WiFi: An Emerging Information Society Infrastructure

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Preface

Europe is entering into the new economy, but little is understood about it beyond its disruptive potential – only that the transition phase from a post-industrial to a globally networked knowledge society is likely to take 20 or 30 years. The STAR project – Socio-Economic Trends Assessment of the digital Revolution - is focused on the analysis of the development of the Digital Economy in Europe, in order to contribute to a better understanding of the conditions leading to sustainable social and economic growth patterns – how to survive the transition phase.

STAR is an initiative of ***Key Action II "New Methods of Work and Electronic Commerce"****, one of four key actions of the* ***User-Friendly Information Society Programme****. The IST Programme is part of the European Union's Fifth Framework Programme for Research and Development. Its objective is to ensure that all European citizens and companies benefit from the opportunities of the emerging Information Society. Key Action II is designed to both give workers and enterprises a competitive edge and to improve the quality of everyone's working life. It embraces technologies and issues as diverse as teleworking, the virtual company, logistics management and trading goods over the Internet. It aims to develop and demonstrate world-best work and business practices, exploiting European strengths in software, mobile technologies and enterprise management.*

STAR original research will contribute to achieve Key Action II goals by analysing evidence on the multiple changes brought about by the new economy in the socio-economic system and their policy implications. The consortium will interact with a Forum of experts within and outside the IST Programme to receive feed-back and insights on STAR results.

STAR results will be published as a series of Issue Reports, Executive Briefings, and workshop presentations addressed to policy makers, industry managers and research experts. A Summary Report (annually from 2001 to 2003) will offer a synthesis of the overall conclusions, and present scenarios for the evolution and socio-economic impact of the digital economy in Europe.

This report belongs to STAR Issue Report series. The list of Reports is published in annex. All reports are available for downloading from the project's web site at *www.databank.it/star*.

The opinions expressed are those of the authors and do not necessarily represent the official views of the European Commission or any other organisation or institution.

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Executive Summary

The aim of this Issue Report is to take stock of the first years of the emergence of WiFi. In order to do so, we shall study "WiFi" as a *hybrid* mixing "technical" characteristics (the objects which constitute the network) and "social" characteristics (in the broadest sense, since they include economic, strategic, institutional and even marketing questions). This concept allows us to encompass several aspects:

- How technical specificities of WiFi infrastructure allows users, or groups of users, to take charge of deployment and maintenance of networks and favours "grass-root" network operations?
- How communities of users organise to access, share and create the knowledge needed to reach the objectives they pursue?
- What is the role of WiFi network communities in the build-up of local demand for high-speed services?
- What kind of relationship can such "bottom-up" initiatives entertain with local public bodies, whose project is to develop high-speed offering on their territory?
- What are the business models of the for-profit business operators? Will they succeed and, if so, will they leave enough room for WiFi network communities to subside?

Given the emerging nature of the WiFi phenomenon, the questions we wished to deal with could not be supported by available results. Therefore, we have established our own original set of data, largely obtained *via* qualitative approaches. This was mainly obtained by seven European case studies of WiFi network communities, complemented by desk research.

First, we address the historical and technical aspects of WiFi and its regulation. We conclude that WiFi does favour the emergence of alternative WiFi infrastructures modes. Such a possibility is based chiefly on the open characteristics of the technology and on the current fragile state of the telecommunications sector. Of course, the appearance of WiFi community networks is in no way technologically determined: they are the product of the co-operation between this favourable technology and "leaders users", who are technical enthusiasts and interested in the non-commercial aspects of radio networks for the transport of data. Clearly, the simplicity of the services proposed by WiFi community actors shapes their existence. This explains the reluctance of WiFi community networks to offer added value services to their users, such as security or transparent roaming. Reciprocally, the very existence of these WiFi networks means that, in order to be successful, the future UMTS networks will be obliged to offer superior or different services from those already offered by the WiFi networks.

The second part analyses WiFi network communities in terms of learning dynamics and of roles played by these communities in the emergence of the local information society. We conclude that WiFi network communities focus less on knowledge production than on efficient sharing of equipment and existing knowledge at local level. We distinguish four types of communities, depending on their topology ("ring" *vs* "star") and their ideology ("content-sharing" *vs* "access-

sharing"). These communities could be relevant stakeholders in the governance of local telecommunications offering, notably in poorly equipped areas.

The third part briefly examines the business side of WiFi emergence, in order to initiate a discussion on the future of the sharing of this technology between co-operative and commercial offerings. Roughly speaking, WiFi business models organise along two alternate value chains – though no business model has proved to be financially sustainable yet:

- currently, site owners manage the contact with the final customer, but rely on network operators and roaming-services providers;
- in the future, especially in the European context, mobile network operators could try to deal directly with their final customers by offering them WiFi as a supplementary service. In this model, site owner's role is reduced and roaming-services provider's independence is threatened.

Do these trends mark the inexorable reduction of the space of cooperative action linked to WiFi? No-one today can give a definite reply to this question. However if there is a field which today sees the dynamic of cooperative uses of this infrastructure not only persist but even develop, it is that of local development.

Finally, we will draw from these various elements recommendations to public authorities in order to:

- manage in the least ossifying way possible the spontaneous dynamics of WiFi access offerings ;
- and to leverage the activities of WiFi network communities in the reduction of the "digital divide".

Introduction

What is Wireless Fidelity – or WiFi? A wireless communication standard between computers, as explained by an IT engineer? A simpler corporate computer networking system? Or a range of commercial high-speed Internet access services, as offered by an increasing number of coffee houses, hotels and airports? Or maybe a re-socialisation movement in urban centres and deeply rural areas alike, applauded by the non-specialised press[1]? All those things at the same time, undoubtedly, and many other things as well.

The aim of this Issue Report not to predict the future but to take stock of the first years of the emergence of WiFi to better understand its nature and importance. In order to do so, we shall study "WiFi" as a *hybrid*[2] mixing "technical" characteristics (the objects which constitute the network) and "social" characteristics (in the broadest sense, since they include economic, strategic, institutional and even marketing questions). This concept allows us to encompass several aspects:

- How do technical specificities of WiFi infrastructure allow users, or groups of users, to take charge of deployment and maintenance of networks? Why do they favour "grass-root" network operations?

- How communities of WiFi users organise to access, share and create the knowledge needed to reach the objectives they pursue?

- What is the role of WiFi network communities in the build-up of local demand for high-speed services?

- What kind of relationship can such "bottom-up" initiatives entertain with local public bodies, whose project it is to develop high-speed offering on their territory?

- What are the business models of the for-profit WiFi operators? Will they succeed and, if so, will they leave enough room for WiFi network communities to remain active?

By focusing on these interactions between the technical and social sides, we aim at avoiding two analytical bias. First, a technophile mirage which would consider that the creation of a new technology shall naturally lead to progress for society. Second, a "top-down" vision, in which users give up any active role in the decisions on technology diffusion. Let us dig a little further in both these aspects:

- WiFi network communities seem at first sight to adhere to a very "Jeffersonian" utopian concept of social dynamics (Bar *et alii*, 2000). This trend sees in technology the possibility of resolving any weakness resulting from existing practices, be it political, social or commercial. Such a technological determinism sees the virtual digital form as an ideal solution to

[1] Numerous articles since 2001. In France, articles were published in Libération (since June 2001), Le Monde (since September 2001), Les Echos (since March 2002), La Tribune (since May 2002), Le Figaro (since November 2002), Nova, Télérama, etc.

[2] In the sense given to this word by Latour (1991).

the shortcomings of the real world[3]. However, it is firmly contradicted by analysis[4]. It can even have the opposite effect, as noted by Paul David who sees in the maintenance of this "technological ideal", at a time when the Internet is entering its maturity phase of development, the conditions of the current contradiction of its initial project[5]. These threats are incarnated by the commercial proposals of infrastructure providers which, under cover of technical development, cause damage that goes to the heart of the project of the network of networks, the *end-to-end* logic. Do WiFi network communities all share this objective of technological Utopianism (which would considerably limit their persistence over time) or is there a variety of organisational forms and community organisational and motivations which make any appraisal of the future of these communities more complex? As Brian Arthur[6] emphasises, the historical reading of the spread of other network technologies tends to favour the concept of the transformation of technology into "amenities", the point at which the technology disappears behind its use[7]. From this perspective, where the uses influence the success or failure of a technology over the long term, the analysis of high-speed access must be inspired by an analysis of uses and organisations of its providers over the long-term. This is only partially doable in the case of WiFi, which is currently in its initial development and diffusion phase rather than in a phase of appropriation by its users as a transparent amenity. We will nevertheless draw our inspiration from these approaches to propose a long-term analysis, to the extent available, of the technology and analyse the modalities of its emergence and of its cooperative uses.

- The setting up of an infrastructure initiated by its users has turned upside down the traditional model of top-down planification (by public authorities or powerful operators). Some specialists thus defend the thesis of a model driven by the "first mile", illustrated by WiFi[8]. According to this theory, "essential uses" can trigger the launch of an access offering. This is opposed to the standard reading where the pre-existence of access capacities allows for uses to develop, with the bottleneck ("essential resource") being the "last mile" to the end user. This theory of an infrastructure offering driven by demand is in line with an approach based on the network being set up and run by the actors-users collectively organised as a community, or alternatively by local institutions (public or private) which have grown tired of being "forgotten" by the high-speed networks proposed by infrastructure operators. It does not, however, offer us any guidance on the future of these approaches: are they sustainable only solely in an initial phase, to test the existence of a need and therefore the willingness of users to pay for a service

[3] Proulx and Latzko-Toth (2000)
[4] Three factors are radically opposed to this concept, more precisely in the case of the Internet:
  - a technology never functions alone but in relation with existing technical systems and organisations which influence its potential,
  - if the information has free aspects linked to its "public asset" dimension, information with real value is never cheap,
  - the market economy principle of the information sector leads systematically to concentrated structures.
[5] David (2001)
[6] Arthur (2002)
[7] John Seely Brown quoted by B. Arthur (2002)
[8] Marchandise and Vincent (2002)

which could encourage operators to offer, in a second phase, commercial solutions? Or can they serve other purposes, other than merely acting as a temporary link between local individual users and commercial operators?

Given the emerging nature of the WiFi phenomenon, the questions we wished to deal with could not be supported by available results. Therefore, we have established our own original set of data, largely obtained *via* qualitative approaches. This was mainly obtained by seven European case studies of WiFi network communities, complemented by desk research[9] and interviews with observers and commercial actors. Further details on the methodology are presented as Appendix of the present Issue Report.

This Issue Report contains three parts. In the first, we address the historical and technical aspects of WiFi and its regulation. In the second part, we analyse WiFi network communities in terms of learning dynamics and of roles played by these communities in the emergence of the local information society. In the third part, we briefly examine the business side of WiFi emergence, in order to initiate a discussion on the future sharing of this technology between co-operative and commercial offerings. Finally, we will draw from these various elements the public recommendations which seem necessary to manage in the least ossifying way possible the spontaneous dynamics of WiFi access offerings.

[9] This *Issue Report* relies to a large extent on the preparatory work carried out in the Spring of 2003 by a group of young researchers (Dominique Combescure, Pierre Humblot, Guillaume Jego, David Suissa) under the supervision of the authors of this work, based on technological themes and surveys among the community networks referred to in the report. We wish to thank all the people who agreed to answer our questions. We are nevertheless solely responsible for any possible errors of interpretation of their remarks that may be contained in this report.

1. "Born to be Open »: Technology and Regulation of Wireless Fidelity

Our first aim is to understand how the characteristics of WiFi have encouraged the development of original initiatives by users who have become producers of their own emerging infrastructures through *WiFi network communities*.

Whilst this section deals with wireless Fidelity – or WiFi – as a technology, it is important to note that the authors of this study do not believe in any sort of technological determinism in the evolution of WiFi. However, we do not believe either in what would be a symmetrical "sociological determinism" and, although we will not focus on the technical aspects of WiFi, we feel it was not possible to eliminate entirely the technical aspects of WiFi from our analysis of the community forms taken by the users of such technology. Precisely, we build this analysis on what community leaders said of the technology, aiming at depicting the *perceived* technological characteristics of WiFi – according to users.

WiFi network communities have been created on the basis of the use of a technology, more than anything, and they are composed to a large extent of technical experts. The recreational exploration of the technology roots their motivation for participating. In Lyon (France), the standard profile elaborated by the founders of the community of the association's members is someone who wants "*to test the WiFi and be the first to have fun while discovering this medium*"; in Cardiff (United Kingdom), "*the initial group was composed of people who like chatting about technologies and who wanted to promote WiFi in order to cover, with high-speed Internet access, areas which don't interest Telcos commercially"*; in Madrid (Spain), "*we wanted to start a huge technical discussion about what would be possible to do with WiFi technology, and what is the best approach to build the broadest network."*

Finally, if the perception of available technologies shapes the emergence of these communities, *vice versa* the existence of these emerging cooperative infrastructures has an influence on the current technological and economic development of WiFi – indeed of the whole radio data transport sector. In fact, the "leader users", members of these communities, bring with them their objectives, in particular that of keeping the initiative in the creation of high-speed services, and of enhancing their autonomy with regard to traditional telecommunications operators. Subsequent evolution of these technologies, which are not yet stabilised, will tend to integrate the values and ambitions of these first users.

After an overview of the emergence of WiFi (section 1.1), we will examine the current state of the technical standards of the WiFi family (section 1.2) and explain the main parameters of the installation and management of a network using these technologies (section 1.3). We will then examine the regulatory framework which has accompanied the rapid development of WiFi (section 1.4) and address the strategic issues of WiFi versus another "socio-technical hybrid" in the same area, UMTS (section 1.5). This will prepare the second part of our analysis, which will focus on the inner functioning of WiFi network communities and on their role in the emergence of the information society at local level.

1.1. A short but eventful history

By virtue of their standardisation, WiFi technologies allow equipments owned by different users to operate together. They can be used, at least on a small scale, without any unified network planning. This ease of use explains how WiFi favours the emerging of infrastructures alternative to telcos'. It is important, in our view, to take into account the technology's origins, in accordance with the perspective developed by Paul A. David, who considers that the means of coordinating and assessing mature technologies are very strongly characterised by the initial development phases of those technologies[10]. Openness and autonomy can be explained to a large extent by the origin of these standards, which were initially drawn from the world of computers, rather than from the world of telecommunications. In the computer sector, a wide variety of equipment coexists on the same network; as a result manufacturers are obliged to develop a high degree of interoperability, which means that they cannot rely too much on other equipments in the network to ensure the correct functioning of their own equipment.

The origins of WiFi are to be found in the computers networks of private companies. According to the site of Charles-Evrard Tchekhoff[11] (American University in Paris): "*originally, WiFi was conceived to extend the Ethernet networks of private companies. Currently [in 2002], this use remains the most current because the WiFi chips are more and more often integrated in the laptop computers with which the companies are equipped in great number. WiFi was first used to avoid the installation of wiring in the buildings and to thus reduce the costs of infrastructure. It also made it possible to extend the existing network to cover conference rooms, offices, and warehouses with performances equivalent to the cabled network. Lastly, [these networks] started to authorise the connection of collaborators visiting from outside the company. From this idea of nomadic use within a building, came rather naturally the idea to extend the access to the Intranet to employees outside but near the company.*"

The technological development of WiFi can be traced back at least in part to a proprietary local wireless network technology linking personal computers, created by Xircom[12] at the beginning of the 1990s. In 1997, after seven years of work, the *Institute of Electrical & Electronics Engineers* (IEEE), an international standardisation body, created the IEEE 802.11 standard. This standard defines an Ethernet wireless network technology – simply replacing the cable wires by radio waves to transmit data. The 802.11 standard operated in the 2.4 GHz waveband and offered speeds of around 1 to 2 Mb/s. The IEEE then immediately started to work on improving this first standard.

It took two years for this standardisation work to be translated into a product successfully marketed to the general public. In the summer of 1999, Apple unveiled Airport, the first consumer peripheral device to use what was to become the 802.11b standard. While users and manufacturers started to look closely at these innovative wireless networks, Nokia demonstrated the capacity of these standards to absorb an important volume of traffic in an open environment by

[10] David (2001)
[11] www.ac.aup.fr/~a34355/IT/history.html
[12] Xircom is a manufacturer of network peripheral devices for PCs. It was acquired in 2001 by Intel.

assuring the wireless connectivity of the Networld+Interop trade fair of September 1999.

Today, several variants of the 802.11 standard have been developed. Currently, the most used technology in company wireless networks, domestic networks and *hotspots* or communities is the "b" version of the 802.11 standard, known under its trade name of WiFi (*Wireless Fidelity*)[13]. The 802.11b standard was ratified in June 2001. In February 2002, the 802.11g standard was approved by the IEEE and, in October 2002, the 802.11a standard was added to the family. The story goes on…

WiFi was initially conceived for very local use and as a simple substitute for cable on closed local networks. As of today, it remains above all dedicated to that use. Nevertheless, the idea of extending it to open networks emerged very rapidly. In the period of the "Internet bubble", this idea developed in the form of operators of Internet wireless public access points (*hotspots*). In 1993, Brett Steward, an engineer working at AMD had the idea of using this technology to offer public data connectivity services. Having left AMD, he set up Plancom in 1995, then Mobilestar (which was subsequently acquired by VoiceStream and became T-Mobile) and Wayport, which were the first commercial actors to offer *hotspots*.

One of the most important announcements in the area of commercial *hotspots* was made in February 2001, accompanied by great media fanfare: Starbucks unveiled an important investment programme intended to set up 802.11b *hotspots* in all its coffee houses within three years. This announcement was effectively followed by the installation by T-Mobile of access points in several hundred Starbucks in the USA. The commercial success of this operation was, however, far from clear-cut[14].

Hotspots operators multiplied at the end of the 1990s. In the euphoric atmosphere of the "bubble", they embarked on extremely ambitious development programmes, close to the *business plans* of the new telecommunications operators entering the market. However, they have been badly affected by the crisis which affected all Internet stock in 2000-01. Numerous commercial actors disappeared.

Against that backdrop, original initiatives began to emerge. IT enthusiasts had the idea of using the equipment of wireless networks to share resources among themselves, without any need for the networks of telecommunications operators or Internet access providers. The first of these *community networks* seems to have been created in Pittsburgh (USA) in January 1999. In Seattle (USA), the Seattle Wireless group got strong press coverage by publicising its ambitious project to cover the whole of the city with an alternative network. At the same time as these associative networks were emerging, another practice developed: the piggy-backing of insecure company networks, to access the Internet only with a WiFi client card. In April 2001, the term "*wardriving"* was invented to describe this practise which, by promising ubiquitous Internet access straightaway, seemed to outrace UMTS and the high-speed mobile networks. Knowledge and use of WiFi then developed rapidly among technology enthusiasts.

[13] Though "WiFi" originally referred to 802.11b equipment, we will in the course of this report follow the current trend and use this term for all variants of the 802.11x family.

[14] This question is dealt with in greater detail in the third part of this *Issue Report*.

To sum up, the history of the IEEE 802.1x family of standards has favoured the emergence of alternative infrastructure modes: because they originate in the world of computers (and even the world of microcomputers), they are based on autonomous, interoperable and inexpensive equipment; because they emerged during the "Internet bubble", the idea of using them beyond the limits of company networks was credible; finally, because of the explosion of that bubble, the initial commercial actors disappeared or struggled, paving the way to WiFi network communities.

1.2. A mature, but evolutionary technology which allows high-speed access

The most used standard at the current time, IEEE 802.11b, relies on the so-called "2.4 GHz" waveband[15]. This band is divided into 14 channels of 22 MHz whose central frequencies are separated by 5 MHz. Adjacent channels overlap, so only three of the 14 channels are entirely isolated and can therefore be used simultaneously. The 802.11b standard allows each channel a theoretical maximum speed of 11 Mb/s, which corresponds to a practical accessible speed of 5.5 Mb/s taking into account error correction techniques put in place (modulation in *Direct Sequence Spread Spectrum* or DSSS). As on an Ethernet wired network, the available capacity is shared by all the machines having access to the network: the 5.5 Mb/s accessible rate is thus shared between the various users[16].

The actual speed available to a user therefore varies between several dozen and several hundred kb/s, depending on the extent to which the network is busy. These speeds are higher than those of ISDN and compare somewhat favourably to those of ADSL or cable Internet connections currently offered to private individuals, while remaining below the "real" high speed connections to be found on local wired networks (from 10 Mb/s to 1 Gb/s for the most recent version of Ethernet, for example). This potential speed is sufficient for traditional IT network use, as well as for several more advanced uses. Thus, 802.11b networks can easily carry e-mail, support the exchange of small files or "web-browsing", as well as the peer-to-peer applications for sharing limited size files (audio, short videos).

The maximum omni-directional range of a signal transmitted by a 802.11b terminal without additional amplification (which would be illegal) averages a hundred metres, varying according to transmission power and physical characteristics of the antenna location (walls, rebounds, etc.). This short range is due to the low power emitted by a 802.11b device (less than 100 mW, compared with the 2 W or 8 W of GSM systems). Network communities also put in place directional point-to-point connections, by adding directional antennas to the standard equipment. Greater distances (up to several miles) are then accessible, even without amplification.

[15] 2.400-2.4835 GHz, to be more precise.

[16] WiFi community networks have become laboratories for tests on both current and the latest technologies. Test *in vivo* can turn out results very different to those announced by equipment manufacturers: an initiator of a WiFi community in Paris considers that the 802.11b at 11 Mb/s theoretic corresponds in reality to a mere 1 Mb/s.

If the 802.11b standard is the most widely used, the technologies of the 802.1x family are nevertheless evolving rapidly; the different variants available or in the course of being standardised are intended to improve the performances of the basic 802.11b standard in one dimension or other :

- the 802.11a standard was developed in order to offer higher-speed services, using another waveband, that of "5.1 GHz"[17]. The 802.11a allows users a maximum theoretical speed for the transfer of data of 54 Mbits/s, which corresponds to an average practical speed of approximately 27 Mbits/s. Using another frequency band, this standard is not compatible with the 802.11b;
- the 802.11g standard, which aims at increasing speed on the 2.4 GHz band. This version puts the emphasis on upward compatibility with the 802.11b: it uses the same waveband and implements technologies used in the 802.11b, expanding on them in order to increase the theoretical speed up to 22Mb/s or 54Mb/s[18].

The rapid pace of innovation has not prevented computer manufacturers from increasingly proposing 802.11b devices: WiFi cards, for instance, are becoming standard equipment on laptop computers. Nevertheless, the speed with which the standards in the 802.11 family are evolving and the uncertainties about technological choices (using 802.11g or a combination of 802.11a and b, for example) complicate all investment planning: an important investment may be made obsolete overnight (in terms of speed or security) by the next generation of standards. According to one of the initiators of the WiFi community network, it will be another five to ten years before wireless network technologies are fully mature.

The profusion of WiFi standards and equipment is favourable to the emergence of alternative infrastructure modes: technological uncertainty limits risk-taking by traditional economic investors, while the low cost of WiFi network equipment makes it accessible to individual actors and small groups. Terminals represent the bulk of the cost, which is therefore almost linear with number of users. This is not the traditional model of telecommunications operators, which are used to recovering their considerable fixed overheads over a long period of time.

This domination of terminals over central equipment (which can be done away with completely in one of the standard's user modes, the so-called *ad hoc* mode) stems from a standardisation process from the world of computers and consumer electronics, rather than from that of telecommunications. Even today, Philips is responsible for the IEEE 802.11 sub-group; WECA, the alliance of industrialists promoting WiFi, includes all the big names in the IT and consumer electronics sectors[19], several telecommunications components manufacturers (Ericsson,

[17] The 5150-5250 MHz waveband is far less used than those around 2 GHz, which makes it possible to reserve more Hertzian spectrum for the 802.11a than it was possible for the 802.11b. The 802.11a standard can therefore propose 8 channels of 20MHz which do not overlap. This means that 8 access points can cohabit in a small space without interference (coimpared to 3 with 802.11b).

[18] As this Issue Report is finalised, work has just started on 802.11n, which shall massively enhance the technologies used at various levels in the current standards to obtain data rates in the 300 Mb/s range.

[19] Hardware: Apple, IBM, AMD, Acer, Canon, Dell, Epson, Fujitsu-Siemens, Gateway, HP, Intel, NEC, *n*Vidia, Olitec, Palm, Panasonic, Philips, Samsung, Sony, Texas

Lucent, Motorola, Nokia, Nortel), but very few operators (ATT, NTT). As these companies from the computer and electronic sectors sell equipment operated by their customers, they are naturally more open to the practices of community networks than telecommunications operators, which provide services using their own networks.

If, as we have seen, WiFi history is already quite long and its technicalities are not that intricate, why were observers so surprised by the sudden emergence of WiFi as a network technology?

At the end of the 1990s, at a time when UMTS and the wireless local loop (WLL) were news, the 802.1x technologies were entirely ignored in the debate, notwithstanding that 802.11 was standardised in 1997 and Apple's Airport was a success in 1999. Why was WiFi turned down by observers as a potential technology for the growing data transmission needs of users of mobile telecommunications networks, as well as a means of freeing Internet users from the inconveniences of wired connections?

According to one of the initiators of the Madrid network, "*the emergence of WiFi wasn't expected by people who were waiting for a new free network, because in their mind, a new network had to be faster, had to propose a broad bandwidth."* It is frequent in fact, especially in the world of IT, to note that the criteria used to assess a innovation remain subject to the evolution of the strictly technological performance, while the adoption of the innovation is subject to a far wider range of factors (cost, ergonomy, retro-compatibility, change in uses, etc.). As a metter of fact, WiFi is not revolutionary in terms of speed, nor is it major technological advances for roaming or nomadic use – unlike UMTS, for example. What really characterises WiFi is its decentralized network management: the network exists as soon as first piece of equipment is active and extends automatically as and when other pieces of equipment are added. There is no centralised management *a priori*, no user declarations (except for security reasons), no control of the volume of data exchanged or the speed. This reinforcement of the user's role in relation to that of operators in the connectivity is not dissimilar to the trend observed in the computer sector in the years 1970 and 1980, from very centralised architectures (*mainframes, time-sharing*) to the now predominant microcomputers.

In other terms, the management of a WiFi network differs from a traditional radio telecommunications network by its simplicity; that simplicity has opened the way to the emergence of decentralized WiFi infrastructure modes. In order to better understand how, we shall now turn to the way WiFi networks are operated.

1.3. The setting up and management of unsophisticated, but efficient networks

The architecture of a WiFi network is very similar to that of a local wired network. The only difference is the radio equipment, namely:

Instruments, Thomson, Toshiba, US Robotics; software: IBM, Microsoft; networks: Cisco, Hugues.

- the *access points*, which play an equivalent role to that of routers in an IP network on Ethernet and which assure the interconnection between the radio part and the wired part of a network;
- the *customer cards*, which are installed on a laptop computer or a PDA and simply play the role of a network card. These cards exist in different forms. Given that the majority of devices using WiFi technology are laptop computers, the most widely used card is the PC format card (ex-PCMCIA).

In a network, an access point is linked to an local area network or Internet connection. The other computers or communicating devices (PDA, also digital juke-boxes, etc.), equipped with a WiFi card can be connected to the access point. They create a local network between them, which allows them to exchange data between them via the access point or to connect, again through the access point, to the Internet. All the traffic on the network goes through the access point, which plays the role of router within the network and a bridge to the outside.

This set-up of a WiFi network is widely spread today, either for domestic or company networks. It uses the so-called "*infrastructure*" user mode of 802.11b equipment, for the access point plays a distinctive part and centralize routing. A second mode, the "*ad hoc"* mode, dispenses entirely with centralising equipment. In the *ad hoc* mode, each computer connected to the network acts as a link to the other computers in the network. The network is reconfigured in real-time. The two modes are used in WiFi community networks, which therefore develop according to two alternative architectures. When the "*infrastructure*" mode is used, the network is "*structured*"; when the "*ad hoc*" mode is used, the network is "*meshed*".

The choice between one or the other of these two architectures amounts to selecting what will be simple and what will be complicated in the network's management[20]. Meshed networks facilitate the real time optimisation of the routing, but they require burdensome dynamic routing protocols to be established. This complexity has led certain communities to abandon the generalisation of the *ad hoc* mode.

Irrespective of the topology selected by their initiator, the ease with which it is possible to set up WiFi networks has always been crucial for the development of community network projects. This absence of barriers is clearly illustrated by the start-up of the Geneva network, as one of its initiators recalls. He had tried to install a WiFi link to connect his flat with that of a friend to share the costs of an ADSL Internet connection – since they both used the Internet extensively for their work and an ADSL connection is very expensive in Geneva. Despite their IT skills (one of them works for an Internet access provider, the other uses Linux), they did not really expect the link to function smoothly enough to be able to cancel one of their ADSL subscriptions and saw WiFi merely as a back-up technology. Soon, their installation surpassed all their expectations, opening the way to the development of numerous other links.

Other than IT and network expertise, the setting up of a WiFi network also radio technology skills. In fact, setting up a network with several access points involves

[20] It seems that the rationale leading to prefer one of these architectures corresponds, in the majority of cases, to community policy choices, according to the objectives of the structure which manages the deployment of the network.

superimposing short omnidirectional links around access points and longer directional links between these points. Radio technology know-how is therefore essential for setting up WiFi community networks. As this know-how is rare, that could have been an obstacle to the emergence of community networks. However, that is not the case, thanks in particular to the cooperation between WiFi enthusiasts and radio hams hobbyists (CB users).

According to one of the initiators of the Madrid network, "*people who had passion for radio ham, view in WiFi technology a real revolution. That's why today the countries where this wireless technology is the most developed are those where there was a real radio ham activity."* According to one of the initiators of the Lyon network, "*WiFi is neither more nor less than a pooling of the skills of IT specialists and radio hams. With WiFi, as IT experts we can have fun managing the services offered as a system and network administrator, but we need a technician whose role is to go and put up an antenna and direct it to another antenna and that has nothing to do with IT. It is the domain of the radio ham. We have seen that we can't do anything without them and we collaborate very closely with them*". Another advantage of this partnerships with radio hams is that the latter have the access to the roofs necessary for the installation of WiFi antennas. According to the same person, "*IT experts do not have access to roofs. The radio ham club of Lyon has premises, masts and antennas and they have therefore participated in the life of the association by putting up antennas."*

The simplicity of managing WiFi networks, the flexibility of architectures and the low economic barriers to entry therefore allow a strong decentralisation of networks. The initial installation of a network is carried out very locally, with very limited ranges. The cost of managing the infrastructure is small for each person, but would become expensive if infrastructure could not be installed in private homes and managed by users themselves. This is propitious for the emergence of small-scale community networks, typically centred around a small group of individuals who have technical expertise.

The remaining question is whether these networks can be implemented on a wider scale, interconnected with each other, and offer sufficiently secure services to constitute a credible alternative to the infrastructures of telecommunications operators.

Networks rapidly become complex as soon as the number of machines connected increases and the addressing problems become too burdensome to be managed by hand. However, network management tools are starting to emerge to make this management automatic: communities are testing and adapting tools that they need as and when this type of problem appears; they represent therefore an innovative force based on the principle of "*test and learn*". Thus, according to a WiFi hobbyist in Madrid, "*Madrid Wireless has developed a tool to make automatically assign an IP address to a new node, whereas in France or in other country, everything is done by hand."* According to one of its initiators, the association Consume is even more advanced and will create a dynamic network capable of reorganising itself automatically according to access points whether or not they are active, in order to avoid any manual planning of the network.

Finally, operating a network implies to deal with network security issues. This seems contradictory with the very concept of a network open to all, without any controls, which is the underlying principle of most community initiatives.

If WiFi has undeniably advantages for developing high-speed services in public places, a far from negligible drawback at the current time is the lack of security with the 802.11b standard. It is naturally easier to capture a flow of data transmitted via radio waves than via a cable – even if these data flows are encrypted – and that has led to numerous possibilities of taping and intrusion in WiFi networks. In fact, the standard defined by the IEEE was intended to be simple and therefore does not have any advanced security mechanisms, such as those which exist in GSM/GPRS networks. In the area of user identification, the standard proposes the configuration of a SSID (*Service Set Identifier*), authorising access to a wireless network. That allows an access terminal to check whether a new piece of equipment connected to the network is authorised to connect to it. But all it takes is for an unauthorised party to recover this SSID (often a simple name) by tapping the network or by "*social engineering"*, to be able to connect fraudulently.

To avoid any tapping of communications, the 802.11 standard therefore proposes a security protocol at link level, somewhat imprudently called *Wired Equivalent Privacy* (WEP). WEP is based on a technique of encoding data transmitted with a coding based on 40 bits. However, WEP encoding can easily be broken by using a flaw in a sub-protocol it uses (RC4)[21]. Subsequent evolutions of the WEP have tried to resolve these difficulties, but this protocol seems a bit weak to ensure on its own the security of a WiFi network.

With that in mind and in order to protect against it for the time being, the simplest solution is to assure the security at the level of the information transmitted, as is done for confidential communications on the Internet, rather than at the level of the radio link. As a initiator of Brussels Citizens' Network puts it, "*[complete] security is not possible in the air. (…) It is not possible to install a firewall in the air."* This involves encoding the data to be transmitted on the radio network before transmission. This creates a *Virtual Private Network* (VPN). This solution is widely supported by operators, but remains relatively burdensome to implement: it is therefore suitable above all for company type users.

All in all, however, the security problem does not seem to have discouraged WiFi community initiatives. The security shortcomings of the radio link do not concern them directly since they use this link without any special security worries. Moreover, the security of the machines of network users is the responsibility of those users. Finally, the security of shared equipment (routers Internet access firewalls, for example, in structured networks) is ensured by traditional techniques, with which the initiators of communities are often familiar on account of their professional background. Thus, in Lyon, the initiators of the community consider that the security of their network is one of their strengths. "*At the level of security, we propose the same thing as an IAP, that is precisely our strong point".*

The simplicity of operating a WiFi network favours the emergence of alternative infrastructure modes: centralised management of the network is clearly a solution

[21] See for example Borisov, Goldberg and Wagner (2001); Arbaugh, Shankar, Wang and Zhang (2002).

to the difficulties which appear, but other solutions are suitable for the decentralised management model used by WiFi community networks.

If, therefore, there seem to be no real technical obstacles to setting up these alternative infrastructures modes, what is the situation from a regulatory point of view, in particular as regards the availability of frequencies?

1.4. For the time being a limited regulatory framework, opening a fragile space to alternative infrastructures

The 802.11b technology, which is the most widely used today, uses the so-called 2.4 GHz[22] waveband. Today, apart from localised technical difficulties linked to the freeing of frequencies by their previous occupants, these bands are essentially free and open in all European Union countries. Accordingly, numerous appliances – such as microwave ovens – already use this range of frequencies. The initial uses of WiFi, notably domestic networks and private inside networks, are therefore entirely free and require neither the allocation of frequencies nor any prior declaration of the network. This initial facility, which is the rule in microcomputer hardware and which is in total contrast to the complex procedures for the allocation of frequencies or the auctioning of the Hertzian spectrum, is particularly important for the success of WiFi equipment: there are no regulatory barriers to the emergence of localised initiatives. The downside is the risk of interference, jamming and saturation of this band, since no actor whatsoever enjoys exclusivity.

The more or less generalised freedom of use of the 2.4 GHz band reflects a public intention. This waveband has been systematically freed up in recent years at international level from the systems that used it (notably the military, for example in France). The European Commission's action in favour of the liberalisation of the 2.4 GHz band was important, since the Commission declared itself resolutely in favour of a complete liberalisation of the wavebands linked to WiFi. For instance, in August 2002[23], it called for greater flexibility in the regulations in the five European Union countries where liberalisation was not complete at the time (France, Spain, Italy, Greece and Luxembourg).

Nevertheless, the regulations governing 802.11 wireless networks still vary in their details between countries, even between regions or areas. The most advanced projects for WiFi community use appear to be in the countries where the regulations are the most flexible; however, the regulatory controversy triggered by the non-availability of the 2.4 GHz band in France, for example, received important media coverage which publicised and provided the initial boost for the development of certain communities[24].

The regulatory situation in the European Union countries which we have studied

[22] 2.400-2.4835 GHz, to be more precise.
[23] European Commission (2002)
[24] The ban in May 2000 of the Provence Wireless de Mane (France) network, which used as yet non-liberalized frequencies, provoked a scandal, which publicized the WiFi concept outside the circles of hobbyists, by linking this technology to the problem of high-speed Internet access in areas not covered by high-speed wired access.

can be summarised as follows:

Country	Situation
The Netherlands	No licence required
Spain	No licence required
Belgium	Licence required for transmission beyond 300m
France	Declaration to telecom authority necessary for all structured networks active outside and comprising strictly more than one point-to-point link.
United Kingdom	Licence exemption

There has been close cooperation between the activists of WiFi network communities, on the one hand, and the regulator and the public authorities, on the other hand, in France and the United Kingdom – which pursue their own objectives of making Internet access available on a wide scale throughout the country. As one of the initiators of Arwain's project specifies: "*One key point is that the government wants to make the UK a leader in the world concerning the radio-networks and so supports initiatives such as Arwain's project".*

The 5.1 GHz band, used by the 802.11a networks, is less available, because its use has only recently been reserved at international level for wireless networks. Its use is either forbidden of requires to apply for a licence. In France, it is still prohibited for outside use. In Great Britain, according to the initiators of Arwain's network, "*The use of the 5,1 GHz band is limited for military and satellite up-link reasons (temporary licences can be allocated)."* Certain operators would like to see this band dedicated to commercial services in order to distinguish between the services that they want to set up and private, domestic or community networks which flourish in the 2.4GHz band.

The absence of licences is naturally crucial for the emergence of alternative infrastructures: the licence application process, even simplified, is far too complex and too long to be respected by most of the communities which co-ordinate these projects. However, if this freedom facilitated the initial boom of WiFi community networks, its outcome remains uncertain in a context where, with the growing number of actors, spectrum can become rare. Rarity of spectrum motivated the rationing of the number of operators and the supplanting of alternative modes by deep-pocketed commercial players in FM radio or mobile telephony, for example[25].

This raises the question of the prospects of the spectrum used by the WiFi networks becoming saturated. In Montauban, the initiators of the community recognise that they are encountering "*problems of saturation, but tools for administering the network are starting to arrive*". One can distinguish three levels of saturation problems:

- **saturation at users level** : even within a 802.11b network, the multiplication of users can lead to saturation of the 5.5 Mb/s shared by all the users of a channel. The traditional solution is to add smaller size cells. In infrastructure mode, if an access point is saturated, the solution consists in dividing it into two access points, each of which is accessed by half of the users. These modifications are marginal in the majority of cases: to quote the initiators of

[25] As discussed in Lessig (2001), chapter 5.

the Lyon network, "*if we notice that in one place the network is insufficient, we will add a second access point to try and re-establish it*";

- **saturation at networks level** : the co-existence of different WiFi networks on the same territory can lead to interference once the three totally separated channels are used. Network managers must then either set up point-to-point links within the network to limit the risks of interference, or share the available channels. This situation regularly occurs when separate initiatives are launched on the same territory: that was the case in Portland, Oregon, between T-mobile and private users who had installed their own wireless network[26]; in Paris between the Wixos experiment[27] and sub-groups of Paris Sans Fil; in Geneva, between Swisscom and the SFNet community network;
- **saturation at technology level** : WiFi networks present in an area can interfere with other equipment using the same frequencies. These appliances include microwave ovens, wireless telephones and devices using Bluetooth technology. In that case, the transmission rate of the network falls; packets interfered with are systematically retransmitted, limiting the transmission band available for the following packets.

This question of saturation is well known and solutions, although limited, exist for structured networks. The question is more complicated for meshed networks using the *ad hoc* mode. In the words of one of the initiators of the Cardiff network: "*we are playing with [meshed networks] but don't believe that there is sufficient bandwidth to make the extra complexity worthwhile."* Actually, in *ad hoc* networks, all the machines use the same channel, which exacerbates the problems of network congestion. However, the initiators of WiFi community networks are not all in agreement about the effect on the transmission band of the use of an *ad hoc* network. In fact, the *ad hoc* mode does not use the same system organised into an hierarchy where all communication must pass through a bottleneck (the access point). Consequently, architectures which require less use of the transmission band than in structured networks are conceivable. According to the initiators of the Brussels citizen's network, the more users there are in a meshed network, the more utilisable transmission band there is, since every node offers transmission band – after adaptations of the routing and DNS protocols which, as mentioned, are the subject of ongoing research – and since the distances between nodes are smaller, the power emitted can be reduced.

This question of interference is likely to become increasingly important as the number of WiFi networks grows. Telecommunications regulators will therefore certainly have an important role to play in avoiding a possible conflict between operators and communities. Certain members fear that the introduction of *hotspots* into the public domain may disturb the community networks already installed and that, unless there is stricter supervision of WiFi activities, the law of the jungle will apply to their detriment.

There are two conflicting approaches to regulation. Certain operators would like to be allocated an exclusive waveband covering a specific area, so as to establish their commercial services without the risk of any interference. For other observers[28], however, that would assume that shortage of spectrum is general,

[26] Charny and Fried (2002)
[27] Carried out by the RATP, the Parisian urban transport authority.
[28] Notably Jean-Michel Cornu, Scientific Director of the Fondation Internet Nouvelle Génération (FING).

whereas in reality this shortage only exists in a few areas (city centres, commercial and industrial zones). They would therefore prefer a less stringent regulatory mechanism, for example by establishing priorities for the use of certain bands rather than exclusive use. A system of reserved channels would be less favourable to WiFi community projects, whose development approach would be hard to reconcile with the process of allocating channels imagined by regulators.

Finally, it should not be forgotten that other regulations can have an important influence on the growth of alternative telecommunications infrastructures. According to the initiators of the Geneva network, "*since 1 April 2003, all telecommunications operators in Switzerland are obliged by law to keep all the mails which are handled by their networks for six months. In this context, WiFi can be disruptive since it cannot control what each person does."*

If, for the time being, regulatory policy has favoured the rapid development of WiFi in Europe, the new challenges concerning handling disputes between networks and the unwavering policy of opening WiFi community networks to unidentified users will need to be resolved in an innovative way in order to avoid more stringent regulations which might prove disastrous for emerging infrastructures.

In this regard, it must also be borne in mind that although, for the time being, telecommunications operators have only a marginal place in the rapid development of data transmission radio networks, the situation is likely to change with the progressive opening of UMTS third generation mobile networks, with which the WiFi networks will then be potentially in competition.

1.5. The implementation today of the promises made yesterday, but since delayed, about UMTS

As summed up by the FING, "*the two technologies [UMTS and WiFi] could find themselves in real competition. Unlike GSM which has cells of 15 km, UMTS uses mainly micro-cells and pico-cells of several hundreds of metres, like the WiFi networks. UMTS, planned by the operators, has the advantage of being backed by the resources of large companies power which guarantees the long-term viability. WiFi is, on the contrary, extremely flexible and adaptable thanks to the extremely low cost of the equipment. It offers users direct high-speed access today to Internet protocols"*[29].

If WiFi today is at the forefront of news in the area of the wireless transmission of computer data, it has in fact replaced in this role the *star* of the 1990s, which was considered as the future of telecommunications: UMTS or the third generation of mobile telecommunications networks (after the analogical and digital generations of GSM, TDMA or CDMA according to the countries). There have been considerable delays in rolling-out UMTS, which was conceived in the mid-1990s and due to be rolled-out in 2002-03; the delays are due not only to technical problems, but also, and above all, to the financial difficulties of numerous telecommunications operators following the bursting of the "Internet bubble". Those financial difficulties were, of course, not helped by the race for the very

[29] www.fing.org

expensive UMTS licences[30]. If some UMTS networks are now open, most of them will not become operational before 2004 at the earliest, and although some hybrid or moderated solutions (iMode, GPRS) are available, the commercial results have sometimes been disappointing (WAP).

The increasingly strong interest shown by telecommunications operators in WiFi must therefore be seen not only as a genuine interest in a technology which can be integrated into their offerings but also as a way of focusing media attention by offering data radio transmission and Internet access services, pending the roll-out of UMTS – or as fear of seeing the standard in which they have invested very heavily becoming obsolete even before it has been exploited commercially. However, this media coverage is two-edged: although it reassures consumers about the capacity of telecommunications operators to offer such services, it also gives certain legitimacy to existing alternative offerings, such as the local cooperative infrastructures which are the subject of this study.

Moreover, the development of WiFi networks by traditional telecommunications operators is complicated by the fact that there is a risk that the WiFi network's deployment and management model, as well as the modalities of invoicing for the service, may be very different from those used in mobile telephony. Hence, the creation of a WiFi network is risky for a telecommunications operator, not so much on account of the technical costs, rather from the point of view of the marketing costs (invoicing, advertising, etc.) which can prove to be not only high, but even counter-productive if they confuse the future message on UMTS.

The WiFi/UMTS comparison is not as favourable to UMTS as could be thought on first analysis. We shall now review these different aspects.

The first advantage of the 802.11b standard over UMTS is that the cost of deployment and equipment is affordable, even for private households. Today several access point models exist, many of which have routers and firewall capacities. The average cost of such equipment is 200 euros. The cost of *hotspots* terminals intended for commercial operators is far higher since it can reach 20,000 euros[31], notably for 802.11a/b dual-band access points. However, even these maximum costs seem low compared with those of a UMTS base station. Certainly, WiFi has a far smaller range than UMTS. Many more access points are therefore necessary to cover the same area, which increases the overall cost of the solution if the aim is to achieve broad territorial coverage but, if the aim is only partial coverage, WiFi can prove to be the most effective solution.

Today, WiFi cards can be bought for approximately 80 euros, the differences between models being due to varying reception qualities. *A contrario*, the prices of UMTS terminals are still very high compared with the cost of a WiFi card. At Three (Hutchison 3G) in Great Britain, the first European operator to launch these 3G services, these terminals currently cost between 249 and 449 pounds (approximately 400 to 700 euros), that is to say 5 to 9 times more than the 802.11b PC Card. In fact, with UMTS it is necessary to buy a new terminal, whereas the WiFi technology can be integrated into existing standard equipment. If this cost is added to that of a laptop computer, the comparison becomes favourable to UMTS. This kind of retro-compatibility is a factor favourable to the

[30] STAR Report (2001).
[31] Journal du Net (2003).

adoption of WiFi – supposing that potential UMTS users do already own a laptop or would need one to use efficiently their UMTS device. Recently, manufacturers of laptop computers have started to integrate WiFi cards directly into their products. The openness of the 802.11b standard and its computer origins are important advantages here.

The second advantage of WiFi in relation to 3G is its speed. Following the standards of the 802.1x family, the practical speeds (shared between all the users of an access point in a structured network) reach 5.5 Mb/s, even 27 Mb/s. This compares with the maximum individual theoretical rate of UMTS, which will not exceed 2 Mb/s. For little used cells, where the simultaneous rate of all the users does not exceed 27 Mb/s, the individual rates in WiFi can therefore prove more than or at least as comfortable as those of UMTS.

The cost of the UMTS operating licence has constituted a considerable barrier to entering this market. Only sufficiently solid and powerful actors have been able to acquire the necessary frequencies and therefore there are few new entrants on the UMTS market. *A contrario*, the WiFi sector is today marked by a large number of actors, including a strong percentage of new entrants, which ensures a more rapid and more dynamic exploration of the possibilities offered by the technology.

One of the major advantages of UMTS over WiFi lies in its important roaming capacities – moreover WiFi actors speak more readily of *nomadism* than mobility for the 802.1x solutions. In fact, if WiFi allows roaming within the same local network, it does not manage the reconnection when there is a change of network. Roaming in WiFi is more akin to a re-selection of an access point, that is to say the "hand-over" by the terminal when it detects an important deterioration in the level of reception. This "hand-over" functions without any cut in multimedia sessions, on condition that the access point belongs to the same local network. Otherwise, the change can be made but, as it requires an IP address change, it causes an interruption in the data flows transmitted and received by the end mobile user.

Roaming in WiFi is therefore not optimal. Research is being carried out in order to improve it, as well as on network control protocols in order to improve the distribution of users between the adjacent access points. All these questions have been resolved in an integrated way in 3G standards such as UMTS. Likewise, UMTS offers seamless connectivity and hand-over services, albeit at a reduced speed.

It is however still necessary to check that there is a real need for seamless reconnection. Not surprisingly, the initiators of WiFi network communities remain somewhat sceptical.

This comparison of the characteristics of WiFi and UMTS leads some actors to consider that these two technologies will in the end be more complementary rather than in competition. According to *Business Week*, "*in the end, no single technology will dominate mobile communications*[32]*".* Likewise, one of the

[32] Business Week (2003).

founders of the Geneva network, asserts that "*UMTS is an additional tool, with a different role from that of WiFi.*[33]*"*

For some coordinators of WiFi network communities, WiFi is not really a threat to UMTS. For one WiFi activist in Paris, "*WiFi is the interval necessary between the current GSM or GPRS and UMTS. UMTS remains indispensable over time since WiFi does not have any accounting, billing, authentication like UMTS. UMTS has a global vision of the situation; it is a globalised service accessible from anywhere while WiFi was conceived purely for local operations. WiFi currently deludes people into thinking that it will compete with UMTS but it is nothing more than the mobile telephone of the 1980s that people have in their apartment."*

To conclude, the technological family based on digital mobile telephony (GSM, GPRS, UMTS) seemed to be leading to future data transmission networks that would be ubiquitous and operated in a similar way to those of voice networks, offering a guaranteed, but expensive, service. The WiFi community network proposes another balance: no service guarantee, but lower costs. Coordinators of WiFi network communities emphasise that they are not endeavouring to offer "operator" class services: for those of the Lyon network, "*today, we can afford to have a node which crashes, possibly to be cut off. (…) If we applied for a licence, that would be difficult to manage. At the current time we do not have any obligations towards users. They are very aware that if ever thunder strikes, if non-one can repair their system in two days, it will not be repaired in two days. Whereas in the framework of ISP services, users expect a quality of service and if there is an incident it must be repaired immediately. Today the network functions correctly since whenever a problem occurs, people are motivated to act. They are motivated as voluntary workers within an association. We have a responsibility towards them, but not in the same way as an ISP would be responsible."*

Clearly, the simplicity of the services proposed by the alternative actors shapes their existence. This explains the reluctance of WiFi community networks to offer added value services to their users, such as security or transparent roaming. That would represent taking a risk of switching to a system with unacceptably high costs for an emerging community and above all of being obliged to adopt a more professional approach, with the attendant risk of discouraging the network's expert members or transforming their status. Reciprocally, the very existence of these WiFi networks means that, in order to be successful, the future UMTS networks will be obliged to offer superior or different services from those already offered by the WiFi networks.

1.6. Conclusion

Based on our analysis of the history, technical characteristics, network management methods, the regulatory framework and the competitive environment of the 802.1x standards, we conclude that WiFi does favour the emergence of alternative infrastructures modes. Such a possibility is based chiefly on the open characteristics of the technology and on the current fragile state of the telecommunications sector. Of course, the appearance of WiFi community networks is in no way technologically determined: they are the

[33] That was also the view expressed, for example, by Sky Dayton, CEO of Earthlink and Boingo Wireless, in his keynote speech at the CTIA Conference in March 2002.

product of the co-operation between this favourable technology and “leaders users”, who are technical enthusiasts and interested in the non-commercial aspects of radio networks for the transport of data.

This relationship can be long-lasting or transitional. We do not yet know whether these communities will withstand the emergence of a competitive architecture, the saturation of its experts market pool and the identification of dominant services. There are grounds for being pessimistic; the history of the adoption of technologies shows that initial not-for-profit uses can give way to more professional offerings based on market economy practices.

However, even if these communities are in the end supplanted by industrialised, standardised services, they have already changed the perception of wireless networks and the demand for high-speed services. The most innovative uses are tested on a large-scale in the field: in Lyon, technological projects aim to offer a “voice on WiFi” service and a WebTV on the wireless network; in Paris or Montauban, neighbourhood uses are developing. The variety of potential architectures is explored by a variety of actors who take advantage of the flexibility of community practices.

A minima, and as for mobile telephony, reserved at the beginning of the 1990s for professionals, the operators hope to diversify progressively their customers for high-speed services. The communities could be the new driving force, perhaps despite themselves, for the rapid development of high-speed offerings by telecommunications operators. Moreover, numerous communities comprise engineers who work for operators and who, by taste or by interest, want to learn more about WiFi networks in an associative framework – in a way perhaps similar to IT specialists who, in their company, are paid to work on open source and free software in collaboration with a community of unpaid hobbyists[34].

In addition, the existence of WiFi networks independent of telecommunications operators can serve as a reminder of the need not to neglect the interoperability of the terminals and networks of operators, as users want to be able to use their equipment to connect not only to networks of operators but also to community networks. This role is played in the world of computers by free software, whose existence and use by a significant proportion of Internet users, for example, prevent commercial software publishers from straying too far from open standards.

These considerations represent a threefold reason for studying closely WiFi network communities:

- to gain a better understanding of the emerging phases of a technology, and public action challenges involved;
- to gain a better understanding, in the case of WiFi, of the emerging services and uses which will be at the heart of commercial offerings in the coming years;
- to try to anticipate the cohabitation or substitution of commercial uses for associative uses.

[34] Strategies of Netscape around the Mozilla community or of IBM around Linux, for example.

The first challenge is closely related to the question of "narrow windows" for public action, as defined by Paul A. David[35]. If the choice by the public authorities in favour of a technology must be guided by a tight schedule, it seems also to require a preparatory action to facilitate the emergence of original infrastructures and the exploration of the range of possibilities – including criteria for assessing competing technologies[36]. Supporting community networks could therefore be a means, for the public authorities, to accelerate this exploration, without being pressurised directly or indirectly by operators or industrialists.

The second challenge is that of knowing which cooperative model can play the role of high-speed local network operator, and subject to which conditions, by favouring which services and what quality of service. Certain projects are very ambitious, following the example of that of Lyon which, over and above the installation and management of access points, proposes its expertise to secure the network. On the contrary, other projects are satisfied with merely providing assistance to users, without worrying about creating a consistent network.

Finally, in order to determine whether the WiFi community movement is here to stay or not, we need to understand why individuals choose to participate in this type of project, instead of being satisfied with the commercial offerings made available to them by operators. The shortcomings of such offerings could be transitory, notably:

- current ADSL prices, which are prohibitive for truly high-speed access;
- the unsuitability of the customer services of the traditional operators for users who want more than simple Internet services (web and mail);
- the concerns of users regarding the asymmetry of information between them and their operator, in particular as regards interference in their surfing and keeping their personal data[37];
- the need to learn outside the market in order to use new information services. Free help networks develop locally until most people reach a sufficient knowledge level.

By answering these shortcomings, WiFi network communities have attracted a number of people. The key motivation of the initiators of WiFi network communities was to break free from the constraints of paying for high-speed access and to create or reinforce a spirit of sharing between members. Will this model be able to co-exist with the commercial offerings that the operators will develop for the public at large?

Communities founded according to this model are often supported by territorial authorities, essentially in areas which do not have high-speed wire Internet access; their aim is to reduce the growing digital divide between rural and urban areas. These initiatives tend to counter the purely commercial approach operators. Will they have an important influence on the regulation of high-speed access?

[35] David (1986).
[36] de Bandt and Foray (1991).
[37] In this regard, it is important not to underestimate the questions related to "shameful" uses of networks, such as the downloading of pornography, nor illicit uses, such as the exchange of content covered by intellectual property rights (music, software).

In order to explore these questions in greater depth, we are now in position to explore the services and uses of WiFi through the working of the communities and the development of these emerging infrastructures.

2. WiFi Network Communities: Learning Dynamics and Role Played in the Emergence of the Local Information Society

The territorial spread of WiFi might be compared to covering a wall with hollyhocks: independent initiatives *bloom*, on a local basis, some spread and give off suckers[38]. Each has a two tier hierarchical structure: the lobe, constituted by the zone of coverage linking the stations to the terminal, and the stem, connecting the cells to each other by distant links. Finally, initiatives can join one to the other until the whole surface of the wall is covered without discontinuity, they can also mutually overlap and asphyxiate each other. This metaphor of the hundred flowers is linked to the dimension of a cultural revolution introduced by WiFi, which, like any technology aiming at social communication, supports and inscribes potentialities of more fraternal democracy. One can go further, and situate more precisely the exact scope of this logic of development to the articulation between the features of regulation and the social features of the usage which accompanies it.

While the regulatory parameters have exercised an influence on the general directions of the social spread of the technology, it is important to pay close attention to the way in which, depending on the situations, the social construction of uses enables these trends to be slowed down or even reversed. Indeed, because it is structured in a decentralised and heterogeneous way, WiFi technology is, no doubt more than any other, marked by a porosity between innovation and use. On the one hand, there is a very great reversibility of technical choices according to the numerous interaction loops between the various players. It is therefore important to give great autonomy in the analysis to the construction of uses, and to the way in which they are socially organised on cultural norms. Here we will highlight this autonomy by an *ethnography of uses* based on a study of the community phenomenon around WiFi.

On the other hand, we make an additional hypothesis in the observation of uses by laying down that a vital element of the social deployment of uses is the construction of a system of justice which ensures the balance of the community. The normative dimension of usage is thus a central dimension of WiFi innovation, and expresses itself through the fact that each community, to find its balance, must lay down rules of justice in several different fields. In order to get a clearer picture, it is convenient to structure this analysis of community usages and their contribution to normative regulation on three levels of analysis.

The first level of analysis (section 2.1) aims to better define the **concrete contributions of these communities** to normative innovation**.** In what sectors of innovation do these communities intervene? What is their contribution? This first level aims to situate the share of these normative innovations in the community contribution to the innovation dynamic, to identify the most common iteration

[38] We are inspired by the beautiful metaphor used by Alessandro Ovi who compared the spread of WiFi to the covering of lake by water lilies (cited by Negroponte in *Wired* 10 (10), October 2002).

loops between innovation and usage. The study was carried out by means of interviews with influential members of various community groups[39]. A second level of analysis (section 2.2) aimed to study the **potential of social enlargement** of WiFi, by insisting on the divergent directions taken depending on the community profiles. We show the diversity of community profiles, by clarifying it thanks to a classification of communities which opposes four types. This highlighting of more detailed portraits of community styles aims to bring out the way in which, on these initial choices, social profiles of users are constituted and to identify if the differentiation of profiles has an influence on the relational features and community « policies », by highlighting the difference between those explained in words and those demonstrated by practice. Finally, our analysis of the community contribution to WiFi technology will be completed by a 3rd chapter of study (section 2.3) which will endeavour to examine the role of the communities in the **collegiate management of alternative infrastructures** in the zones not covered by broad band. The monographs of communities which have developed in rural areas to bring a technology coupling “satellite and WiFi” constitute the basis of this analysis.

2.1. A moderate contribution to innovation of amateur circles

The early and free spread of the WiFi norm in public specifications, the low relative cost of the equipment necessary to install a WiFi network , and the usage tolerance granted for a low power occupation (but without paying a licence for the frequency band) are three regulatory type factors which considerably reduce the barrier of entry for the testing of this innovation. These various elements encourage the influx of numerous operators notably amateurs, and their central place in innovation. However, from the favourable trend to reality, the autonomy of uses must be taken into account, and, compared to other wireless telecommunications innovations (radio, cibi), the quantitative weight of amateurs is globally less, their contribution to innovation is less general and thus, the coupling is less tight.

What is the contribution of the community to innovation in the case of WiFi? This question must be documented by the empirical approach, but it assumes remobilising the historical work on radio (Douglas, 1987) and the ethnographic focuses on cibi (Boullier and Bleuzen, 1995), wireless communications techniques to which WiFi is comparable.

It is no doubt because they attenuate the costs of investment that all wireless innovations are stamped by the place of amateur communities in the innovation dynamic: thus in the upstream phases of innovation, the community sector and not the market sector still plays a major role, more important indeed than for innovations such as the Internet where the public university sector is going strong (Flichy 2000). This fact is found with WiFi. However, compared with the case of radio, where amateurs poured in to the extent of making it “the kingdom of the wireless amateur” from 1889 (date of Marconi’s invention) to 1927 (date of the law restricting the allocation of frequencies which tolled the knoll of the amateurs' role), WiFi is still experiencing a more moderate influx. For radio the supply of volunteers was boosted by the massive arrival of demobilised amateurs who had

[39] See our “WiFi Community Guide of Interview” in the methodological appendix of the present report.

been trained in this practice in the Army, as well as by, for both radio and cibi, the recovery of army surplus equipment. In contrast, WiFi only recovered the frequency band from the military sphere, and the supplying of communities from public equipment is very rarely observed. Another difference compared to radio is due to the lesser intensity of practice of the amateurs involved in WiFi network communities: whereas radio was characterised by an intensive professionalism of the amateur world (who were at the origin of the first radio broadcasting stations), only a tiny fringe of WiFiers is "professionalized", and even a minority among the initiators of communities (despite the fact that this is the category in which those most expert and most involved people are concentrated[40]).

In radio, amateurs contributed at numerous levels to the progress of innovation, to the extent of participating directly in it by finishing their construction (Douglas 1987). More modestly, the contribution of WiFi amateurs to innovation is certainly abundant, but it is focused especially on the « life size » testing of equipment, and on the software layer making the network work. There are local technical experiments on equipment: In Brussels, the WiFi Citizen's Network conducts experiments on helicoid antennas, created in the framework of a cooperation with Africa. But experiments on equipment are reduced to a very rudimentary handicrafts or even folklore level. The schoolboy rite of the « chicory tin », rather generalised in all the communities encountered, demonstrates this well: it consists in making a link of maximum range with an ordinary salvaged preserve tin; the tins enable antennas of up to 6 km to be reached (record established at Paris Sans Fil). At Paris Sans Fil, the initiators recounted to us jokingly the tests they are conducting to find which preserve tin works best on these makeshift junctions. « The tea tin, which is smaller, is better than the Ricoré one » (leader of Paris Sans Fil). The gap between the professionalism of the radio amateurs and the lack of seriousness and means of the WiFiers is manifest:

« *Let's take a very simple example. We as WiFiers and computer experts, the super thing for antennas is the chicory tin. I showed a chicory to the president of an am radio club and I was almost insulted. He told me that it was too much work, much too complicated for such poor quality. He told me that there were much simpler things which worked much better*. » (MH, Wireless Lyon)

The nature of the relation between the amateurs and innovation can be described as an attentive *watch*: there are numerous initiators who visit the shows from time to time in order to gain some strategic information about the future of WiFi.[41]. Technically the best coupled community in our panel, that of Lyons, even tried to organise a specific WiFi show in April 2002, but had had to cancel it for lack of candidates to manage the organisation (the active cell was limited to 4 people).

[40] We only encountered one provincial WiFier community in which the activity is more professional-like. At Wireless-Lyon, to our question on the social composition of the public adhering to the association (what other categories do you see as being important in the association ?), the founder replied with a burst of laughter: « *the future creators of businesses. Some introduced themselves as such from the start. At the last meeting, out of 40 there were easily a dozen members who said that they were going to set up their own business or that they had already done so or that they were in the process of doing so, and on WiFi* ».

[41] Describing his visit to the Cebit, an initiator of the Geneva network said his main reason for satisfaction was to have better understood how and over what time scale the norm was going to develop.

One can even go further and note the *conservative* impact on technical innovation created by the community conglomeration. The WiFi network communities hardly participate in the benchmark between norms. Almost all the WiFi network communities we have observed limit themselves to testing the 802.11b version, which is the most widespread: no community has the means to really test the most significant alternative norms such as - the « a » or the « g ». Moreover, the predominant place of the communities in innovation creates a dynamic of conformism since they favour evolution scenarios which maximise downward compatibility: they object to the « a » which forces a jump on changing frequency, they are less reticent about the « g » which tips development more towards the software layer. This predilection for conformism is explained by the communities' and their members' lack of financial means to absorb the purchase of dual band terminals.

The density of the interactions between technical norm researchers and experts is weak and the number of computer researchers specialised in the norm in the WiFi network communities is limited. The most crucial part of the WiFiers activity is then the life size test of the ordinary version of the existing norm, the 802.11 «b». The communities give themselves the express aim of demonstrating its *limits*.

Transposing the network features of wired Ethernet, the WiFi norm depends on the sharing of a cell's transmission band among all the users connected to it. The communities encounter problems of congestion in their growth phase (saturation, interference) and solve them by designing routers which lay down rules of justice. Thus, the amateurs have developed routing software enabling the access to resources to be allocated between the different members by decreeing traffic priority rules.[42]. The communities also establish allocation keys to evaluate which place to give the different types of exchange: numerous communities (Consume in London, Airwain in Cardiff, Network in Brussels…) explain rules of sharing between the exchange of video files (divx) or video games on line (Counterstrike). More generally, like the *peer to peer* networks, they depend on an adjustment of remunerations to the size of the contribution paid by each. But, whereas the remuneration in *peer to peer* is usually done according to a decentralised even dyadic classification, the justice system put in place in the WiFi network communities is based on a centralised allocation of resources. The setting up of a computerised system of increasing or reducing accessible transmission speeds depending on the amount or the direction of the information having transited between the user and the rest of the network is being discussed in certain communities. Allocation keys are being negotiated and discussed. Faced with the problems of saturation linked to the clogging of the 2.4 GHz, this equipment in the technique of the norms of justice will be a major challenge for the local wireless networks in the coming years.

2.2. What social enlargement? Community typology

A central particularity of WiFi is its local anchorage. Because of the few hundred meters geographic range of the wave, the communities set up are the size of the neighbourhood, the residential block. The difficulty of containing the wave within

[42] US communities have created some dynamic optimisation software, preventing « guests » on a WiFi node from degrading the performance for the others, while remaining authorised to share the band when excess capacity is available.

the walls of the home was then transformed into a resource for the community dynamic. Consequently, the WiFi community must find the right balance between a logic of penetrating the local fabric, which aims to develop the sociability of the neighbourhood, and a homophile logic which depends more on extending links at a distance. In the first case, the antenna placers discuss with people of mixed ages and cultural compositions. In the second case, network leaders who have become WiFi experts move around to help set up points of access and a backbone of the WiFi network promoters situated in neighbouring towns. There is great diversity of modes of social extension and of spatial extension of WiFi network communities. Several parameters must be brought out to clarify these differences between the dynamic of social enlargement of each of these communities.

WiFi network communities can be presented as being globally opposed according to two parameters, the one depending on the normative configuration which explicitly drives their promoters, the other depending on the nature of the technical plan which lays out their relationship. On the one hand, the first parameter, their *ideology*, essentially indicates their strategic positioning in relation to the Internet. On the other hand, the second parameter, their *topology*, indicates their exact technical choice of operating mode designed for laying out the network. This typology brings out four major types of communities, which have many differences between them. Painting this typology, which, globally, enables a dial to be drawn, will be the object of this chapter.

The ideological parameter is no doubt the most explicit and the most frontal, and for this reason the one which, having the most structuring effect, has the most explanatory power. It opposes communities which, on the initial model of *Consume* in London, favour the model of Internet access by mutualising the transmission band, and the communities which, on the initial model of the Citizens' Network in Brussels, reject connection to the Internet and favour the constitution of an autonomous and municipal exchange network. Each of these ideological models has spread according to a logic of geographic proximity. Consume has made emulators near Cardiff (if the Welsh group is not called Consume, this is because in the region the word has a different connotation than in London, and connotes an idea of destruction). The Citizens' Network in Brussels has sown in the neighbourhood of Lille and Louvain. This ideological parameter is sufficiently marked for it to be customary in the taximony of WiFi phenomenon to give it a leading role, classically opposing an Anglo-Saxon model favouring access to a continental model favouring content.

However it articulates in a subtle way with another parameter, topological, which gives it great complexity. The topology chosen to run the network oscillates between two operating modes. Thus, are classically opposed a « ring » topology, operated in ad hoc fashion, and a « star » topology, operated in more structured way. Although there is a certain inter-dependence between the ideological parameter and the topological parameter, since the « ring » topology makes the connection with the Internet network more delicate, as it is shown by the Brussels case, certain atypical cases can be found, of « ring » topology communities which favour an access model (this is the case of SRFnet in Geneva, or again of Paris Sans Fil), and cases of "star" topology communities which favour the own content model (this is the case of Wireless Lyon).

The typology also expresses a social choice, although the association is much less systematic. The positions of the community in relation to the topology are more varied: some claim the choice of their topological model, others progressively discover that it reins them in like a discipline. They then aim to compensate the effects of the topology by other mechanisms. However these topological models, like agents of the actor-network theory, entail structuring effects.

2.2.1. *Four community cases*

2.2.1.1. The Citizens' Network in Brussels

The first community case concerns those having a "ring" topology and a "content" ideology, rejecting Internet access. The typical example is the Citizens' Network in Brussels.

On 15 September 2001 the first meeting on WiFi in Belgium took place. About fifteen interested people were at the origin of the creation of the community. The community does not originate from computer buffs, but from socially heterogeneous profiles. The leader of this community is a doctor who had discovered WiFi as a reliable technology enabling him replace cables when he did biomechanical bone tests. The Citizens' Network was conceived as a network for neighbourhoods, serving local life in Brussels. The aim of the project is to build an Intranet on the scale of a city. The first node was lit on 31 December 2001. The Citizens' Network charter explicitly refuses Internet connection, including for adherents who are legal entities (associations). Moreover, the topology is a *meshed network*. There is no structure in the network, no sub structure and therefore no sub network mask. The notion of backbone is forbidden in the citizens' network.

2.2.1.2. The Consume community in London, UK

The second community case concerns those having a "ring" topology, but an Internet access ideology. The typical example is Consume in London.

In July 2000, James Stevens and Julian Priest drew up the founding text of the community. The initial text insisted on the fact of finding a means of linking members among themselves, Internet not being reserved to a few privileged people. This text was then shared through the consume.net web site. In order to bring together people interested by the uses of WiFi on their London initiative and to gather their points of view, they also developed a mailing list. By these means they succeeded in assembling 1000 people and in setting up a network of more than 200 nodes (in the London region). The United Kingdom government moreover recognised their legal structure.

Beyond managing a network in London, Consume wishes to be a « brand », an identity, a rallying name, on which any local initiative anywhere in the world can lean in order to affirm its legitimacy in the face of governments and local operators. A convincing example of this support supplied by Consume is the Arwain community in Cardiff. Joining Consume is free of charge, it is just necessary to bring one's own equipment and to construct and connect this new node to the network of members already existing in the neighbourhood.

In order to achieve a meshed network managed dynamically according to the additions and withdrawals of nodes, Consume works in partnership with different companies. According to them the best solution developed at present is MeshAP (John Anderson, locustworld.com). While meshed networks are developing in a town by town approach, James Stevens believes a meshed network on the national or planetary scale is still far away.

2.2.1.3. Paris Sans Fil in Paris, France

The third community case concerns those having an own “content” ideology, but which have a « star » topology with Access Points. This is the case of the Paris Sans Fil network

Paris-Sans-Fil was created in February 2002. The aim of its two founders, two computer engineers, was to promote wire technology in the Paris region. But, progressively, another project was substituted for this initial wish to coordinate the development of the WiFi network over a large expanse such as Paris, that of facilitating the installation of WiFi networks with help and advice. The network is star structured, according to the classical principle of IP station addressing. The aim of the Paris Sans Fil association, which was set up to aid the community legally is to encourage the constitution of exchanges on the city level, between access points connected to the network. The relationships taking place at present enable exchanges of local services to be created between the inhabitants of nearby neighbourhoods and even in the same building. The exchange of information is not exclusively peer to peer as might be thought. In fact, thanks to this new means of communication, exchanges of physical goods may be carried out: for example someone can make available an exhaustive list of his video cassettes, someone else can then ask him to lend him a cassette, then a third person can ask the same, the first person can then make this cassette available by leaving it in a place accessible to all where they can recover this cassette. To illustrate this we can cite the example of a Paris Sans Fil adherent who made one of his video cassettes available in a café near to his home, then the other adherents recovered the cassette and exchanged it among themselves, always replacing the cassette in the café.

2.2.1.4. Wireless Lyon, France

The fourth community case concerns those which have « star » typology, and an Internet access ideology. The typical example is Wireless Lyons.

Created in April 2002 by Nicolas Prost, Thomas Venard and Mehdi Hamida, Wireless Lyon is a 1901 law association which today groups about a hundred members, the great majority of whom live in the Lyons conurbation, but also with a presence in Le Mans, Grenoble, Paris and soon Bordeaux. Wireless Lyon claims a professional and structured approach which the other WiFi network communities in France lack.

Wireless Lyon encourages partnerships with companies. In return for their expert knowledge of WiFi, the companies undertake to lend or even give equipment. When a private individual wishes to install an access point, the purchase of equipment is incumbent on him. The association intervenes to offer him rock

bottom prices and to give him technical advice. In return they expect members to participate actively in the life of the association.

2.2.2. *The way in which the community « compensates » the topology*

The dependence on a network topology entails particularities of political configuration of the communities among users. These particularities may either be accepted in the form of consent or enthusiasm, or either rejected as disciplines and compensated for. In particular, as the size of the community WiFi network increases, the "ring" topology has given rise to reticence.

In terms of opening to new members, the « ad hoc » mode seems very restricted. It makes the insertion of a newcomer difficult: any newcomer engenders the modification of the addressing and routing tables. So the technical choice of social equality, which encourages the adoption of the "ad hoc" topology, is accompanied by the corollary which constitutes a barrier to entry. Thus, in an ad hoc network, if two of the stations of the network are out of range of each other, they will not be able to communicate, even if they « see » other stations. Indeed, contrary to the « infrastructure » mode, the *ad hoc* mode does not offer a distribution system capable of transmitting frames from one station to another.

Conversely, the « infrastructure » mode, which depends on a hierarchical base, makes the arrival of a new adherent very simple. He just has to add himself as a client to the access point to which he is connected. Therefore, as they became aware of this induced problem, certain « ad hoc » communities have put in place tools to manage the routing automatically, notably in the case of new adherents in order to avoid any manual planning of the network.

« In order to do that they need to mesh the nodes together: Because of the limitation of people's experience in the technical side of UNIX, it became obvious that they would have to identify methods to dynamically add or subtract nodes of the network. The best option (MeshAP) they see has been developed by John Anderson and delivered by locustworld.com. The author of the solution is following the Consume script to develop a system which will be able to auto-adjust and accommodate a growth. The solution is in two parts: a software that one can download on one's PC for free (or one can buy an customised hardware enabler for about £300), the capabilities for the meshing of the network, the dynamics linking together the nodes. There is a registration system called WINA. Once one runs the software on one's computer, one gets a key that one enters into the WINA web site so that one's computer is identified in the mesh network. The system will thus manage the path between the different nodes. That's currently the most scalable system imagined. »[43] *(Consume, UK observation)*

The increase in the sizes of the network makes the gap in the levels of difficulty in accepting newcomers depending on the topology of the network manifest. Because of this, at present, this problem is no longer an "induced" problem, encountered by chance and which one tries to resolve, but a « structuring »

[43] Again according to one of the initiators of Consume, « *another solution for mesh network is HostAP. Thanks to this solution, one turns one's PCs into both a client device and an access point and also a bridge. It currently requires a technical and configuration knowledge. Therefore the set-up can be difficult for some people.*"

feature of the network, explicitly chosen for the contribution it makes to the social shaping of the community.

The second induced effect of the « topological » choice concerns the more or less great ease of interoperability with the Internet network it allows. Thus, the choice of a topology entails consequences on the positioning of the network with respect to the Internet. The “structured“ topology simplifies access to the Internet: in fact, this topology is based on protocols derived from the practices of the wired Internet; consequently, each machine in this topology disposes rather simply of an IP address which facilitates interconnection with the Internet. On the other hand, the “circular” topology of meshed networks creates problems of interoperability of the WiFi network with the Internet network. The stations composing the network are not designated according to the identifier required for transmission under the TCP/IP protocol. This difficulty can be accepted as it is, or else countered by compensating mechanism. In Brussels, for example the Citizens’ Network had to set up a specific routing protocol, the *Adhoc on Demand Vector Protocol* (AODV), enabling IP packets to be transited within their network topology thanks to a “multi hop” system, by progressive exploration in the neighbourhood of each node. Similarly, the resolution of web addresses thanks to DNS machines is made complicated by the absence of a node dedicated to the resolution of these addressing problems.

Two unforeseen consequences of the initial choice of topology thus appeared with the familiarisation dynamic of the communities with the technology. In manifesting themselves, these two consequences were the occasion for a reflective retreat of the members from the initial topological choices. They then have to choose between two attitudes. Some communities decided to accept the induced consequence by making a forming organ of the style of the community of it: thus the « ad hoc » topology community in Brussels, having become aware of the difficult compatibility of the circular topology with the accession of new members and with Internet connection, made of it a salient feature of their community system, a means of protecting a closed and strongly egalitarian mode. Other communities decided to get round the induced consequence by inventing compensating mechanisms: thus the “ad hoc” topology community, Consume, in London developed WINA and AODV systems to remedy the isolation caused by their initial choice.

Other communities, taking into account the negative consequences of the initial choice, took the more fundamental decision to modify the topology of their community: that was the case of Paris Sans Fil which switched from an “ad hoc” system to a “structured” system.

2.2.3. *The varied dynamics of social enlargement*

The “morphological” evolution is thus very tied to the dynamic of expansion chosen by the WiFi community. In part, this dynamic of expansion follows a natural path: thus any WiFi community which increases its length of life naturally sees the number of its adherents increase and consequently experiences an expansion both in spatial extension - its number of nodes increases - and in density - within each node the number of connected users increases. However, given this « natural » framework of evolution, the community controls the direction of its mode of expansion. On the one hand it can favour a « spatial »

model of expansion by emphasising the backbone of the network and the connection of nodes to extend its metropolitan base; on the other hand it can favour a model of “burying itself in the locality” by emphasising the capillarity of its penetration in the blocks and buildings of the community network. In the first case, the community is coordinated on a more “centralised” mode and makes its priority the improvement of the central infrastructure of the big interconnections. In the second case, the community chooses a more “decentralised” or “closer” mode and makes it its task to help local micro-groups, building (Paris Sans Fil) or block of houses (Brussels) so that they easily realise their connection and in this way are joined by the maximum number of neighbours.

The Madrid example is perhaps the best able to make us understand this opposition between the two dynamics of expansion. Two associations cohabit in the same city of which one, Red Libre, has the objective of improving the general architecture of the network, and the other, Madrid Wireless, on the contrary, has the objective of neighbourhood help to users who wish to install a local cell. Red Libre in Madrid is an association founded in 1999 by Simon J. Mudd and two friends at the University of Madrid and which has set itself the very ambitious objective of proposing a sufficiently simple and effective general architecture. In the longer term, Simon J. Mudd does not conceal his desire to see all the WiFi networks regrouped by interconnected districts to form a real MAN, and all these MANs interconnected among themselves to give national coverage. Madrid Wireless was created at the same time as Red Libre. However the association was not motivated by the same technical vision as RedLibre, but was looking more for pragmatism in the deployment of a network on the scale of Madrid. In the beginning, its vision had more success than Red Libre, as it is shown by its greater number of members and a more active forum. And while RedLibre was directed by three leaders, Madrid Wireless has always made it a point of honour to keep a collegial management: no member is above the others, every decision must be discussed and approved collegially. As John Mudd notes « Madrid Wireless consists in helping anyone who wishes to install a point of access and join the Madrid wireless network”.

The community contribution to WiFi technology presents features which distinguish it from the classical cases of the history of innovation (radio, cibi, Internet). The contribution of amateur circles is moderate, and based on a « flexible » coupling between the community and the experts in the norm. The contribution made by the community is situated especially in the improvement of systems of allocation and regulation able to reduce the problems of saturation and interference linked to the use of an early but limited norm.

These communities have strong social homophilia. The homophilia is explained by the premium given to Linux users in the leadership of WiFi network communities, because they control a key resource in the constitution of the community. It is strengthened by the initial underground positioning of these communities, which has given impetus to a logic of social cooption. The relational structure of these communities is marked by high involvement spread among a large number of members, but also by a volatility of their public. The influx at entry is great, the learning effects are weak, the benefits in terms of reputation for the experts are reduced. Mutual technical help gives pre-eminence to relationships of assistance over relationships of epistemic cooperation. There are few cognitive interdependencies giving rise to the development of complex knowledge.

These general properties may be qualified by underscoring four different development schemes, depending on the positioning of the community in relation to an ideological parameter and a topological parameter. Overall, these parameters show us that WiFi is likely to orient itself towards two opposed dynamics of expansion: according to one logic, which favours homophilia, it is liable to coordinate strongly socially homogenous communities (computer engineers, electronic engineers, artists, doctors, cartographers, scientists), at great distances from each other. According to the other logic, which favours penetration in the local fabric, it is likely to support the emergence of a space of sociability at the local level , even a neighbourhood public life and to renew the fabric of the community. The attitude of the public authorities might play a decisive role in tipping the balance to one side or the other of the evolution.

2.3. *The role of WiFi network communities in the collegiate management of alternative infrastructures*

The reality of a « collegiate » management of the network lies at the heart of the logics of regional development when WiFi constitutes a solution to the wide band access of non covered zones (WiFi/satellite coupling solutions in an integrated connectivity offer). The question of the telecommunications infrastructure takes on a public interest dimension in the same way as public roads and motorways. The communities constitute a part of this, a key variable of economic models which remain to be validated and which seem to depend largely on the hypothesis of services to users taken in charge by associations. Moreover, since the deployment models are not yet stabilised, it appears that they should be explored by experiments in which once again the associations are a major factor of these « test and learn » dynamics.

2.3.1. WiFi / satellite coupling in an integrated connectivity offer

While broad band is mainly present in urban areas, satellite seems to be able to bring solutions in rural zones. Numerous public and semi public research bodies underline that in the coupling of satellite with WiFi the logic of mixed technologies seems to better meet territorial needs, notably because of the « flexibility » of these mixed mechanisms. As most of the players interviewed emphasise, it is reasonable to think that satellite can play a role in certain opening up scenarios at the regional, national or international level. For several months commercial offers proposing to distribute a local neighbourhood network (WiFi or existing wired) have been seen to emerge, connection to the Internet being supplied by a bi-directional DVB-RCS type satellite terminal. So broad band connection solutions by satellite appear as an alternative to currently existing broad band technologies[44]. It should be recalled that the principle of this mechanism consists in establishing a (bi-directional[45]) link by satellite in a site [46]; and to connect it to

[44] On French territory numerous experiments are in progress, borne depending on the case by European programmes, SEMs (Mixed Economy Companies) or semi-public associations.

[45] The first generations of satellite connections (directional Internet links) corresponded to a transitional stage of the technology and of the market and are in the process of disappearing ; as they depended on a RTC or RNIS modem connection they did not

the surrounding houses by WiFi links. Numerous economic analyses of mixed solutions of this type coupling satellite technologies and WiFi to serve zones (most often but not exclusively rural) not covered by broad band are available today[47]. All depend on forward looking economic models; here we will endeavour to only recall a few facts to develop at greater length the structuring elements of the associated management models. As regards the profitability of the projects, the studies seem to converge on the idea that a stagnation point can be rapidly reached (between 18 months and 3 years). For all that, many insist on the "taking in charge" of the users' installation by the associations. These models depend on a certain number of hypotheses which seem only able to be verified by a test of the different projects being deployed.

In the French context, we will retain a study taken up by several public and semi-public bodies: by taking the tariffs of ADSL offers as a reference for an initial investment of the order of 1500 euros a balanced budget is attained as from a dozen users in a range of 0.5 to 2 km for serving outlying villages for example; as far as villages of over 1500 inhabitants are concerned, the probability of collecting the users necessary for balancing the operation financially seems plausible (less than 2% of households). It seems that if the server is well configured and as long as the equipment does not suffer damage, the point of access needs practically no intervention; almost all maintenance tasks concern possible breakdowns of the point of access appliances, the frequency and gravity of which are at present difficult to assess for lack sufficient experience to determine the probabilities. In exchange for some imperfections (safety, sensitivity to breakdowns - the local users depend on a single point of access relying on several sophisticated electronic appliances which constitute a factor of vulnerability), this solution has the advantage of being immediately operational (several studies emphasise that the service can be operational in a short time , six months on average if there is a sufficient « core » of decided users) and affordable for supplying broad band to small groups of users not served by ADSL or by cable. The idea advanced by some is that in this case the support of local municipalities should be rather of a moral and logistics order by refraining from subsidising that which does not need to be subsidised, which would lead to superfluous administrative heavy handedness and a harmful wait and see attitude. For "very" rural zones, the hope of profit is so low that an entrepreneurial model is not conceivable and only the taking charge of the project by an association is viable. From the hypothesis that the service supplied is limited to the point of access and that each client manages to acquire, install and make his adaptor work himself, the management of users consists essentially in conducting an information and mutual help network and mobilising new users. So, it appears that the validity of these models often depends on the hypothesis of a service managed in the form of an association.

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meet the criteria of the permanently open line, independent of the telephone, which is a fundamental feature of broad band access.

[46] This is the « point of access » that is to say the place where the users' individual connections come together to access the Internet via the satellite link. This main point of access brings together the satellite link equipment, the WiFi terminal as well as the authentication and maintenance server.

The satellite transmitter/receiver is by which the output arrives in the middle of the group of houses to be served. It is composed of a parabolic antenna fitted with an LNB head, a DVD modem and an appliance which ensures the interface with the local network (router, hub, firewall, etc.).

[47] On the AFNET sites (http://www.afnet.fr)

2.3.2. Communities and "test and learn" dynamics

Faced with the need to take a position rapidly, and to do so in the conditions of an extremely changeable economic environment, numerous companies recognise today the limits of purely analytic strategic approaches. In the sector of ICTs, « test and learn » type strategies have been much practised in the field of services. This learning dynamic envisaged on the side of the suppliers seems at the heart of WiFi mechanisms: deployment, antennas… Indeed, in the systems of connection by satellite, it can be emphasised that the classical methods of planning infrastructure projects are not the best adapted to the extent that it is only a question of selectively placing appliances which are interchangeable, interoperable and displaceable. So it is not pertinent to define the overall economy of the project ex-ante, an incremental approach consisting of getting a minimum core under way then extending it according to the users' demand and the available products seems to better meet the changing reality of a technology and a market in rapid development.; it is in fact also easier to implement. From this same analysis perspective, it can be emphasised that unlike ADSL where a standard modem can be uniformly distributed to all clients, WiFi connections make it essential to take account of the topology of the premises to determine case by case where the antenna should be placed and what adaptor is most suitable. Finally, it should be recalled that among these devices, the « preserve tin » antennas which are easy to manufacture make satisfactory substitutes for directional antennas which in the shops have too high gains (14 to 24 dBi).

As one of the members of the 'Ile de Ré (France) WiFi association' emphasised « when you observe a territory more closely you realise that it is in the care given to the details of developing the infrastructure according to the precise users/uses encountered step by step that you can become relevant: the deployment of the network is haute couture and not ready to wear! ».

2.3.3. Variety of stakes and areas of governance attached to the question of WiFi

The concept of « governance » enables varied institutional situations to be adapted to, and to be used to describe both the functioning of an enterprise (corporate governance[48]), of a State (governance) or the functioning of an international system (global governance). We will retain the concept here for its descriptive scope which escapes from territorial frontiers and enables the notion of pluralism to be evoked. The idea of governance refers therefore to all the players , who are so many stake holders in a project of society and who, in relation to the general interest, are bearers of a specific stake. Both in the academic and professional literature concerned by WiFi, and in the words of the players interviewed in our study, the theme of governance is frequently mentioned. It seems to us that the problems raised by the concept of « governance » can be considered in terms of three questions which, by successive layers of analysis, circumscribe the specificities of the « hybrid »[49] mechanism which constitutes WiFi.

[48] For the currents of analysis which set the problem of shareholders in that of the different stakeholders of the company.

[49] In the sense of the « socio-technical » mechanism we have described in our introduction.

2.3.3.1. The governance of the reduction of the digital divide by WiFi

The first part covers the widest acceptance of the notion of governance: that of the different stake holders, of the players in a general interest project bearers of a specific stake. We have developed this point at length. We will mention it here through the metaphor of the history of lighthouses (a classic example of a public good) and maritime signalling, taken up by the WiFi community of the Ile de Ré (France) to illustrate the generic problem of governance: the idea that a public good does not necessarily have to be supplied by the government. Indeed, throughout the centuries, lighthouses have been built and managed by private investors, maritime corporations and associations of the private and public sectors, not counting governmental bodies and organisations. In this perspective, the analysis of projects to deploy WiFi in rural zones for example, underlines the reality of governance. The management structures of the projects often correspond to associations composed of mixed syndicates of local municipalities and users' associations. Let us take an extract from the site of the « WiFi Montauban » association (France), situated in a rural zone: « *Our aim is to create a community network. … in the current state of affairs, only a network of this type offers the rural world the chance of accessing the information highways. It is very easy to imagine constituting a network on the scale of a village, of a community of municipalities, then a development by inter connections*». Indeed the connection (and inter connection) project by satellite seems to be well advanced.

Beyond this let us recall that one of the stakes of governance is to lead to envisaging the question of accessibility to ICTs beyond the usual discussions on the digital divide. Thus the problem is not only « access » but the « real use of ICTs ». This question of « uses » and thus of the practices and contents, depends in part on the dynamics of adoption which start by learning about the technology which, for a very large part of the population, is « off market », and for which the associations –community networks- seem to play an essential role. The public manifestations organised by the association of Montauban (France) on « the market place »[50], attracted the curiosity and then the interest of a population of farmers who had not budged for a commercial promotion day organised by a telecommunications operator. So it is the members of the association, of whom many are « r-urban » (they work in town –urban- and live in the country –rural-) perfectly integrated into the rural environment in which they live, but also laboratory technicians, computer practitioners, who promote the technology among the farmers. In the case studied, the lifting of the impediments to change (which are numerous for these populations) seems to be able to occur thanks to non commercial language and practices, based on the relations of confidence established with these promoters of WiFi use.

This example underlines the recurring character of our observations on the necessity, for a novice user, to be able to call on the intermediation available nearby between the technology and the use he can make of it, in order to help and guide him in his choices. The members of the communities (even the community itself when, a little less novice, one can contact the collective site directly in order to obtain replies to one's questions) fulfil this intermediary function. We have observed that these communities, which depend essentially on ties of assistance, nevertheless do not function as epistemic communities aiming to produce new knowledge, the most often technological. If the motivations which

[50] and the theme of which was the construction of WiFi relay antennas.

drive the promoters of communities was limited to their wish to « play » at setting up an effective network, an alternative to the offers of traditional operators, or of defying the official networks and the top down decisions by their control of new types of direct interaction relays (CB post), or yet their taste for technical complexity depending on heterogeneous skills (in radio, mapping, network management, groupware, etc), it could be supposed that the objectives of spreading WiFi among nearby novices would be quickly counterbalanced by the "cost" of the permanent repeated requests for advice and technical assistance. If these communities are going to last long, it seems to us that it is because they may have the intention of participating in a social dynamic, as the example of advice to local neophyte users in Montauban suggests. The burden represented by the request for assistance is surely as difficult to bear and may tire even the most motivated. Nevertheless, it fits into the personal adhesion to promote actions in favour not only of spreading WiFi, but above all so that broad band access can be offered (and its assisted use) to those who were not benefiting from it. The whole stability of this interaction therefore depends on the way the "technical" contributors can be rewarded: by help based on other skills contributed by the users (in forms close to the localised exchange systems), by the relay brought by local public officials, even by the simple satisfaction of seeing the emergence of a dynamic of horizontal interaction between local citizens around WiFi proposals.

For "marginalised" populations the social fracture may be « reduced » by the effective use of the technical mechanisms supported by appropriate services and contents and made routine by the play of the social registration of uses (it can be noted that in France for example, in many projects developed in the rural environment, the social housing (HLM) offices are stakeholders and represented by neighbourhood agencies) [51]. Experiments, not linked to WiFi, but supported by different cities in Europe to promote the use of the Internet in order to organise encounters between offers and demands for small services, testify also to the encounter between this type of population and a public offer of learning by use.[52]

This problem of use also prevails for the broad band access of the initiated populations: it is known that the practices of an experienced netsurfer are considerably modified by access to broad band, notably by the development of collective uses of which a large part is delimited by the social network developed IRL (In Real Life)[53]. All the same, while the involvement in the social network is an explanatory factor of adoption, the use of the Internet can play the game of strengthening proximity relations while offering them the possibilities of improved access, of « delocalisation » of social relations (according to A. Gidden's terminology) and opening to other social groups.

[51] The association of Montauban (France) has organised several manifestation days in a concert hall which traditionally welcomes young people from different social backgrounds.

[52] Programme supported by the European Community, IST 5th PCRD, « SOSS: Smart Organisation for Small Services », www.sossnet.com

[53] C. Charbit and V.Fernandez (2003) « Sous le régime des communautés: interactions cognitives et collectifs en ligne » paper prepared for the Revue d'Economie Politique, special number coordinated by Michel Gensollen (to appear in 2004)

2.3.3.2. The governance of the reduction of the territorial fracture via WiFi mechanisms

In most European countries, it seems that the ICT sector players have essentially played the game of competition and installed broad band access infrastructures on the most attractive parts of the territory. Despite the multiplicity of access technologies on the local loops (xDSL, cable network, radio loop, satellite and on-line PLC - power line carriers), the result is a segmentation of the territory by addressable markets which leaves numerous territories not covered.

In the United Kingdom for example, and despite the extensive network offered by BT, 10 to 20% of the population will not be touched by its offer in 2005. The main competitive offers have not attempted to fill these geographic gaps, but rather to attack the historic British operator on its most profitable markets. But, WiFi, having a lower installation cost and not necessarily requiring wide coverage or agreements extended to other operators, has allowed the appearance of start-ups aiming to be profitable where the previous providers of broad band access technologies could not expect to be so. The risks are great, but this approach today seems to be relayed by the Regional Development Agencies who see in these players partners contributing, sometimes without this being their main motivation, to local development[54]. In France, this observation of the gaps in the broad band network seems to be even more radical. Thus a recent study of the Regional Telecommunications Observatory on the information society[55] attests the differences and contrasts which exist on French territory. It appears in fact from the study that 15 million French people, and 80% of the territory run the risk of finding themselves without an offer. In fact only 9,000 of the 36,000 municipalities are covered today. Moreover, the study shows that only 1.6% of national territory have at least two Internet access technologies available. Yet, at a time when the development of Internet uses makes it an essential neighbourhood tool for the creation of new forms of democracy and new methods of production, the territorial communities (region, department, municipality, community of municipalities) are seeking to catch hold of it both for the growth of local economies and for the socio-political development of the territories concerned (social, cultural, ecological, civic and political parts). Correlatively, the territorial communities are seeking mechanisms to preserve the integrity of their territory and to valorise their local resources. For these communities, the stake of governance is to encourage the deployment of broad band infrastructures but also to keep local control of the production and distribution of information.

In this perspective, some of the communities observed are seeking, in the manner of the Stockholm model, to fuse intranet and internet uses into WiFi projects. Among the cases studied in this report may be mentioned Brussels, partially Cardiff or Paris Sans Fil, and that of the community of Montauban (France). In this latter case, the community wishes to constitute a portal as well as a sort of intranet on the scale of the micro-region so as to encourage an interaction of the players in local life: user/services relations, the administered/public authorities, intra and inter associations, development of local projects,… but also to open the micro-region to the Internet.

[54] Richard Wilson, 2003 « Cheap broadband for all: can it ever happen ?" Analysis, http://www.analysis.com/Articles

[55] http://www.ortel.fr

Moreover, local governance seems to be seen by certain players interviewed as the occasion to develop a common knowledge constructed in the collective action[56] and also to participate in nourishing the collective representations which strengthen social cohesion.

This orientation of « territorial governance » some times clashes with the fears of the operators in place. Thus the AFIM (Association Française de l'Internet Mobile) which groups operators, service providers and constructors, drew up a note in March 2003 consisting of set of proposals aiming to develop WiFi in France and Europe.[57]. This text above all consecrates the new competitive role which local communities might play in the world of access providers and network operators. For them, the rules of conduct should thereby guarantee the opening of local markets (against the risk of predatory offers, of unfair competition on the part of players acting on the basis of public financing, of the closing of markets in favour of players pre-approved by the local authorities,…). What can be concluded is that in fact, through WiFi technology, the geographic sites, the physical proximity, are penetrating the world, up to now reputed to be global, of the Internet.

But these local communities can either, as seems to be the case in the United Kingdom, support the commercial proposals of start-ups offering WiFi networks on the zone, or weave links with the WiFi network communities in order to help them construct their « new role » as local broad band network access providers. Faced with the wish of certain powerful operators to brand name and reappropriate, it seems that it is through links with local decision makers that the cooperative practices of WiFi which we have analysed can make what is at the heart of their motivation last: the search for a more collegiate and autonomous management of broad band access networks.

2.3.3.3. Governance of « information flows » and local dynamic linked to WiFi

In the prolongation of the problem of local governance, of local control of the production and distribution of information is found that of the setting up of technical mechanisms allowing the physical localisation of contents.

Local communities contest the topological reality of the Internet on the international level which today depends on a small number of hubs[58]. The « verticality » of flows, from the local to the (inter)national GIXs where a « peering » is operated and more precisely, the obligatory passage by the long distance networks of the local multimedia flows (video stream, voice, videoconferences,…) is today put into question. For some the stake of alternative infrastructures is notably to bring the multimedia contents of the users closer. The argument put forward is that most incumbant European operators, builders of infrastructures, position themselves on the services/contents market and own an IAP which is systematically the biggest in the country. The development of broad band uses (Web TV, consultation of servers video, …) ever more infrastructure

[56] One might see there an application of the notion of « community of practice » developed by Wenger, E. (1998) *Communities of practice : Learning, Meaning and Identity*, New York, Cambridge University Press.

[57] www.association-afim.com

[58] which moreover goes against the initial objective of a strongly redundant network.

consuming should accentuate even more the IAP/operator convergence. Thus a certain number of players are throwing into question the architecture of AIP/operator networks in that they introduce important biases: “What is the place of the identifying contents of a territory?” “How to carry local interest contents/ services on distant architectures?”. The idea is then to take back the industrial logics of delivering content « as near as possible to the user » (Content Delivery Network), to “repatriate” the contents too heavy for the backbones. New international communications architectures which are function of the localisation of the contents to which they will give access are therefore sought for. These new architectures can aim to stock multimedia contents as close as possible to the user, on the periphery of international backbones, as soliciting the local access networks to relieve the international communications (GIX) arteries and nodes from the transit of local broad band streams.

Given impulse and carried by the community, the idea depends however on an economic logic, the conditions of implementation of which should be defined: institutional, economic and technical.

3. The markets and strategies associated with the WiFi infrastructure

The emergence and beginning of the spread of a technological innovation are often marked by a succession of stages which articulate an initial period of appropriation and development led by informed amateurs, motivated more by technological passion than market prospects. A phase of "professionalisation" succeeds these initial uses, both from the initially cooperative players and from the products and services offered, which sees the variety of technical options decline and opens discussion on the standardisation of the technology in question. This "market re-appropriation" of the technology may finally lead to its radicalisation via the evolution from the status of innovation to that of a commodity in a third stage.[59] To this very "pre-determined" reading of the dynamic of technology dissemination flagrant counter examples have often been opposed such as the keeping of a cooperative dynamic in the open source world, which is a persistent rival to Microsoft's domination in the software market.

What about WiFi: are its community uses destined to disappear for the benefit of a more efficient market logic? Who are the players today in the offer of this technology? For what market targets?

As we have seen, it would seem that the phase of professionalisation is well under way whereas the technological competition (between WiFi and UMTS) has not yet resulted in the domination of one standard over the other. The first observations seem to plead rather for keeping both technologies, targeting specific uses, but both figuring in the set of commercial proposals of the big operators. This "issue" arises from an apparent "re-appropriation" since the history of WiFi technology (as we saw in the first part) originates in the computer industry. In fact the major players of this sector have in no way abandoned the game and seem to be relying on WiFi to penetrate the world of telecoms network infrastructures. This is any way the case in the United States, whereas in Europe it would seem that the big mobile phone operators prefer to "keep hold" of this field which they nevertheless approached late in the day, in particular due to the reticence they could legitimately manifest in the face of the rise of a technology which openly positioned itself as an alternative to UMTS, which had already cost them so much[60].

This section does not aim to provide a complete catalogue of the WiFi market and all the positions of the players. It rather aims to extract in a literature almost totally derived from the professional press and in the interviews conducted with certain providers (operators), the few key elements which will enable us to provide a guide to the main trends which seem to be appearing.

[59] Source: interview with François Bar, June 2003

[60] It seems that in Europe, the commercial spread of WiFi was initiated in Scandinavia (as from 1999) to give rise to a variety of experiments in other regions. These experiments are however very much behind the spread of WiFi in Korea, the leading country in the field. (Business Week , April 28, 2003)

For this, we will first present the WiFi market. We will stress the case of some actors instead of detailing the variety of players composing this market. We will next touch on the strategies retained in function of the factors encouraging or restraining the spread of WiFi and according to various business models, highlighting particularly the question of strategic policies for infrastructure deployment. We will conclude by discussing the respective places of cooperative modes and commercial modes of WiFi offers.

3.1. Inventory of the market

Confronted with the reality of a market which is still stuttering and immature, with income prospects that are still very uncertain, we have been seeing an avalanche of announcements from national fixed and mobile operators since the second half of 2002. The incumbent operators who up to then had remained on the side lines, seem to want to make up for lost time. To convince oneself of this, it is only necessary to observe the number of communiqués announcing the creation of strategic partnerships[61], or announcing the forthcoming deployment of a major WiFi network[62].

Up to now in fact, the entrants to the market were rather pure players of modest size who gave little information on their WiFi networks deployment strategy. Among these pure players, certain have succeeded in gaining a good reputation thanks to the pertinence of their development model: as an example we can cite the North American operator, RoomLynX specialised in the integration of WiFi networks in the hotel environment which today covers more than 300 different sites. In contrast, other operators such as TMobile (ex Voice Stream) have shown that this market does not generate sufficient income to deploy a new infrastructure from scratch, and that it was necessary to moderate the investments in line with demand. Indeed, market reality contrasts with these announcements: the only nationally deployed network is that of the Starbuck's cafés by TMobile which up to now has ended in a financial failure. Thus the expenditures linked to the installation of hot spots in all the cafés of the chain in the United States, as well as those linked to Internet connections are not covered by the 1.06 users who pay a connection of 46 minutes a day on average to access the wireless network[63]. The only experiments which seem to have a positive return are those resulting from local projects such as setting up a network on the scale of an hotel or an airport.

Thus, whether they depend on specialised services niches, on specific partnerships with certain types of hot spots or have greater pretensions, the dynamic of the WiFi commercial offer is, as its more cooperative establishment, marked by an "test and learn" approach. WiFi technology, rather than being massively deployed according to network coverage logics (even public service logics if access to broad band should become possible for every one on a territory) is spreading incrementally. It starts from places likely to house

[61] We can give as an example the economic interest grouping set up by the three big mobile phone operators established on the French market « Orange, SFR et Bouygues Telecom font cause commune », www.journaldunet.com (5 June 2003)

[62] As attested by BT's recent announcements « British Telecom voit grand » www.journaldunet.com (4 February 2003)

[63] « Public Wireless LAN: The Business Opportunity » R. Dineen & S. Anderton, *OVUM* 2002

consumers who can be anticipated to have a positive propensity to pay (hotspots such as airports, big hotels, congress halls etc[64]) and companies looking to extend their Net access in a non-wired mode. It emerges in contrast as a technology liable to constitute an alternative to commercial offers or to their complete absence, in the context of community and local type deployment, once again in constricted zones.

Table 1: Who are the players in the WiFi market?

Equipment, network and content providers	Holders of physical sites	Clients
• Equipment manufacturers • Integrators (specialised or not in a sector) • IAP • Service operators • Content providers (generic or specific) • Roaming brokers	• Cafés • Stations • Airports • Hotels • Public areas (urban or rural)	• Mobile general public • Residential general public • SME • Mobile professionals • Major accounts

Concerning the content access, network and equipment providers, we can underline the following elements.

The great majority of networks deployed at present are of small size. For example a café or restaurant equipped will generally have less than five access points. In any case, the differentiating factors are the services associated to the wireless networks. Authentication and invoicing mechanisms or more simply the services linked to a place of deployment (for example the planes schedule in an airport) are the sensitive points of WiFi networks.

If it is wished to summarise the opportunities which these different types of provider find in extending into the WiFi market, it can be noted that:

- The telephone operators have three advantages: their client base, their brand and their control of invoicing (enabling their clients to settle a wide range of services including WiFi access on the same bill). In the WiFi market they can seize the opportunity of making their status evolve into that of WISP and so differentiate themselves by offering their clientele (for mobile operators) a bundle of services including WiFi or extending the voice services of public phones to Internet offers (for fixed operators).
- The equipment suppliers and content providers benefit from their experience and are in a position to extend their offer to bespoke platforms, terminal software, integration and security systems, etc.
- There is a last and important segment in this group of operators. These are the players who offer all integrators, whether specialised or not, the possibility of participating in their roaming agreements. At present they are in some way the corner stone of the development of the WiFi market because they offer the final users the possibility of accessing, not a particular network, but a panel of networks, which significantly increases the attractiveness. Their unifying role

[64] according to certain semi-public sector respondents in Nice, the Côte d'Azur, for instance, appears to be the first European hotspot in terms of WiFi access equipment situated at Nice Airport, in the major Cannes hotels etc.

with distant networks is nevertheless threatened by the agreements made between established mobile operators (such as the partnerships mentioned above).

Roaming agreements, a prolific market which supports the paying offer of access in hotspots

Currently, the roaming market is growing rapidly: it consists of offering a WiFi operator the integration of all the WiFi networks he operates to a panel of third party networks. This panel has dual interest: from the point of view of the end user who subscribes to a panel integrating N other networks, there will only be one contact for invoicing and a single interface connection (and so only one password to remember). From the point of view of the operator who decides to participate in the panel he can hope in return to recover the clientele of all the N networks passing through his zone of coverage. Moreover he externalises the system of authorisation and above all of invoicing (which he is still not able to ensure). Today there are several recognised brokers such as Boingo, iPass in the United States and Pass-One in Finland.

- The owners for their part, find a new means of developing their sites, a prospect of creating loyalty among user clients, an opportunity of increased consumption, and a differentiation linked to the offer of specific services to WiFi users on the sites and extracting a rent for the WiFi connections established by their clients

The end market is that of all direct WiFi users. Two reasons motivating the adoption of WiFi technology can be distinguished. The first objective is to install a wireless network at home or in the company's premises in a way extending the wired access. In this specific case the use of WiFi remains confined in a restricted space. There is another case in point for which the private individual or the professional will equip himself with WiFi to access networks beyond his walls (in a hotel, a restaurant, etc). This time it is more a case of "nomadic" use.

It appears from all the studies conducted on WiFi that its price of access is still too high: more than $50 a month, even if that is lower than other wireless broad band accesses, and singularly restricts its mass distribution[65]. This element moreover pleads for maintaining the attraction of connecting to a community type network. This cohabitation of both types of offer is nevertheless threatened since major price cuts (or the integration of this service in a bundle) are announced for the future.

3.2. Strategies of the players

Mobile operators are today seeing a market, especially in Europe, which is reaching its phase of maturity. They are therefore looking for strategies of differentiation and loyalty creation in a context in which the ARPU is declining. The uncertainties about the commercial consequences of the financial commitments in UMTS weigh on their behaviour. It is thus difficult today to recognise in their WiFi strategies a desire to intervene to restrict the process of dissemination (while awaiting 3G) or a real objective of catching an opportunity which is shown to be more accessible today than UMTS. Are the very voluntarist announcements of BT (setting up an extensive network of hotspots) there to discourage the competition or to really start a process of extended dissemination to which numerous experts give no credit in the short or medium term? The

[65] In Korea, where penetration is very advanced , the price of access is much lower, of the order of $20 a month (Business Week, April 28, 2003).

prudent strategies of Orange and Wanadoo in France (targeting prestigious partnerships with Air France or Accor[66], beginning to distribute WiFi access packs intended for the general public[67]) are also a way of "being there without being there" and of testing the cannibal character of WiFi offers compared to Ethernet connections, or even the possibility of selling more than one ADSL connection to the same client (private individual or SME).

Their strategy in any case consists, as always in the first stages of diffusion of a technological innovation, in targeting the « potential early adopters » and testing on them the methods of payment and the offer of services which will be the basis of more general approaches to the general public in the future These leader users are as always the professional clientele: on the one hand in the search for company WiFi equipment and in the more individualised equipment of their businessmen. The expectations are for an apprenticeship in WiFi in the internal uses of the company, then to delocalise into public places which are the hotspots and finally to impact the SMEs and the general public which most consultants' studies only consider plausible as from 2004-2006[68].

3.2.1. Factors encouraging or retarding the spread of WiFi

The elements which are liable to encourage the spread of WiFi concern both the « technical » aspects and the « uses » aspects. From a technical point of view, it is above all in the low cost needed to equip and operate a hotspot that the potential for deploying this technology seems to reside (even if on a more large scale, a WiFi network is currently a high expenditure regarding the uncertainty of the pay-offs).

These considerations are accompanied by "usual" expectations of the growth of the two key elements of future uses of the ICTs: mobility and broad band.

The brakes to the spread also involve considerations of a dual nature, both technical and in terms of uses. As often, the most uncertain are not the technical aspects. Thus the questions of security, of risks of interference, of incompatibility between the different WiFi standards presently being discussed, of stakes in the matter of roaming and invoicing do not seem insurmountable (see Part 1). The only basic technological snag is that of the autonomy of the batteries for WiFi (or of Blue tooth for that matter), which are very energy consuming, and which reduce by close to 30% the declared autonomy of laptops. This difficulty leads WiFi access to be considered as non-mobile accesses because logically plugs on the electricity network should be associated with places equipped with WiFi access. The *non wired* would in reality become an *other wired*. This observation thus led one of the operators interviewed to define its strategy as that of an alternative operator depending on all the infrastructures liable to provide broad

[66] www.orange-programmepartenaires.com/partenaires/docs/WiFi/CP_WiFi_ACCOR.doc

[67] Since May 2003 Wanadoo has offered « broad band access – ADSL router - WiFi USB access point » bundle which enables one to install one's domestic WiFi connection easily; http://www.francetelecom.com/fr/espaces/journalistes/communiques/CP_old/cp030515.html

[68] According to the consulting companies, Analysis being more optimistic than IDC in this matter.

band access not yet appropriated by the established telephony players. So the model envisaged is that of an offer comprising in the longer run access in » carrier current » (electricity network) and in WiFi, depending on the places and the uses. In this case the WiFi locations can be interpreted as a “first stage” which benefits from access to the electricity network in order to guarantee the electricity supply to the terminal. These accesses are liable, in the longer term, to become broad band connection points directly. This orientation, which is technologically interesting, singularly limits the « revolutionary » character of wireless but contributes greatly to facilitating its use.

Finally, we have already mentioned an important brake: the endeavour to protect the (expected) income from 3G.

So, the problem for WiFi strategy is related essentially to the uncertainties about demand (as for a large number of telecoms innovations). What is the « Killer Application » of broad band “mobile”? What are the services and acceptable price levels to induce consumer purchasing? What could lead to a more massive spread of portable computers among the general public (initial condition which may be found for the existence of WiFi terminals) ?

3.2.2. A structuring of business models

We have seen in the description of the end market that it is possible to distinguish two major problems for the different WiFi uses: public access (for mobile users in public places) and private access (which consists in a non wired extension of the LAN for more flexible use within a house or its immediate perimeter, and especially to facilitate the organisation of meetings and video conferences without pre-existing heavy infrastructures in the company world).

If we concentrate on the « public access » aspect, two extremes to the range of WiFi business models, including a set of intermediary cases, come out of all the preceding considerations. We are now going to clarify what opposes the two models and the value chains which can be associated with each of them.

At one extreme, we can show an « owner of the premises » oriented model. In this, the relation to the WiFi client is directly ensured by the manager of the site, who can offer secure access (often thanks to certain partnerships). These may or may not be free of charge, and if not, be remunerated following a pre-payment mode or a supplement to the hotel or restaurant bill. The management of the network is most often out-sourced but could also be ensured by the site’s IT department (even by its telecoms subsidiary if it exists, which is the case of certain airports). The coverage, or rather the availability of the service may be ensured on a single site or all those of the chain involved but not beyond (except if the status of this department or this subsidiary is sufficiently stable to enable it to offer its services to other sites than those of the parent company).

If the WiFi offer is broken down into the hotspot part (managed by the owner who keeps direct contact with his client in this supplementary offer of broad band access) and a back office part, we can then enumerate a variety of cases according to whether the back office is ensured by a WISP, a virtual WISP (case of Boingo), or a wholesaler.

At the other extreme is a « (fixed or mobile) telecoms operator » model. The client in this case does not have any particular relations to maintain with the owner of the geographic site. His WiFi access is invoiced to him directly in the framework of his subscription to his operator. The invoicing therefore depends entirely on the contract passed with the operator (in the form of a particular subscription, of an extension to the standard subscription or payments per act inserted in the overall bill). The communication of data by broad band is controlled from beginning to end by the operator, who once again, with this new service, makes optimum use of his general infrastructure and the variety of roaming agreements he has been able to make with third party operators. In fact the coverage proposed is directly extended, national and international.

Depending on whether one is in one case or the other, the intermediation between the provider of the site and the Internet access provider is not of the same nature. To summarise, we can say that the more the site owner wishes to keep a certain control (not total control but not his total exclusion either) of the WiFi service offer to his clients, the more the « pure WiFi players » will find a place on this market. And this is sometimes a consequence of a system failure. Indeed, looking at it from the user's point of view, the first problem with which he is confronted is that of authentication to connect to the network. If he has three subscriptions to three different networks not having a roaming agreement, he will have to memorise three different logins corresponding to the three authentication systems. Conversely, if the three networks pass by the same broker to participate in a roaming agreement, there is no problem. The user will then only have one portal to connect himself to the three networks. The most mediatised broker at present is Boingo. If on the other hand appropriation by telecoms operators is widespread, this type of player is threatened.

3.2.3. A key question: «top-down » or « bottom-up » infrastructure?

There are two opposing WiFi network operating strategies: on the one hand the general development of a new infrastructure is certainly a reflex in the telecommunications sector. In the manner of GSM networks, certain operators are attempting to deploy a network having the best possible coverage to make it more attractive. The failure of the Starbucks chain experiment led the great majority of operators (and consultants) to prefer today a "bottom up" deployment strategy. With this strategy, the operators ceaselessly dimension and re-dimension the capacity of their network according to demand.

But, although investors prefer the less risky vision of the « bottom up » model, we have been seeing in recent months a reversal of trends with the announcement of the arrival of mobile operators (notably in France and the United Kingdom) on the market. In a no doubt even more ambitious way, the Cometa network was announced in the United States at the end of 2002. This is a consortium founded by AT&T, IBM and Intel which envisages deploying a WiFi network over the whole United States accessible to everyone[69].

From the user's point of view, the questions of security and ease of use remain open. However, WiFi presents, as we have seen in part 1, the advantage of being

[69] « Cometa's WiFi Business Will Struggle Early to make a profit », Gartner First Take, 12 December 2002

compatible with existing terminals (portable computers and PDAs). It thus constitutes a real threat for UMTs candidates. The result of this technological competition has every chance of resolving itself by a sharing of demand between “on the move” uses and “at the pause” uses. The two types of services will no doubt be provided in the operators’ basket of offers.

But beyond the strict WiFi market, these providers can see in the deployment of this network a learning approach for broad band wireless users, enabling by this same path more profitable services to be identified. The existence of these opportunities would singularly threaten the community offer of WiFi access. However, today it is in the sites where WiFi uses are the most developed that commercial offers (the profitability of which is effectively far from being proved) coexist with community offers. (Los Angeles, San Francisco, etc.). It seems to us that these trends will in fact leave the most strategic sites for setting up WiFi access (airports, big hotels and internal company sites) in the hands of the market. The question may be asked for public or semi-public type organisers (university campuses, hospitals, government departments, etc) but the stakes in terms of security of the network and the amount of exchanges to handle rather prompts the recourse to recognised players on the market. On the other hand, in urban zones where community access is strongly developed, it may limit the possibilities of non free expansion. However, as we have noted, the degree of commitment of the technical experts involved in the communities may experience a saturation phase either linked to the congestion effects caused by the influx of requests for assistance from neophytes, or linked to the deception about the absence of forms of reciprocity in the exchange between technical contributions (from WiFi experts) and contributions of other natures (from members of local communities). This lassitude and the effective character of the market offer might incite a certain number of community players to migrate towards commercial offers, all the more so that they will then be provided with expert knowledge putting them in a position to select the most pertinent.

Do these trends mark the inexorable reduction of the space of cooperative action linked to WiFi? No-one today can give a definite reply to this question. However if there is a field which today sees the dynamic of cooperative uses of this infrastructure not only persist but even develop, it is that of local development[70]. The partners of the “alternative experts” of the first phase are often today local institutional players and this particularly (but not only) in zones not served by broad band access. This new axis of opposition to very “top down” decisions (national authorities, authority of operators providing infrastructure) is seeing the question of a “neighbourhood” information society reappear capable all the same of contributing to opening up certain zones (see previous section).

[70] P. Montubert (August 21, 2003), « WiFi in France : No mass commercial rollout of hotspots yet, more hope for municipal wireless deployments » in *Muniwireless.com*

Conclusion: WiFi and Public Authorities

The analysis conducted in the present *Issue Report* leads to the following recommendations to public authorities :

i. Operational problems of interference between networks may be limited to densely populated areas. In sparsely populated areas, local co-ordination may be sufficient. Applying an *a priori* general frequency allocation system for players at national level would amount to organising a disguised shortage of the spectrum, on the pretext of wanting to reduce risks of interference[71]. Moreover, this would favour the incumbant players, who are capable of bearing the financial or administrative weight of a selection process. With the emergence of WiFi, data telecommunications networks are breaking up, players are multiplying and their size is decreasing. This development is analogous to what happened with protection of privacy in the 1990s: we moved from a threat mainly borne by the public sector and its very large databases (fiscal, social and police) to a diffused threat carried by many data holding companies. The regulatory framework is adapting gradually, by substituting an efficient system for settling disputes to the benefit of the consumer instead a priori regulation of operators by a general law. An analogous development of the regulatory framework could be tried out in frequency bands affected by WiFi:

   - where only one network is present (rural areas, private grounds), there is no need for specific regulation such as frequency band pre-attribution as it would hamper the spontaneous dynamics of WiFi emergence;
   - where two or more networks co-exist (urban centres), an ex post system for settling conflicts will be put into place.

ii. As we have often noted in this report, the test, learn and experimentation approach seems to be necessary, including on the side of the regulators. Today, some zones are trying to set up an adaptive mode of regulation depending on the use of the WiFi. In the Bay Area, north of San Francisco, frequency sharing has been established around three types of use. The first covers emergency calls (police, hospitals, etc.) which have absolute priority. Paid use is then served. The remainder of the time the band can be used for co-operative uses.

iii. Due to their structure and way of operating, WiFi network communities are fragile and extremely sensitive to “administrative burdens”. Just like the establishment of operator licences, the increase in obligations linked to the supply of connectivity services and data transport would be fatal to them. Thus, requiring WiFi network communities to keep connection data, or making them liable for the illegal practices of some of their users or members would cause them to stop operating. It does not fall within the remit of this report to judge the conclusion to be drawn from this statement of fact, and external considerations can lead to sacrificing this alternative infrastructure

[71] F. Bar, S. Cohen P. Cowhey, J. B. Delong; M. Kleeman & J. Zysman (2001) “The Next Generation Internet: Promoting Innovation and User-Experimenation” in BRIE-IGCC E-conomy Project *Tracking a Transformation,* Brookings Institution Press Washington, D.C.

for the benefit of other goals (e.g. such as the battle against terrorism). Nonetheless, we need to be aware of the heavily negative effects of imposing such obligations on these social forms.

iv. National or local regulation in terms of providing connectivity services must be neutral with regard to the technologies and players. This normally leads to global and local operators and WiFi network communities being treated rigorously equally, in terms of partnerships with community bodies, the allocation of public contracts or access to public resources (high points, spectrum). Nonetheless, temptations to engage in "near-standard" approaches will increase for operators in the data communication domain (for network planning, billing, roaming, voice, security, etc.). The existence of independent WiFi networks which fully comply with the 802.1x and Internet standards plays a similar role to that played by open source software in networked IT. The latter makes a “call for interoperability” to proprietary software producers, by making consumer “lock-in” strategies more difficult. Their existence therefore has a direct interest in terms of controlling the dominant players’ market power. In this respect, national and local competition policy should be favourable to them.

v. The digital divide is partly due to the fact that a sizeable portion of European people has not reached an adequate level of knowledge of the possibilities offered to them by networked IT, and do not have the minimum level of competence to take practical advantage of these theoretical possibilities. The learning needed for the dissemination of the information society cannot transit solely via the marketplace, because the training to be provided is both extremely personalised and requires specific confidence. Social networks (local solidarities) seem to be one of the better ways of spreading this type of skill rapidly. Public powers should therefore favour WiFi community networks which put the emphasis on local information and assistance over those which are dedicated to “prowess” among lobbyists.

vi. Further research is needed to assess the outcome of the growing involvement of local public bodies in WiFi community networks. National authorities should regularly conduct evaluation of local experiments in order to assess the reality of local uses, competence building and participation of local agents in broader economic and social activities. A balance is to be found between these positive effects and the risk of creating geographical monopolies which would hamper business competitors to supply cheaper or better services.

Appendix: Methodology

All of these questions which we wished to deal with cannot be supported by avowed results, given the emerging nature of the phenomena observed. The data which we worked on was thus largely obtained via qualitative approaches, with some nuances.

1) As regards analysing WiFi communities:

- observation of a broad panel of WiFi communities and an analysis of the content available on the web
- selection of seven accessible WiFi communities to carry out surveys and which were interesting because of their established age, the variety of their goals and their varied geographical origin. In this regard, we wish to point out that our approach by no means pretends to supply a representative analysis of national trends which could differ depending on the Member States. It rather proposes a reading of the diversity of forms of community present in Europe, without this diversity being able to be articulated according to national borders on the basis of our results. Finally, it is spontaneously limited by the open or closed nature of these communities. For instance, it seemed that very lively communities could have been analysed in Greece, (less in Italy or in Germany) but our repeated approaches to their leaders did not meet with success.
- Direct face-to-face or telephone surveys with certain leading members of these communities (from 1 to 4 depending on the communities) in order to feed the discussion guide enclosed with this methodological annex.
- Performance of statistical processing on a target community, that was particularly interesting from the length of its lifetime, its pace of expansion and our access to the data affecting it: Paris Sans Fil.
- All of these steps linked directly to the life of communities was supplemented by a series of discussions and exchanges of information with experts on the subject (François Bar from USC in the United States, Christian Sandvig from the Oxford Internet Institute in the United Kingdom, Gwenael Amieux from FING in France, etc.).

2) As regards the commercial aspects of WiFi:

- Essentially desk research, notably thanks to the synthesis and the placing in perspective of the abundance of professional journalism devoted to the subject.
- Discussions with the strategic managers of various WiFi operators: pure players, an operator which is a subsidiary of a major European airport, the historical operator

3) As regards the "technology and regulation" aspects:

- Desk research and selection of relevant information in the statements collected during the surveys among the communities
- Interviews with WiFi experts, telecoms networks researchers and practitioners

Wifi communities Guide of interview

1) Understanding community dynamics and evolution

- Why was your community set up: gather WiFi users? Promote wireless networks technologies? Share technical expertise? Ease network planning and coordination? Create a whole new network, a credible alternative to operators? networks?
- Who are the members of your community? How many are they? What is their profile? Are they mainly expert computer users?
- Why would someone enter your community? What would be their motive?
- How was the community born and how does it grow?
  - Are there formal or informal recruiting procedures? What are they?
  - What is the fee (in money or time) incurred to become member of the community?
  - How was the initial group constituted? Did the first members know each other before the community was started? If so, what was their relationship?
  - What were the a priori motives of the creators of the community?
  - Are the initiators of the community still its current leaders? If not, how did the change occur?
  - What are the present motives of the community leaders? Are they the same motives than that of the initiators?
  - How do community members use the community technical network (if it exists)? Is their a difference based on their seniority in the community, on their proximity with community initiators/leaders, on their age?
- How important is geographic localisation of members to the community? Is there a boundary to the community geographic footprint? Are there members out of this footprint and what is their status?
- What are the relationships between your community and its neighbouring communities? Would your community be better viewed as federal or confederate? What relationships does your community have with federative networks such as national/regional portals of WiFi communities?
- Does your community exclusively rely on its Web site, or does it also organize real-life events? Are there real-life meetings, debates, discussions on projects? How do members communicate among themselves? Do they use portable and fixed phone, group and sub-group meetings?
- What are the long-term projects of the community: is it supposed to be permanent or transitory? Are the projects explicitly stated and what are they? How do members of the community partake in their definition?
- One of our work hypothesis is that WiFi community can follow two alternate life-paths:
  - The techno-push path: the community started in a technophile group who wanted to share technical expertise and make use of technical objects; it then opened progressively towards a broader public (still limited by the necessity to possess adequate equipment and knowledge); on this rather techno-centric network, social uses of the technology then started to appear among members and are progressively becoming dominant;
  - The Social-pull path: the WiFi community stemmed from pre-existing groups and social practices, as a tool to facilitate sharing among members of those groups; then the technical side of the community grew (for instance because a network was set up, and not only access points to the Internet); then technology-savvy users joined the community and enhanced the network.

  Would you agree with this two-path hypothesis? If so, on which path would you say your community is? If not, what types of WiFi community dynamics would be more suitable?

- What tools are used to manage the community? is there a website accessible only/mainly through the community WiFi network (MAN)? Is there a map of members and access points localisation? Do you use mailing lists, forums, wikis? What are the

most used tools and what are they used for? What was the evolution in the use of these tools?

- WiFi communities around the world seem to use pretty much the same online toolkit (wiki and forums). Would you agree with that statement? Why is it so, in your opinion? How did you choose the tools you would use in your community?
- Does your community have any links with economic actors? Do you offer members purchasing counsel? Grouped purchasing? Does an economic actor (shop, vendor, operator, local government body?) sponsor your community (through advertising, hosting, partnership on projects?)?

2) Understanding WiFi uses

- What do members of your community do using their WiFi equipment? Please distinguish (if possible):
  - individual (such as Internet access) from collective (online gaming) uses;
  - uses that remain within community boundaries from uses with other people;
  - local-life uses (such as local citizens? debates, building/neighbours discussions) from exterritorial uses.
  - Are there actual uses of WiFi technology in your community which is not similar to high-bandwidth Internet access? Are there specific practices allowed for by WiFi technologies?
  - Do you believe that using WiFi technologies reinforce social bounds between community members (what of bounds with external people)?
  - Do members of the community create contents and services specifically oriented towards community members (or a subgroup): building online portal, neighbourhood mailing lists, chats or newsgroups, community-wide search engine??
  - What does not work in your community? Are there uses that you thought would arise that did not occur?
  - Would you say the WiFi community has become a sort of representative body of its members, an intermediary between them and other actors? Does it lobby local or national governing bodies? Is it active in contestation of telcos market power?

3) Understanding the technical side of things

- Would you believe that a steep increase in the number of WiFi users within your community area could lead to spectrum saturation and data-rate trouble? Do you see such a prediction as realistic and why? How would you deal with it?
- Is there presently a permanent network (MAN) in the community area? Does it work satisfactorily? What are the longer-term projects as far as network is concerned?
- Can you figure a context in which a regulation body would be needed to organise the way WiFi networks are set up? What do you think would be the best geographic footprint of such a regulator?
- What are the technologies that WiFi must interoperate with in order to allow seamless mobility and high-bandwidth mobile uses (such as IPv6)? Do you think such an immersive experience will occur and when?
- Do you think WiFi is a competitor or a complement to 3G (UMTS) operators? networks? If a competition should arise, what technology would win and why?

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