Paper submitted to the IMP Conference 2103, Atlanta

NETWORK COOPERATION BETWEEN MOBILE OPERATORS - WHY AND HOW COMPETITORS COOPERATE?

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Abstract

After year 2000 with the introduction of third generation (3G) mobile networks a new type of cooperation between competitors emerged, network sharing. Cost reduction is often mentioned as the main driver for network sharing. However, cost aspects are only part of the story "why" operators cooperate. In this paper we discuss multiple aspects of "why" operators cooperate and also "how" competing mobile operators cooperate.

Besides cost the "why" aspect is discussed in terms of market position, market entry and exploitation of the resources and skills of the sharing partner but also drawbacks of sharing. The patterns of cooperation are illustrated by analyzing how roles, responsibilities and resources can be distributed among the mobile operators. The findings are based on case studies where we make comparison in three different domains. In the time domain we compare network sharing in Sweden the years 2000 and 2010. From a cost perspective the drivers to share networks have decrease since many base station sites can be re-used. Anyway, new network sharing companies are formed in order to make the network operation more efficient.

We also compare cooperation between operators at the Swedish and Indian mobile markets. In both countries the competition is very strong. Network sharing is used but in India the cooperation is organized through tower companies, hence the operator cooperation is weak.

Finally we look into network sharing principles for indoor network deployment in Sweden. The cooperation between operators is strong but not as strong as for the network sharing joint ventures. The tie between two operators can be said to be weaker since several mobile operators, the facility owner and also enterprises may be included in cooperation. In addition the investment risk is lower.

Keywords

Actors, resources and activities, business models, competition & cooperation, mobile broadband network deployment, network sharing, outdoor & indoor deployment, techno-economic analysis

INTRODUCTION

This paper addresses the issue on why and how mobile network operators (MNOs) cooperate with their competitors. Traditionally telecom operators, especially the former state-owned monopolies, have had a lot of different resources and competencies in-house and offered services using a vertically integrated value chain. In the 1980´s, the Swedish incumbent "Televerket" (now TeliaSonera) internally had many type of resources: network deployment, civil works, development and manufacturing of switches and handsets and, own R&D departments. Today, the situation is very different for the mobile operators. Activities like tele-marketing, helpdesk, and billing can be outsourced, characterized by cooperation in a traditional buyer-seller context. Another trend involving close cooperation between mobile operators and network manufacturers is outsourcing of operation and maintenance of the networks. Managed services are increasing the share of the business and revenues of companies like Ericsson, Huawei and Nokia-Siemens Networks. The network management services are in many cases, especially in emerging markets, combined with the deployment of network equipment and network roll-out. This results in close cooperation between providers of the managed services and the mobile operators. All the mentioned types of cooperation are done in a buyer – seller setting.

However, with the introduction of third generation (3G) of mobile networks after year 2000 a new type of cooperation emerged, the sharing of networks between competitors (Village et al., 2002) (Beckman & Smith, 2005) (Frisanco et al., 2008). In Sweden, a close cooperation between mobile operators was established using joint ventures for the network planning, deployment and operation of mobile networks. Two network sharing companies have existed for more than 10 years. When fourth generation (4G) networks were announced in Sweden the business landscape changed. One of the sharing partners in one of the joint ventures decided to build its own network. The result was that a new joint venture was formed, while the two existing joint ventures continued its business (Markendahl, 2011). Hence, the Swedish network sharing companies are interesting to investigate in order to examine "why and how" the cooperation between competitors is established.

The business aspects of shared networks are often discussed in terms of cost but some researchers address the risk, benefits and barriers for network sharing (Oliver Wymann, 2007) (Tankard, 2010). This addresses to some extent the "why share?" question but the "how to share" aspect is not that much researched from a business model perspective. In this paper we will use the Swedish network sharing cases as a starting point for the discussion. We will make a comparative analysis in three different domains. In the *time domain* we will analyze how network sharing strategies have changed in Sweden during the years 2000 and 2010 (Markendahl, 2011). Next, we compare network sharing in Sweden and India, as these countries have a totally different *market structure* and level of development for mobile services (Markendahl & Mölleryd, 2012). Finally, we discuss network sharing for indoor deployment where different technical solutions and business models are outlined (Markendahl, 2011) (Ghanbari, 2013).

The overall purpose with the paper is to identify and describe different patterns of cooperation used by mobile network operators. The key research questions are:

1. What are the drivers and obstacles for cooperation among mobile operators?
2. How is the cooperation between mobile network operators organized?
3. What are the roles of mobile network joint ventures?

RELATED WORK

Shared networks and business aspects

Descriptions of options for sharing of technical resources among cooperating operators were common during the years after 2000 when different strategies for sharing of base station sites, antennas, and radio equipment were presented (Village et al., 2002) (Beckman & Smith, 2005). Business opportunities and potential cost savings was described in a number of white papers from the telecom vendors that started to appear after year 2000. The benefits and barriers of network sharing are discussed in some papers (Tankard, 2010) (Oliver Wymann, 2007). Frisano, et al. (2008) presented a business analysis using a business model classification approach proposed in (Oliver Wymann, 2007). Besides this classification of business models the "how to share" aspect is not addressed from a business perspective when it comes to mobile operators. For WiFi and hot the cooperation patterns and business models are analyzed in (Bar & Park, 2006) (Markendahl & Mäkitalo, 2007) (Cox, 2008) (Middleton & Potter, 2008).

Cooperation, competition and co-opetition models

Different types of co-opetitive relationships between competitors are described in (Bengtsson & Kock, 2000). The relationships are characterized as being cooperation dominated, equal or completion-dominated. In (Luo, 2007) co-opetition is characterized in terms of intensity and diversity. In (Gnyawli et al., 2008) a framework is described where co-opetition occurs with high or lower intensity between the partners. Mobile operators compete on a national telecom market with few other actors. Similar markets with few large actors, the dairy industry in Finland and the brewery industry in Sweden, are analyzed in (Bengtsson & Kock, 2000). Tensions due to unstable or changing market conditions are discussed in (Luo, 2007) (Park & Russo, 1996). For network sharing a number of tensions can be identified although this type of co-operation is long-term and characterized by stability. One potential cause of tension is if one partner wants to improve its own market position by getting a greater share of the jointly created value resulting from the cooperation (Ritala & Hurmelinna-Laukkanen, 2009). These findings are also related to the value network configuration for mobile operators that are used in (Andersen & Fjeldstad, 2003). Three main groups of parallel activities: marketing and contract management, service provisioning and infrastructure operation.

Cooperation for indoor networks

Three major indoor solutions are picocells, DAS and femtocells. As a smaller scaled implementation of macrocells, in-building picocells are generally owned by wireless service providers; therefore they adapt the same cooperation patterns as macrocells (Smallcellforum, 2012). But, the major cooperation in in-building mobile network deployments are augmented most likely on DAS approaches which have been discussed for a long time (Saleh et al., 1987) (The DAS forum, 2012). These discussions mainly consider sharing of resources, i.e. infrastructure, sites, spectrum etc. (Mumtaz et al., 2012) (Offergelt et al., 2011) (Khan et al., 2011). Besides analysis of local Wi-Fi and private networks in (The DAS forum, 2012), an analysis of some business scenarios are presented in (Markendahl, 2011). Regarding femtocells, MNOs and manufacturers have mainly discussed deployment of femtocells in white papers from a single operator point of view, where deployed networks consist of home usage and so called residential Femtocells (small offices i.e. SOHO) (Offergelt et al., 2011).

RESEARCH APPROACH AND DATA COLLECTION

Analysis Approach

The overall question on why and how operators cooperate are answered by analyzing a number of cases. These cases are different; the network sharing agreements in Sweden using common joint ventures, the network sharing through tower companies in India and the cooperation among mobile operators, facility owners and enterprises in order to enable a common indoor infrastructure. The data about these cases are collected through a number of meetings and interviews with different types of actors, see next section.

For the interaction between market actors and the involved economic processes we use basic ideas from business network research concerning processes (Håkansson & Snehota, 1995) (Mattsson & Johanson, 1992). We complement this by discussing the value proposition, the firm organization and value chain, and the position of the firm in the value network (Chesbrough & Rosenbloom, 2002) (Markendahl, 2011). With this approach separate activities, responsibilities and use of specific resources by different actors could be identified. This type of analysis provided input to the design of maps showing the distribution of activities among actors. Often the activities belong to certain groups of responsibility.

Examples are activities like network planning, survey of site locations, site construction and installation that is part of the activity group network deployment. The actors perform certain activities using some type of resources. The control of a resource and the responsibility for the related activities are closely linked. The business analysis is focused on the cooperation aspects and the relations between the actors in the network of actors that provide different mobile services to end-users. The analysis will provide insights about the following aspects (Markendahl, 2011) (Frisanco et al., 2008):

- What activities and actors that are included in the value network,
- How the roles are distributed among actors,
- The interaction patterns between actors
- What actor(s) that organize the value network.

For description and analysis of patterns of cooperation and competition we use the co-opetition dynamics framework proposed by Bengtsson et al (2010). The dimensions of cooperation are degree of complementarity, degree of trust and the tie strength (i.e. the characteristics of interaction between parties in terms of duration, frequency of contracts). The dimensions of competition are degree of symmetry, degree to which parties perceive each other as competitors, intensity in competition, and degree of hostility existing between parties.

Both cooperation and competition can be weak or strong and the different combinations are used for the analysis. A typical example of “co-opetition” occurs when both cooperation and competition are strong. This situation will result in tensions between the partners, “high degree of hostility and symmetry” (Bengtsson et al., 2010), and high degrees of trust and tie strength, meaning that parties are willing to cooperate.

Collection of Primary Data

One set of interviews was made in 2010 with representatives for mobile operators Tele2, TeliaSonera and Telenor. The objective was to collect insights and experiences of the mobile operator after 10 years of network sharing in Sweden (Markendahl, 2011). A second set of interviews was done in 2012 with representatives for the network sharing companies in Sweden. These are all joint ventures formed by the mobile operators: Swedish UMTS Network AB (SUNAB), 3G Infrastructure (3GIS) and Net4Mobility (N4M). The interviews were done with the present CEOs of SUNAB and N4M and with the former CEO of 3GIS. The questions were about drivers for sharing, the role of the joint venture, what kinds of activities that have been part of the cooperation (and not) and finally the lessons learned from the cooperation.

In order to analyze the technical and business feasibility of local area networks and indoor deployment solutions it was essential to develop some level of understanding about current indoor solutions, deployment strategies and business models. Hence, a number of actors have been interviewed about requirements, problems and different solutions; Swedish operators, facility owners and user organization, equipment vendors and system integrators, see table I.

Outsourcing and managed network services have been discussed with Ericsson and 3GNS and Icomera (Markendahl, 2011) (Ghanbari, 2013) (Markendahl & Ghanbari, 2013).

Table 1 Interviews about indoor networks carried out with Swedish actors 2011-2013

Company	Type of actor	Position/department of interviewed person(s)
Telia	Mobile operator	Network planning department, indoor solutions
Tele2	Mobile operator	Manager network planning
Spring Mobile	Mobile operator	Marketing manager
The Cloud	Hot spot operator	Manager Nordic Operations
Ericsson	Equipment vendor	R&D network deployment
Ericsson	Equipment vendor	Global services research
3GNS	Network services	R&D
Powerwave	Equipment vendor	Marketing
Icoemara	Equipment vendor	CEO and R&D
Absolute Mobile	Systems integrator	CEO
MIC Nordic	Systems integrator	CEO
Jernhusen	Facility owner	Marketing
Swedish parliament	User organization	IT department
Uppsala University	User organization	IT department, corporate network planning
Royal Inst of technology	User organization	IT department, corporate network planning

During a trip to India in February 2012 eleven meetings were organized in order to obtain data and capture an understanding of the Indian telecom market. We met representatives of three major mobile operators: Bharti Airtel, Idea Cellular and Reliance Communications, and the largest independent tower company GTL Infrastructure. We also had meetings with telecom manufacturers, telecom analysts and with advisors at the Ministry of Communications & IT and the Telecom Regulatory Authority of India (TRAI) (Markendahl & Mölleryd, 2012), table 2.

These interviews made it possible to establish an in-depth knowledge about the Indian mobile market, the main issues that were addressed during the interviews are listed in table 3.

Table 2 Interviews carried out at the Indian field trip in February 2012

Company/organization	Industry	Position/department of interviewed person(s)
IIFL	Investment bank	Senior Telecom Analyst
Idea Cellular	Mobile operator	Chief Technology Officer, Chief Financial Officer Senior Manager, F&A, Finance & Accounts
GTL Infrastructure	Tower company	Senior Vice President, Corporate Affairs President Operations, Vice President Marketing, President, Investor Relations & Strategic Planning
Reliance Communication	Mobile operator	President, Head of Investor Relations
Nirmal Bang	Investment Bank	Senior Research Analyst
Bharti Airtel	Mobile operator	Group Director, Corporate Affairs President, Corporate regulatory,
Qualcomm India Private	Equipment manufacture	Vice President, Gov. Affairs India & South Asia
Ministry of Communications & IT, Wireless Planning & Co-ordination, DoT,	Government Ministry	Wireless Advisor to the Government of India,
Telecom Regulatory Authority of India (TRAI)	National regulator	Advisor on Broadband & Policy Analysis
Bharti Airtel	Mobile operator	Head of network planning
Vihann Networks Limited	Equipment manufacture	CEO and Chairman, Advisor AVP – Defence & Security Solutions

Table 3 The issues addressed during the interviews in India 2012

Company/organization	Issues addressed
IIFL	Indian mobile market, Competition, Capex, Price development
Idea Cellular	Mobile competition, network sharing, prices, spectrum policy, regulatory framework, mobile technologies, profitability, mobile pricing
GTL Infrastructure	Network sharing, infrastructure, tenants, competition, towers, backhaul
Reliance Communication	Mobile market, competition, network sharing, mobile broadband, regulatory framework, mobile technologies, spectrum allocation
Nirmal Bang	Mobile market, prices, network sharing, growth and profitability
Bharti Airtel (parent company)	Mobile market, outsourcing, competition, market development, network strategy, internationalization, access to spectrum, 3G, 700 MHz, backhaul
Qualcomm India Private	Mobile broadband, spectrum policy, mobile technologies Wimax vs LTE, CDMA, spectrum valuation
Ministry of Communications & IT	Spectrum policy, spectrum allocation, Network sharing, spectrum caps, spectrum auctions, spectrum valuation, international harmonization
Telecom Regulatory Authority of India (TRAI)	Spectrum allocation, cost calculation, regulatory framework, spectrum pricing, competition, network sharing
Bharti Airtel	Network planning, outsourcing, network, mobile market, mobile coverage, backhaul, fiber
Vihann Networks Limited	Spectrum valuation, competition, regulatory framework, mobile market, network equipment, handsets, rural market

NETWORK SHARING IN SWEDEN

The Development of Shared Networks in Sweden

In December 2000 four 3G licenses were awarded. Two of the operators had GSM services, Tele2 and Europolitan (later Telenor). Two operators were entrants at the Swedish market, Orange and 3 (Hi3G or Hi3G Access). Orange did not deploy any network why the 3G license was returned to the Swedish regulator PTS and the spectrum was later allocated to the other licensees. Europolitan and Hi3G formed a joint venture and started the network company 3GIS (3G Infrastructure). Network sharing was allowed under the condition that the operators provided own dedicated networks for at least 30% of the population. The result was that Hi3G and Europolitan did build both own networks and a shared network. The operators also agreed that users of Hi3G could roam into the 2G networks of Europolitan in areas were Hi3G did not provide any 3G coverage. This agreement was terminated in 2008.

The incumbent TeliaSonera, did not get any 3G-license but the two competitors Tele2 and TeliaSonera decided to build a common 3G network using Tele2's license. The two companies formed a joint venture called Svenska UMTS Nät AB (SUNAB) for planning and building a new 3G network. Both operators continued to run their own GSM networks.

In April 2009, Telenor and Tele2 announced an agreement to form a joint venture called Net4Mobility for deployment of a "4G" network using LTE technology. TeliaSonera had decided to build its own 4G network and was not interested to expand its cooperation with Tele2 to include LTE. TeliaSonera launched the first commercial LTE network in the world in July 2010. From 2011 TeliaSonera, Tele2 and Telenor all market and offer 4G mobile broadband services. For the spectrum auction in the 800 MHz band Telia, 3 and Net4Mobility acquired 10 MHz each and in the 1800 MHz band Telia and Net4Mobility acquired the licences.

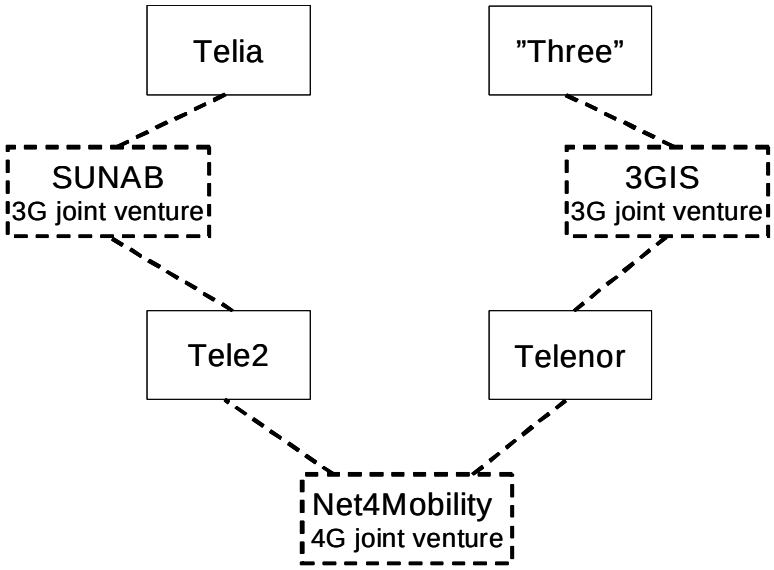


Figure 1 Mobile operators and network sharing joint ventures in Sweden

Distribution of Roles and Responsibilities

Networks can be shared in a variety of ways, both technically and business wise, see (Village et al., 2002) (Beckman & Smith, 2005). The network sharing strategies are different for the two Swedish 3G network sharing companies. Telenor and Hi3G in addition to the shared network operated by 3GIS also run their own 3G networks. Hence, there are three separate networks, see figure 2. Telenor, Hi3G and 3GIS all have their own network planning groups. 3GIS has no own end-users, as they just provides capacity to Telenor and Hi3G.

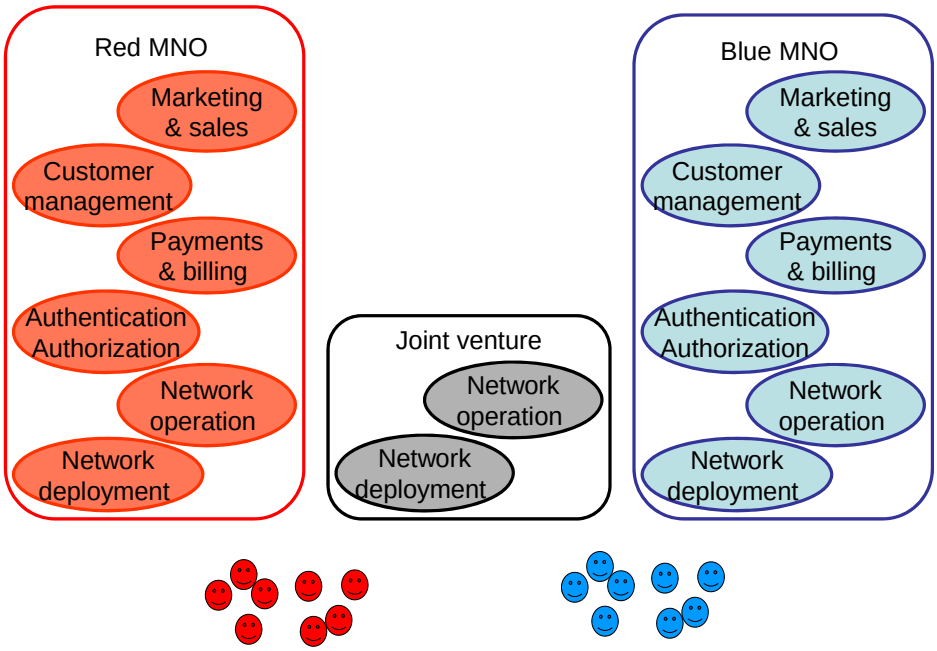


Figure 2 Example of distribution of roles among operators, the case 3G networks provided by Hi3G and Telenor

The cooperation between TeliaSonera and Tele2 is slightly different to the case of Telenor and Hi3G. There is only one 3G license, the one awarded to Tele2, and one 3G network. Tele2 and TeliaSonera are both owners and customers of SUNAB, but they are also suppliers. SUNAB does not have their own network planning group, but rather uses resources of Tele2 and TeliaSonera. In each of four geographical areas one of the operators is responsible for the network planning and deployment. Each operator also has its own Network operation center (NOC) for monitoring and control of the network.

For all network sharing cases the operators compete for end-users. All resources for marketing, customer relation management, and billing are controlled by the separate mobile operators. It is only activities related to planning, deployment and operation of the mobile networks that are done jointly. Traffic data and user statistics of each operator is not available to the sharing partner. The “control of own customers” used for network sharing is the same as for other types of cooperation where operators share network resources, e.g. national roaming and Mobile Virtual Network Operators (MVNO).

Findings from interviews about network sharing

In both the cases of SUNAB and Net4Mobility the involved operators have three distinct roles. Besides being owners and customers of the networks services the operators are also suppliers to SUNAB and Net4Mobility for the planning, building and deployment of the networks. The SUNAB network is divided in four geographical areas, where TeliaSonera and Tele2 are responsible for planning and deployment in each of the two areas. The agreement includes incentives for the operators to build at the lowest possible cost while maintaining a predetermined quality. The same approach with area responsibility is used for Net4Mobility.

In order to cooperate with a competitor there needs to be a common short and long term strategy. This includes deployment plans, investment plans, specification of network features and how to manage existing sites. It is seen as difficult to exit a sharing agreement, even though conditions for an exit are included in the agreement. The sharing partners have to agree on several aspects, like for example:

• How much of the network should be shared?

• How to share costs for investments and use of the network?

• How to make decisions for network expansion?

• How to do when one partner wants to build out the network?

Reduced network cost is an obvious driver for sharing. At the interviews a number of other aspects related to network sharing were also mentioned: The market position of the sharing partners, the number of new sites that needs to be deployed, the cost structure of the network and the availability of spectrum. For a small operator or a new entrant it can be beneficial to have an established operator as a partner. The new partner can obtain access to the brand, network competence, existing sites and transmission with backhaul. There are a number of observations of network sharing that can be made on a strategic level.

- Sharing was the only feasible solution to enable a cost efficient deployment to fulfill the coverage requirements stated in the 3G licenses in Sweden.
- For the largest operator TeliaSonera, network sharing was the only way to enter the 3G business since they did not get any 3G license.
- The motivation for sharing was not entirely related to the 3G network itself, all operators wanted to protect some part or all of the existing business. The key question was if the operator would enter the 3G business at all.

However, it was not obvious that the existing GSM mobile operators should enter the 3G business and build 3G networks. A representative for one of the operators stated: *"One option for us was to focus on voice services and continue with GSM*

At all interviews the lower degree of independence was mentioned as a critical issue. The operators do not have full control over the network strategy and investments. The decision making on investments is slowed down, it takes more time and efforts. The savings in network CAPEX is easy to estimate while it is more difficult to estimate the *"cost"* for the loss of independence when it comes to network strategies. *" Hence, you should not believe that network sharing is an easy way to save costs".*

At the same time many benefits of the sharing can be identified. In the SUNAB case the cooperation did work very well during the first six years when the network was deployed. SUNAB seems to have worked well as a neutral actor that can balance different interests. The conditions in the sharing agreement are explicit, more traffic by one operator leads to higher fees. SUNAB has strict control of the traffic and generates data for the charging of the operators. One risk with outsourcing of network deployment, operation and maintenance to a third party is that the own organization will lose competence. In the long term this may reduce the ability to make strategic network decisions. The cooperation between TeliaSonera and Tele2 was reported to have been beneficial when it comes to network competence and experience. Both companies have learned from each other. The cooperation at the technical level works fine as long as the market and strategic issues are handled at a higher level.

Changed Conditions for Network Sharing

We can see significant differences when comparing network sharing in the years 2000 and 2010.

- **User demand.** In the year 2000 it was unclear to the operators what kind of "3G services" that would be offered. In the year 2010 there is a clear demand for mobile broadband access; customers are familiar to mobile broadband dongles and smartphones.
- **Density of base station sites.** In the year 2000 a new 3G network was deployed with a large number of new base station sites as more than 99,9% of the Swedish population had to be covered. Due to the higher carrier frequencies at 2.1 GHz denser networks than the existing GSM networks at 900 MHz were needed, requiring massive capital investments. In Sweden network sharing has contributed to that the operators could deploy a large number of sites and meet the license requirements. This has resulted in extensive coverage for the 3G networks. This means that future deployment of “4G networks” (LTE) to a very large extent can be based on re-use of existing base station sites.
- **Cost of radio equipment and transmission.** The intense competition among network equipment manufactures has pushed down prices during the last couple of years, (Markendahl, 2011).This enables operators to replace existing radio equipment with new equipment (LTE) for only EUR 10K per base station. The capacity to cost ratio has improved more than an order of magnitude within a few years. The transmission capacity was not a bottleneck in the year 2000, the capacity could e.g. be provided by 2 Mbps leased lines. In order to meet the capacity demand in the year 2010 the transmission to sites need to be upgraded, in many cases with optical fiber connections.
- **Spectrum availability.** The access and control of radio spectrum is extremely important for mobile operators. More radio spectrum means that more capacity can be offered for a fixed number of sites, while fewer spectrums implies more sites and therefore higher costs. More radio spectrum also means that higher data rates can be offered, which is vital for the competition between operators.

When it comes to competition, the view among the interviewees was that network sharing in Sweden has not had any negative consequences. The competition for end-users and pricing has not been influenced by any agreement among sharing partners. On the other hand, mobile broadband prices are low in Sweden. It was also mentioned that in a country like Sweden, the incentives for future sharing agreements may be lower than before.

NETWORK SHARING IN INDIA AND COMPARISON WITH SWEDEN

The Indian Telecom Market is very different to Sweden

The mobile communication market in India differs a lot compared to the situation in Europe. The Indian telecom market is dominated by mobile communication services. It is a mass market with very low prices. More than 900 million SIM cards make it to the second largest mobile telecom market in the world. At the same time the fixed line penetration is just around 3% (35 million) and year 2012 the total number of broadband connections was 14 million of which 3 million are mobile broadband connections using the 3G services. Voice services and pre-paid dominates. The average revenue per user (ARPU) is very low and around € 2 per month, i.e. 1/10 compared to Europe. The price per voice minute is very low (half a Eurocent) and the number of voice minutes per user and month is high (400 min), higher compared to Europe.

The market is very fragmented, operator and spectrum licenses are awarded in 22 regions (called circles) and the number of operators in each circle is 10 – 12. There exist state owned operators but none of them are among the largest. The high number of operators has led to an intense competition and very low prices. After 2008 when new operators entered the market the (already low) voice prices decreased by 60 %. Another issue for operators is the limited amount of spectrum that has been awarded. GSM operators typically have 4,4, 6,2 or 8 MHz in the 900 MHz band, and 3G services operators have been awarded 2* 5 MHz, this is more or less 1/10 compared to the spectrum available for mobile broadband for European operators. Operators pay license fees to the government, a kind of royalty (or tax), around 6-8% of gross revenues. Moreover, the spectrum allocation process is complex and has caused a lot of uncertainty. In early 2012 the India's Supreme Court decided that 122 spectrum licensees that had been awarded at first-come-first-served basis in 2008 should be quashed. The decisive argument was that these licenses had been granted to companies during an arbitrary allocation process.

Network Sharing in India

Network sharing is common in India but it is organized in a different way compared to Sweden. The operators rent space and some equipment at the base stations sites that are operated by tower companies. The operators share the tower, power, cables, equipment room and other non-telecom equipment, it is labeled passive network sharing since no active equipment, i.e. radio transmitters and receivers are involved. A key driver for network sharing is to lower the cost base. With tower companies mobile operators can avoid long term investments in costly towers and site equipment. Instead of investing capital for 20-30 years operators are tenants leasing space, capital expenditure is replaced with operational expenditures. The tower companies act as real-estate companies making investments and taking on the risk.

The rental agreements are designed so that the more tenants at a site the lower the cost for each tenant and at the same time revenues increase for the tower company. The interviews indicate that currently the focus is to increase the number of tenants per site rather than building new sites. In one case the target was to go from "just below two" tenants to around three tenants per site. There are a large number of base station sites (towers), more than 400 000 in total in India and many tower companies. There are also many different types of ownership structures: i) Owned by a single operator, ii) Owned by two or more operators or, 3) Independent tower companies

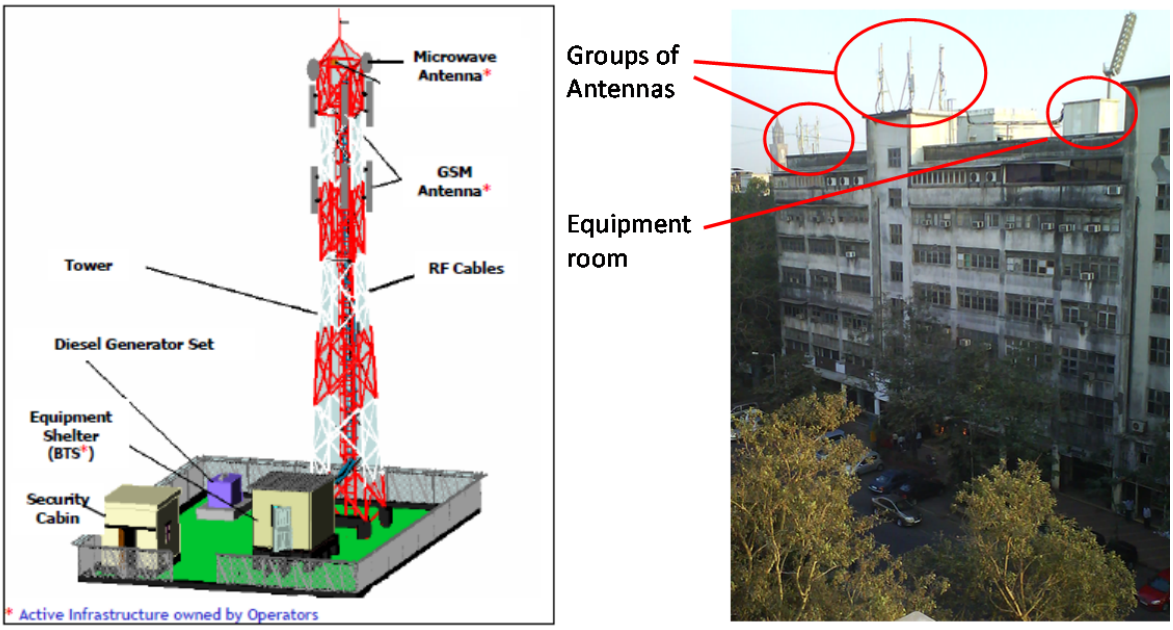


Figure 3 Examples of base stations sites, to the left using a ground based tower (picture: GTL investor info 2011), to the right a rooftop site in downtown Mumbai (photo by authors 2012)

Comparison of Network Sharing in India and Sweden

The tower companies have different owners, and it can be one or several mobile operators or companies that are not related to any operator. In the same way any operator can be a tenant at any site, see figure 4. This is different to Sweden, where the network sharing joint ventures are self-contained and more closed entities. The owners are the ones that make decisions about network investments but at the same time they are also the main customers and suppliers of knowledge and resources for network planning and deployment, see figure 5.

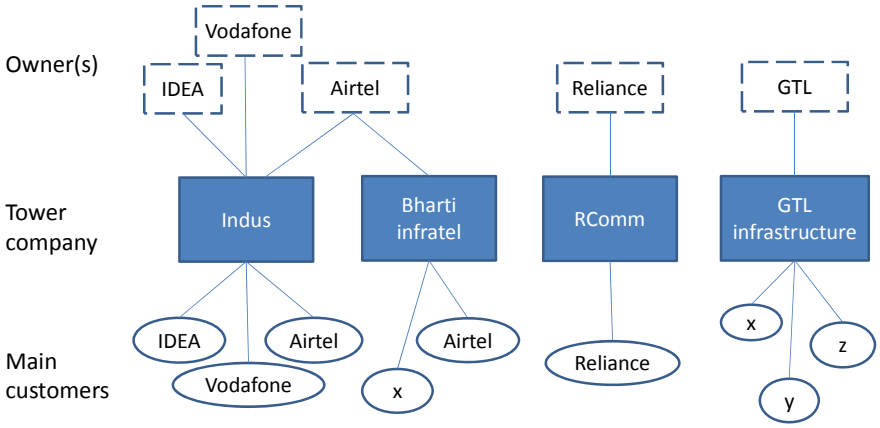


Figure 4 Illustration of market structure with owners and customers for tower companies in India

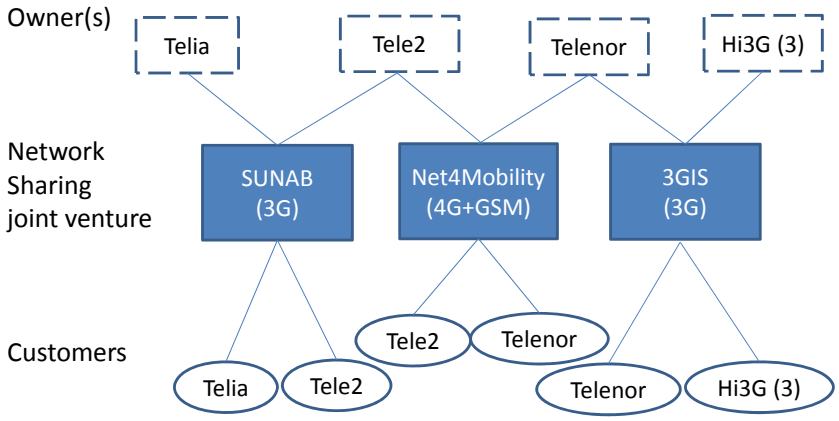


Figure 5 Illustration of market structure with owners and customers for network sharing companies in Sweden

The purpose of the Swedish joint ventures is to deploy, manage and operate the entire mobile networks. To deploy and maintain base station sites is an integrated part of the business. The cooperation is done within the jointly owned networks sharing company, where the owners have to agree on investments and then share the costs and split the work to be done. Other operators or joint ventures are allowed to rent space on commercial terms.

In India deployment and operation of sites is the core business for the tower companies. The operators rent space and pay a fee on commercial terms, regardless if the tenant is an owner or not. The operators place their active equipment in the sites and can control the networks. The cooperation is implemented using an independent actor. The decisions to build new sites are taken by the tower companies.

What kind of sharing is allowed and not?

In Sweden operators are allowed to share sites, non-telecom and radio equipment and also radio spectrum. This has been used by the network sharing companies leading to a high degree of cost efficiency for the 3G networks; and the radio capacity has been build out when needed.

In India, the situation is totally different. Until now, active sharing has not been allowed. However, according to the new National Telecom Policy 2011 (NTP 2011) active sharing is proposed for GSM operators with the lowest amount of allocated spectrum (2*4.4 MHz). At the same time the proposal in NTP 2011 says that operators have to pay license fees also for the band of the sharing partner. It is believed to effectively prevent operators to enter active sharing agreements.

During the interviews active sharing was discussed in terms of new business opportunities for the tower companies. Since, they own all passive equipment it would be a natural extension to also own active equipment. This would improve the efficiency for the overall system. The mobile operators then could rent also radio equipment, even if the control of spectrum is in the hand of the operators. This is however at topic for future research and regulatory initiatives.

SHARING OF INDOOR NETWORKS

In Europe the mobile operators have a long tradition of sharing indoor and local area networks in public places like subways, arenas and shopping malls. A common solution is the distributed antenna system (DAS) where operators and facility owners cooperate using macro base stations of the same type that is used for the outdoor networks. However, when local networks are discussed in terms of small cell solutions and offloading of data traffic, then the multi-operator context seems to be forgotten. In this section we describe the traditional indoor sharing and the identified challenges that we have identified and finally we outline the possible business options for future sharing of indoor networks.

Existing indoor sharing in technical and business domain

Indoor multi-operator systems are common in subways, shopping malls and large office buildings. The commonly used solution so far is called Distributed Antenna Systems (DAS). In order to be meaningful the premises covered needs a certain size and traffic volume. DAS is not a solution for the home or small companies. An indoor infrastructure in the form of a distribution network is deployed and the mobile operators can connect their base station equipment to this distribution network, see Fig 6.

One often claimed advantage of the DAS is that each antenna port delivers higher capacity at the respective coverage spot compared to small cell where the capacity is limited to the portion deliver by the local cell. This makes the DAS system more suitable to handle large fluctuations in traffic at the premises, for instance in a lunch canteen, a conference facility or other places were the users shift locations during the day.

The distribution of business roles using distributed antenna systems (DAS) are shown in Figure 7. The deployment of the DAS system is a cooperative effort while network operation and customer & billing related activities are handled by each operator (Markendahl, 2011).

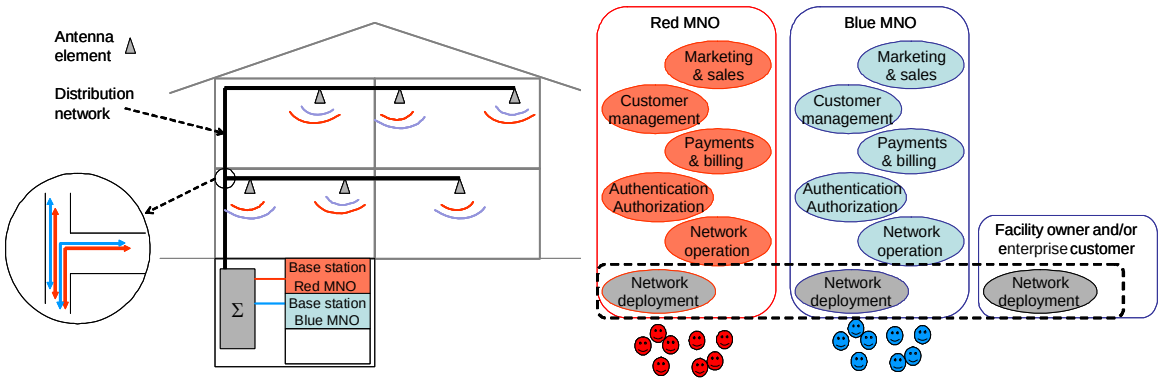
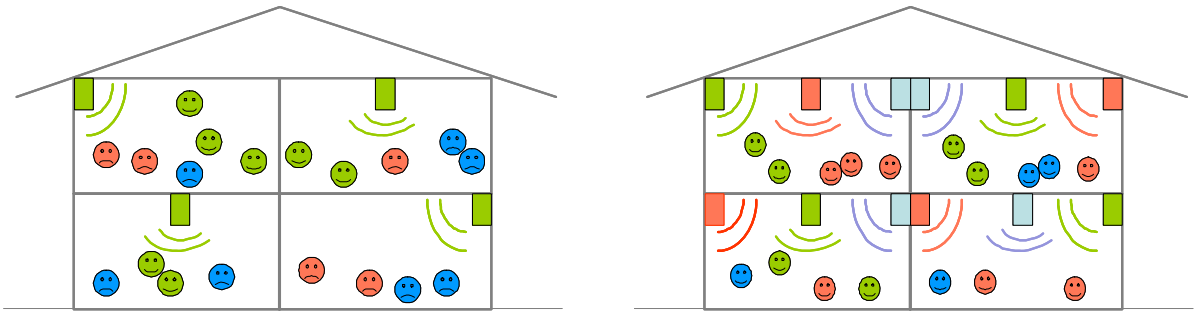


Figure 6 System overview of distributed antenna system (to the left) and business roles for operators sharing an indoor infrastructure using distributed antenna systems (to the right)

Network sharing is a commonly used solution for macro cellular networks when mobile operators want to exploit benefits of sharing infrastructure, typically to save network costs. For local area and indoor networks infrastructure sharing using distributed antenna systems (DAS) and repeaters are commonly used solutions to improve indoor coverage. For these applications multi-operator solutions are well known and supported by both standardization bodies and by collaboration practices. However, as mentioned when local small cell indoor networks are discussed then the operator cooperation seems to be forgotten.

Small cells are often presented in a single-operator context. This does not comply with market demand and practices. Facility owners neither want one single mobile operator to dominate the capacity provision (Figure 7a) nor accept multiple indoor infrastructures provided by multiple mobile operators (Figure 7 b). Deployment of multiple single-operator small cell networks would be a costly solution and in most cases not practically feasible from a customer or facility owner perspective with multiple operators involved in planning, deploying and maintaining separate networks.



a) One single-operator femtocell network b) Multiple single-operator femtocell networks

Figure 7 Different options for deployment of smallcell (femtocell) networks

Premises owners tend to use only one set of femtocell access point (FAP) that are only managed by one operator (as managed services) for their entire networks and interact with only one operator. At the same time they want to serve all subscribers existing in their premises from different MNOs' networks. The main drivers for sharing in small cell networks that are slightly different compared to macrocell networks could be depicted as;

- CapEx and OpEx preventions and reductions
- Increased traffic and capacity
- Improved network coverage and quality
- Regulatory issues
- Lower entry barriers
- Spectrum allocation

The technical enablers of sharing in small cell networks are femtocell access point (FAP), integrated femtocell Wi-Fi access point (IFWAP), femtocell gateway (FeGW), operation and maintenance nodes and, most importantly, spectrum.

Active sharing

The radio access network typically involves FAPs/IFWAPs and the immediately connected FeGWs that manage the access points. Active RAN Sharing involves sharing the gateways and access points across multiple entities with either separate spectrum resources for each entity or shared spectrum resources through spectrum pooling (Vadada, 2011). Active RAN sharing for Smallcell networks can also enable several new interesting deployment scenarios. For example, a content provider (e.g. YouTube) may lease resources from an 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.

In the first implication of this sharing model, frequency is shared between operators in Multi Operator Core Network sharing model (MOCN) that in this case means the FeGW is shared between different operators deciding upon forwarding the traffic to desired core network. Another model is when both operators connect to their respective CNs via a common FeGW but dedicated frequencies are used in the radio access network implementing a Multi Operator Radio Access Network (MORAN) sharing approach. In first approach, that the capacity is shared between operators, one PLMN id would be used for all subscribers indoors while in the second approach each operator has its own licensed frequencies and its own PLMN id.

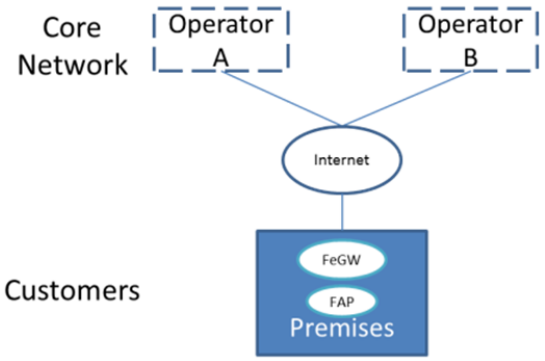


Figure 8 Active sharing where operators share infrastructure and radio frequencies

Sharing by roaming into a local network

Roaming model of sharing for Smallcell networks is the case that an operator accommodates its subscribers and also another operator's subscribers under its covered premises whilst second one may or may not proceed with the same approach. The important agreements that are subject to bind are roaming agreements between operators in case they want to collaborate in terms of roaming with each other. In the first subcategory of roaming that is called *Mutual Roaming* two or more operators cooperate with each other in terms of serving each other's subscribers. The roaming agreements bind operators to accommodate other operators' subscribers as well as theirs while forwarding them (i.e. their voice and data traffic) to their respective operator's core network. The main outcome of such a roaming model 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 operator's subscribers but the agreement is not mutual. Both cases would look alike from subscribers' point of view but they differ when it comes to business roles amongst actors.

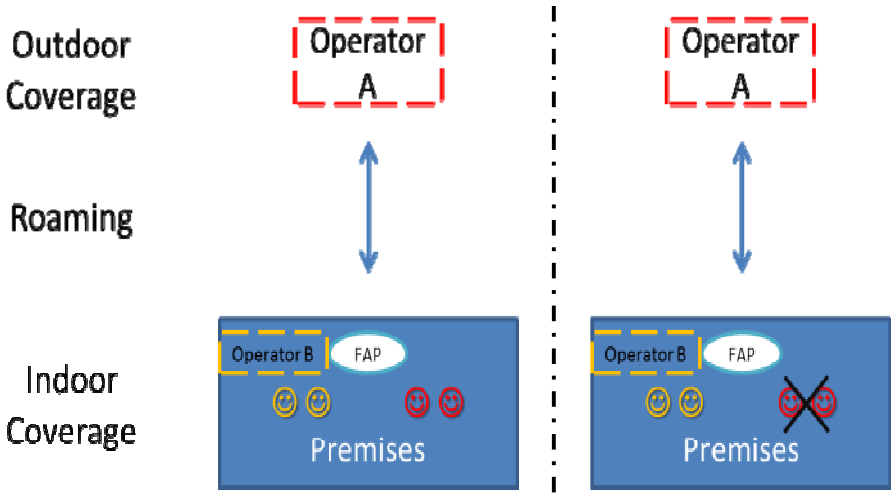


Figure 9 Mutual and non-mutual roaming

Wholesale Sharing

The main objective of implementing a wholesale sharing system for shared Smallcell networks is to help existing operators who want to focus more on their subscribers by targeting contents and services. The idea to shift value chain towards less focus on network and more on content/services enables the migration towards such comprehensive systems. In such a model, MNOs will be able to focus by leaving operation and management 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. In the CS model, a third party plays the important role of operating and managing the network by offering an end-to-end system 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.

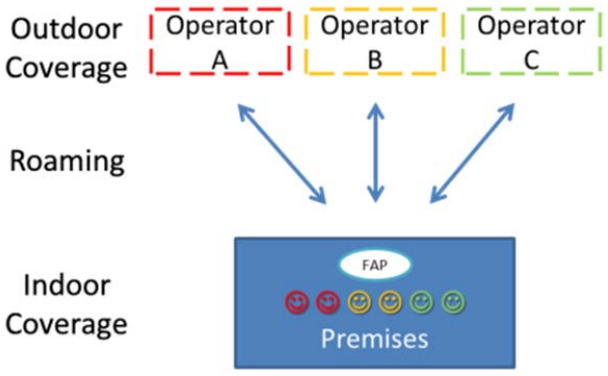


Figure 10 Wholesale sharing for indoor small cell networks

Whom to share with?

There are two options for sharing of small cell networks. The first option is collaboration in the form of a Joint Venture (JV) and the second option would be collaborating with a MSP. A joint venture is a form of collaboration between different MNOs or MVNOs in case they lack in certain assets that is possible to fulfill by others and yet is a viable trade off to collaborate with them. Since early types of sharing used to bring lots of complexities in terms of agreements, decision-makings, systems changes and policies between co-sharers, it was needed to form a new method of collaboration. Therefore, the joint venture concept is a standalone entity that is derived from co-sharing entities. The JV should be able to make its own decisions in order to avoid complexities related to dependencies in decision makings at the same time each entity's representative should accomplish its parent firm's general policies.

A MSP is the business partner that handles network O&M for the operator helping them changing their business models by focusing more on non-technical side of their business. To be more precise, the MSP can act in two manners, one being only an outsourcee for NOCs and related issues to it, and on the other hand to be a representative of a comprehensive system (wholesale sharing) by taking control of assets such as spectrum and network infrastructure while leasing them back to MNOs in right time right place.

COOPERATION AND COMPETITION

In all cases the competition between mobile operators are strong. For the cooperation between mobile operators we can identify both weak and strong behavior. The Swedish network sharing joint ventures are examples of very strong cooperation where infrastructure, base stations and spectrum are shared. The degree of trust and the strength of the tie are high, the operators share investments and risks. This may lead to high tensions as mentioned in (Bengtsson et al., 2010) the interviews showed cases of disagreements about when and where to invest in networks. We can also see that the cooperation strategies are different for the mobile operators. Telia did not enter any new network sharing agreements for 4G networks in Sweden but deploys a shared 4G network in Denmark together with Telenor. The company strategy is to not share networks in countries where Telia has a leading position. On the other hand Telenor and Tele2 move in the direction of more cooperation. They do not only form a new network sharing joint venture for the 4G networks, they also include the existing GSM networks.

In India the cooperation between operators is weak, the cooperation is done through tower companies. No sharing of active equipment is used. The regulation makes sharing less attractive.

For indoor networks in Sweden the cooperation between operators is quite strong but not as strong as for the network sharing joint ventures. Usually the operators use their own spectrum and radio base stations. The tie between two operators can be said to be weaker since more than two operators participate in the cooperation. Several mobile operators, the facility owner and also enterprises may be included in the deployment and operation of an indoor network. The indoor network cases also reveal another aspect that may result in both a weaker and a stronger tie between the actors. Since there usually are paying customers (enterprises) the risk for operators is lower which implies a weaker tie. On the other hand the agreements are long term which implies stronger tie. The competition is also somewhat weaker for the indoor case. The indoor deployment is a joint effort enabling indoor coverage for customers of all operators.

CONCLUSIONS

When GSM systems were introduced mobile operators did compete with network coverage and an own mobile network was a key asset. When 3G networks were introduced and the operators needed to deploy a large number of new base station sites the business landscape changed and competing mobile operators started to share network resources. In Sweden mobile operators cooperate very closely using network sharing joint ventures. For deployment of 4G networks in Sweden the incentives to share networks may be lower due to large number of existing base station sites (that can be re-used for LTE) and since the price for radio equipment (capacity) has been reduced substantially the last years.

Besides cost reductions other drivers for network sharing can be to maintain a market position, to enter a market or to exploit the resources and skills of the sharing partner. Often mentioned drawbacks of network sharing are less flexibility and independence when it comes to network investments and difficulties to differentiate the service offers.

The close cooperation in Sweden through joint ventures where sites, transmission, radio equipment and spectrum are shared can be compared with the situation in India. Due to telecom regulation the operators are allowed to share only passive equipment and the sites. Active sharing has been discussed but spectrum fee for shared networks is an obstacle. In India the network sharing is organized through tower companies where operators are tenants at the sites.

For deployment and operation of indoor networks shared infrastructure is common in subways, office buildings, arenas, etc. Several operators and the facility owner cooperate on a local basis for a specific building or site. This is common for use of distributed antennas systems. Similar shared network concept should emerge also for indoor pico- and femtocell solutions although discussions on heterogeneous and small cell networks usually are done in a single operator context. We claim that shared indoor network solutions need more research due to the fact the facility owners will not accept multiple indoor networks.

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