GSM coverage in remote locations

White Paper

Abstract
This paper examines the options available to the Mobile Network Operator (MNO) seeking to extend GSMN coverage into remote or challenging locations. Standard expansion of a GSM network is well established as a route to increasing coverage for the operator. However, in many cases this is constrained by the ARPUs (Average Revenue per User) required to cover the increased costs. This paper looks at the PMN alternative, based on proven and established GSM technology and utilising standard mobile phone. This approach avoids introducing the element of competition which could, potentially, increase MNO churn. It uses the GSM standards and so can be scaled to match the demand at a specific location. This will lead to a greater ARPU for a given deployment for the MNO.

Introduction

The global system for mobile communication (GSM) has become the dominant standard used in global wireless communication markets. Today, GSM has been deployed in over 600 networks in 200 countries and accounts for more than 80% of all digital mobile wireless subscribers. Worldwide, there were 1 billion GSM subscribers in 2004[1] and by mid 2006 it had reached the 2 billion mark[2]. The Western European markets are now reaching 100% saturation, which has seen a shift in focus to more developing markets in Latin American, Asia and Africa. Even in the North American markets, GSM technologies have seen phenomenal growth as Time Division Multiple Access (TDMA) has been replaced in many networks.

The three central reasons for the phenomenal success of GSM are:

- Standardisation
- Economies of Scale and
- Global Roaming

From its inception, GSM developments were committed to openness and interoperability. This has resulted in a common infrastructure based on open standards that are accessible to all. In turn, this has generated competition and driven down costs and, at the same time, enabled rapid market expansion.

The economies of scale generated have driven down prices of handsets from their position of luxury items, when they were first launched, to the commodity item they are today. The reduction in the cost of handsets and services, supported by imaginative packaging of devices, text and call minutes, has been an important driver in the take up of GSM mobile phones.

The ability to roam, or use a mobile device on different GSM networks, is one of the core features of the standard. In recent years the rise of the mobile has provided business and private users with the ability to remain contactable across an ever increasing number of locations. As issues of SIM compatiability in different geographies have been overcome and coverage has increased, this has led people to expect mobile coverage anywhere in the world. Indeed, it is now an expectation that users can take their mobile phone with them and use it.

Mobile Network Coverage

For economic reasons, GSM coverage today is, predominantly, in the more densely populated areas of the world. This expectation of total coverage is, therefore, is putting pressure on Mobile Network Operators (MNOs) to expand networks and improve coverage to more remote locations. When decisions about creating new coverage areas are being made, one of the key concerns for an MNO is to maximise average revenue per user (ARPU) for a given capital expenditure.

---

[1] GSM White Paper – Gareth Jenkins
[2] GSM World Press Release June 2006

Coverage can, of course, include a number of different aspects. For example, an MNO might wish to provide a GSM network at a remote mine or other asset, or they could be investigating the possibility of generating revenue for customers at a hotel or casino complex. Or it could be that the MNO has customers that are demanding secure and private access to a GSM network at specific locations within normal coverage areas, such as a political conference or military deployment.

The issues raised by poor or restricted coverage have resulted in the development of several alternative solutions. These can be summarised into three groups:

- expansion of the national network
- work with partners to deliver an alternative technology or
- use of a private GSM network

This is not an all encompassing list, but these solutions cover the most likely options for consideration. The decision on which option to use is, typically, a financial one related to usage expectations and return on investment expectations.

Extending the existing GSM Network

The year-on-year spend on GSM telecommunications equipment has averaged about $25bn. At present, there are over 600 live GSM networks worldwide and each of these requires hardware and software.

A large scale national or international GSM network is an expensive technology to deploy and even the largest MNOs do not provide a network with 100% coverage. Rather, they create a core network and cover locations outside this through roaming agreements. The question for the service provider then is how to create infill of the coverage in the most cost effective areas, bearing in mind the ARPU likely to be generated at such locations.

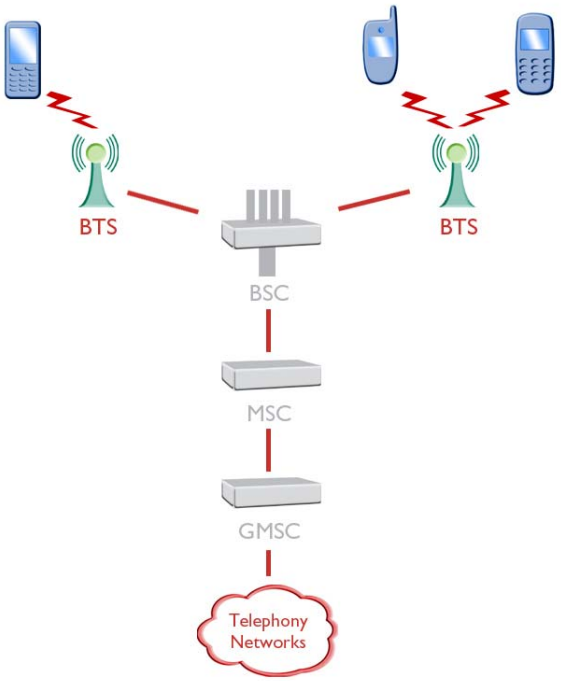

Figure 1: A conventional GSM network

A conventional GSM network (see figure 1 above) is made up of several hardware and software based components. This figure illustrates a highly schematic representation of such networks. The core components (shown in grey) are the base station controller (BSC), the mobile switching centre (MSC) and the gateway MSC (GMSC). These components, along with various associated databases (not illustrated), provide functions such as access to the network, billing and call control. The GMSC provides gateway capabilities to other telephony networks. The base transceiver stations (BSC) provide the air interface between the GSM capable device and the rest of the network.

In order to build a network, an MNO will need to buy, install and manage all the elements of the network. A typical fully equipped macro Base Transceiver Station (BTS) is in the $100-300K range and a macro Base Station Controller (BSC) than can handle 50-100 BTS sites is approximately $4m. The core of the network also requires a minimum of three Mobile Switching Centres (MSC) to create triangulation at a cost of at least $3m.[3] Other hardware and software components are also required to provide services such as billing and registration and well as system, bandwidth and device management.

As an indication of the scale of GSM deployments, in the UK, the Vodafone and O2 networks utilise around 6000 BTS sites each and for the T-Mobile and Orange networks, which use a higher frequency, the number of BTS sites needed is nearly double. This clearly illustrates the capital intensive nature of GSM deployments.

[3] GSM White Paper – Gareth Jenkins

Obviously, a full network is not required for every coverage infill project. However, as a minimum a BTS and sufficient space on a BSC will be required. The cost of a fully equipped 3-sector BTS has to be weighed up against the expected ARPU at this location. Often, this will prove not to be a positive business case. The cost of deployment, management and upkeep may not be covered by the ARPU at lower density usage locations. However, the customer demand is driving this sort of deployment forward.

Partnering to Extend the Coverage

A less capital intensive option for the MNO is to partner with other telecommunications operators to provide a shared coverage plan at remote or infill locations. The partners will, typically, be other MNOs where the partners agree to share the costs of the deployment and its management. Another option is for the GSM operator to partner with a provider of WiFi solutions, although this raises issue of support for mixed technology networks. However, both these options have difficulties associated with them. The most common problems arise from the fact that this approach will not only require cost sharing but also revenue sharing, so clear agreements need to be in place.

MNO Partners

The cost of revenue sharing will be most keenly experienced if the partner is another MNO. In this scenario, one MNO will establish a roaming agreement with a partner MNO. Such a roaming agreement will provide not only GSM access for calls but also to other services such as voicemail. An agreement of this nature will also require mutually agreed service level agreements (SLA) and maintenance and renewal agreements. On top of these legal issues is the question of competition.

Figure 2: Partnering Agreements

An MNO (see figure 2 in red) could use a partners network (shown in blue), with necessary agreements in place, to provide a roaming coverage at a remote location.

The primary reasons for providing coverage at remote locations is to increase the customer base and raise ARPU. However, a risk of such a partnership is that it could result in the loss of customers to the partner's network.

WiFi Partners

WiFi, a wireless network based on the 802.11x standards, is becoming increasingly popular and common. In fact, an increasing number of coffee bars, hotels and bookshops in North America and Europe offer WiFi connectivity. Although originally focussed on data connectivity, WiFi can also be used for voice connections with a suitable phone. These hot spots are a boon to business and private customers alike as they offer internet access away from their normal networks. A WiFi network is relatively cheap and easy to set up. A WiFi network is a wireless IP network and, as such, it would allow devices, with the correct software applications, to make telephone calls using this IP network. The option of WiFi is attractive because of the increasing availability of hot spots. This has led to the growth of dual mode handsets that allow users to make calls from a dual mode WiFi and GSM handset from the remote location. However, today many mobile users still do not have a dual mode handset so the target market for WiFi coverage is reduced.

Figure 3: GSM integration with WiFi

One of the possible options is to provide an IP network at the remote location based using WiFi (figure 3). The WiFi network would require specific handsets and a gateway to provide translation between the remote WiFi network and the main MNO's network.

There are also potential technical issues since WiFi was not originally designed to carry voice. In fact, there are a number of technical considerations that could preclude the use of WiFi as a coverage infill option for GSM. The main ones are that there is no guarantee of quality of service (QoS), capacity or handoff on the WiFi network. A lack of QoS on WiFi networks can result is severe degradation of voice quality, sometimes to the point where voice becomes inaudible. There is a problem of capacity due to the original design of the network being for data only. This means that, as there is no collision avoidance and voice traffic is delayed, the voice can be rendered inaudible and delays in speech can be significant. Handoff can be a major problem because there is no way to move from one WiFi cell to another during a real time voice session, resulting in dropped calls as the user moves around the site. There are two more considerations from the handset point of view. Battery life is extremely limited on all devices currently using WiFi as there in no passive standby available with GSM handsets. The second is the cost of dual-mode handsets being 4 to 10 times that of a standard GSM capable handset.

It can be argued that wireless VoIP has great promise to lower costs to the end user and simultaneously increase productivity. The prospect of wireless VoIP delivering these advantages has been much heralded and is eagerly

awaited. However, the existing wireless infrastructures available today largely fall short of these aims.

Therefore, in most cases today, WiFi is not considered by MNOs as a suitable technology partner for a GSM coverage solution.

Private GSM Network

A private mobile network (PMN) provides GSM coverage at a set location, in the same way that a macro network but at a greatly reduced cost. This is because the chief costs of the BTSs used on a macro network are orders of magnitude more expensive than the costs of nano and pico BTS units.

A PMN uses the same architecture as the macro MNO networks but with lower capacity components operating at lower power outputs. This allows the operator to reduce costs while generating new ARPU. The added advantage of a PMN is that it can support a closed user group that could be restricted, for example, to just the workers on a specific site, e.g. a mine or, alternatively, it could be part of the all inclusive package offered at a holiday resort.

Figure 4: A Private Mobile Network

The use of a private mobile network at the remote location would allow the end users to retain the same handsets and also provide them with a consistent interface for telephony. The private mobile network could be provided using server equipment at the remote location or the server hardware could be provided at a central site with a simple IP connection to a remote BTS.

If access is required to other networks, such as a landline call or a call to another country, the PMN could be connected via standard ISDN, data circuits or even satellite for this backhaul. The type of backhaul selected would depend on the location and the traffic required. The PMN could be integrated into existing mobile infrastructures allowing the MNO to route calls and text messages and to bill for these calls and text messages. If the relevant roaming agreements are in place, then Customised Applications for Mobile Enhanced Logic (CAMEL) services would also operate. This will allow roaming users to access services (such as voicemail) on their home network.

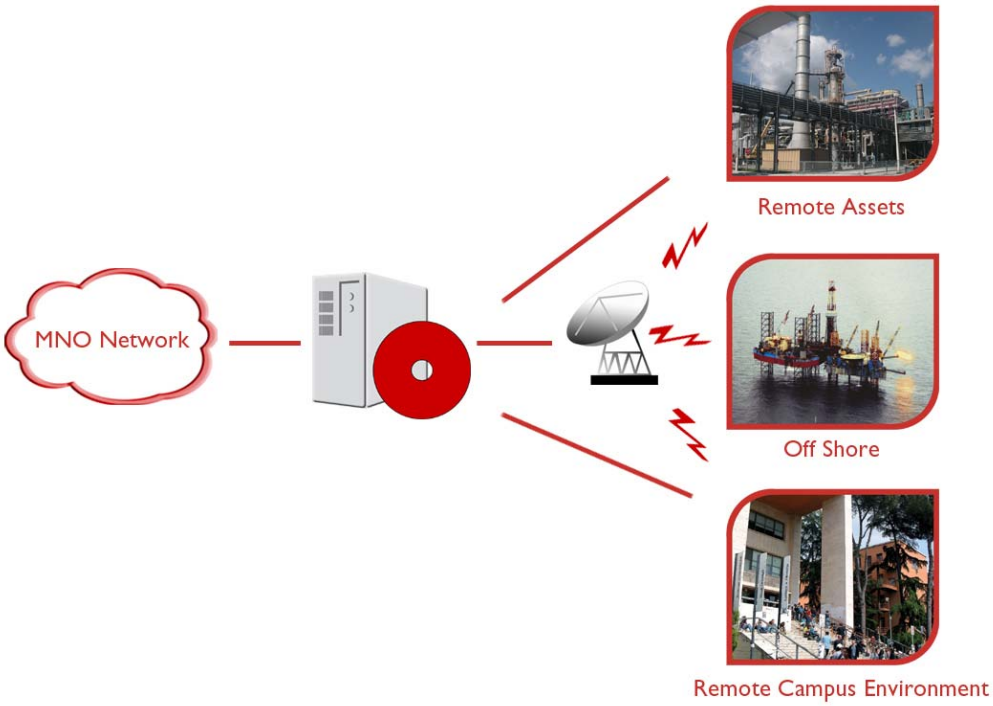

Figure 5: Private Mobile Network Deployments

Private mobile network solutions can be deployed in many different environments that currently have poor or no GSM coverage. Voice and data traffic will be backhauled to the main MNO network either using standard IP connections or using a satellite link.

The customer gains with a PMN because they are able to use their standard GSM handsets - unlike a WiFi solution – with its inbuilt directory and known capabilities. Perhaps of greatest importance to the MNO wishing to extend its coverage is that the private GSM network offers a solution they can own and control. A higher ARPU through lower installation costs and the lack of revenue sharing promises a better and predictable RoI.

A private mobile network is not designed as a full replacement for a macro MNO network. It is aimed at providing coverage at a specific location. The support for large numbers of users would not be cost effective. However, a PMN will act as a bridge between no coverage and the expense of a macro GSM installation.

As a consequence of the design of a private mobile network, integration with the full billing infrastructure will be limited. This will require an alternative approach to billing for this type of solution. Calls between two handsets on a PMN would not be seen by the network's billing engine. However, this does offer the opportunity for a 'flat fee' approach to charging for a PMN. Calls from the PMN handsets into the MNO network would be visible to the billing engine and would, therefore, be charged as normal, as would calls from other networks into the PMN.

Cost Model (ROI)

The cost of deploying any network has to be balanced against the expected revenue that will be generated. The revenue generated depends on two factors, the number of people using the network and the amount that they use the service. The capital expenditure is then amortised over a number of years.

$$\frac{\text{Total cost}}{\text{Amortisation period}} < \text{ARPU} \times \text{No of Users}$$

The larger the remote site's opportunities for growing its customer base, the the sooner the investment can be repaid.

Conclusions

Standard expansion of a GSM network is well established as a route to increasing coverage for the operator. This technology is proven and has been in use for a number of years. Handsets are increasingly capable of running on all three standard GSM bands, allowing users to roam between different networks. However, the main consequence is the high cost of such large scale deployments. This means that large ARPUs are required to cover the increased costs.

Therefore, driven by cost considerations, operators are looking for alternatives. One such alternative, WiFi has now been around for a number of years and is slowly establishing itself as a recognised technology. However, the cost calculations, need for additional specialised handsets and the issues of quality of service, which will escalate as demand grows, are likely to be inhibitors for widespread uptake of WiFi solutions by operators in the next 2-3 years.

A second alternative is a private mobile network based on proven and established GSM technology and utilising standard mobile phone handsets. A private mobile network can provide a solution to the thorny issue of GSM network coverage that does not have the cost issues or require revenue sharing agreements. This approach avoids introducing the element of competition which could, potentially, increase MNO churn. Based on the GSM standards, a private mobile network can be scaled to match the demand at a specific location. This will lead to a greater ARPU for a given deployment for the MNO.

For further information contact enquiry@privatemobilenetworks.com or visit www.priviatemobilenetworks.com

wp080401

Headquarters/Registered Office
Private Mobile Networks Ltd, York Road Industrial Estate, Thirsk, North Yorkshire, YO7 3BX
T: +44 (0) 1845 571571 **E:** info@privatemobilenetworks.com **W:** www.privatemobilenetworks.com