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**VIRTUAL NETWORK OPERATION  
Strategy, Structure and Profitability  
by  
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**THE ECONOMICS OF TELECOMMUNICATIONS**

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## ABSTRACT

This report describes and analyzes critical conditions for achieving net benefit from opening the value-chain in telecom by introducing virtual network operators (VNOs). These are facility-less operators that outsource most of basic service production, while focusing on a smaller core business in intelligent network operation, service innovation and distribution. Whereas one essential condition for profitable return is that the VNO is granted significant influence both over service offerings and the price margin between final user price and rental price, this is far from a sufficient one. In addition, several conditions related to transaction attributes, production technology and supplementary resources along with sufficient degree of effective competition and efficient governance, must also be fulfilled.

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## 1. Introduction

The purpose of this paper is to analyze how incumbents and new entrants may benefit from opening the value-chain in telecoms and from creating virtual network operators (VNOs). The latter are facilities-less service providers that own and control only a smaller core of selected network devices and service applications, while contracting out the remaining network and application services that are necessary to provide the final service bundle to customers as promised. To profit from their business, the price difference between final user price and rental price must cover more than the VNO's own service production cost. Generally, this margin is narrower, and the chances for extra profit smaller, when prices and services are tightly controlled by the network operator than when prices and services are less controlled by network operator and correspondingly more influenced by the VNO itself (or by the regulator on behalf of the VNO). Under certain conditions related to service transactions, production resources, competition and governance, this separation may contribute both to more efficient utilization of existing network resources, and to more efficient development of new networks and services. Whereas this possibility is also recognized by many regulators, the net benefit of virtual network operation tend still to be regarded as too uncertain and probably negative.<sup>1</sup> The main reason for such skepticism seem to be the expected negative incentive effects that such a regulation may have on investment in future networks such as in 3<sup>rd</sup> generation mobile network (UMTS network). However, this negative effect will depend on both the financial model chosen for building and operating such networks and the industrial dynamics released by opening the value-chain in general, and introducing virtual network operators in particular. My intention with this paper is to start a more open and critical assessment of this difficult, but very important question.

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<sup>1</sup> This was the conclusion reached by the British regulator Ofcom and Norwegian Department of Communication that recently evaluated the concept of virtual operators in mobile communication.

## 2. The Essence of Virtual Business Practice

### 2.1 The Core Issue

As indicated above, the crucial question is whether logically separable activities – basic network services and enhanced (advanced) services - are technologically separable, and if separable, whether they still are too interdependent to justify full corporate separation. If so, what may be causing such interdependence between technologically separable activities? On the other hand, if basic and enhanced services are technologically separable, but only moderately interdependent, what is then the most efficient mechanism for safeguarding the underlying investment in physical infrastructure, supplementary resources and service capabilities? Would simple contracting suffice, or will more hierarchical structures be needed such as strategic alliance or long term exclusive contracts? Transaction cost economics, the premier theoretical approach in analyzing such problems, will serve as our theoretical guide, here applied in a somewhat more resource-centric and dynamic fashion than usual.

### 2.2 Defining Virtual Network Operators

Virtual network operators (VNOs) are operators that own and control a minimum of higher-layer network infrastructure while contracting out all of the remaining lower-layer infrastructure (cables, switches, etc.). Alternatively, a VNO may be defined as an enhanced service provider that owns and controls only those facilities that produces the enhanced features that may differentiate its services from those of its competitors, whereas all the remaining basic infrastructure is rented, or the associated network service bought, from facility-based operators. Since intelligent facilities and service applications are the primary means by which VNOs make revenue and profit, these should also be owned and controlled by VNOs. Normally, expected profit-margins will be lower on transport and access service that virtual operators only rent or buy, than on intelligent nodes and application that the operators privately own and actively manage, unless prices are set below cost by the regulator.

Physically, the VNO's own network devices and service applications can either be hosted by the incumbent or by the VNO. In the latter case, VNO's devices and applications are connected to those of the incumbent across more or less standard interfaces, making the former more or less independent of the latter. To create virtual network operations, access not

only to the incumbent's physical network but also to his Operational Support Systems (OSS) software is an absolute necessity. These are computer databases and systems that provide services and network management, administration, planning and repair functions, as well as functions related to customer operations, such as customer care and billing. In other words, whereas network facilities and service applications are the hardware and software needed to produce and deliver telecom services to final users, interface standards are specifications that more or less seamlessly interconnect the hardware and software of the VNO with those of the incumbent or other complementary network operators, making the former interoperable with the latter. In this respect, opening the value-chain essentially means turning previously closed and proprietary interfaces into open and non-proprietary ones, while simultaneously offering network facilities and service applications that newcomers can afford to rent or buy. Except for the latter renting and pricing issue, opening the value-chain in telecoms is strikingly similar to opening the value-chain in the computer industry. In particular, as telecoms converge with computing, lessons from the computer industry may increasingly become relevant for the telecom industry.

Also facility-based operators are forced to buy network services from each other when subscribers of one network call subscribers of other networks. Normally, the cost of using a larger network will be lower, because of economies of scale, than using a smaller network (given sufficient capacity utilization).<sup>2</sup> When selling at approximately the same final user price, this will result in a higher profit margin, and therefore also a higher stock market price per subscriber, for the larger than the smaller network.<sup>3</sup> This will be true at least up to some size level (given the same usage level per subscriber), dependent on attributes such as subscriber density, network configuration, service-dependent resources etc. Due to constantly evolving network technologies and service applications, there are currently few reliable estimates of the minimum efficient size of telecom networks. Potential scale economies may still be substantial since the use of both telecom network and service applications have the typical scale economic cost structure of very high fixed and very low (close to zero) marginal costs. Strong belief in scale economies is also the driving force behind many of the recent

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<sup>2</sup> Economies of scale depends on the size of the fixed cost component and the functional relationship between cost per subscriber and number of subscribers. While some service costs vary proportionally with the number of customers, others vary digressively or not at all. With zero fixed costs, only the latter two cases warrant larger network to be higher priced per subscriber than smaller networks due to larger economies of scale.

<sup>3</sup> Typically the price per subscriber of the larger Mannesmann mobile network (ca. \$ 7.000) was almost twice the price of the smaller Orange network.

mergers and acquisitions, especially in larger liberalized markets such as in the US fixed telephony market, but also in the rapidly growing mobile communication market where operators on the average are younger and smaller (also in terms of market share) and have larger growth and technical development potential than in the fixed-line market.

Thus, virtual network operators will only survive to the degree such economies of scale can be attained just as well by selling to external as to internal service providers; that is, by separating network operation from service provision. Since this cannot be excluded, some incumbents have already started to explore the profitability of VNOs, especially in foreign market where the roles are reversed, and the need for an alternative VNO-strategy is more pressing.<sup>4</sup>

### **2.3 The Separation Issue**

Dividing integrated telecom enterprises into distinctive businesses, separated by technical and contractual interfaces, has for quite a while been the standard approach for introducing competition in the telecom sector, strongly promoted by regulator and new entrants, and gradually accepted by incumbents. Considerable differences still exist, however, concerning which activities to separate out, and to what degree. While regulators and new entrants seem to prefer that technologically separable activities should also be organized as independently owned businesses, most incumbents are strongly against this. Their objection would generally be that most activities that seem to be technologically separable, are considerably less so, and of those that are, many are still too interdependent to justify full corporate separation. Forcing corporate separation between activities sharing the use of common non-redeployable and/or non-tradable assets would simply cause transaction costs to exceed the associated separation benefit (positive competition effects). Incumbents have therefore been considerably less reluctant in accepting the location of interconnection points outside systems of highly interdependent or non-tradable resources than inside these systems as suggested by initiatives such as local loop unbundling and mobile network roaming (Ulset, 1998a).

Recent interconnect arrangements, especially of the less intervening kind, have not only made it easier for telecom brokers and resellers to buy and sell excess capacity, but also enabled

new entrants to seamlessly interconnect their smaller network with the larger network of the incumbent. Now, as the telecom technology has turned more complex, higher technical layers have been added to the basic infrastructure, and more specialized service and support functions have developed, the question of separation has also been extended to include these layers, services and functions. Dividing the infrastructure into independent layers would help to create technology-independent services and service-independent technology. It would also make it possible for independent operators to specialize on different layers and to combine their services, under some kind of bundling contract, into either standardized or more customized packages for sale to final users.

Whereas the regulator have regarded corporate separation as a last resort measure for developing competition, incumbents have claimed that such separation will seriously weaken their technical abilities and economic incentives to develop new services. Their argument would be that network facilities, although technically separable, are still too much interdependent, or too difficult to rent out, to justify full corporate separation. Albeit less openly debated, a more threatening possibility would be that such regulatory enforced separation would enable virtual operators to take full control, not only over value-added services, but also over the customer base, thereby reducing physical network operation to a low-margin commodity business (pure transporters of non-differentiable bit streams).

### **2.3.1 Technological separation**

As technologies and markets have kept evolving, the issue of separation has also become more complex. This relates not only to organizational separation which may vary in degree from accounting to full corporate separation, but also to technological separation which may vary in terms of effectively separable layers, from the lowest physical substrate layer to the highest final user applications layer.<sup>5</sup> Due to the enormous complexity of modern telecom network and services, along with the large share of non-allocable sunk cost, defining and

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<sup>4</sup> This has led Telenor and BT to develop a business plan for a software-based telco, named Facet, which illustrate perfectly the VNO concept (Halbo et. al., 1999a, 1999b).

<sup>5</sup> Neither should telecom services include only network services made separable through initiatives such as local loop unbundling, mobile network roaming and the widespread use of Internet technology. Relevant services should also contain distribution of information, education, entertainment and electronic commerce over the Internet, as well as the full range of specialized downstream customer services and support such as wholesale, retailing, customer support, system integration, outsourcing and consulting, the latter being probably more separable from network infrastructure than content distribution.

pricing unbundled elements and services unambiguously, has been very difficult, almost impossible, causing substantial uncertainty and skepticism among incumbent operators. If the infrastructure should be forced open by regulators, incumbents fear that the associated price for renting or leasing network elements would no longer cover their cost, thus destroying their incentives for investing in new infrastructure and in the development of new services. No wonder then, that initiatives such as local loop unbundling, asymmetric roaming and virtual network operation has been strongly rejected by most incumbents.

### **2.3.2 Administrative separation**

Whereas the technical separation issues are many, varied and highly complicated, the associated organizational separation question is always the same; namely, what corporate boundaries and structures are likely to become the most efficient and sustainable ones in the telecom sector? In particular, what corporate boundaries and structures are most likely to survive the first waves of privatization, mergers, acquisitions and restructuring following the recent massive deregulation and liberalization of the telecom sector? More strategically, what are the major sources of competitive advantage in the larger telecom sector, and what is the most efficient or profitable organizational structure for developing and deploying those assets? Is dominant market positioning still the most important profit-generating source, or will distinctive competencies replace market power as the primary source of sustainable supernormal profit (economic rent). This is also the main question of this paper, focusing mainly on the separation of virtual (facility-less) from physical (facility-based) network operation.

## **2.4 The Competitiveness Issue**

### **2.4.1 Competitive advantage in general**

To answer the above question, we first need a clearer understanding of possible sources of competitive advantage and how these may be affected by separation. First of all, to attain competitive advantage in general, companies must be able to develop and deliver products or services at lower price or higher quality than their competitors. This can be achieved by developing superior competence (e.g; technology, management, marketing etc.), by building

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stronger market positions (e.g., dominance, legal patents, exclusive licences etc.), or by some combination of the two (i.e.; lower cost due to earlier entry and deeper learning over longer time). For example, the previous monopoly operators could operate their nation-wide networks at lower accounting cost per minute than their competitors, not only due to over-depreciation during the previous monopoly period, but also due to superior competence in running those network accumulated over a longer period of time.

Then, superior competence can be used partly to reduce production costs, partly to develop more functional products at higher price. Whereas in the first case, competitive advantage and extra profit is the outcome of cost leadership, in the latter case this is the result of product differentiation and innovation leadership. Underlying both cost leadership and innovation leadership, there usually are some valuable assets that are both relatively superior compared to those of the competitors, and inimitable or otherwise protected from leaking out to competitors. In the cost leadership case, these resources are used to produce an increasing number of identical or closely related products at more rapidly declining unit costs than possibly managed by competing operations. In the innovation leadership case, common resources are used for developing faster or less costly processes than those of competitors. To the degree specific resources that contribute to the development of cost leadership or innovation leadership are difficult to trade in ordinary markets, competitive advantages will be more rapidly developed and more efficiently exploited by units of the same enterprise than by comparable units organized as independent suppliers in the market or as part of another and differently diversified and integrated enterprise.<sup>6</sup>

In other words, the non-tradability of the services associated with the development and the subsequent utilization of critical resources is the major conditions for corporate integration. Note that “non-tradability” is here used comparatively, meaning that development and/or utilization of these resources is considerably more costly or time-consuming to carry out by independent firms in a market than by integrated firms. This distinction corresponds of course to the more general distinction in transaction cost economics between autonomous and coordinated adaptation (Williamson, 1991) and, in particular, to the distinction between

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<sup>6</sup> Resources such as network and competence in running the network can be traded either as objects in which case the respective physical or human assets are permanently sold, or as services in which case they are only rented out for a specified period of time. When competence is rented out, the objective may sometimes be to transfer or duplicate competence to the benefit of the client, in which case the competence both is rented out and sold.

autonomous and systemic innovation in the innovation literature (Teece, 1986; Chesbrough and Teece, 1996). In the systemic case, technical improvement or innovations in single components would require simultaneous changes of the other components making up the larger system. Under autonomous innovation, however, individual components can be replaced by new ones without negatively affecting the functioning of other components or the system as such.

#### **2.4.2 Competitive advantage from virtual network operations (separation)**

The existence of independent VNOs, however, poses a rather crucial dilemma. By specializing in the more advanced higher-layer features, virtual operators may on the one side reduce lower-layer physical operation to a low-profit commodity business without leaving sufficient surplus to finance next-generation infrastructure investment. On the other hand, by specializing on more advanced features, virtual operators may also contribute to a higher innovation rates in the deployment of higher-level applications and development of value-added services.

In general, by focusing on a smaller core of resources, virtual operators may achieve extra profit to the degree these resources are valuable, rare and inimitable (Barney, 1997, chap. 5), as specified in the listing below:

Sources of competitive advantage (including both physical and human assets):

- Valuable assets (effective in significantly reducing cost and improving quality and price)
- Rare assets (generate economic rent due to “scarcity”)
  - different (significantly different from competing alternatives, relatively unique)
  - non-substitutable (no useful substitute; absolutely unique)
  - specific (irrelevant to copy)
- Inimitable assets (difficult to copy/duplicate)
  - invisible: unaware of the underlying knowledge
  - tacit: non-codified or difficult to communicate
  - sticky: inseparable from the person possessing the competence
  - diffused: distributed over a larger number of team members

- natural monopoly: extreme scale and scope economy
- Patented assets (illegal to copy)

Resources such as physical and human assets are valuable to the degree they have potential large effects on profit or value added. They are rare in the sense of being either scarce (few competing suppliers), different (very different from similar resources at the competitors' disposal; even unique), non-substitutable (no useful substitute to perform the function) or specific (of less productive value for alternative users or uses). Being rare in the absolute sense means that no useful substitute exists (e.g. telephone lines before cellular and satellite). Resources such as technology, knowledge or competence may be difficult to duplicate or copy either for "technical" reasons: to the degree they are invisible, tacit, sticky or diffused; or for economic reason: to the degree they constitute a natural monopoly or exhibit extreme degree of economies of scale or scope. Given that the above resource-based conditions are met, VNOs will still need efficient organization and management structures to transform potential sources of competitive advantage into sustained competitive advantage with above-normal return.

To reach expected growth in advanced services and content, large-scale investment in broadband capacity will be needed both in the transport and access network. Most observers agree, however, that the chances of achieving higher margin by means of product differentiation is far better on advanced service and content than on transport services and local access. Being deeply embedded in, and practically inseparable from, the larger physical network, service development tools will for some time remain an integral part of the installed IT-systems. This, however, may gradually change as the older circuit-switching network is replaced by next generation packet-switching IP-network. The Internet technology may then cause intelligence in service development to be transferred from the IT-systems in the network to intelligent servers and computers belonging to virtual operators and final users, thus making the underlying physical network basically dumb (and correspondingly unprofitable).

Which type of company will be best positioned or endowed to achieve such differentiation advantage on the next generation IP-platform - large integrated enterprises or networks of smaller specialists - is still unclear, although most operators and observers seem to believe in the large-scale integrated structure as the most efficient and profitable one. For example, local

incumbents still prefer merging with other incumbents, so that larger synergies and cost reduction (5-10%) can be attained, instead of competing on duplicated facilities and personnel in each other's home markets. The synergy from merging, however, can seldom be achieved without negative competition effects, including the attended risk of rising costs in the longer run. At least from a welfare economic point of view, mergers should not be recommended unless the positive synergy effects substantially exceed negative competition effects.

The most efficient alternative to competing on duplicated resources may, however, not be corporate integration, but rather duplication-less competition, based on leased lines, interconnection, unbundling or similar shared network usage such as mobile network roaming between otherwise rivaling operators. In particular, to the degree virtual operators develop into a rather efficient solution for new service creation and network capacity utilization, the synergy effects of mergers may easily turn negative. Virtual operators may win extra profit if cheap transport and access services are combined with advanced functionality and value-added services, produced by the VNO's own facilities and capabilities. On the other side, virtual operators will probably not be able to capture extra profit to the degree the supply of supplementary resources and services are monopolized, unless the price on those resources and services is regulated and offered at prices below historic full-cost (e.g., equal to long run incremental cost). At the same time, VNOs who rent, rather than own basic infrastructure, are compelled to specialize on a narrower field of core assets to achieve competitive advantage, the effects of which could be that additional benefits from higher specialization exceed additional transaction costs from more dispersed and specialized operations.

#### ***2.4.3 Expropriating economies of scale and scope (core assets)***

The crucial question is, however, not the size of economies of scale and scope, but whether physical operators of larger network can prevent VNOs, as well as facility-based competitors, from "expropriating" a significant share of such economies. Such expropriation of surplus will be prevented to the degree the quality is lower and/or the price higher on services that the incumbent delivers to external customers than to internal ones. For several reasons, this may often be the case.<sup>7</sup> Even though the regulator officially prescribes and expects that the same quality and price are offered external customer as that to internal subsidiaries, this objective

will normally not be achieved, due to technical difficulties and conflicts of interests. In turbulent times where technology standards, regulation and business practice are still evolving, both technical incompatibility and conflicts of interests will normally work against external customers.

As long as the incumbent controls the only fixed-line access network available, competing physical network operators can be prevented from achieving economies similar to that of the incumbent, simply by providing access services of lower quality or higher price to competitors than to himself. The conditions and mechanisms making this possible are the same as for virtual operators mentioned above. In the access market, however, alternative radio, cable, electrical and cellular access may soon develop into a competitive alternative to fixed lines (even with ADSL installed), and when this happens, the incumbent's first mover advantage will soon be gone. This will subsequently also help virtual operators that will be in a stronger position to buy competing high-quality access and supplementary support services at a lower price. Net brokers and retailers will also buy and sell network capacity, but contrary to VNOs, these will only compete with physical operators on service provision, not on network operation. Consequently, one may regard brokers and retailers as representing a more promising complementary growth opportunity than VNOs who will also be regarded as potential competitors.

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<sup>7</sup> This has been the experience in USA ever since the FCC tried to implement the unbundling regime as part of the Telecommunication Law of 1996.

### 3. Virtual operation in ICT

To get a somewhat deeper understanding of the economic effects of separation, let us take a closer look at the development of the ICT industry, especially the computer industry and the Internet business.

#### 3.1 Lessons from the computer industry

##### **3.1.1 *Open proprietary standards, innovation and growth***<sup>8</sup>

Until the late 1970s nearly all computers were large machines used for mind-numbing calculations and book-keeping, mostly bought by larger organizations that could afford their price and service costs. Computers such as mainframes and minicomputers were the most complicated machines ever produced. They were sold in a relatively small number, and mostly produced by large companies that were vertically integrated from basic circuitry, computer platforms and operating system software to application software and distribution. Newcomers had a hard time breaking into the business for several reasons. First, few had the resources necessary to enter at all levels simultaneously. Second, for those who entered at one or two levels, the small number of independent supplier and distributors made it immensely costly to operate. Third, due to the machines' complexity and service needs, most customers were reluctant to buy from anyone but large, established suppliers.

Until then vertical integration had served two purposes. First, by internalizing the process, computer makers controlled technology leakage so that incompatible systems could be developed and sold to increasingly captive customers. Second, by internalizing the process, the computer makers could develop and deploy firm-specific assets more efficiently for the production of differentiated products. Since the production system was linked together by closed interface technology, bilateral monopolies had arisen between component suppliers and assemblers that could be managed more efficiently by hierarchy than by market contracting. All these production systems remained therefore vertically integrated until challenged by a significantly more efficient technology, the personal computer (PC) technology. With this technology installed, distributed computing and networking soon became a more flexible and efficient alternative to the mainframe system for ever-more complex and power-consuming

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<sup>8</sup> This subsection is previously published in Ulset (1994).

tasks. Since the new computers could be assembled from hardware pieces and software components supplied by independent firms in the market, the new computer industry was never vertically integrated as the old computer industry. Coordinated by open interface standards, interchangeable components were outsourced to achieve economies of scale without the risk of excessive transaction costs. The need for vertical integration to control technology leakage and to manage firm-specific assets along the value chain decreased.

From its inception, the personal-computer market assumed a different pattern from the established industry, mainly because of rapid diffusion of new technology. The chip manufacturers were now able to cram a simple version of a computer's central processing unit, the circuits that did most of the actual computing, on to a single chip, a so-called microprocessor. Around this, a small cheap machine could be assembled from readily available parts used to supply the consumer-electronics industry. The most successful of all personal-computers, the IBM-PC, based on Intel's microprocessor and Microsoft's operating-system, became the industry standard for which a large number of application software firms wrote their programs. Fortunately for both firms, full property rights to the basic technology were retained in the initial contracts with IBM, and due to this, a large number of chips and software copies could be sold at a premium price to a booming computer industry. A parallel rapid growth in compatible application software, developed by innovative third parties, created the "network externalities" that substantially improved the value of the underlying technologies. Since Intel and Microsoft through incremental innovations succeeded in keeping their technologies both proprietary and in strong demand, huge monopoly profits ensued. As IBM's losses kept skyrocketing, it became gradually clear to everybody that Intel and Microsoft had profited substantially more from the success of the PC than any PC-maker, including the largest of them all until then, IBM.

As additional software, equipment and network products were developed, the value of possessing an IBM-compatible computer continued to grow (so-called network externalities), and so did the sales and use of such computers. Spawned by a constant stream of technical innovations and improvements, mainframes and minicomputers lost out to PS network and stand-alone PC for steadily more complex tasks. As distributed computing and networking continued to replace the old mainframe system, the demand for open interface standards and intersystem compatibility continued to rise, stimulated by a more open system strategy. This was most strongly demonstrated by Sun Microsystems. Soon open product standards and

open network systems were demanded by most customers and supported by most computer makers. When open technology standards were supplemented with conversion programs and internetworking technology, the level of interoperability increased even more. Consequently, most personal-computer makers were never vertically integrated. Separate groups of firms supplied parts, fully assembled machines (platforms), operating-system software and application software.

By attracting a larger number of potential innovators, open standards contributed to the growth of network externalities, and thereby to the profitability of the firms that controlled these standards, such as Intel, Microsoft and Novel. Companies that did not control technology standards, including most computer makers, benefited less. When open and dominant standards are owned, patented or difficult to imitate, the owner of the standards will also tend to get rich. The assembler, however, will not tend to get rich unless some additional proprietary technology or competence is added to the system. While earning extra profit became constantly harder for computer makers, the owners of the original and incrementally improved standards got constantly richer. The emergence of open, but still proprietary standards, thus fundamentally redistributed competitive advantages and economic profits, from computer makers such as IBM (and Norsk Data) to chip producers such as Intel, and software firms such as Microsoft, Novel, Word Perfect and Lotus. Also the system-users benefited immensely. As long as they stayed within the dominant IBM-standard, customers could freely choose between a growing number of high-performing low-priced computer systems, and no longer needed to be exploited by their chosen computer maker.

However, proprietary standards will still exist, and as more companies start outsourcing a larger share of their component production, leading component technology may even develop into world standards. To the degree that these are owned by one supplier, considerably higher profits can be earned after the production systems have disintegrated than previously (which was and still is the case for Intel in microprocessors and Microsoft in operating-system software). Although positions as profitable as those of Intel and Microsoft are extremely rare, many firms regularly develop proprietary technology with significant profit potential. Even if future technology standards should be less proprietary than before, technological innovations within these standards can still be kept proprietary.

### **3.1.2 Dominance and antitrust**

Seldom can successes as impressive and positions as dominant, as those of Intel and Microsoft be achieved without the active use of monopoly power. Clever tricks and ploys that may pass when performed by non-dominant firms, may not pass, however, when carried out by dominant businesses. Gradually, this was also realized by Intel who wisely moderated its practice when requested to do so by the US Federal Trade Commission. Microsoft, however, did not moderate when asked to, but continued to punish companies that developed competing products (e.g., Netscape, Sun Microsystems) or customers that sold competing products (e.g., IBM, Gateway). The findings of the subsequent antitrust case of *U.S. v. Microsoft* thus unambiguously showed that Microsoft routinely used its monopoly power to crush competitors, even leading the judge to portray the company “as nothing less than a social menace” (Business Week, 1999, Nov. 22: 45).

After the court officially declared Microsoft a monopolist, regulators started to discuss remedies of which there are two major types: one behavioral type and several structural ones. The behavior remedy will require close supervision over issues such as pricing and contracts with other companies, eventually making the government the permanent overseer of Microsoft. Being very difficult to monitor, supervision of such behavior may either become overly costly and stifle innovation, or unreliable if not fully implemented. Structural remedies contain several dramatic measures such as breaking up the company into three vertically disintegrated companies (operating systems, application software, Microsoft Internet business) or three vertically integrated Mini Microsofts (“Baby Bills”), or forcing Microsoft to auction or license out proprietary technology to competing companies. The question is how to punish Microsoft and stop its abusive conduct while encouraging innovation and protecting the consumer. Although the different remedies may help to restrict monopoly pricing and power abuse they are not without costs and limits. Disintegration will not create competition in the market for operating systems, partitioning Baby Bills and auctioning Windows may fracture the Windows standard, and open-source code licensing may facilitate illegal copying. In any case, remedies can only be recommended if significant net benefit can be expected. Benefit can be gained from structural remedies both in terms of making the core technology more accessible and less costly for downstream customers, and in terms of making innovations in complementary products easier to develop and more profitable to commercialize for related businesses. Significant investment disincentives are, however, also

involved since structural remedies will make investments in operating systems less profitable for the main firm. A final decision is still pending and may remain so for quite a while.

### **3.2 Lessons from the Internet**

Under the virtual network operation model, modern technology enables coordination across firm boundaries as if the respective individual firms were parts of the same enterprise. The Internet has not only enabled the development of the World Wide Web and electronic commerce, but increasingly also a more advanced division of labor and inter-firm specialization, without the usual increase in transaction costs, also internationally. Through Web-based searching and ordering (internet/extranet/intranet), a larger portion of peripheral and semi-peripheral activities can be outsourced to external specialist, leaving a smaller and more focused portion of core activities to internal specialist, the effects of which would be quality improvement and production cost reduction, without the usual off-setting increases in transaction costs. A number of industries are now exploring these opportunities, but nowhere are these more challenging than in the multi-layered infrastructure of telecom service provision of which the Internet Protocol and WWW themselves are parts.

#### ***3.2.1 Open non-proprietary standards, innovation and growth<sup>9</sup>***

Internet was born about 30 years ago out of an effort to connect together a US Defense Department network called the ARPAnet and various other radio and satellite networks. The objective was to build networks that could withstand partial outage (like bomb attacks) and still work. In the ARPAnet model, communications occur by having computers talk to each other and ensures that the communication is accomplished. The network itself was assumed to be intrinsically unreliable as any part of it could disappear at any moment. To send a message, the computer simply had to put its data in an envelope, called an Internet Protocol (IP) packet, and address the packets correctly. The demand for networking then spread quickly, and Internet developers from US, UK and Scandinavia, responding to market pressure, began to put IP software on every conceivable type of computer. By then the International Standards Organization (ISO) had already spent years designing the ultimate standard for computer networking without making much headway. Users, however, adopted the IP instead. So did companies that developed workstations for local area computer networks (LANs), allowing all computers on such LANs to access ARPAnet facilities. One of those newer networks was

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<sup>9</sup> This subsection is previously published in Ulset (1996).

NSFnet, commissioned by the National Science Foundation, with the objective of connecting computers of major universities. Due to bureaucratic and staffing problems, NSF decided to build its own network based on the ARPAnet's IP technology.

Demand grew rapidly until the computers controlling the network and the telephone lines connecting them were overloaded. The network needed upgrading and professional management, and the contract was awarded to Merit Network Inc., which ran Michigan's educational network, in partnership with IBM and MCI. The number of connecting networks kept growing, gradually also including non-IP-based networks connected by special *gateways* technologies.

The ultimate authority for where the Internet is going rests with the Internet Society, or ISOC, a voluntary membership organization whose purpose is to promote global information exchange through Internet technology. ISOC appoints a council of elders, called the Internet Architecture Board, or the IAB, which meets regularly to confirm standards and allocate resources, such as addresses. It decides when a standard is needed and what it shall be. When a standard is required, it considers the problem, adopts a standard, and announces it via the network. The Internet Engineering Task Force (IETF) is another volunteer organization. It operates through working groups which anyone can join. These groups makes different recommendations that either are made available to anyone or sent to IAB to be declared a standard. These standards make computers from different vendors communicate, favoring no one in particular, whether IBM, Sun or Macintosh.

The participating networks financed by governments or private users, connect without a charge, only by adopting the open IP technology or some non-IP-technology with gateway to the Internet. The modern web servers and web browsers have spawned further growth. Although the Internet was for several years mostly used for information exchange and marketing, new communication software was gradually introduced allowing the Internet to also carry interactive voice traffic. By mid-96 the Internet reached nearly 5 million host computers and approximately 20 million users.

### **3.2.2 *The Bearer Service Concept of the Open Data Network***

In addition to its primary information purpose, the widespread acceptance of the Internet Protocol has organizational ramifications. By implementing the Internet Protocol, a spanning

layer is being built that separates lower-layered basic infrastructure (network services) from higher-layered value-added applications (customer services) thus creating the basic condition for the development of separate markets. The Internet Protocol enables applications to request network services independent of underlying physical network technologies. Moreover, new underlying network technologies may either substitute for, or co-exist with, existing network technologies without significantly affecting the broader system, enabling so-called autonomous innovations.

This kind of architecture separating service offerings from infrastructure facilities, is by the National Research Council more generally described as Open Data Network with four levels:

*“i) at the lowest level is an abstract bit-level service, the bearer service, which is realized out of the lines, switches, and other elements of networking technology; ii) above this level is the transport level, with functionality that transform the basic bearer service into the proper infrastructure for higher-level applications (as is done in today’s Internet by the TCP protocol) and with coding format to support various kind of traffic (e.g., voice, video, fax); iii) above the transport level is the middleware, with commonly used functions (e.g., file system support, privacy assurance, billing and collection, and network directory services); and iv) at the upper level are the applications with which users interact directly. This layered approach with well-defined boundaries permits fair and open competition among providers of all sorts at each of the layers”.*

In other words, the “bearer service” functions as a technology-independent network layer that resides above the technology substratum and enables interoperation between diverse, high-level applications and various underlying network infrastructure (Figure). As noted by Gong and Srinagesh (1996, 1997), this bearer service market may not prove sustainable unless competing services are differentiated. If not sufficiently differentiated, Bertrand competition will lead to destructive pricing for network services with close-to-zero marginal cost. One way to avoid Bertrand competition is through bundling of bottom-layer transport with higher services, closer to final customers (vertical integration). As facility-based companies integrate with others at higher layers, variable costs rise significantly along with minimum efficient size. Policies that promote competition in the provision of unbundled bearer service will therefore eventually fall. However, since bearer services that includes Quality of Service

guaranties for bandwidth, delays and losses, is not a commodity as pointed out by Kavassalis et. al. (1998), it can be differentiated by (i) choosing different substrate technologies, (ii) designing a different network typology than their competitors, and (iii) designing a different pricing policy for their service. The crucial point, however, is not whether the service can be differentiated, but whether such differentiation can be copied or imitated by competitors (Barney, 1997). It probably can be, but more easily by facility-less providers (virtual network operators) that are less restricted in choosing between competing substrata and networks, than by facility-based operators that are primarily restricted to choosing among their own substrata and networks.<sup>10</sup>

### **3.2.3 Internet and convergence**

According to many observers, the extraordinary rapid diffusion of Internet will soon also speed up the long expected convergence of the ICT industries.<sup>11</sup> That is, as the technologies for producing voice, data and video services converge, so might also the respective companies producing the associated devices and services. If so, we should now already have witnessed a large number of telephone companies expanding through mergers, acquisitions and generic growth into closely related fields. These would include not only a larger number of nearly identical operations and closely related wireless and cable networks, but also upstream equipment and content production as well as downstream data processing services and content distribution. Similarly vertical and horizontal expansion should be expected among other ICT companies, such as equipment suppliers that could have expand into television distribution and telephone network operation, and cable-TV companies into network operation, telephone services and data processing.

Over the last decade or so, there have also been many attempts at integrating these and similar activities, but until quite recently with only moderate success. As suggested above, interface standardization and tradability of complementary assets could be one the most plausible reasons. That is, by diversifying into related activities that share common resources, significant costs can be saved, superior assets developed, and extra revenue created, but only

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<sup>10</sup> In the same way as travel agencies owned by one of several competing airlines would be more restricted and less competitive than independent agencies

<sup>11</sup> Since this hypothesis is more thoroughly discussed elsewhere (Ulset , 1998), only a few introductory remarks and tentative conclusions are included here. ICT means Information and Communication Technology

to the degree essential conditions are fulfilled, concerning the attribute of underlying resources, and the corporate organization employed for using those resources. First of all, superior assets should be safeguarded by *contractual, legal, and strategic means*, that either (i) prevent such assets from leaking out to competitors or (ii) protect the corresponding profits from being captured by more strongly positioned suppliers or customers in the subsequent commercialization phase. Second, activities should be organized into business units and divisions, and internal governance systems (financial versus behavior control) designed and chosen for those units and divisions according to tradability of common resources so that financial control is selected over behavior control for non-related, but not for highly related activities where the opposite relation holds. As attributes of critical resources or services change, so should also their divisional structure and governance systems. I expect efficient telecom operators to be those that adjust their boundaries and restructure their divisions accordingly, and inefficient operators to be those that don not.

In a previous report (Ulset, 1998) I questioned the value of integrating primary telecom services not only with upstream equipment production, but also with upstream content production, as there is little common resources to be shared with these. As far as I could observe then, also midstream distribution of media products was little more than a pure conduit, where telecom operators basically provided a transport network of sufficient capacity for the respective media products. Downstream IT-services are probably more closely related to electronic equipment production, than to network operation, and should therefore normally be more efficiently carried out by computer companies or specialized distribution and service companies, than by network operators.

Since there are considerable physical and human assets to be shared, the economies from integrating voice services with data communication and video distribution should normally be significant,. However, as these assets are becoming increasingly tradable, the cost savings from integrating may gradually decline. Quite similar benefits could be obtained from expanding the number of local networks and from integrating transport networks with local access networks. However, also here tradability of critical resources is increasing, and the value of integration thus declining due to technology standardization and pro-competitive interconnection policy. If this is still the trend, the range of activities from which most telecom operators may gain a competitive advantage may gradually shrink towards that of a

pure conduit. However, until more systematic and recent data is available, the above statements should be regarded as largely untested hypotheses.

### **3.3 Preliminary Development in telecom**

#### **3.3.1 *The Sense and Teletopia initiatives***<sup>12</sup>

*Sense Communications* is a Norwegian-based firm that according to itself will provide new and innovative fixed and mobile services in the European market based on contractual agreements with existing fixed and mobile network operators. Originally their business strategy was to offer small and medium sized enterprises (SME) tailor-made communications services on an all-inclusive basis. Sense classified themselves as a virtual network operator (VNO) which offer services using other network operators' access and switching networks, only equipped with a minimum of network elements such as (i) Gateway Mobile Switching Centre (GMSC), (ii) Home Location Register (HLR) with Authentication Centre (AUC), and (iii) Subscriber Identity Modules (SIMs).

Sense wanted to use Telenor Mobils network to provide its own customers with direct network access and additionally offer one-stop-shopping of telecom services including; Virtual Private Networks (VPN), GSM, Centrex, FMC-services and voice-mail. High demand services should be offered from their IN-platform, others via contractors. Thus, the normal modus for Sense' customers in Norway would be roaming in Telenor Mobil's network, while connection in Sweden had to be provided through Telenor Mobil's international roaming agreements. Sense planed to invest NOK 1,3 billion (£100m) by year 2000, totally dependent, however, on access and interconnection with the networks of existing operators.

After a series of difficult negotiations with Telenor for interconnection, and with owners and creditors for additional money and equipment, Sense went bankrupt in March 1999. Soon after the company was reestablished by new owners. The previous NetCom assistant marketing director, Nadir Nalbant, was elected CEO. Then, after Elkjøp, a large electrical equipment chain (now Dixons) became owner and distributor of services Sense pioneered the launching of Free Internet (no subscription fee) in Norway. The competitors Telia, Telenor and Tele1 were completely taken by surprise. The demand was enormous, and by November,

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<sup>12</sup> The technical information source for this subsection is Halbo et. al. (1999a, 1999b).

Sense had delivered 50.000 Free Internet packages. In relative terms, this was equal to the success of the British company Freeserve one year ago. Now Free Internet is also offered by Telenor, Tele 2 Norge, Telia Norge, Dagbladet/Powertech, X-stream/Domino, TV2, NetCom GSM og CyberCity. Also Teletopia and Gratistelefonen will soon be launching their product.

Recently the new Sense signed a contract on buying traffic capacity and SIM-cards from Telenor which allows them to sell mobile services in their own name. Both parties are now seemingly well satisfied with the outcome. Stig M. Herbern, CEO of Telenor/Telia Mobile for the Nordic countries, says that this deal will stimulate competition and contribute to the development of mobile communication. Like old Sense, the new firm requires access to Telenor's mobile network on their own terms. They want to manage, not only resell, mobile traffic on Telenor's mobile network. Recommendations (largely negative) are formulated by the Department of Communication ready to be debated and finally ratified by Stortinget during the Spring session. In December Nadir Nalbant of Sense was elected "IT-manager of the year" by Telecom Revy for his contribution to bringing Free Internet to the people, and for stimulating innovation and competition in the Norwegian market.<sup>13</sup>

In 1994 Teletopia was established as the fourth telecom operator in Norway, after Telenor, Telia and Tele 2. The company is still a relatively small virtual network operator with 26 employees and revenues of 94 million NOK, specializing in the production of advanced telecom services such as 800-numbers. The company has captured a number of large customers such as Oslo Lufthavn, TV2, Statens Vegvesen, NetCom Klart Svar and Norsk Rikstoto. Teletopia have also been allocated a number series for premium rate services, freephone, split charging, universal access numbers, voice mail services, and personal number (UPT). Using their own service logic and servers, but the same access to the customers as Telenor, its business idea is to compete with Telenor in value added service provisioning for content providers. Teletopia has demanded a special network access to Telenor's network for value added service provisioning and with the same call cost per minute as for Telenor's internal service providers. Establishing a profitable business has not been easy. Since its inception in 1994, Teletopia has been almost constantly occupied with court litigation with

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<sup>13</sup> Stimulated by the Sense initiative, several other virtual (facilities-less) operators have also started to negotiate for mobile network access, not only with Telenor Mobile, but also with NetCom. Increasingly, these (Tele 1 Europe, GTS Norge and Site Communications) may seem to prefer NetCom to the less flexible Telenor (cf. digi.no, 03.02.00, "Lei av å stange hodet i veggen" by Frode Eriksen).

Telenor and negotiation with the regulator (Post- og Teletilsynet) to improve its operating conditions.

Until quite recently, Teletopia also intended to become an active user of the next generation Universal Mobile Telephone System (UMTS). If access to the coming UMTS network can be acquired, this will be used to test a small network in Oslo with the intention of developing more user-friendly and interesting telecom services (i.e.; Teletopia as mobile VNO). Final customers may still be the subscribers of real UMTS network operator. If this goes well, Teletopia may soon be able to offer exciting new services without the added risk of large-scale investments. Their competitive advantage is therefore not large scale and dominant market position, but flexibility and innovativeness.

### **3.3.2 Responses by regulators and incumbents**

As indicated above, the initial responses to the various VNO-initiatives have been strongly negative from incumbents and their owners. Regulators, however, who would like to see more infrastructure competition, have had a more positive attitude. As long as virtual network operations do not benefit incumbents, but only subtracts revenue and weaken their market position, their reactions can only be negative. Gradually, the negative response has changed especially in Telenor who have come to realize that open access in terms of unbundling and roaming would not only be required by the regulator as a condition for allowing Telenor to merge with Telia, but also by Telenor as part of their internationalization strategy. To become accepted as a VNO abroad, Telenor must also be willing to accept foreign as well as domestic VNOs at home.

#### 4. Summary and Tentative Conclusion

In this report we have analyzed how incumbent and new entrants may benefit from opening the value-chain; that is, by creating separate facility-less network operators that profit from service innovation while outsourcing basic network operation to facility-based operators. Being a relatively recent phenomenon in telecom, the instances of virtual business practice described and analyzed above include not only examples from telecoms, but also from the computer industry and the Internet.

Quite obviously, to profit from outsourcing, specializing and downscaling in general, and from virtual network operation in particular, the price margin of remaining “virtual” operation must cover its costs. Since this revenue margin is likely to expand with the VNOs own freedom in service innovation, packaging and pricing, granting such freedom can be regarded as one necessary, but still not sufficient, condition for achieving net social surplus from this type of business practice. In addition, certain conditions related to service transactions, production resources, competition and governance mechanisms must also be fulfilled. In particular, according to transaction costs economics, corporate integration would be the organizational solution of choice for technologically separate activities, only if these are operated on the basis of assets that are highly non-redeployable or otherwise non-tradable. As indicated above, such non-redeployability and non-tradability may be caused by investment in technology and supplementary assets that are highly specific, lacking alternative users or uses (i.e.; non-redeployable), or very difficult to transfer to alternative users if they are highly invisible, tacit, sticky or diffused (i.e., non-tradable). To the degree the respective technologies, resources and capabilities are also valuable and potentially rare (ranging from relatively unique to absolutely non-substitutable), these assets may under corporate integration develop into more sustainable sources of competitive advantage. Increasing tendencies towards outsourcing in general, and virtual network operation in particular, indicate, however, the opposite trend: that technically separable services are produced on the basis of increasingly redeployable and tradable assets. Whereas some of the separated activities and operating units are well positioned to protect their already unique assets or to develop new ones (e.g., differentiable content or value-added services, developed and produced by facility-less operators), others are less well positioned (e.g., non-differentiable

transport services, produced by facility-based network operators). Due to significant increases in expected traffic volume generated by a growing volume of innovative services, supplied by virtual (facility-less) operators, also network operators may earn significant positive rent with only minor differentiation of their own network operation and basic service provision. Effective competition, released by the recent regulatory reforms, is one of the driving forces to this embryonic restructuring process. The other major force is of course digitized technology advances.

Somewhat obviously, both the computer industry and the Internet world illustrate that whereas innovation and growth are enhanced by open standards, huge profits can only be accumulated by large-scale sales of products or services based on some kind of monopoly positions upstream or downstream. Lacking such monopoly positions, most computer makers (assembler) and Internet Service Providers (ISP) are typically characterized by small profit margins. Even among the most successful and high-priced online and e-commerce companies (e.g.; American Online and Amazon.com) operating profits have been tiny, even negative, due to low-priced introductory offer and large-scale marketing investment, combined with unrestricted competition in mostly non-proprietary production facilities. On the other hand, expected profit in terms of stock market value (price/performance ratio) may sometimes be enormous. Once again, the most obvious reason is almost unlimited demand growth expectations combined with giant scale economies (high fixed, but zero marginal costs) in providing digitized content over future broadband networks to millions of consumers. Being easily copied or imitated, however, private content by itself cannot be any permanent source of competitive advantage. Neither can the distributing networks, operating support systems and service applications, to the degree these are built on open and non-proprietary technology platforms. Under such a regime, turning these devices, systems and applications into a seamless system that works may be the only remaining source of competitive advantage. However, also here network operators are but one of several contenders, the others being software makers and service providers.

Whether integration will have intended effects or not will most likely depend both on the innovation incentive of the network operator and certain key attributes of the resources used to produce the outsourced products and services. Increased use of non-proprietary and open interfaces between network devices, operation support systems and service applications across different technology layers (facilitated by the TCP/IP protocol) have not only contributed to

making all these more separable, but also more tradable. Consequently, this has also increased the value of contracting (renting out shared devices, systems and applications or selling only the associated services) in relation to full corporate integration. Furthermore, under oligopolistic network competition, service innovation will probably be more strongly promoted by facility-less operators, as above exemplified, than by facility-based operators. Then, the profitability of both virtual and non-virtual operators will depend on attributes of their core assets, especially the degree to which these assets are valuable, rare (different, non-substitutable, specific), inimitable (invisible, sticky, tacit, diffused, naturally monopolized), or patented. If inimitable, essential resources may still be made tradable by specifying, clarifying and bundling essential component under some kind of protective renting or leasing agreements, or by spinning essential resources off into a stand alone unit capable of selling the associated services to a larger number of competing customers without too much leakage of private technology and knowledge.

My conclusion is that in the telecom services industry competitively critical assets are becoming increasingly separable, tradable and less monopolized, and therefore ready for being outsourced and more widely dispersed among a larger number of specialized players, along with private knowledge needed to further develop these assets. Subsequently, this may cause virtual (facility-less) operators to develop stronger innovation incentives and competencies in service provision, and non-virtual (facilities based) operators to develop stronger capabilities in digitized network operations on the basis of increasingly more commoditized and less monopolized production assets.

## 5. Discussion and Further Research

The emergence of virtual operators is but one example of a more general trend towards the outsourcing of production tasks found in many industries, especially in those producing or using complex system such as computers, ships, cars, oil & gas extraction systems, telecom networks, etc. In particular, since outsourcing threatens established positions inside integrated companies, this kind of change is regularly met by heavy protest and resistance until the old integrated companies are either outcompeted by more efficient newcomers, or separated or broken up by regulator (as in telecom). Of course, there is no economic reason either for outsourcing or for breaking up integrated companies unless the resulting structure is more efficient in developing and utilizing the essential resources needed to produce high-quality and low-cost telecom services.

As part of a more general outsourcing trend, experience from other industries may not only prove helpful to telecoms, but also provide a suitable testing ground for more basic theory. The respective hypotheses should be derived not only from the type of strategic and resource-based transaction cost theory outlined above, but also from related economic contract theories such as agency theory and property rights theory. In the long run we may hope that competition will select the most efficient structure, but in the shorter run many visible and invisible factors and mechanisms may influence the restructuring process, of which we still have only moderately verified knowledge. To improve upon this, more rigorous empirical research is called for.

## References

- Barney, J. B. (1997). *Gaining and Sustaining Competitive Advantage*. Reading, MA.: Addison-Wesley.
- Business Week. *Special Report*, Nov. 22, 1999.
- Chesbrough, H.W, and D.J. Teece (1996). When is Virtual Virtuous, *Harvard Business Review*, January-February, 65-73
- Gong, J. and P. Srinagesh (1996). Network competition and industry structure, *Industrial and Corporate Change*, 5, 1231-1241
- Gong, J. and P. Srinagesh (1997). The Economics of Layered Networks, in L. McKnight and J. Bailey (eds.), *Internet Economics*. MIT Press, Cambridge, MA, 63-77.
- Halbo, G., C. Mallett, M. Freestone, M. Trill. (1999a). Exploiting the edge in intelligence to build a SoftTelco business. Kjeller, Telenor Research and Development (R&D report, R 108/99).
- Halbo, G., C. Mallett, M. Freestone, M. Trill. (1999b). Business plan for 'Facet,' a software based telco. Kjeller, Telenor Research and Development (R&D report, R 109/99).
- Kavassalis, P, T. Y. Lee and J.P. Bailey. (1998). Sustaining a Vertically Disintegrated Network Through a Bearer Service Market. In E. Bohlin and S.L. Levin, *Telecommunications Transformation: Technology, Strategy and Policy*, IOS Press
- Teece, D.J. (1986). Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy, *Research Policy*, 15, December, 285-305
- Ulset, S. (1994). Commercializing Technology in Network Industries, *SNF Working Paper*, 104/94
- Ulset, S. (1998a). Hvordan organisering av infrastruktur kan bidra til utvikling av bedre og billigere teletjenester. *SNF-rapport 25/98*.
- Ulset, S. (1998b). Optimal Organization of the Converging Information and Communication Technology (ICT) Industries. Theoretic analysis and some illustrative data from the Norwegian market. SNF-report, 27/98.
- Spiller, Pablo T, S. Ulset, and B.A Zelner (1996). Strategy, Structure and Global Networks. Studies of the telecommunications sector, *SNF-report 27/96*
- Williamson, O.E. (1991). Comparative Economic Organization: The Analysis of Discrete Structural Alternatives. *Administrative Science Quarterly*, 36, June.

## **PUBLIKASJONER INNEN TELEØKONOMI 1998 –**

- Ulset, Svein  
Gooderham, Paul  
*Internasjonalisering av telesektoren. Generelle lærdommer og spesielle utfordringer for Telenor.*  
SNF-arbeidsnotat nr. 16/2000, Bergen.
- Ulset, Svein  
*Virtual Network Operation. Strategy, Structure and Profitability.*  
SNF-Working Paper No. 15/2000, Bergen.
- Foros, Øystein  
Kind, Hans Jarle  
Sørgard, Lars  
*Access Pricing, Quality Degradation and Foreclosure in the Internet.*  
SNF arbeidsnotat nr. 12/2000, Bergen.
- Foros, Øystein  
Sand, Jan Yngve  
*Asymmetrisk regulering innen telekommunikasjon.*  
SNF særtrykk nr. 03/2000, SNF, Bergen.
- Ulset, Svein  
*Ekspansive teleselskap. Finansiering, organisering og styring.*  
SNF-rapport nr. 64/1999, Bergen.
- Sannarnes, Jan Gaute  
*Ulike reguleringsregimer i telesektoren sett ut fra et dynamisk perspektiv.*  
SNF-rapport nr. 58/1999, Bergen.
- Seime, Gunn Randi  
*Konkurransen i det norske mobiltelefonimarkedet.*  
SNF-rapport nr. 49/1999, Bergen.
- Methlie, Leif B.  
Pedersen, Per E.  
*Multimedia Banking*  
*Bankenes strategiske situasjon. Ny teknologi – ny konkurransearena – ny struktur.*  
SNF-rapport nr. 41/1999, Bergen.
- Pedersen, Per E.  
*Multimedia Banking*  
*Programvareagenter i elektronisk handel. En kartlegging med vekt på agentbaserte tjenester og finanstjenestesektoren.*  
SNF-rapport nr. 40/1999, Bergen.
- Pedersen, Per E.  
*Multimedia Banking*  
*En agentbasert tjeneste for produkt- og leverandør-sammenlikning av finanstjenester.*  
SNF-rapport nr. 39, 1999, Bergen.
- Pedersen, Per E.  
Nysveen, Herbjørn  
Jensen, Leif Magnus  
*Multimedia Banking*  
*En eksperimentell studie av atferdskonsekvenser ved bruken av agentbaserte tjenester i finanssektoren.*  
SNF-rapport nr. 38/1999, Bergen.

- Fjell, Kenneth  
Foros, Øystein  
Gabrielsen, Tommy S.  
Hagen, Kåre P.  
Sørgard, Lars  
Vagstad, Steinar
- Problemstillinger for videre forskning på prising av tele-tjenester.*  
SNF-rapport nr. 27/1999, Bergen.
- Fjell, Kenneth  
Hagen, Kåre P.
- Oversikt over forskningsprogrammet i teleøkonomi ved SNF: 1996-1998.*  
SNF-rapport nr. 26/1999, Bergen.
- Fjell, Kenneth  
Foros, Øystein  
Hagen, Kåre P.  
Sørgard, Lars
- Telenor – bare lave priser ?  
Drøfting av Telenors rabattstruktur utfra et bedriftsøkonomisk og samfunnsøkonomisk perspektiv.*  
SNF-rapport nr. 23/1999, Bergen.
- Stahl Gabrielsen, Tommy  
Vagstad, Steinar
- Konkurransereform i telesektoren: Hvordan rasjonalisere observert atferd?*  
SNF-rapport nr. 65/1998, Bergen.
- Methlie, Leif
- Multimedia Banking  
Strukturendring i bank. Distribusjon – grovanalyse.*  
SNF-arbeidsnotat nr. 31/1998, Bergen.
- Methlie, Leif
- Multimedia Banking  
Strukturendring i bank. Strategisk posisjonering – grovanalyse.*  
SNF-arbeidsnotat nr. 30/1998, Bergen.
- Foros, Øystein  
Ulset, Svein
- Naturlige grenser for teleselskapene.*  
SNF populærvitenskapelig særtrykk nr. 10/1998, Bergen.
- Ulset, Svein  
Spiller, Pablo
- Organizing Global Seamless Networks: Contracts, Alliances and Hierarchies.*  
SNF Reprint No. 26/1998, Bergen.
- Ulset, Svein
- Infrastruktur og konkurranse i telesektoren.*  
SNF særtrykk nr. 27/1998, Bergen.
- Ulset, Svein
- Value-Creating Interconnect  
International Competition in Global Network Services.  
Technology, Organization and Performances.*  
SNF-report No. 28/1998, Bergen.
- Ulset, Svein
- Value-Creating Interconnect  
Optimal Organization of the Converging Information and Communication Technology (ICT) Industries.  
Theoretical analysis and some illustrative data from the Norwegian market.*

- Methlie, Leif B.  
Nysveen, Herbjørn
- SNF-report No. 27/1998, Bergen.  
*Multimedia Banking*  
*Kundeatferd ved bruk av Internett og andre kanaler.*  
SNF-rapport nr. 29/1998, Bergen.
- Ulset, Svein
- Verdiskapende samtrafikkavtaler.*  
*Hvordan kan organisering av infrastruktur bidra til utvikling av bedre og billigere teletjenester. En analyse av betingelsene for konkurranse og samarbeid i telesektoren.*  
SNF-rapport nr. 25/1998, Bergen.
- Spiller, Pablo T.
- Value-Creating Interconnect.*  
*Unbundling and the Promotion of Local Telephone Competition: Is Unbundling Necessary in Norway?*  
SNF-Report No. 03/1998, Bergen.
- Bjørnenak, Trond  
Gabrielsen, Tommy Staahl  
Vagstad, Steinar
- Verdiskapende samtrafikkavtaler.*  
*Prising av samtrafikk.*  
SNF- rapport nr. 02/1998, Bergen.
- Andersen, Christian  
Sannarnes, Jan Gaute
- Analyse af tilgangsafigifter ved irreversible investeringer under usikkerhed.*  
SNF-rapport nr. 07/1998, Bergen.

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