

Content Delivery and Vertical Integration in On-line Content Markets

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Abstract

On-line content delivery and vertical alliances between conduit and content providers are nowadays crucial issues in on-line content markets. In this paper, we discuss and compare two types of model for on-line content delivery: *push* and *pull*. We assume non-zero marginal cost for network transits, justified by the presence of network services for content delivery (like data caching). Under both models, we show that the rationale behind vertical strategic integration between conduit and content providers in the case of successive monopolies.

1 Introduction

On-line content delivery is receiving increasing attention from commentators, scholars and advisers, especially after the Napster dispute. Moreover, recent mergers between Internet Service providers, large cable companies and content providers or data aggregators¹ (portals) have raised a challenging question for economists: what is the rationale for vertical integration between content and conduit firms?

Because of its scarce integration with computer science, economic theory does not offer any simple answer to this issue. As will be clear below, so far economists have failed to recognize the existence of different kinds of deliverable content and the new network functions needed for structuring, filtering and querying such multimedia streams. Thus, economists usually tend to elude an issue that seems crucial to recent advances in computer science: does vertical integration between conduit and content provider turn out to be an optimal strategy, independently from how on-line content delivery is operatively organized?

In what follows, we review the existing literature on content delivery by discussing recent results proposed by economists and computer scientists. Then we introduce a simple

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¹ For instance, recent mergers between AOL and Time Warner, AT&T and MediaOne; MCI/WorldCom/Sprint; Vivendi/Seagram/Canal Plus.

microeconomic model to study the price decisions of content and conduit providers. For simplicity, we suppose that both content and network transit markets are successive monopolies² because of the: (i) tight copyright protection of contents; (ii) exclusive ownership of network loops; (iii) huge network effects; (iv) high switching costs.³

More specifically, we can envisage a content firm supplying non-substitutable content at negligible marginal costs with totally paid-off upfront costs (that is, exclusive U2 videos or MP3s), and a network firm owning an essential network loop, without which it is impossible to reach some content consumers. This framework allows us to focus on double marginalisation effects and second mover advantage in price decisions. Moreover, we consider two cases: (i) firms which do not have sufficient information about consumers to implement price discrimination; (ii) cases when price discrimination is allowed. Here we will concentrate on the first by assuming linear prices. A companion paper will explore the second case.⁴

The so-called “Napsterization” (that is, content digitalisation and transfer protocol convergence; see Rapp, 2000) of content industry represents a highly profitable business for providers, but poses some key challenges to network and content firms. Therefore, a crucial task is to understand how such types of firms can implement new services while maintaining the availability, performance and security of their traditional networked applications. In fact, to supply such new services there are the costs of data flow management, replication and scaling. Therefore, in what follows, we suppose that a conduit firm provides some network services for content delivery (like caching, adaptation, media scaling etc. ...; see below) at a constant marginal cost. These costs are paid by content providers and consumers at a given constant share.

Finally, following computer science theories, we discuss two models of content delivery: a *Pull Model*, in which contents are pulled by consumers and a *Push Model* where multimedia streams are pushed in the web by a provider. In particular, we show that vertical integration is a profit-maximizing decision for both providers, except when contents are pulled and network service costs fall heavily on consumers. Hence, our conclusion is that incentives for vertical integration between providers are weaker when light contents (that is, GIF images) are pulled by consumers, than in the case of heavy multimedia streams (like video conferences) pushed into the web by a content firm. Therefore, we can predict several integration waves for Next Generation Internet when large multimedia streams (like TV on demand) will be dispatched worldwide.

The paper is organized as follows. In the next section we review and discuss the economic literature on content delivery. In section 3 our set-up and main result are presented. Section 4 concludes.

2 Literature review

Although the above issues have caused considerable debate on specialized newspapers, so far digital content delivery has not been widely investigated, either by economists or by computer scientists. Computer scientists are used to modelling network infrastructures which maximize the value added of on-line content delivery value chains. A network

² Spengler (1950) is the main contribution on successive monopoly price decisions.

³ For an analysis of information market features see Shy (2001).

⁴ A preliminary version is available upon request.

infrastructure is given by a *physical layer*, which provides physical connectivity services, a *network layer*, through which network services are implemented, and a *content layer*, which manages content flows. Consistently, the dimensions of service value-chains are defined in terms of network connectivity and bandwidth, as well as through implemented functions for content delivery (for example, free configuration of content viewer plug-ins).

Indeed, as stressed by Liver and Dermier (2000), a crucial component of any content delivery value chain is the quality of network transits. Unfortunately, this is not normally guaranteed on an *end-to-end* basis by the conduit provider, and cannot be easily controlled by those who provide the on-line content. Hence, any content delivery model should include a *Service Level Agreement* on connectivity between providers. Given traffic aggregate estimates and network latency expectations, this agreement has to specify the network service quality and its relative price at any time of day.

In a similar vein, Rousseau and Duda (2000) and Harumoto et al. (2000) suggest some technical functions that an information system (that is, the union of a content server, a network infrastructure and a client browser) should have in order to deal with advanced multimedia streams and to ensure a sufficiently stable quality of service. To support new multimedia applications and services, they argue, not only do transit conditions have to be continuously negotiated between providers, but also a dedicated infrastructure is needed. This infrastructure has to provide *active network services*.

MacLarty and Fry (2001) help us to understand what active networking means. On-line content delivery usually requires stable network bandwidth, together with no interconnection breakdowns. Nevertheless, given variable network utilization, optimal transport protocols and scheduling change almost continuously. In order to deal with this problem, *data caching* and *adaptation* can be implemented at the network service level. *Caching* within an informative network (like the World Wide Web) is an optimization procedure which selects optimal data transport protocols, allowing for reductions in network download latency and server interconnection breakdowns. Similarly, the *adaptation* of media stream formats is a function through which a dynamic distillation of media streams is realized in order to adapt transmissions to network conditions. To implement these services, a network provider supplies active network services (other active network services are: *media scaling*, that is, the dynamic manipulation of pieces of content sent through the network at different bit rates and the efficient *scheduling* of packets to reduce data loss rates) through a fully integrated Web platform. On this platform, MacLarty and Fry (2001) propose to adopt protocol entities, called *proxylets*, to enhance protocol functions between servers and facilitate data caching and adaptation. These proxylets can be implemented in JAVA and stored in JAVA Archive files on a *Proxy Server* linked to the content provider's server and to consumers' web browsers. This proxy server is a machine able to recognize proxylets and to select optimal data transfer protocols.

A real world example may help. Following MacLarty and Fry (2001), suppose that a Japanese consumer wants to listen to an audio sample stored on a content provider's server hosted in the United States. Without active networking, the content has to be fully downloaded before it can function. On the contrary, using a proxy Server, a proxylet is downloaded onto the machine from another server, then the proxylet transforms the audio sample in the best format (for instance, Real Time transport protocol packets) compatible with real-time streams. In many cases, this change of format may reduce waiting times or data losses.

Consistently, in what follows we imagine dealing with a network infrastructure for content delivery composed of two Web servers (one for each firm), a client browser and a proxy server, through which some active networking is provided. Figure 1 illustrates our network infrastructure and its layers. Through this infrastructure, on-line contents may be delivered using either a *Pull* or a *Push* model (see Liver and Dermier, 2000 and Rousseau and Duda, 2000). In both models, price decisions are taken sequentially with different actors initiating the transfer of contents. In the Pull model, data transfers are required by consumers, which select and retrieve some usually light information products hosted on a web server. In the Push model, a firm offers heavy on-line contents to some previously identified consumers who may or may not accept the offer. The pull paradigm is nowadays dominant in the Web and within peer-to-peer communities. It works efficiently for light data packets, which can remain on a Web server for several weeks or months. However, all new network applications for live-streaming require full synchronization of data flow and are managed through a push model.

Let us illustrate how both models work for the network infrastructure described above (see Figure 2).

The Pull Model: some consumers want to buy one unit each of a content from a content provider (for instance a video-interview with Bono Vox, exclusively released on the web by U2.com). Content consumers send a request to their network provider using their web browsers. The network firm, who monopolistically manages a network loop, without which the content firm cannot deliver its product, re-directs the request to the content provider together with the *price for network services* (t) required for that data format. Then, the latter decides whether or not to provide the content. In the affirmative case, it provides a *content price* (p) to the NP's server. Finally, prices are sent to each consumer, who may or may not decide to buy.

The Push Model: in this case the content provider first decides on content prices (p), then sends proposals to consumers through a network loop, managed by a conduit firm. The latter directs proposals to its subscribers, selling network services to the content firm at a price (t). Once consumers have decided to buy the content, their replies are then re-directed to the content provider.

The very few existing economic contributions on on-line content markets simply ignore that some applications require contents to be pushed by the content provider (like video-conferencing, Internet Radio or WebTV), while other contents (MP3, DivX, e-books) can be pulled directly by consumers.

Furthermore, economic modelling suffers from a considerable delay in analysing the topic of on-line content delivery. As Rubinfeld and Singer (2001) underline, economists not only do not suggest rationales for vertical integration between providers, but they also do not have a model to analyse the anticompetitive effects of vertical integration between content firms and conduit operators. About the latter, they claim, at least two kinds of discriminatory behavior may be possible for an *integrated provider*: (i) *content discrimination* (that is, not to accept rivals' content on my conduit) or (ii) *conduit discrimination* (that is, not to allow my content to be delivered by an alternative network provider). Under certain conditions, largely discussed in their paper, both practices are profitable for an integrated firm and harmful for de-integrated competitors.

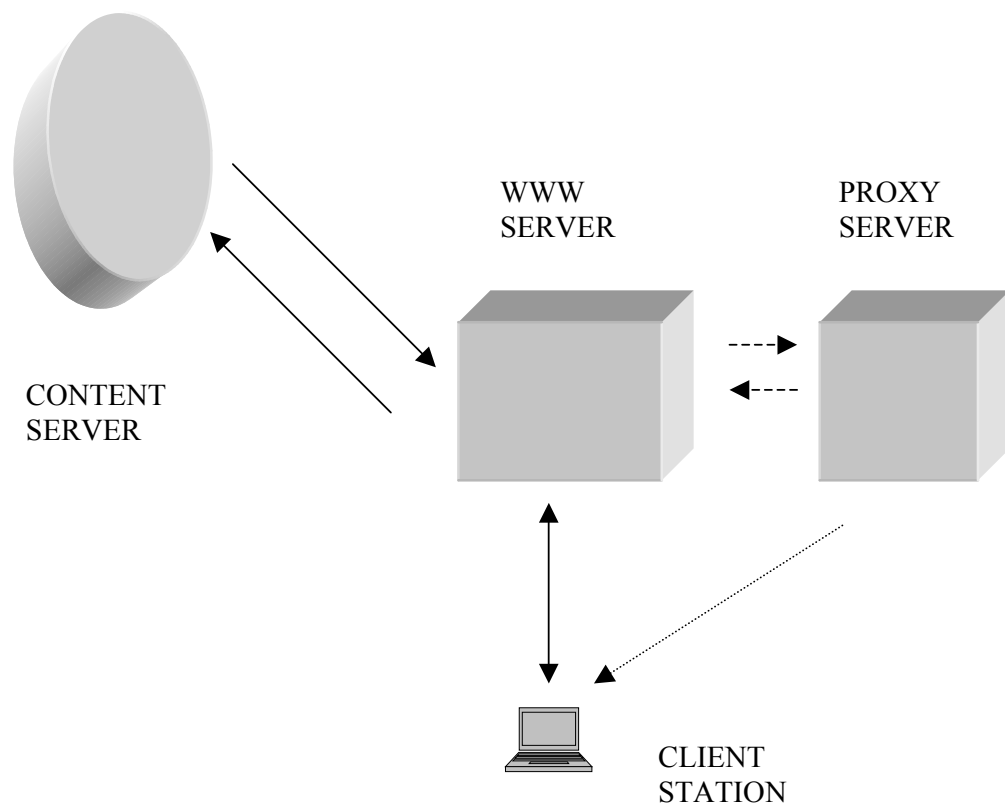
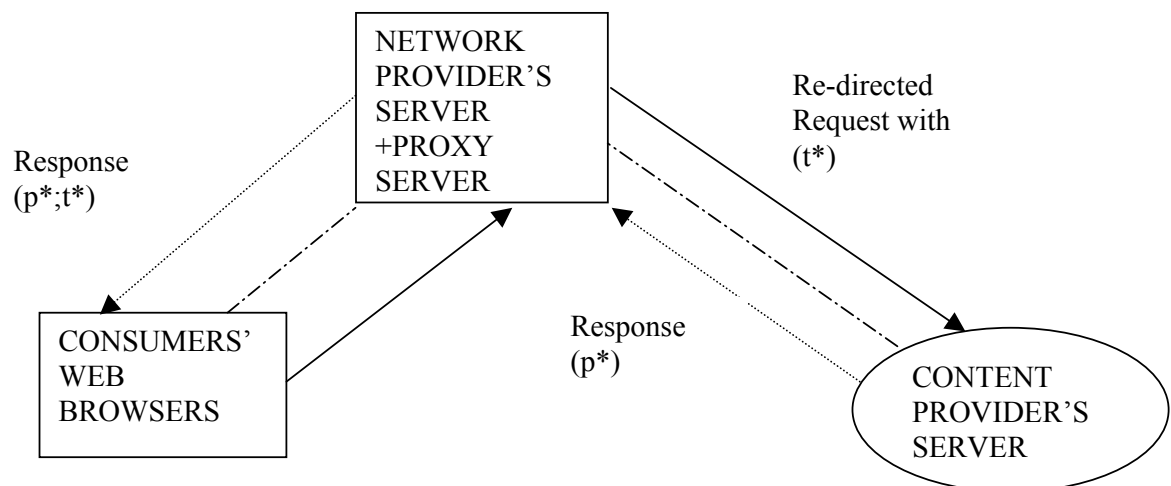
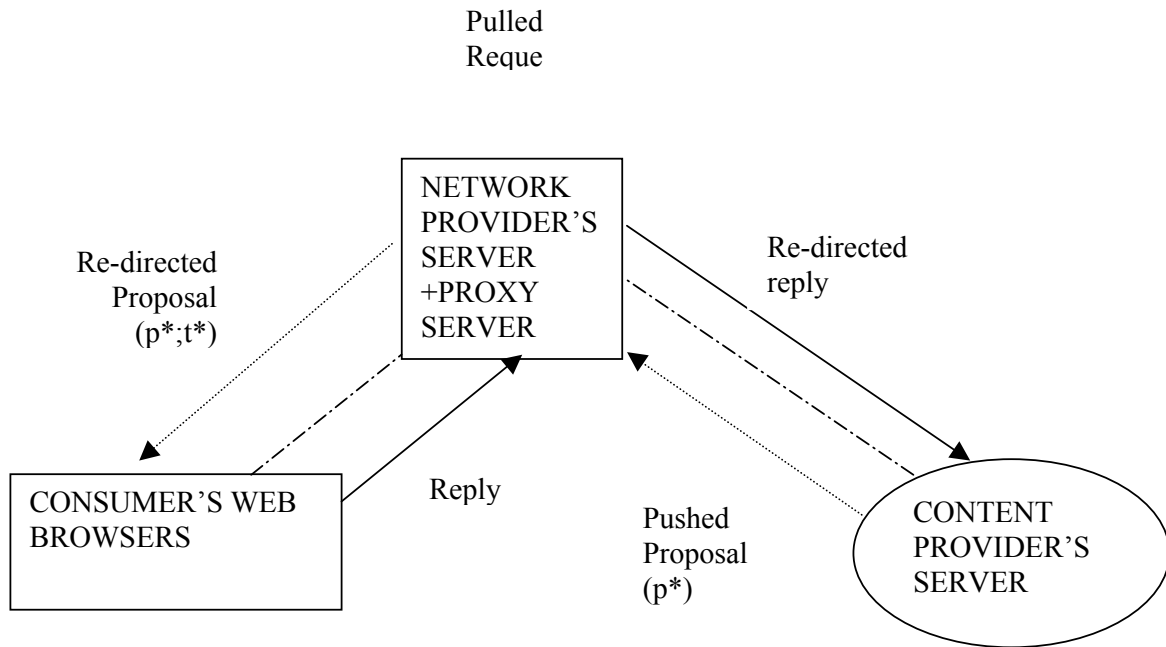


Figure 1: The network infrastructure



(a) The pull model



(b) The push model

Figure 2: Online content delivery models

Nevertheless, in Rubinfeld and Singer (2001), the *vertical integration* between providers is assumed, and not explained or justified. Readers are simply referred to classical industrial organizational rationales for vertical integration.

Jungsuk and Chang (2000) try to justify vertical integration using a two-stage game between two oligopolistic firms: a content provider and a conduit provider. In the first stage of the game, providers simultaneously choose product quality, and then compete in price. Defining service quality in terms of download waiting time, and assuming zero marginal costs for both providers, they determine which effects have second-stage price bundling on aggregate profits and service quality. Their results show that a *strategic vertical alliance* generally increases both.

Some observations on Jungsuk and Chang's paper may further help to introduce our set-up. Firstly, they model price competition between content and conduit providers, not treating network services and content markets as separate market structures. Hence, their set-up is unlikely to be able to deal with successive monopolies. In this scenario, vertical price externalities may become a crucial issue. Secondly, Jungsuk and Chang (2000) propose a multi-stage/simultaneous competitive game. Nevertheless, this may not be the most appropriate game form, since network applications for content delivery usually have a sequential structure (see Liver and Derrler, 2000) and price decisions are consistently taken sequentially. Especially where both providers are monopolists and can impose *take-it-or-leave-it* choices on the other player, first (or second)-mover advantage plays a crucial role in aggregate profit partition. Finally, if some active network services are essential in

defining the quality of services, some non-zero marginal costs may be raised in performing these functions. Hence, their assumptions of content delivery quality simply defined as waiting time and zero marginal transit costs are in doubt here.

Thus, the literature reviewed above does not provide a satisfactory answer to our starting question: is profitability of vertical integration between network firms and content providers invariant with respect to different network architectures for content delivery? In order to explore this issue, in the following pages we develop a simple microeconomic model.

3 Successive monopolies, content delivery and vertical integration

Consider the above network infrastructure and the two models of content delivery. On the demand side, let us suppose we have N consumers. For the sake of simplicity, each of them buys only one unit of content. Preferences are represented by the following utility function:

$$(1) \quad u = \delta s_0 - p - b$$

where δ is a preference parameter for quality, uniformly distributed on a unit support; s_0 is the content quality, p is the price paid by consumers for a unit of digital content and b is the price of receiving the content. Let us suppose that $b = \alpha t$, where t is the network transit price required by the conduit firm to deliver the content, and that $\alpha \in [0,1]$ indicates the share of t paid by consumers. Traditionally, if utility is lower than zero, then consumers do not buy. Hence, other things equal, the content is purchased by those consumers characterized by $\delta \geq \frac{p + \alpha t}{s_0}$.

Therefore, aggregate demand for contents is equal to:

$$(2) \quad D_c = N \left[1 - \frac{p + \alpha t}{s_0} \right]$$

On the supply side, the conduit provider sells network bandwidth to the content firm for delivering its products. Supplied contents have been paid off by previous users (that is, sold to radio or TV programs) and thus the content marginal costs of production are zero. Moreover, since the network truncations we deal with are assumed to be un-congested, their marginal usage costs are equal to zero, too.

Nevertheless, the conduit firm's marginal costs are not zero, since some network services are implemented through a proxy server. These services are seen to be crucial for implementing a sufficiently high level of s_0 , without which market extension might collapse. Let us assume, for the sake of tractability, that their quality is fixed and their marginal costs are equal to c . Moreover, assume that $1 < c < s_0$, that is, active network service marginal cost is not negligible, and reservation prices of top-quality consumers ensure at least network cost recovery. Hence, the firms' problems are simply given by:

$$(3) \max_t \Pi_{NP} = (t - c)N \left[1 - \frac{p + \alpha t}{s_0} \right]$$

$$(4) \max_p \Pi_{CP} = [p - (1 - \alpha)t]N \left[1 - \frac{p + \alpha t}{s_0} \right]$$

With a Pull model of content delivery, firstly the conduit provider chooses a profit-maximizing price by taking p as fixed. This affects consumer demand for the contents. Then the content provider selects a profit-maximizing price for its product. Obviously, with a Push model, price decisions take place the other way around. Thus, we have two sequential games with perfect information. In both cases, we can determine Nash equilibria using a backward induction procedure.⁵

In the case of de-integration, equilibrium prices and profits in a Pull/Push Model of content delivery are respectively given by:

$$(4) \quad p_{pull}^* = \frac{s_0 - \alpha^2 c}{1 + \alpha}; \quad t_{pull}^* = \frac{1}{2(1 + \alpha)}[s_0 + (1 + 2\alpha)c]$$

$$(5) \quad p_{push}^* = \frac{s_0(3 - 2\alpha) + (1 - 2\alpha)c}{4}; \quad t_{push}^* = \frac{s_0 + c}{2}$$

$$(6) \quad \Pi_{pull}^{NP} = \frac{N\alpha(s_0 - c)^2}{4(1 + \alpha)^2}; \quad \Pi_{push}^{NP} = \frac{N(s_0 - c)^2}{8s_0}$$

$$(7) \quad \Pi_{pull}^{CP} = \frac{N\alpha(s_0 - c)^2}{4(1 + \alpha)}; \quad \Pi_{push}^{CP} = \frac{N(s_0 - c)^2}{16s_0}$$

where NP indicates the network firm and CP the content provider.

Thus, it is easy to show that $\Pi_{push}^{NP} > \Pi_{pull}^{NP}$; $\Pi_{pull}^{CP} > \Pi_{push}^{CP}$; $t_{push}^* \geq t_{pull}^*$ and $p_{pull}^* > p_{push}^*$ for any value of α .

Intuitively, these results are explained by evoking a *second-mover advantage* (Amir and Stepanova, 2000). In each model, the first mover sets a lower price to boost consumer demand. Then second-movers set higher prices to extract a larger portion of consumer surpluses. We get a clear-cut illustration of these effects, when we focus on how the network service price changes in the two models of content delivery, and with respect to parameter α . In fact, in the Push Model of content delivery, a network provider sets the highest price of data delivery, regardless of the proportion of the final price paid by consumers. The content firm lowers the content price by an amount parametrized to the network service marginal costs. On the contrary, in the Pull Model, network transit price strictly decreases with respect to α with $t_{pull}^* = t_{push}^*$ only if $\alpha = 0$ and $p_0 = s_0$.

With vertically integrated providers, price decisions are taken simultaneously by the integrated firm (IP , henceforth). When we maximize joint profits with respect to p and t ,

⁵ Calculations are available upon request.

we obtain that, with a non-negative network services price, equilibrium prices and profits are given by:

$$(8) \quad t_{IP}^* = 0$$

$$(9) \quad p_{IP}^* = \frac{s_0 + c}{2}$$

$$(10) \quad \Pi_{IP}^* = \frac{N(s_0 - c)^2}{4s_0}$$

Note that the vertical integration alleviates vertical price externalities and double marginalization effects⁶. The content price is now higher than the de-integrated content prices in both models of content delivery ($p_{IP}^* > p_{pull}^* > p_{push}^*$) but t is now equal to zero.

Comparing, (10) with de-integrated provider equilibrium profits for both models of content delivery, we can show the following

Proposition: With the Push model of content delivery, vertical integration is always an optimal strategy, whereas with the Pull model of content delivery, vertical integration increases profit if and only if content quality is low. Moreover, in the case of higher content quality, vertical integration is profitable in the Pull model if and only if a small portion of active network services costs is paid by content consumers.

Proof. Comparing (10) with the sum of the profits appearing in (6) and (7), it is easy to get that:

$$\Pi_{IP}^* > \Pi_{push}^{NP} + \Pi_{push}^{CP}$$

for all values of model parameters. At the same time, for the pull model, we have:

$$\Pi_{IP}^* > \Pi_{pull}^{NP} + \Pi_{pull}^{CP} \text{ if and only if } s_0 < \bar{s} = \frac{4}{3}, \text{ or}$$

$$s_0 \geq \bar{s} \text{ and } \alpha < \bar{\alpha} = \frac{[s_0(s_0 - 1)]^{1/2}}{s_0 - 1} - 1 \quad \text{QED.}$$

Intuitively, vertical integration between content and conduit providers is a profit enhancing strategy, whereas large bandwidth multimedia streams (like real-time data flows) are pushed in the web by providers, or small bandwidth contents of low quality can be pulled directly by consumers.

⁶ Double marginalization effects can persist after vertical integration especially if branches of bigger organizations behave autonomously. Here, we do not consider the issue of internal organization of divisional corporations. For contributions on divisional firms, see Bàrcena-Ruiz and Espinosa (1999) and relative references.

On the other hand, if a Pull model is adopted by providers for light size contents (like HTML pages or GIF images), vertical integration may involve lower profits if high quality has to be ensured and consumers are supposed to pay (almost all) network service costs. In this case, internalising these costs may induce a reduction in network management revenues which are not fully compensated by larger selling revenues. Thus, with the exception of the latter case, large merger and acquisition activities in on-line content markets are likely to be predicted. Since nowadays the public Internet is essentially based on the pull paradigm, accordingly to our set-up, we can predict that vertical integration tendencies will be reinforced as soon as new multimedia applications are sufficiently widespread.

4 Concluding remarks

In this paper a basic assessment of vertical integration rationales for network and content providers has been presented and discussed. As recently stressed by Rollen and Wey (2003), intense and cross-border merger activities by large oligopolistic firms are a peculiarity of *New Economy* markets. In particular, *Machinery and Computer Equipment* and *Business Services* have been the industries with the highest number of mergers during the '90s. This trend raises several issues concerning regulatory economics. Among them, one pernicious problem is how to sustain competition in markets where product complementarities, non-convex costs and demand-side economies of scale generally make consumers better off, the higher the degree of market concentration. Our discussion suggests that in the next decade, many mergers will probably take place in *On-line Content* markets as well. Like computer markets, these markets are characterized by network effects, service complementarities and switching costs. Furthermore, in on-line content markets many contents ought to be monopolistically provided on the Web by labels through copyright protection. Thus, on-line content markets may be described as concentrated markets with well-grounded tendencies to huge merger activities. Once this description is accepted, a reformulation of the above dilemma for regulatory agencies may emerge. Given the actual conditions, is it socially preferable to block vertical integration waves, thereby inducing double-margins, or is it socially better to accept mergers and acquisition tendencies in on-line content markets as long they increase consumers' satisfaction and firms' profits?

In our view, on the one hand this dilemma involves serious consideration of the extent of copyright protection since it is one thing to download replicable content sold at a monopolistic price, and another to repeatedly download non-manipulable content. On the other hand, solving the issue may require the definition of a regulatory framework for on-line content markets, in which competition policies are logically intertwined with inevitable market concentration.⁷

After the AOL-Time Warner case, the European Commission stressed the importance of vertical integration and vertical foreclosure for on-line entertainment and media industries. As has been emphasized by a consultant's speech to the Competition DG: "*The Commission found that the new entity resulting from the merger would have been able to play a gate-keeper role and to dictate the technical standards for on-line music delivery,*

⁷ In this context, regulation could foster effective competition between different kinds of information networks (cable TV, satellite, telecomm, fiber-optic and others) or impose common carriage.

that is, the streaming and downloading of music from the Internet. Consequently, AOL/TW could end up holding a dominant position on the emerging market for on-line music delivery”.⁸ For instance, vertical integration and the development of new technical standards for content delivery could foreclose on-line music markets, reinforcing the network effects and positive feedback for large providers owning a critical mass of contents. Our discussion confirms such concerns, and may help to predict that vertical alliances will increase in the near future, moving from a WWW-based pull paradigm to a synchronized push paradigm for large data transfers.

5 References

- Amir, R. and A. Stepanova (2000) “Second-Mover Advantage and Price Leadership in Bertrand Duopoly,” Discussion Paper No10, Centre for Industrial Economics, University of Copenhagen.
- Bàrcena-Ruiz, J.C. and M.P. Espinosa (1999) “Should Multiproduct Firms Provide Divisional or Corporate Incentives?” *International Journal of Industrial Organization*, 17: 751-64.
- Fry, M. and A. Ghosh (1999) “Application Level Active Networking,” *Computer Networks*, 31: 655-67.
- Harumoto, K., T. Nakano and S. Shimono (2000) “An Architecture for Adaptive Multimedia Content Delivery,” *New Generation Computing, Computing Paradigms and Computational Intelligence*, 18: 375-89.
- Jungsuk, C.O. and S.G. Chang (2000) “Incentive for Strategic Vertical Alliances in On-line Information Product Markets,” *Information Economics and Policy*, 12: 155-180.
- Liver, B. and G. Dermmler (2000) “The E-Business of Content Delivery,” IBM Research, Zurich.
- MacLarty, G. and M. Fry (2001) “Policy-based Content Delivery: An Active Network Approach,” *Computer Communication*, 24: 241-248.
- Mendes Perreira, M. (2003) “Vertical and Horizontal Integration in the Media Sector and EU Competition Law,” Speech delivered to European Commission Competition DG, Brussels.
- Paltridge, S. (1999) “Mining and Mapping Web Content,” *Info*, 1: 327-341.
- Rapp, L. (2000) “The Napsterization of the European Content Industry,” *Info*, 2: 551-569.
- Rollen, L. and C. Wey (2003) “Merger Control in the New Economy,” *Netnomics*, 5: 5-20.

⁸ See Mendes Perreira (2003).

Rousseau, F. and A. Duda (2000) “An Advanced Multimedia Infrastructure for WWW-based Information Systems,” *Netnomics*, 2: 279-91.

Rubinfeld, D.L. and H.J. Singer (2001) “Vertical Foreclosure in Broadband Access?” *The Journal of Industrial Economics*, 49: 299-318.

Shy, O. (2001) *Economics of Network Industries*. Cambridge, (MA), US: MIT Press.

Spengler, J. (1950) “Vertical Integration and Anti-trust Policy,” *Journal of Political Economy*, 58: 347-52.