24TH EUROPEAN REGIONAL CONFERENCE OF THE INTERNATIONAL TELECOMMUNICATIONS SOCIETY, FLORENCE, ITALY, 20 - 23 OCTOBER 2013

INVESTMENT STRATEGIES FOR DIFFERENT ACTORS IN INDOOR MOBILE MARKET IN VIEW OF THE EMERGING SPECTRUM AUTHORIZATION SCHEMES

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Abstract

Nowadays the regulatory landscape is changing towards more flexible spectrum management schemes, such trends are expected to make additional spectrum resources available and lowers the spectrum access barriers. These emerging spectrum authorization schemes such as secondary access (TV White Space) and Licensed Shared Access (LSA) are expected to be a mean for new actors rather than the traditional MNOs to have access to spectrum resource at reasonable cost. Accessing spectrum resources will allow actors such as facility owner, mobile virtual operators, internet service providers (ISPs) to invest in indoor mobile network infrastructure. Those actors can act as Local Network Operators (LNOs) and build their business models around providing the mobile services in spotty locations where there seems to be a “hole,” or lack of service coverage in a particular area within the mobile network operators (MNOs) service footprint.

This paper highlights the difference between the indoor deployment thinking and the outdoor deployment thinking when it comes to the spectrum bands of interest and the possible business models of MNOs and LNOs. In summary, the possible investment strategies for provisioning the indoor mobile services vary in the mobile network operators (MNOs) and local network operators (LNOs) cases due to surrounding economic and regulatory aspects. The main finding in this study indicates that the willingness of mobile network operators to invest in dedicated indoor solutions is driven by the balance between the potential revenues and the deployment cost. Moreover MNOs have more spectrum and investment options compared to LNOs whom must bond their investment strategies to the available spectrum resources (i.e. the regulation conditions to access the spectrum).

1 Introduction

The demand for mobile broadband access has increased dramatically in recent days in terms of connections number and traffic volume. Further on most of the data traffic in mobile networks is originates from indoor or local area locations such as office buildings and shopping malls. The main challenges of the mobile operators nowadays, is how to extend their wireless coverage inside buildings to deliver high-quality mobile services which is a difficult challenge to be achieved by outdoor mobile network due to the attenuation of the radio signals. This problem is exacerbated for wireless service providers that use higher frequency bands for their transmission medium where radio-frequency signals attenuate more rapidly inside concrete or steel structures.

Higher data rates are dependent on the quality of the signal at the receiver; therefore it is important to extend the network coverage capabilities of the macro-network into more confined radio environments. WiFi and femtocell are gradually becoming potential technologies for solving such problem and provisioning mobile network services in indoor locations due technology maturity and reasonable deployment costs.

In spite of the attractiveness of the use of the unlicensed spectrum solution (namely Wi-Fi), studies as in (Kang, et al., 2012) discuss the possible negative impact on the network capacity as a result of the network densification due the lack of good interference coordination mechanism. On the other hand the lack of seamless handover solution between Wi-Fi and cellular systems may lead to lower user's experience. The femtocells deployment could be considered as solution to mitigate the interference problem, and enhance the user's experiences since it operates in the same licensed spectrum similar to the outdoor macro-cell networks. Moreover in the femtocells case the mobile operators can assure the required quality of service to customers, by making efficiently planning for the spectrum use (Kang, et al., 2012).

Securing the licensed spectrum for indoor femtocell deployment is always a challenge for MNOs. However the use of TV white space and radar bands based on secondary access schemes and the emerging licensed shared access schemes (LSA) is gotten more and more attention these days. Moreover changes in the prominent national regulator authorities (NRAs) views that used to treat femtocell similar to the outdoor mobile deployment are noticed in the last few years. For example OFCOM, the United Kingdom communications regulator is discussing the possibility of allocating portion of the 2.6-GHz band for exclusive femtocells deployment. Moreover in Sweden as per PTS, there is a plan to allocate 5 MHz in 1.8 GHz (IMT band) for unlicensed use by first quarter of 2014.

In the literature, rising number of publications that address the technical and business issues of the spectrum resources use. The principle objective behind such work is to explore the optimum ways for attaining the future spectrum demand for high capacity wireless network, with special focus on indoor deployment. The use of secondary access spectrum option by incorporating cognitive elements in the deployed femtocell (cognitive sharing for licensed spectrum) has been discussed in (Matthias Barrie, 2012). In same context two spectrum schemes - split spectrum and common spectrum for the femtocells deployment in a 4G network have also been addressed in (Bai, et al., 2009). A simple decision model that examine the possible choices a potential secondary spectrum entrant may take when considering cost and revenue components have been introduced in (Weiss & Cui, 2012). Moreover some studies discuss the different spectrum value in the context of outdoor deployment and it is impact on the company strategic position in the market (Mölleryd, et al., 2010). While in (Chiras, 2012.), the deployment of femtocells by utilizing the TV white space has been studied in relation to different scenarios available to the involved actors; namely the Mobile Network Operator, Facility Owner, Wi-Fi operator and only a TV White Space operator. Similarly a techno-economic evaluation of the LTE-femtocell deployment in TV White Space versus the use of licensed spectrum has been performed in (Karonis, 2012).

The aim of this paper is to discuss the perceived differences in the spectrum value between wide and local area network deployments. Our discussion has been complemented by exploring the investment decision of different actors in indoor mobile market focusing on the available schemes to access the spectrum resources. Schemes such as the licensed, unlicensed, shared access (secondary access) and licensed shared access (LSA) has been used in our discussion and analysis aiming to answer the following questions:

RQ1: How the value of the spectrum resources varies between the outdoor deployment and indoor deployment scenarios?

RQ3: What is the impact of the different spectrum authorization options on the actors invest strategies?

2 Methodology and Scenarios

A dual quantitative and qualitative research study is undertaken to perform the work in this paper. The quantitative part of the dual study is devoted to the discussion of the differences between macrocell and femtocell deployments focusing on deployment cost and spectrum demands. While the qualitative part is intended to enrich the discussion with the perspectives of different actors (i.e. Local Network Operators (LNOs) and Mobile Network Operators (MNOs)) on the available spectrum access options and their associated investment decision. Towards this end, representatives from industry and regulatory authorities had been interviewed during the period 2010-2013.

2.1 Description of the Quantitative Study

2.1.1 Users Demand

To perform the quantitative part of the dual study, the deployment of a mobile network infrastructure to meet the expected subscribers demand within a densely-populated business district in an area of one square kilometers has been considered. Ten thousands mobile subscribers are assumed to be uniformly distributed in ten (10) five floors buildings within the aforementioned business district. The expected demand and capacity requirement in this business district can be estimated based on the statistics periodically released by the Swedish regulatory body (PTS) on the monthly subscriber demand in the country which ranges between 2 to 5 GB per month and the published forecast reports issued by partners from industry such as Cisco and Ericsson that estimate a 10 to 30-fold increase in the global mobile data traffic in the forthcoming five years. Guided by the above statistical and forecasted figures, two levels of the mobile subscriber`s demand per month are assumed in this paper to count for current and near future demand. The two assumed demand levels are 5 GB for low demand and 20 GB for high demand. The deployment cost incurred to satisfy the subscribers demand within the concerned area using either macrocells or femtocell deployment solution depends on the number of base stations that is needed. In order to estimate the number of base stations in each deployment solution (i.e. macrocells and femtocells), the coverage and capacity characteristics of the used radio base stations (RBSs) need to be specified. The achieved capacity per RBS varies according to the used radio access technology (RAT) and bandwidth. We consider a radio access technology with spectral efficiency of 1,67 bps/Hz; this number can represents the average spectral efficiency in a typical LTE macrocell. However in the femtocell case, an average spectral efficiency of 2 bps per Hz is assumed due to the expectation of better SNR value. Beside the RBS capacity, the cell-size of the used radio base station affects the required number RBS as well. By using the same methodology as in (Markendahl & Mäkitalo, 2010), cell radius of 3 Km and 20m could be estimate for macrocell and femtocell respectively.

2.1.2 Cost Structure

The components of total investment cost to be borne by operators to deploy a mobile network to satisfy the anticipated users demands as previously described, includes the radio site build-out cost (i.e. civil work, radio equipment and backhaul solution, auxiliary systems etc.) in addition to the spectrum license fee. In Sweden, The cost of deploying one macrocell ranges between k€ 50 and k€ 200, for the purpose of this paper, the cost of deploying a new macrocell site is taken to be around k€ 100. While the deployment cost per base station in in the femtocell deployment case is estimated to be in order of k€ 1.

2.2 Description of the Qualitative Study

The primary data for enabling the conducted qualitative analysis was collected via a semi-structured data collection method where representatives from industry and regulatory authority have been interviewed. A first round of interviews was conducted in year 2010. Here Swedish mobile operators TeliaSonera, Tele2 and Telenor and telecom manufacturers Ericsson, Huawei and Nokia Siemens Networks

(NSN) were interviewed about drivers and obstacles of network sharing in general. Interviews were also made about indoor deployment solutions and business models. In addition to the actors mentioned above, interviews were made with the Swedish and UK regulators (PTS, Ofcom), with equipment providers and system integrators (Absolute Mobile, MIC Nordic and Powerwave), with the Swedish real estate company “Jernhusen” and with big organizations using indoor solutions (the Swedish parliament and Uppsala University).

In Year 2012 a second round of interviews was done with focus on indoor deployment, shared solutions and the role of third party actors. In addition to telecom manufacturers (Commscope, Ericsson and NEC) we interviewed companies with focus on local network solutions and services (Cloudberry, Icomera and MIC Nordic) and on management of networks of other actors (Ericsson Global Services and 3GNS). Valuable inputs were gathered from train companies in the UK and in Sweden (Keolis, SJ, SL and Transitio) as well.

3 Spectrum Authorization Schemes

Providing more frequency spectrum is one important means of meeting the rapidly increasing demand for wireless data in a cost efficient way. As the demand for high data rate wireless services continues to increase the spectrum availability become an issue; the he Frequency Allocation Tables for many countries might give the impression that the RF spectrum is over-used and congested. But measurements of actual spectrum usage show that depending on location, frequency, and time of day, large amounts of spectrum are being underutilized (FCC, 2013) (International Telecommunication Union, 2012) (BEREC/RSPG, 2011). This waste is caused by inefficiencies in the fixed legacy approach to spectrum licensing where a single licensee is allocated a specific frequency band, and is bound by particular technology constraints within that band. This licencing approach overlooks the fact that the licensee may not be using that spectrum all of the time or in all locations. To resolve inefficiencies of the traditional spectrum management schemes, regulators have looked at more flexible and dynamic ways of licensing spectrum. For example, the European Commission (EC), following in the footsteps of the US regulator, wants to create a framework for scarce radio spectrum to be shared by multiple technologies and players.

The European Union's executive arm called on regulators within the area to adapt more quickly to technical advances, which improve spectral efficiency and allow wireless technologies to coexist in one band. It has set out its first list of objectives, as part of the five-year Radio Spectrum Policy Programmer, approved by the European Parliament in February 2013 (Commissioner, 2013). The overarching aim is to harmonize spectrum allocations and rules for mobile broadband, but the EC is keen to look beyond conventional bands and processes to find new sources of frequencies, and to use them more efficiently. The European Commission urged regulatory regimes to catch up with technological advances that enable more efficient use of mobile spectrum. Today the EU took a step towards formalizing that, with the introduction of a proposal for spectrum sharing Announced by Neelie Kroes, VP for the European Commission, the proposal "*is an essential part of the solution to dealing with the wireless crunch… by using new technical possibilities to create a secondary market for spectrum rights*." This document highlights the importance of technologies to share radio frequencies; as well as the need to create incentives and legal certainty for innovators. It proposes ways to promote wireless innovations to share spectrum more efficiently, in particular:

- Developing a common approach to identify beneficial opportunities to share spectrum (BSO) in the internal market;
- Providing economic incentives and legal certainty for users to develop and deploy spectrum-sharing technologies, for example based on sharing contracts;
- Authorizing shared spectrum access with "guaranteed rights of use", as a tool for regulators to leverage economies of scale for wireless innovation;
- Monitoring and extending the harmonized license-exempt internal market bands.

If we look historically to evolution of the different spectrum schemes, two main practices for allocating and authorizing the use these radio spectrum bands could be identified; namely the Individual Authorization and General Authorization, as shown in Figure.1. However as will be illustrated in the following subsections, many practices and the authorization options are continuously emerging from these two broad options in view of the technological advances and regulations harmonization activities at the continental and the international basis (METS2020, 2013).

3.1 Individual Authorization (Licensed)

In the individual authorization practice, the right to use a specific spectrum band is exclusively granted by the National Regulatory Authority (NRA), to specific actor for certain period of time and within specific geographical region. Two schemes of spectrum access authorization exist within the individual authorization based on the concepts of primary usage and secondary usage as shown in Fig.2. In the authorized primary license, the licensee will have an exclusive access right to use the assigned spectrum and enjoy protection from harmful interference caused by secondary users. However, other primary license holders with equal access rights could exist in the same spectrum band, this scheme known as co-primary sharing (or shared primary access), e.g. mobile service (IMT) and Fixed Satellite Services (FSS) co-existence in 3.5 GHz band. In the authorized secondary scheme the aim is to allow other users to use the spectrum (or part of the spectrum) that has already been allocated to one or more primary users by applying appropriate sharing rules that protect the services of the primary users and provide a certain level of QoS for the services of other licensees. Fig.2, gives a good illustration by the emerging and the evolving concept known as Licensed/Authorized Shared Access (LSA/ASA) which is is a framework or arrangement to share spectrum between a limited numbers of users. Under the

LSA framework a primary license holder (incumbent) will be allowed to grant spectrum access rights to one or more other users who can use the band in accordance with a set of pre-defined conditions and regulations (METS2020, 2013) (Zander & Markendahl, 2013) (Forge, et al., 2012) (Parcu, et al., 2011).

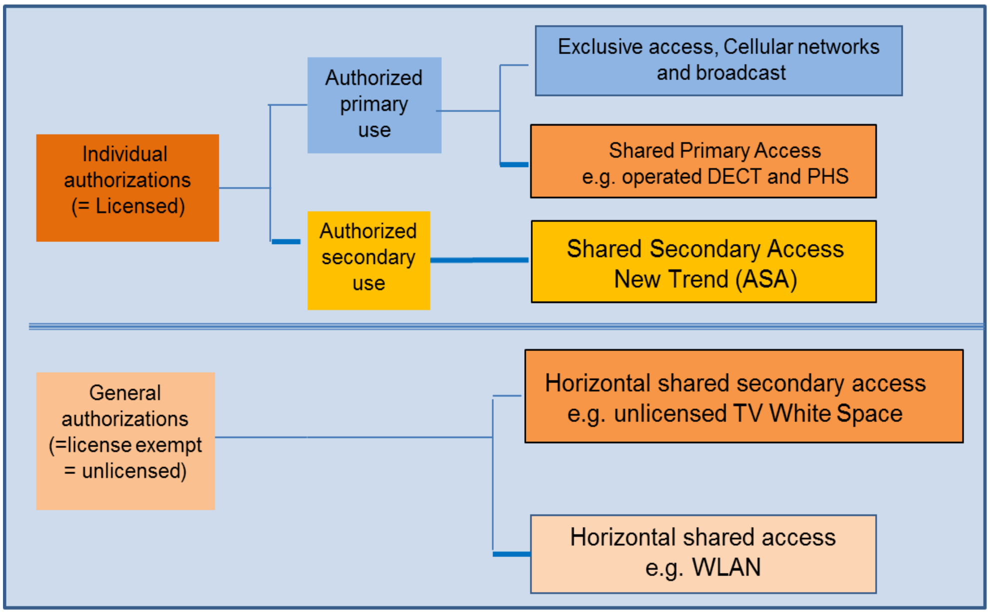

Figure 1: Spectrum Authorization Options

3.2 General Authorization (Unlicensed or License exempt)

In the general authorization practice, the access right to use the spectrum is granted without any license fee to all actors if certain technical and regulation conditions are met. These unlicensed bands are shared between different systems without any guarantee of any sort of interference protection, which may jeopardize the QoS. As illustrated in Fig.2, two types of General Authorization could be seen; namely unlicensed shared access (also known as Horizontal Shared Access) and the secondary horizontal shared access. In the Horizontal shared Access, users share the band horizontally without protection rights against each other (the most common example is the ISM band at 2.4 GHz). While in the Secondary Horizontal Shared Access, there is a condition to protect the service of users with higher priority (primary users). The secondary access in the VHF/UHF TV band, often referred to as TV white space (TVWS), could stand as good example of the Secondary Horizontal Shared Access (Simic, et al., 2012) (Forge, et al., 2012).

3.3 Light-licensing

Light-licensing is another spectrum access scheme that mixes aspects of individual authorization and general authorization schemes as shown in Figure-2. Light-licensing is typically applied in situations where there is no or little immediate concern about interference (such as Amateur, Maritime (Ship) stations). However it will be desirable from NRAs spectrum management perspective to perform a check if the planned usage is likely to cause problems to other already existing usages; and accordingly a record about the spectrum will be required through automated selfservice licensing, e.g. user self-registration of radio devices in an online database with automated interference check (METS2020, 2013).

Individual authorisation (Individual rights of use)		General authorisation (No individual rights of use)	
Individual licence	**Light-licensing**		**Licence-exempt**
Individual frequency planning / coordination Traditional procedure for issuing licences	Individual frequency planning / coordination Simplified procedure compared to individual licensing With limitations in the number of users	No individual frequency planning / coordination Registration and/or notification No limitations in the number of users nor need for coordination	No individual frequency planning / coordination No registration nor notification

Source: CEPT ECC Report 132

Figure 2: Light –Licensing Scheme

3.4 Spectrum for Femtocell: Licensing and legislative framework

Several national and international regulatory bodies have taken specific steps to clarify issues of policy and regulation relating to femtocells. As a new technology, femtocells do raise numerous questions about the modifications that may be necessary on the existing regulation framework. In this regard issues such as the impact of femtocells on spectrum licensing, public health concerns (power levels for femtocells operation), security and privacy concerns beside the ownership of femtocells need to be addressed. To answer the main regulator concerns about how to allocate spectrum resources for femtocells deployment, two possible operation types for femtocell should considered; i.e. WiFi-like operation (unlicensed spectrum) and cellular system like operation.

Regulators mostly prefer not to allocate exclusive frequency band for femtocell, deployment. In Europe, Radio Spectrum Committee (RSC) state that *" femtocells operate as part of the operator's existing network (using the same frequencies) and that the operator remains in control of the femtocell at all times, it is reasonable therefore to assume that femtocells will comply with the existing technical licensing conditions in each specific case"* (SamllcellForurm, March 2011). Similar approach is adopted in the ASIA-PACIFIC TELECOMMUNITY (APT) as can be found in the published questionnaire in September 2011 (APT, September 2011). APT regulators are convinced that although Femtocell Access point (FAP) may be installed in user premises, a key feature of its operation are monitored and controlled by the host network. Apart from this view, in in which the Femtocells operate in licensed or regulated spectrum (Unlike Wi-Fi), some regulator bodies are discussing the possibility of allocating portion of the 2.6-GHz band for exclusive femtocells deployment (such as OFCOM) or using part from the unlicensed 1800 MHz in

Europe and USA, that traditionally allocated to the DECTS for femtocell deployment..

An international agreement and harmonized spectrum allocations may be required to enable private individuals and local operators (i.e. such as facility users) to deploy and use femtocells without being tied to the radio regulation in specific country (Wi-Fi like operation).

4 Spectrum Value and Deployment Strategies

The use of low frequency bands for outdoor deployment (wide area coverage) are of significant benefits due to their good propagation properties such as long range and the low wall penetration losses. In other hand wide bandwidth is beneficial not only in provision of high data rates and capacity but also from a cost perspective. In general, the value of additional spectrum in the outdoor deployment can be figure out by knowing the additional costs incurred if the additional spectrum needed was not acquired. Analysis using this so called engineering value is presented by many researchers (Plum Consulting, 2011) (Australian Communications and Media Authority, 2009) (Mölleryd & Markendahl, 2013). In many cases the engineering value show great variations due the assumptions made and the relation of engineering value to auction prices may greatly vary.

In essence, more system bandwidth in outdoor deployment means less number of base stations will be required to satisfy a given demand; which means considerable cost saving as can be seen from Figure-3. In Sweden the mobile operators have spectrum allocations in the 800, 900, 1800, 2100 and 2600 MHz bands. In the three upper bands the operators have up to 60MHz. However, with network sharing and spectrum pooling cooperating operators can have well above 100MHz. These benefits are evident when compared to the benefit of operators with less amount of bandwidth as can be extracted from Figure 3. Moreover, in outdoor deployments, licensed shared access (LSA) is beneficial as it gives the operators extra exclusive usage rights and can be added to their licensed spectrum which move their deployment cost to the right in Figure 3. Other types of spectrum access are of less interest for outdoor deployment since other users may have access to them as well.

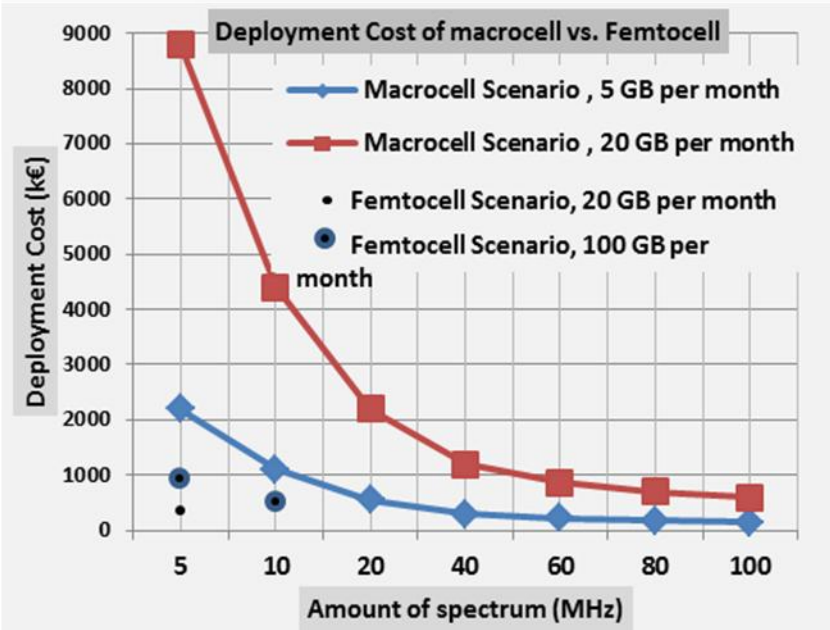

Figure 3: Number Of Macrocell Base Stations

In contrast, the deployment of indoor wireless access implies short range communications in spotty locations. The positive impact of wall penetration losses lead to reduction of interference from neighboring cells especially when higher frequency bands are utilized. The small coverage area of dedicated indoor nodes is main enabler for re-using the spectrum resources many times. Moreover, in indoor deployment scenarios, the use of more spectrum bandwidth do not necessarily lead to less number of radio base stations, this is due to the coverage bottleneck where specific number of femtocells will be required to cover each floor any way as shown in Figure-3.

5 Investment Strategies in indoor mobile Broadband Market

Traditionally the investment in mobile network infrastructure has been made by mobile network operators (MNOs) motivated by the long term licensing policy that gives MNOs the right to utilize spectrum blocks exclusively and the opportunity to keep new competitors out of the market. Mobile network operators, such as Vodafone, Orange and T-Mobile, employed dedicated armies of network engineers to build and manage industry infrastructure. Nowadays this vertically integrated value chain, in which all business roles are handled by the MNO, is changing toward Horizontal unbundling approach where mobile network operators started outsourcing network construction and operations to service providers, typically the equipment suppliers. Such shift in value chain are pushed by changes in customers' demands, technological advances and regulations pressures. Moreover, cooperation strategy between networks operator is took place. The joint-ventures to deploy a denser 3G and 4G networks in Sweden can be good example for cooperation strategy between MNOs. In this regards, during the last decade TeliaSonera has offered mobile broadband services using a shared network together with Tele2 and then enter into joint venture Net4Mobility together with Telenor. It seems that Tele2 found a lot of benefits in network sharing that overcome the drawbacks to be less independent (Chambers, 2013).

In forthcoming subsection, we will introduce four types of actors/companies in order to cover the possible different roles in the indoor mobile ecosystem, which includes network operator (i.e. MNOs and MVNO), Equipment Vendors and solution providers, internet service providers (ISPs) and Facility owner as seen in Figure-4.

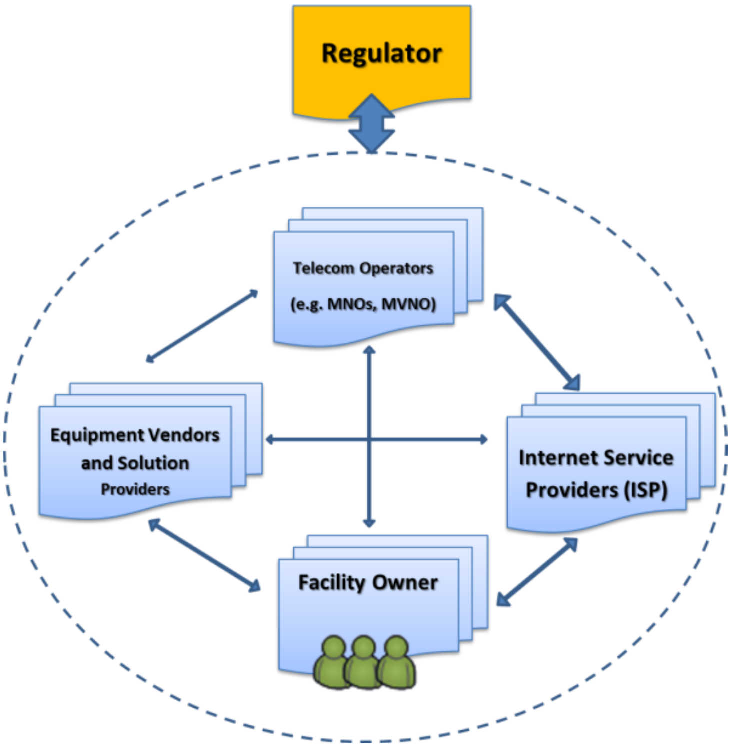

Figure 4: Actors in Mobile Ecosystem

5.1 Mobile Networks Operators (MNOs)

Mobile Networks Operators (MNOs) are traditional stakeholders dominating the mobile business domain. MNOs typically deploy dense outdoor cellular network (i.e. macro, micro and Pico base stations) which enable national or regional level coverage. MNOs rely on outdoor cellular site for provisioning good Quality of Service (QoS) and sustaining competitive advantage in the market supported by the availability of a stable and guaranteed access to spectrum resources (License Protected frequency bands). As the licensing spectrum strategy bears high-volume capital expenses, MNOs always favor activities leveraging their costly investments in spectrum licensing. Based on our discussion in section 4, the addition of more spectrums can lead to overall reduction cost as long as the spectrum price remains small compared to the network infrastructure cost: a condition that is challenging to indoor deployment. This explains why MNOs are reluctant to use their licensed spectrum bands for indoor deployment, even at the expense of QoS. Moreover, deploying an indoor mobile network brings extra activities and overhead to MNOs. Normally, due to the establishment of relations with a number of facility owners which is not within the scope of the MNO core business. In other hand the motivation for wide-scale indoor deployment may come from the pressing need to achieve better coverage and capacity taking in consideration that around 80% of the mobile traffic comes from indoor locations as per Cisco forecast. Amongst the benefits for MNOs are: decreased customer churn, increased customer loyalty, delivery of location enabled services and bundled offerings, proliferation of customer lifetime value.

In response to the data traffic explosion, MNO consider using solution such as offloading the mobile traffic into the widely adopted wireless local network. The problem of using this approach is the fact that Wi-Fi network has not been designed as a mobile technology; i.e. the mobile subscribers cannot seamlessly move between Wi-Fi networks and outdoor cellular sites. That is why more attention is given nowadays for indoor smallcell deployment (i.e. femtocell) which perceive as mean to allow network operators to have better control on the provided QoS compared to WiFi. The question is to dedicated spectrum resource for femtocell deployment or not. If the same macrocells frequency band is used for femtocell deployment co-existence and interference problems may arise. In other hand, mobile network operators are usually not willing to allocate part of their licensed spectrum for dedicated femtocell deployment as mentioned early. This leaves the challenge of how best to exploit both cellular and Wi-Fi coverage while delivering a simple customer experience to the end users. Answer may be found in the recent advances in WiFi standards and new trends in manufacturing and deploying an Integrated Femto-WiFi (IFW) access point may put an end to such shortcomings. Even though, the IFW access points still need to use the licensed bands of MNOs.

5.2 Mobile Virtual Network Operators (MVNO)

According to the International Telecommunications Union (ITU), MVNOs are "*operators who provide mobile communication services to users without their own airtime and government-issued licenses". *Mobile Virtual Network Operators (MVNO) normally depends on the infrastructure of the MNO to provide their services without having a mobile network of their own. This dependency may vary from leasing the radio transmission capacity (where the MVNO is known as a full MVNO) to extreme form in which the MVNO provides its contents or services on top of the MNO network (where the MVNO is called a service provider (SP) or a thin MVNO). The SpingMobil case, in Sweden, indicates that MVNO could own its indoor mobile network infrastructure and enter into different roaming agreement with hosting MNO. In this regard, Spring Mobil provides indoor coverage for voice services at the company premises whereas nationwide outdoor coverage is provided by the partner Tele2 (that recently acquired Spring Mobil).

5.2.1 Internet Service Provider (ISP)

The Internet Service Provider is known as actor that provides the Internet connectivity. It usually has a long term contract with the end customer, both residential and enterprise, offering Internet access through different connection types like copper wires, fiber optic or fixed wireless access network. ISPs can also provide Wi-Fi hotspots in public places for their nomadic broadband customers for an increased service differentiation among other similar players, in this case they may know as Wireless Internet Service Providers (WISPs). WISPs have been established in the mobile market as providers of local area broadband access through unlicensed band of the Wi-Fi technologies. The competitive advantages of WISPs stem from owning the backhaul solution. The targeted locations are mainly crowded public venues like airports, hotels, restaurant and pubs or highly touristic places. Income is generated based on two different business models. In the first case, in free public places like airports or train stations, the end user might pay a monthly or single-time access fee to the WISP. In the second case, in places like hotels or pubs, the venue owner might offer free internet access to its clients as an added service for differentiation and improved customer satisfaction. This is achieved through a signed contract between the venue owner and the WISP.

Good examples for such trend can be provided by Vodafone Greece and HOL (Hellas Online) which deploy on 1st of April 2013 the first public combined 3G Femto-Wi-Fi service for the customers of more than 150 restaurants and fast-foods across Greece. By using this service, called "Free 3G Hotspot", clients of the two restaurant chains, Flocafe and Goody's, can connect freely to the Internet using either the 3G Vodafone network through an indoor femtocell or using HOL Wi-Fi service. When a Vodafone mobile subscriber enters the "free" area, the hand-over to the small cell is achieved and after a five minutes delay the customer receives an SMS announcing about the free-surfing area. When the mobile device is registered to the indoor cell the generated traffic is free of charge to the monthly data allowance only for the Vodafone's customers.

5.3 Facility Owner

Facility Owners (FOs) who has direct interaction with customers find them step by step been more involve in the mobile business. Facility Owners are keen to provide high quality mobile broadband in their premises as additional mean to increase their customer satisfaction. The end-users in the FO`s indoor mobile network be customers established from the FOs core business (e.g. hotel) or passing by the site location (e.g. mall). FOs can deploy and operate their own indoor mobile network infrastructure or authorize a third party to deploy indoor network infrastructure within their premises. Due to their major asset, i.e. site operation in addition to their customer base, FO has strength bargaining position with actors who willing to enter the indoor mobile broadband business.

5.4 Network Venders and the Solution Providers

Nowadays network vendors such Ericsson, Huawei gain an additional role in the mobile ecosystem by offering fully outsourced network management arrangements. However this new role, which known as managed service provider (MSP), is not restricted to network vendors, small companies may play this role as well.

Cloudberry, which is a company provides small cells to consumers and enterprises in Norway, provides a good example for MSP model. Cloudberry own small cells network, offering their services to big enterprises or mobile operators. The business model of Cloudberry Mobile was built around offering a new type of service called SCaaS (i.e. Small Cells as a Service) by deploying and operating small cell networks that both major and smaller mobile operators can use. The motivation behind Cloudberry business model is providing mobile coverage and capacity where the customer needs it; in place hard to be covered by the outdoor cellular network.

5.5 Spectrum Options and actor business relations

As stated in the previous sections, the indoor mobile market could contains many players, e.g. MNOs, Internet Service Providers, Real Estate companies, Hotel as shown in Figure 4. Different levels of cooperation between those actors could exist depending on their business models and the available spectrum access options.

5.5.1 Managed Service Providers (MSP)

MNOs perceive the use of secondary access, unlicensed bands or LSA as additions to the existing licensed bands of MNO`s that can provides them with flexibility to expand their networks coverage and capacity to indoor locations. The advantage of using dedicated frequency bands or LSA, for indoor deployment will enable MNOs to have better network planning capabilities in term of avoiding possible interference between indoor and outdoor cellular networks, assuring QoS level and imposing security measures as illustrated in Figure-5. Although MNOs may be look into alternative/additional spectrum bands using schemes like unlicensed, licensed shared access or dedicated licensed bands (local licenses) for indoor mobile deployment as shown in Figure-5, MNO not real willing to deploy the indoor mobile network infrastructure and tend to outsource the operation and maintenance activities as well. In such a case, an opportunity for a managed service providers (MSP) business strategy could emerge for actors such as the network equipment vendors. The MSP may utilize part of the MNO's spectrum resources to deploy the indoor mobile network infrastructure as shown in figure-4. Ultimately this business strategy option depends on how ambitious the MNO in terms of saving costs and taking risks to utilize part of his licensed spectrum for indoor deployment.

5.5.2 Local Network Operators

On other hand actors such as WISP may choose to go for independent business strategy by invest, deploy and operate an indoor mobile network infrastructure. The terminology LNOs used by the authors to describe business models concentrates on the provision of mobile services within spotty locations characterized by high subscribers demand such as office buildings and shopping malls. The drivers behind the necessity to deploy dedicated indoor systems can be the need to avoid or eliminate the inherent problems with wall penetration losses when relying on the use of outdoor base stations and/or the desire of users in the concerned locations to enjoy dedicated and guaranteed capacity.

For LNO, spectrum resources could be secured via different spectrum access options as shown in Figure-5. One option is to use more licensed spectrum which is costly and hard to secure that why actors such as WISP may prefer to act as virtual operator rather than LNO and use other actor infrastructure (namely MNO). A second option is to use more unlicensed spectrum bands made available by recent allocation in IMT/IMT-advanced: i.e. 5 MHz allocated in 1800 MHz. This option is cost-effective and enables seamless operation and interoperability with the existing cellular systems when compared with the use of WiFi. A third option is to exploit spectrum bands allocated for other non-communication systems using the Horizontal Shared Secondary Access authorization scheme (e.g. Broadcasting (TVWS) and aeronautical bands as shown in Figure-5). The key obstacles for cognitive radio and Horizontal Shared Secondary Access authorization scheme are the availability and cost of network and end-user equipment. In this connection, the use LSA scheme could provide long term and stable conditions that may induce manufacture support to invest in user and network equipment.

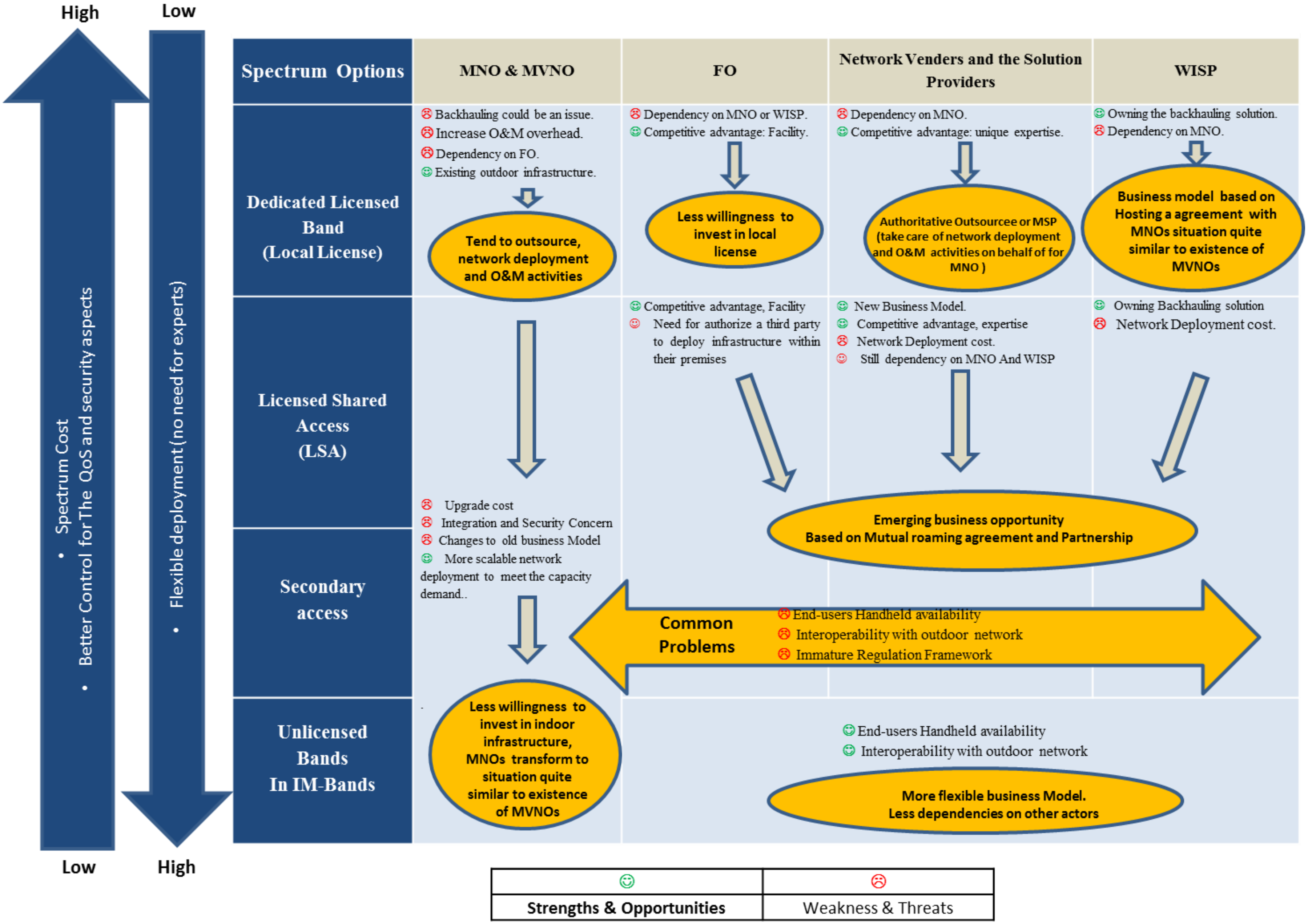
High
Low
Spectrum Cost
Better Control for The QoS and security aspects
Flexible deployment (no need for experts)
Low
High
Spectrum Options
MNO & MVNO
FO
Network Venders and the Solution Providers
WISP
Dedicated Licensed Band (Local License)
Backhauling could be an issue.
Increase O&M overhead.
Dependency on FO.
Existing outdoor infrastructure.
Tend to outsource, network deployment and O&M activities
Dependency on MNO or WISP.
Competitive advantage: Facility.
Less willingness to invest in local license
Dependency on MNO.
Competitive advantage: unique expertise.
Authoritative Outsourcee or MSP (take care of network deployment and O&M activities on behalf of for MNO)
Owning the backhauling solution.
Dependency on MNO.
Business model based on Hosting a agreement with MNOs situation quite similar to existence of MVNOs
Licensed Shared Access (LSA)
Competitive advantage, Facility
Need for authorize a third party to deploy infrastructure within their premises
New Business Model.
Competitive advantage, expertise
Network Deployment cost.
Still dependency on MNO And WISP
Owning Backhauling solution
Network Deployment cost.
Emerging business opportunity Based on Mutual roaming agreement and Partnership
Secondary access
Upgrade cost
Integration and Security Concern
Changes to old business Model
More scalable network deployment to meet the capacity demand..
Common Problems
End-users Handheld availability
Interoperability with outdoor network
Immature Regulation Framework
Unlicensed Bands In IM-Bands
Less willingness to invest in indoor infrastructure, MNOs transform to situation quite similar to existence of MVNOs
End-users Handheld availability
Interoperability with outdoor network
More flexible business Model. Less dependencies on other actors
Strengths & Opportunities
Weakness & Threats

FIGURE 5:

6 Conclusion

Traditionally the mobile business is characterized by two major interrelated market entry and investment barriers: costly network infrastructure and spectrum licensing. The high spectrum fees paid by cellular operators for spectrum bandwidth is normally justified due the expected limited number of licenses; i.e. a limited number of competitors able to exploit this scarce resource of spectrum. This long term licensing approach of spectrum has been protecting its owners from new entrants, resulting in formation of powerful oligarchies in most national mobile markets. That is why the spectrum licensing (exclusive access) is always seen by operators as essential mean to provide high quality of service and sustain competitive advantage in the market.

Due to the exponential growth in wireless data traffic and the increasing importance of wireless connectivity in the economy, the regulatory landscape is changing towards more flexible spectrum management schemes. Coupled with the attractiveness of using low-cost low-power indoor smallcell to meet the demand for high capacity, may reduce or eliminate traditional barrier to enter mobile market (i.e. high spectrum fees and costly network infrastructure). The Challenge for the traditional mobile network operators is how to adapt and stay ahead of the possible new group of competitors.

In the first part of this paper we investigated the difference between wide and local area network deployments in term of frequency bands of interest and the value of using more spectrum bandwidth per radio site. Our main findings indicate that the compelling economic arguments to utilize more spectrums for outdoor network expansion are based on the fact that using more spectrum resources in the existing macrocell base stations means that network operators can deploy less number of new sites and exploit previous infrastructure investments. Moreover in outdoor deployment, exclusive access over long time to frequencies with good coverage and propagation properties (e.g. "low frequency bands") are important for network strategic position in the market. Own frequency bands with favorable propagation characteristic will enable network operators to provide better mobile services (i.e. QoS) in indoor and outdoor locations compared to its competitors.

On other hand, the indoor mobile network is characterized by short-range communication that can be accommodated in spectrum with short range propagation characteristic ("high frequency bands"). Moreover indoor smallcell such as Femtocell Access Points (FAPs) are coverage limited which has two consequences: first, the frequencies can be re-used in more efficient manner and second the use of more frequency bandwidth per smallcell results on overprovisioning of network capacity without significant cost reduction. In summary, due to the differences in the engineering value of the spectrum resources in indoor and outdoor deployment MNOs are reluctant to permit the use of their dedicated licensed bands for indoor deployment, even if better QoS can be achieved.

Our discussion in second part of the paper has been extended to explore the investment strategy of different actors in indoor mobile market in view of the available spectrum access options. Our findings in this part undercover that the MNOs investments in outdoor network are normally protected by long term licensing policy. MNOs who own these licensed spectrum and outdoor network infrastructure, look for more spectrum in order to expand its mobile network infrastructure into indoor locations in more cost efficient way. Another actors that who don't have licensed spectrum resources, we call them in this paper Local network Operators (LNOs) will simply not be able to provide any kinds of mobile services unless they utilized unlicensed spectrum resources. The possibility to possess spectrum resources at reasonable cost via the emerging authorization options such as LSA could open new business opportunities for those LNOs. Furthermore, unlicensed spectrum resources in IMT-Bands and the use of secondary access (TVWS) could be highly appealing spectrum options for indoor deployment. Moreover in view of the technical, i.e. techniques for assuring quality of service in license-exempt spectrum, and regulation development, usage of LSA and secondary access could soon become an enabler for MNO`s indoor business as well. In this regards, the harmonization of spectrum use for LSA and secondary access network across multiple countries will lead to economies of scale in the equipment production and encouraging more equipment vendors to provide products built around a common set of frequencies suitable for all territories.

Acknowledgement

Part of this work has been performed in the framework of the FP7 project ICT-317669 METIS, which is partly funded by the European Union. The authors would like to acknowledge the contributions of their colleagues in METIS, although the views expressed are those of the authors and do not necessarily represent the project.

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