Mobile Infrastructure Sharing











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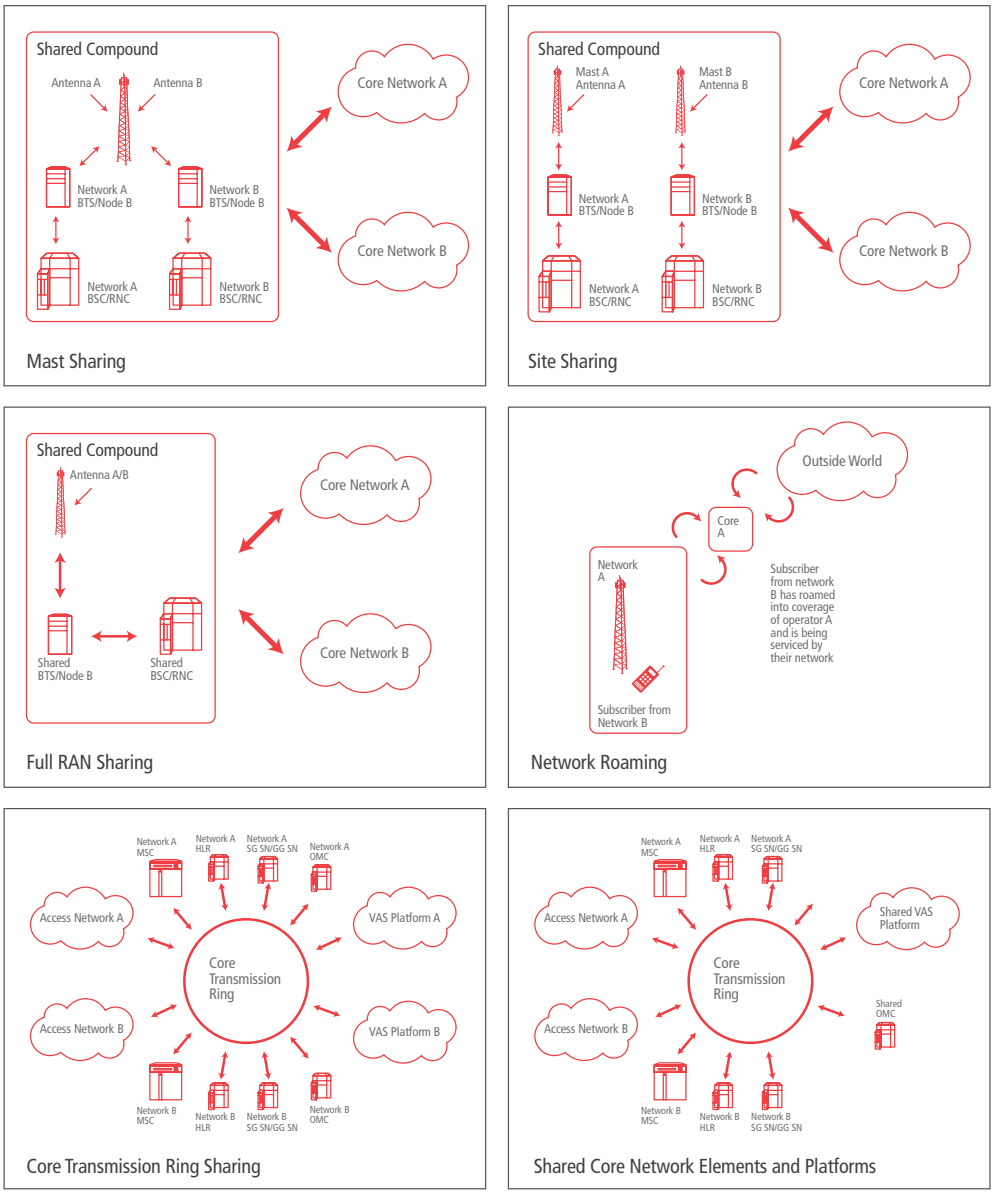


1 Executive Summary

Commercial considerations, rather than regulatory mandates, appear to be driving the increasing trend for MNOs to adopt a variety of infrastructure models. Examples of mobile network sharing can be found in both mature and developing markets, with 3G providing an added impetus to assess the commercial and regulatory viability of network sharing.

Network sharing may take many forms, ranging from passive sharing of cell sites and masts to sharing of radio access networks (RANs) and other active elements such as network roaming and the core.

Figure 1: Infrastructure sharing



Whilst technically it could be possible for operators to share any amount of equipment, implementation can be complex for some forms of sharing. This is particularly true where existing networks are being joined together as opposed to the rolling out of a new, single network. Considerations that must be addressed include the load-bearing capacity of towers, space within sites, tilt and height of the antenna and adverse effects on quality of service (QoS) when antennas are combined and differing standards employed by the equipment vendor. Therefore, site sharing, mast sharing and network roaming are the most common forms of infrastructure sharing due to their relative technical and commercial simplicity. RAN sharing is gaining commercial traction.

The strategic rationale for engaging in infrastructure sharing differs between new entrant and incumbent operators, 2G and 3G networks and mature and developing markets. Based upon interviews with MNOs and infrastructure providers supplemented by desk-based research, our initial analysis indicates the following:

- MNOs in mature markets: Infrastructure sharing may reduce operating costs and provide additional capacity in congested areas where space for sites and towers is limited. It may also provide an additional source of revenue but may be limited by differing strategic objectives.
- MNOs in developing markets: Infrastructure sharing may expand coverage into previously un-served geographic areas. This is facilitated via national roaming or by reducing subscriber acquisition costs (SACs) by sharing sites and masts or the radio access network (RAN). Infrastructure sharing is also increasingly being used in congested urban centres where new site acquisition is difficult. However, it may be less likely to occur in markets where coverage is used as a service differentiator and, if mandated, could potentially reduce investment incentives for continued network roll-out.
- 3G network operators: Operators are taking the opportunity to reduce capital and operational expenditure by sharing infrastructure from the start of the build-out. This is technically more attractive than joining existing 2G networks since operators, in many markets, are seeking to use 3G to differentiate their products and services, rather than networks. Sharing a new network removes the complexity and cost associated with replanning existing networks but requires commercial agreement on operations and upgrade costs.
- New entrants: National roaming can be used for a limited fixed period, usually the first few years of network deployment, to quickly expand coverage and in instances where initial cash flows are limited.
- Third party infrastructure providers: Infrastructure funds are showing more interest in acquiring or establishing third party mast or radio network businesses.
- Network equipment manufacturers: Infrastructure sharing may reduce revenues as less equipment is required by operators. However by assisting in the network planning process and offering managed network services, equipment manufacturers may be able to differentiate their offerings.



Regulatory interest in infrastructure sharing is three-fold; it has efficiency, competition and environmental aspects. Before granting approval to infrastructure sharing, national regulatory authorities (NRAs) typically weigh up the positive efficiency and consumer gains against the possible competitive harm and assess whether the gains have been incurred in the lowest cost manner. Positive outcomes include:

- Optimisation of scarce resources and positive environmental impacts;
- Decrease in duplication of investment, reducing capital and operational expenditure;
- Positive incentives to roll out into underserved areas;
- Improved quality of service, particularly in congested areas;
- Product and technological innovation as operators compete on service differentiation;
- Increased consumer choice as entry and expansion become easier; and
- Reductions in wholesale and retail prices for mobile services.

These positive outcomes are weighed against any competition concerns arising from a decrease in network competition or refusal to provide access. Regulators must:

- Distinguish cases where dominant firms act to harm competition from situations where they act so as to meet competition, recognising that the latter is necessary for the existence of a healthy competitive market.
- Determine the relevant timeframe. Regulatory measures aiming to foster competition in the short term may harm it in the longer term. For example, imposing shared access mandates on an incumbent's facilities will tend to increase competition in the short term but decrease long-term incentives for network rollout and the likelihood of two or more viable competing networks in the long term.
- Consider both retail and wholesale mobile markets. Where there is effective end-toend competition in retail markets then it is usually not necessary to regulate wholesale markets.

Our initial analysis into regulatory approaches suggests that:

- Infrastructure sharing is usually commercially driven rather than mandated by regulators;
- Regulatory approval is almost always given for passive infrastructure sharing and in many cases regulators encourage MNOs to enter into commercial agreements. Acknowledgement is given to the environmental and efficiency benefits of sharing and the generally limited competition impact. In some cases, it has been noted that site sharing could increase competition by allowing operators access to key sites necessary to compete on quality of service and coverage;
- In most case regulatory approval is also given to RAN sharing as MNOs maintain separate logical networks so the impact on network competition is assessed to be neutral.
- Proposals for active network sharing such as core network sharing or national roaming may require more market specific, competition analysis than passive sharing and RAN sharing;
- Competition rules apply to national roaming agreements. Regulators tend to permit national roaming where networks are either in their early stages of roll-out or in rural or peripheral geographic areas. Increasingly regulatory authorities, including the EU Commission, are stating that the competitive harm initially associated with national roaming may be lower than first envisaged and therefore a greater number of national roaming agreements are being permitted; and

Our analysis suggests that there has been an increase in the number of commercially driven infrastructure sharing agreements between operators. This can be attributed to a number of drivers, although our interviews suggest that the three key factors are:

(i) 3G licensing, and the associated need to new entrants to quickly establish national coverage and for new site acquisition by all operators;

(ii) downward pressure on ARPU leading operators to seek cost savings; and

(iii) congestion in urban areas alongside a lack of new sites.

Regulators usually take a competition-based approach to assessing requests for sharing approval, based upon an analysis of efficiencies versus competitive harm and considering national market conditions. For the most part, this has led to passive infrastructure sharing and RAN sharing being approved and often actively encouraged and, increasingly, for more active forms of sharing to be allowed, subject to roll-out obligations.



2 Introduction

Examples of mobile network sharing can be found in both mature and developing markets, with 3G providing an additional impetus to assess the commercial and regulatory viability of network sharing.

This paper considers:

- The types of network infrastructure sharing models which are available to operators.
- The strategic rationale behind network sharing.
- Regulatory considerations and drivers.
- Technical and environmental issues.

The paper is based upon a series of interviews with mobile network operators and infrastructure providers, a literature review and analysis of existing examples of site sharing. Its purpose is to set out some of the key themes associated with infrastructure sharing and to provoke discussion on this issue. It is not intended to provide a definitive view on the advantages and disadvantages of particular aspects of network sharing.



3 Types of network sharing

For the purpose of this paper we have classified sharing broadly into five categories:

- Site sharing.
- Mast (tower) sharing.
- RAN sharing.
- Network roaming.
- Core network sharing.

Passive sharing is usually defined as the sharing of space or physical supporting infrastructure which does not require active operational co-ordination between network operators. Site and mast sharing are considered to be forms of passive sharing.

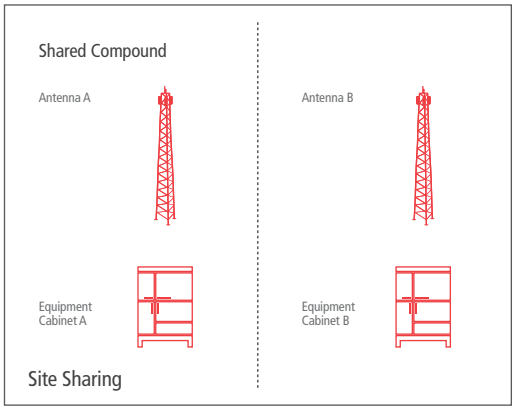
The remaining categories, listed above, are considered forms of active sharing as they require operators to share elements of the active network layer including, for example, radio access nodes and transmission. For RAN sharing, MNOs continue to keep separate logical networks and the degree of operational co-ordination is less than for other types of active sharing.

Network sharing across these categories may include a number of parties. Whilst there may be significant commercial and practical hurdles to overcome, there are no fundamental reasons why multiple operators cannot share networks. For example, up to six operators share a single site in India. Agreements may concern individual sites, a number of sites or particular regions. Passive sharing and RAN sharing do not require a fully merged network architecture and there are examples of unilateral, bilateral (mutual access) or multilateral agreements.

3.1 Site sharing

Site sharing, involving co-location of sites, is perhaps the easiest and most commonly implemented form of sharing. Operators share the same physical compound but install separate site masts, antennas, cabinets and backhaul.

Figure 2: Site sharing



In the figure above, the solid line around the equipment and masts represents the fenced-off compound that the operators will either own or lease. Within this compound each operator usually installs their own infrastructure separately from that of other operators. However, they may decide to share support equipment, including shelters, power supply and air conditioning. This form of sharing is often favoured in urban and suburban areas where there is a shortage of available sites or complex planning requirements.

3.2 Mast sharing

Mast, or tower, sharing is a step up from operators simply co-locating their sites and involves sharing the same mast, antenna frame or rooftop.

Figure 3: Mast sharing

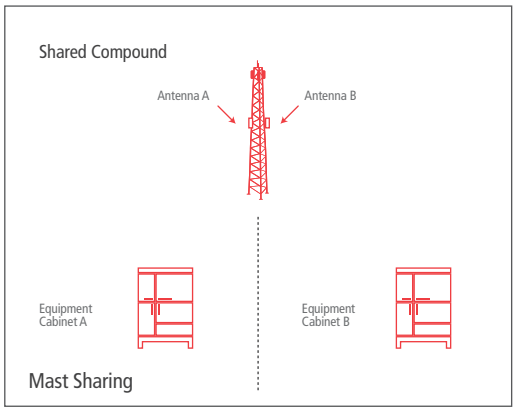


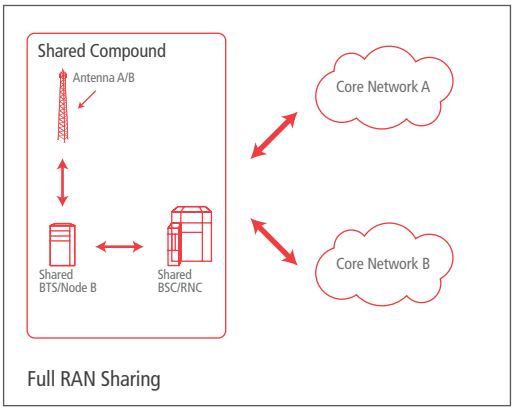
Figure 3 shows a single fenced-off compound within which operators will install their own access infrastructure, ranging from antennas to base transceiver station (BTS) cabinets. However, each operator will install their own antennas onto a shared physical mast or other structure. The mast may need to be strengthened or made taller to support several sets of antenna. As for site sharing, operators may share support equipment. Operator coverage remains completely separate.

There are alternative options available to operators when considering mast sharing. For example, third party structures such as chimneys and steel power pylons perform comparably to operator masts in terms of providing the required height and load-bearing capacity. In built-up areas, rooftops may be shared by several operators. Third party infrastructure providers, such as Arqiva and Crown Castle, may also enter the market specifically to provide shared antenna sites to telecoms operators and broadcasters.

3.3 RAN sharing

RAN sharing is the most comprehensive form of access network sharing. It involves the sharing of all access network equipment, including the antenna, mast and backhaul equipment. Each of the RAN access networks is incorporated into a single network, which is then split into separate networks at the point of connection to the core. MNOs continue to keep separate logical networks and spectrum and the degree of operational co-ordination is less than for other types of active sharing.

Figure 4: RAN sharing



The above figure illustrates how RAN sharing might work between two partner networks. In this scenario both operators share all the access network elements to the point of connection with the core network. At this interconnect point each operator then splits out the traffic from its respective customers on its own core network ring for processing by its own core network elements and infrastructure. The exact implementation may vary between different operators depending on the local implementation.

Included in the access network are:

- Radio equipment.
- Masts.
- Site compounds.
- Backhaul equipment.



Operators may face challenges in implementing a shared RAN network formed from existing networks, as their architectures have evolved independently to date. For example, there may be complications around inter-working of equipment purchased from different vendors and operational procedures and control mechanisms.

3.4 Core network sharing

At a basic level, the core network consists of:

- Core transmission ring.
- Switching centre (with the home location register (HLR)).
- Billing platform.
- Value Added Systems (VAS) that represent logical entities and may also form part of the core network.

The core network may be shared at one of two basic levels, namely the:

- Transmission ring.
- Core network logical entities.

3.4.1 Transmission ring sharing

Where an operator has spare capacity on its core ring network, it may be feasible to share this with another operator. The situation may be particularly attractive to new entrants who are lacking in time or resources (or desire) to build their own ring. They may therefore purchase capacity, often in the form of leased lines, from established operators. Fixed network operators, such as British Telecom and Cable & Wireless, which sell capacity on their network on a wholesale basis often provide operators with an interim mechanism to roll out a network quickly while they make arrangements to implement their own architecture. However, if both companies use the same joint transmission and switching core then their services will become more aligned as they will have the same infrastructure capabilities. Any service, function or process that one operator implements can be replicated by the other as they have the same infrastructure capability.

3.4.2 Core network logical entity sharing

Core network logical entity sharing represents a much deeper form of sharing infrastructure and refers to permitting a partner operator access to certain or all parts of the core network. This could be implemented to varying levels depending on which platforms operators wish to share. A simple example may be sharing the equipment identity register (EIR) function, which on its own may be expensive but as a pooled resource between operators becomes more attractive.

The benefits for sharing core network elements are not as clearly defined as those for sharing the access network. It is conceivable that there may be some cost reductions in operations and maintenance but the scale and practicality of these remains uncertain. Operators' focus for network sharing to date has concentrated on elements in the access network since the cost savings in this area are typically more significant and better understood.

3.5 Network roaming

Network roaming can be considered a form of infrastructure sharing although traffic from one operator's subscriber is actually being carried and routed on another operator's network. However, there are no requirements for any common network elements for this type of sharing to occur. As long as a roaming agreement between the two operators exists then roaming can take place. For this reason operators may not classify roaming as a form of sharing as it does not require any shared investment in infrastructure. When roaming agreements come to an end they can be renegotiated either with the existing host network or another operator with minimal effort and transitional impact.

Roaming can be further divided into the following categories:

- National roaming.
- International roaming.
- Inter-system roaming.

3.5.1 National roaming

National roaming occurs between operators (that are usually direct competitors) within the same country code as they provide service within the same geographic region or within different geographic regions. Agreements permitting, users are allowed to roam onto a host network if the home network is not present in a particular location. In the early days of network deployment this meant that operators could compensate for lack of presence and offer users contiguous coverage and service using the same handset and SIM. This is particularly useful in areas of low subscriber density where the payback period for a dedicated site by each operator may not be justified.

3.5.2 International roaming

This has similar characteristics to national roaming, but occurs between operators within different country codes. Users can continue to use their handsets abroad and receive the same basic voice service and any VAS they subscribe to (provided that the host network is capable of supporting this). On an international basis, roaming is complicated by the fact that regulators dedicated different frequency bands to the same technology in different jurisdictions. Handsets need to be (and typically are) capable of operating at different bands.

3.5.3 Inter-system roaming

Inter-system roaming occurs between networks operating to different standards and architecture as in the case of 3G and GSM roaming. Inter-system roaming generally facilitates the introduction of new standards and technologies as it provides a mechanism for the new platform to offer coverage from launch at a level associated with a mature network. It helps build revenue quickly and mitigates against any user perception that the service will not be available to the same level as with established networks and technologies. Inter-system roaming imposes more challenging requirements on user terminals and networks as they have to be able to support calls on both standards and maintain calls when changing between standards. This additional complexity may add to the cost of network operations and maintenance in the short term, which may be offset by additional roaming revenue. Examples of this can be seen in many countries. In the UK, a national inter-system roaming agreement existed between Hutchison and O2. The agreement is understood to have come to an end, with Hutchison awarding its new roaming contract to Orange.

4 Strategic rationale for infrastructure sharing

4.1 Drivers of infrastructure sharing

The commercial drivers of infrastructure sharing and the types of infrastructure sharing agreement are likely to differ between countries and according to levels of market maturity.

- In the early phases of network development, infrastructure sharing is most commonly site-sharing and roaming, which are used to facilitate quick network roll-out, at a lower cost, by new entrants. Facilitating sharing can provide an additional revenue source and lower costs to the incumbent operators.
- As networks mature, and their focus shifts from deployment to service innovation, drivers such as cost reduction become increasingly important as operators seek to optimise profits and revenues. In this context, two or more incumbent operators may seek to join part or all of their individual networks and to build out additional coverage in a unified manner.

A number of broad key strategic and commercial drivers exist:

- Network expansion into underserved areas that would otherwise be unprofitable or have a payback period greater than the business target.
- Cost reduction.
- Incremental revenue sources.
- Capex / opex optimisation.
- Facilitation of market entry.

The table below provides some of the key drivers for each type of infrastructure sharing separately from the perspective of the network using another network's assets (except for RAN sharing, which often implies a truly shared investment in a common set of assets).

Figure 5: Key drivers for different types of infrastructure sharing

Type of Sharing	Strategic Drivers
Passive	
Site (co-location)	• Reduced site acquisition times for new entrants • Access to locations of strategic importance, particularly where space for new sites is limited • Increased likelihood of obtaining planning permission for new sites • Reduced opex (site lease) • Expansion into previously unprofitable areas by reducing capex and opex requirements • Environmental and alleged health concerns, for example, increasing pressure from environmental groups on existing operators to reduce the number of cell sites due to health concerns
Mast (tower) times	• Reduced site acquisition and build completion • Reduced capex (site build) • Reduced environmental and visual impact
Access	
RAN coverage	• Reduced number of sites and masts for the same • Reduced capex and opex (shared physical backhaul) • Reduced environmental and visual impact
Core network	
Fibre ring	• Capex and opex saving where spare capacity
Core network elements	• Delayed investment in core network elements • Reduced maintenance and operational costs
VAS systems	• Delayed investment in VAS system elements • Increased capacity VAS systems • Enhanced capability • Reduced maintenance and operational costs
Roaming	
National	• Reduced or delayed infrastructure investment • Increased coverage
International	• Increased service coverage
Inter-system technologies	• Facilitation of the introduction of new • Seamless interoperability between operator's own separate 3G and 2G networks • Delayed investment in new technology infrastructure

In the following section, the key drivers are described for each of the different types of infrastructure sharing.

4.1.1 Site sharing

The main driver for operators to co-locate sites is to reduce the acquisition and build time for new sites and to increase the chances of gaining planning approval. With multiple operators and dense coverage needs, acquisition of sites, with all the necessary governmental approvals, is becoming more complex and lengthy. Environmental and health-related lobbying is further contributing to this.

Ascertaining legal ownership of sites in towns is a stumbling block to faster roll-outs in many markets. This is common to both new entrants, seeking to quickly build out coverage, and incumbent operators who seek to further increase coverage into underserved areas or to roll out additional cell sites to ease congestion or improve in-building coverage.

In urban areas, sites are often located and constructed on rooftops and other high structures. As there is a limited supply of such locations, operators may have little choice other than co-locating sites.

Operators often face increased opposition to building new sites from local residents and other pressure groups and the situation may be alleviated if sites are located near existing infrastructure. In cases where site access is particularly critical, for example where the site could be classified as an essential facility, use of regulatory powers may be required where commercial agreement cannot be reached.

In rural areas, construction costs such as power supplies and access roads constitute a significant percentage of the total site build costs. In such cases, there may be an incentive for operators to co-locate to reduce their individual capex investment and the site payback period. Reducing the costs associated with building out sites may make it commercially viable to serve previously unprofitable areas. During our interviews a number of operators noted that they viewed site sharing as being an effective method of reducing subscriber acquisition costs in rural areas and increasing the geographic area which is economically viable to cover.

4.1.2 Mast sharing

Mast sharing is a step up from simple site sharing. The purchase, assembly and construction of the mast base forms a major percentage of the overall construction costs and therefore mast sharing has the potential to significantly reduce operators' capital expenditure, particularly during the network roll-out phase. For the Indian market, it has been estimated that mast and site sharing together may allow operators to save close to 30% on capex and opex . Passive components may make up to 50% of the total network cost and therefore a 30% saving could reduce overall costs by up to 15%.
There are three variants of mast sharing:

- Use of existing sites and masts: If a co-located site already contains a mast suitable for sharing, then operators can reduce the capex investment required by the new party thereby reducing the payback period. Instead of the capex outlay, the new operator would pay a rental charge to the mast owner.
- Existing site requiring a new mast: The cost savings depend upon the type of existing infrastructure and the pricing structure employed. For example, where a mast must be replaced with a stronger or taller mast to allow for multiple antennas, then the cost of dismantling and reconstruction could outweigh any savings to one or more operators. The relative level of saving depends on the pricing methodology employed; for example, under an incremental costing approach, the new entrant could be liable for the entire dismantling / reconstruction cost. In this case, it could be more cost-effective for the new operator to opt for site sharing or potentially develop its own standalone site. However this needs to be balanced against possible planning approval delays and the costs of provision of access, power and data links.
- New site and mast: Capex can also be saved when operators jointly pay for the erection of a new mast in a new site. Although a larger mast would potentially be required and this may delay planning approvals, this is generally outweighed by the division of cost between the operators.

The benefits of mast sharing must be balanced against future requirements of a network operator, as modifications and alterations may be restricted on a shared mast.

1 Same drivers as for co-location and mast sharing.

2 http://www.expresscomputeronline.com/20070305/market02.shtml, Pinakin Gandhi Vice President - Strategic Planning and Investor Relation, GTL LTD (India)

3 For example, reported as being 40% of an Indian network operator costs in the above article. The proportion is typically higher in more rural areas



4.1.3 RAN sharing

One of the key drivers of RAN sharing in mature markets is to reduce operational network costs in a climate of increasing downward pressure on ARPU. Sharing part, or all, of the RAN network produces substantial savings for operators and it has been estimated that cost savings could increase free cash flow by up to 20% for a typical European operator . RAN sharing may also be commercially appealing in rural and peripheral areas with lower subscriber density and low ARPU users. In dense urban areas such as city centres, operators need to have much denser antenna locations to ensure minimum quality standards. This increases the cost of equipment and roll-out, which encourages sharing. Where existing networks overlap, RAN sharing allows operators the flexibility to redeploy infrastructure to more remote areas that may have previously been underserved.

RAN sharing produces incremental revenues for both parties as it implicitly increases the coverage footprint of both networks. This allows them to capture traffic they might otherwise have been unable to capture. The scale of this will depend on the individual circumstances of the operators and is difficult to estimate due to the many factors involved, such as geography, coverage and network overlap. Agreements also need to provide a process to demonstrate compliance with regulatory requirements.

4.1.4 Core Network

The cost drivers for core network sharing are the same as those for RAN sharing, but tend to be lower in value. Multiple operators may seek to share one core network, thereby dividing the network capital costs between them. Interviews with leading operators indicate that they do not view the additional savings from core network sharing to be particularly substantial in developed markets.

4.1.5 Roaming

Roaming produces benefits primarily through delayed or reduced investment in network infrastructure. This is particularly beneficial to new entrants who require time to establish coverage footprints similar to that of incumbents. However, it is generally not seen as a long-term solution for operators as it reduces their own margin potential and agreements typically do not count towards roll-out obligations imposed by regulators within operators' licensing agreements.

Allowing a subscriber to roam onto other networks is beneficial from a service continuity perspective, but operators may prefer to carry the traffic on their own networks whenever possible in order not to share the revenue with their competitors. In the longer term, new entrants are likely to seek to establish their own comparable footprints. An example of such an agreement can be seen in the UK between Hutchison and O2 and between T-Mobile and O2 in Germany.

4.2 The business case for infrastructure sharing

Whether there is a business case for infrastructure sharing depends on a number of factors, including:

- The maturity of the market and the desire of the carriers to differentiate their services based on quality of service and coverage.
- The planning approaches used by individual carriers and the degree of network roll-out already achieved.
- The technology being rolled out.
- Levels of mobile market penetration in the country.
- Technical and operational limitations.

In determining whether or not to share infrastructure for coverage purposes, operators in the first instance decide if service differentiation based on coverage is important to their overall business. This is a particularly relevant question for operators in emerging mobile markets as it may not be sensible for the operator to share its network if it has invested in a coverage-based approach, as this will reduce its competitive advantage. For example, marketing campaigns based on relative coverage levels were provided as a possible reason why infrastructure sharing agreements have not been progressed in Tanzania. As operators move towards 3G, interviews have indicated that service provision rather than network characteristics is the key differentiator and therefore infrastructure sharing of 3G assets appears more prevalent than for 2G.

4 Analysys press release, 18 April 2007, Analysys hosts industry discussion on mobile content services and network sharing.

5 Vodafone, Bharti, Idea to form independent tower company", Wireless Federation, December 10th, 2007, http://wirelessfederation.com/news/category/essar/

6 Interviewees have indicated that infrastructure sharing is less likely where MNOs compete on coverage. Although, in these markets, it could be argued that there is a greater incentive for some smaller operators to share their networks in order to compete with those with the highest coverage levels

Infrastructure sharing is increasingly being used to provide additional capacity, rather than for coverage purposes. In dense urban / suburban areas, it can be difficult to find suitable new sites or to obtain planning permission for new towers and this is driving the popularity of site and mast sharing in these areas. This was noted as a key driver in our interviews.

Site and mast sharing appears to slowly be gaining in popularity in lower income and more rural countries. This includes investments into independent third party infrastructure companies. For example, Vodafone Essar, Indian infrastructure company Bharti Infratel and mobile operator Idea Cellular have agreed to form an independent tower company, Indus Towers, to provide site and mast sharing services in India to all operators on a non-discriminatory basis . Based on interviews and desk-based research, we have identified an initial set of strategic drivers for companies in different markets and operating at different frequencies. Finally, site sharing in areas already covered by MNOs may provide an opportunity for network modernization leading to advantages such as lower energy consumption.

- MNOs in mature markets: Infrastructure sharing may be employed to reduce operating costs and to provide additional capacity in congested areas where space for sites and towers is limited. It may also provide an additional source of revenue. For example, MNOs may compete for national roaming agreements with new entrants, particularly those that target a different customer segment, to smooth traffic profiles and increase revenues without significant additional investment.
- MNOs in developing markets: Infrastructure sharing is employed to expand coverage into previously un-served and under-served geographic areas, particularly rural areas. This is facilitated via national roaming or by reducing subscriber acquisition costs (SACs) in these areas by sharing sites and masts or the radio access network (RAN). However, infrastructure sharing may be less likely to occur in markets where one or more operators are using coverage as a service differentiator . Increasingly, infrastructure sharing is also being used to increase coverage and improve quality of service in densely populated urban areas where it is difficult to acquire new sites.
- 3G network operators: As operators are building out 3G networks they are taking the opportunity to reduce capital and operational expenditure by sharing infrastructure from the start of the build-out. This is commercially and technically more attractive than joining existing 2G networks since operators are seeking to use 3G to differentiate their products and services, rather than networks, and sharing a new network removes the complexity and cost associated with replanning existing networks.
- New entrants: National roaming may be used in the first few years of network deployment to quickly expand coverage and in instances where initial cash flows are limited. It may allow for an initial focus on network build in urban areas whilst providing customers with the opportunity to use their mobiles on a national basis.
- Third party infrastructure providers: Infrastructure funds are showing more interest in acquiring or establishing third party tower businesses. These have proved popular with operators and there are cases of operators joining together to form infrastructure businesses.
- Equipment manufacturers: Infrastructure sharing may be expected to reduce the amount of equipment purchased from equipment manufacturers. However, by assisting in the network planning process and offering managed network services, equipment manufacturers may be able to differentiate their offerings

5 Economic and regulatory considerations

Regulatory interest in infrastructure sharing is three-fold: investment, competition and environmental aspects. Infrastructure sharing is cited as a mechanism for decreasing costs and potentially resulting in greater coverage, improved quality of service and lower retail prices, whilst having a positive environmental impact and optimising national scarce resources. However, the national regulatory authority (NRA) must weigh these positive impacts against competition concerns arising from a decrease in network competition. While the economic effects of infrastructure sharing need to be assessed on a case-by-case basis, there is some scope for generalisation. This is reflected in the development of some common features of the regulators' approach to infrastructure sharing globally. Based on our initial review of global regulatory precedent, the common themes that are emerging are:

- Sharing of masts and sites is generally encouraged and permitted, and in a few cases mandated.
- RAN sharing, albeit a recent development, has generally, but not in all cases, been permitted by regulators, provided that operators' coverage requirements are met.
- National roaming has in some cases been mandated and in others encouraged, in particular at the early stages of 3G roll-out and in peripheral areas, while it has also been identified as a potential threat to competition in a limited number of cases.
- MVNO access, where commercially negotiated has been considered to facilitate competition, and in some cases it has been mandated where operators have been found to have market power.

Below, we first consider the efficiency and consumer benefits associated with infrastructure sharing, and then consider competition policy implications and regulatory precedent.

5.1 Efficiency improvements: coverage, quality and pricing

Network sharing is increasingly favoured by policy makers as a way of ensuring more rapid provision of 3G services and on environmental grounds. On this basis the European Union has consistently ruled in favour of permitting passive network sharing and more recently also national roaming under the caveat that competition rules are respected.
The sharing of sites and masts, national roaming and RAN sharing tend to impact coverage, quality of service and pricing of services to consumers positively, as the cost saving characteristics of infrastructure sharing allow for increased efficiency. In particular, they may lead to efficient and positive consumer outcomes:

- Optimisation of scarce national resources: For example, land or spectrum may be used more efficiently and this may also have a positive impact on the wider economy.
- Decrease in duplication of investment: This tends to reduce costs to operators and prices to consumers.
- Positive incentives to provide services in underserved areas: By reducing costs to individual operators less revenue is required to justify serving low demand areas.
- Improved quality of service: In congested areas, there may be black spots without coverage and impair quality of service.
- Product and technological innovation: Permitting operators to compete on service innovation and technology rather than solely on coverage.
- Increased consumer choice: As entry and expansion become easier and speedier through network sharing, consumers benefit from an increased choice of provider.

Firstly, all forms of infrastructure sharing are usually characterised by increased efficiency in the use of resources, where capacity exists. For example, where an incumbent or an independent third party already owns or leases land and has built masts that could also be used by a second or third operator, it is usually more efficient to use these existing investments rather than making new ones, where capacity will not be fully utilised. This will have benefits for the wider economy as land is available for other uses, in particular in densely populated areas where little space is available.

Similarly, all forms of infrastructure sharing generally reduce costs and prices to consumers as they reduce the investment lay-out and opex required to provide a given level of service. For example, for sites and masts, the sharing allows costs to be spread amongst a larger number of users. Regarding RAN sharing, the cost savings noted above of up to 30% indicate that prices to consumers are likely to be affected positively through competition.

As regards national roaming, it should usually provide incentives to enable services in unserved and underserved areas in developing countries and in rural and peripheral areas in developed countries. This is also the case for RAN sharing.

Network sharing permits competition in more mature mobile markets to focus on service and technological innovation as it releases opex and capex. Innovative technologies may include 3G services, but also seamless converged services with access to their mobile any time anywhere, both for business and consumer use.

Finally, particularly in developing countries, network sharing facilitates faster roll-out of entrant networks. This ensures that consumers have the choice of an additional alternative provider more quickly than would otherwise be the case. In some circumstances, fast roll-out is necessary for entrants to be able to have a viable business at all, as much depends on their ability to compete quickly to obtain a revenue stream from the start to begin to pay back the investment made in spectrum.

7 BT's insight into Radio Access Network Sharing Strategy", Presentation by David Stronge, BT Ireland at the IIR conference on Network Sharing on 19th January 2008.

5.2 Impact on competition

Regulators face the challenging task of correctly distinguishing cases where dominant firms act to harm competition from situations where non-dominant firms act so as to meet competition. Whereas the former may provide grounds for intervention, the latter is necessary for the existence of a healthy competitive market. These competitive assessments are usually undertaken on the basis of national competition laws and typically assess whether: (i) the efficiency gains outweigh any competitive harm; and (ii) whether the same level of efficiency can be achieved in a less harmful manner. This task is complicated by the consideration of the relevant time horizon. In the short term, regulatory measures aiming to foster competition may harm competition in the longer term. For example, imposing regulatory mandates for shared access to an incumbent's assets and facilities will tend to increase competition in the short term. However, it will reduce competition in the long term as it decreases incentives for network roll-out hence decreasing the likelihood of two or more competing networks viable in the long term. When considering this issue, it is important that regulators consider both retail and wholesale mobile markets since where there is effective end-to-end competition in retail markets it is usually not necessary to regulate wholesale markets.

Infrastructure sharing can be a business strategy allowing firms to lower costs and prices to consumers, and to increase competition by facilitating speedy network roll-out for new entrants. Refusal to share infrastructure or excessive charging for infrastructure facilities may, if pursued by a dominant provider, affect competition adversely.

From a regulatory point of view it is relevant to distinguish between the following forms of sharing:

- Site and mast sharing (passive sharing).
- RAN sharing.
- Core network sharing.
- National roaming.

In the following, the potential competitive impact of each of these is considered separately.



5.2.1 Site and mast sharing

Site sharing (co-location) and mast sharing is normally considered not to materially affect competition since operators retain control over their own networks. In the context of the European Framework for Communications Services site sharing has always been encouraged (never mandated), although not as a means to increase competition but for efficiency and environmental reasons, as outlined above. Where cost savings are achieved then these may be passed on to consumers in the form of lower prices.

As discussed in section 4, in many situations operators may be expected to draw up agreements for site sharing on a commercial and voluntary basis. However, there may of course be reasons why firms may not wish to share infrastructure. Incumbents with a large, costly network may not want to share their assets thereby creating a temporary barrier to entry. Whilst this needs to be traded-off against incentives to build a viable second or third network in the long-term, where such sharing is refused in particular in rural or peripheral areas the effect may be to reduce competition. However, this is more relevant to national roaming and is therefore discussed further below.

Cyprus is the only example that we have reviewed where it has been suggested that the lack of availability of passive infrastructure, and in particular sites and masts has held up or slowed entry and progress of the second mobile competitor. This has been exacerbated by the fact that the legal framework for the erection of masts and sites was unclear, planning permission hard to obtain, and the fact that both entrant and the incumbent faced a situation where many masts and sites were built illegally due to the slow planning process.

Regulators could conclude, in such situations, that mandating access to sites and masts may ease network roll-out and increase the degree of competition between entrant and incumbent. However mandating passive infrastructure sharing may not necessarily be the most effective remedy for nurturing competition.

- It may be less costly in terms of investment incentives to streamline planning laws rather than imposing onerous conditions on existing operators which may be difficult and costly to implement. Implementation of site and mast sharing appears to be a challenging task where property rights of existing masts and sites are unresolved. This may in some countries be exacerbated where the legal framework is not sufficiently robust to allow firms to have confidence in the enforceability of contracts and agreements signed between them and where there is a general lack of confidence in the court system more generally.
- The regulator may be able to provide encouragement and incentives for commercial sharing agreements to occur absent of regulatory mandate. This could include simplified planning processes for shared sites or potential tax breaks. A market-based solution to infrastructure sharing may better reflect changing market conditions and lead to greater flexibility for both the party requesting and the party providing access.

5.2.2 RAN sharing

RAN sharing has generally been considered as competitively neutral in Europe and in the US so far with regulators. Agreements have, for example been put in place in Spain, and are also considered in the UK between T-Mobile and Hutchison and in Italy between Wind and Hutchison.

5.2.3 Core network sharing

Core network sharing is in its infancy and although commercial proposals have been discussed, there are limited examples of this occurring in practice. Whilst such agreements may lead to greater efficiency, principally through economies of scale effects, regulators may be concerned about the impact of decreasing wholesale competition. However, provided that the retail mobile market remains competitive then there may be limited opportunities for vertically integrated MNOs to leverage any increase in wholesale market power into the retail market. Therefore the competitive harm to consumers may be minimal compared to the efficiency gains. However, any robust conclusion could only be drawn following a review of the proposed sharing deal and with reference to the particular market conditions.

5.2.4 National roaming

National roaming has in the past been more controversial than the other forms of sharing considered above, although there is an established regulatory view today that is also widely accepted amongst operators. Generally, national roaming is accepted and sometimes encouraged, where:

- A new entrant needs to build out his network quickly.
- Demand and ARPU are estimated to remain too low to justify the roll-out of a second or third network, such as in rural or peripheral areas.

In Europe, two competition cases during the early phases of network roll-out helped establish the principles that underpin the current regulatory views on the potential impact of roaming on competition. In 2006 in O2 v. Commission the Commission argued that national roaming, by definition, restricts mobile network-based competition with respect to the scope and speed of coverage, retail prices, network quality and transmission rates. The European Commission agreed to exempt national roaming from competition law temporarily in urban areas for a short start-up period until O2 had set up its own network. However it envisaged that this exemption would be phased out across specific cities and regions covering about 50% of the population by the end of 2008. The European Commission also intended that roaming in rural areas should have been phased out by the end of 2008.

The European Court of First Instance (CFI) annulled the European Commission's decision holding that the Commission had not presented sufficient evidence regarding the effect of the national roaming agreement on competition, and the Commission decision's claim that national roaming per se qualifies as an agreement between competitors restricting competition (Article 81(1)). The CFI also noted that roaming may benefit competition in that it may allow the smallest competitors to compete on a more equal basis with major players.

However, generally it is agreed that there is a trade-off between national roaming and long-term competition between networks, in particular where roaming occurs in urban areas or more generally regions where the market can take more than one or two players each with their own networks. As noted in section 3 above, roaming differs from RAN sharing in that one operator actually uses another operator's network, implying that the two are not competing in the operation and build of network infrastructure.

5.3 Regulatory approval for infrastructure sharing

A regulator may decide to provide approval for sharing, actively encourage sharing or mandate access. Any regulatory decision should be made based on an analysis of the competitive impact of infrastructure and in line with good regulatory goals, for example transparency, efficiency, non-discrimination and independence.

Recognising the public and environmental benefits of site and mast sharing, the EU has actively encouraged this activity since the first mobile licences were issued. Site and mast sharing was only mandated in a limited number of countries, such as Cyprus, India (limited to Delhi and Mumbai) and Norway (limited to incumbent operator Telenor offering co-location).

In the following figure we provide an overview of regulatory treatment of the different types of infrastructure sharing globally. This is based on a sample of information from regulators' websites and that provided during interviews and is not necessarily intended to be a representative sample.

8 Bird and Bird, Commission Decision on German 3G Mobile Network Sharing Agreements Partially Annulled, Wilko Van Weert, http://www.twobirds.com/English/publications/articles/Decision_German_3G_Mobile_Network_Sharing.cfm

Figure 6: Regulatory controls

Country	Has sharing been mandated?	Has sharing been approved?	Differentiated approach to national roaming depending on geographic area
Australia		√ Regulator is supportive √ RAN sharing permitted	
Austria	√ Antenna masts and powerline masts must be shared if technically feasible, in particular in relation to frequencies	√ Only for 3G networks and limited in duration and by coverage agreements	
Channel Islands		√ Operators shared Arquiva owned infrastructure	
Denmark	X	√ Regulator is supportive of some forms but not others	
Finland		√ Subject to meeting minimum licence requirements	Regulated for 3G on 2G
Germany	X	√ National roaming, time limited √ Limited RAN sharing	√ Roaming in urban areas to be phased out before roaming in rural areas
Hong Kong	√ Can be directed to share if in the public interest or if commercial negotiations breakdown		
India	Mandated in Delhi and Mumbai	√	X
Italy		√ Regulator is monitoring the situation	
Jordan	Regulator only intervenes if commercial negotiations fail	√	
Netherlands	X	√	X
Nigeria	√	√	X
Norway	√ Telenor obliged to provide national roaming	√	X
Pakistan	X	√ Some forms of sharing (site and mast) are actively encouraged. Other forms are under consultation	X
Spain	X	√	
Sweden	√ Regulator occasionally intervenes where commercial negotiations fail	√ Shared 3G network which serves 70% of the population has been permitted	
UK	X	√ National roaming time limited √ RAN sharing announced	√ Roaming in urban areas to be phased out before roaming in rural areas

Where permission for national roaming has been given, it has sometimes been given on a time-limited basis. For example, the European Commission required national roaming in Germany to be phased out in urban areas after three years and in rural areas after five years. A similar ruling was applied in the UK.

EU Position on Infrastructure Sharing

Within the EU, NRAs must adhere to European Competition Law, specifically Article 81, and the EU Communications Directives when assessing proposals from the MNOs to share infrastructure. The NRAs are obliged to consider each proposal separately and there is no blanket approval mechanism from the EU.

Chapter 1 of the EU Competition Guidelines defines the criteria under which infrastructure sharing, or indeed any merger, could be considered anti-competitive. However, NRAs also typically look towards article 81(3) which discusses efficiency gains and the notion that efficiency gains should be weighted against competitive harm however any competitive harm must not be greater than that needed to achieve the efficiency gain.

Article 12 Section 2 of the Framework Directive (2002/21/EC) sets out that where undertakings are deprived of viable alternatives because of the need to protect the environment, public health, public security or to meet town and country planning objectives, Member States may impose the sharing of facilities or property (including physical co-location) on an undertaking operating an electronic communications network only after an appropriate period of public consultation. It is further provided that the national regulator shall encourage the sharing of facilities or properties.

Article 12 of the Access Directive (2002/19/EC) sets out that a national regulator may impose obligations on operators with SMP status, i.e. an operator with power to act independent of its competitors and customers on a specific market, to meet reasonable requests for access to, and use of, specific network elements and associated facilities where the regulator considers that denial of access or unreasonable terms and conditions having a similar effect would hinder the emergence of a sustainable competitive market at the retail level, or would not be in the end-user's interest. Operators with SMP status may, under this Article, sub-section (f), be required to provide co-location or other forms of facility sharing including duct, building or mast sharing. It follows from this that an operator may become obliged not to withdraw access to facilities already granted.

5.4 Controls on charges

In general, it appears that regulators tend to rely on operators to engage in commercial negotiations to set a price for infrastructure sharing. The price is then set based on the relative bargaining power of each operator – the operator with the site may be receiving additional revenue for a relative low cost but could be "assisting the competition", whilst the operator requesting access will be saving costs provided the price paid is below that which it would have paid to build its own site. Therefore, except in the case of particularly strategic sites, it is likely that there exists a price range over which a commercial agreement could be made.
In the few cases that we have reviewed where regulators have chosen to regulate the prices on infrastructure sharing for access to existing sites, this has often been at incremental cost. However, an incremental cost concept for sharing is not always particularly clear.

- Where an operator must replace the existing mast for a stronger tower to accommodate the new operators' equipment then the incremental cost concept would imply the new operator should be liable for the cost of the new mast and associated civil works. Whilst it may be unfair to expect the existing operator to incur additional cost as a result of sharing, the requirement to pay for replacement masts on an incremental cost basis could create a barrier to infrastructure sharing.
- It is reported that CDMA equipment has higher running costs than GSM equipment and therefore differential charges may be appropriate. These are not always clearly captured by an incremental cost approach.
- Incremental cost does not capture the incremental benefits, for example antenna in a certain position (e.g. higher-up) may have a higher value than on another part on a mast.

Therefore, any regulatory controls on charges must be carefully thought through and could be better used as a safeguard measure where commercial agreements on pricing, as opposed to access per se, cannot be reached.

5.5 Regulatory safeguards

MNOs may perceive the economic benefits to sharing and adopt a collaborative approach. Whilst preference is usually given to management by incentives, it is not uncommon for regulators to put safeguards in place, particularly to mitigate any anti-competition concerns. The nature of the safeguards depends on the type of infrastructure that is being advocated and the extent to which sharing is permitted or encouraged rather than being mandated. Examples of safeguards include:

- Capacity being sold on a first-come, first-served basis.
- Operators being required to log all infrastructure sharing activities and the logs to be made available to the regulator, if requested.
- Regulator acting as a negotiator to move along commercial negotiations.
- Infrastructure permitted and commercial negotiations encouraged but with mandated access and conditions should negotiations fail.

Jordan and Nigeria have regulatory safeguards in place and both advocate suitable capacity sharing whilst performing a dispute resolution role should commercial negotiations stall. In the Netherlands, the NRA intervened following a dispute between KPN and Dutchfone that resulted in the enforcement of site and mast sharing.

However, it should be determined whether the regulatory safeguards are intended to address any competition concerns arising from the sharing of infrastructure or competition concerns that may arise from the refusal to share infrastructure on a basis which is agreeable to both parties. It appears that, except in cases where infrastructure sharing is mandated, the majority of regulatory safeguards are intended to address the former.


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6 Technical and environmental considerations

There are a number of technical considerations and environmental benefits that accompany infrastructure sharing agreements.

6.1 Technical limitations to infrastructure sharing

6.1.1 Passive infrastructure sharing

Passive infrastructure sharing requires the consideration of many technical, practical and logistical factors although the principle is simple in theory. Any potential impact must be assessed and fully understood before sharing commences to ensure that there are no adverse effects on the operation of the site and the supporting network equipment and systems. Operators must consider items such as load bearing capacity of towers, azimuth angle of different service providers, tilt of the antenna, height of the antenna, before executing the agreement.

6.1.2 Sites and Masts

While new masts can be built taking into consideration the ultimate load-bearing capacity required, existing masts may not have been designed to cater for the additional load requirements of service providers who decide to share. Existing masts will have to be assessed on an individual basis as a mast may be capable of sustaining the additional load there may physically not be enough space left on the mast to accommodate extra equipment. If the site is optimally located in the shared network architecture then it may be viable for the site to be redesigned. This would be more applicable to masts located in urban city centre sites where the revenue the site generates justifies the additional investment required. There is also the consideration of whether an alternative site location can be found and how this would impact on network performance, in which case it may make more business sense to keep the existing location and re-build despite the additional cost.

In urban areas and city centres rooftop sites tend to be the dominant form where the load- bearing capacity of the building and foundation becomes significant. Rooftop sites offer a limited amount of space to house additional equipment, which again may require an expensive re-design if sharing is to proceed.

Urban sites also impose stricter requirements on the number of antennas that can be placed due to their aesthetic impact. This may require operators to choose combined equipment which results in poorer performance and additional limitations on modifications and network enhancements.

As site technology has improved, operators have increasingly made use of disguised sites which simulate street furniture such as lampposts and trees. These provide the operator with a mechanism to potentially increase planning approvals as they do not attract attention and minimise public concerns. Local planning authorities tend to favour these constructions above overt steel mast constructions and so are more likely to approve such applications. These types of sites have limited capability for sharing as they are constructed to be as small as possible. Operators such as 3UK, who had to roll out a network as fast as possible, made heavy use of these site types, which are largely unsuitable for sharing.

MNOs who share sites and utilise their own microwave backhaul network will have to ensure that they can accommodate the necessary microwave equipment on the tower or mast and still maintain line of site to the next site in the chain or to the hub point. This is largely a function of height (if the antenna is high enough then it will have a line of sight over and above the surrounding clutter and terrain) which may restrict the number of suitable sites for sharing. The operator may of course circumvent this through the use of fixed line backhaul where this is available.
In developing nations or those with more relaxed planning regulations operators have tended to install much higher and heavier load-bearing masts than the minimum specification they require. This provides them with some flexibility in the future for the own evolving network architecture but also means that the mast is more likely to be of a suitable construction for sharing.

6.1.3 RAN Sharing

RAN sharing may have an adverse effect on quality of service (QoS) levels due to the reduction of signal strength when antennas are combined, although this does not apply to leading 3G RAN sharing techniques . For example, in India operators felt that the use of common antenna could pose problems as the strength of the signal may be reduced by 3dBs by combining the signals. This represents a reduction in output power and impacts the coverage footprint of the network, which means it may not fulfil the QoS parameters in some areas.

The drop in signal strength not only reduces the overall coverage footprint but also has a negative impact on the in-building penetration of the carrier. This may be of less significance in rural areas where subscribers accept lower in-building coverage levels, but may have a major impact in suburban and urban areas where users are more likely to use their handsets indoors. Any significant decay in the in-building signal strength as a result of RAN sharing may act to counter the reduction in sites due to the requirement to maintain sufficient in-building coverage. This effectively means that the operator has to compensate for the loss in signal strength either through the introduction of new sites or leaving sites in the network that might have been removed if antenna equipment were not combined. The full impact of this will of course vary from operator to operator and according to factors such as frequency of operation. Other factors such as antenna developments will come into play that may mitigate the negative aspects in the medium and long term.

6.1.4 Core Network Sharing

Core network sharing poses technical limitations with regards to the technology platform of the operator and the standards employed by the equipment vendor. Traditionally 2G networks have been specified and designed on a circuit switched architecture. GPRS technology was implemented as a mechanism to introduce some of the advantages of packet switched networks. The more recent 3G networks have been specified with a more modern IP-based architecture in mind. IP-based technology is considered a more flexible platform and provides the mechanism for 3G operators to interwork with other IP-based systems as these develop and become available.

Given the general trend towards IP based technology, the likelihood is that, looking ahead, 3G networks should be able to benefit most from core network sharing as they already employ the standards and architectural components required for sharing.

6.1.5 Roaming

Roaming agreements have been in place almost as long as GSM technology has been in the marketplace. Roaming does not require any shared infrastructure as such, but an agreement that allows for an exchange of customer data. There are some technical requirements to ensure that the information is exchanged in the correct and timely manner but these are now well understood and easily implemented. The lack of any serious technical hurdle to roaming is demonstrated by the sheer number of agreements in place across the globe.

6.2 Environmental impact

The main environmental impact of networks relate to:

- Proliferation of masts.
- Power consumption.
- Handsets.

In this section we look at the impact that infrastructure sharing can have on these environmental issues.

6.2.1 Proliferation of masts

One of the most visible environment impacts of networks is the proliferation of masts. This is the public face of the network and one that is most likely to attract attention. Paradoxically while the public demand the services provided by networks they oppose the infrastructure required to deliver the service, due to aesthetic and broader environmental concerns. The situation is more pronounced in the developed world where environmental issues receive much higher media and public attention. This provides operators with the challenging task of providing service while at the same time addressing the environmental concerns of the public who are ultimately their customers.

9 For example, RAN sharing with dedicated carrier or MOCN (Multiple Operator Core Network) for UMTS900.



In the situation where two networks with similar coverage characteristics decide to enter into a RAN sharing agreement, this allows for a reduction in the total site portfolio of the combined network. The reduction in sites will have a positive impact in that it will reduce the number of towers and masts in the environment. However the reduction is on the premise that the networks have significant areas of overlap. If the operators should have networks such that the coverage is complementary then this will not produce the saving in sites and the impact on mast proliferation would be minimal.

Operators who share masts whilst maintaining separate networks are restricted to the number of masts they can share due to minimum vertical and horizontal separation requirements for antennas. Even if the mast has the required load bearing capacity it may not provide sufficient spacing to accommodate the antennas. This situation is likely to improve as antenna technology advances and new technologies that better facilitate mast sharing become available. The military forces (which are often ahead of civilian technology) already have technology available to fit multiple antennas in close proximity on vessels such as battle ships. These systems are being adapted to allow commercial companies to benefit from the same technology, helping them reduce the number of masts they require by being able to share smaller and more restrictive towers.

Quintel Technology Ltd is an example of such a company which produces a range of antennas which supports multiple operators and technologies in a single antenna unit. These systems appear as a single unit but allow for some independent operator flexibility in setting tilts. Such units have the expectation that operators agree on the azimuth and height of the antenna as this would be the same for all. However the technology does expand the range of candidate towers for sharing, providing operators with greater choice.

6.2.2 Power consumption

Like any other form of infrastructure in the modern world, mobile networks require power to operate. National operators often have to cover large geographic regions and install thousands of sites to provide the services required of them both from a commercial and a legal point of view. Operators have to keep their networks running on a continuous basis 24 hours a day, 365 days a year, regardless of utilisation. Demand for service may drop to zero during night time hours on certain sites but operators have no option to switch the site off during these hours as they cannot predict subscriber movements.

As a function of their size and operating requirements, networks consume large quantities of power with all the associated carbon footprints. One report from Actix, a company specialising in software solutions for mobile operators, suggests that networks consume 61 billion kWH of energy per year with an average site responsible for 10 tonnes of carbon emissions per year.

Although this might appear to paint an environmentally hostile profile we should put this into a global perspective before drawing any adverse conclusions. Mobile networks account for a mere 0.12% of primary energy use as compared to 23% used for travel and transport.

Advances in chip technology and the processing power of servers and electronic systems in general mean that the amount of equipment required to crunch the same amount of data continues to reduce, with the associated reduction in energy consumption. Equipment such as Mobile Switching Centres and Base Station Controllers which used to fill several equipment cabinets and take up large amounts of floor space, have now reduced to one or two cabinets depending on the manufacturer. This not only results in a direct power saving in the amount the actual network element consumes but may also reduce the peripheral power consumption, such as air conditioning.

Operators typically ensure that critical systems have a back up mechanism to ensure continuity of service and business operations. In some cases this means having a duplicate system available for activation if the primary system fails. However, for time-critical systems or those with high financial impacts the backup system may need to be on hot standby or parallel running. As network technology continues to improve this may be a potential area where power saving could be realised, if systems become inherently more reliable and reduce the need for back-up or standby systems.

While technology may help reduce the power consumption of individual elements of a network, this will be offset by increases in the number of network elements as the network continues to grow capacity and expand into new areas.

Operators have a finite resource in the amount of spectrum they have been allocated and the equipment has a limitation on the number of calls or frequencies it can cope with. Once a limit is reached, if the operator wishes to increase the number of subscribers it can process in any one area it has no choice but to increase the number of sites. These sites do not add benefit in terms of coverage but are deployed purely for capacity reasons. Operators who share networks can look to optimise the number of these sites are well as the number of coverage sites in more rural and less densely populated regions to reduce the overall site count. Any reduction will produce a direct saving in energy consumption and reduce the operator's environmental impact.

There is a growing industry in green technology that specialises in producing energy from renewable sources or with zero or reduced carbon impact. Such technologies include solar power, wind power, wave power and bio fuels. Operators should be in a position to benefit from these technologies as the amount of power they can generate continues to improve. Motorola has already successfully trialled a combined solar and wind powered base station in Namibia, which not only reduces the environmental impact of the site but also makes it more feasible for operators to deploy sites in remote regions by negating the need for traditional power supplies or maintaining a fuel generator.

10 Source: Ericsson – Sustainable energy for mobile communications June 2007

6.2.3 Handsets

There are an estimated 3 billion mobile phone subscribers worldwide, all of whom require handsets to make and receive calls. This number is likely to grow significantly in the coming years as markets such as China, Indian and Africa continue to develop. Manufacturers working together with operators constantly develop new phone models that they use to acquire new customers, as well as to entice existing customers to upgrade. According to reports from Gartner, global mobile phone sales reached 251 million units in the third quarter of 2006.

This produces a significant impact on the environment both in terms of the manufacturing process and the effects of disposal at the end of the product life cycle. Although network operators are not responsible for the manufacturing process they do have a part to play in the disposal of products. In 2006, a group called ESPOO was created as part of a European Commission pilot project comprising mobile manufacturers, network operators, suppliers, recyclers, consumer and environmental organizations.

The group was led by Nokia with the aim of reducing the environmental impact of phones through improvements in performance and raising consumer awareness and participation in take-backs (reverse logistics) and recycling.

Handsets that are discarded carry valuable metals in addition to toxic elements. Belgian company Umicore specialises in reclaiming precious metals such as silver, copper, platinum and gold from handsets and other electronics using a environmentally-sensitive process. However, according to Umicore's estimates, the company and its competitors received only 1 % of all handsets discarded globally in 2006.

In the developed world many mobile phones are disposed of when the user upgrades to a new model even though the phone is fully functional. Operators, together with other stakeholders, can set up schemes to encourage users to recycle their phones as and when they decide to upgrade, thus reducing the impact of network services on the environment.

Appendix 1 Country Examples

Figure 7 Summary

Country	Operators	Details of sharing agreement	Regulatory position
Australia	Telstra and H3G	Commercially negotiated 3G site and RAN sharing. Telstra purchased 50% ownership of H3G network assets. 3GIS, an administrative group, was established to own and operate H3G's existing RAN and funds future network roll-out plans as agreed with Telstra and H3G.	Regulator approved sharing of 3G RAN.
Brazil	Various	Country is split into 11 licensing areas with 4 operators licensed in each. These operators are encouraged to share both passive and active infrastructure, particularly in rural areas that may be uneconomic to serve otherwise.	Sharing permitted provided standalone roll-out obligations are met
Channel Islands	All operators	Arquiva owns sites and towers and rents access to any 2G or 3G operator who requests access.	Passive sharing is permitted but not mandated. Recognised that a reduction in the number of sites needing to be built was positive.
Cyprus	Vodafone and Areeba	Site sharing and national roaming arrangements.	Mandated co-location and national roaming.
Germany	T-mobile and 02	Site sharing of 3G networks. 02 uses T-mobile network for national roaming.	Site sharing permitted as it encourages faster roll-out and expansion into rural areas. It does not restrict competition as is limited to basic infrastructure. National roaming exempted from competition rules.
Hungary			MNOs have no access-related obligations as the NCAH did not find operators with SMP in the mobile access market in 2005. There are no MVNOs established in Hungary.
India	All operators	Commercially negotiated agreements, with 30% - 40% of sites currently shared. Sites generally shared on a 1-for-1 basis, with the exception of those funded by the USF. Bharti Infratel owns over 20,000 sites and holds an approximately 42% stake in Indus Towers, the recently announced joint venture between Bharti, Vodafone and Idea, which has over 70,000 sites. Bharti Infratel and Indus Towers will provide site and mast services to all wireless telecom operators in India on a non-discriminatory basis.	Regulator approved sharing of cell sites and is currently consulting on sharing of RAN and other network elements. Site and mast sharing is mandated in Delhi and Mumbai. This was opposed by the MNOs.
Italy		The first commercially negotiated wholesale access agreement was recently signed by one mobile operator with a large distribution company, and other agreements are currently under negotiation.	There is no obligation for mobile network operators to sign wholesale access agreements.
Latvia			Access and origination market was notified to the Commission in November 2006. However, no national roaming obligations on the two leading operators imposed on the grounds that the new entrant was obliged by its licence conditions to affect certain levels of network investment.
Luxembourg	Three mobile operators	The strict security and health rules imposed would make it difficult to carry out facility-sharing and co-location. This seems to have delayed the development of third generation mobile networks in Luxembourg.	3G network roll-out has been slightly delayed, partly due to the procedures for obtaining planning permissions for mobile masts and antennas. National regulation came into force in January 2006 setting out the procedures for applying for such permissions, and imposes legal time limits for each step of the three-step procedure. However, the three-month time limits imposed under the law do not seem to be observed in practice, and the procedure therefore would be long.

Country	Operators	Details of sharing agreement	Regulatory position
Malta	Vodafone and Go Mobile	As per regulatory requirements.	Both operators jointly held to have SMP, obligations with regard to cost-orientated and non-discriminatory access, including full MVNO access and national roaming.
Netherlands	Albert Heijn on KPN Debitel on KPN and Vodafone Easy Mobile on KPN Hema on KPN Scarlet on Orange UPC on Orange Versatel on KPN Tele2 on KPN T-mobile and Orange	Commercial MVNO agreements Co-operation in building UMTS infrastructure (estimated to have saved the companies up to $785 million each)	OPTA does not regulate MVNO agreements directly. NMa and OPTA allowed collaboration in the construction of UMTS network components on the condition competition existed between each party.
Norway	Telenor (single dominance) and TeliaSonera's NetCom plus a small number of MVNOs	A number of commercially negotiated and regulated agreements between the main operators and MVNOs. Commercial agreements between Telenor and TeliaSonera.	Telenor is obliged to provide national roaming and MVNO access, publish tariffs and reference offers, implement accounting separation, and is subject to price and accounting controls for national roaming. Telenor also has an obligation for co-location. All operators may share sites and masts, RNC (Radio Network Controllers) may be shared physically, but operators must retain logical control over their networks and spectrum. All transmission routes, i.e. optic fibre, cables, P-P radio lines may be shared. As regards core networks: The MSC (Mobile Switching Centre) may not be shared. The Ministry of Transport and Communications may, subject to an individual consideration, allow fulfilment of the coverage requirements through roaming in networks based on other technologies than UMTS (W-CDMA) provided such networks can offer sufficient capacity and that the arrangement is without substantial disadvantage to subscribers.
Pakistan	Telenor, Ufone and Warid	Telenor and Ufone announced a commercial agreement to share sites and towers in 2006. The cited aim was to reduce network roll-out costs and make rural network roll-out more viable. Warid later joined the sharing agreement. Mobitel, the largest operator by coverage and subscribers, opted not to join the consortium.	National telecoms policy encourages infrastructure sharing. Currently, the regulatory environment in Pakistan does not oblige the licensees to share infrastructure with their competitors. Each licensee is expected to build or lease the infrastructure it requires, although the licence they own allows them to share their infrastructure on commercial arrangements. PTA, so far, has not issued any guidelines to regulate the matter.
Spain	Orange and Yoigo (Telia Sonera) Yoigo and Vodafone Spain	In January 2008, commercial agreement to share transmission infrastructure and sites for a 5 year period. Yoigo, the 4th licensed operator using W-CDMA, has a commercially negotiated national roaming agreement to use Vodafone's network. This provides it with national coverage despite its own network being limited principally to urban areas.	Regulator has not currently objected to the proposed arrangement. All Spanish MNOs, TME, Vodafone and Amena may be facing obligatory MVNO access arrangements although the regulator's joint-dominance finding is currently under appeal by Vodafone.
Sweden	All licensed operators	There are five operators, four of whom have formed two separate consortiums of two operators each. Each consortium has built out a joint network.	Regulator permitted this level of sharing, but required each operator to maintain 30% of its network separately.
UK	Vodafone and Orange H3G on O2	In July, announced plans to share radio access network. Commercially negotiated national roaming.	EU commission approved all sharing models, no mandated infrastructure sharing.
USA	Various including AT&T Wireless and Cingular.	Various operators engage in the sharing of both passive and active elements. This includes the joint network sharing deal of AT&T Wireless and Cingular.	The FCC has assessed a number of infrastructure cases but has taken a non-interventionist approach.

11 http://www.npt.no/pt_internet/eng/resource_management/frequency_management/licences/3G-auction03/infrastructure.html



Case studies

Country: European Union

Individual NRAs within the EU are required to notify the EU Commission of decisions taken on infrastructure sharing. The awarding of 3G licences led to an increase in applications to share infrastructure and particularly for new 3G operators to be permitted to use national roaming to provide full geographic coverage. These applications included:

- T-Mobile and O2 in Germany; and
- T-Mobile and O2 in the UK.

Initially the EU took a negative view of the benefits versus costs of infrastructure sharing and pointed towards the potential negative impact on competition. As a result, although national roaming was permitted for new entrants it was often time limited. National roaming was permitted in rural areas for a longer period than for urban areas. Other European NRAs followed the Commission's approach and as such active infrastructure sharing was limited.

The operators challenged the EU Commission's decision. The European Court of first instance ruled in favour of the operators and stated that the EU had overplayed the competition concerns. This has led to greater opportunities for operators to engage in infrastructure sharing.

Country: Cyprus[12]

In Cyprus there are two MNOs, CytaMobile-Vodafone and Areeba-MTN Cyprus, the former with a 90% market share in 2006 in terms of subscribers and Areeba with a 10% market share. Cytamobile, the mobile arm of the state-owned fixed-line operator teamed up with Vodafone following the entry of Areeba, which was granted its mobile licence on 4 December 2003 for a period of 20 years. Under this licence, Areeba had the obligation to ensure that its network reaches 50% territorial coverage by December 2005, which was achieved. This coverage needed to increase to 75% by the end of 2007. Both MNOs have 3G licences and provide related services. In 2006, mobile penetration in Cyprus reached 113.6% (100% in 2005), with 900 000 subscribers.

Cyprus provides an example of how lack of site and mast sharing may be followed by more protracted competition problems, litigation and mandated national roaming later on.

Sites and Masts:

From 2002 to December 2003, no town planning licences were required and the incumbent operator installed many masts/antennas without any such licence. As a result, CytaMobile was able to install and expand its mobile network to one comprising approximately 470 base station sites by 2004. With the granting of the mobile licence to Areeba, both the incumbent and the second MNO face major delays and difficulties in the roll-out of mobile network. In the current legal environment, the erection of masts and antennas requires permission from planning authorities under the relevant town and country planning regulations, together with a building permit from the designated planning authority. Moreover, building permit practices differ between building authorities. Consequently, of the 84 applications that the incumbent had filed for building permits between September 2004 and November 2006, only three were granted. As for the second MNO, applications for building permits on government-owned land have been pending for more than a year and no such licence has been issued to date.

To remedy this situation, the legal framework for the erection of antennas and masts has been amended. This included a framework for the harmonisation of granting mast and antenna roll-out in Cyprus for which town planning and building permits are required as well as an amendment of legislation on building permits.

Due to the slow process of granting the requisite permits and licences for the installation of fixed and mobile networks, operators also have had the problem of maintaining illegally built masts / antennas. Several market players underlined that, in view of the particular administrative system and the relevant legal provisions, most of the antennas / masts are considered to have been built illegally by both the incumbent and the second MNO. Following the Decision of the Supreme Court of 30 June 2006, stating that the mobile base stations of the incumbent are illegal because they were built without building permits, the incumbent operator had to remove three base stations following District Court decisions taken on the basis of the Supreme Court decision. The second MNO also faced

12 Source: Commission staff working document annex to the communication from the commission to the european parliament, the council, the european economic and social committee and the committee of the regions european electronic communications regulation and markets 2006 (12th report), brussels, 29 march 2007, sec(2007) 403, [com(2007) 155]

repeated orders from different public authorities to remove its existing base stations for lack of the requisite permits.

Problems with national roaming

Cyprus is one of the rare Member States where the mobile access market has been found not to be competitive. Therefore, CytaMobile-Vodafone has been designated as having SMP. The incumbent operator's regulatory obligations (pricing) on the retail mobile market were revoked on 1 April 2005 by the regulator due to the fact that no mobile retail market is defined in the Commission Recommendation, but following a competition case brought to the Commission for the Protection of Competition ("CPC"). The CPC issued an interim order in July 2005, requiring the incumbent operator to raise its prices to the pre-April 2005 rates, and imposed a CYP 2.2 million (€3.8 million) fine on the incumbent in January 2006 for abuse of a dominant position in the market for mobile telephony services. In its comments following the notification of the mobile access market, the Commission called upon the regulator to impose price regulation with regard to the national roaming services the incumbent is obliged to offer to Areeba. The Commission noted that the price of national roaming services should be cost-based and permit a suitable margin between the incumbent's retail tariffs and its wholesale national roaming tariff. The price of national roaming was fixed by the OCECPR at €0.0214, which the second MNO found to be twice as high as it should be from its own cost calculation. As a result, the Weighted Average Cost of Capital (WACC) in mobile prices changed to 14.19%.

The price for wholesale national roaming services was crucial in Cyprus, as the second Areeba had not yet completely rolled out its own network. It is still having problems with the roll-out of its masts and antennas because of the administrative slowness of the granting process (town planning and building permits are both required). As a result, the coverage of the second MNO is still very meagre (55% in July 2006), despite its obligation to reach 75% territorial coverage by December 2007 and its desire to achieve total territorial coverage as soon as possible.

Country: India

The Telecom Regulatory Authority of India (TRAI) has recommended infrastructure sharing as a method for increasing mobile telephony coverage levels. It cited the benefits as being:

- Increased ease of acquiring cell sites, particularly given the Indian planning regulations, allowing sustainable growth
- Improvement of quality of service through better coverage
- Improvement in the aesthetics of the landscape
- Reduced costs of infrastructure creation
- Optimal use of scare resources
- Faster service roll-out
- Affordable tariffs for consumers

However, it noted a number of technical issues that operators would need to address in site sharing agreements. These included:

- Number of antenna per tower
- Direction and tilt of antenna
- Interference-free operation for each operator
- Desired azimuth and AGL for each operator

Rather than regulating infrastructure sharing agreements, the TRAI opted to take a safeguard regulatory approach and stated that "the process of sharing infrastructure should be transparent and non discriminatory. All licensees must announce on their web site the details regarding the existing and future infrastructure installations available for sharing with other service providers. A time limit of 30 days for negotiations between access seeking and provider should be the normal practice."

Initially infrastructure sharing was restricted to site and mast sharing and telecom companies were not allowed to share active infrastructure such as optic and feeder fibre cables, radio links, network elements, backhaul, antennae and transmission equipment. Service providers feel that infrastructure sharing can achieve its desired goals only once sharing of active infrastructure is permitted. Thus TRAI released its consultation papers in November 2006 inviting comments from stakeholders on infrastructure sharing, including active sharing. Though most stakeholders encouraged infrastructure sharing, making the same mandatory was strongly opposed except for in sensitive areas like Lutyens Bungalow Zone

13 Financial Times Corporate Profile: Lebanese phone group seeks big market share

By Kerin Hope, December 19 2006 11:37 viewed on 11.02.08 at: http://www.ft.com/cms/s/1/6d199d18-8ea8-11db-a7b2-0000779e2340,dwp_uuid=e12e0162-8548-11db-b12c-0000779e2340.html

(LBZ), Cantonment areas, Central Government and State Government office buildings, Designated Forest or Green Belt areas and Government Residential colonies, etc., where installation of cell sites by individual operators is either difficult or is not permissible due to lack of policy, security or aesthetic concerns. The TRAI did not support spectrum sharing or backhaul sharing from BTS to BSC as it determined that this would have a negative impact on competition.
The Government and mobile operators launched a joint initiative called "Project Most" aimed at encouraging infrastructure sharing. This has led to positive outcomes, for example:

- The mobile operators have all entered into commercial agreements to site share. Vodafone estimates that approximately 30% to 40% of sites are now shared, Given that, for example, Vodafone is estimated to roll out roughly 2000 towers per month and Bhari around 3000 per month then this significantly reduces the level of capex expenditure. Sites are shared on a one-for-one basis.
- There are examples of some towers, particularly in Delhi, being shared by as many as six or seven operators. Given tight planning regulations in major Indian cities, this has helped all operators to provide sufficient capacity and coverage in major cities.
- Population and geographic coverage levels in India were stabilising due to falling ARPUs making it unprofitable to roll out into more rural areas. The cost savings from infrastructure sharing are encouraging mobile operators to step up their coverage plans.
- Mobile operators have received subsidies from the universal service fund towards rolling out shared towers in rural areas. The first subsidy applied to 8000 towers with an additional 10,000 shared towers expected to be built out following the second tender. This has also facilitated greater network coverage in rural areas.

There have been a few technical and commercial issues in relation to infrastructure sharing, although we understand that these have generally been resolved between operators and are built into SLA / costing agreements. These issues include:

- Existing masts not being strong / large enough to permit all operators to share the mast. Where a mast requires upgrading then it has been unclear who should pay.
- CDMA operational costs are higher than GSM, due to greater air-conditioning requirements. This has required CDMA operators to pay relatively higher access charges.
- Debates over antenna positioning are common.
- Prices for sharing depends on the position of equipment and location of towers and towers are meant to be shared on a one for one equal basis – however there is sometimes disagreement over the meaning of "equal".

To date, tower sharing agreements between the MNOs have been driven by coverage requirements rather than as a source of additional revenues. However, Bharti, Idea and Vodafone have recently created a joint infrastructure company and will compete against the other independent tower companies, including American towers, in the Indian market place. The three companies have announced that they will merge their existing infrastructure assets in 16 service licence areas into a new company, called Indus towers. Indus towers will be independently managed and operators and will offer services to all operators and other wireless service providers like broadcasters and broadband providers. Vodafone has stated it expects cost savings of $1bn over the first five years of infrastructure sharing and has indicated the main benefit will be accelerated expansion of coverage, particularly in rural areas.

Country: Germany

The 3G licence conditions state that each 3G licence holder is required to build its own network and to ensure its 'competitive independence' during the lifetime of the licence. This means that service providers are not allowed to share backbone facilities such as switching centres even though they can share network elements such as masts and antennas. The regulator (Bundesnetzagenteur) ruled that infrastructure sharing of wireless sites, masts, antennas, cables, combiners and cabinets was permissible – provided that full legal control of the networks and competitive independence remains intact.

In July 2003, the EU Commission approved 3G mobile network sharing in Germany. In its decision it:

- Confirmed that site sharing in itself does not raise competition concerns
- Confirmed that national roaming between licensed network operators benefits consumers by allowing the operators involved to offer better and quicker 3G coverage. This is particularly true for less built-up and rural areas
- National roaming will be temporarily excepted for competition rules, with urban roaming exempted for a shorter period than rural roaming
- Roaming will enable the smaller operator on the market (02) to launch earlier and better services

Following the decision, the regulator set out the following infrastructure sharing principles:

1. Shared use of sites, masts, antennas, cables and combiners is permitted under the Award Conditions.
2. Shared use of Site Support Cabinets, or SSCs (= more than one Node B in a single SSC) has no further implications for functions control (full legal control of the operator's network) and the independence of the licence holders as competitors and is thus compatible with the Award Conditions.
3. Use of logically distinct Node Bs in one and the same unit instead of physically distinct Node Bs at the same site is covered by the Award Conditions if the individual cooperation agreements guarantee that each licence holder will retain functions control and competitive independence. The preconditions are:

- each licence holder has independent control of his own logical Node Bs so that he can operate his assigned frequencies only (no spectrum pool);
- no exchange of any data relating to competition beyond that required for technical operations takes place (e.g. customer data);
- separation of the Operation and Maintenance Centres;
- operation of additional own Node Bs (to guarantee the operator's planning autonomy);
- no regional splitting up of coverage areas that rules out network and coverage area overlap.

4. Use of logically distinct RNCs in one and the same unit instead of physically distinct RNCs is covered by the Award Conditions if the individual cooperation agreements guarantee that each licence holder will retain functions control and competitive independence. The preconditions are:

- each licence holder has independent control of his own logical RNC, particularly of the usage-sensitive cell load and power;
- no exchange of any data relating to competition beyond that required for technical operations takes place (e.g. customer data);
- separation of the Operation and Maintenance Centres;
- possibility of operating additional own RNCs (to guarantee the operator's planning independence);
- connection of the operator's own Node Bs, operated solely by himself, to his own logical RNC.

5. Shared use of the core network, i.e. of the MSC, would lead to a spectrum pool and is thus incompatible with the requirement of functions control as set out in the Telecommunications Act and the UMTS Award Conditions.
6. Transitional arrangements on the shared use of MSCs are ruled out in light of principle 5.

Following the decision, T-mobile and O2 entered into agreements to site share 3G infrastructure. This was restricted to passive infrastructure. 02 also began to nationally roam on T-mobile's network. The terms and conditions, including prices, were commercially negotiated.

Country: UK

In May 2001, Oftel issued its first note for information on 3G mobile infrastructure sharing in the UK. It noted that there was an obligation on the Director General of Oftel to encourage the sharing of facilities and that this duty encouraged, but was not restricted to, the sharing of mobile masts. However it was also noted that: (i) proposals for infrastructure sharing must not breach the Wireless Telegraphy (WT) act which states that licences and spectrum, in particular, cannot be transferred between parties; and (ii) encouragement should not compel an operator to engage in anti-competitive

behaviour. Oftel noted that in assessing proposals, it would weigh up the potential benefits including environmental and earlier delivery of 3G services at a lower price, against disadvantages including a lessening of competition and resulting implications on coverage of quality. Any individual proposal would be assessed on the detail of the commercial arrangements and its consequences for consumers. It would also have to abide by UK and EU competition laws.

In April 2003, the EU Commission approved 3G network sharing in the UK. This was on the assertion that it would assist in promoting quicker and better coverage, particularly in remote areas. Roaming was permitted outside the top ten cities and was expected to be phased out over time in smaller cities. The EU commissioner stated "this decision strikes the right balance between infrastructure competition in 3G markets and the immediate customer benefit of having faster and wider roll-out of advanced 3G services." Following the decision, T-Mobile and O2 entered into commercial agreements for site and mast sharing. H3G also used O2's network for national roaming, being charged a commercially negotiated 10ppm.

In July 2007, Vodafone and Orange announced plans to work towards a full network sharing agreement. If it goes ahead, it would lead to the shared management and maintenance of the radio access network (mobile telephone masts) of each company with the long term intention to eventually consolidate and share the radio access network. An arrangement would also be put in place for the build and future roll-out of the radio access network. The arrangement will be exclusively for Vodafone UK and Orange UK. Orange stated that, "As well as improved efficiency in network operations, customers will also benefit from the extension to coverage that this agreement would bring and the speed at which Orange UK and Vodafone UK will be able to increase 3G coverage and services. Under this agreement, both operators would remain competitive and retain full responsibility for the quality of service and products they offer customers while sharing radio sites and radio network equipment." However, this agreement has since stalled.

In December 2007, T-Mobile and Hutchison confirmed plans to share their 3G networks. As neither has a fixed line broadband offering it has been suggested that they will use the increased coverage and capacity of the shared network to focus on mobile broadband offerings. The two companies formed a management company, Mobile Broadband Network Ltd, and envisage the combined network should reach 90% of the population. The initial focus is on extending wide area coverage to rural areas by moving 5000 base stations from places where the two networks overlap. Then the focus will shift to improving indoor coverage in dense urban areas. The parties claim this will create Europe's most extensive HSDPA network. The joint venture will last until 2031 and makes provisions for the sharing of LTE (the 4G version of W-CDMA). However, the agreement doesn't cover 2G as 3 still has a network roaming agreement with Orange.

Country: Pakistan

Infrastructure sharing is permitted and actively encouraged by the regulator and government in Pakistan. However, the regulator has stated that incentives, rather than a mandate, are the best method for ensuring that this happens successfully in practice.

In its consultation document on the subject, the regulator provided a number of reasons for encouraging infrastructure sharing:

- Aesthetic landscape of the country is changing.
- Without sharing, the networks are underutilized and inefficient.
- Land hiring and agreements with land owners posing complications.
- Security issues are rising.
- Clearance procedure delays hamper roll-out.
- Due to inefficiency, systems are cost-ineffective.

The regulator stated that, "A need is thus felt to have a framework in place guiding and promoting the sharing of communication infrastructure. Present individualism is reflecting underutilization of BTS sites and resources and is also a burden on the operators. There is also general public concern over effects on health and environment due to growing numbers of BTS in cities, towns and rural areas. It is therefore imperative that resources are pooled and cost shared in planning and setting of BTS."



The regulator is currently consulting on active infrastructure sharing of nodes and backhaul capacity. It believes that this may encourage further roll-out into rural areas.
In July 2007, Ufone and Telenor initially entered into a commercial agreement to share their infrastructure (towers and sites) for 10 years. Warid and Paktel later joined this agreement, leaving only Mobilink excluded. Mobilink has traditionally traded on its leading coverage.

Country: Hong Kong

In Hong Kong, telecommunications operators are encouraged to negotiate for sharing of facilities on a commercial basis. However, under section 36AA of the Telecommunications Ordinance, the Telecommunications Authority (TA) may direct the licensees to share use of facilities where it is in the public interest to do so. In considering whether or not to issue a direction in the public interest to share a facility, the TA will take into account the following factors:

- whether the facility is a bottle neck facility;
- whether the facility can be reasonably duplicated or substituted;
- the existence of technical alternatives;
- whether the facility is critical to the supply of service by the licensees;
- whether the facility has available capacity having regard to the current and reasonable;
- future needs of the licensee or person to whom the facility belongs; and
- whether joint use of the facility encourages the effective and efficient use of telecommunications infrastructure;
- the costs, time, penalties and inconvenience to the licensees and the public of the alternatives to shared provision and use of the facility prior to issuing such direction.

Regarding the terms and conditions of the shared use (including the rental prices), the parties are required to reach an agreement within a reasonable time. If the parties cannot reach an agreement, the TA may determine the terms and conditions for the shared use of the facility and provide for fair and reasonable compensation payable in the circumstances of the case. The compensation determined by the TA will include the relevant reasonable costs attributable to the provision, use or sharing of the facility. In calculating the costs, the TA may select from alternative methods what he considers to be a fair and reasonable costing method.

Country: Norway

The Storting, Norway's parliament, supported the Government's proposal for a framework for infrastructure sharing. On the basis of a recommendation from the Norwegian Post and Telecommunications Authority (NPT), the Ministry of Transport and Communications has decided the following regarding 3G infrastructure sharing: Within the minimum coverage requirements, the following components may be shared within the area covered by the concession's minimum coverage requirement:

- Antennas and masts: All sites, masts, antennas, cables, combiners, power supply, buildings etc.
- Node B: Node B may be shared physically, but operators must retain logical control over their own base station.
- RNC (Radio Network Controllers): RNCs may be shared physically, but operators must retain logical control over their networks and spectrum.
- Transmission: All transmission routes, i.e. optic fibre, cables, P-P radio lines may be shared.
- Core networks: The MSC (Mobile Switching Centre) may not be shared.
- Frequencies will not be shared.

Country: France

ART (Autorité de Régulation des Télécommunications) supported sharing of 3G infrastructures between service providers, as long as frequencies are not shared. It added that it did not want the sharing agreement to prevent the development of effective competition in the 3G market, which must be beneficial for subscribers. ART defined following five levels of sharing and their compliance with conditions for issuing 3G authorizations:

a) Level 1: Sharing of sites and passive elements
This form of sharing consists of common use by multiple service providers of all or part of the passive elements of the infrastructure. This would

include sites, civil engineering, technical premises and easements, pylons, electrical supply, air conditioning, etc. This type of sharing is not only permitted, but encouraged. This "level 1" sharing also includes the pooling of transmission elements that are not part of the UMTS architecture, such as connections between base station controllers (BSC) and network nodes (MSC and SGSN) or connections between base stations (node B) and base station controllers (BSC). Such pooling is possible if these elements are not directly from the UMTS network.

b) Level 2: Antenna sharing
This level is defined as pooling of an antenna and all related connections (coupler, feeder cable), in addition to passive radio site elements. Since an antenna can be considered a passive element, antenna sharing can be included in the more general issue of passive infrastructure sharing mentioned above and therefore complies with the telecommunications act.

c) Level 3: Base station sharing (Node B)
Base station sharing is possible as long as each service provider:

- maintains control over logical Node B so that it will be able to operate the frequencies assigned to the carrier, fully independent from the partner service provider
- retains control over active base station equipment such as the TRXs that control reception/ transmission over radio channels

d) Level 4: Base station controller (RNC)
RNC sharing is possible since it represents maintaining logical control over the RNC of each service provider independently.

e) Level 5: Sharing of backbone elements
This consists of sharing switches (MSC) and routers (SGSN) on the service provider's fixed network. The frequency usage authorizations issued by the Authority are assigned intuitu personae and cannot be transferred. Accordingly, the Authority must exclude infrastructure sharing solutions that lead to a pooling of frequencies between service providers. The sharing of backbone elements does not comply with the French regulatory framework if it leads to such pooling of frequencies. This is the case when backbone elements are shared along with the radio portion.

Country: Brazil

National Telecommunications Agency (ANATEL) set out the rules on infrastructure sharing amongst telecommunications service providers. The rules set out the conditions and standards for sharing of ducts, conduits, poles, towers and utility easements in the telecommunications sector. Instead of a price list, ANATEL has prescribed a calculation methodology for actual infrastructure costs. The major points in the Resolution are:

a) Only infrastructure over-capacity may be shared with other telecommunications companies

b) Acts or omissions aimed at protracting an agreement between telecommunications companies will be treated as unfair competition under antitrust laws

c) Caps on the amount payable by the telecommunications service providers applying for use of another service provider's infrastructure were adopted

ANATEL has permitted both passive and infrastructure sharing amongst 3G operators. It has licensed 4 operators in each of the 11 geographic licensing areas and permits these regional operators to share network infrastructure provided that individual roll-out obligations are met. In practice these means that operators are allowed to use each other's networks to provide services in areas that have less than 30,000 inhabitants.

Country: Jordan

Telecommunications Regulatory Commission of Jordan issued a statement is in regard to the implementation of Infrastructure Sharing and National Roaming for mobile telecommunications service providers. In this statement, the TRC has concluded, "it is impractical to publish an exhaustive set of rules with respect to collocation and infrastructure sharing matters. Instead, the TRC will address any issues related to capacity, availability or other situations that may arise on a case by case basis. In instances where the requesting service provider and the other service provider fail to reach agreement in these matters, the TRC will conduct an investigation. Upon completion of its investigation, if the TRC has determined that infrastructure sharing or collocation is indeed feasible, it will then issue a decision regarding the terms, conditions and time frames under which infrastructure sharing or collocation (or both) will be provided."

Country: Netherlands

In the Netherlands, NMa (Netherlands Competition Authority), OPTA (Independent Post and Telecommunications Authority), and the V&W (Ministry of Transport, Public Networks and Water management) issued a joint memorandum that provided comprehensive clarification on collaboration in the deployment of 3G networks in September 2001. They agreed to allow 3G service providers to collaborate in the construction of 3G network components on the condition that competition between service providers continued to exist and that service providers compete against one another in providing 3G services. While they shared the opinion that collaboration in 3G network deployment could contribute to a more rapid 3G roll-out, they clarified that collaboration must be limited to the joint construction and use of the 3G network infrastructures such as masts, aerials and network operation. On this basis, they did not permit the joint use of frequencies and core networks.

Country: Sweden

In 2000, the regulator granted UMTS licences to four operators: Vodafone, Hi3G (a joint venture between Hutchison Whampoa and Swedish company Investor AB), Orange and Tele2. All had agreed to 99.98% population coverage by the end of 2003. The UMTS licence conditions permit sharing up to 70 % of the radio infrastructure necessary to meet the obligation, which was estimated to require 10,000 masts to be built,

On 24 July 2003 a new Act on Electronic Communications came into force. It stated that an operator, regardless of SMP status, may be ordered to provide, in return for commercial reward, co-location or other opportunities for shared use of property or other resources. If an operator cannot reach a voluntary agreement on commercial terms for mast sharing, it may request the NRA to impose an obligation. A precondition for such an obligation is that it is required in order to protect the environment, public health or public security, or to achieve the objectives of public planning.
The PTS indicated that a rejected application for a construction permit shall be sufficient in order to prove that co-location or access is required for environmental reasons. This was significant as due to public concerns, municipalities were increasingly rejecting planning applications.

The opportunities for sharing the network infrastructure have further increased through the forming of two consortia. A licence and network sharing agreement has been entered into between Tele2 and the incumbent TeliaSonera (who unexpectedly failed to gain a licence) and a joint venture network operator, 3GIS, was set up by Hi3G, Vodafone and Orange. Orange has however since withdrawn from the Swedish market. Therefore Tele2 and TeliaSonera share one network and 3 and Telenor partly share a 3G network. Nordisk Mobiltelefon have their own separate network and this means that in all parts of the country where there is 3G coverage there are at least three overlapping networks.

The 3GIS network is the world's first shared 3G network, and it is estimated that it serves around 70% of the Swedish population. Regulations on the extent of infrastructure sharing, that require each operator to own at least 30% of its network on a non-shared basis, appear to prohibit it from expanding further. Nokia was selected as the equipment provider and network manager for the network.

The stated mission of 3GSI is 'to deliver cost-effective network coverage and capacity to their owners and customers". 3 Sweden noted that a risk reduction and cost savings, particularly in rural areas, were a key driver of the agreement., Other potential benefits have been noted as: (i) by using one network infrastructure, each party covers only 50% of the CAPEX and OPEX required; (ii) sourcing equipment as a single entity enables volume purchases, and the resulting economies of scale mean further savings; and (iii) choosing a single vendor contributes to a faster roll-out, fewer technical and process issues and more harmonious integration of all network functionalities and services.

There have been some reports of operators having difficulties in reaching mast sharing agreements. For example, the PTS has agreed one request to impose an obligation to share a radio mast, and has since received nine further requests. However the creation of 3GIS appeared to result in a lessening of complaints.

Country: Denmark

The Danish Act on the establishment and joint utilisation of masts for radio communication



purposes states its purpose as being the limitation of the number of masts and the implications on the surrounding areas. For this reason, the regulator has been supportive of the mobile operators' commercial agreements on the sharing of masts and towers. The majority of mast share agreements appear to be in rural areas.

However, the regulator has not allowed sharing of radio access networks and core infrastructure despite requests from the operators that wish assist them in meeting their 3G coverage obligations in a cost-effective manner. Originally the 3G licences required 90% coverage by end 2008, however this was reduced to 80% population coverage (approximately 35% geographic coverage) at a hearing prior to the auctions as it was noted that the cost of covering the remaining 20% was disproportionately high. Some of the operators proposed the building of a joint network system to cover the remaining 10%-20%, however this was reject politically on the grounds that it would alter the real number of licences and would infringe on the principles of infrastructure competition. However, the operators have been permitted to sign both 2G and 3G national roaming agreements with each to increase the coverage levels of a particular operator. These have been agreed on a commercial basis; for example, Telia Denmark permits national roaming on its network.

Country: Finland

The Telecommunications Market Act was amended in 2001 with a view to obliging 2G licensees with SMP to negotiate roaming with 3G network operators. The statutory obligation for national roaming is restricted to 3G-2G networks. Access to the networks of 2G operators with national coverage has been organised on the basis of service provider agreements. This has been criticised and challenged by the new entrants, who argue that these agreements do not provide for genuine full capacity agreements and that the authorities should mandate 2G-2G roaming as a pro-competitive tool and, more generally, further develop mobile access regulation as is possible under the special access provisions of the current Directives and under the new framework.

In the spring of 2002 Telia, which had previously served its mobile customers through a service provider agreement with Radiolinja, concluded a roaming agreement with Suomen 2G and carried out a customer migration operation. Radiolinja undertook measures, some of which were considered to breach the law by the authorities. For example, FICORA ordered the company to immediately re-open Telia's subscriptions.

The Communications Market Act introduces a provision allowing the NRA to impose access to SMP-operators' mobile networks by mobile service operators and mobile virtual network operators. It also provides that the NRA may impose an obligation on mobile operators with SMP to allow access to their SIM-card capacity by alternative operators. During the consultation period, Sonera and Radiolinja expressed concern about this provision, because they considered that such access should be based solely on commercial negotiations, as is already the case with access to Radiolinja's SIM card.

On 15 April 2004, the Government decided to refine the terms of the 3G licences and permitted licensees are allowed to construct a part of the networks together. However each licensee's own network, independent of shared infrastructure, must provide 35% coverage of the population.

In mainland Finland, licences to provide UMTS networks are held by Radiolinja Origo Oy, Sonera Mobile Networks Oy, Suomen 3G Oy and Finnet Networks Ltd. The need to amend the licences is cited as arising from the development of the European markets and of third generation technology usage, which have been slower than expected, as well as of changes in the licence ownership bases after 1999. It was deemed appropriate to set coverage requirements with strict deadlines. A reason to amend the licence terms was that the earlier terms did not allow joint construction or use of networks.

All licensees agreed to the amendments. Ministry of Transport and Communications monitors the development of 3G mobile networks and services and made proposals on the commercial opening of networks and possible coverage requirements by 30 November 2004.

Since this change, commercial agreements on mast sharing, network sharing and national roaming have been signed in Finland. The regulator has the power to step in should commercial arrangements be agreed on a timely basis between operators. These agreements have also been seen in the 2G environment, for example Telia Mobile signed a

national roaming agreement with Suomen 2G. They have also led to establishment of a number of MVNOs, since operators are permitted to share 65% of their networks.

It has since noted that it believes infrastructure sharing could save operators 3%-10% on site costs, 1%-2.5% on microwave links and 1-2.5% on backhaul (as a percentage of total cost) .

Country: Australia

The Regulator appears to actively support site and mast sharing and has permitted a number of operators to share radio access networks. However, sharing of core networks does not appear to be actively encouraged.

One of the largest commercial deals occurred in August 2004 between Telstra and Hutchinson. This was cleared by the ACCC who assessed the benefits outweighed the potential competitive impact. Telstra will pay $450 million to Hutchison Telecommunications Ltd for a 50% share in ownership and operation of its 3G radio access network infrastructure. The deal ended speculation about whether Australia's biggest telco would build its own network or negotiate a share deal to meet its target of rolling out a 3G network by the end of 2005.

The cost to Telsra of building a network over four years would have been $900 million to $1.0 billion. Hutchison Telecommunications is one of Telstra's main rivals in terms of mobile subscribers. However, Telstra CFO John Stanhope stated that "competition between the two telcos would remain with each continuing to own separate core networks, application and service platforms, and conducting their retail 3G businesses independently and in competition with each other" and "This is the sharing of the radio access network ... so for customers there is still strong competition out there at the retail end."

Telstra stated the deal was undertaken to save on costs of entering the 3G market and that "we get a tried and tested network at half the cost." Telstra launched its 3G services to customers in 2005, utilising the entire H3GA network footprint of more than 2000 base stations covering Sydney, Melbourne, Brisbane, Adelaide and Perth. The parties agreed to maintain a world-best network and to adopt technological innovations as they occur to ensure the network remains at the cutting edge of 3G capability. Decisions on network development will be made and funded jointly. The joint enterprise will utilise the existing spectrum holdings of both partners and will operate until the expiry of those spectrum licences in 2017 or later.

3 stated that "In light of announcements by Singtel/ Optus and Vodafone that they intend to build their own 3G networks, this agreement recognises that the interests of the industry and the nation are best addressed through this type of infrastructure sharing arrangement."

14 http://www.tml.tkk.fi/Opinnot/T-109.551/2003/kalvot/UMTS_Inv_05_03_v3.ppt#257,2,Background

Appendix 2 Network Architecture

In this annex we describe, at a high level, a generic network architecture that may be deployed by a mobile operator. Subsequently, this set of network elements is used to define the various forms of infrastructure sharing.

Figure 8: Mobile Network Architecture

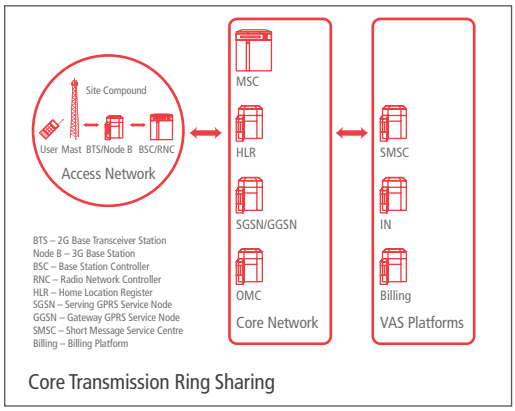


Figure 8 illustrates the logical split between the access network and the core network. A further distinction is made between the core network elements and the platforms which provide value added services such as short message and voice mail services.

Access Network

This consists of the following four elements:

- **User Equipment:** This is radio equipment in the form of a handset or terminal such as a data card which the user possesses for connection to the network.
- **Mast:** Physical structure which hosts the antenna equipment needed for broadcasting the operators' network signal. The mast may be a purpose-built dedicated tower or another structure with suitable height such as rooftops and chimneys.
- **BTS/Node B:** The equipment cabinet that houses the electronics and system necessary for the transmission and reception of signals between the network and the subscriber. For GSM operators this cabinet is referred to as a Base Transceiver Station (BTS) while 3G operators refer to this as the Node B. Functionally they both reside within the same space on the network hierarchy and perform the same basic tasks but at different standards and technologies.
- **BSC/RNC:** The Base Station Controller (BSC) is a 2G element which is connected to several BTS cabinets and gathers the data from these and forwards to the core network for further processing or routing. The BSC has some intelligence and is able to route calls between BTS cabinets if they are both connected to the same BSC. In the 3G world this functionality is performed by the Radio Network Controller (RNC). It also resides in the same position in the network hierarchy.

Core Network

The core network consists of four key elements:

- **MSC:** The Mobile Switching Centre (MSC) has overall control of routing and switching calls both within the network and to external network. It is equivalent to fixed line switches but specified, designed and built to service the particular needs of mobile networks.
- **HLR:** Operators need to record and have access to information about all their subscribers and the services they subscribed to. The Home Location Register (HLR) stores all the information for every customer using service on the operators' network.
- **OMC:** Networks are dynamic in their day-to-day operation and require constant monitoring to ensure service and performance is maintained. This requirement is fulfilled through the Operations and Maintenance Centre (OMC).
- **SGSN/GGSN:** Between the roll-out of 2G and 3G an interim standard called General Packet Radio System (GPRS) was introduced to provide some of the benefits of packet switched networks, such as higher data speeds over the existing circuit switched GSM network. This new standard, often referred to as 2.5G, required the addition of some core network elements such as the Serving GPRS Service Node (SGSN) and the Gateway GPRS Service Node (GGSN) to process the data from GPRS connections.

Value added service systems

A mobile network may comprise a number of value added service (VAS) systems. The three most common are described below.

- **SMSC:** The Short Message Service Centre (SMSC) provides the platform necessary for the sending and receiving of text messages.
- **IN:** The Intelligent Network (IN) platform enables operators to provision features such as complex billing based on tariffs such as friends and family and time of day as well as other value added features.
- **Billing:** This is the billing platform which takes the subscriber call records and processes them to produce the required billing amount.







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