# The business challenges in communicating, mobile or otherwise

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Abstract

This survey paper analyses some of the fundamental economic and management science issues concerning the communications and information economy ,with special emphasis on mobile communications. Are first highlighted major trends such as the balkanisation of the communications networks , and the advent of competitive tariffs. This leads to a move away from time and distance based charges to tariffs covering bandwidth, service , and contents use. It is noted that very few resources have gone into the analysis of that sector and its inter-relations with others. The paper advocates for more visibility and research into the unique aspects of the communications and information sector. It does so by making an inventory of key economics ,management, and computational economics research issues in need of contributions, selected from the following areas: public communications infrastructure and tariffing principles, sales of communications services, public access and equal access policies, competitive access pricing, communications industry finance, engineering-economic studies, information contents and macroeconomic issues. Finally , the specific aspects of models of the communications and media sector are addressed in view of modelling work. This includes variables, pricing and production models for both communications and information contents . The most unique contribution is here a formal model for quantifying and pricing knowledge , both for consumption and for assets building .

# 1. Introduction: The major trends in communications

Dear Rector Magnificus, dear colleagues, ladies and gentlemen!

## 1.1 Trends

One can wonder why there should be attention given to such a sector as communications and media, in relation to management and economics research.

After all it is just a branch like others, smaller than say insurance within services, but larger than consumer electronics within manufacturing. However, in an age where information, including it's creation and distribution, is by some considered as the dominant factor for economic development, it isn't even identified in national or U.N. accounts! Thus the first claim here: telecommunications and media is the fourth sector, besides the primary, secondary (manufacturing) and tertiary (services) sectors. According to some estimates (WTO and Financial Times), the communication services alone represent worldwide about 900 Billion Euros (2001), of which only about 30 % is open to real competition worldwide, and where the aftermaths of wild liberalization are now leading to phase of partial reconsolidation. Media and contents represent in turn 820 Billion Euro (2001). In 1995 the average spend by communication user worldwide was 905 USD (Source: ITU), but this is estimated to be only 810 USD in 2001 due to a faster growth in the number of users worldwide than revenues.

Next, as it deals ultimately with immaterial communication and information contents, it is, in an open world economy, the driving factor for globalization. Information and communication resources are as important to overall welfare and competitiveness as natural resources.

But what are exactly these communication and information resources is still an open issue, although fundamental trends emerge. Whereas the previous remarks mentioned communication and information resources as a driving factor for globalization, it really was not due to regulatory, national, and monopoly constraints. And it is not yet free from such constraints today! The trend is

nevertheless away from closed (geographically or service defined) monopolies, to quality and equal access control.

For communications, there is a fundamental shift away from distance and duration (72,89), to bandwidth and services. For information resources there is a shift away from physical media (and the rights attached to them), to knowledge and contents access charges, although not much has been achieved in terms of measuring these knowledge resources.

Finally, few branches have seen such a technological revolution, under the combined assaults of microelectronics, of software engineering, of optical & radio engineering, of intelligent agents, of storage technology, of communication protocols, and of multimedia techniques. The net economic effects have been on one hand to offer alternative communications and media access/storage technologies, but also to displace or allow to create totally new services for consumers and businesses alike. Whereas the intelligence in the networks is growing too, there is a trend away from dumb terminals, towards distributing and customization of these services, turning each consumer into a producer of information and a configuration agent in networks.

Mobile services, networks and content epitomize the above factors to their fullest (82,83). While barely emerging in Scandinavia in the early 1980's with analog NMT systems and heavy expensive terminals for voice only, today worldwide number of users of mobile networks is beyond 1.1 Billion worldwide, over 420 Million new terminals are sold annually (2002), and over 400 new operators plus 2000 new value added service companies have emerged. Although technology has played a crucial role in this emergence, it has not really fuelled the growth which is more attributable to social and business factors driving a growth faster than the Internet:

- Personal ubiquity, even reaching a stage where a mobile terminal is an essential addition to a human body, like a watch or spectacles
- Mobility, enabling new or better usages
- Location, as a value enhancement to mobile services (87,88)
- Personalization of services, contents and ultimately letting the user define his usage profile (87,88)
- Some time replacement for fixe infrastructure
- Much higher levels of security than the internet

## 1.2 Actors

No economic issue can be discussed without stating who the actors are. The seven basic categories are the following (89).

*Customer*

Private households, corporations (small and large), government bodies, multi-site institutions, and migrant/mobile users.

*Operators*

All own some network infrastructure or access infrastructure, and charge subscription based fees and consumption based tariffs for use of these facilities, which they invest in, besides acquiring customers and maintaining operations (see 83).

*Equipment providers*

They provide the equipment, terminals and the software technologies required by the operators and often by the service providers.

*Content owners* (sometimes called: media owners)

These entities own intellectual property rights (including: labels, trademarks, franchises, etc....) about the creative material (eventually stored on suitable media) which can be sent through the networks at the request of customers.

*(Value added) Service providers*

They deliver the standard or some customized services using the networks, and sometimes facilitate the access to contents provided by the contents owners; they may even operate networks they legally do not own, but license the access to (e.g. Mobile virtual network operators MVNO's); they may also carry out the billing or customer support for a diversity of access media

*Regulatory bodies:*

They dictate the policies, the rules and watch tariffs and charges.

*Governments*

As actors balancing the interests of the other actors, or being an actor by themselves different from regulators with self-interests like spectrum taxation.

Recent history has shown the hidden importance of the finance industry as an eight actor often acting for its own account, besides for the account of any of the parties above.

Of course, there are endless discussions as to how and why those seven (eight?) basic categories can mix, and should mix. For example, are operators and value added service providers really two separate categories? Another example relevant to especially mobile business is when banks and operators will converge for payment fulfilment and other operations. How "pure" can an operator be in terms of providing infrastructure? This lecture will not discuss the issues involved in mixed roles.

This lecture will rather show how the rules whereby these actors interact are radically changed under the combined effects mentioned in Section 1.1. The changes propagate amongst actors in two opposite directions:

*Top-down* from all actors (except customers): deregulation in public services means uncertainty as to which economic, social and policy rules still to keep, which all have business implications, such as e-or M-commerce (90), and effects on tariffs; the migration due to change also means discrepancies and reverse forces.

*Bottom-up* (from customers): the Internet based services, as well as the facilities offered by consumer electronics (mobile phones, TV's, portable or network computers) are based on a combination of a technology-push enhanced by individual role playing in social terms, bottom-up, with trial-and-error, so that economics or business issues either only surface when there is a crisis, or only late in the process.

The role of management research is to help all these actors assess issues and devise approaches to them.

### 1.3 Scope

This lecture will not address fulfilment aspects of transactions carried out using communication networks, nor electronic payment systems, auctions, etc.., aspects all widely researched at the Rotterdam School of management. Likewise it will not dwell into policies for intellectual property rights.

The lecture apologizes for the sometimes quite complex interactions, the detailed chains of which cannot always be stated in detail here, but for which influence diagrams could serve as graphical visualizations when dealt with.

## 2. Management and economic research so far in communications and media

So far, telecommunications and media was looked upon, as mentioned, as an isolated branch, for which one would engage in such studies as:

- Relations between demographics and income level to predict penetration of communication services, or of TV sets
- Forecasting of fixed, multimedia and mobile subscribers (35,44,47,55)
- Effective pricing strategies to retain customers (49) (national and weekend rates, prepaid rates, abolition of peak rates, simplified charge bands, per second pricing, Sunday specials, friends and families, surprise savers, rewards for volume, flat capped national mobile access package, free-phone tariffs, distance-capped rates)
- Identification of the factors that affect price elasticity in order to optimize tariffs for each market segment; data are sometimes hard to find, but some exist (13,67)
- Tariffs compatible with public interest for operators, while allowing for amortization and capacity increases through investments (53)
- Wireless access pricing versus fixed telephony pricing, with wireless tariffs coming down to the same or lower rates than fixed narrowband connections; worldwide, the wireless premiums over fixed public access are no more in average than 19 %, and even lower when wireless penetration is high (69)

- Tariff rebalancing between local/long distance rates as well as established/new/call-back operators or between mobile/mobile/ fixed access operators due to roaming, and currencies (65)
- Pricing and bundling with a subscription and/or service, covering wireless handset subsidies (66); the link with options pricing models has been made for this problem area
- The price of mobile fraud, and counter-measures
- Measuring and analyzing the profitability of service customers through the use of cost allocation, market segmentation, and competitive analysis (38)
- Internet and Mobile Internet pricing structures, with trade-offs between access charges and shared used of otherwise end-to-end private connections (see also Section 3.4.C)
- Auctioning of frequency bands according to the usual principles of auctioning non-replaceable resources (32); worldwide spectrum auctions have already earned governments enormous sums, but with some bad side effects!
- Shadow pricing of spectrum based on spectrum scarcity (as implemented in Canada); thus is based on the decomposition of spectrum consumption by coverage, bandwidth, and exclusivity
- User segmentation by service use (46)
- Economic effects of different intellectual property and royalty schemes
- Innovation in services and networks (28)
- Telecommunication market structure (42)
- Labour productivity amongst telecommunications operators

However, many of the very big issues have not been researched in a consistent and persistent way. In the mobile area, too much has been tied to variants or features (business and technical) to some specific standards or products. Many pieces of research were mostly advocating for some concept or theory, and just testing it out on communications and media, or were just implicitly focusing on a specific technology or product (for example: WAP).

The ambition of this lecture is to show directions beyond that, and to:

- Post of number of key problems, point at some possible approaches, to trigger work in these areas

- Summarise some key new concepts, illustrated by the above, which may serve in specific theories for management or economics research dealing with the sector of communications and media, and of mobile business in particular

## 3. Key business problems in communicating: a sample

### 3.1 The balkanization of public communications infrastructure and tariffing principles

In general the term of "balkanization" refers to structural fragmentation.

Under the combined effects of deregulation, new licensing policies, technology and service differentiation, the former backbone or mobile national and international networks, with their corporate network adjuncts, are being balkanized into many interconnected network families, each with a distinct user community and differentiated capabilities. This means that the flat price regimes that have encouraged wasteful use and discouraged responsible network engineering, will soon be gone. Gone too will be the painfully slow response times, or luxuriously prompt connection times from communication networks. Users will get what they pay for, even if they have to pay a lot. This means:

- for generic services, pricing based on service quality levels (so-called "QoS: quality of service " levels[1])
- for customized or personalized services, pricing based on enterprise value or personal value (87,88)

Balkanization however not only happens from technical reasons, as highlighted above (29). The emergence of multiple networks can be considered to happen as the result of a combination of the following processes (numbered 1-9):

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[1] The notion of quality of service has different dimensions, such as response time, delay, resolution, integrity/security and subjective quality (voice, video, etc..). One example is e.g. graphics resolution, where 256 x 256 could be a low quality, while 1024 x 1024 could be a higher one. Likewise unprotected communications would be a low security QoS level, while full encryption and authentication would be a high QoS level. The notion of quality of service is different from bandwidth, and it should indeed be considered so in the context of this paper.

*Process 1*: more powerful technology leads to new transmission options and thereby to competition and the breakdown of monopoly.

*Process 2*: the merging of telecommunications and computer technologies breaks down traditional barriers separating different industries and undermines monopoly power.

*Process 3*: in the information age, a communications or media monopoly becomes too powerful and its scope needs to be limited.

*Process 4*: government regulation proves incapable of controlling a monopoly, and is therefore replaced by policies encouraging a competitive industry structure.

*Process 5:* large businesses fight restrictions, service differentiation and standard tariff structures, based on natural monopoly.

*Process 6*: the diversification of communications media and services makes it difficult for any one provider to serve all sub-markets without competitive entries

*Process 7:* incumbent or dominant supplier's efficiency (or lack thereof) eventually leads to the emergence of competition.

*Process 8:* competition is a policy chosen to enhance efficiency, personalization/ customization and technological development.

*Process 9:* the breakdown of a dominant player is due to the very success of the traditional system in advancing services and in making them universal and essential .As the system expands, political group dynamics take place, which lead to redistribution and over-expansion. This provides increasing incentives to exit from a sharing coalition, and to an eventual tipping off the network from a stable single coalition to a system of separate sub-coalitions (in the game theoretical sense)(39).

Another conceptual formulation is to look at the balkanized networks as a collection of many heterogeneous rule-of-thumb agents who are loosely coupled, leading to industry pricing by parallel and genetic strategies (40).

Research issues include:

**Define, standardise quality of service (QoS) quality levels so as to allow for their pricing and possible regulation**

This is a totally new field of economics research, where, around a service access protocol described as a state transition graph between service connection and selection nodes, one would have to model quantitative features (called Quality of service "QoS" measures) to be collected from network management systems, while also pricing differently each transition in the previously defined graph.

**Is statistical pricing possible, and what are the costs and benefits?**

Today, each single connection or packet, and it's passage through a network, is duly registered (individually, or through aggregates). This makes call data recording systems and billing systems extremely complicated and expensive. It also leads to growing litigation between operators as to how to price transit traffic. The issue is furthermore complicated by the fact that most communications media link to any given piece of information some header/wrapping information, the transmission of which represents overhead (often reconfigured dynamically within the networks). A radical departure from this past and present would be to justify, in economics terms, pricing schemes relying on statistical properties of the traffic (89, 91): this first step would involve service level agreements (SLA) between operators dealing with statistical moments or aggregates of the traffic distribution instead of call data records (CDR or IPDR) In a next step quality of service features could be added still using the same traffic distribution parameters (78,79) This last dependence on service levels makes the research different from work done e.g. in electrical energy pricing from peak or other statistical features of the energy flow. One approach would derive from the notion of a temporary lease of a stochastic number of connections from source to destination, with equalisation around the worst sustained QoS service quality. Revenue to an operator would in this way ultimately depend on available bandwidth at any time, and on fluctuations in overall external demand.

**Can individual tariffs be defined?**

As the number of dynamically changing service requests and service levels will be changing rapidly and will also be very high, a radical approach is to consider individual pricing and individual tariffs (86). In the area of mobile access, a key

driver for this are personalized social behaviours and needs to access content (87,88). This would rely on a real time dynamic "tatonnement" (heuristic adjustment) processes implemented at a combination of the terminal an of the service server. This pricing principle is of course subject to intermediate stages, such as having one such individual tariff per user community, or by user category. This revolutionary concept, open for economics research, is technically feasible in that the cascade of routing tables and dynamic routing algorithms can be enlarged to include the dynamic rate "tatonnement" process via a simple distributed auctioning algorithm.

**Positive externalities in network connection**

When stating the economic case for pricing / tariff, a central issue is the question of negative externalities of usage explained as non internalized costs (28). There are also non internalized benefits in users connecting to e.g. the Internet (56) and thus to mobile Internet. Each user's benefit or utility of being connected increases with the amount of other users already connected (e.g. in the case of SMS's, MMS', of mobile imaging, e-mail, communities) .The same force was at work in the infancy days of telephone. The economic argument for internalising negative externalities in terms of costs should by the same token apply to the need of internalising the positive externalities of connection. Research is needed on the trade-off between the two, and on the impact of usage tariffs on both sides.

**Traffic aggregation and regional exchange points**

While the networks get fragmented, some specific types of traffic get routed via remote locations to achieve basic end-to-end connectivity, and this leads to overhead transit costs which may become very large .In the mobile field, the EU has authorized several competing 3G mobile operators to share infrastructure, which is a variant of the same model when ownership aspects are filtered out. For example, a huge portion of intra-Asia Internet traffic is still routed over the USA; another example is that of operators having integrated or owning a share in mobile networks where transit traffic from base stations is routed via the fixed network of another operator. This leads to initiatives aiming at traffic aggregation between regional operators, between clusters of mobile access sub networks, and also at collective bargaining. In economic terms this means that transactions and tariffs get exposed to possible unfair overheads negotiated by collective bargaining, and vice-versa that some agents may deny a transaction while enjoying extra-territoriality. Research into principles for resolving such situations is timely.

### 3.2 Communication services sales

**Service and access bundling for subscription packages**
Today each user may have physical access to different access networks (telephone, mobile, Internet, broadband, cable, satellite, TV), owned or not by the same or different operators, and which he relies on for diverse services and QoS qualities of service. For all such combinations, different rates would apply, some regulated, some not, and anyway complex billing and payment would be necessary. One way around this is to have operators offer service and access packages, bundling together, say x number of local telephone calls, with y minutes of long distance calls, with z minutes of mobile connections, with t Internet packets sent or received. Research is needed, linking user behaviors, with costing and profit margin issues, to define innovative subscription packages.

Key issues are:

- Deciding how many services to bundle, and which ones, for which user groups
- Pinpointing the customer segments where bundling strategies will generate incremental income
- Impact on brand differentiation
- Maximising demand while minimising the impact on revenue from constituent services

The above use of the term “bundling” is the usual one in telecommunications, i.e related to service bundling as defined. There is no claim here as this being more general or to applicability to more general bundling schemes as researched in (80,81)

**Behavioural learning and customer categorisation**
Whereas by and large fixed networks, corporate networks, and television networks do not allow for, and do not exploit customer usage information, mobile networks do and the data in the HLR’s (home location register) allow for very interesting customer categorisation. Also it turns out that some user groups do not mind revealing personal or behavioural parameters (87,88). The techniques used are either statistical profiling, neural networks, machine learning or other “data

mining" techniques (cluster analysis, linkage analysis, categorisation analysis). This is useful for network capacity allocation etc ... What they fail to do however is to incorporate economic household data in order altogether to reduce the risk for churn or for the non-payment of bills, and to offer proactively new services. In general, most operators do not like to carry to costs, information disclosure risks, and customer care costs of too fine segmentations, although some competitors are bound to exploit this adversity.

**Transient users**

This is an example of a new category of users demanding possibly just the opposite of A), i.e. non-discriminatory subscription unbundling (76)! Amongst such transient groups are to be considered low-income urban non-subscribers with frequent relocations, many of which have wholeheartedly endorsed mobile services with pre-paid usage. The cause of disconnection for this group of non-subscribers is associated not with connection charges but with toll usage. Once off a network, transience in addition to administrative and regulatory hurdles, acts to keep non-subscribers disconnected for prolonged periods of time. Research could map out economic incentives and regulatory safeguards to meet the demands of this group, especially for wireless services. The issue is not easy as those who would be considered low-income by most standards spend a significant share of their income on communications.

### 3.3 Public access and equal access policies

One political or regulatory concern is, in today's model, to mandate equal and universal access to some key services. The term "universal" is linked to location and economic resources According to Article 2 (g) of the EU interconnection directive, universal service means a defined minimum set of services of specified quality which is available to all users, independent of their geographical location, and, in the light of specific national conditions, at an affordable price. In the days of monopoly operators, this was achieved by letting other subscribers carry the incremental investments and costs. In a deregulated framework, competing operators have a hard time supporting the subsidies to specific locations or user groups, while new operators emerge catering to those groups, but at higher costs or lower service levels. The issue if furthermore complicated by historical emphasis on telephone universal access, while demands are most pressing now for mobile services and Internet access. Anyway, the issue is just at its beginnings as the

policy is still enforced at the operator level, and not attacked from the user-driven perspective, i.e. allow for access to at least one of the networks irrespective of the technology used. For example, WLL (wireless in the local loop) is a brilliant access technology for sparsely populated or poor areas.

Research issues include:

**Redefining universal access policies and their costs/benefits**

Research is needed in terms of redefining the whole concept of universal access within the context of balkanised multiple competition networks (and especially access types such as mobile and Internet). The main results should be cost/benefit analyses and verifiable policies. The options are many: special tariffs, bandwidth reservation, taxes, social benefits.

**Access for public benefits: e.g. access to high bandwidth Internet traffic, or to distance learning**

For the educational and research communities, and possibly for some other cultural and religious needs, three options exist:

- either select their communication ‘s providers by a competitive selection, accepting tariffs and quality of service set for other communities
- or: obtain an extension to the universal access regulations to cover that access, as it can be considered key for their operations in view of their public interest
- or: set up their own network operations, meaning e.g. that high speed Internet services for universities and research could be provided by an operator owned co-operatively by the users

As furthermore most of these services would have specific technical characteristics, besides their “public interest“ dimension, research is needed to shape up the regulatory, tariff, and amortisation schemes best serving those special needs.

### 3.4 Competitive access pricing

The field of competitive access covers in economic research, all studies of access from competitive suppliers. As communications is moving to a deregulated multi-supplier context, most of traditional economic analysis applies for the first time. Nevertheless, entirely new research areas emerge, irrespective from technology evolution. It should also be pointed at the fact that sectoral economic analysis, as it models the usage side of communication services, is paramount to pricing analysis (90).

**Bandwidth or service brokers**

Whereas transmission capacity is today in oversupply ("the fiber optic glut"), this is not bound to remain so as wasteful exploitation is to be reduced very soon, company cultures permitting ...This will inevitably lead to switch-less brokering opportunities either for bandwidth, esp. "high bandwidth on demand", for spectrum, or for services such as bulk messaging, on the paramount technical condition that each such can indeed technically be treated as a well defined quality-consistent commodity (84). The voice roaming clearing houses of mobile operators are already an established set of such brokers, as are some "pure" backbone international transmission capacity suppliers, some callback resellers, and some brokering enterprises (73). Roaming costs oscillate now in the range 45-100 cents/minute in North America. The research should here allow not only to estimate auctioning or brokering margins, but also hedging and other trading mechanisms, and the overall impact of such a function in the communications and media sector. Getting more detailed, the research might point at arbitraging aggregation on the interconnection rates through intelligent switching. Nevertheless, resale of capacity or bulk commodity services (such as SMS) without added-value appears to be a business whose "raison d'être" is directly related to how far established providers are from cost-based pricing.

In the field of broadband, it is conjectured (25) that the brokers must operate on wholesale prices. It is the most balanced approach offering increased profit potential to incumbents, new entrants and service providers at the same time as fuelling growth in broadband applications. Wholesale led pricing via brokers also needs very little regulatory intervention.

**Open markets for communications capacities**

In a not distant future, this author predicts that there shall emerge established "open" markets for spot as well as time-limited communication capacities, replacing bilateral or consortium agreements. This may be surprising to those who

believe that the communal "free" market of early Internet access days will prevail: it is just not sustainable, and service differentiation anyway will demolish that model. The television and broadcast industries have already for some years operated via clearinghouses closer to market conditions than to brokers. To research the nature of financial products offered on this communications market, traffic data are needed, but hard to get (13, 48,50). Network management technologies become a pre-requisite, especially so-called "distributed network of networks" management software. It is likely that an options market could flourish very fast covering bulk transmission capacities (84), and that enterprises will push for auctioning of bulk mobile services such as MMS, location updates, etc…

**Flat fee Internet pricing**

In a large measure, the initial success of the Internet is due to regulatory anomalies, meaning that the tariffs for local calls (as used for access to an Internet service provider "ISP") have been low, simultaneously with the fact that the IP traffic as such has been usually priced for free, or with a flat fee (64) The profit to the local operators from ISP's for access costs is now basically zero, but if a fee as low as 1-4 UScents /minute could be enforced, the operators would enjoy an immediate but not-lasting profit surge adding to increased tariffs revenues from local calls by end-subscribers. This access charge is bound to decrease when cheaper higher bandwidth access mechanisms will emerge (cable, DAB, satellite).

The poor performance and quality levels are driven in large part by the lack of pricing feedback. Paying a flat fee for access, users have no incentive to conserve bandwidth. Internet telephony will exacerbate the problem, tying up bandwidth as users arbitrage the current artificial spread between international tariffs for voice and data.

One by-product of flat fee pricing is a lack of incentive for ISPs and National service providers to relieve congestion by adding capacity. Growing Internet traffic is also now taxing local switches (and sometimes routers), as no mechanism exists to recover the costs of adding needed switch capacity.
Finally, the IP message decomposition into packets, the packet handling and routing, all take fundamentally advantage of the marginal costs of sending messages; also, Internet is asynchronous so, for low quality of service measured in delays, current Internet pricing is efficient due to its simplicity.

An alternative reasoning path, in favour of flat Internet pricing, goes as follows. An Internet pricing which is not based on the product of access time and access bandwidth, perhaps modified by a simple QoS factor, will be too complicated to implement, and therefore will not happen. An Internet pricing which levies a time-based very low rate (0.03 UScents or less/minute) would, seen by the general public, appear to be an overcharge, and for the Internet service providers, seen as putting them into bankruptcy.

While all kind of "fixes" can be and are being considered, key research issues remain as how to globally enhance quality of service across networks which have no common control, but usage-sensitive settlements.

It should be added that anyway emerging technologies like Resource reservation protocol (RSVP or equivalents), traffic prioritisation and "tag switching" will also put an end to flat Internet pricing, offering instead of QoS quality of service guarantees. And here again, mobile Internet, especially from GPRS and 3G will pave the way (82).

**Network interconnection pricing**

The TELRIC (Total element long run incremental cost) model is used in the USA by the FCC to price interconnections between networks. This model bases interconnection prices on the cost of efficiently constructing comparable facilities today. The issue is of course that such a model does not account for existing infrastructure or it's provisioning, in which case prices would be very high and not allow competition. Other models or principles exist, like no fees are charged, or auctions. Research is needed on the incentives for operators to upgrade or not their infrastructures at current market prices to achieve a higher independence or dependence from other operators. The introduction of EU directives goes in this direction, but is far from solved e.g. in the mobile roaming case.

**Bandwidth pricing (static and dynamic)**

As the operators are moving to a bandwidth and service based charging structure, a research issue is the pricing of bandwidth. While at one end of very high fixed broadband, this is not an issue really as long as bandwidth capacity glut exists, it is still crucial in mobile services when one will realize that not all mobile services need the maximum bandwidth offered by the mobile access network. In (20) is proposed a detailed model which includes:

1. **A static pricing sub model** with one bandwidth product (raw bandwidth), N producers, and 5 input components (transmission equipment, switching/routing equipment, interconnection transmission cables, access, and licenses); the gross production of traffic is a Cobb Douglas function in terms of all 5 input components, besides labour ; the returns on scale are constant ; the log(price) is the sum of the log(marginal cost) and of a log(mark-up), but this mark-up in turn has a multiplicative elasticity parameter.

2. **A marginal cost pricing sub model**, where:
   - the cost of transmission bandwidth is a negatively exponential function of the cumulated bandwidth capacity
   - the cost of licenses is proportional to the population and the bandwidth capacity in the geographical area
   - the cost of the switching capacity is proportional to the population density and to total traffic (in Erlangs)
   - the cost of interconnection transmission is proportional to the square root of the km-circuits available in the area

3. **A dynamic tariff adjustment sub model**, where the actual tariff is displaced from a nominal static price due to errors in estimating the current cost and demand elasticities; there is an incremental cost incurred in adjusting the tariff from the nominal static level; the adjustment dynamics is by a parallel Jacobi equation minimising the discounted sum of the deviation between the nominal price and the cost of changes in the tariff (60). See also (83) for 3G mobile tariffs modelling.

**Refilling**

Refill is the process whereby carriers, which have a bilateral agreement, route calls through a third operator (or country) with a lower rate than their own. This is breaching e.g. the international accounting rate system where the two operators would just balance their bilateral traffic measured in minutes depending on the location of the originating calls. Because the receiving carrier ultimately receiving the minutes does not see where the traffic call originated, the call routing is regulatory illegal but economically efficient. Research is needed on the effects of refill and of new rules for e.g. international simple resale, and also on the use of private networks in bringing refill traffic outside settlement systems. It should be

noted also that by depriving some operators /countries from settlement payments, these operators can invest less in network upgrades.

### 3.5 Communications and information industry finance

Research issues include:

**Analysis of operator assets**

In finance, communications and media pose thorny problems of valuation of fixed assets, brand assets, knowledge assets, and customer base assets. The first line of thought is the traditional discounted cash-flow based valuation; these valuations are less and less accepted because of rosy forecasts. The alternatives are the value based evaluation with cash flow multiples and the per-POP/per-line /per-cable /per-subscriber access valuations. The unit POP means the millions of people in an area covered by a licence. However, these indicators too have flaws when over time the average revenue per such POP/line/subscriber falls. Research can now be conducted on valuations of already privatised operators, to provide for guidelines and sanity checks for future IPO/ market flotations/mergers and acquisitions.

**Micropayments**

In electronic payment systems (a part of "electronic commerce") (62,63), appear the interesting problem arising from large number of very small payments, each subject to a transaction and communication charge. These charges distort the accounting, although one could argue that the sheer volume of such transactions over networks with low tariffs make it preferable to recoup the transaction costs in other ways. One solution approach is via brokers selling script to end users and paying the information publishers, and another uses stored and refillable value (e-cash). This research issue is key to the development, or not, of electronic money.

### 3.6 Engineering-economic studies

As many alternative technologies get developed, the operators, as well as the equipment manufacturers are faced with major technology choice decisions. While highly technical, the specific studies will normally not be carried out as research. Nevertheless, some general issues remain.

**Software reutilization for service creation**

Most communications systems today involve development costs with a 20/80 % hardware/software breakdown. For each selected system, a number of standards

must be complied with, which are usually quite specific besides the related applications software. The choice is between the added costs of using costlier software engineering technologies allowing for some degree of portability for the generic system parts, and fully custom fast prototyping developments. Research would be useful as to the life-cycle perspective of this choice, not the least in view of the long lifetime of the systems versus the shorter lifetime of some underlying technologies (software development platforms, processors, semiconductor processes).

**System life-time issues**

The dominant communication switch systems are today designed for 30-40 years lifetime, and full backward compatibility is maintained. The lifetime of most TV networks is also quite long. On the other hand, some router based networks assume equipment life-times of less than 7 years, with no backward compatibility. Research is needed, assuming deregulation and competitive prices (revenues and investments) to see if, over the long run, economic development is best achieved by the first type of design as opposed to shorter-life time designs.The work on similar cases for consumer products is not applicable, as these are supposed without substitution, whereas traffic types can be substituted.

**Competing standards**

In many specific communication technologies, standards compete, and eventually get implemented with choice amongst them by users, operators and service providers. However, from the user perspective, these standards, for a given access type (e.g. wireless telephony, or cable telephony, or router protocols), may be incompatible, thus forcing duplicate investments by all these actors. Actors may be forced to such duplicate investments because of the non-overlapping service choices of the alternate access standards. And even when a common standard is defined in broad terms (like for mobile 3G networks, and its two key variants), no service definition standards exist. Research should try to analyse from a microeconomic viewpoint, by user communities, and a macroeconomic point of view, the advantages and disadvantages of competing standards.

**Emerging industries using communications and media sector economics**

This is a self-reflection onto which industries might emerge from research as the one outlined above and below.

One example is new revenue collection (formerly: billing) software allowing for an operator to bundle services and compute the corresponding charges. So called billing mediation platforms exist, covering in one implementation wireline, wireless and Internet traffic from the same provider and producing one bill. For over 30 years, the french Minitel systems, now copied by Japanese i-Mode, allow the operator to mediate content access or services owned by partners, and to bundle it with preferential traffic routing. Many other personalised features should be introduced (68, 87, 88).

The same concept holds true when one bill can be produced when accessing contents from hundreds of on-line newspapers, or based on ATM based pay-per-contents cell solutions, or on mobile IPv6 packet by packet tariffing (83, 85,91). In the later, a flat rate (bandwidth dependent) applies to the permanent virtual circuits (PVC's), while each cell of contents is charged (61,91).

Another by-product of these research issues is the need for transaction processing and accounting procedures able to cope with the explosion in inter-operator cross charges (as discussed in Section 3.4.D) (91). The explosion is proportional to the product: (number of traffic types) x (number of operators interactions -with combinatorial growth) x (times of the day).

Another related research issue is to determine how intelligent billing can build brand loyalty. With a choice of carriers, if billing is inaccurate or complex, subscribers will take their business elsewhere. New billing systems also offer personalised messages to create awareness and build brand loyalty. This is especially true for usage-based tariffing. Do you want simplicity and high prices, or complicated prices and shopping around?

Section 4 below will address knowledge assets and their measurement (quantity and value). This leads immediately, out of value-added trading principles, to the concepts of information or knowledge tailors/brokers/navigators, which for a price help access or disseminate custom knowledge using adequate communications. E.g. an insurance broker becomes an information and knowledge tailor who will mix, blend and adjust insurance for small segments of the market in a way which is not possible today without communications technologies.

**The bandwidth growth law**

Many economists have analysed the impact of "Moore's law" which claims that computer processor power (measured by the number of gates on a single processor chip) doubles every 18 months, this leading to drastic evolution in the price of processing power (measured in MIPS).

What economics, as many in industry, have missed, is the bandwidth growth "law":

"The total bandwidth of communication systems will triple every year for the next 25 years"

This "law" is a consensus opinion not necessarily first established by thorough analysis.

This is tied to scientific and technological achievements in the field of erbium doped photonic amplifiers minimising loss over long distances in optical fibers, coupled with WDM Wavelength division multiplexing technology. WDM takes more bandwidth per bit than older techniques (TDM), but it reduces power to combat non-linearities and divides the bit-stream into multiple frequencies in order to reduce dispersion. For years communication carriers and other consortia have laid fiber, but what is not said openly, is that 60% of the fiber remains unused for communications, and even that leading edge lit fiber is used at less than 0.1 % of its intrinsic capacity. With WDM, one fiber can today carry 3 Terabits/s The "bandwidth growth law" implies that broadband networks are more efficient regardless of how numerous and smart the fixed terminals are. Also, placing the emphasis on pricing of bandwidth and of the bottlenecks represented by the processors and memory/servers is insufficient.

By the way, it is estimated that software only increases in cleverness by 5 % a year (43,71). And the price erosion on access terminals (telephones, mobile handsets, TV's) is about 25%/year at same capabilities level.

### 3.7 Information contents

Diverse communication facilities make it easier to provide better information services to more targeted user communities. User information can be made more

complete and more readily available. Diverse equipment and networks will lead to a robust "hosting" market, with reduced investments in equipment's and skills.

**Electronic communities of interest (also called virtual communities)**
Contents and service differentiation pose a challenge to commodity contents providers such as free radio or broadcast. The differentiated networks will be far more hospitable to electronic communities, since customer segments will naturally gravitate to the networks targeted for their use. As their loyalty grows, users will look to these communities for communication, information and transactions. The contents providers that organise these electronic communities will capture more than a fair share of a rapidly expanding added-value. Research is needed on media and contents access pricing within these communities, based on scenarios where their own contributions should be valued as well. The uniqueness in this research is the self-developing volume, price and promotion.

**Economic rationality and media contents selection**
If economic rationality is built upon self-interest and consistency, how does it work as to economic decisions in the communications and media sector? In other words, what can rational expectations and choice theories imply for media selection and consumption? This requires probably a careful look at the psychological and cognitive factors driving decisions. Does bounded rationality and lack of information about information impact media selection? What would change in the results if the rationality would be expressed in terms of a measure of knowledge and not just in nominal terms (see Section 4? Strangely enough no one has considered the parallel between the "borrow young, save in mid-life, and run down the savings in retirement " cycle for monetary assets and its equivalent for knowledge assets. The Nobel prize work by Gary Becker and Kevin Murphy is highly relevant to choices in the media area, e.g. in the special case of addiction (to TV or Internet).

**Household economics of communications and media**
From the point of view of household economics, and to a lesser extent business economics, the total budget going to communications and media is competing with other family budget items. This is probably the overriding constraint in tariffing access and usage of communications media and contents. Furthermore, competition then will exist between access media types: wireline access, wireless

access, TV access, cable access or Internet access. However, the value/cost of contents accessed must be plugged in.

This issue is an important one, i.e. the elasticity and displacement between budget categories in favour of communications and media. Estimated elasticities are given in (20):

- elasticity of telephone line growth vs. demand : 4 %
- elasticity of long distance telephone line growth vs. demand : 5.5 %
- elasticity of traffic vs. GDP : 10 %
- elasticity of traffic vs. tariffs (Europe) : -15 %

Here is assumed that a 1% increase in demand results in increase the percentages stated above.

The tariffs applicable to Web access must be traded off against household budget constraints, and operator investments; e.g. the wireline networks today are designed to serve at any time only 10 % of all subscriber lines and for short durations, which conflicts with Web usage patterns.

**3.8 Macroeconomic issues**

If we take as assumption that the communications and service branch is a sector, then key macroeconomic issues appear

In the subsequent discussion here, some equations are proposed, and should serve, as basis for empirical testing not yet completed. Subsequent analysis should refine these models at the sectoral level to highlight different demand structures and transactional terms (90).

**A) The production and investment factors of the communications and media sector**

The aggregate production value P would be the combined value of traffic, tariffs, QoS service levels, and accessed contents value; we conjecture here the formula:

**P= $\Sigma$ (Traffic(n) xTariff (n) x exp ($\alpha$(n). Value (Knowledge quantity (n) accessed)))** *(Eq 1)*

where: n =service quality and accessed media:
$\alpha$ is the weighting function dependent on service / quality

which includes an additive sum over traffic types and distributed accessed contents, with an elasticity vs. the value of this accessed knowledge as modelled in Section 4 .4

The investment value I is the sum of the infrastructure and service provisioning investments, plus the investments in knowledge assets, both eventually with amortisation:

**I = Infrastruct. invest + Service provision. invest + Knowledge assets invest. - Amortisation** *(Eq 2)*

Imports and exports should be modelled as the traded traffic value, and knowledge assets traded value:

**Trade balance = Exports (P) - Imports (P) + Value (Exported(Knowledge)) - Value(Imported(Knowledge))** (*Eq 3)*

Research is needed to verify these models, and to generate the input-output matrices showing cross-impacts on other sectors and branches.

### B) Impacts of the communications and media sector on sustained development

It is of high interest to evaluate such impacts in order to determine at a macroeconomics level the communications and media infrastructure investment levels concurrently with other investments, such as transportation, energy, etc., and the effect of R&D (54). Attempts have also been made at using business cycle theory as a further refinement (45).

**C) Reciprocal market access**

Under the telecommunications agreements of the WTO, reciprocity is considered for communications and media services. As some countries consider safeguards, research is needed, e.g. using the above models A) to track the impact over time.

**D) Impacts of standardisation choices on employment in manufacturing industries and service industries**

Once the above production and trade models have been estimated, and once input-output analysis has been performed (not easy for lack of data...) one of the first key questions to be investigated is the impact of the technical standards choices on employment in the manufacturing industries and service industries (see Section 3.6.C). This applies not only to the communications and media industries, but also to consumer electronics, and creative services. It is especially noteworthy to analyze why manufacturing outsourcing by equipment suppliers to contract manufacturers has been claimed to be for cost reduction reasons, while in fact it is mostly because of the effect of standardization and better technical insulation of the proprietary elements.

### 3.9. New players for mobile business and services

Few are today seeing that, as for any economic sector (say the yet un-named 4 th sector discussed in this lecture), its activities can occur within highly diversified companies and public bodies! Communications services supply does not have to be confined to operators when deregulation is in force (WTO agreements). Again, because of less legacies of all sorts, mobile services and value-added mobile services are to spearhead a revolution. Here are some examples:

- home appliance suppliers, and possibly real estate management companies, may very well end up managing Bluetooth and/or Wireless LAN networks
- oil companies and their dealers may choose not to let public operators "refuel" private and professional vehicles with communication services and content via WLAN when they stop at petrol stations; after all, they already refuel the drivers with food also, so ..
- realizing the enormous cash amounts held in connection with mobile pre-paid services, banks may very well decide to merge their funds handling systems with the billing and authorization systems of value added providers

to the operators; this makes sense in emerging countries where the mobile infrastructure is often ahead of the banking IT infrastructure.

- harbours and airports may very well want to streamline their logistics flows by adding VPN (Virtual private network) features to GPRS or 3G systems. Rotterdam and Schiphol are cases in point.

## 4. Specific economic concepts for modelling communication and media sector

As mentioned in Section 2, this lecture also aims at defining some key distinctive concepts from the communication and media sector, which economic research about it should rely upon, and have sofar neglected.

That sector is a network industry of heterogeneous loosely coupled agents, like energy (11,40). Linkage analysis must be used in network industries to map out inter-relations. Linkage analysis is used to link various data points or events together, using a combination of cluster analysis/correspondence analysis (18)/time series. Production models also must also be used, especially in relation to other sectors and for econometric modeling. However, the big problem here has been the lack of quantified variables and measurement methods covering altogether the communication services and the contents being distributed, which we are addressing below.

| *The information economy and employment* | Share of employment in 1993 | Growth of employment 1989-1993 |
|---|---|---|
| Goods | 14.7 % | -6.5 % |
| Services | 70 % | 5.2 % |
| Information (publicity, entertainment, communication, publishing, software, computers, higher education, medical diagnostics, financial markets) | 15.3 % | 3.2 % |

Table 2: Business Week's estimate (November 1994) on the role of the three major sectors in employment figures

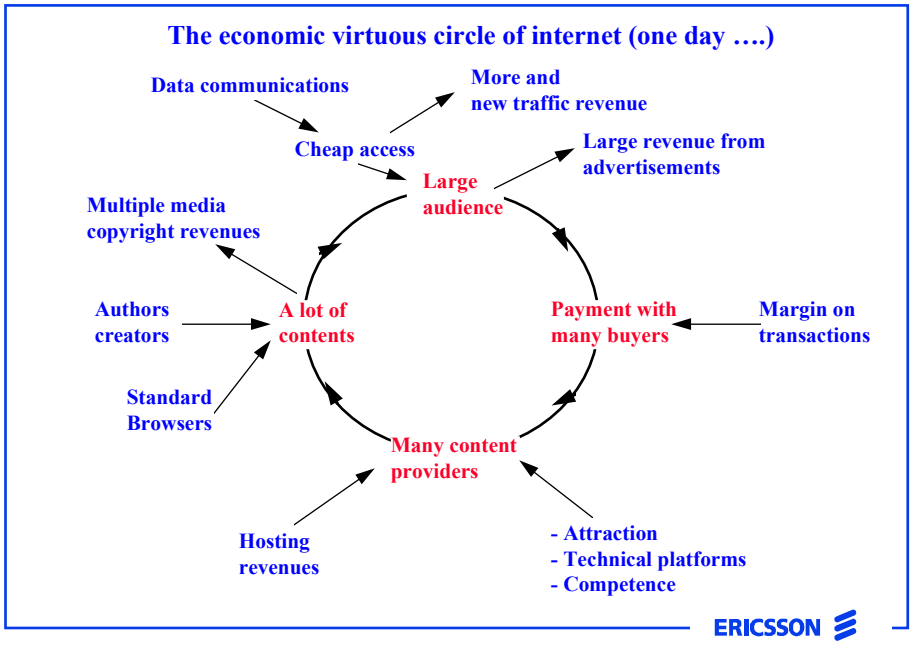


Figure 1: The Web based contents economic cycle

### 4.1 Variables applicable to communications

The key notions are:

**A traffic variable** measuring a service flow from an user to one or several others, for each selected service, with a prescribed QoS service level, through:
**A communication graph** with sub graphs, coalesced nodes, and overlapping nodes labelled with different media/bandwidth features; all edges in this graph have a bandwidth, distance and access type label
**A contents provisioning graph** eventually partly overlapping with b), at each node of which a content of a given type can be supplied, stored or created

More mechanistic, older priority queue models (3) offer a far too simplistic framework.

### 4.2 Pricing of communication variables

The key pricing functions for communication services are:

**Node-to-node pricing** based on QoS service level, and the paths between these nodes, using:
**A service level function mapping** linking delays, bandwidth, information loss, service type, to a QoS service level (see Section 3.1.A)

### 4.3 Variables applicable to media and knowledge: measuring knowledge

Concerning contents, and of course subject to further research, it is indispensable to move to a measure for knowledge quantity and assets, where after they can be valued. The difficulty is in finding measures, which are subjected independent. Much research is needed in this area, but it is already possible to outline an approach (20), detailed out below. The other known theoretical approaches to finding a measure of the value of information have been:

- Marginal analysis of the value of the service provided by this information (57,58)
- Equilibrium theory based determination, by using the fact that the information flow may destroy risk sharing possibility (59)
- Games of information (22)
- Single / multi-period stochastic pricing of information flows in a dynamic framework, with profit maximising by the seller consisting in selling this information "as is" but only to a fraction of traders (74,75)
- Knowledge and media assets pricing from a knowledge indexing perspective (20 and below)

Already, in the accounting area, the International Accounting Standards Committee (IASC) has published a draft standard E 50, June 1995, which defines immaterial knowledge assets, if and when linked to intellectual property rights; no measurement principle is done however, but their amortisation is accepted in Standard E80 over the shortest of the utilisation duration, and a maximum period of 20 years.

In artificial intelligence has been designed (21), and ever since, has been largely used, the notion of frames, which is a hierarchical description of a piece of

knowledge, in terms of semantic interrelations between its components and attributes they each have (22,30). In other words, a frame is a knowledge representation which includes declarative and procedural information in predefined internal relations belonging to generic types, called slots; each frame has a number of knowledge slots, or a tree-based hierarchy hereof, for facts about the concepts represented in the frame. The larger the number of levels/slots in a frame, the more complex the knowledge; the more attributes each slot has, the wider the diversity of the realisations or categories .A frame may apply at a low level (such as one image in a video) or to a higher level (the whole video), with different semantic attributes and descriptions at each. Thus one must define a knowledge acquisition flow constraint, i.e. the rate by which a human can acquire and index (for later retrieval) a piece of knowledge, analyse it, and retain the structured knowledge; this acquisition rate may be low, medium, or high. The acquisition process can take place with fine granularity (e.g. each individual piece of knowledge is being indexed) or with coarse granularity (e.g. between aggregate semantic notions which alone get indexed)

A possible knowledge quantification estimate K is thus for a body of knowledge:

**Knowledge quantity K = Knowledge acquisition rate (granularity dependent) x Number of different frames acquired (weighted by the Number of semantic nodes in each frame , and by the number of attributes by frame)** *(Eq 4)*

Standardisation work has taken place to achieve standardised and normalised definitions of these notions (23). Domain ontologies serve as filters allowing estimating the knowledge quantities from different domains. The measurement tools for Knowledge quantities K according to Eq. 4 operate essentially as frame indexing engines.

### 4.4 Pricing of knowledge: the "difference"

Valuation of knowledge, as detailed below, will have to recognise the types of information, and their relation in relation to the business processes (52). The valuation of information allows for example to:

- Improved decision making
- Justify communication and information technology investments

- Pricing financial bids for knowledge assets, companies
- Improve product design and resource allocation to such designs
- Outsourcing decisions

Knowledge assets become them the valuation of accumulated and depreciated knowledge.

What is special with the cost structure inherent in the production of knowledge is that it has very high fixed costs of production and almost negligible incremental costs: this applies to human creativity, as to duplication of media. This is why the market of knowledge is characterised by the existence of very large numbers of actual or potential creators of knowledge, but of a few large sellers able to capture, and resell this knowledge and creation. Both the cost and the market structure indicate differential pricing is the most likely outcome. Sellers enjoying market power will try to identify and extract as much as possible of their customer's willingness to pay for the knowledge. This is not the only the outcome of profit maximising behavior, but also in many cases the only possible way to make a knowledge available openly and widely.

Price differentiation can be implemented in some of the following ways:

- Assuming high/low willingness to pay according to characteristics of the consumers, e.g. for business/educational, large/small quantity, on-peak/off-peak use
- Characteristics of the knowledge such as timeliness, by different QoS service levels (e.g. delay, visual, security, quality,...)
- Personalization (87,88)

Along with differential pricing, other ways of pricing knowledge and information goods are:

- Bundling, e.g. for software
- Site licensing
- Subscription and metering (for films, Web pages, but also software)

However, in all cases, the value of a quantity of knowledge K (fine or coarse) will be:

**Value (K)= Access price to this knowledge (K) + Price (K) x K (Knowledge quantity consumed)** *(Eq.5)*

### 4.5 Generic production function for the communication and media sector output value

The generic production function is then simply (see Eq 1 for an example):

**P = f ({Traffic, Tariff (traffic)), (Knowledge, Value of knowledge), Labour, Investment in traffic, Investment in knowledge)**
***(Eq. 6)***

This production function also covers output from telework (now called e-Work), work centres, electronic commerce, and economic/business activities as those in Section 3.6.D.

## 5. Conclusion

The communications and media sector is a major element of modern economies, and deserves much more research than has been carried out so far. Furthermore, very challenging new issues linked to immaterial networks, social / behavioral rules, and distributed contents have to be analysed by novel approaches. Mobile services and networks, and their diffusion amongst users, enterprises and industries, constitutes the most lively area in which this research can be carried out.

## 6. Thanks expressed

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