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Cooperation patterns in Smallcell networks

- Risks and opportunities to distinguish the win-win model

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Abstract

Cooperation and collaboration with either competitors and/or other actors in the ecosystem seems to become a relevant method for Mobile Network Operators (MNOs) in order to decrease costs and boost revenues at the same time. But, there are always risks and imperfections in front of such models such as losing control over network, empowering existing or potential competitors and unwillingness to contribute evenly in different cases with other actors. In this paper we discuss possible cooperation patterns for indoor smallcell networks, adopted from successful cooperation patterns in macro cellular networks. This is done by analyzing three main areas: Deployment of smallcells, sharing strategies and outsourcing. Based on the works done in this field, an intersection of these three areas is missing that is studying possible cooperation patterns with all possible actors (operators, third parties and Facility owners) of shared smallcell networks.

The aim of this paper is to see how it is possible to enable cases where all involved actors benefit from the cooperation pattern, by looking into existing solutions as well as proposing new patterns that a multitude of actors may be willing to adopt. Since there is no distinct answer for such a question, the proposed Wholesale model or Comprehensive system helps mobile operators to rethink about smallcell specific business models. This investigation enables distinguishing between *revenue-efficient* and *cost-efficient* smallcell network deployments for both operators and other investors.

Index Terms– *Business model, Competition, Co-opetition, Femtocell, Indoor mobile deployment, Network sharing, Outsourcing, Smallcell, Spectrum, Wholesale*

1 Introduction

Considering sharing as the most proper start for forming cooperation between operators, there are three major approaches that can be adopted; Passive network sharing, Active Radio Access Network (RAN) sharing and Roaming. Since network sharing, solely, may not have enough potential to bring the utmost financial benefit for an operator, collaboration with other actors such as third parties (i.e. outsourcees) also emerged during recent years. Focusing on macro cellular networks, discussions considering both horizontal and vertical partnership has been conducted while the same discussions seem to be rare and hard to find regarding in-building mobile solutions, especially when it comes to smallcells¹.

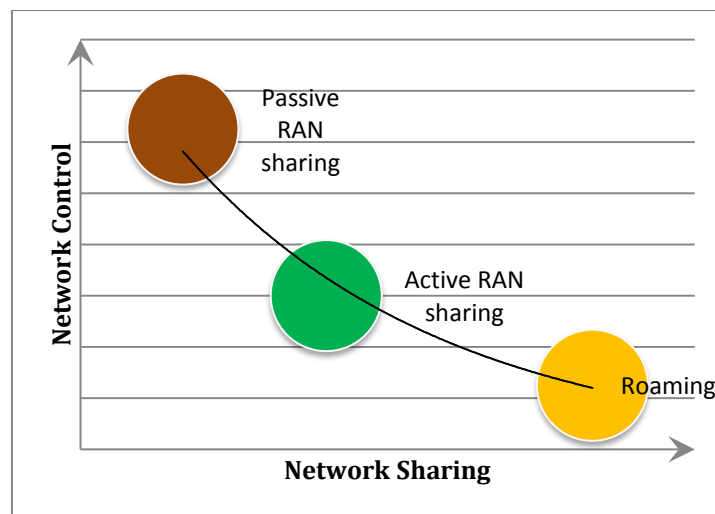


Figure 1-1 A winning model for mobile operators

The main reason that smallcells are yet considered as single-operator networks is that MNOs still presume their networks as macrocell networks where the deficit of capacity and coverage should be resolved by macrocells. But it is not foreseen that macrocells may soon be unable to satisfy the uprising indoor data demand. At the same time, the lower Total Cost of Ownership (TCO) of smallcells in comparison to macrocells, challenges MNOs towards deploying smallcells. More importantly, when it comes to indoor networks the actors are slightly different from outdoors but with stronger footprints on the deployment models of the network. Facility Owners as the “hidden” actor in this ecosystem have a complete different agenda from other actors.

By the advent of femtocells², as an accepted technology for indoor coverage and offloading mobile data from macrocells, cooperation in smallcells need to be investigated more. Since the number of involved actors in the convenient cooperation patterns in smallcell networks are more than macrocells (i.e. MNOs, outsourcees, regulator and Facility owners), considering an exclusive wining model for operators may not be the case anymore. Therefore,

¹ The *Small cell* definition is adopted from Small cell Forum. Small cells are low-power wireless access points operating in licensed spectrum and are operator-managed and feature edge-based intelligence. For more detailed description visit: <http://www.smallcellforum.org/aboutsmallcells-small-cells-what-is-a-small-cell>

² The *Femtocell* definition is adopted from Small cell Forum. Femtocells are smallcells that connect standard mobile devices to a mobile operator's network using residential DSL or cable broadband connections. See also www.smallcellforum.org

representing a Win-Win model for all collaborating actors that corresponds to all actors' business models and agendas by satisfying both their strategic and financial expectations seems to be the answer. The proposed win-win model should be able to surpass the losses in the tradeoff between Network Sharing-Network Control Figure 1-1.

1.1 Problem motivation and research questions

The aim of this paper is to cover the existing gap in studies on provisioning cooperative indoor smallcell networks. Therefore a proper cooperation pattern for Small cells is totally missing since all studies done are based on single operator small cell networks. This paper intends to resolve the issue that how the ecosystem will become after adopting cooperation patterns in smallcells. The goal is to present a proper model where all actors (old and new) may profit by both lowering costs as well as making new revenue streams. To enable solving the proposed gap, the following Research questions are proposed:

1. *How could spectrum frequency be utilized in different shared indoor mobile networks?*
2. *Who are the actors in the shared indoor mobile networks ecosystem?*
3. *How could Facility owners cause new relations between actors in the ecosystem?*

1.2 Methodology

This paper is focused on analyzing the potential business opportunities for services based on deployment of shared indoor smallcell mobile networks that we believe are capable of capacitating the future demand. The discussions move away from the old indoor solutions (DAS) to more up to date technologies (femtocells) starting with the technical design, network architecture and business models between different actors. The business analysis is based on assuming that the technical issues are resolved and multi-operator smallcell devices work properly. The discussion is followed by the same patterns done for discussing benefits, drawbacks and limitations of different cooperation patterns investigated for macrocells (Oliver Wymann, 2007) (Markendahl & Mölleryd, 2012).

Drivers for sharing, how it started, what kinds of activities that have been part of the cooperation patterns and finally the lessons learned from different cooperation patterns are gathered from interviews with representatives of Swedish mobile operators Tele2, TeliaSonera and Telenor in order to collect experiences of 10 years of network sharing. Another set of interviews were done in early 2012 with representatives for network sharing companies in Sweden that are joint ventures formed by mobile operators: Swedish UMTS Network AB (SUNAB), 3G Infrastructure (3GIS) and Net4Mobility (N4M) (Markendahl & Mölleryd, 2012).

Outsourcing of managed services for MNOs in their smallcell networks is assessed by focusing on economic issues. The interaction between market actors and the involved economic processes are also discussed. For analysis of the interaction between market actors we have used concepts and ideas from business network research (Håkansson & Snehota, 1989) (Mattsson & Johanson, 1992). The ARA model was used to enable the mediation between technology and economic values. We complement this analysis by discussing the value proposition, the firm organization and value chain, and the position of the firm in the

value network (Chesbrough & Rosenbloom, 2002). The primary data is collected via semi-structured interviews with 3rd parties active as outsourcees (Cloudberry Mobile, Icomera AB, 3GNS AB), local network operators (Spring Mobil, Tele2, Telia, TheCloud), and equipment vendors and system integrators (Ericsson, Huawei, Powerwave, MIC Nordic).

1.3 Related Work and contribution

Network sharing has been discussed widely for outdoor networks by focusing on resource sharing, such as spectrum and site sharing (Khan, et al., 2011) (Oliver Wymann, 2007) (Tankard, 2010) (Markendahl & Mölleryd, 2012). For heterogeneous networks joint operation of macrocells and pico/femtocell has been discussed in details (Frisanco, et al., 2008). Technical considerations and impairments of Femtocells and the tradeoff between coverage and capacity gains (Khan, et al., 2011) are the other discussed issues in this area. Viable business models based on network sharing patterns have been presented by (Landström, et al., 2011). How spectrum can be shared in smallcells, as the picocell layer in Heterogeneous networks, is also presented by (Capdevielle, et al., 2011). Techno-economic analysis of indoor network deployment have recently been presented in (Markendahl, 2011) (Frias & Pérez, 2012) but multi-operator aspects are considered only in Markendahl (2011), where in this paper we will elaborate it by discussing smallcells.

Economic issues of outsourcing as the vertical cooperation pattern were considered mostly by (Frisanco, 2009). (Friedrich, et al., 2009) presented brief insights into the motivation for network outsourcing and the rationale behind vendor selection from the operator perspective. (Chaudhury & Terflath, 2009) explained the risks and pitfalls that come with network outsourcing deals for network operators in their study, where they provide brief suggestions for the operators, in particular on what they can outsource and on what qualities in vendors that they need to look out for. Spectrum on the other hand and different alternatives to allocation of more licensed spectrum are currently discussed, examples are secondary spectrum access, licensed/ authorized shared access (LSA/ASA) (Forge, et al., 2012) (Parcu, et al., 2011) as well as secondary access and LSA and ASA concepts (Zander, et al., 2013).

As it can be observed most of the existing discussions are based on single operator deployment of Small cells by manufacturers and MNOs. As a result, discussions on multi-operator cooperative small cell networks are missing. Due to this shortcoming no proper win-win pattern for involved entities has been introduced so far. In this paper we discuss different vertical, horizontal and a combination of vertical and horizontal cooperation patterns in indoor Small cells. We also analyze the business roles between different actors in order to evaluate the level of collaboration between operators and 3rd parties, specifically by introducing the challenges in front of actors in this regards. Eventually we introduce the wholesale sharing model as an almost win-win scenario for cooperation smallcells.

1.4 Paper outline

The paper is outlined as follows; section 2 introduces the main rationale behind deploying smallcell networks as well as the affecting factors in deployment. In section 3 different sharing strategies viable for Small cells are introduced and discussed while section 4 deals

with outsourcing network operation and management in smallcell networks. In section 5 the business roles among involved actors of the smallcell ecosystem are analyzed that is complemented by introducing the challenges in front of them. Eventually, section 6 concludes the paper by distinguishing between traditional and possible future smallcell operators and answering the research questions.

2 Deployment of small cells

MNOs are used to consider coverage as the main issue in order to expand their networks while capacity seems to become more concerning these days. Taking into account the huge amount of data traffic consumption by mobile users, MNOs started worrying about the cost of provisioning their networks. The so-called data crunch is even more highlighted when Figure 2-2 tries to illustrate the problem. Although some experts do not accept the rationale behind this figure, it helps understanding that by the time data becomes dominant over the voice the revenue would not increase at the same rate as previous. The reason is that, costs are closely related to the amount of data being consumed but the prices are subject to decrease for marketing reasons leading to the scissors effect (Figure 2-1). In a sense, it could be inferred that it is time to change the business landscape, to upside down the value chain where previously the services have been built on top of the access infrastructure as added values.

There are different issues needed to be considered when it comes to deployment of smallcell networks. It is also possible to consider each Femtocell base station as a macro base station but in a very smaller scale. Then the technical parameters to be considered are almost the same, instead of the ones regarding build-out and installation. Since Femtocell Access Points (FAPs)/Femtocell base stations are designed in a way that they just need to be connected to the backhaul, which in this case is any available internet connection with sufficient capacity, the following list would depict the important criteria for deployment of smallcell networks based on femtocell technology:

- Spectrum and Backhaul,
- Femtocell devices,
- Installation, Operation & Maintenance,
- End User (Premises).

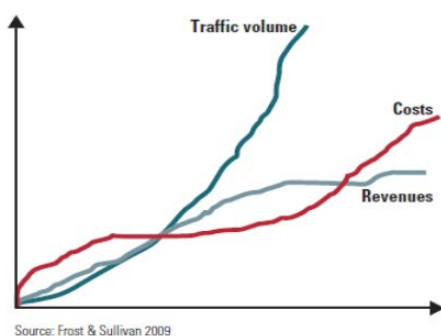


Figure 2-2 Traffic volume vs. Costs vs. Revenues

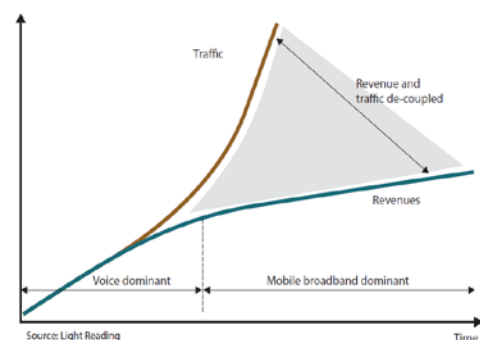


Figure 2-1 Scissors Effect

Spectrum and Backhaul

The capacity offered by FAPs is definitely delivered by the spectrum allocated to such devices. It should not be forgotten that already manufactured and distributed FAPs are generally designed for a specific (limited) number of users predefined. The spectrum frequency being used on the other hand is the same licensed spectrum being used by existing macrocell base stations although there are some ongoing researches on manufacturing FAPs using unlicensed spectrum as well.

The backhaul for Femto devices is simply any available existing internet connection that brings enough capacity to support users connected to the FAP. This issue is one of the major differences boosting femtocells over macro base stations since the costs for backhaul generally take into account up to 70% of transmission OPEX (Chevalie, 2009). Now that almost all offices and homes already have high speed internet connection, the backhaul seems to be not of an important issue for FAPs.

Installation, Operation & Maintenance

The FAP installation is the least concerning issue when it comes to deployment of smallcell networks. The devices are designed in way that no on-site assistance may be needed while installing them. In a sense, the end user just needs to plug the device into the internet connection and wait some time letting the device adjust and register itself with the network.

The Femtocell Management System (FMS) as the third element of Femto networks' architecture is located in the operator network where plays a critical role in the provisioning, activation and operational management of FAPs using industry standards such as TR-069. It could be framed that FMS is the most critical node in ensuring the scalability of a smallcell network to many devices existing in the network. As one of the main drivers for deploying smallcell networks, FAPs' activation and provisioning must be plug and play that must not require any on-site assistance. This feature is mainly obtained by the functionality of FMS. Many standard bodies specify the use of the TR-069 family of standards as the base device management framework for femtocells. This protocol is widely used in DSL modem and residential gateway deployments, and uses a proven web-based architecture that can scale to support millions of devices. The FMS is mainly composed of two primary elements, the Device Manager application and the Automatic Network Planner application. The Device Manager Implements functions such as remote configuration, remote diagnostics, fault management, software upgrade, performance data collection and device authentication. The Automatic Network Planner adds Radio Frequency (RF) planning algorithms, RF configuration and a northbound interface to Operational Support Systems (OSS).

End User (Facility owner)

FAPs are designed in a way to be located close to end users improving mobile experience for them and the subscribers existing in such premises. From the beginning, the main idea had been designing devices for home or small offices with limited usage to a specific number of users (residential femtocells). As the concept has matured, the idea of enterprise femtocells has become more interesting for both MNOs and larger customer segments that would mainly target Small-Medium Enterprises (SME). The solution being used for either of these two

methods is the same with a small differentiated configuration for Enterprise FAPS. The differentiated configurations enable using multiple small cells with overlapping coverage where femtocells in the same enterprise associate, and co-operate/collaborate with each other. The system comprises Distributed Intelligence across femtocells with enhanced auto-configuration and performance across the entire enterprise.

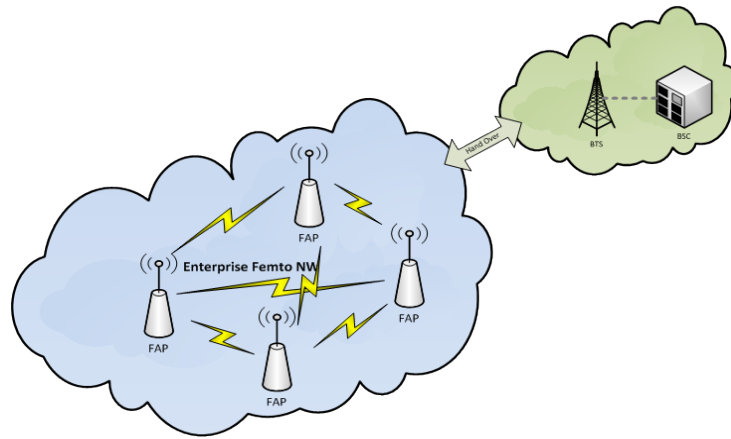


Figure 2-3 Enterprise Smallcell network

The existence of SME femtocells highlights the importance of the Facility owner which in this case can be a business firm, a sport arena, a train station or even a shopping mall. The existence of SME FAPs is based on the assumption that the Facility owner would like to bring a higher level of services and quality within its premises for customer satisfaction.

3 Sharing strategies and lessons learned

It is predictable that Facility owners tend to benefit from one and only one network and interact with only one network operator at the same time they want to serve all subscribers existing in their premises from different MNOs. On the other hand the main benefit of network sharing for MNOs would be OpEx prevention and saving, where CapEx savings would also be negotiable. The sharing models viable for Smallcell networks are almost the same as sharing solutions of Macro networks of which the main targeted model is the so called *Wholesale Sharing* or *Comprehensive System*, with regards to the fact that CapEx for smallcell networks is quite less in comparison with macrocell networks.

3.1 Drivers of Sharing

The major negotiable drivers for sharing in smallcell networks could be depicted as the following list. The direct effect of sharing in smallcells on the major drivers is discussed here:

- OpEx prevention and saving,
- CapEx prevention,
- Improved Spectral Efficiency,
- Enhanced Capacity,
- Better network (coverage and quality),
- Regulations,
- Less entry barriers,
- Data crunch, and
- Spectrum allocation.

OpEx & CapEx

The direct effect of sharing on OpEx is only related to Network OpEx that is a portion of the general operational expenditures for any MNO. Considering a European mobile operator's OpEx breakdown, it can be seen that Network OpEx embrace a big part of general OpEx, meaning that any possible prevention/saving method would cause a considerable change in expenditures (Figure 3-1). It is quite interesting that implementing shared smallcell networks would prevent extra OpEx for macrocell network providers at the same time it saves operational expenditures for smallcell networks. A typical breakdown of Network OpEx for a European MNO, offering mobile services based on macrocell networks (Figure 3-2), shows that operational expenditures for a smallcell network can be categorized into two major segments which are: a) Support System and b) Operation & Maintenance. Therefore, by implementing a system that is capable of sharing resources in an efficient way, MNOs would be able to save on both these segments that are the representatives of network operational expenditures. The idea is to share costs with the same entities that resources are shared with.

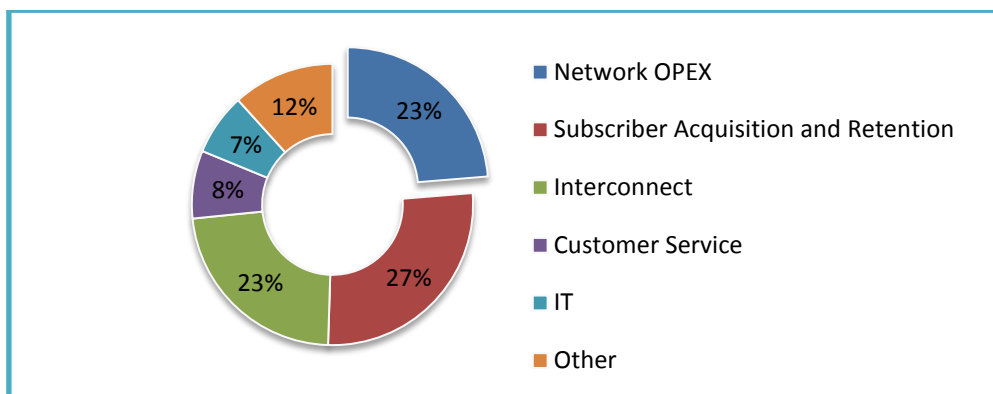


Figure 3-1 Typical OpEx Breakdown for a European Mobile Operator

Source: (Buvat, 2010)

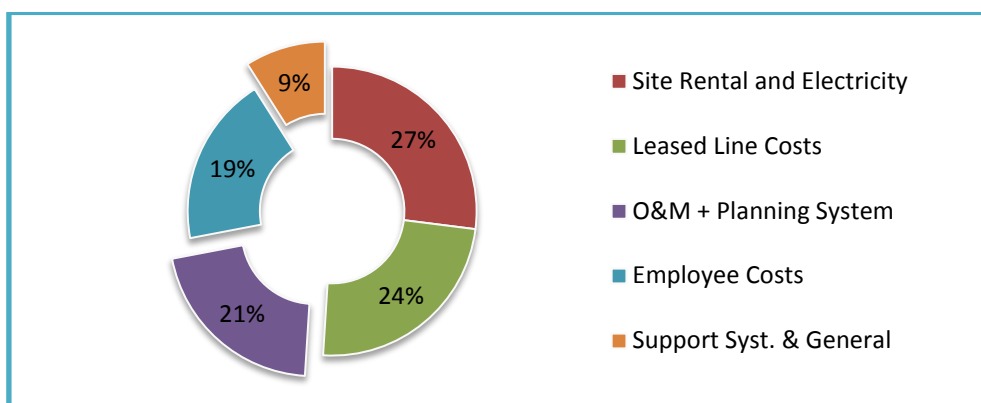


Figure 3-2 Typical Network OpEx break down based on Macrocell Networks

Source: (Harno, 2010)

A MNO's CapEx breakdown would mainly consist of network, marketing, interconnection and some extra costs (Analysis Mason, 2012) of which network CapEx embrace a big portion (almost 30%). Rolling out smallcell networks would prevent adding extra expenditures to operators' budget list. Depending on the chosen sharing model, operators may benefit from sharing spectrum, remembering fact that spectrum price is related to spectrum licenses which itself is categorized in CapEx.

Regulations and Entry Barriers

Stimulating sharing can enable economies of scale and competition among service providers, while dominating this situation is a key issue for most National Regulatory Authorities (NRAs). By provisioning the legislative system, the regulator could oblige carriers to implement models of sharing in order to enhance the level of competitiveness and create a more fair ecosystem for entrants. On the other hand, regarding the spectrum deficit dilemma, sharing approaches of licensed spectrum can be on the regulators' agenda. In order to resolve deficit of access to finance for new comers (operators), collaboration patterns are inevitable. The idea to overcome such dilemma by collaborating with existing actors (the ones with SMP) is a key to soften market entry for smaller actors. Such collaborations, regardless of its intrinsic risks, could be motivated as a *win-win* situation for both newcomers and existing carriers by considering the possibilities of lowering expenses. According to different applicable scenarios, a new operator could either become a MVNO or MNO. On one hand the lack of assets, such as spectrum licenses or CapEx, are supposed to be more easily prevailed and on the other hand particular actors of the indoor mobile network ecosystem (e.g. Facility owners) could also enter the market by taking a role in deployment of smallcell networks.

Spectrum allocation

The scarcity of available or reusable spectrum is leading to spectrum deficit in the near future (Kavehrad & Chowdhury, 2012). Experiences show that there is a limit for installations of new base stations, because eventually the RF signals would interfere with co-existing signals. As an answer, shorter-range transmitters and receivers that use dedicated cellular frequencies (i.e. femtocells) can be used in order to fill these so-called gaps in coverage. The idea of reusing the spectrum in smaller cell sized areas helps preventing the interference that is inevitable by deploying more dense networks by the aid of macrocells. Still, the spectrum deficit caused by traffic growth per cell site highlights the idea of sharing licensed spectrum when it comes to smallcell in mobile network deployments (Barrie, et al., 2012).

3.2 The main beneficiary of sharing

We identify three groups that most benefit which are: MNOs, O&M outsourcees and Subscribers. Although smallcells sharing models are derived from macrocell network sharing, it should be noticed that CapEx structure for smallcell networks do not fully comply with macrocell networks but some minor segments are missing for smallcell networks. Therefore, network sharing is still viably beneficial for MNOs. Considering active sharing as a part of wholesale sharing, it is still negotiable how MNOs would be able to differentiate their services while they use the same active devices and spectrum licenses. On the other hand, in case there is a shortage in existing licenses for different mobile generations (e.g. 3G or 4G), it could be inferred that the regulator also benefits active sharing since this issue can be solved by collaboration of MNOs using the same licensed spectrum. The MNOs would also benefit this situation since spectrum is one of the main assets for any mobile operator. One way to look at this situation could be considering a newcomer MVNO who does not possess any spectrum license and needs to collaborate with an existing license owner.

The last group is the subscribers. To be more precise, the subscribers could be segmented to residential and enterprise. The residential category itself contains both home user and

SOHO where the enterprise category could cover SMEs, public places like sport arenas, and big enterprises. The fact is that, residential and enterprise users would benefit from sharing differently. The major advantage for enterprises is accommodating subscribers from different operators within the same location plus reduced prices according to lowered CapEx and OpEx for MNOs, on the other hand residential users may benefit from lowered prices in accordance with lowered prices due to reduced CapEx while experiencing better quality of services.

3.3 Sharing models

The major enablers of network sharing in the context of smallcell networks are: Femtocell Access Points (FAP), Integrated Femtocell Wi-Fi Access Points (IFWAP), Femto Gateways (FeGW), Operation and Maintenance (O&M), and most importantly Spectrum. FAP, IFWAP and FeGW support sharing with minimal negative influx, while the other two aspects though need more cautions. Regarding network O&M, MNOs have different approaches, some believe in keeping Network Operation Centers in house while some have totally outsourced it. This shows that MNOs' policies in operating networks could be a barrier if it wants to be shared.

Spectrum allocation and access

For both mobile operators and third party actors it is of an interest to investigate alternatives to traditional licensed bands. Mobile operators want to avoid interference or "wasting" licensed bands, while for third party actors getting control over spectrum is a key to enter the business. At the same time, the recent allocation of unlicensed bands in the 1800 MHz band in countries like UK, Sweden and the Netherlands enable any actor the possibility to offer GSM voice services in local environments. This offers the possibility to use cellular technology without involving mobile operators. The GSM handsets are already available while another driver is that new smartphones will have LTE in the 1800 MHz band.

For indoor and low power systems another option is to exploit frequency bands allocated to other types of systems and applications. An example is broadcasting and the use of TV white spaces, i.e. TV channels not used at a specific location. Other examples are use of aeronautical bands just above 1 GHz and radar bands in the range 2.3~3.4 GHz (Zander, et al., 2013). A key aspect here is that manufacturers of networks and user devices will support the radio access technologies in these spectrum bands. The lack of manufacturer support is often mentioned as a major weakness for cognitive radio and secondary spectrum access solutions. However, more long term, investment friendly and less risky approaches like LSA are currently discussed (Parcu, et al., 2011). Another important aspect of spectrum allocation is the co-existence of macro and femto/picocell layers. One well known example for closed access femtocells are the coverage holes that appear around femtocells for devices connected to distant macro base stations using the same or adjacent channel (Markendahl, 2011). Standalone bands dedicated for small cell use hence would imply two types of benefits to mobile operators: 1) avoidance of interference with macrocells and 2) bands below 3GHz can be used for wide area macrocell deployment. Hence, roaming or third party indoor solutions not using licensed operator spectrum will provide additional benefits to operators.

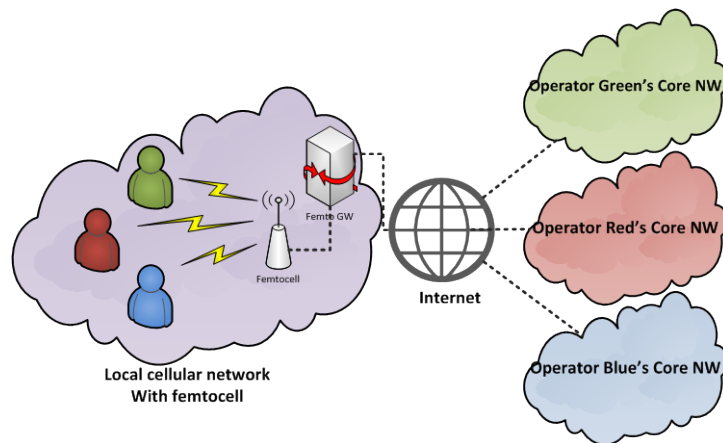


Figure 3-3 RAN Sharing in case of co-existence of FemtoGW (MORAN)

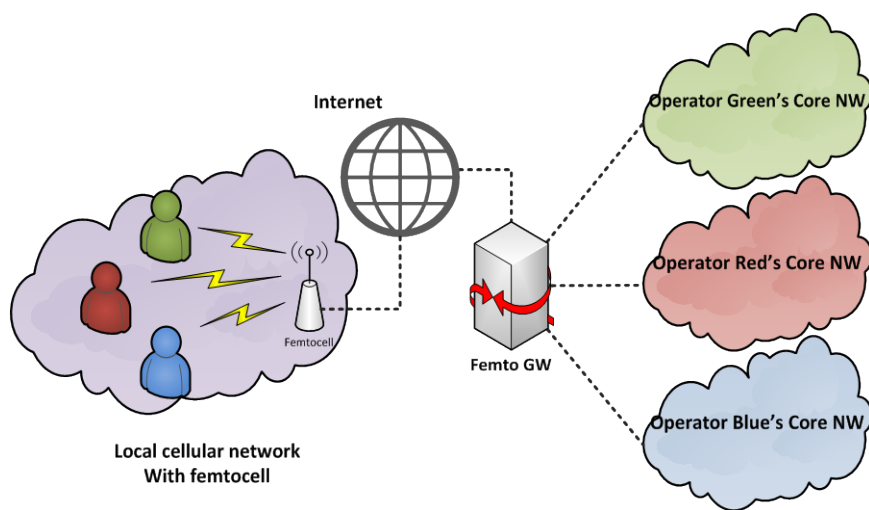


Figure 3-4 RAN sharing with shared FemtoGWs (MOCN)

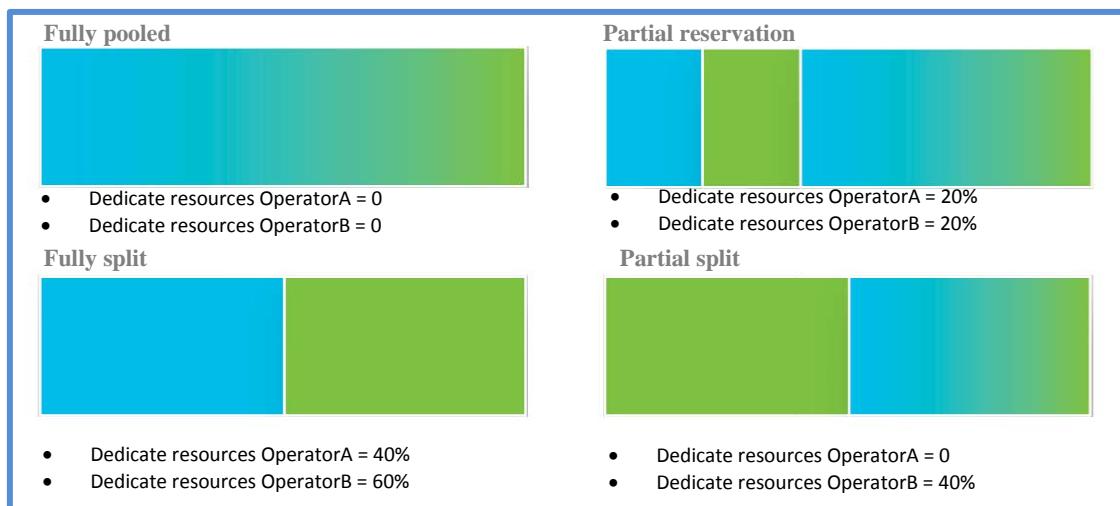


Figure 3-5 Capacity sharing at FeGW

source: (NEC, 2012)

Active Sharing (RAN sharing)

The Radio Access Network typically involves FAPs/IFWAPs and the immediately connected gateways that manage the access points (in case the FeGWs are located at the same premises that access points co-locate). Active RAN sharing involves sharing the gateways and

access points across multiple entities (e.g. network operators) with either separate spectrum resources for each entity or shared spectrum resources through spectrum pooling (Vadada, 2011). Active RAN sharing for smallcells enables several new interesting deployment scenarios. An example could be a content provider (e.g. YouTube) that leases resources from a MNO (e.g. Verizon) to improve service quality to its customers or to share costs for enabling video services to mobile users (Browning & Campbell, 2011) where this model generates new revenue streams for the MNO.

Two different implementations of RAN sharing are illustrated in Figure 3-3 and Figure 3-4 where the main difference is in the location of the Femto GW. This difference distinguishes the RAN sharing models by being either a Multi Operator Radio Access Network (MORAN) sharing approach or a Multi Operator Core Network (MOCN) sharing. In the second case, the frequency is also shared among operators, which means one PLMN id would be used. Figure 3-5 represents different spectrum sharing schemes in this essence. While Figure 3-5 also illustrates how the used frequencies would enable differentiation factor while a MOCN approach is being used.

Roaming

As the second sharing model for Smallcell networks, it is possible to subcategorize Roaming into two approaches. These approaches differ from involved actors' point of view but are technically the same. Technically speaking, Roaming model of sharing for smallcell networks is the case that the hypothetic operator A accommodates its subscribers and also Operator B's subscribers under its covered premises whilst Operator B may or may not proceed with the same approach. The important agreements that are subject to bind are roaming agreements between operators while they want to collaborate in terms of roaming.

The first subcategory of roaming is *Mutual Roaming*. In Mutual Roaming, the main outcome could be expanding the coverage area for different MNOs in order to expand their covered territory. In the second model, *Non-Mutual Roaming*, one operator accommodates its own subscribers and also one or more other MNO's subscribers but the agreement is not mutual. This model can be the case for many different types of business models and agreements. Two major viable cases are discussed here via two scenarios. It should be mentioned that both scenarios would look alike from subscribers' point of view while they differ when it comes to business roles.

Scenario A: consider a MVNO that do not possess any spectrum license and only targets enterprises and offers mobile solutions for businesses with a limited known number of users. The operator in this case binds a roaming agreement with a MNO that already owns spectrum. The MVNO implements a smallcell network for the respective enterprise offering them subscriptions and other services. The subscribers are under the MVNO's network coverage while they are inside the covered premises but they will roam to the MNO's network when they leave their office. On the other hand, the MNO's subscribers are not able to benefit the MVNO's smallcell network even if they enter its covered premises (Figure 3-6). It should be added that the roaming agreement could be expanded to other co-existing MNOs in order to expand the coverage for MVNO's subscribers. In this case the spectrum is needed to implement the network that may only be obtained from one MNO.

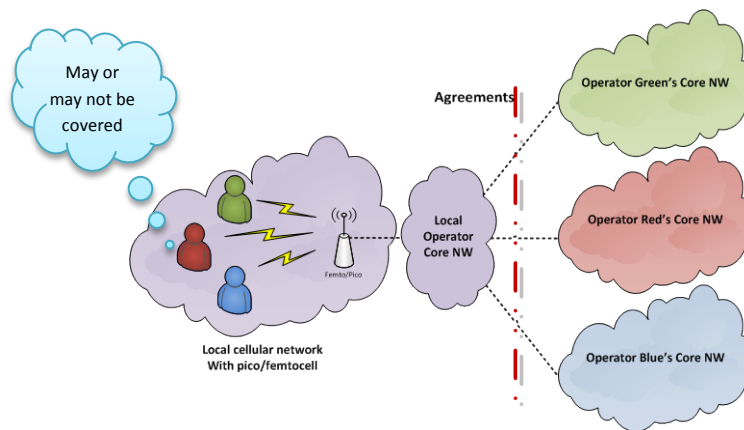


Figure 3-6 Multi-operator solution using local Roaming

Scenario B: a MNO that is a new entrant to one specific market tends to target only enterprises by offering them mobile solutions. In this case, this MNO possesses required spectrum licenses that enable deploying the smallcell network, but the relative costs to outdoor network deployment are not considerable for it and also the outdoor networks are not the targeted segment. In this case, the MNO deploys the network in an enterprise covering all their premises offering them subscriptions and other services they need and makes roaming agreements with other MNOs that already have coverage outdoor in order to enable its subscribers use their devices whilst they exit the covered premises as well (Figure 3-6). Like previous scenario, the agreements could be made with more than one MNO.

Wholesale Sharing (Comprehensive system)

The main objective of implementing a comprehensive system for sharing smallcell networks is to help existing MNOs who want to focus more on their subscribers by targeting contents and services. As it was discussed earlier, the idea to shift the value chain towards less focus on network and more on content/services enables the migration towards comprehensive systems. In such a model, MNOs will be able to dynamize their services by leaving operation and maintenance of their networks to existing network management specialists. After describing the model, it would be easily derived that the comprehensive system brings a simpler governance structure whilst operators retain the right level of control over the network to reach their business goals. The comprehensive system goes deeply hand-in-hand with outsourcing, which is the third area of deploying indoor networks. A third party plays the important role of operating and maintaining the network by offering an end-to-end solution to different MNOs. The idea is to level up the managed services' maturity by implementing such a system. In this system, MNOs would be able to lease the capacity they need just in time for expansions and/or when they want to roll out their systems.

3.4 Important factors

Differentiation

A differentiation strategy calls for the development of a product or service offering unique attributes that are valued by customers and customers perceive to be better than or different from the products of the competition (Porter, 1980). Since such differentiation for MNOs only comes by better coverage, higher data rates and better quality of services, it could

be deduced that sharing simply does not comply with it. The reason to disagree with this idea is the upcoming changes in the business landscape for MNOs and telecom services, the change in the value chain towards putting telecommunications on top of the contents/services, business processes and consumers (Mölleryd, et al., 2009). Remembering and Figure 2-1, MNOs have to reduce their costs trying to resolve the negative impacts of the *scissors effect*. In the next step they try to adjust to the differentiation strategy in another way like serving better services. It should be mentioned that prior to the point that MNOs started accepting sharing, they would consider sharing as a threat since they assumed their co-sharing partners (and at the same time competitor) may nobble and abuse the agreements.

Spectrum vs. Capacity vs. Coverage

In order to be able to bring the capacity needed, three techniques are candidate: improving spectral efficiency, denser infrastructure and obtaining more spectrum licenses (Zander, 2012). According to Cooper's Law of spectral efficiency (ArrayComm, 2012), the possibility of solving the problem by enhancing spectrum efficiency is not an option as well as acquiring more spectrum licenses, since the number of available licenses are limited. Therefore, the most valid solution is densification that could actually be a major driver for deploying smallcell networks considering the fact that as time goes on, more mobile users would be indoors instead of outdoors. Still, one could negotiate that the important issue that comes with densification is its related costs, which in femtocell's case would be quite low based on the fact that the deployment costs would only be relative to the equipment costs that are relatively quite low.

4 Outsourcing Network Operation and Management

The smallcell network O&M, based on the used sharing model, can be either done by the operator itself or an authoritative outsourcee. In some models it is more relevant to outsource O&M to an outsourcee. For instance, in case of MORAN sharing, since the FeGW is located at the customer's premises and shared among different operators, it is more admissible to operate the network by one singular outsourcee who controls the existing smallcell network. Another case of outsourcing O&M here is by implementing comprehensive systems. In case of such approach, it is the authoritative third party that is acting as a full outsourcee of network O&M for respective MNOs. Since in terms of operational expenditure, any indoor mobile network complies with more or less the same pattern as a macrocell networks, it can be depicted that the operational expenditure of such networks could be broken down typically as listed below. Although Customer Relations (customer acquisition, customer retention and customer services) enfold the biggest portion, at the same time Network OpEx embraces a bigger effect on operator's policies:

- Network OpEx,
- Customer Relations (CR),
- Interconnect,
- IT,
- Other.

In order to reduce OpEx, outsourcing network O&M is a valid option by accepting the change in business landscape described earlier. By adopting this model, the Network Operation Center (NOC) could be migrated to the outsourcee, creating a more dynamic business environment for the MNO. Due to complex business models for network operators in terms of gaining revenue at the same time handling costs, such entities need to focus more on their core business and try to lessen the burdens brought by technical functions. The idea to decouple CR and network OpEx is the main driver for founding the so-called authoritative third parties or at the same time called Managed Service Partner (MSP). Since Managed Services could be defined as the practice of outsourcing day-to-day IT management responsibilities as a strategic method for improving operations (Wikipedia, 2012), it could be inferred that a MSP is a company that is capable of being an outsourcee for operation and maintenance of an operator's network while the services offered are not considered as a wholesale sharing system (or a comprehensive system).

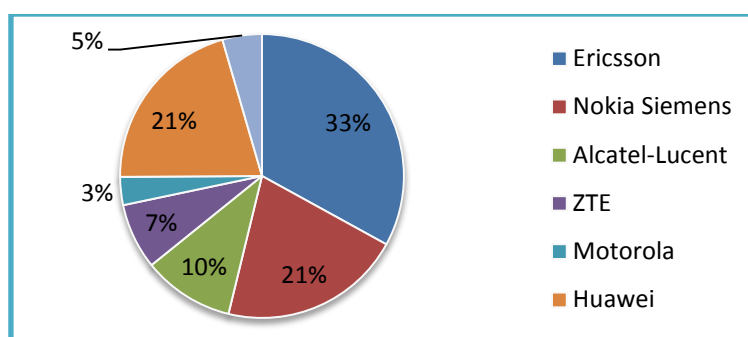


Figure 4-1 Market share of mobile infrastructure vendors (2010) Source: Portio Research Ltd.

Two major groups could be mentioned as valid MSPs for smallcells. The first group that already acts as MSP for macro cellular networks is Network Vendors (NV) (Figure 4-1). Since these companies are specialists in developing and manufacturing specialized telecom equipment, they better know how to operate and manage it in the most efficient way³. It should also be added that MNOs also trust their networks' infrastructure supplier when it comes to outsourcing the same networks' operation back to them. The second candidate then would be companies with fewer resources than NVs, but at the same time enough O&M competency. The reason that such firms are a viable choice to the outsourcing dilemma is less complexity of their business models as well as higher efficiency due to simplicity of their organizations in comparison to the first group. As a valid example of second group, there are some MSPs that offer a new method of deploying smallcell networks as a service for mobile operators called Small Cell as a Service (SCaaS).

4.1 Small Cell as a Service

SCaaS is an emerging model that allows third parties to roll out smallcell networks and then rent it to several operators thereby lowering the barrier to entry for deployment and total costs (Duffy, 2012). In this field, over the second quarter 2012, Virgin Media announced it is trialing LTE small cells in the UK ahead of launching its SCaaS offering, and Colt Telecom announced it is already in trials with a major European operator. Furthermore, two new

³ Greger Blennerud head of Marketing Mobile Broadband at Ericsson AB

companies Cloudberry Mobile and ClearSky have launched their own offerings in Europe and the US, respectively, targeting smaller operators. It is considerable that now there are more smallcells than macrocells deployed worldwide. The industry has passed a very important milestone and in the process changed the future direction of mobile networks. It could be interpreted that the days of small numbers of expensive cell towers have given way to the era of high numbers of low cost mini access points. Without this change, the mobile network simply could not sustain the continued growth in data usage⁴. Such a dramatic network transformation opens up interesting new models and over the past quarter the SCaaS idea has been gaining traction. It allows third parties to build networks that several mobile operators can use, thereby reducing costs and time to market. At the moment, this is being targeted at major operators that are looking for a simple route toward establishing a smallcell network as well as smaller players that have found the barriers to entry too much to enter.

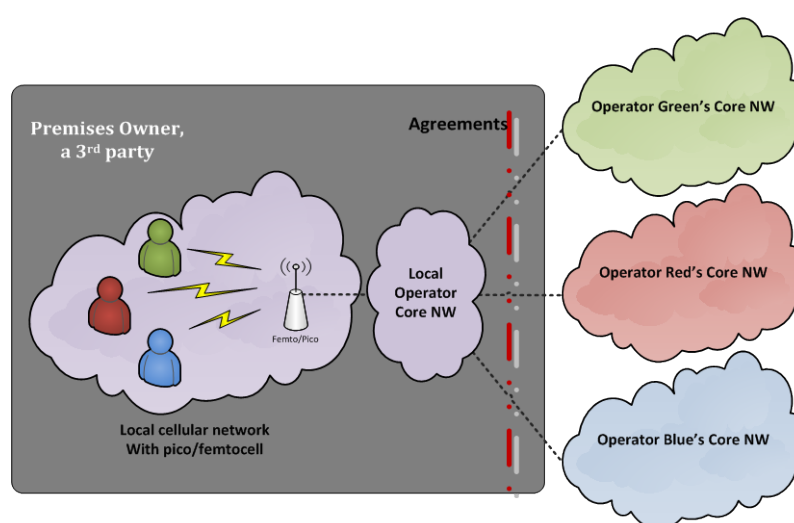


Figure 4-2 SCaaS implemented by Premises owner or 3rd party

Cloudberry Mobile: a case study

Cloudberry is a startup that provides small cell networks to enterprises in Norway. Their aim is to provide both mobile coverage and capacity where the customers need it. Based on their experiences, Cloudberry aimed at providing small cell services wholesale to other mobile operators in Europe and elsewhere. (Jenssen, 2012). Cloudberry offers SCaaS, where a smallcell network gateway (FeGW) is hosted and all the logistics of rolling out residential and enterprise femtocells are remotely operated. Cloudberry claims that since they understand how this needs to interwork with the internal business processes of the operator, they can also advise on the most appropriate marketing strategy as well. Cloudberry's focus is on the residential and enterprise markets and will subcontract and/or partner to serve both worlds. From the background of Cloudberry's CEO and CTO, while working at Network Norway, which is one of the pioneers in the concept of enterprise smallcells in the region, they claim to have gained considerable experience of what it is like to launch and operate this kind of service as an operator. By gaining both the marketing and technical expertise, they are capable of reducing the risk and timescale to deploy femtocells, which is believed to give

⁴ Dimitris Mavrakis, principal analyst at Informa Telecoms & Media

smaller operators a differentiating advantage. The target customers of Cloudberry are the smaller network operators in European countries, typically the 3rd or 4th, who do not have such large network assets as their larger competitors. Cloudberry's solution may also be attractive to some MVNOs. By providing small cells to their own customers at the primary places where they are used, Cloudberry can help differentiate the service they deliver and give them a significant competitive advantage.

5 Business analysis of roles and actors

The major actors of the smallcell ecosystem can be categorized as:

- MNO/JV,
- Network Vendors,
- Managed Service Partner (MSP),
- Facility Owners (FO), and
- Regulator.

A generic smallcell ecosystem could look alike Figure 5-1 where all possible business relations between actors are illustrated. It should be highlighted that the regulator (NRA) is considered to have an administrative role, looking after the relations and businesses. Since the Facility owner (*Hidden Actor*) determines how the network should be deployed, they prefer to avoid multiple infrastructures running in their facilities as well as preferring interacting with only one entity in different stages (deployment and operation). The PO's role in the decision making process becomes more vivid when the Facility owner is considered as the whole or partial owner of the physical infrastructure of the network.

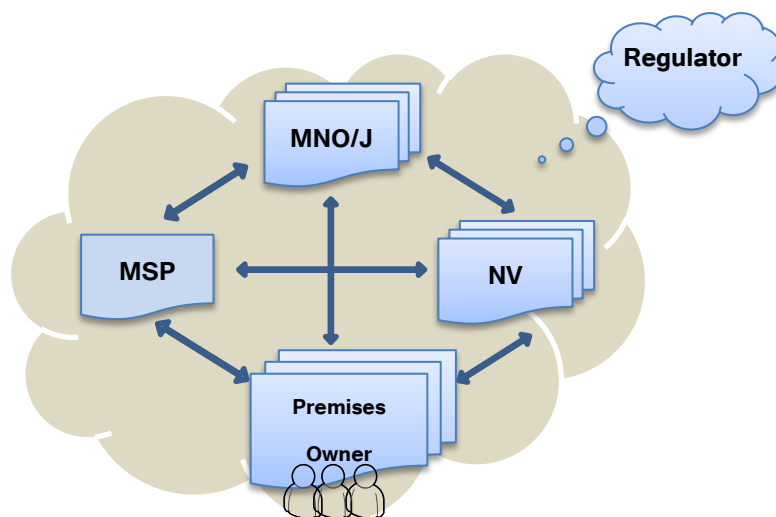


Figure 5-1 Smallcell Networks ecosystem

Based on described sharing models and outsourcing scenarios, the following list of 6 cooperation patterns can be adopted by different types of operators for small cells:

- [1] A JV deploys and operates the indoor networks.
- [2] A MNO/JV deploys the network and a third party operates the network.
- [3] A MSP deploys the network and handles its O&M as well, for either one MNO/JV or more.

- [4] A MSP deploys its own network and makes roaming agreements with MNOs/JVs for outdoor coverage.
- [5] An enterprise deploys and operates its indoor network and makes roaming agreements for outdoor coverage.
- [6] A MSP (that is also a NW vendor) deploys the network and also takes care of its O&M offering a *comprehensive system* based on Service Layer agreements while making roaming agreements for outdoor coverage.

Table 5-1 discusses different scenarios of deploying Smallcell networks along with a more vivid description of the business relations between actors involved. The proposed cooperation patterns could be interchangeably used in these scenarios based on the needs. The main outcome of each solution is general, considering that they might be broken down to sub categories from which any actor may benefit diversely. This table also illustrates that according to different standpoints of operators and third parties, the relevant options may differ in a specific type of partnership. This matter elucidates the fact that operators and third parties have different business goals that may or may not coincide. Therefore, it could be derived that the most mutually profitable option would be the one that both parties consent to.

Table 5-1 Cross comparison of Operators and third parties points of view on Smallcell networks

| | From Operators' point of view | | | From third parties' point of view | | |
|----------------------|-------------------------------|-------------------|--------------|-----------------------------------|--------------------|--------------|
| Type of partnership | Main actor | Outcome | Valid option | Main actor | Outcome | Valid option |
| Share | JV | Save CapEx | 1 | JV | Added value | 2 |
| Outsource | Authoritative third party | Save OpEx | 2 | MSP | Added value | 2 |
| Share & Outsource | MSP-JV | Save CapEx & OpEx | 2 or 3 | MSP | Added value | 3 |
| | | | | Enterprise | Special services | 5 |
| Comprehensive System | MSP | Great Flexibility | 6 | MSP | New revenue stream | 6 |

5.1 Challenges

Big brother dilemma

Existence of actors with SMP in any market, that due to specific reasons (either public or hidden), do not support suggested cooperative patterns can lead to the *big brother dilemma*. For instance, in case a major NV that is one of the biggest macrocell network O&M outsourcees in the world does not support network sharing or even smallcells in the beginning would cause the MNOs in that respective market to avoid adopting such patterns or technologies in order to avoid confronting the big brother.

ISP dilemma

When smallcell networks start growing in large scales, the Internet Service Providers may see this situation both as a threat and an opportunity, since smallcells heavily rely on existing internet connections indoors as the backhaul for their networks. Considering that the bandwidth dedicated to the internet connection is enough for both smallcell traffic and other previous services concurrently, smallcells add extra throughput to the overall data volume been consumed beforehand. As a result, ISPs may contemplate that the MNOs are benefiting

from the ISPs resources without sharing the emergent revenue with them determining they want some portion of the revenue as well. In some cases, the ISP that serves the Internet access in a specific premise is the rivalry MNO that also offers broadband services. On the other hand, since ISPs are mainly experiencing low margins in their benefits, they can oversee this challenge as an opportunity by offering better rates to such smallcells operators.

Regulator

Authorizing usage of shared licensed spectrum is a must that needs to be regulated by the NRAs in order to enable some cooperation models. This idea goes along with regulating selling network capacity along with allowing third parties to own active resources. By introduction of wholesale network sharing in macrocell networks, regulators were persuaded to consider shared spectrum licenses as a response to spectrum deficit. This way, comprehensive systems would also benefit from the situation, encouraging third parties to act as one. Otherwise, one of the main drivers behind rolling out CSs that is benefiting from shared active assets would then be counteracted. On the other hand, regulators may decide upon forcing operators by making legislative constraints in order to dominate economies of scale and more importantly economies of scope which would in the long run profit end users.

6 Conclusion

As a result, MNOs can be categorized into two major groups; Traditional and Third party operators (Figure 6-1). This shows that pre-existing telecom business models that are basically based on the infrastructure business are soon to be changed diversely. The major upcoming shift would be migrating towards OTT services and outsourcing the network O&M to third parties and MSPs. Based on Figure 6-1 and the cooperation patterns discussed in Table 5-1, in order to maximize benefiting from the possible opportunities, a recommendation table is formulated that also briefly describes the justification of each recommendation .

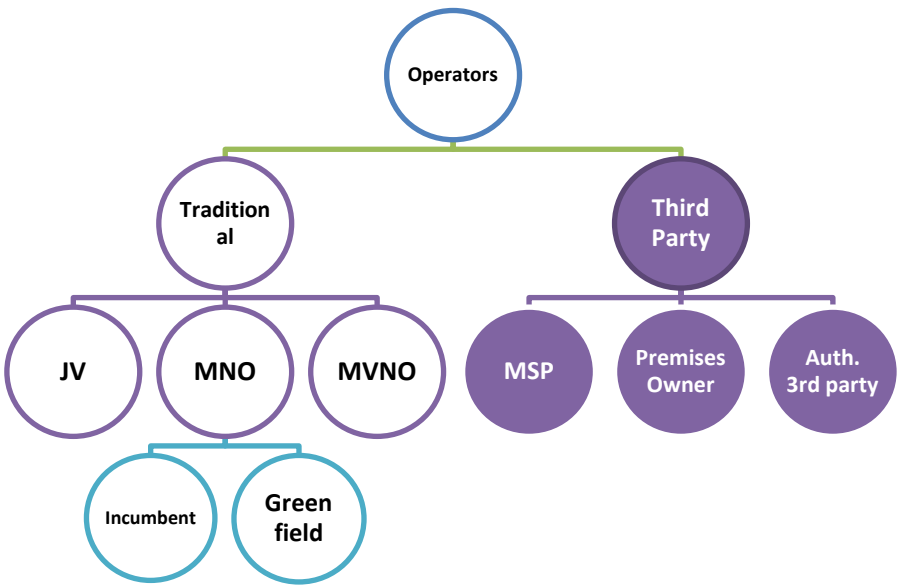


Figure 6-1 Traditional operators vs. Third party operators

Table 6-1 Recommended cooperation pattern for different operators in smallcell networks

| | Traditional operators | | | | Third parties | | |
|------------------------|---|--|--|---|---|---|---|
| Type of partnership | MNO | | JV | MVNO | MSP | Facility Owner | Auth. 3 rd party |
| | Incumbent | Greenfield | | | | | |
| Rationale | Reduce OpEx mainly by outsourcing | Reduce CapEx mainly by sharing | Reduce CapEx & OpEx | Reduce CapEx & OpEx | Generate new revenue stream | To offer specific services | To obtain added value |
| Recommended option | 2 or 3 | 3 | 6 | 6 | 6 | 5 | 2 |
| Justification | They already have SMP and are not willing to risk their position by sharing | They have enough financial credibility to implement their solo network | Sharing is the origin of JVs, so reducing costs is a convincing factor | SMP deficit is their reason to be a virtual operator, so lowered costs is a KPI | Their agenda is to partner-up with other actors and offer CSs | They try to cover a niche market | They are believed to be specialists in O&M that do the job in an optimized manner |
| Further recommendation | Act as a CS provider | Benefit from CSs and focus more on core business activities | Outsource O&M entirely | Focus on CR and stay flexible | --- | Create a new format of model 6 and benefit from CSs | --- |

Eventually, in order to conclude the discussions, the proposed research questions are answered:

How could spectrum frequency be utilized in different shared indoor mobile networks?

Based on the adopted cooperation pattern by involved actors, the spectrum utilization could be different. Most importantly, in case the CS concept is adopted, licensed spectrum should be shared that is not quite common. The main issue then would be enabling sharing spectrum by the NRA, meaning that the shared use of a licensed spectrum should be first regulated; otherwise wholesale sharing is not possible to be implemented.

Who are the actors in the shared indoor mobile networks ecosystem?

As stated in section 5, main actors of the ecosystem are MNO/JV, Network Vendor, Managed Service Partner, Facility Owner, and Regulator. Out of which the main discussion of this paper is around MSPs and how existing of this actor would change the ecosystem by introducing wholesale smallcell network sharing. On the other hand the different ideology of the regulator as well as the FO also shows the complexity of the winning cooperation models.

How could Facility owners cause new relations between actors in the ecosystem?

As the *hidden* actor, FO has the final say in how the smallcell network should be deployed and who should operate such a network. Therefore, based on the FO's agenda, it will be determined how multiple actors will be able to cooperate since there would be most probably one actor at the end which interacts with the Facility owner. Since we believe that the FO will be eventually the whole or partial owner of the infrastructure, the decision on who shares with whom will be finally made by the PO. As a result the tradeoff between control over own network and the extent of sharing for carriers also depends on PO's agenda (Figure 6-2).

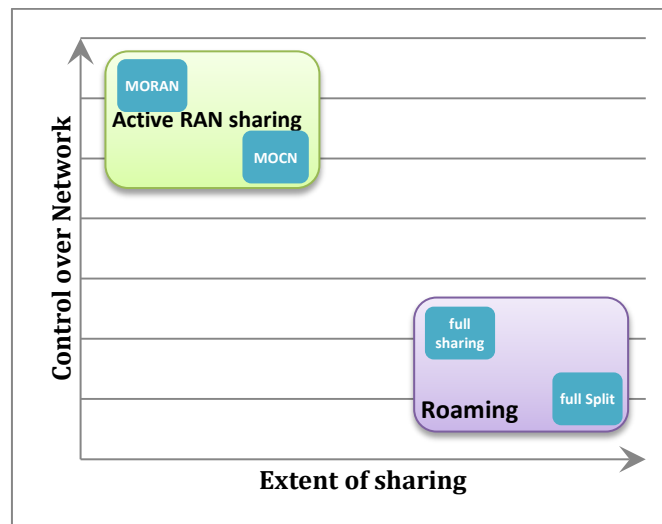


Figure 6-2 Trade off between network control and extent of sharing in smallcell networks

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