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Martin Fransman, Jackie Krafft

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Telecommunications

1 **Introduction: mapping the industry with a layer model**
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Overview

What is the telecommunications industry? How does it relate to other activities in areas such as computing, software, semiconductors, the internet and electronic commerce, and the media? Where are its boundaries? What products and services should be included within it? What are its major markets? Which companies should be included in the industry?

In this paper, we tackle these important questions by developing a layer model in order to map the industry. Layer models generally have a long and distinguished history in the telecommunications and computing fields. In the area of engineering and software design, they allow engineers to reduce and render tractable the awesome complexity of complex systems. They help to achieve this purpose essentially by decomposing the system into relatively autonomous subsystems that interact with each other through an interface that is often standardized in order to facilitate coordination. But, in this paper, the layer model does more than merely decompose a complex system into component subsystems. While each layer may be thought of as a subsystem (usually further subdivided into sub-sub-systems, and even further subdivided), the layer model also, by its nature, draws attention to the interdependence of each layer on the layers below and above it.

By decomposing the telecommunications industry into different layers, and further by analysing the interdependence between the major layers that compose the industry, we will provide a detailed assessment of an industry, characterized by recurrent technological innovation and faced with an increasing diversification of demand. The reader should note that this article draws heavily on our telecoms website: http://www.TelecomVisions.com.

1 Introduction: mapping the industry with a layer model

In this article, the layer model is used to map the telecommunications industry and to understand its connection with 'connected' industries and activities such as computing, software, semiconductors, the internet and electronic commerce, and the media. In that perspective, the layers will refer here to different domains of economic activities which are considered as separable though related, and evolving. Depending on their technological background, their structure, their date of entry, and their ability to capture market opportunities, firms can develop some of these activities either internally or through mergers and acquisitions, and outsource others through market or cooperation agreements. In any case, it is of crucial importance to understand the process by which firms are able to enter or exit activities in the different layers. This specific issue will be omnipresent in this paper.

The basic layer model is described in Table 1 which provides a mapping of the telecommunications industry in the 2000s (see TelecomVisions.com for further details).

Table 1 The basic layer model

Layer	Activity	Example companies
VI	Consuming/customers	—
V	Applications Layer, including contents and packaging (web design, online services, broadcasting services, etc.)	Bloomsberg, Reuters, AOL/Time Warner, MSN, News Corp, etc.
IV	Navigation and middleware (browsers, portals, search engines, directory assistance, security, electronic payment, etc.)	Yahoo, Netscape, etc.
III	End-to-End Connectivity (Internet access, web hosting) TCP/IP	IAPs and ISPs (e.g. Freeserve, etc.)
II	Network (optical fibre network, DSL local network, radio access network, Ethernet, Frame Relay, ISDN, ATM)	AT&T, BT, NTT, MCI, WorldCom, Qwest, COLT, Energis, etc.
I	Equipment and software (switches, transmission equipment, routers, servers, CPE, billing software)	Nortel, Lucent, Cisco, Nokia, etc.

2 Characterizing the telecommunications industry layer by layer

Layer I: The equipment and software layer

In Layer I telecommunications equipment and software is produced. This includes not only the 'network elements' that are the building blocks for networks of various kinds, but also customer equipment such as mobile phones, PCs and information appliances of different sorts, as well as software for billing, IT and management applications. Three types of companies are present in Layer I: (1) traditional telecommunications equipment companies (most with a long history, like Siemens and NEC, and some with recently acquired younger data networking equipment companies, like Lucent with Ascend, Nortel with BayNetworks); (2) relatively new data networking companies (Cisco); and (3) computer hardware and software companies (Oracle, Sun, EMC). Firms within that layer are extremely specialized: the penetration of equipment suppliers in other layers is indeed a very rare, punctual and transitory phenomenon.

Layer II: The network layer

Layer II contains the networks that carry the bits (binary digits) that are the lifeblood of the infocommunications industry. Examples are local, long-distance and international networks based on technologies and standards such as optical fibre, radio access (including cellular and fixed radio), cable, DSL, satellite and Ethernet. The services provided in this layer include telephone, fax, ISDN, frame relay, ATM and leased circuits. Services sold on the carrier's carrier market are also included here. All these services are closely associated technically with the networks over which they run and it is for this reason that it is usually the network operators that run the networks that also provide these services. The network operators that populate the network layer can be divided into three groups: (1) incumbents, such as the global 'Big Five' – AT&T, BT, France Telecom, Deutsche Telekom and NTT; (2) original new entrants, that is the companies that were first allowed to compete with the incumbents when liberalization was introduced into the USA, UK and Japan in the mid-1980s, namely MCI and Sprint in the USA, Mercury/Cable & Wireless in the UK, and DDI, Japan Telecom and Teleway Japan in Japan; and (3) new new entrants, including WorldCom, Qwest, Level 3, Global Crossing, Global Telesystems, COLT, Energis, Vivendi, Mannesmann, etc. The reason for distinguishing between the original new entrants and the new new entrants is that their strategies and behaviours are significantly different and, in fact, the former companies have tended over time to be acquired by the latter.

The TCP/IP interface

An event of great significance for the industry emerged with the evolution of the Transmission Control Protocol/Internet Protocol (TCP/IP) which came to play an important role in facilitating networking between computers and networks. Likewise, within the network layer (Layer II) TCP/IP has facilitated the transfer of bits across the different networks, many of which use significantly different technologies. Furthermore, TCP/IP has also enabled a technical separation of the network layer (Layer II) from the service layers above it (Layers III to V). This has meant that service providers need not own nor control their own networks, but can depend on network services bought on the market from network operators. In this way, TCP/IP has allowed the possibility of vertical specialization between the different layers, enhancing the potential for specialist facilities-less service providers to emerge and prosper. It has facilitated new forms of industrial organization while creating the possibility of new layers in the industry with new products and services, and new company players.

Layer III: The end-to-end connectivity layer

The companies active in this layer provide services such as e-mail, internet access, voice over the internet (Voice IP), web hosting, intranet and extranet-related services, virtual private network services and mobile services. Many players in Layer III are network operators, active in Layer II, who have vertically integrated 'forwards' into the end-to-end connectivity layer. However, specialist facilities-less service providers also compete in Layer III and some specialize only in this layer. These include, for example, internet access providers (IAPs) and internet service providers (ISPs) that offer connectivity-related services but, apart from a few switches, may have very little of their own networks, preferring to buy network services from network operators in Layer II. Also included are resellers who sell connectivity in retail markets having bought it from others wholesale. These resellers are essentially involved in arbitrage and do not own nor control their own networks.

Layer IV: Navigation and middleware layer

The services provided in Layer IV figuratively 'sit on top' of the connectivity that has been provided in Layer III. These include navigation-related services that allow users to find their way around the connected networks of the internet and locate further services. Navigation-related services include browsers, search engines and portals, made possible by the advent in 1990 of the World Wide Web. They also include more conventional services like directory assistance and yellow pages. 'Middleware' is also located in Layer IV. This is primarily software-related services that 'sit' between the connectivity layer (Layer III) and the applications layer (Layer V). Examples of middleware products include security systems, such as firewalls used to protect websites, and electronic payment systems. Firms in Layer IV include Netscape, Yahoo, Lycos, Excite and a host of software companies that provide specialist middleware products. Many of these companies, internet-related in the minds of investors, have achieved extremely high market capitalizations as a result of rapidly appreciating share prices. It seems then that it is the new entrants who have performed best in the navigation part of Layer IV, rather than the larger established computer hardware and software companies, and the telecommunications equipment companies.

Layer V: The applications layer

With networks, connectivity, navigation and middleware being provided, it is possible for applications to be developed and distributed. These applications include the creation and packaging of content. Examples of services provided in this layer include: video-on-demand; electronic-commerce services such as online shopping, banking and auctions; social services such as online health and educational services; web design; mobile phone services such as stock market prices, news and weather; premium services such as racing results; databases; broadcast. Examples of companies and services that have a notable presence in Layer V include AOL/Time Warner, Microsoft's MSN, NTT DoCoMo's i-mode internet mobile service, Bloomberg, Reuters and broadcasters such as News Corp.

Layer VI: The customers

At the top of the five layers are the customers. We think it is important to envision the customers as constituting a discrete layer, although this is not the usual practice in layer models. It should be noted that customers include not only those purchasing the final telecommunications goods and services, but also 'intermediate customers' who purchase intermediate products and services. These include, for example, the specialist facilities-less service providers who are customers buying network services from the network operators.

In this section, each layer was considered as an isolated system. In the next two parts, we will focus on the interdependence between layers, by choosing two specific entry keys, namely on the one hand the downstream layers (Layer I and II), and on the other hand upstream layers (Layers III to V).

3 The evolution of downstream layers

According to the analyses of some economists (Laffont and Tirole (2000) are a recent example) the structure of the Telecoms Industry changed fundamentally in the mid-1980s in Japan, the UK and the USA as a result of deregulation. It was deregulation that created the rules for new entrants to enter the telecoms services market and compete with the incumbents. This ushered in a new era of competition.

According to these analyses it was both necessary and sufficient to 'get the prices right'. More specifically, incumbents had large existing networks and low marginal costs and benefited from network externalities. This meant that it was necessary, in order for new entry to be viable, to introduce new rules requiring incumbents to allow new entrants to interconnect their networks with the networks of the incumbents at the right price. The analytical trick was to determine the 'right price' which would provide appropriate incentives for both incumbents and new entrants to compete. The fact that marginal cost pricing, the optimal practice in competitive industries, was inappropriate in the Telecoms Industry characterized by high fixed and sunk costs and low marginal costs made the trick even more demanding. Nevertheless, the conclusion was that the 'right price', together with the interconnection rules, provided both the necessary and the sufficient condition for a competitive Telecoms Industry to emerge.

However, an understanding of the interaction between Layers I and II in our layer model – namely the interaction between network operators and specialist technology suppliers – shows that the matter was far more complicated than these economists have implied. In short, entry required not only an appropriate regulatory regime and the 'right' interconnection price – though entry certainly did require this – it also required access to new technology. And this new technology was supplied by a group of specialist technology suppliers without whom entry would have been far slower and new entrants would have been significantly fewer in number. As a result the speed in introducing competition, as well as the intensity of competition, would have been much lower without the specialist technology suppliers.

The new entrants

In most analyses of the Telecoms Industry by conventional economists technology tends to be treated as an exogenous force, falling like manna from heaven and then providing the impulse for the growth of the industry. The empirical study of the most important new entrants into the telecoms services market, however, shows that technology has played a key role in the process of successful entry.

While it certainly is true that the incumbent, a former monopoly network operator and supplier of telecoms services, benefits significantly from sunk costs and low marginal costs to the detriment of the new entrant, new technology has provided a countervailing opportunity for the new entrant. Counterbalancing the importance of sunk costs and low marginal costs is the power of new technology that is capable of providing the new entrant with competitive weapons that include superior reliability, provisioning flexibility, bandwidth and security. In some areas and for some time the incumbent's strengths (sunk costs and low marginal costs) become its weakness (legacy systems that are not worth scrapping immediately but which are not capable of providing the same characteristics as the new technologies). A close reading of the company studies undertaken by financial analysts of new entrant firms such as WorldCom, Qwest, Level 3, Global Crossing, GTS, and Viatel in the USA and COLT, Energis and Atlantic Telecom in the UK reveal the extent to which superior technology has driven the valuation of shares in these companies. High market values, in turn, have facilitated both successful entry and growth by giving new entrants such as these the 'currency' with which to make mergers and acquisitions and access to loan markets on relatively attractive terms. As a result, almost without exception, the successful new entrants have performed better than the incumbents in terms of stock market indicators, an outcome that cannot be explained by the 'getting the prices right' paradigm.

Access to superior technology also explains the apparent paradox of firms that have had nothing to do with telecoms, and to begin with have little telecoms knowledge and competence, becoming some of the most successful new entrants. Examples include Mannesmann in Germany (recently taken over by the British mobile operator, Vodafone) which was an engineering company; Olivetti that was involved in computers and business machines (and acquired the Italian incumbent, Telecom Italia); COLT, the most successful rival of BT in the UK, that was established by Fidelity, the largest US mutual fund; WorldCom, a major rival to AT&T that was started by Bernard Ebbers, a motel owner, and his colleagues; and Qwest, begun by Philip Anschutz, who started as an oil-made billionaire. Entrants such as these were able to enter and prosper largely as a result of their access to the latest technologies. In short, technological barriers to entry were low. Again, the 'right prices' paradigm has little to say about this phenomenon.

Specialist technology suppliers

If technology has played the important role indicated in this section, where has it come from? The answer is from a group of specialist technology suppliers who have come to specialize only in Layer I of the industry (see the layer model above). The biggest and best known of these specialists include Lucent, Nortel, Ericsson, Nokia, Alcatel, Siemens, NEC, Fujitsu and Motorola. Their specialization in Layer I is the best example of vertical specialization in the Telecoms Industry (a form of industrial organization that is similar to that found in the computer industry – see TelecomVisions.com for a more detailed comparison of these two industries).

Here too, history matters. These specialist technology suppliers did not fall like manna from heaven, ready to supply the latest technologies to all new entrants who could pay for it, smoothing the latter's entry. Indeed, all but one of the firms mentioned in the last paragraph are old firms; the origins of Lucent, Ericsson and NEC, for example, go back to the late nineteenth century. Most of them began as telecoms equipment manufacturers, supplying equipment to the national telecoms monopolist – the so-called PTTs – who took the lead in researching and designing the equipment and other technologies that their networks required in their laboratories that quickly became the major source of technical change in the industry. These laboratories included AT&T's Bell Laboratories (whose researchers won more Nobel prizes than any other industrial laboratory), BT's Martlesham Laboratories, NTT's Electrical Communications Laboratories and France Telecoms's CNET laboratories. The relatively simple task of mass manufacture was left to the specialist equipment suppliers.

Over time, however, these specialist equipment suppliers, through complex processes of learning and knowledge creation, began to do more of their own R&D and gradually became powerhouses of technical change in their own right. By the 1980s they were challenging, and in some areas even surpassing, their erstwhile network operator masters at their own game. Astoundingly, by the turn of the century the main specialist equipment suppliers were some four times more R&D-intensive than the five major former monopolist incumbents, AT&T, BT, Deutsche Telecom, France Telecom and NTT (see Fransman (2000b) for a detailed analysis).

Conclusion

The discussion in this section of the interaction between Layers I and II throws further light on the dynamics of the Telecoms Industry by analysing the intricate relationship between both incumbent and new entrant service providers, on the one hand, and specialist equipment suppliers on the other. In this way the layer model assists in the task of analytically endogenizing the role of technical change as a major driver of the Telecoms Industry (see Fransman (2000b) for further details).

4 The evolution of upstream layers

The great revolution involving the TCP/IP interface is that, in the upstream layers, many different firms could appear and operate without controlling their own proprietary network and especially without bearing the prohibitive costs of constructing such a network. In fact, the technical separation between the network and the services potentially offered implied that firms could simply lease the infrastructure from network operators, or develop on it some switches and points of presence to connect their customers end-to-end. Because the access to technological infrastructures was greatly facilitated by the TCP/IP revolution, their main efforts to create competitive advantage were focused on the provision of an extended set of applications, and more generally on their ability to capture market opportunities faster than other firms. At the origins, a small, flexible company structure seemed to be better adapted to react to the new challenges imposed by the increasing diversity of demand, and was an important element in gaining a competitive advantage. At the moment, however, consolidation seems to increase significantly the average size of firms in the upstream layers. These features reveal that drastic changes are occurring within and between upstream layers. A deeper understanding of who does what within these layers and why is then absolutely needed.

In this section we will focus in particular on the following questions: How did Layer 3, which contains Internet Access Providers (IAPs) and Internet Service Providers (ISPs), originate and what is its relationship with the other layers? How can we explain the diversity of strategies followed by firms in upstream layers, namely the fact that moves of consolidation/integration by big players coexist with the specialization of a large number of smaller IAPs and ISPs? Taking into account this diversity, how will the upstream layers evolve in future?

The emergence of Layer III and its relationship with the other layers

In the 1980s, the Internet was primarily used to connect universities and research groups. Within this period, 'packet switched' technologies, together with the generalization of URL addresses and Hypertext links, led to concrete applications, especially the real-time transfer of documents and e-mail between dispersed groups of scientific users. New fixed operators such as MCI and Sprint – firms that were competing primarily in the

network layer of the telecommunications industry (Layer II) – constructed long distance and international backbone networks to carry Internet traffic. This allowed them to move into Layer III (the layer that provides connectivity) as Internet backbone providers. At this stage, however, Internet applications were not yet market driven. Even though these private firms provided Internet backbones, the global operation and management of the Internet was still undertaken by the National Science Foundation (NSF) in the United States. With the administrative and technical assistance of ANS (a joint venture of IBM and MCI), the NSF created NSFNet, a network connecting research groups in the USA at a local, regional and national level.

It may be concluded, therefore, that Layer III in the 1980s was essentially composed of a public ISP (the NSF) which delegated some limited activities (like the operation of some parts of the network) to private firms. The scope of services offered by the NSF was relatively restricted, and only later would be enlarged with the 'privatization' of the Internet.

In the 1990s, new challenges appeared both from a technological and a market point of view and had a significant impact on Layer III. The development of the World Wide Web allowed a multiplicity of new services such as data transmission, e-commerce and the development of websites which are now profitable commercial opportunities. With the viability of the Internet having been established, and with the traffic increasing, the NSF decided in 1995 to leave the management and operation of the Internet to private firms. This allowed Internet backbone providers such as MCI and Sprint to expand their markets. This also favoured the entry of a large number of new firms in Layer III in order to provide both Internet access to firms and residential customers and Internet services such as e-mail. These new firms are often referred to as Internet Access Providers (IAPs) and Internet Service Providers (ISPs), although the same firm might provide both sets of functionality. The most successful of these included UUNet (later acquired by Worldcom) and AOL in the USA, Freeserve in the UK (that was the first firm in Europe to offer free Internet access, though the customer still had to pay the time-based cost of the local call). As a matter of fact, Layer III is then composed of two distinct categories of firms: (1) the IAPs which carry the Internet packets and are generally affiliated to firms from Layer II looking for diversification into a value-added activity to recover the sunk costs involved by the development of their backbone network, and (2) the facilities-less ISPs which offer value-added services to customers and are increasingly linked with firms operating in 'middleware' or 'content' activities (Layer IV and V).

For the 2000s, the trend is difficult to anticipate. Some events from the late 1990s, however, can possibly provide us with a vision of what will happen over the next few years. The use of the Internet is now widespread, with constant technological innovation (e.g. high capacity and intelligent networks) and open-ended applications (e.g. video-conferencing, e-commerce, IP telephony, web design, broadcasting services). In this context, different types of strategies are followed by firms in Layer III. The first strategy, generally followed by firms present also in Layer II, is to extend and upgrade the networks to meet the demand for high speed Internet and associated applications. Those following the second strategy focus on content activities and progressively leave Layer III to become one of the leaders in Layers IV and V. Finally a third strategy consists of an exclusive specialization in Layer III. Indeed, consolidation/integration moves coexists with specialization processes in Layer III.

The coexistence of consolidation and specialization within and between upstream layers

Gradually consolidation and integration occur within and between the different layers of the telecommunications industry. These strategies generally allow big players to move from one layer to another, and to gain a competitive leadership or to extend it on related activities. Different cases are observable.

First, big players in Layer II tend to integrate players in Layer III. For example, WorldCom, a firm that began as a reseller in 1983 and went on, helped by a rapidly rising share price, to develop its own long-distance and local networks in Layer II (the network layer), acquired MCI and tried to acquire Sprint (though it was thwarted by the US regulator). This allowed WorldCom to move from Layer II into Layer III and become one of the major Internet Backbone providers. Consolidation also occurs amongst the IAPs and ISPs. One example was UUNet that became one of the largest independent IAPs/ISPs in the USA, before being acquired by WorldCom..

Secondly, big players in Layer III tend to leave this layer to focus especially on other layers. For example, AOL, a firm that began before the Internet era as a network supplier of value-added information services, quickly adapted to the rapidly diffusing Internet. Though some predicted that AOL would be undermined by the Internet, this did not happen. Indeed, by the turn of the century an astounding 40 per cent of the total amount of time spent by Americans on the Internet was spent within AOL's 'walled garden'. At first AOL began to develop its own network. However, it soon decided that it should leave the transport of its traffic to specialists and accordingly sold its network (and that of Compuserve which it had acquired) to WorldCom. In January 2000, AOL further transformed itself. Having abandoned its networks, it acquired Time Warner with two purposes in mind. The first was to acquire the content that would distinguish itself from other IAPs and ISPs (and allow it to continue charging its customers a monthly fee). The second was to guarantee access to both residential and business customers by acquiring Time Warner's cable network, the second largest after AT&T's. In terms of our layer model, therefore, by early 2000 AOL had integrated downstream, from Layer III into the network layer

(Layer II) and upstream into the applications and content layer (Layer V). Indeed, it also integrated into Layer IV (the navigation and middleware layer) by acquiring the browser, Netscape.

However, despite these moves of consolidation and integration by the big players, there still are large numbers of smaller IAPs and ISPs who specialize in Layer III, even though there is a good deal of debate regarding their longer term viability. Part of the problem is that Internet access and many Internet services (such as e-mail and web hosting) are becoming a commodity business driven by economies of scale and scope. The advent of free Internet access is robbing IAPs and ISPs of much of their revenue and making it increasingly difficult to differentiate themselves. While content may be a key differentiator (as AOL has recognized), the cost of differentiated high-demand content is prohibitively high for many smaller IAPs/ISPs. The end result, very likely, is a significant shakeout through exit, merger and acquisition, and falling new entry.

We may conclude, therefore, that connectivity per se, as a functionality, has become a commodity, capable of being provided by a large number of players. For those who have specialized in the layer providing connectivity – Layer III – to survive and prosper it seems that a diversification in the upstream and/or downstream directions is becoming increasingly necessary.

Conjectures about the future evolution of upstream layers

Three main conjectures were generally formulated by experts in telecommunications. First, network operators would massively integrate firms in the end-to-end connectivity layer, the navigation and middleware layer and applications, and the content packaging layer. Secondly, service providers would integrate backward into the network layer. Thirdly, facilities-less service providers would decide to stay in the services layer. We should not consider that one of these conjectures will dominate others. Rather, we should think that the complex reality will provide examples of each of these scenarios, and that the crucial issue is the understanding of why these different scenarios may occur. To date, network operators integrate firms in upstream layers, generally in order to increase their margins, sometimes to differentiate themselves, considering that from the supply (equipment) side they all rely on the same type of technology. Service providers integrating backward are less documented, but cannot be neglected if we consider market capitalizations of facilities-less service providers in regard to network operators. Specialized service providers will certainly remain in Layer III, but will not play the dominant role that they used to.

5 Conclusion

Within the telecommunications industry, some crucial issues will deserve further research in the next few years. The following list only stresses some of them that were not especially developed in this article:

- The equipment suppliers tend to be characterized by an increasing concentration. How can we explain this phenomenon? Is it a transitory or a more permanent feature? Can we consider this phenomenon as a simple implication of the currently observed concentration at the level of the telecommunications carriers? Is it possible to elaborate further developments on that point?
- The new challenges of Internet access are about to drastically change the organization of the telecommunications industry. What will be the role of equipment suppliers in this context? Will they continue to favour the entry of new firms in the high speed Internet area? What will be the economic determinant of this new process of entry?
- The development of 3G mobile phones may generate also important restructurings within the organization of the industry. How 3G mobile phones will be developed from a technical point of view? What potential market applications and services will be favoured by mobile operators? Presumably, a close coordination between equipment suppliers, mobile operators, ISPs/IAPs, and content and middleware groups is expected, but high uncertainty remains on the profitability of this business activity and associated applications.
- Financial conditions, namely the achievement of high performance on stock markets, significantly contributed to the emergence and growth (through merger) of the main competitors in telecommunications industry. How will these specific financial conditions tend to evolve over time? What will be the impact on the key dimensions of the innovation and competition processes?

MARTIN FRANSMAN
EDINBURGH UNIVERSITY
JACKIE KRAFFT
CNRS-IDEFI-LATAPSES-SOPHIA-ANTIPOLIS

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www.TelecomVisions.com (Analyses what will happen to the telecommunications industry over the next five years, with specific contents on industry mapping, key questions, guest visionaries, current events, workshops, key resources and site bibliography.)

See also: COOPERATION AND COMPETITION; DEVELOPMENT AND DIFFUSION OF TECHNOLOGY; GROWTH OF THE FIRM AND NETWORKING; INDUSTRIAL DYNAMICS