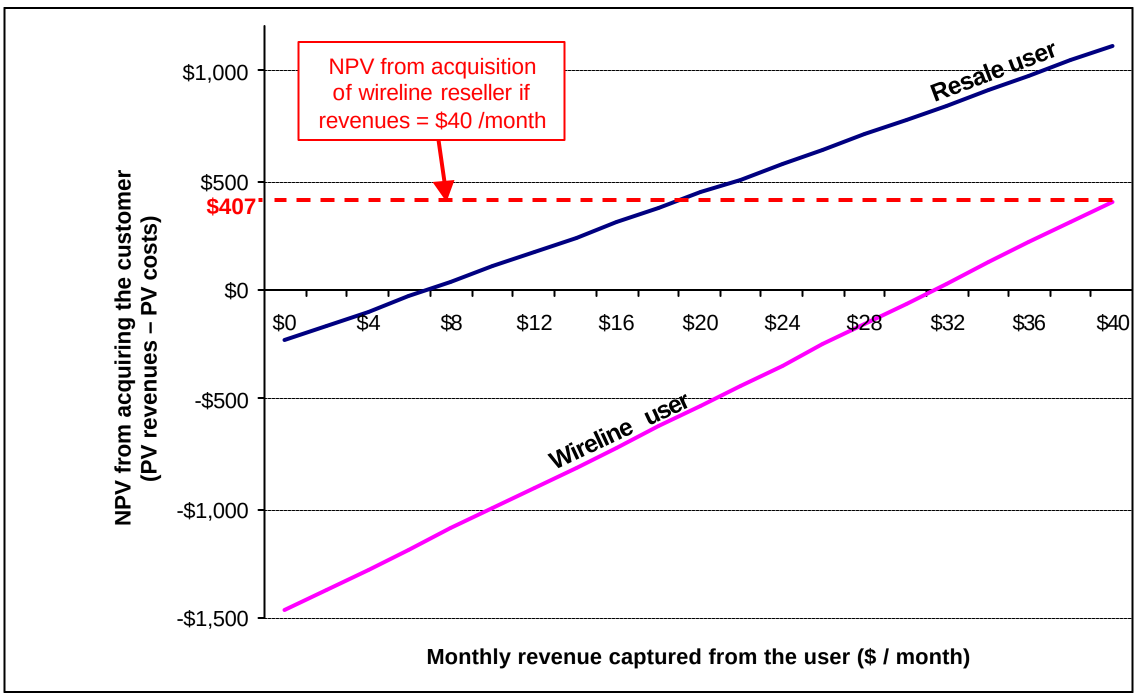

Figure 14: Compared profitability of resale and wireline users

Figure 14 above compares the net present value for the carrier of adding a resale user to the NPV of adding a wireline user to the customer base, for given monthly revenues captured from these users. It is interesting to several extents:

1. It shows that if the carrier can captures as much revenues from a resale user as from a wireline user, then the acquiring a resale user is much more attractive to him, not matter what this level of monthly revenue is. The explanation is to find in the very large upfront costs that the carrier needs to incur when it acquires a new wireline user.

2. It indicates that the carrier breaks even around $7 per month with resale users, against $31 per month when it acquires a wireline user. Therefore, it shows that it may not be very difficult for the carrier to make resale users profitable.

3. When one compares a wireline user to a resale user, one should not forget that it is not necessarily relevant to compare the profitability of resale and wireline users for identical monthly revenues. Indeed the revenues that the carrier manages to capture from resale users are expected to be lower than the revenues it captures from wireline users (see section 5.4.3 above). Assuming that the carrier gets $40 per month for a resale user, Figure 14 shows that the acquisition of each resale user is worth about $400 to him (net present value of profits).It also shows (see dotted horizontal line) that a resale user is worth $400 only if the carrier manages to secure at least $19 per month from him.

Chapter 6 Qualitative discussion

6.1 Introduction

While the cost model presented in Chapter 5 was concerned with the effect of acquiring a given resale user, this new chapter stands back and focuses on the large-scale impacts of broadband resale to the carrier. It will complement the cost analysis of Chapter 5 (which tells us whether a resale user taken individually may be profitable to the carrier or not, and under which conditions) to start addressing the question “should the carrier endorse and engage into broadband resale?”

However, if quantifying the impacts of broadband resale on a provider's costs could be done in the previous chapter (because data could be reasonably gathered or estimated), quantifying impacts that involve user reaction (e.g. demand and revenue) would be highly speculative given that this kind or resale has not yet emerged, and is therefore not undertaken in this thesis. Instead, this chapter provides a qualitative discussion of the potential impacts of broadband resale on the carrier, both positive and negative.

In this chapter we can relax the assumption made in the previous chapter that the carrier is a DSL provider, and we will go back to the less restrictive assumption that the carrier is a provider of wireline services (i.e. cable or DSL). However, since this chapter relies on the major takeaways from Chapter 5 (namely, that for the carrier the upfront costs, the recurring costs, and the recurring revenues are all three smaller for servicing a resale user than for servicing a wireline carrier), this relaxation of assumption implies that these general takeaways also apply to the case of residential resale of cable modem broadband – an assumption that we consider reasonable.

The chapter will unfold in two steps. First we will identify the high-level impacts of broadband resale on the carrier’s customer base: the apparition of two new categories of customers (the resellers and the resale users) because of broadband resale will deeply modify the structure of the carrier’s customer base that was homogeneous before. We will try to find out the main characteristics and likely intensity of the identified effects of broadband resale. Then, we will present other sources of value (mostly strategic) that broadband resale may represent for a wireline carrier.

6.2 Impacts on the carrier's customer base

If the carrier were to engage into broadband resale, then a new category of customer would appear: the resale user. The carrier's customer base would go from a homogenous nature (since in the initial state all the carrier's customers are traditional wireline customers) to a mix of wireline and resale customers. This section strives to analyze the main characteristics and determinants in this transformation of the customer base.

Figure 15 depicts the major flows customers that we foresee between the three categories "non-customer", "wireline customer", "resale customer". As can be seen, we have identified five major flows of customers going from one category to another one, which will be described in the rest of this section:

1. **Direct cannibalization**, a flow of current wireline customers deciding to cancel their subscriptions and switch to broadband resale services.

2. **Indirect cannibalization**, a flow of non-customers who have an a priori interest for broadband services, but eventually decide to go with broadband resale rather than wireline broadband.

3. **Attraction of resellers**, a flow made up on non-customers who find wireline broadband appealing *only* because of the possibility for them to become resellers, and get additional revenues thereof.

4. **Attraction of resale users**, a flow made up by the customers who are a priori not interested in wireline broadband, but find resold broadband appealing[213] and go with it.

5. **Conversion**, a long-term flow of resale users eventually switching to wireline services[214].

[213] Most likely because of the price differences expected between these two services.

[214] As we explain below in this section, this flow could allow a potential new cost-efficient channel for acquiring wireline customers.

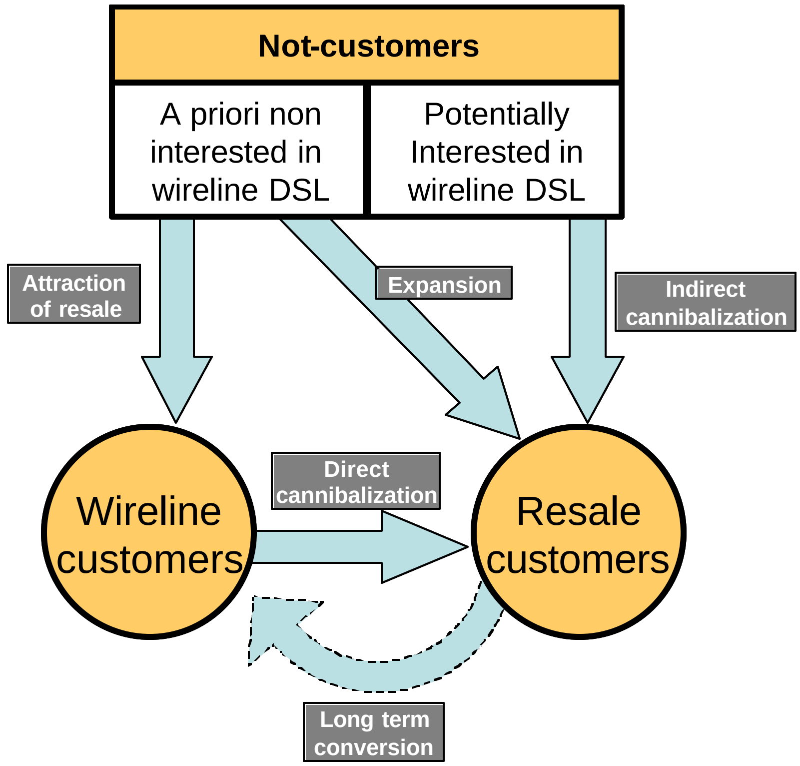

Figure 15: Major incremental flows of customers expected from adoption of broadband resale

As we can already see, some effects of broadband resale will tend to increase the size of wireline customers ("attraction of resellers", "conversion"), while some other effects will on the contrary tend to decrease the base of wireline customers ("direct cannibalization", "indirect cannibalization") – but the benefits of the base or resale customers. However, all the effects increasing or decreasing the base of customers do not impact the carrier's profitability in the same way, because of the different costs involved by these effects (for instance, we will show that direct cannibalization is much more harmful than indirect cannibalization, in spite of the similarities between them both). These issues will be discussed in the rest of this section, even though they will often be limited to describing the factors determining the impact of each flow on the carrier's profitability, as well as the likely extent of.

6.2.1 Cannibalization (direct / indirect) of wireline service

In the section 4.4.2 of the previous chapter we analyzed comparatively wireline broadband and resold broadband. We eventually came to the conclusion that resold broadband could be considered as a degraded version of wireline broadband. In addition, we also mentioned the intuitive result that resold broadband was likely to be provided at lower costs than wireline broadband (first because of its lower quality, and second because of the lower cost of providing it. Therefore, resold broadband appears as a cheap substitute to traditional wireline broadband.

As a result, we expect that this substitute will appeal to some of the current subscribers (or prospective customers) of wireline DSL: attracted by the lower price of resold broadband, some users may be tempted to cancel their current DSL subscription and switch to resold broadband (by connecting via one reseller of their neighbors' from then on). In this situation, the demand for one of the carrier's products (resold broadband) would reduce the demand for another of his products (wireline broadband), hence the designation of "cannibalization". The less differentiated these two forms of broadband services will be perceived, and the greater negative impacts cannibalization by broadband resale will have on the carrier's customer base. Cannibalization will actually take two forms: direct and indirect, as shown on Figure 16.

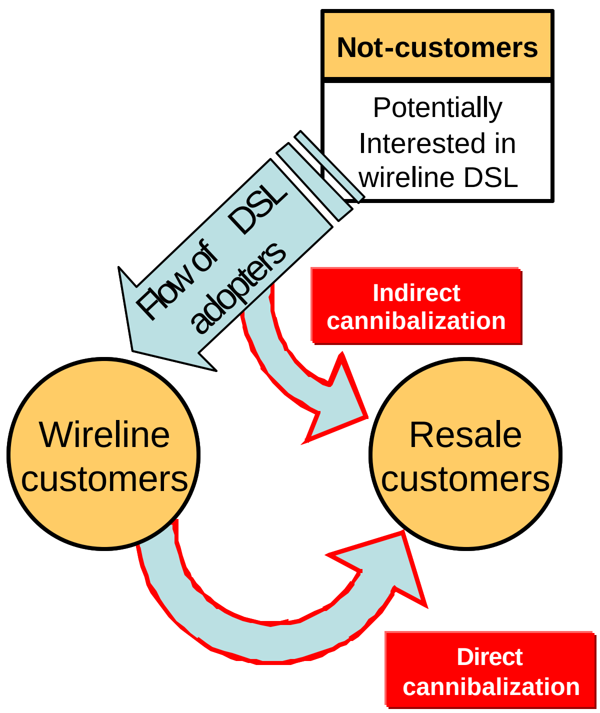

Figure 16: Direct and indirect cannibalizations

6.2.1.a Direct cannibalization

Direct cannibalization will concern current subscribers of wireline broadband services. When resold broadband will find its way to the market some broadband customers may figure out that this new type of service better fits their needs (in terms of features and price), and thus eventually decide to cancel their subscription and switch to broadband resale services. The most vulnerable customers to cannibalization are probably the ones finding wireline broadband a significant expense.

The two main factors that will impact the extent of cannibalization will be: 1) the relative pricing of resold service versus fixed service; and 2) the relative quality of resold service relative to fixed service. If price of service purchased from reseller is sufficiently low and/or its quality is sufficiently high, cannibalization will be more extensive.

However, direct cannibalization is likely to be limited by high switching costs – which correspond to all the elements that make painful the process of canceling an existing subscription and initiating another one (of another sort, or with another provider). In the case of wireline broadband, the switching costs are substantial. Many current subscribers of wireline services are committed to keep their line on the long-run (usually, the longer the contract duration and the smaller the price per month proposed by the carrier). If recently acquired customers wanted to switch to resale services, they would have to wait until expiration of this commitment or to pay the remaining monthly fees. And moreover, the mere process of canceling a subscription and switching to resold broadband is likely to be painful and time consuming for the customers (two characteristics that the carrier has very little interest to see changed): it usually implies spending long time on the phone with the carrier's customer services, stop automatic billing, find a reseller of broadband in the near area, negotiate a price with him, configure their LAN to new settings… This process is uncertain, time-consuming, and may imply foregoing any Internet connection during the intermediary period.

On top of the significant switching costs, there is another point explaining why direct cannibalization should not be too high. Most current subscribers to expensive wireline broadband services can be qualified of "early adopters", and have a high valuation for connection speed. For this reason, they are unlikely to be prone to switch to lower-bandwidth services such as resold broadband[215].

As seen in our cost model (section 5.2), providing DSL services implies that the carrier engages large-upfront costs (mainly the large costs of acquisition and of provisioning), that can usually be then recouped

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[215] As the Yankee Group analysts put it (about risks of cannibalization by cheap broadband packages): "*A large migration to the low-end packages is unlikely, specifically among long-term broadband subscribers. For these customers, such as telecommuters, home-based businesses, and other tech-savvy customers, low-speed services will require a significant and unacceptable change in their online habits. Current broadband users are largely, if not entirely, made up of the early-adopter segment that has a longer online tenure and whose Internet usage exceeds that of an average household*" ([Gramaglia 2002]).

thanks to positive recurring cash-flows during the customer life. Most of these upfront costs are *sunk*, since they can not be recovered once engaged[216].

Direct cannibalization implies the transformation of an existing wireline customer – for which large sunk costs have already been engaged – into a resale user. As will be explained in greater details in section 5.4.3 we expect resale users to generate much lower recurring cash-flows (for the carrier) than wireline users. If these low recurring cash-flows may be sufficient to recoup the normally low upfront expenses implied by the acquisition of a resale user, they may not permit the carrier to recoup the high upfront expenditures implied with acquiring a wireline user. Because direct cannibalization implies replacing the promise of future high recurring cash-flows by the promise of much lower recurring cash-flows, it is unambiguously harmful to the carrier's profitability.

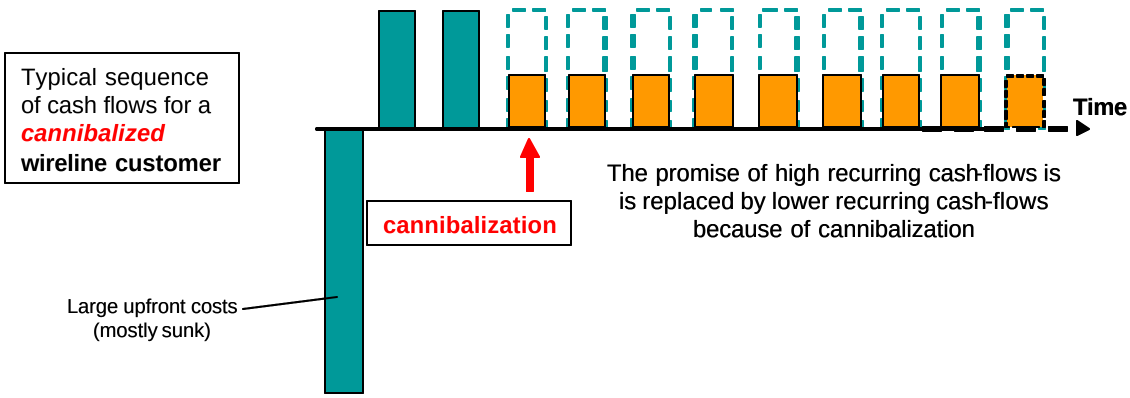

Figure 17: Typical timeline of cash-flows for a cannibalized customer

6.2.1.b Indirect cannibalization

For the same reasons why existing subscribers may want to cancel their subscriptions, prospective customers interested in broadband services may also decide to use resale broadband, while they would have subscribed to normal wireline services otherwise. This indirect cannibalization will translate into a smaller growth of the base of wireline customers than without broadband resale.

[216] Note however that the costs that translated into capital (such as the purchase of a line card or a DSLAM slot) are not sunk cost: if a customer gets cannibalized, then these equipments are freed earlier than expected and can be attributed to other newly acquired customers.

For a prospective user, getting "indirectly cannibalized" does only require that she changes her mind and chooses resold broadband instead of wireline broadband. Therefore, contrary to the case of direct cannibalization, there are almost no switching costs involved, and therefore the extent of indirect cannibalization risks to be much larger than the extent of indirect cannibalization[217].

While direct cannibalization has been shown unambiguously harmful to the carrier, this is not necessarily the case with indirect cannibalization. If resale users are expected to generate smaller monthly positive cash-flows (see section5.4.3 page 117), they do not require the carrier to incur large sunk costs, as with wireline customers. If resale users were to be overall more profitable to the carrier than traditional wireline customers, then the carrier may want to encourage indirect cannibalization, by aggressively promoting resold broadband. Of course, all will depend on the revenues that the carrier manages to secure from resale users, and refers to our discussion in section 5.4 above.

6.2.2 Net expansion of the customer base

For the carrier, endorsing broadband resale means offering a new type of product to the potential users. We saw in section 6.2.1 above that resold broadband risks to appeal to customers that would otherwise go with traditional wireline broadband – giving rise to cannibalization effects. However, provided that resold broadband and wireline broadband are perceived as different products (which we expect – see section 4.4.2 above for a comparison of these two goods), broadband resale will also appeal to customers that were not interested in wireline broadband until then. In other words, offering broadband resale is a means for the carrier to expand[218] his market by addressing a larger demand. Addressing a larger market will fuel the growth of the carrier's customer base by attracting customers who would otherwise have stayed away from broadband. In this chapter, we will study the attraction by broadband resale of customers who otherwise would not be interested by broadband services. This "attraction effect" will correspond to the

[217] If the wireline and resold broadband goods are different enough and target different demands, then the extent of indirect cannibalization may end up small. It seems for instance that the introduction by the carriers of cheap lower-bandwidth broadband packages did not hurt the sales of their "traditional" plans (higher bandwidth and more expensive), as explained by The Yankee Group: "early results indicate that tiered services do not cannibalize revenues. At Cox Communications, for example, the percentage of consumers subscribing to its flagship product at $34.95 per month has not changed in markets where it has tiered services (…) Thus tiered prices do not pose a major threat to the revenue streams of broadband service providers" ([Gramaglia 2002]).

[218] Here "expansion" must be understood as referring to the offered *product mix*, in the price-characteristics space.

transformation of “non-users” of broadband into 1) resellers (leading them to subscribe to wireline services), and 2) resale users[219].

6.2.2.a Net attraction of resellers

Some users may stay away from broadband resale for budget constraints, even though they value connection speed very high; for example, many students and other young people are in this situation. Such users could regard broadband resale as an opportunity to subscribe to a DSL wireline connection at low cost: engaging into broadband resale will allow them to get revenues from their DSL connection, and use them to pay their monthly fee to the carrier[220]. We expect this promise of revenues to entice some of these users to get a wireline broadband subscription.

However, we do not expect this flow to be very large. The number of resellers will in all cases remain much smaller than the number of traditional wireline users and the number of resale users (one reseller can serve tens of resale users), and therefore the attraction of resellers is likely to concern relatively few people.

6.2.2.b Net attraction of resale users

The net attraction of resale users appears very similar to the indirect cannibalization effect: in both cases, a non-user decides to become a resale user. The only difference relates to the initial state of mind of this non-user: if he was already thinking about getting a broadband connection, then there is an *opportunity cost* in having this person going with broadband resale: this is a cannibalized customer. To the contrary, if the user was not interested at all by broadband before broadband resale, then it will be a “net attraction”, and no opportunity cost intervenes.

In a survey performed by McKinsey, 61% of online households that do not have high-speed access expressed interest in subscribing to broadband services ([McKinsey 2001,p.25]). And according to the Yankee Group, 72% of this population cites the too expensive cost of broadband as a reason preventing

[219] Note that broadband resale may also serve to provide wireless broadband services to passersby – which could in a sense be also considered as an expansion of the market served by the carrier. However, as we explained in section 1.2 about this thesis’ perspectives, we consider this usage as out of this thesis’ scope.

[220] Depending on how the carrier shapes its relationship wit the resellers, more “integrated” systems can be envisioned: for instance, the carrier may compensate the resellers for engaging into broadband resale by offering them lower costs (or free) DSL connection.

them from subscribing to it ([Gramaglia 2002]). From these two surveys, the cost of broadband services appears to be a crucial element currently impeding the development of wireline broadband.

Given our assumption that resold broadband will be offered at lower prices than wireline broadband, we should expect resold broadband to be very attractive for those many households that were not subscribing to wireline broadband until now because of its high costs, forming the "attraction flow" depicted on Figure 15. Note that these acquisitions can entirely be attributed to broadband resale, since they would not have occurred without it (the attractions that would have happened anyway are being scored in the indirect cannibalization flow). As a consequence of this "attraction flow", the carrier's customer base will increase in size and heterogeneity of demand, as more customers are acquired thanks to resale.

In the next section we will see that these acquisitions may be the prelude to another flow, on the longer term: the conversion of resale users into wireline users.

6.2.3 Conversion of resale users into wireline users

6.2.3.a Customers lack understanding of the benefits of broadband

Since broadband is an experience good (cf. paragraph 4.4.1.a in the literature review), the most important source of information about it is actual experience with it. McKinsey analysts evaluate that the potential demand for broadband at today's price point (i.e. the households that *should* already have switched to broadband, given their expressed tastes and given the price they are currently paying for narrowband connections) is 38% of online homes, while only 11% have subscribed to broadband services in practice (figures of 2001, [McKinsey 2001, p.27]). They conclude that *"Broadband providers can do more to capitalize on low dial-up satisfaction levels by closing the gap between perceived and delivered value"*, and that this gap will be closed *"as the broadband buying experience becomes smoother"*.

In spite of broadband being patently an experience good, narrowband users potentially interested by broadband have for now almost no way to figure out what broadband would add to their current narrowband online experiences: *"the average consumer lacks an understanding of the broadband experience and cannot equate its value with a $50 per month price"*([Gramaglia 2002]).

6.2.3.b Resale broadband would allow prospective customers to "test" the broadband experience

Traditionally analysts identify five stages in the adoption process of a new product by customers: consumer awareness, interest for the product, evaluation of the product, trial, and adoption ([Kotler

2000]). With wireline broadband, prospective users cannot go through this whole process, because a prospective user trying broadband and then two weeks later deciding not to go with wireline broadband is tantamount for the carrier to a user churning after only two weeks, and therefore has a disastrous impact on the carrier's profitability (large upfront provisioning costs were incurred[221], and are balanced by almost no revenues). For this reason, most carriers require the new users to commit themselves for a minimum duration (usually 12 months), making the trial of wireline broadband impossible in most cases.

To the contrary, experimenting resale broadband appears a much easier and cheaper process (for all the players). The process for getting a connection is much easier: the prospective customer can borrow a wireless card (from friends, or even from the reseller), install it in its computer and *associate* with the reseller's AP, all this in one or two hours, while getting a wireline connection may require long waiting times (several weeks in the busiest periods). Of course, this process will not be costless, and in section 5.2.2.b we estimated the provisioning cost between $20 and $60 for a resale user. However, we consider that the resellers may define a "light provisioning" procedure that would be much less costly to him[222]. Even if the resale user finally needs to pay for part or all of these provisioning costs, these costs will be low (probably in the range $20-$30) and do not compare with the costs implied by trying wireline broadband.

From this perspective, resale may allow some prospective customers to experience the smoother "buying" process called for by McKinsey analysts (cited in section 6.2.3.a above): because of low upfront setup costs, a current dialup user may more easily try broadband for a few days or weeks via resale, and delay its final decision (between sticking to dialup, or switching to broadband) to the end of this trial period.

To sum up, the low upfront costs implied with serving an additional resale user enable to create a cheap "first-contact" with some users who show interest for broadband (resold broadband as it happens). This "pipeline" function of driving new customers to the carrier's wireline services may actually represent one of the main benefits of broadband resale, if the carriers adapt their strategies to foster this attraction effect (we can imagine strategies where the carrier would indicate to hesitating prospective clients who is the

[221] See section 5.2.2.b about the provisioning costs. Note that in this section we consider a customer hesitating whether or not to adopt broadband, and therefore we consider that most marketing costs of customer acquisition (destined to create awareness) have already been incurred, and therefore are sunk. The provisioning costs therefore represent most of the incremental upfront costs that are not recoverable afterwards.

[222] For instance, each reseller could have a pre-configured resale-account for "trials", and could simply give the adequate login and passwords to prospective users. Moreover, no special setup related to billing will be required, making the provisioning easier.

reseller living the closest to their place, and even rent them a wireless reception card, so that they can test the benefits of broadband for a given period, and then make up their mind).

6.2.3.c Broadband resale as a two-step acquisition strategy

The two-step acquisition of prospective wireline broadband customers through resale (as seen in the previous chapter) could be generalized to all the resale users, including the ones who initially were not considering going to wireline broadband.

After discovering broadband through resale, and being convinced of its advantages as compared to dialup (its higher transmission speed, but especially the permanent connection), these users may rapidly find themselves suffering from the shortcomings associated with resale: increased congestion at peak times, unexpected service shutdown because of "handling errors" on the resellers' side, recurring interferences from other electromagnetic sources in the same spectrum range (e.g. microwaves)… after having learnt the main features of the experienced good resale by trying it, and discovered that it was fitting their needs, some of these users may in a second step consider switching to wireline services. If the carrier's long-term objective was to increase its base of wireline customers (because of the stronger ties it can establish with wireline users, or because resale users proved less profitable than wireline users), it could try to trigger (or at least facilitate) switches from resale to wireline services (by offering some special "conversion packages" to the interested resale consumers). This two-step acquisition process is depicted on Figure 18.

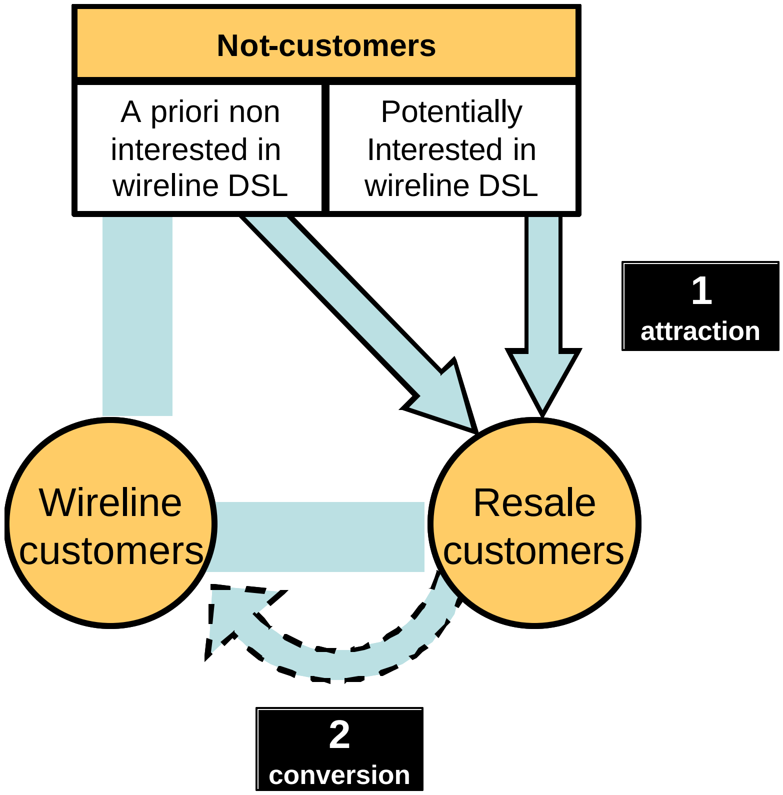

Figure 18: Two-step attraction process

Behavioral and social sciences (such as [Joule 1999]) have proved that two small consecutive decisions complementing each other are much easier to obtain from others than a unique more significant decision. From this perspective, resale may be an intermediary step between dialup and wireline broadband subscriptions, and the carriers may leverage it in order to fuel the growth of their wireline customer base – if its interests call for such a strategy. This utilization of broadband resale to indirectly fuel demand for wireline services stresses even further the similarities of resold broadband with the cheaper plans recently introduced by the carriers: *"The underlying objective of low-price, low-speed products is to induce migration to broadband, giving consumers an opportunity to experience the advantages of higher access speeds."* ([Gramaglia 2002]). The carrier's ability to convert its resale consumers into wireline consumers may be a crucial factor for determining whether resale is advantageous or not to the carriers.

6.2.4 Conclusion

In this qualitative discussion, we identified several effects that broadband resale could have on the carrier. They will happen concurrently, and often work towards different direction. Quantifying the intensity of these effects is very speculative since it involves knowing the demand for resold broadband – for this reason we kept our analysis on a qualitative level.

Figure 19 graphically represents our sense of the magnitude of the effects we identified. They are speculations on our part, reflecting the qualitative analysis presented in this section 6.2. However, assessing what will be the equilibrium customer base's structure resulting from all these effects (which would enable to come up to a definitive answer as to whether broadband resale is advantageous to the carrier or not) would require a quantitative modeling of all these effects, and would constitute a good extension of this thesis.

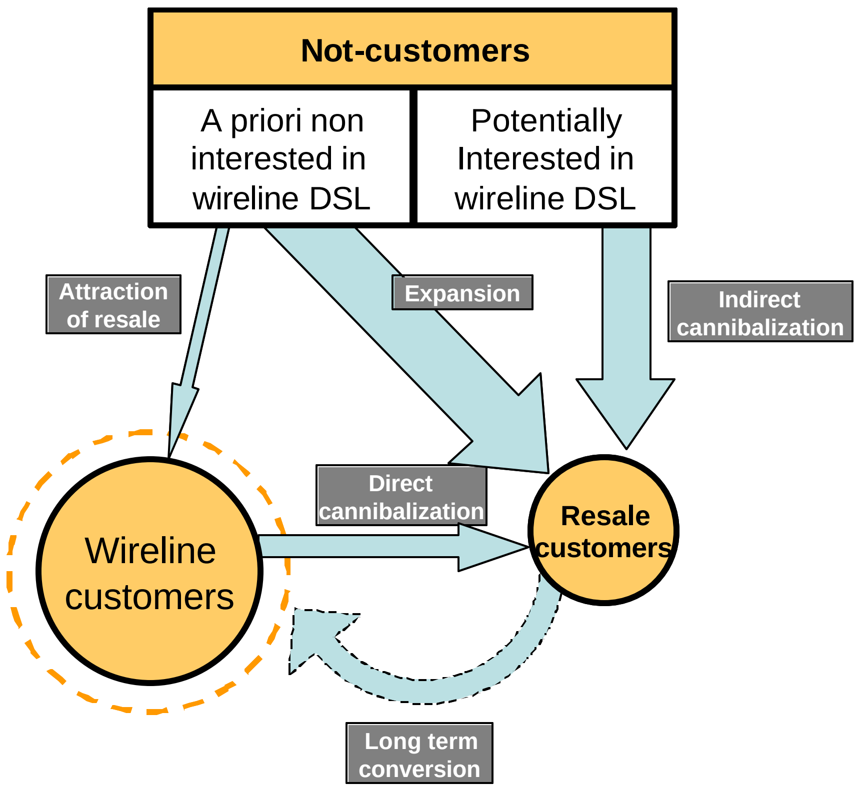

Figure 19: Our speculations about the magnitude of the identified effects

6.3 Indirect strategic benefits of broadband resale

This section will describe other potential sources of value from broadband resale. These sources will often appear on the long-term and in a diffuse manner, and are therefore very difficult to quantify. However, they may in the end constitute the bigger part of the value to the carrier of broadband resale.

6.3.1 Facilitated price discrimination[223]

Broadband resale makes perfect sense in the context of the current price discrimination policies in which most carriers are currently engaging[224], as we mentioned in section 2.1.1 about the broadband market. As put by The Yankee Group's analysts: "*Tiered prices (…) offer the best opportunity for broadband access providers to increase market penetration and corporate revenues. Tiered services were introduced over a year ago in order to expand the target market for high-speed access. Unlike discounted, full-speed broadband services, tiered services offer lower speeds for lower prices.*" (in [Gramaglia 2002]).

To many extents, broadband resale may be seen as the ideal tool for price discrimination. Not only it is a "low-price low-speed" (at least under our assumptions) product called for by The Yankee Group, similar in it to the cheap plans now proposed by broadband companies, and should therefore bring the same benefits (note that these benefits relate to the paragraph 6.2.2 about using broadband resale as a two-step method to acquire new customers). But also, as we will detail in the next chapter, broadband resale has a tremendous cost advantage as compared to the more traditional cheap low-speed plans now proposed by the carriers[225].

If broadband resale gets to spread, wireline broadband will tend to be purchased only by customers with high valuation for bandwidth, reliability, or predictability of the connection's performances. The monopolist will be able to take advantage of these customers' lower elasticity of demand to charge a higher markup price to these users (and to market other premium services to them, such as multiple IP addresses, Voice over IP…). On the other hand, the lower-valuation customers will not be excluded from the carrier's consumer base, since they will be able to report themselves on resold broadband, whose price will be kept low over time.

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[223] See section 4.2 about discrimination along the quality dimension, in the chapter about economic literature review.

[224] Charter Communications, for example, offers a tiered, limited-speed (256-Kbps) cable modem service at $24.95 per month, over $20.00 less than the high-speed price, to consumers who lease their modem and subscribe to basic cable TV service (source: [Gramaglia 2002]).

[225] The costs to the carrier for providing a low-speed DSL connection compare with the costs of providing a normal-speed DSL connection, since low-speed connections are usually nothing else than curbed normal-speed connections (ongoing costs will probably be saved on transport, but it is marginal).

6.3.2 Low-cost entry in the wireless market

The broadband resale model envisions an architecture based on the carrier's DSL plant combined with a multitude of resellers-owned access point, which de facto creates a wireless network in urban areas, on top of which the carrier could provide advanced wireless services in the future. These urban Wireless-LANs, are actually very similar to the currently burgeoning free-networks except that they would be based on economic rather than "libertarian" principles.

Broadband carriers should leverage their existing wireline existing infrastructure by benefiting from the great synergies existing between them and the nascent W-LAN market. What HSBC analysts mention for Japan also holds for the U.S.: *"W-LANs use DSL, FTTH and other wired connections with ISPs, plus wireless connections. Thus, mobile telecom carriers with wireless technologies and fixed-line operators are afforded major opportunities for synergy with W-LAN."*([HSBC 2002]).

Such strategies would make sense because of the costs advantages that current infrastructure would provide to these broadband carriers: *"network costs for [classical] wireless-LAN are a large portion of total costs. Mobile Internet Service and other stand-alone companies have to lease networks, but established carriers with fixed-line networks can keep down additional costs because they already own DSL and FTTH networks"* ([HSBC 2002] p.21). Entering at almost no cost a normally capital-extensive industry such as the wireless industry entails potentially great value, and a strategic use of broadband resale could help wireline broadband carriers play a greater role in the future wireless environment.

The extent of strategic implications from engaging intro broadband resale cannot yet be fully envisioned. However, in the face of the embedded uncertainty there is some intrinsic value in the mere fact of – prudently – taking this way, in order to be able to benefit from opportunities that would occur later on. This intrinsic value could be calculated using real option theory.

6.3.3 Increase of the carrier's addressability

In our vision of broadband resale, wireless LANs devices are used to "expand" the addressability of DSL lines beyond the limits of the DSL subscriber's household, and enable several users to use the same DSL connection. Until now, we have presented this new form of access as a potential alternative to getting a wireline broadband connection. However, there are cases where broadband resale will be more than a mere alternative to a wireline solution, and broadband resale will represent the only available broadband solution for some users and broadband resale will therefore allow the carrier to provide services to more users. This will notably be the case each time a person is interested by having a broadband connection, but does not have any personal phone line available to him through which he could receive DSL services. A typical illustration could come from teenagers whose parents refuse to subscribe to broadband services: if this teenager really wanted to do online gaming (which requires a broadband connection), he could reach an agreement with a reseller of his neighbors. Broadband resale would enable the carrier to serve some of those customers who had not access to wireline broadband services.

6.3.4 Improved marketing efficiency thanks to resellers

As competition increases between DSL and cable and the broadband market enters a more mature phase, marketing is destined to gain importance: its strategic importance is great, now that the market starts being driven by the demand (and, correspondingly, prices), while until now it was rather driven by the supply (availability of the service, technological characteristics). The requirement of matching products, pricings, and demand goes increasing, and marketing is gaining importance in this maturing market (the costs of acquisition of a new wireline customer are expected to grow from $125 in 2001 to $175 in 2005, according to [McKinsey 2001]).

Adding the resellers' layer in the value chain actually dramatically changes the nature of the final good provided to the end-users. The two main advantages that these resold services entail as compared with classical wireline broadband services are 1) its wireless nature, and 2) the resellers' ability to more narrowly shape the product (in terms of technical characteristics, of pricing…) to the local market's specificities, thereby better fulfilling the customers' needs. Provided that the resellers get sufficiently well compensated for the acquisition of new customers, the carrier can expect them to take upon them the responsibility of attracting new resale users, in a much more efficient way than what it could do, because of his "local" characteristics. The reseller will be able to efficiently propose the services to their acquaintances, and to adequately customize their offer to them (notably in terms of pricing).

As the result of both a better-tailored marketing action and its responsibility being transferred onto the resellers, the marketing costs to the carrier of acquiring a new wireless customer is expected to be much lower than for classical wireline users.

Chapter 7 Conclusions

This thesis examines the possibility of wireless resale of wireline broadband connections by residential consumers. To simplify the analysis, the thesis focuses on the case of a monopoly provider of wireline broadband services and that carrier's incentives to allow residential broadband subscribers to resell services via a wireless LAN (WLAN) such as WiFi. In this model, a reseller (one of the initial customers of the carrier's wireline services) would expand the reach of his wireline broadband connection by connecting his DSL modem to a WLAN Access Point. This thesis analyzes the potentials of amplifying wireline broadband as a new solution for providing broadband access to fixed customers at their locations. The potentials of broadband resale for providing connectivity to mobile passersby on the street are out of this thesis' scope.

7.1 Regulatory challenges to broadband resale

We have identified two policy issues that could challenge our model of residential broadband resale:

- The availability of unlicensed spectrum. After comparing the regulation of unlicensed spectrum in Europe and in the U.S., we concluded that the U.S. offers a more attractive opportunity than Europe for experimenting with the residential broadband resale, mostly because the lack of trans-national regulatory authority in Europe which has contributed to slow adaptation of national regulations and has impeded the development of wireless LAN products in Europe.

- Congestion: because spectrum is a scarce shared resource, its availability for each user depends on the number of other users using it concurrently. Therefore, one of the main policy challenges that will need to be faced in the medium and long run is the problem of how to manage congestion in unlicensed spectrum. We proposed three approaches for alleviating the congestion problem: licensing new bands of spectrum, allocating additional unlicensed spectrum bands, or developing new technical solutions which can more efficiently utilize available spectrum.

7.2 Profitability of resale users

Because of 1) the resale users lower willingness to pay for resold broadband, and 2) the necessity for the carrier to share the revenues from broadband resale with the resellers (for instance in the form of incentives and compensations), we conclude that the carrier will not be able to capture as much revenue from resale users as from wireline users. On the other hand, providing resold broadband to an additional user implies relatively small upfront incremental expenditures (we estimate them between $35 and $90) and small incremental recurring costs for the carrier (estimated between $2.4 and $7.6 per month), notably thanks to the shared character of broadband resale.

Framing adequate relationships with the resellers will be crucial for the carrier, since its ability to capture revenues from the resale users depends thereof. If the carrier manages to secure more than $7 of monthly revenues[226] from resale users, then our estimates show that each resale user should be considered by the carrier as profitable *by himself,* since in such a case the present value of the incremental cash-flows generated by the acquisition of a resale user is positive[227], and should be preferred to the status quo by the carrier (everything else being equal)..

7.3 Impact of resale on the carrier's customer base

We expect residential broadband resale to impact the structure of the carrier's customer base in three ways:

1. **Direct cannibalization** of the existing customer base. This effect corresponds to the transformation of current customers of wireline services into resale customers. We explained that this effect is likely to be harmful to the carrier, because 1) the carrier has already engaged the high upfront cost for providing wireline services to the customer (these are sunk costs), and 2) the monthly cash-flows that can be expected from a resale user are likely to be lower than from a wireline user.

2. **Indirect cannibalization**, impacting the flow of acquired customers. This effect corresponds to the prospective customers who were a priori interested in subscribing to wireline broadband and who eventually decide to subscribe to broadband resale services. This effect will reduce the growth rate of the wireline customer base. Its net impact on the carrier's profits cannot be

[226] Note that this value corresponds to the higher end of our range of estimates.
[227] Using a discount rate of 10%.

forecasted with certainty, since it will depend on how the profitability of a resale user compares to the profitability of a wireline user.

3. **Inflation of the customer base**. Because resold broadband is expected to be cheaper than wireline broadband (and of lower quality), we expect this product to appeal to some people who are not otherwise interested in wireline broadband. Addressing a new segment of customers thanks to "diversification" into broadband resale will fuel the growth of the carrier's customer basis (via the transformation of "non-customers" into "resale customers"). In addition to this, some technology-savvy persons with low incomes who could not get wireline broadband because of its too high cost may be tempted to subscribe to wireline broadband with the aim of engaging into broadband resale: the revenues from broadband resale may possibly recoup the cost of purchasing the DSL line.

4. **Longer-term conversion of resale customers into wireline customers**. Finally, we foresee potentials for broadband resale as a means to facilitate the acquisition process for wireline broadband. In this view, broadband resale would enable prospective users to test broadband at low costs, before making up their mind about sticking to dialup connections or switching to broadband. This mechanism is particularly interesting given that broadband is an experience good.

7.4 Further research

Our analysis of broadband resale focused mainly on the incremental costs falling to the carrier if it acquires an additional broadband user. As a consequence, our analysis allowed us only to provide the ranges of monthly revenues for which we expect a broadband resale to be profitable. An interesting extension to this thesis would consist in thoroughly analyzing the revenue side of the profitability equation for resale users, in order to come up with a definitive answer as to whether acquiring a resale user will be profitable to the carrier. Such an analysis of the revenues from broadband resale users will not be possible without precisely defining processes by which the carrier can capture these revenues, and thus making more restrictive assumptions about the relationship between the carrier and the resellers.

If we have qualitatively identified the effects of broadband resale that we expect at a macro-level, we did not model them quantitatively. Therefore, another possible extension for this thesis would consist in a global analysis of the effects for the carrier of broadband resale. This analysis would account for the changes in the carrier's customer base due to broadband resale, and would give valuable insights as to whether broadband resale is profitable to the carrier *overall*.

In this thesis we have never explicitly modeled the existence of competition from other companies on the market for broadband provision (even if competition was implied in our analysis of the churn rates and of the strategic benefits that the carrier could draw from broadband resale). Explicitely modeling our residential broadband resale vision in the context of a duopoly (at the carrier's level) would give a more realistic vision of the broadband industry, by accounting for the competition between cable and DSL providers, and would provide a more dynamic vision of broadband resale and of its strategic value.

Appendix I: Pricing of broadband services observed in September 2002

Carrier	Techno	Country	New pricing	Date	Source
Volume-tiered pricings					
Optus	Cable	Australia	Download Volume tiered: 550 MB for $54.95 to 10 GB for $265.95 Users exceeding cap see speed throttled down to 128k until next period; Optus will alert the user via email once they reach 80 per cent of their capacity for that month	July 1st, 2002	[BNN 2002] [Osman 2002]
Telstra	Cable and DSL	Australia	Volume-tiered pricings; $55 for 300MB to $340 for 10GB; extra MB = $0.12 to $0.16 Uncapped speed		[BNN 2002]
Speed-tiered pricings					
Charter Communications	Cable	USA	Tiered pricings based on speed starting at $29.99 60% customers choose lower speed	For over 2 years	[Black, 2002] [SDR 2002]
Cox	Cable	USA	Tests slower speed cable in Las Vegas for $34.95 And 128kbs/128kbps for $24	Still a test	[Black, 2002] [Choney 2002]
SBC – Yahoo!	DSL	USA	Speed-tiered pricings between $43 and $60 per month		[SBC Yahoo] [Black, 2002] [SBC 2002] [SDR 2002]
Wanadoo, Tiscali, Terra, Skynet…	DSL	EU: Belgium, Italy, Portugal, Spain, Sweden…	Mostly speed-tiered pricings		[Davies 2002]
Covad	DSL	USA	Four speed-tiered plans, from $40 for 200kbps to $60 for 1.5Mbps		[Choney 2002]

Verizon	DSL	USA	Two speed-tiered plans: 768 kbps for $50 and 1.5 Mbps for $60 No setup fee; modem provided		www.verizon.net
ATT Broadband	Cable	USA	Speed-tiered pricing 3 Mbps for $80 1.5 Mbps for $46		[SDR 2002]
Rogers Communications	Cable	Canada	2 speed-tiered pricings at $40 and $25		[BNN 2002]
Unmetered pricing					
All UK retail	DSL	UK	Prices in UK dropped to 30 GBP for higher speed Has to buy modem	May 2002	[Lewis 2002]
BT – wholesale price	DSL	UK	Dropped from 50 GBP to 15 – 25 GBP No cap	April 2002	[Lewis 2002]
Time Warner Cable	Cable	USA	MAY charge additional fee to users who dl more than specified limit But for now, still flat-rate unlimited	future	[Emling 2002]
FreeDial.biz	DSL	UK	unmetered Very cheap : 13 GBP for 512 kbps		[BBC 2002]
Comcast	Cable	USA	So far reluctant to offer “lite” plans		[BNN 2002]
Bell South	DSL	USA	Single flat-rate plan for now		www.fastaccess.com

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