Telecommunications Evolution: the fabric of Ecosystems

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Abstract— **This paper provides a summary of ideas presented in a number of lectures during 2009, the first one on February 18th in one in Sao Paulo at the International Workshop on Telecommunications. It is the result of activities at the Future Centre, the Telecom Italia research centre on economic and strategic studies in Telecommunications.**

Index Terms— **Business ecosystems, future of Internet, new business models in telecommunications, technology evolution, Telecom Operators challenges in the next decade.**

Resumo— **Este artigo fornece um resumo das idéias apresentadas em várias apresentações durante o ano de 2009, a primeira delas em 18 de fevereiro no International Workshop on Telecommunications em São Paulo. É o resultado das atividades do Future Centre, o centro de pesquisa da Telecom Italia em economia e estudos estratégicos em telecomunicações.**

Palavras chave— **Ecossistemas de negócios, futuro da Internet, novos modelos de negócios em telecomunicações, evolução da tecnologia, desafios para as operadoras de telecomunicações para a próxima década.**

I. Introduction

The Telecommunication Market, as we know it in developed Countries, is shrinking in terms of revenues, and there seems to be no trend-change on sight. Connectivity will be more and more ubiquitous, available and capacious and it will be available at lower and lower price. In developing Countries the situation is different since growth in customers and usage dominates the market, but that won't last beyond the first years of the next decade as the number of (cell) phones approaches the number of human beings. Besides, most developing Countries have a lower spending capability resulting in less income for the Telecom Operator in a business that is becoming less and less labour intensive and therefore less sensitive to labour cost. Hence, revenue and margin problems are hitting Operators worldwide, independently on their turf and the prospect looks bleak.

If we want to seek growth opportunities we need to look outside of our historical turf.

The purpose of this paper is to lay out a "fil rouge" from the changes that are taking place in the market as result of technology evolution, competition and regulation, driving down the transaction cost and hence stimulating the aggregation of many players into ecosystems, to the analyses of what opportunities can be leveraged by a Telco Operator through ecosystems.

There is no silver bullet on sight and business will remain as it is in terms of dynamics, competition and hurdles. Money will still need to be "gained" at the expenses of someone else. No free lunch. But some of the rules of the game have already changed and a few more will change in the next few years.

II. It is no longer Biz as usual ...

As Telecom Operators we cannot cheat ourselves into believing that it is business as usual, that we are just facing an economic downturn that will soon be over. If we are not doing anything, as well as if we keep staying the course, we are going to fade away.

This is not, yet, true, in growing markets, like third world Nations. However, we should be aware that in many of those Nations the market grows but the ARPU is significantly lower than the one we are used to.

There is a curious, potential, threat coming from these growing markets (some 5 years away): these markets are seeing the deployment of the very latest technology, having efficiency ranking first, both OPEX and CAPEX. In ten years time we might be facing the situation of a flat network having island of cheaper communications able to attract business or, even worse, forcing other areas to decrease prices to match the international competition.

There is a further effect to be taken into account: EBIT in telecommunications is very high (I have heard it being described as high as drugs and prostitution) if compared with other sectors, like consumer electronics. And we are going towards not a convergence but a collision in terms of biz with these other sectors. The expectation of margin decrease is well founded.

Here are some changes affecting our biz:

1) The future in telecommunications used to be fairly predictable. Technology was driving evolution and technology roadmaps are fairly accurate. We could tell with reasonable accuracy what would be the processing speed of microprocessor, the capacity of a storage device and the transmission speed of a line within a five years time. Operators used to take these forecast as starting point to design their network evolution and, in turn, that network plan was the measuring stick for planning service deployment.
   In these last two years we have seen that technology roadmaps continue to be accurate but the evolution is steered by the market since technology is no longer a bottle neck. Once evolution is steered by the market forecast becomes very difficult. More than that. If the market goes one way, funding are directed to those technologies supporting that direction of growth, hence also technology evolution gets affected. In 2003 it seemed (technologically) clear that LCD screen would be

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soon superseded by SED and NED screens. These latter offered better performances. What happened was that the market massive adoption of LCD drove manufacturers to invest more on that technology (this leading to a continuous improvement) diverting funds from those other technologies (that did not left the laboratory stage). Today LCD technology is leading the market place and will likely continue to do so in the next five years.

2) There used to be few Innovators clustered around big Companies and institutions shelling out lot of money for research. Names like Bell Labs, NTT Labs, CNET rung a bell in many people in the last century. Now we are witnessing innovation everywhere, carried out by small groups all over the world. In a way Innovation has become affordable and the reason is the big platforms that have been created, call them logistics, transportation, communication, have dramatically decreased the cost of moving innovation from the point of creation to the points of possible adoption and the transformation of many users into players, receiving innovation and adding on, thus further creating innovation. Because of this, innovation has also become affordable. Cell phones are costly innovation sold at a bargain price and stimulating innovation in many field. Best way of using mobile payment? It is not Japan, but Central Africa. In Japan the mobile payment is leveraging on the banking system, in Africa it is replacing a (barely existing) banking system.

3) Physical resources, be it capacity of lines and storage or performances in computation and transmission, used to be the bottleneck in provisioning services. Being a smart engineers meant to be able to make the most out of these scarce resources. Efficiency was the way to distinguishes oneself from competition. We are seeing (and in certain areas we have already seen) a dramatic change in this respect. Storage and processing grow more than our needs, display resolution is reaching our physical limits, bandwidth is bound to become irrelevant since we will have more than needed. As this physical limitations fade away the competitive advantage shifts from efficiency to simplicity. Interfaces are winning the customer heart (and purse).

4) It used to be that to make a call you looked for a telephone. And you assumed that beyond that telephone there was a working infrastructure taking your voice to your called partner ear. Cell phones have changed this scenario. You no longer have to look for a telephone and you no longer assume a specific infrastructure (when you are abroad most of the time you don't know, nor care, who is the infrastructure provider you are using). WiFi areas will further dilute our perception of the infrastructure that as a matter of fact is becoming a variety of infrastructures. If years ago all terminals were alike, now customers choose the terminal they like, and change it at whim, they go back home if they happen to forget their cell phone. They cannot tell twisted pair from coax but they know the difference between that particular cell phone and the 2,000 models that have appeared on the market last year. Although technology massively permeate the infrastructures and new technology is deployed every day, the technology at the edge is the one that makes the difference in the market and in the service offering.

5) Huge industrial clusters have marked the last century landscape. As production tools got more sophisticated and expensive, large scale production was the only economically viable solution. The trend, however, is towards more flexibility in the next decade in production tools and more possibility of customization of products by embedding services at the point of sale and during its life time. As already pointed out where efficiency won the market now customization and flexibility win.

6) "You give me something, I'll give you something" was a well known saying going back to the ancient Romans. This translates into the way of life that if you want something you have to pay for it. Apparently, in several areas affected by the digital society this is no longer the case. The fact is that the commerce of atoms costs tangible resources, the commerce of bits does not. You cannot copy a paper book without paying for ink and paper but you can duplicate as many times as you want a digital book with basically no expense. This has opened the way to creative marketing and different biz models. But this is also shifting the value from the entity being marketed to the relationships being created with that entity.

Another significant shift, significant for its implication and for the change of cultural model, is the different position of standards. Standards were, are and will be, very important. But, actually, it is not the standard per sÃ© of being important, rather its effect on the biz and on the end user: the biz needs standards to streamline production and open the market; the end user needs standard to ensure compatibility of what has been bought with the present and future environment.

These two "needs" remain unchanged; what changes is the way to meet them.

If you just think at the 80ies and the work carried out by the Joint Expert Picture Group for the definition of a standard to represent images (known as JPEG) and now you look at the variety of coding used (JPG, GIF, TIFF, RAW, NEF, EPS, PIC, PSB, BMP, RLE, TGA, VDA, VST to name but a few ...) it is easy to tell that something is "wrong". At the same time, all of us use seamlessly any kind of image file, most of the time without even noticing the type of coding used. Then, on the other hand, we can say everything is "right".

Fact is, the need to provide a uniform way to access images has been solved not by the standard but by applications able to seamlessly access a variety of coding and present to us, the end user, the image. This is a general trend, that has gained momentum, as access to "goods" has become mediated by computers and applications. The burden of providing homogeneity has shifted from the goods to the access facilities.

Now, this opens up interesting scenarios for Network Operators. In principle, any object can be mirrored in the network and this mirror image can be used to decouple physical specificity from services and information. These latter can be offered by a variety of business that can exploit the connectivity to the object through the mirrored image. It is up to the party managing the connectivity between the mirror and the object to find the most appropriate ways to connect and adapt information and services to the specific needs (and characteristics) at that particular time. Notice how awareness on the object position and environment can enhance the delivery and provide the end user with a better experience.

The future of networks will resemble a bit the conceptual Internet of today. A cluster of infrastructures ensuring flat end to end connectivity: point to point, point to multipoint and multipoint to multipoint. Connectivity will be perceived as a property of the ambient, togetherness as well as liaison. It will morph into services like deferred delivery, prompting, tracking, adaptation, preservation, computation. All these services can be considered as part of the conceptual network and since they are detached from the physical networks are also known as "the Cloud" spanning networks and embedding a variety of service providers. Someone is going as far as saying that in the future terminals will not connect to the cloud but will become part of the cloud. More adventurous ones say that the trend is towards terminals being "the Cloud".

This conceptual evolution is fostered by significant changes in the physical infrastructure: technology evolution makes it possible to create an infrastructure based of optical fibre covering most of the territory. This coverage is completely flat, a few lambda switches will route huge flux, each of several, each consisting of several hundreds Gbps, over fibres with capacity of several Tbps.

The amount of transport capacity will exceed the amount of data that we can imagine to have in the next fifty years. Recent forecast by Cisco estimate the world traffic to exceed 600 Exabytes (billion of billions of bytes) by 2013; compare this figure to the less than 20 EB transported in 2003.

How much can be the total amount of data that need be transported in the longer term? Well we can provide a rough estimate by making some assumptions like the amount of people involved, the type of traffic and respectively the number of machines and their traffic demand. It turns out that the lion's share is taken by ultra high definition television (the 4k and 16k standards providing respectively images with 4 and 16 times the definition of today's HD television). Holographic communication (it is not yet on sight) and 3D movies are not increasing the bandwidth needs significantly. Voice is also a minuscule fraction of the total amount of communication. Take as market space 8 billion humans (we can expect this amount beyond 2020) and assume a 4 hours of use of UHD television plus 2 hours of lower definition telecommunications and 6 hours of being in touch with voice and text and you get something like 160 ZB (Zettabytes) representing a 10,000 fold increase with respect to the 2003 traffic. Add to this the machine generated traffic (including webcams for automatic surveillance) and you get an estimated total of about 200 ZB.

This kind of capacity can well be provided by just 2,000 fibres with today's available technology and less than 100 if we are looking beyond 2020. Hence, the Italian backbone would be able to support this kind of worldwide demand. The bottleneck will be the switching point: we will have optical switches, lambda switch, and optical add drop multiplex to manage this kind of data flow.

The edges of the fibre network will be terminated by radio drops of many different kinds. Here the single transport capacity will be severely limited, constrained by the usable spectrum available (in the 200MHz - 5 GHz range with the sweet spot around 1 GHz). In the near term, next decade, we will see the coexistence of a variety of radio access points with terminals in charge of selecting the most appropriate one (in general connectivity will be provided by the one serving the smallest cell covering the terminal, since this is the one providing the most efficient use of the spectrum). The pervasive presence of fibre will be exploited by a multitude of radio access, each covering a very small area (pico, femto cells). In the longer term, beyond 2020, we can expect a multitude of radio mesh networks connecting to fibre access points. What in the next decade will be small cells will be replaced by radio mesh whose nodes are the terminals. These will, particularly in urban and dense communications ambient, like malls and airports, will replace the smallest cells, since every radio device will provide and share its own cell. Shannon limits (that we have already almost reached in terms of spectrum efficiency with today's technology) will be circumvented by extending the MIMO principle to the extreme of having terminals negotiating to solve interference in the received signals.

Fibre and radio evolution are therefore insuring that the physical infrastructure will keep exceeding the demand of the market in terms of capacity. Clearly, this evolution requires significant investment and Telecom Operators will match it to market response. This will continue to create unbalance among different areas. We will see a number of new players, from municipalities to single individuals, taking care of local infrastructures, bearing the costs and offering connectivity to third parties to recoup them.

This is another reason leading to a variety of networks and shifting the focus from the infrastructure itself to the conceptual connectivity (both in terms of management, service provision and offering).

How will the end user find his way through this heterogeneity? The seamless access will no longer be a characteristics of the network design (although a lot of organisational aspects need to be addressed) but will relay on the terminal capability of choosing the "appropriate" gateway and using the corresponding signalling and communications interface. Applications like Fring (available for the iPhone) are showing the way: access interoperability managed by the terminal, not by the network.

III. Technology Evolution and Business Impact

Technology has been evolving at a consistent pace in the last fifty years. This path is going to continue as far as we can see in the next decade. We are, however, reaching a performance point where we are seeing an impact on the rules of the game. This is what I am going to consider in the next sections, specifically looking at storage, processing, sensors and display technology evolution. These are not the only ones affecting the Operators Biz in the next decade. For more on other technologies, like autonomic systems, statistical data analyses, pervasive and embedded computing take a look at the referenced publications.

A. Storage

The original digital storage solutions have basically disappeared (magnetic cores, drums, tapes, etc.) to leave space to new technologies, like magnetic disks, solid state memory, and polymer memories (on the near-term horizon).

As of 2008, hard drives, or devices using magnetic disks for storage, reached 2 TB capacity in the consumer market, and 37.5 TB disks are expected to appear in 2010 (from Seagate). Storage capacity of 100 TB will become commonplace by the end of the next decade. The new leap in magnetic storage density is achieved through heat-assisted magnetic recording (HAMR).

Solid state memory has advanced significantly, and compact flash cards are cheap and ubiquitous these days. They were invented in 1994 and have moved from a capacity of 4 MB to 64 GB as of 2008. A capacity of 128 GB should become available in 2009 (solid state disks [SSD] based on flash technology appeared in 2007).

The announcement at the end of 2008 of new etching processes able to reach the 22-15 nm level (down from the current 60-40 nm standard) clearly show that more progress in capacity is ahead.

This increase in capacity is placing flash memory on a collision course with magnetic disks in certain application areas, like MP3 players and portable computers.

They consume only 5% of the energy required by a magnetic disk and they are shock resistant up to 2,000 Gs (corresponding to a 10ten-foot drop).

The bit transfer rate has already increased significantly and there is a plan to move their interface to the Serial Advanced Technology Attachment (SATA) standard, the one already used by magnetic disks, thus raising the transfer speed to 3 Gbps By comparison, the current Parallel Advanced Technology Attachment (PATA) interface tops out at 1 Gbps.

Polymer memory has seen an increased effort by several companies to bring the technology to the market. Commercial availability is likely in 2010. Polymer memory is made by printing circuit components on plastic, a precursor to fully printed electronics.

Its big advantage over other types of memory is in its extremely low cost and potential capacity. In an area the size of a credit card, one could store several terabytes (TB) of data (see Figure 1).

Data will be stored both at the edges and within the network. Ericsson predicts that a 1 TB cell phone will be available in 2012, home media centers in will be able to store the entire life production of a family in their multi-TB storage, exabytes (EB; a billion billion bytes) will become commonplace at data warehouses for data-based companies like Google?, Snapfish?, Flickr?, Facebook?, and those to come in the future. Institutions and governments will harvest the digital shadow of their constituencies daily to offer better services. Raw data generated by sensors will have economic value through statistical data analyses.

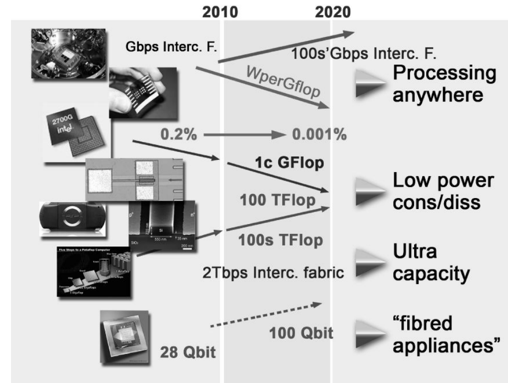

Fig. 1. Storage capacity evolution.

Storage is becoming one of the most important enablers for business in the next decade. What is the consequence of this continuous increase in storage capacity?

Clearly, we can store more and more data and information; however, the real point is that this huge capacity is changing paradigms and rules of the game, affecting the value of the network and its architecture.

Because data is everywhere, the flow of data will no longer be restricted from the network toward the edges. The reverse flow will be just as important. In addition, we are going to see the emergence of local data exchange, edges to edges, terminal to terminal. The first evolution makes the uplink capacity as important as the downlink (leading to the decommission of ADSL), and the second emphasizes the importance of transaction-oriented traffic: "Updates" achieve greater importance and possibly are perceived as the real value that some provider may deliver.

Raw data, but this also applies to information as soon as one is drowning in information, makes sense only if it can be converted into perceptible chunks of information relevant to the current needs for a given user (person and machine).

As we discuss in the following, storage could disappear from sight, replaced by small "valuets," a mixture of applications and sensors or displays able to represent a meaning valuable to a user. We are starting to see this appearing as tiny apps on the iPhone?. They mask the data, the information, the transactions required, and even the specific applications being used. The new way of storage cards embedding communications and applications is a further hint of the way the future is going.

B. Processing

Processing evolution is no longer the sole axis of increased performance. Other factors, like reduced energy consumption and ease of packaging, are growing more and more important. As in the past, when the continuous increase in processing performance expanded the market, now decreasing energy consumption and cheaper packaging of the chip in a variety of objects are opening up new markets.

Intel declared in 2005 that they were targeting a 100 times reduction of energy per GFLOP by 2010; as of 2008, they were on target to achieve that. A decrease in power consumption enables the packaging of more processing power in handheld devices, like cell phones: The issue is not the resulting reduced drain on the battery, but rather the reduced heat dissipation. A 500-watt cell phone will burn your hand long before its battery runs out.

Second, and possibly with far-reaching consequences, very low-consuming devices could be powered using alternative power sources, such as conversion of sugar circulating in the blood into energy for tiny medical devices delivering drugs and monitoring certain parameters in the body, conversion of surface vibration into energy for sensors placed in the tarmac of roads to measure traffic, or conversion of wireless radio waves into energy using evanescent waves to power sensors in a closed environment.

As the cost of producing sensors decreases, the economics shifts to their operation and powering is a crucial factor. Because of progress in decreasing power consumption, we can be confident that the next decade will see an explosion of sensors and along with that an explosion of data. By 2005, only a tiny fraction of microprocessors produced ended up in something that could be called a “computer.” Most microprocessors ended up in devices like microwave ovens, remote controls, cars, and electronic locks, to mention only a few categories. In the next decade most objects will embed a microprocessor and most of them will have the capability to be connected in a network (to The Network). This will change dramatically the way we perceive objects and the way we use them.

Part of this change will be enabled by the rising star of printed electronics. This manufacturing process, based on a derivative from inkjet printing technology, is very cheap - two to three orders of magnitude cheaper than the silicon etching currently used for chips. Additionally, printed electronics is cheaper to design (again three orders of magnitude cheaper than etching silicon) and can embed both the processing and storage and the antenna for radio communication and, if needed, a touch-based interface, avoiding the cost of packaging. In principle it will be possible to write on goods as easily as we stick labels on them today.

This described evolution is in the direction of what can be called microprocessing.

We will continue to see evolution in the opposite direction, that of “supercrunchers.”

In this direction we are seeing a continuous increment of processing speed achieved through massive parallel computing with hundreds of thousands chips within a single machine exceeding the PFLOPS today and the EFLOPS in the next decade (billions and billions of floating point operations per second). We are also going to see more diffused usage of the cloud computing paradigm in both the business and business-to-consumer environments. The consumer is unlikely to appreciate what is really going on behind the scenes, that some of the services he or she is using are actually the result of massive processing achieved through a cloud computing infrastructure.

Looking at the longer term, we can speculate that cell phones and wireless devices in general may form a sort of cloud computing for resolving interference issues, thus effectively multiplying spectrum usage efficiency. The major hurdles on this path (which has already been demonstrated as technically feasible from an algorithmic point of view) are the energy required by the computation and communications among the devices that make it practically impossible today and in the coming years.

C. Sensors

Sensors are evolving rapidly, getting cheaper and more flexible. They embed the communications part and thus are ready to form local networks. Sensors open up a wide array of services. Think about the thousands of applications that are newly available on the iTouch? and the iPhone, exploiting the accelerometer sensor.

Drug companies are studying new ways to detect proteins and other substances.

What in the past required long, expensive tests executed by large, very expensive machines can now be done cheaper, quicker, and easier by one or several sensors in combination. Some of these sensors are being targeted for embedding in cell phones, like the one able to analyze breath as the person talks into the mircophone. Over time, the sensor can detect the presence of markers for lung cancer. SD-like cards containing tens, and soon hundreds, of substances will be plugged into the cell phone, enabling the detection of a variety of illnesses well before clinical signs appear.

Now, this is not just an application, although an interesting and valuable one. It is a driver to miniaturize sensors, to make them more flexible and responsive to the environment and thus able to pick up telling signs. Hundreds of sensors will be constantly producing data that will become a gold mine to derive meaning. Communications is the enabling factor because this data needs to be seen as a whole to derive meaning. We’ll see this in a moment when considering statistical data analyses.

Other researchers are investigating e-textiles, special fibers that can be woven into clothing to sense a variety of conditions and the presence of special substances like sugar and proteins, thus providing data to detect several pathologies.

Printed electronics will contribute to the slashing of costs to produce and deploy sensors in any object: Pick up something and that something knows it and gets ready to interact.

Sensors are also providing what it takes to transform a collection of objects into an environment. Context awareness will make significant advances because of sensor’s presence everywhere.

At the end of 2008, Intel announced a research program, Wireless Identification and Sensing Platform (WISP). They expect WISP will be available in the next decade and will be able to provide identification of any object, including our body, through a sort of miniaturized Radio Frequency Identification (RFID) forming a continuous interconnected fabric. The present RFID technology, over time, will transform itself into active components with sensing capabilities, as the price of sensors goes down.

This probably won’t happen before the end of the next decade. In the meantime, more and more objects will embed sensors and some of these will act as identification, thus avoiding the need for an RFID.

The transformation of an object into an entity that can communicate and can become aware of its environment leads to a change in the business space of a producer.

In fact, this opens the possibility of remaining in touch with a product user, thus transforming the object into a service. In parallel this enables new business models and requires a transformation of the producer?s organization. Most producers will not be prepared for this change, but it will be difficult to resist this evolution because the competition will be ready to exploit the marketing advantages provided by these new "context-aware" objects. Some producers will decide to open up their product communications and on-board flexibility to third parties to let them further increase the features and hence the perceived value of the product. This openness, in turn, will give rise to a variety of architectures, making network platforms and service platforms true service factory and delivery points.

The research work on sensors will create ripples for today's established dogmas, like the ubiquity of IP: Energy efficiency considerations are driving sensors' networks to use non-IP communications and there will be many more sensor networks using ad hoc protocols than local and backbone networks using IP; identity and authentication will need to cover objects and this might bring to the fore new approaches to assess identity. The SIM card is very effective as identification and authentication goes, but it has not satisfied the banking system and it might not be the future of identification.

In fact, cell phones equipped with sensors detecting biometric parameters might provide even better authentication mechanisms and would make it possible to separate the terminal from the user (which would appease the banking system).

Finally, the need for a set of self-standing sensors within an environment coupled with the need to cut energy consumption on each sensor is pushing researchers to work out ever better autonomous systems theory and applications. This is going to have a profound effect on the network ownership and management architecture, as autonomous systems destroy the principle that one needs a central control to deliver end-to-end quality and hence the very foundations of today's telecom operators.

D. Displays

Display technology has brought us the wide, flat screens everybody loves. It has also populated with a growing number of devices with a screen, from digital cameras to cell phones. Digital frames have invaded our homes as well. However, some dreams have not yet come to fruition, like the holographic screen that was supposed to take center stage in our living room according to futurists in the 1960s.

There are many basic technologies available that are bound to progress, particularly in the direction of lower and lower end user cost. The improvement of production processes is the single most important factor in this progress. The lower cost makes it possible to have screens popping up everywhere, which is in sync with our perception of a world based on visual communications. The telephone has been a compromise, but a very successful one indeed; so successful, in fact, that it created a new communication paradigm, so strong that now most people prefer talking rather than communicating over video (the latter is considered much more intrusive, as it brings you very close to the other party).

There are, however, other directions of progress that are important because of the perception impact they have. The resolution of our eye is approximately equivalent to 8 megapixels. Our brain composes the signals received from the eyes in a bigger window whose resolution is roughly equivalent to 12 megapixels (Mpixel). Present high-definition (HD) television screens have a 2 Mpixel resolution (achieved using 6 megadots, a triplet of red, green, and blue makes up one resolution pixel). Hence, although we marvel at the quality of the images, our brain is not fooled. We are looking at a screen, not at reality; we are watching a show, we are not "at the show."

The Japanese have the goal of achieving a 32 Mpixel screen (and the required production chain) by the end of the next decade. A few 4K screens are available on the Japanese market, reaching the 8 Mpixel threshold (see Figure 2). If we look straight at one of these screens, we cannot tell the difference from reality. We already have 8 Mpixel resolution in some products. Many digital cameras, in fact, are now capable of much higher resolutions (for example, one Nikon reflex camera that was announced at the end of 2008 has a resolution of more than 24 Mpixels).

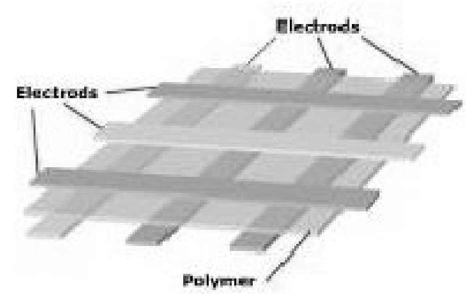

Fig. 2. An 8Mpixel resolution screen scheme.

However, most of the time we are not looking straight at something. Even without noticing, our eyes scan the environment and it is this scanning that allows the brain to create a larger image and to get the feeling of "being there." To replicate this sensation we need to have our eye scanning confined to the screen; that is, we need to be sufficiently close to the screen and the screen dimensions need to create an angle with our eyesight exceeding 160 degrees (when we are looking straight, the angle captured by the eyes is slightly less than 130 degrees).

The increasing dimension of entertainment screens and their increasing resolution will lead us into make-believe situations in the next decade. The bandwidth required to transmit that amount of information exceeds 100 Mbps, so only optical fiber connections will support this standard.

Although we will have LTE and LTE+ (there will always be a successor on the horizon) that will be able to handle those kinds of speed, it does not make economic sense to use all available spectrum for this type of services. Within the home, the situation is different. Optical fiber may well terminate into a gateway that will beam information wirelessly at speeds up to 1 Gbps.

Smart materials will become more and more available to display images and clips. We already have special varnish that can change its colors to create images; electronic ink, on a smaller scale, can display black-and-white text and by the end of this decade it will be able to display color images. We can expect significant progress in this area that will lead by the end of the next decade to ubiquitous display capabilities on most kinds of objects.

This is going to change the look and feel of products and, as pointed out in the case of sensors, it is bound to change the relation between producer and user. As indicated for sensors, these capabilities coupled with open systems and with open service creation platforms will enable third parties to provide services on any object.

Displays are the ideal interface for human beings because we are visually oriented. The coupling of touch sensors or other kinds of "intention" detectors opens the way to new services.

The underlying assumption is that objects will be connected to the network, either directly or, more often, through a local ambient network. This connection in many instances will be based on radio waves, although another strong possibility might be the power lines within a given ambient. The fiber telecommunications infrastructure is likely to stop at the entrance of the ambient on the assumption that the fewer wires you have around your home, the better.

IV. New networking paradigms

The advent of autonomic systems, the multiplication of networks, the presence of huge storage capacity at the edges of the old network (more specifically in the terminals, cell phones, media centre) and the growing intelligence outside the network, will change significantly the networking paradigms. The efforts in the past thirty years have focused on exploiting the progressive penetration of computers in the network to make the network more intelligent. A simple economic drive motivated this evolution, i.e. the network is a central resource whose cost can be split among the users. It makes more sense to invest in the network to provide better services at low cost to low cost low intelligent edges. The Intelligent Network finds economic justification in that fact. The first dramatic shift happened with cell phones, with the mobile network. If you were to develop a network from scratch and you decide to use a fixed line network to provide services, you would have to pay almost 100% of the investment. On the other hand, if you were to deliver the same services using the mobile network approach, the overall cost would be split 30% in the network and 70% in the terminals (and this latter part is likely to be sustained by customers). This reflects the shift of processing, storage and intelligence from the network to the edges, to the terminals using it.

A possible, and likely vision, for the network of the future is a bunch of very high capacity pipes, several Tbps each, having a meshed structure to ensure high reliability and to decrease the need for maintenance, in particular, for responsive maintenance (the one that is most costly and affects most of the service quality). This network terminates with local wireless drops. These drops will present a geographical hierarchy in the sense that we will see very small radio coverage through local wireless networks, dynamically creating wireless coverage through devices, very small cells (femto and picocells), cells in the order of tens of metres (WiFi), larger cells belonging to a planned coverage like LTE, 3G and the remnants of GSM or the likes, even larger cells covering rural areas (such as WiMax when used to fill the Digital Divide) and even larger coverage provided by satellites. In this vision, the crucial aspect is ensuring seamless connectivity and services across a variety of ownership domains (each drop in principle may be owned by a different party) and vertical roaming in addition to horizontal roaming (across different hierarchy layers rather than along cells in the same layer). Authentication and identity management are crucial. This kind of evolution requires more and more transparency of the network to services.

The overall communications environment will consist of millions of data and service hubs connected by very effective (fast and cheap) links. How could it be ?millions? of data and services hubs? Trends are toward shrinking the number of data centres. The technology (storage and processing) makes it theoretically possible to have just one data centre for the whole world. Reliability requires that it be replicated several times in different locations, but still we can be talking of several units!

The fact is that the future will see the emergence of data pulverization in terms of storage. Basically every cell phone can be seen as a data hub, any media centre in any home becomes a data hub. When all these data hubs are added together, millions of data hubs is actually a very low. How can one dare to place, on the same level, a TB of storage in a cell phone, a 10 TB in a media centre and several EB in network (service) data centres? The fact is that from an economic point of view, if we do the multiplication, the total storage capacity present in terminals far exceeds the one present in the network-service data centre (TB*Gterminals = 1000 EB). The economics of value is also on the side of the terminals. The data we have in our cell phone will be worth much more (to us) than the ones in any other place. People will consider local data as ?The Data? and the ones in the network as very important back up. Synchronization of data will take care of reliability but at the same time asynchronous (push) synchronization from the network and service DBs to the terminals will make, perceptually invisible, those centralized DBs.

The same will (is) happening for services. Services are produced everywhere, making use of other services, of data, of connectivity and are perceived "locally" by users. They are bought or may be gotten for free, possibly because there is some indirect business model in place to generate revenues for the service creator and to cover its operational cost. Services may be "discovered" on the open Web or may be found in specific aggregator places. The aggregator usually puts some sort of mark up on the service but at the same time provides some sort of assurance to the end user (see Apple Store). We'll come back to this in a moment.

Once we have a network that conceptually consists of interconnected data-service hubs, one of which is in our hand, possibly another in our home, what are the communications paradigms used?

Point-to-point communications, i.e. calling a specific number, is going to be replaced by a person-to-person or person-to-service (embedding data) communications. This represents quite a departure from today since we are no longer calling a specific termination (identified by a telephone number). Rather, we are connected to a particular value point (a person, a service). Conceptually we are always connected to that value point; we just decide to do something on that existing connection. The fact that such a decision may involve setting up a path through the network(s) is irrelevant to the user, particularly so if these actions involve no cost to the user. The concept of number disappears and with it a strong asset of today's Operators.

The value of contextualized personal information finds its mirror in the "sticker" communication paradigm. A single person or a machine, asks, implicitly or explicitly, to be always connected with certain information. Most of this may reside on the terminal, but a certain part can relate to the particular place the terminal is operating or to new information being generated somewhere else. Communication operates in the background, ensuring that relevant information is at one?s fingertips when needed. It is more than just pushing information; it requires continuous synchronization of user profile, presence/location and ongoing activities. This embeds concepts like mash ups of services and information, metadata and meta-service generation. It requires value tracking and sharing. It might require shadowing (tracking data generated through that or other terminals with which that person/machine comes to interact with).

The variety of devices available for communications in any given environment, some belonging to a specific user, some shared by several users (e.g. a television) and some that might be "borrowed" for a time by someone who is not the usual owner, can be clustered to provide ambient-to-ambient communications that may be mirrored by the "cluster" paradigm. Autonomic systems will surely help in making this sort of communication possible and usual. The personal interaction point, a person will be using, will morph into a multi-window system where one could choose the specific window(s) to use for a certain communication. Similarly, at the other end, the other user will have the possibility of choosing the way to experience that particular communications. In between, there may be one or more communications links and some of these may not even be connecting the two parties, since communications may involve information that is actually available somewhere else and that is taken into play by the overall system.

This kind of communications will be, at the same time, more spontaneous (simple) to the parties involved and more complex to be executed by the communications manager. The communications manager can, in principle, reside anywhere. Surely Network Operators may be the ones to propose this communications service.

Contextualized communications is going to be the norm in the future. It is a significant departure from the communications model we are all used to.

V. The Changing in the Economics of the Marketplace

In a study of 1937 the economist Coase noted that the ideal market is the marketplace itself, where people producing goods can contact directly the potential buyer. In this ideal situation the transaction cost involved in the exchange between producer and consumer is close to zero (the transaction cost is the cost of the time involved in the transaction).

This ideal situation, typical of the pre-industrial economy when the artisan was creating his own product and sell it to people living in the same ambient, has completely disappeared as products have become more complex, thus needing several people to work in an organized way, and the market place has grown providing a larger but more difficult to reach audience.

Organizations were born out of the need to manage transaction cost (they were invented in the ancient times, first for military and religious endeavours, then for commerce involving transport of goods over distance). The industrial revolution with its economy of scale and high investment cost for the production tools could not have been successful without organisations. Organisations are costly, but they make production, delivery and sales possible. Innovation drives down transaction cost, automating some processes, increasing the yield and productivity. In a competitive market these gains are transferred to the end customer. Efficiency is the keyword for any organization operating in a competitive market, this is equivalent to say that organizations are always trying to reduce their operation cost, becoming "leaner" organizations.

Because of their structural cost any organization is finely tuned to operate in the marketplace it targets. It may be impossible to change this operational marketplace aiming at more complex products. These would require an increase in complexity of the organization and at a certain level (referred to as the Coase ceiling) any further increase in organization complexity to support the growing product complexity would create an organizational cost that is higher than the increase of price accepted by the market. Such products, therefore, are "off limits" to that specific organization. A company would need to reinvent itself to operate in that marketplace.

Similarly, a product that can be sold on the market only at a very low price, so low in fact that it is below the minimum organizational cost, is outside of the operational space of that organization.

Here we see another proof of the general distribution law: the smaller a player in an ecosystem, the more players there are. We see this in bio-ecosystems, there are many more microbes than ants, many more ants than human beings, many more human beings than elephants . . . Same applies to biz ecosystems. There is a space for a few big companies and for many more smaller companies.

There is a space for a few costly services and for a myriad of very cheap ones. The problem, of course, starts when some of those cheap services cannibalize the market of the expensive ones.

This is what we are seeing happening with the iPhone Apps Store, with the Android and soon with Nokia Apps Stores. Some Telecom Operators are seeing the Apps store as the proof that there is an untapped business waiting to be harvested by them. Other observers, as myself, see the Apps Store as the proof that the time for making significant money out of services (the so called Value Added Services) is gone (and actually never came to pass).

Notice how part of the service cost is tied to its branding, to advertising and up keeping. These costs are simply not there when we look at services on the Apps Store. Branding is not what is selling them (you are likely to use services on your iPhone without knowing who made them), but word of mouth. No advertisement cost, and basically no up keeping cost. New versions are released to correct malfunctioning, sometimes these are made available for free, some other time you need to buy the service again but since we are talking pennies, who really care?

Apple, after just a year since the opening of its Apps Store, has accumulated a portfolio of over 65,000 apps, and they keep growing. Over a billion downloads in the first months. Now these are numbers. Are they? Well, actually when comparing these figures with the ones of a medium size Operator, like Telecom Italia Mobile who has a market place that is comparable in numbers to the one of Apple (35 million cell phones vs a basically equivalent number of iPhones and iTouch sold by Apple, the former relates to the TIM Italian footprint, the latter is worldwide) we see that TIM has "downloaded" in the same 9 months 20 billion telephone calls vs the 1 billion apps downloaded from Apple. Is this an apple and orange comparison? Yes and no. Yes because those 1 billion apps have likely been used several times each leading to an actual usage that is much higher than 1 B. No because people have paid (when they did) only for the first download. In fact if we compare revenues we see that Apple has made some 60Ml euros out of those downloads whilst TIM made 100 times more.

The overall ecosystem enabled by the Apple store made much more money (3 times as much as Apple) but that is still peanuts if compared to TIM revenues. Those revenues have been split in a way that mirrors the long tail, and that is exactly in synch with the ecosystems distribution of players. A lot of them made very little money, a few much more.

All of these apps are well below the Coase floor for a medium size (and big, of course) organization. Apple wouldn't have been able to develop a fraction of those apps by itself. What they did was to create an ecosystem fabric for smaller players to thrive. In doing so Apple is harvesting some money and is strengthening its position by increasing the value of iPhones and iTouch perceived by the market. The iTunes acts as a seed, attracting players that in turn, all together, create the ecosystem. Each of those players is basically irrelevant, all together they are a strong presence. This is the characteristics of ecosystem, downplaying the value of the single player, and thus ensuring greater survivability, and leveraging on the mass. The evolution (the service offering evolution) no longer depends on the capability of a single (big) player but by the continuous readjustment of the global behaviour of the players. Being small, they are also nimble. And if they are not they disappear but a new players is likely to fill that opportunity space. Therefore the ecosystem is both big, complex and nimble. It effectively outflanks the Coase limits.

This analyses seems to indicate that big companies are doomed. In a way they are indeed but at the same time a few big company may not just survive but thrive in this new environment. They have to shift their business focus to become the big enablers, the actors that fuel the ecosystems providing a scaffolding where many other players can act. Is there a business for these big Companies, one that lays in their Coase Operational Space?

To address this question it is worth looking at the attempts that many Operators made in these last few years to move from an horizontal business approach to a vertical one. Rather than providing just connectivity several Operators have tried to approach vertical segments to provide them with specific services. The general outcome is meagre, to say the least. Take the health care sector, as an example.

Health care in Italy is worth close to 120 billion euro a year. That is three times the total value of telecommunications in Italy (the overall market, including all Operators, fixed and mobile). Making a dent into this business translates into big money. No surprise then that Operators have tried to create a customised offer for health care. What has happened is that part of the money previously made by selling connectivity is now made by selling health care service with connectivity embedded. There hasn't been any significant change in the health care structure and as such no money has actually been shifted.

This is true also for many other sector and it is tied to the efficiency that any sectors has achieved over time. Processes have been finely tuned and any significant change that would completely restructure the sector is strongly opposed by those in the business since that would lead to a loss of efficiency. The ecosystem approach, however, opening the field to many small actors that are fighting on lower revenues layers, can force the big players to restructure the whole sector. Moving from a cure approach to a preventive approach is going to reshape the whole health care sector. This will be enabled by technology evolution but it will happen because a change in the business structure.

Telecom Operators can fuel this change by making infrastructures available at low cost. More players will be using those infrastructures and a little stream of revenues will be coming that way. But that is the long tale, and remember there is relatively little money in the long tail. However, the shift will dramatically change the health care sector and that will potentially open opportunities to many players, including Operators. It is this change that can bring significant money to Telecom Operators' coffers.

The question then shifts from "is there a Business for Telecom Operators?" to "how can a Telecom Operator exploit the new Business Environment?".

I suggest three steps: Attract, Sustain and Lock-in.

- Telecom Operators can use some of their assets to attract other players initiating the aggregation of an ecosystem. Assets that can serve to this purpose are usually called "seeds" since they can sprout an ecosystem. Operators can play the cards of identity, authentication, localization, dynamic profiling often acquired through multichannel presence (fixed, mobile, internet, IPTV). By opening up access to this information they can enable third parties to develop services. Clearly it is easier said than done. Opening up information like "identity" may not be easy, providing third parties with customer profiles may violate privacy. It is undeniable, however, that Operators have interesting information on their customers and the way they are using network resources that could be used to provide them with valuable services. Those that will be able to find a way of leveraging on this information ensuring at the same time protection will be in business.
- Attracting players by providing information that can be used to create new services is not enough. In fact these seeds could well be used by a single (big) company to create the services. What makes a difference is to make available an infrastructure delivering low transaction costs to all players. It is these low transaction costs that enable small players. The infrastructure may be expensive to create by a third party and therefore a small player would not be able to invest on it to sustain his offer. Telecom Operator can sustain the ecosystem by providing the fabric for the transactions among the various players. This can be done also independently of the ownership of a seed.
- Ecosystems are in a dynamic equilibrium, there is very little stickiness since the relationships among players are loose. We see how quick an ecosystem can develop on the Internet and just how quickly it can fade away (see the rise and fall of Second Life, to name but one). It is clear that an Operator deciding to invest money in creating a sustaining platform, and in adapting its systems to make access to some seed information possible, requires some stability to recap the investment. Besides, this stability is also part of the trust/insurance that users are expecting when dealing with an Operator. Users are willingly accepting low reliability in services they get from third parties (particularly if they are not paying for them) but are not prepared to any compromise on reliability when dealing with an Operator.

Indeed, Operators can trim the ecosystem to consistently provide innovation seamless delivery, maintenance, historical records, accountability, version management, seamless operation, aggregation, bundling, hassle free interaction, uniform interface trust. There is a need, and a real possibility, to capitalise on these aspects to lock in both players and users.

VI. Conclusions

In this paper I have pointed out that the change in the technology landscape has reached a point where it has an impact on the business and its rules. Operators will need to rethink their positioning in the market under the new umbrella of ecosystems. Ecosystems can be fostered and Operators being large organizations with strong local presence and strong ties with Institutions, Government and Industries can take action.

This can happen in many sectors, from health care to education, from industrial districts to retail. The future is not going to be, in terms of business, a simple extension of today. Significant changes are ahead and it is better to sail the wind than trying to lower bigger anchors and strengthen the mooring.

VII. References

More extended coverage of ideas on technology evolution and impact is available in the first chapter of the book "Internet Networks: Wired, Wireless, and Optical Technologies, an Exciting Future", and in the chapter "Telecommunications Future" of the book "Next Generation Telecommunications Networks and Services Management".

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