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15 January 2018

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Abstract

Starting with a case-study we illustrate an emerging business model for the *Industrial Internet of Things* that applies to other ITC-based industries as well. We formalize this business model by importing the concept of structural holes into semantic networks and suggest that a similar logic applies to conceptual maps of consumers' behaviour, too.

Introduction

Quick and free availability of information made possible by the Internet has rendered "business as usual" impossible in quite many established industries, ranging from music to news. Many firms have been forced to re-think the assumptions of their strategies, asking themselves what competencies would produce value and, most importantly, how they could harness it. The Internet forced many firms to elaborate radically new strategies and formulate new business models that would question assumptions that they had taken for granted.

Disentangling the concepts of 'strategy' and 'business model' may not be easy on certain circumstances. One approach for conceptualizing the difference is that thinking about a business model implies exploring novel sources of value, whereas strategies are formulated even when no radical change is implied (Shafer *et al*., 2005; Teece, 2010; Zott *et al*., 2011). Another path towards a clear definition is eventually suggested by the observation that envisioning a business model implies exploring a set of possible strategies, only one of which is actually implemented (Casadesus-Masanell and Ricart, 2010). Whatever the definitions that will eventually emerge, it is obvious that firms eventually conceive radically novel business models at certain points in time, and that this happens with or without the Internet (Magretta, 2002; Teece, 2010). However, the Internet made many items available for free that were previously sold on a market, forcing many firms to conceive new business models.

Business models, in general, can be grouped into broad families. For instance, firms that provide free software must "sell" a product that is available at zero cost (e.g., the free *Linux* operating system), but they can make money by providing consultancy on how to install and maintain it. At first, this may struck the reader as quite novel a business model. However, consider what producers of airplane engines do: They typically sell their products at too low a price to make reasonable profits, but they take their earnings from all the maintenance these devices require. While not so extreme a strategy as those adopted by free-software vendors, it nonetheless follows a similar business model (Teece, 2010).

We believe that identifying broad categories of business models is useful for academics and practitioners alike and, indeed, many scholars have proposed sensible taxonomies (Schweitzer, 2005; Gunther McGrath, 2010). This paper reports on a Silicon Valley firm that is developing a novel and interesting business model in a field where lots of technological promises are made but little profits have been harnessed hitherto. While appreciating the innovativeness and peculiarities of a business model that is based on bridging between previously unrelated knowledge, we also recognized that this business model has certain similarities to those adopted by certain other firms in completely different fields. Thus, we illustrate our case-study as prototypical for a new class of business models based on the ability to bridge previously unrelated knowledge.

The rest of this paper is organized as follows. In the ensuing section, the features and potentialities of the Internet of Things (IoT) and the Industrial Internet of Things (IIoT) are discussed. The development of the IIoT is intertwined with the story of *Echelon*, a pioneer firm we studified as a case-study, will be illustrated in the second section. *Echelon*'s business model is expounded in the third section, and generalized into quite general a framework in the fourth section. The fifth section postulates that a similar framework governs certain features of consumers' behavior, followed by conclusions in the sixth section.

Distributed Control, IoT and IIoT

The Internet created unprecedented possibilities for diffusion of information and coordination of behaviour, ranging from crowd-founding to virtual games to flash mobs. It did so by connecting millions of computers in a huge web where flows – unlike those of many previous communication media – are neither planned, nor centralized.

As early as in the 1980s, at a time when the Internet itself was still in its infancy, a few visionary IT specialists speculated that if microchips would be embedded in physical devices that would be allowed to communicate with one another, their functionalities would go beyond those of each single device (Wired, 1993). For example, an occupancy sensor, a light switch and a thermostat could regulate the lighting and temperature of a room as soon as someone entered it. Or, an alarm clock could wake you up but also send a message to a machine that brews a cup of coffee. Similar applications would span as diverse fields as the automation of large buildings, the management of agile productive plants, the regulation of flows along a grid of power plants or, in short, any setting where a large number of heterogeneous devices coordinate their operations while retaining some degree of flexibility.

In 1988, a few prominent Silicon Valley entrepreneurs and venture capitalists founded a company in order to bring this vision to market. *Echelon*, so the name of the company, designed the *Neuron*, a microchip that could be embedded in physical devices which, in their turn, would be connected to one another through the power line network (PLN). *Echelon* would sell the *Neuron* and the *LonTalk* communication protocol, which together made up the *LonWorks* control technology (Lane and Maxfield, 2005, 2009).

The architecture designed by *Echelon* was radically different from the leading technological paradigm of that time. According to the received wisdom of the 1980s and 90s, sensors and actuators would be wired through a hierarchical set of data hubs which would route all information to a central computer which, in its turn, would issue appropriate commands to local devices. By contrast, *Echelon* set out to implement a distributed control architecture. Each device would be endowed with its own microchip, and each device would be able to communicate with any other.

Distributed control is technically superior to centralized control. Its advantages are due to (*i*) scalability, in the sense that devices can be added or taken away without re-programming the whole system, and (*ii*) reliability in front of power shortages, for several microchips working in parallel take a much shorter time to restore normal operation. From a purely technical point of view, there was no doubt that distributed control would make centralized control obsolete.

However, distributed control provides its largest benefits if a large number of heterogeneous devices are connected, which are eventually produced by competing firms. Each of these firms may have an interest in connecting its own devices to one another by means of a distributed architecture, but none of them is happy to see distributed networks where devices from different vendors compete with one another. Each producer in each industry strives to sign contracts where only its own products are used, so each producer typically adds any sort of technical difficulty to impair its devices from communicating with those of its competitors. Thus, we are experiencing the paradoxical reality of a superior technology that is technically available since the end of the 1980s, but that has not been allowed to spread into the economy hitherto (Rossi *et al.*, 2009).

Distributed control did not spread, but it did not disappear either. Rather, it survived and diffused in specific market niches. *Echelon* did not thrive, but it did not go bankrupt either. It rather set on a slow but steady growth path, possibly disappointing with respect to the initial (exaggerated) expectations but respectably positive and reasonably good in the long run.

Quite surprisingly for the disillusioned fans of distributed control, the new century brought a new spike of great expectations. This new wave of expectations also had a brand new name: The *Internet of Things* would connect devices of any sort, making everything *smart*: smart cities, smart homes, etc. Remarkably, the new name did not stress technical superiority (distributed control vs. centralized control) but rather what the devices would do for the final user: They would provide smart environments because they would connect to one another just like computers do.

This focus on consumers is possibly connected with an afterthought that is likely to loom very large in the minds of all actors involved, namely, the possibility that “smart” devices could be used in order to collect big data about consumers (European Parliament, 2015). If this will come true, then distributed control will finally spread, yet not because of its technical superiority but rather because it will allow better consumer profilation. It is a dream, or a nightmare, that is still far from coming true in any case.

Interestingly, *Echelon* is staying away from all talks about big data and IoT. It is focusing on the ‘Industrial’ IoT instead (IIoT), where technical expertise matters and where profits can be made here and now rather than at some distant future. In retrospect, one may observe that throughout its whole existence *Echelon* stayed firmly within the IIoT although it switched its main focus from building automation to power grids to lighting throughout the years. In broad terms, we can observe a certain constancy and coherence with its origins (Hannan and Freeman, 1984) co-existing with the entrepreneurial ability of re-directing its core activities from building automation to power grids to smart urban environments and beyond.

We decided that *Echelon*’s recent developments were worth an investigation, which we did in 2015. We carried out a qualitative research following the guidelines of Classical Grounded Theory (Glaser and Strauss, 1967; Orton, 1997), where our initial expectations concerned the interplay between constancy and adaptability in Echelon's strategy. In particular, we made open-ended interviews to:

- Chris Dingley, VP for Sales (unrecorded);
- Robert Dolin, former CTO and VP for Engineering (recorded);
- Robert Maxfield, Board Member since inception (recorded);
- Sohrab Modi, CTO and VP for Engineering (unrecorded);
- Ronald Sege, CEO and Chairman of the Board (unrecorded).

Handwritten notes were taken in all interviews, including those where recording was not allowed. Excerpts from these notes were submitted for approval.

In parallel to interviewing *Echelon* we actively attended ongoing debates in Silicon Valley on IoT, IIoT and big data. In particular, we were struck by the scheme for a business model proposed by *Claro Partners* (2014), a specialized consultant. Following the methodology of Grounded Theory we combined *Claro Partners*' insights with the inputs provided by *Echelon* in order to arrange higher-order concepts (Glaser, 2002; Glaser and Holton, 2004) which, in our case, translated into a business model that we found interesting and innovative. In a third stage concepts were re-arranged again, drawing similarities with experiences of other firms in different industries. Finally, we realized that certain aspects of this business model would shed light on consumers' behavior as well.

It is worth to stress that, in accordance with the principles of Grounded Theory (Glaser, 2002), our interpretation of *Echelon*'s business model is not necessarily *Echelon*'s own interpretation. It is our own theory, grounded on testimonies provided by *Echelon* as well as other sources.

Change and Continuity

Echelon was founded in 1988 in order to provide distributed solutions to control problems affecting as diverse industries as machineries manufacturing, building automation, consumer durables, and beyond (Echelon, 1990). A choice had to be made. At that time, it seemed reasonable to begin with a section of building automation where the potential advantages from connecting devices to one another were substantial, the so-called HVAC industries (Heating, Ventilation, and Air Conditioning).

Echelon started selling its microchips in 1990. Its initial strategy consisted of stipulating agreements with the main HVAC manufacturers in order to embed microchips in their devices. Since 1996, a new strategy complemented these agreements (Lane and Maxfield, 2005). According to this new strategy, *Echelon* would produce modules with embedded Neuron chips that interfaced via industry-standard interfaces to devices of any maker. These general-purpose modules would be sold to independent 'System Integrators' who in their turn would provide networked solutions for building automation incorporating devices from multiple suppliers.

In 2000, the Italian electricity provider *Enel* asked *Echelon* to embed its microchips in a new series of smart meters that would substitute all previous electricity meters in Italy. For *Enel*, this was not just a means to implement remote reading of its meters. Its CEO aimed at providing home automation solutions through a partnership that culminated in acquiring 7.9% of *Echelon* shares and a sit in the board (Tatò, 2016). For *Echelon*, it meant installing 30 mio microchips while entering a new market. In the subsequent years, smart grids became more important for *Echelon* than HVAC. Applications to building automation were still being made (through system integrators as well as through agreements with HVAC manufacturers), but power grids were the main focus.

However, most electricity providers had little interest in combining intelligent meters with home automation. Most of them were just interested in remote reading of meters, a basic functionality for which cheaper devices were available (Thoma, 2017). Even *Enel* lost interest in integrating home automation with their metering network when a new CEO was appointed in 2002 (Dolin, 2015). For some years *Echelon* continued to focus on smart grids but eventually sold its operations in 2014 (Echelon, 2014).

Echelon left the smart grid in order to enter smart lighting through the acquisition of *Lumewave* (Echelon, 2014). In the course if this transition its discourse also shifted from "distributed control" to the IIoT where *Echelon* became a key player. *Echelon* was founded with the idea of providing a general solution for the problem of control in any industry but, in practice, it could only zig-zag across separate markets such as HVAC, power grids and lighting (Lane and Maxfield, 2009).

What is most remarkable with these strategy shifts is that in spite of all changes, and in spite of all the hype on IoT and big data, *Echelon* never deviated from understanding itself as a firm based on technical excellence. Apparently, this firm has never been tempted by the possibility of using smart devices in order to enter the business of consumer profilation. On the one hand, its zig-zag through strategies and markets is an instance of change management. On the other hand, at a more fundamental level that defines its identity and the source of its competitive advantage, *Echelon* appears not to have ever changed. The many turnarounds of strategy are instances of adaptation (Cyert and March, 1963), but they are also manifestations of a core identity that is just as invariant as the organizational ecologies approach would predict (Hannan and Freeman, 1977, 1984).

This ambivalence can be eventually understood by recallimg the concepts of *capabilities* and *routines*. Capabilities stand for firm-specific, often tacit knowledge that constitutes the core of its resources. Eventually, capabilities can be understood in terms of firm-specific routines if one wants to stress the fact that organizational knowledge is embedded in sequences of actions that are repeated again and again (Grant, 1991; Winter, 2000). This case-study shows that – similarly to other organizational features (Scott, 1998) – only core organizational capabilities and routines contribute to organizational inertia, whereas more peripheral capabilities can be easily adapted to a changing environment.

Finally, our case-study confirms the importance of managerial cognition in detecting opportunities, envisioning strategies and directing action (Garud and Rappa, 1994; Tripsas and Gavetti, 2000; Nadkarni and Barr, 2008; Plambeck, 2012; Hadida, 2014). In our case, *Echelon*'s focus on IIoT comes along with the identification of profit opportunities in IIoT to the detriment of those in IoT (see Appendix A).

A Business Model for the Industrial Internet of Things

In general, IoT/IIoT is a field surrounded by much hype and promises for big expansion, but it is not at all clear how firms will make profits in the brave new world of interconnected things.

Possibly, a hidden presumption surrounding IoT is that it will yield profits insofar it will allow the collection of big data for consumer profilation, but how to make profits with the IIoT is still unclear. We believe that the *Echelon* case is illuminating in this respect.

In general, IoT/IIoT experts claim that the added value of this technology will arise out of a combination of hardware, software and semantic capabilities. In particular, single devices are "smart" insofar they add logical capabilities to physical action whereas embedding them in a network adds a semantic level to the underlying layers of logical signals and physical magnitudes (Yoo *et al*., 2010). Ultimately, customer value is supposed to arise from the ability to link the physical layer and the logical signals to functionalities that have a meaning for the final user or, in short, from the ability to connect the physical to the digital world (Claro Partners, 2014; Fleisch *et al*., 2014).

The main schemes proposed in the literature are reproduced in Appendix B. We found that these schemes entail a very interesting proposition insofar they highlight that customer value arises from the ability to bridge between the technical, physical features of devices and the logical possibilities that arise when they are connected to one another. We also found that the *Echelon* case can fill this scheme with details that make it more general and useful in other contexts.

In the early days, *Echelon* sold microchips that would communicate with one another through the proprietary protocol *LonTalk* (Lane and Maxfield, 2005). *Echelon*'s dream was that of achieving a near-monopolistic position in distributed control, where its proprietary communication protocol would be the only available bridge through which devices would communicate. This dream never realized, either because the big players proposed solutions that would involve their devices only (e.g., the HVAC industry) or because cheaper solutions were available to provide basic functionalities (e.g., remote reading for electricity providers). Today, *Echelon* makes use of an open communication protocol that can be used by anyone (Thoma, 2017). Instead of making profits by selling the real thing (i.e. the *Neuron* microchips, the *LonTalk* communication protocol), it makes profits by designing IIoT solutions for specific customers.

Superficially, this business model is similar to those of certain providers of open-source software who do not make money by selling a software which in any case is available for free, but rather a series of additional services that may include implementation design, installation and maintenance (Timmers, 1998; Gunther McGrath, 2010). However, the difference is that *Echelon* is not making profits on additional services, but rather on its main solution, namely distributed control for the IIoT. This fact deserves closer scrutiny.

In the 1990s and 2000s, *Echelon* based its solutions for building automation and the smart grid on power line communication (PLC). The technical principle is that since electrical signals at different frequency can travel on the same wire without confusing with one another, the wires that host a 220 V alternate current at a frequency of 50-60 Hz can also be used in order to make sensors and actuators communicate with one another through signals at a different frequency. Today, most IoT applications are based on wireless communication (WC) because it is cheaper and easier to set up. However, both media have advantages and drawbacks. On the one hand, WC is difficult or impossible if there are obstacles such as tunnels or large buildings. On the other hand, PLC has trouble getting around transformers and, furthermore, its cost is typically higher than WC.

Today, *Echelon* is proposing arrangements that combine WC with PLC in order to provide more comprehensive solutions than its competitors can do. Value for the customer is created by bridging the physical with the digital as the IIoT experts suggest (Claro Partners, 2014; Fleisch *et al*., 2014), yet the value is not in the bridge itself: it's in the pillars. The bridge – the communication protocol – is distributed by *Echelon* as open source software and can be imitated by anyone. However, the bridge hangs from pillars that are difficult to imitate, particularly the pillar of the physical properties of communication networks that employ both WC and PLC. Bridges can be easily drawn, but bridges rest on pillars, and at least one pillar is difficult to imitate.

Semantic Network Analysis

The above account of a possible business model for the IIoT can be understood by means of the tools of network analysis. However, we shall consider networks where nodes represent concepts rather than social actors, and edges relations between concepts rather than social ties. It is a semantic network rather than a social network.

Semantic networks are an established tool, mainly used in Artificial Intelligence, where nodes represent concepts linked by logical relations represented by edges. In the simplest semantic networks edges represent definitions or assertions, others entail more complex logical relations such as inclusion of certain nodes into higher-order nodes or executing algorithms (Sowa, 1992). Henceforth, we shall represent our semantic network as a bipartite graph where nodes are included in two subnets. Furthermore, our nodes will be assumed to be reciprocally interdependent (Thomson, 1967) albeit the details of their interactions will be left unspecified.

Semantic networks have already been in organizational contexts. Notable instances are the structure of relationships between scientific theories (Leydesdorff, 1991) as well as the structure of the relations between the contents of patents (Yoon and Kim, 2011). Furthermore, social networks analysis approaches semantics when it finds out that innovative knowledge arises out of connecting previously unrelated social actors (Burt, 2004; Rodan and Galunic, 2004; Rodan, 2010; Corredoira and McDermott, 2014).

We shall apply key concepts of social network analysis to our semantic network, a combination that has already been explored and adequately theorized (Downes, 2005; Jung and Euzenat, 2007; Mika, 2007). In particular, we shall employ the distinction between *weak ties* and *strong ties* (Burt, 1992).

In social network analysis the distinction between *weak ties* and *strong ties* has been made *à propos* of social capital. In particular, social network analysis has generated two camps where social capital is either ascribed to dense networks of social actors trusting one another (strong ties), or to networks that are sufficiently sparse for some actors to exploit social capital by bridging structural holes in the network (weak ties). For our reasoning, it is important to stress that recent empirical and theoretical findings have made these two camps more complementary than alternative to one another. On the one hand, empirical investigations have highlighted that these two aspects of social capital eventually produce different effects (Reagans and Zuckerman, 2001; Hemphälä and Magnusson, 2012). On the other hand, both theoretical considerations and empirical investigations suggest that weak ties meaningfully bridge structural holes if there are strong ties of densely connected actors elsewhere in the network (Burt, 2000; Tiwana, 2008; Aral and Van Alstyne, 2011).

Consider on what knowledge *Echelon*'s competitive advantage is based. On the one hand, technical expertise with PLC and WC: This is the first pillar, difficult to imitate particularly insofar it regards expertise with PLC. On the other hand, all the possibilities offered by networking smart devices: This is the second pillar, made of knowledge that is extensively discussed in specialists' circles. Each of these two pillars can be conceived as a set of nodes representing specific concepts: More specifically, a node for WC and a node for PLC would constitute the pillar representing technical expertise, whereas the pillar representing knowledge of what smart devices can do could be made of nodes representing smart bulbs, smart meters, smart lifts, alarms, doors, and so on. These two sets of nodes can be bridged by a communication protocol which, in this case, is freely available open-source software developed by *Echelon*. This bridge is freely available to anyone, as well as the knowledge embedded in the second pillar; however, *Echelon* has some difficult-to-imitate knowledge in the first pillar.

By contrast, consider *Echelon*'s business model in its early days, when it sold its proprietary communication protocol *LonTalk*. In those days, value was supposed to accrue from the bridge. Expertise with PLC was not particularly developed, whereas WC did not yet exist. Similarly, the other pillar consisted of knowledge that was openly discussed, just as it is today.

On the whole, the bridge-and-pillars metaphor can be used to frame different business models, depending on what components provide value. According to this metaphor, value can either accrue because one is able to link to previously disconnected sets of nodes, or because one controls at least one of the two sets of nodes, or both. In the first case, value arises from a weak tie: the ability to bridge between previously unrelated knowledge. This is the most obvious business model, the one that *Echelon* adopted at first. In the second case, value arises from adding nodes and constructing strong ties between them: by adding, or reinforcing a pillar, value arises from the ability to make knowledge flow through freely available bridges. This is a less obvious business model, yet just as viable as the first one.

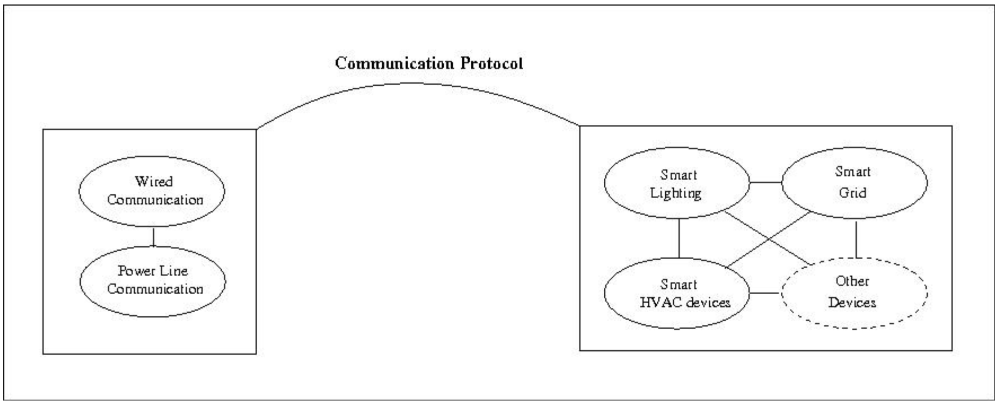

Figure 1. The semantic network underlying *Echelon*'s business model. On the left, the pillar made of knowledge about communication technologies: it is a network made of two nodes, wired communication (WC) and power line communication (PLC). On the right, the pillar made of knowledge about smart devices: it is a network made of a large number of nodes, here summarized as a node for smart lighting, a node for smart grids, one for smart HVAC devices and a residual node. The communication protocol bridges between these two pillars.

In principle one may envisage many different combinations in terms of the number and strength of connections between the nodes that constitute the pillars (strong ties) or the ability to bridge between sets of tightly connected nodes (weak ties). However, we deem that many unconventional business models consist of creating new nodes of knowledge and connecting them with strong ties up to have a new pillar of knowledge, rather than attempting to control the weak tie provided by a bridge. Consider the following examples:

- *Search Engines*. In the early days of the Internet, many search engines battled for market shares. Within a few years *Google* emerged as a clear winner because it had a better algorithm for presenting the results of their search. In the beginning, *Google* was first to order results by the number of hyperlinks pointing to them (competitor *Alta Vista* showed the number of hyperlinks but did not use this information to order results). Later on, Google was the first search engine that exploited users' past searches in order to show those results first, in which any single used was most likely to be interested. In our interpretation, the Internet constitutes one pillar of a huge semantic network where each site is a node. Search engines constitute the nodes of the other pillar, while using one of them amounts to throw a bridge that allows to reach a point in the network. Among the nodes of the pillar constituted by search engines, *Google* reached prominence because it provided the best starting point for a bridge towards the Internet. Everyone can use any search engine for free, so the bridge in itself provides no value. *Google*'s competitive advantage is rather in one of the pillars, which it contributed to create.

- *Social Networks Media*. Communication media such as *Facebook*, *Twitter* or *WhatsApp* arrange social contacts between users that are generally identified by cellular phone numbers according to similar, albeit slightly different rules. In our interpretation, the social networks – the bridges between users – arranged by these media rest on two pillars: on the one hand the phone numbers, on the other hand the interaction opportunities and rules proposed by *Facebook*, *Twitter* and *WhatsApp*. These media do not extract value from the bridges that users establish between their phone numbers, which is generally free for everyone (a minor exception is *WhatsApp* requiring payment of a fee in order to be used on Saturdays). Rather, they extract value from the possibilities they offer for building bridges out of the interaction opportunities that they provide (strictly speaking, in this case we actually have double bridges for any time a user links on to another user it is first a bridge from a phone number to a social communication medium, then a bridge from the medium to a different phone number). Interaction opportunities and interaction rules constitute the unique pillar from which communication media allow their users to throw any number of bridges towards their knowledge of phone numbers.

- *Scientific Publishers*. Scientific publishing used to be quite crowded an industry, with many publishing houses competing for a tiny market where only a few of them managed to emerge. The advent of citation counting changed it. Thomson Reuters' *Web of Science* was the first database of scientific publications where citations, impact factors, h-index and other metrics created rankings of journals, books and their publishers. A few years later one scientific publisher, *Elsevier*, created a similar database called *Scopus*. The *Web of Science* is independent of single publishers, but *Scopus* is not: Since *Scopus* is there, *Elsevier* gained a prominent position among scientific publishers. Our interpretation of this state of affairs is that each publisher is a node in a semantic network about scientific discourse, discoveries and trends: This becomes a pillar once a bridge is put in place. The other pillar entails the ability to search scientific publications in order to extract meaningful indicators: This pillar is made of two nodes, *Scopus* and *Web of Science*. A bridge between these two knowledge pillars is created whenever *Scopus* or *Web of Science* are used in order to evaluate journals and publishers. Unlike free communication protocols between smart devices, these bridges provide revenues because Universities pay a fee in order to use *Scopus* and *Web of Science*. However, this is a minor issue. The remarkable fact is that the industry of scientific publishing changed because a second pillar of knowledge was created – *Scopus* and *Web of Science* – which enabled bridges to be thrown between publishers and databases. In particular, *Elsevier* was quick to exploit this possibility to the most.

The *Elsevier* example has a sequel that suggests a more dynamical framework. Today, after *Elsevier* reached a prominent position among scientific publishers, its rivals are IT-based companies rather than traditional publishers (Pippel, 2017). The issue is that, once the whole of scientific publishing will be online and evaluation of scientific publications will depend on quotations and downloads, the crucial knowledge will be in the algorithms for arranging, selecting and presenting scientific publications to users. In the new knowledge pillar that *Elsevier* contributed to build, other sorts of companies may be more proficient than the pioneers.

This circumstance suggests an important difference between extracting value from bridges and extracting value from building pillars. Extracting value from bridges is a rather traditional, safe activity where a stable flow of profits is likely to be harnessed. By contrast, building new pillars can unleash forces that upset the whole industry landscape, providing revenues that may be substantial and yet uncertain at a time.

The Demand Side

In the previous examples, a firm was able to create or modify a semantic network in such a way that it would provide better bridges between sub-networks, or "pillars." Launching a bridge was quite an effortless activity, but creating a new semantic knowledge network required substantial effort and from this activity value would eventually accrue to the firm.

In all previous examples it was taken for granted that consumers would appreciate a certain functionality. There was no need to explain what new services would be provided. It was implicitly assumed that the supply side was all what mattered, for consumers would immediately grasp the usefulness of the service that was going to be provided.

Unfortunately, this is not always the case. For instance, the launch of the *post-it* was problematic because its usage was not obvious from pictures and verbal descriptions. In the very beginning, its promoters had to visit administrative offices and offer a few items for trial until employees eventually realized what they could do with it (Nayak and Ketteringham, 1994, Ch. III).

We maintain that when the usage and usefulness of a new product is not clear from the outset, marketeers may eventually attempt to create new semantic networks in the minds of consumers using the principles outlined above. For instance, the case of the *post-it* could be interpreted as follows. Once the *post-it* had been invented, there existed a pillar made by nodes describing its technical features, such as 'small leaflets' and 'weak glue'. Consumers would buy it if they had a pillar in their minds describing what the usage of such an object would be, so that a bridge could be established between the concepts representing the object and the concepts representing its usage. Showing possible usages to secretaries amounted to suggest the pillars and bridges of a semantic network. In this case one may claim that it is the bridge that generates value, but the fact is that no bridge could be thrown unless a pillar was there, that represented possible usages of the *post-it*.

Other instances are not as simple. Consider the laser, for example. Its invention triggered a cascade of usages ranging from cutting machines to photocopiers to surgery to devices for measuring distance (Hecht, 2010). We would propose that each of these usages is represented by a concept in consumers' minds, and that from each of these concepts a bridge can be thrown towards nodes representing the laser's technical features. Also in this case, the crucial issue is adding a concept – figuring out a new possible usage – rather than throwing a bridge.

As in the *Elsevier* example reported in the previous section, construction of a new concept in consumers' minds may trigger cascades where previous knowledge is destroyed to such an extent that a whole industry is affected. We submit that the launch of the first smartphone by *Apple* in 2007 – the *iPhone* – is one such instance. At that time, smartphones did not exist. Cellular phones did exist, but the additional functionalities that they offered with respect to fixed phones were limited to a clock, an alarm, sometimes a radio or a torch. When Steve Jobs wanted to explain what the *iPhone* was, he pointed to three objects that potential users already knew: the *iPod* – a device for listening to music – the Internet, and phones (Apple, 2007). That is, he defined the smartphone as a device that would combine functionalities that the public already knew. And this process went on in the subsequent years, with smartphones including previously self-standing objects such as digital cameras, videocameras and GPSs.

Figure 2. Steve Jobs explains what the first smartphone is: Something that allows users to listen to music, navigate the Internet and make a call with one single object (Apple, 2007).

We deem that the pillars-and-bridge scheme that we introduced in order to explain certain unconventional business models can also be used in order to understand the way the smartphone was explained to consumers. Consider existing devices as nodes in consumers' knowledge: One node for the (classical) phone, one node for music players, one node for personal computers to navigate the Internet – other nodes representing digital cameras, videocameras and GPSs could be added to the picture. Steve Jobs did not create bridges between existing devices; rather, he created a new device – a new pillar – from which conceptual bridges could be thrown towards the existing devices. Indeed, so effective a bridge that the new device superseded many of the old ones.

Conclusions

According to Organization Science, *mediating technologies* are those that provide value by making two populations communicate with one another (Thompson, 1967). Typical examples include banks, which mediate between lenders and borrowers, as well as web sites where people buy and sell second-hand objects.

Similarly to the organizations that we have examined hitherto, those that are based on mediating technologies bridge between knowledge bases. However, the organizations that inspired the concept of mediating technologies were such that the structure of communications within the two populations did not matter; for instance, lenders generally do not communicate with one another and borrowers don't do it either. In these conditions, only the bridge matters.

In many traditional situations, the bridge is the source of value. And of course, the fewer the organizations that are able to bridge between populations that would not communicate otherwise, the greater the profits that accrue to them. In the limit, monopolistic profits accrue to the one organization that owns the only bridge through which two populations can communicate.

In its beginnings, *Echelon* thought of a business model where profits would accrue from its ability to bridge, which would be provided by its communication protocol *LonTalk*. It was an instance of a simple mediating technology. However, this business model failed because it was all too easy for competitors to create their own communication protocol.

This is quite general a pattern induced by ICT. Greater possibilities for communication make that, in many cases, bridges must be given away for free because they are so easily imitated. At the same time, greater possibilities for communication mean that the members of those populations between which bridges used to mediate eventually communicate with one another, and they do it creating structures that eventually matter for the final outcome. Bridges have lost much of their importance, but the structure of communication within pillars of knowledge matters more than it used to do. This provides novel possibilities for extracting value by providing novel communication structures within each population rather than extracting tolls from the bridge that connects them. In many such arrangements, the strong ties that create a structure of communication between tightly connected nodes may matter more than the tiny weak ties that bridge between them. In a sense, we are proposing a refinement and improvement of the concept of mediating technologies.

From a slightly different point of view, our proposal is also related to Actor-Network Theory (ANT), a sociological theory of the arousal and acceptance of innovations that highlights the interests and politics of all the actors involved (Hughes, 1986; Law, 1986; Latour, 1988). For instance, ANT analyzed the discovery and diffusion of vaccines highlighting the interplay between Louis Pasteur, the aims of the emerging hygienist movement, the needs of doctors to retain prominence, military interests in making soldiers immune to tropical diseases as well as the behavior of microbes (Latour, 1988). Our approach is certainly less detailed, less rich than ANT. In particular, our simple scheme based on knowledge networks provides a terribly crude description of interests and power positions which, in our case, are limited to those arising from commanding relevant knowledge.

However, ANT bears some similarity with our proposal in that it reconstructs complex networks where social actors make it possible for an innovation to have a value because social actors find it convenient. ANT does not have any simple rule for generating value and, certainly, from ANT's point of view our bridge-and-pillars framework appears at the very least simplistic. Goals are also different, however. ANT is a complex and generalist approach that can be applied to any innovation, provided that sufficient resources are invested into it. Our framework does not aspire to generality but hopes to be useful for understanding certain specific business models. From this point of view, our modest contribution may be hopefully accepted by ANT theorists as a useful first-order approximation.

Acknowledgements

We thank *Echelon* for interviews and information disclosure. In particular, we wish to express our gratitude to Robert Dolin and Robert Maxfield for their help and support.

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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APPENDIX A

Interview with Echelon CEO

Consumer and industrial market are very different. The problem with the consumer market is that, yes, you have a lot of applications and devices to connect, a lot of opportunities and so on, but you have few profit margins. We are already established in the systems of building automation, air conditioning and heating, systems of smart meters, as you know in Italy with Enel, so we felt it was a natural consequence evolving towards this direction. We have the tool, the customers, and the alliances and now we're investing a lot of money in industrial IoT solutions. We're using our experience with LonWorks and PLC [Power Line Connection] *to integrate outdoor lighting, indoor lighting, energy management and security on a common platform.*

Although the consumer IoT gets more press attention, the real financial and societal potential lies in the industrial IoT. The cost of connecting to the IoT is dropping. Ten years ago, it was about $10 per connection, now it's $4 for a Wi-Fi module or Echelon chip, and soon it'll be $2. Also, and this is important, customers don't really buy an 'IoT.' They buy solutions to certain vertical market problems. As for vertical market opportunities, we see lighting as the one with the biggest immediate potential, because connecting highly controllable and sensor-enabled LED lights can have many, many benefits in terms of health, customer satisfaction, asset utilization and learning. Beyond lighting, we foresee big opportunities in transportation — such as locomotion, aircraft telemetry and smart traffic systems — and the smart grid.

(Sege, 2015)

APPENDIX B

This appendix entails the received wisdom on business models for the IIoT. In particular, Figure (B1) shows the scheme of Fleisch et al. (2014), whereas Figure (B2) shows the scheme of Claro Partners (2014). Albeit neither scheme differentiates between IoT and IIoT, both of them assume that value coincides with customer value, thereby ruling out any possibility that the value arises out of the possibility of consumer profilation. Thus, we find that both schemes are particularly relevant for IIoT, rather than IoT.

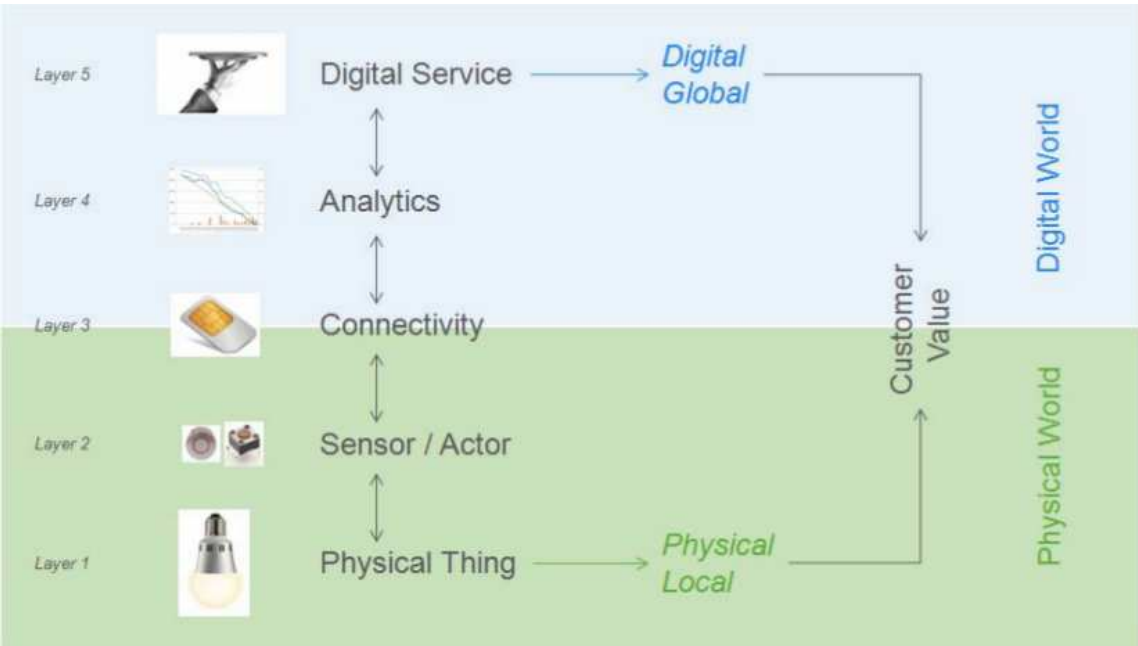

Figure B1 (Fleisch *et al*., 2014). Customer value is supposed to arise at the interface between the physical and the digital world. Bi-directional arrows between functionality layers mean that each layer should be designed in conjunction with neighboring layers.

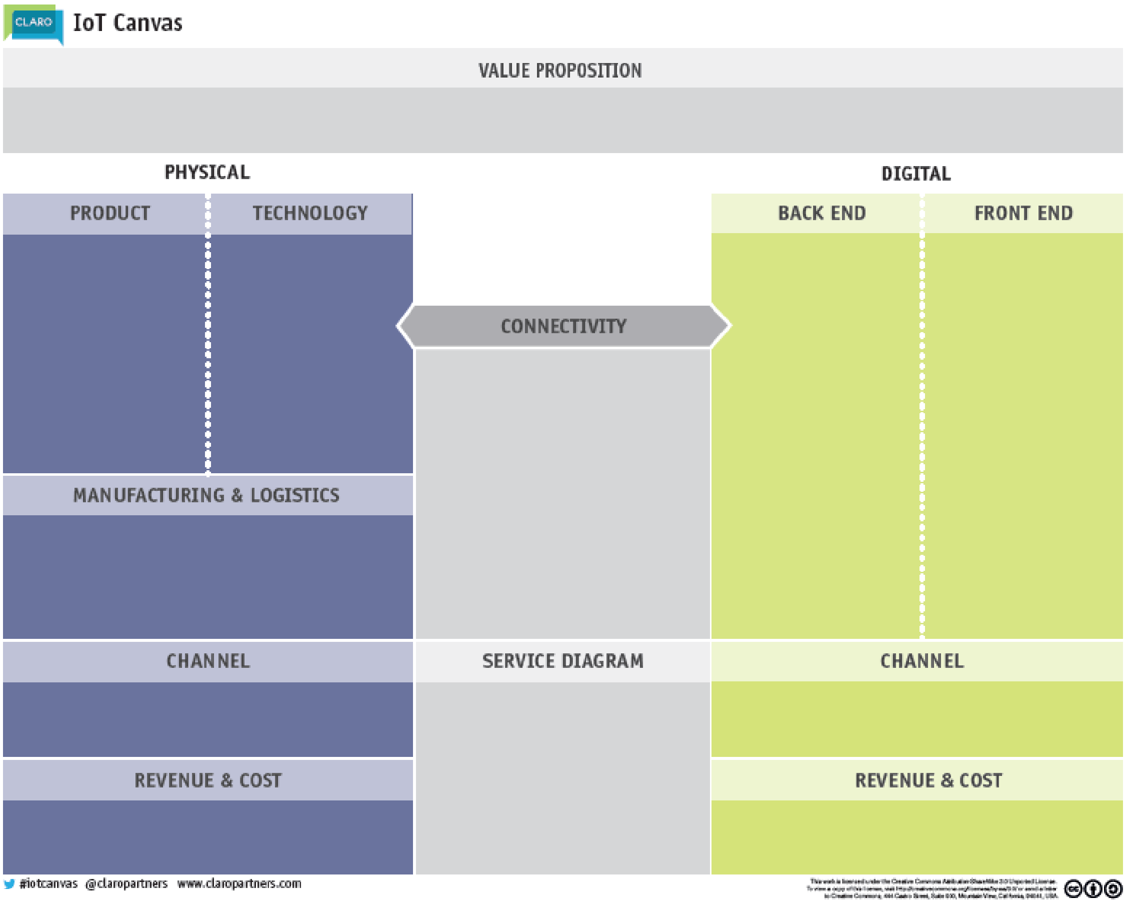

Figure B2 (Claro Partners, 2014). Customer value is supposed to arise from the ability to connect the physical world to the digital world.