The Case for Picocells

Operator Business Cases

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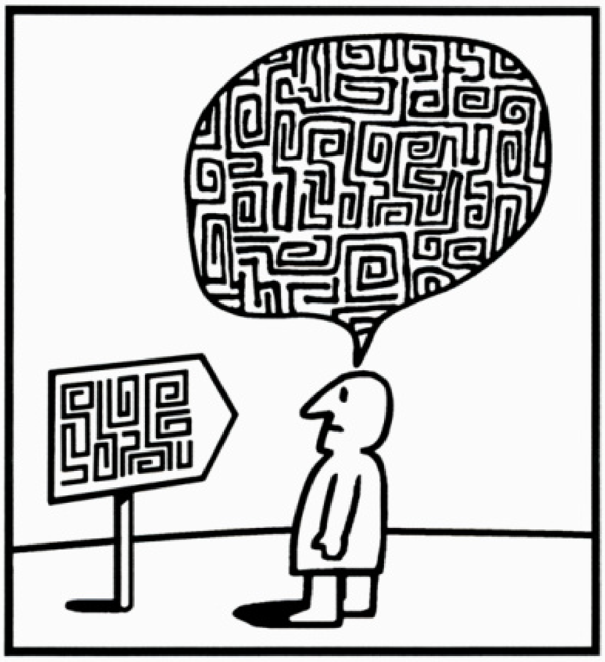


ip.access is a leading manufacturer of GSM, GPRS, EDGE and 3G in-building infrastructure equipment. Its nanoGSM® picocell solution is used by mobile network operators around the world to provide coverage in hard to reach areas, and to add targeted capacity in high-use hotspots.

This paper explores the role of 2G picocell deployments, both for enterprise coverage and for capacity enhancement, and examines the business case for picocells from the point of view of the mobile network operator.

Whilst the consumer market is migrating from 2G to 3G, business users are not showing the same level of demand for 3G and there is a continuing role for 2G within enterprise. There are a number of reasons for this:

- Open environment to support existing handsets. GSM is the world's most widely deployed and widely supported mobile technology and the majority of business handsets in use are GSM. One of the benefits of a 2G picocell solution versus other alternative solutions is that no new devices are required (e.g. dual mode WiFi/GSM handsets). Handset upgrades can be costly and, in many cases, companies operate a three year handset upgrade/replacement programme.
- The business demand for 3G services is yet to be seen. Whilst the consumer market is pushing 3G as a way to enjoy richer content and applications such as video streaming, faster data speeds are not the same driver for business users. Most business applications such as email and field force automation can operate successfully over GPRS networks. BlackBerry, for example, only has one 3G device in its portfolio, demonstrating that for many business applications, the faster speeds of 3G are unnecessary at this stage.

1 Introduction

Picocells are tiny, low power 2G base stations that plug into an IP connection to provide a mobile signal directly inside offices and other buildings.

Delivering high-quality mobile services inside buildings is a tough challenge for the macro network because walls attenuate the radio signal.

Improved in-building coverage increases customer usage and can drive customer acquisition and retention strategies.

Not only is a picocell able to extend network coverage and capacity where none previously existed, but it does this at very low cost because the traffic is backhauled to the mobile operator's core network over the customer's existing broadband link.

These cost savings can be passed on to customers in the form of targeted "office zone" tariffs, making the mobile phone competitive with the fixed line telephone. Thus, picocells have the potential to play a significant disruptive role in Fixed Mobile Substitution (FMS).

This paper explores the business case for picocells from the point of view of the mobile network operator and focuses on two important scenarios:

- Macrocell offload – deploying picocells to provide extra capacity in areas where the macro network would otherwise need to be upgraded to cope with demand.
- Enterprise in-building coverage – deploying picocells to provide coverage inside corporate offices where the macro network signal is weak or non-existent.

ip.access has built several models that can be used to analyse the cost savings that can accrue through the deployment of nanoGSM picocells versus alternative solutions. The purpose of this paper is to provide a fuller discussion of the models and the assumptions made. (The propositions that will help operators to realise these business benefits are explored in detail in a separate paper.)

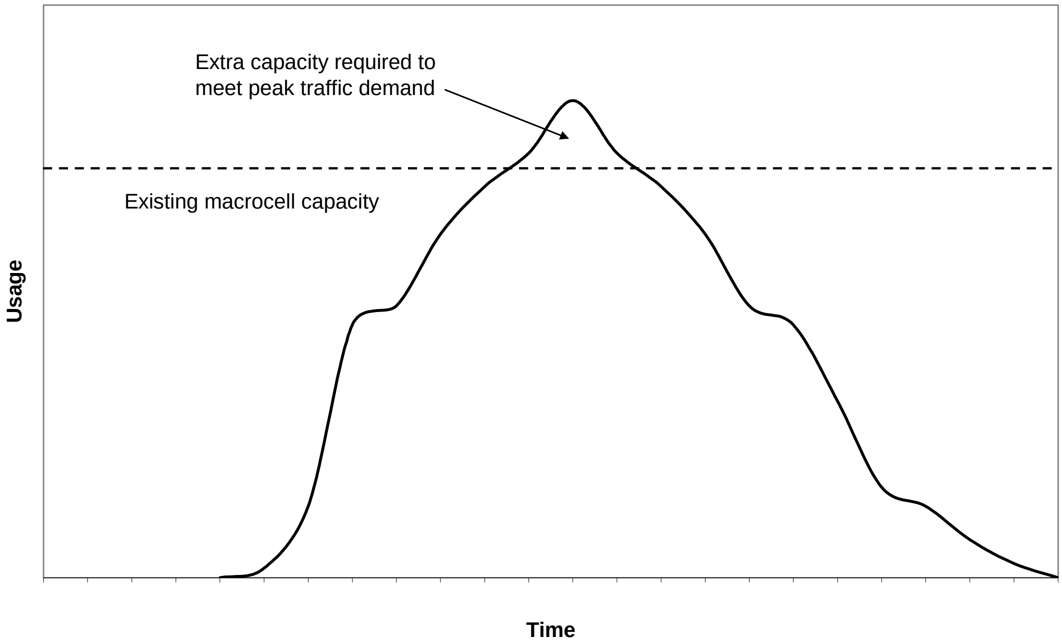
2 Macrocell Offload

2.1 The Need for Picocells

As mobile phone usage increases in built up areas such as city centres or business districts, the macrocell network can come under increasing pressure at peak times (the busy hour) and, in this situation, operators have to consider installing additional capacity to meet this peak demand.

Figure 1 plots a typical daily network usage scenario with peak demand exceeding existing capacity. If left unchecked, this will result in increased connection failures and dropped calls during this time.

Figure 1 Typical network usage scenario



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There are a number of options to mitigate this:

- Install more macrocell sites.
- Add extra capacity (transceivers) to existing macrocell sites.
- Upgrade the cell sites to the next generation technology (e.g. 3G/UMTS) that uses a different frequency allocation.

Installing more macrocell sites is not an easy way to scale up the capacity of the network in line with usage, since there are a finite number of suitable sites in a built up area and frequency reuse issues may limit the amount of spectrum available. Other factors to take into consideration include the high cost of acquiring the site and installing the equipment, and the length of time it takes to get a cell site operational – from the initial RF planning stage to site selection, site planning, acquisition and build.

Adding extra capacity to existing sites is the quickest and cheapest of the options listed above. However, as only certain hotspots within a given area are subject to capacity limitations, adding extra capacity to existing sites may not be a targeted approach. Furthermore, there may be no possibility of adding extra capacity if the cell site is built out to maximum capacity already.

In terms of the installation of a 3G overlay, signal attenuation is greater for 3G making it harder to penetrate buildings. Additionally, for 3G to successfully offload users from the 2G network would require a significant migration to 3G handsets – otherwise the build-out of 3G capacity would not be matched by a similar level of end user migration/offload.

In all three of the scenarios above, the investment is not as cost effective as it could be because it is being underwritten only at peak times; at all other times, the existing network capacity is sufficient.

Picocells are sometimes seen as solving in-building coverage issues only. Whilst this is undoubtedly true, deploying picocells can also be the quickest and most cost effective way to solve network capacity issues, even in the presence of a good macro network signal. In-building placement is desirable because this is where a large proportion of mobile traffic originates: the share of voice & data traffic that is made from within buildings is estimated to be more than 60 per cent[1].

As picocells offer greater benefits compared to macrocell deployments – for example: better in-building coverage, much quicker deployment, and more targeted deployment (the operational radius of a cell can be as low as 30 metres) – the investment in picocells goes beyond merely providing busy hour capacity. Picocells deliver tangible operator benefits at *all* times of day, such as increased usage and enhanced customer satisfaction which, in turn, can drive customer acquisition and retention strategies.

Figure 2 plots a typical daily network usage scenario with peak demand exceeding existing capacity. However, with a proportion of usage offloaded from the macro network to the picocell network, upgrades to macrocell capacity can be minimised.

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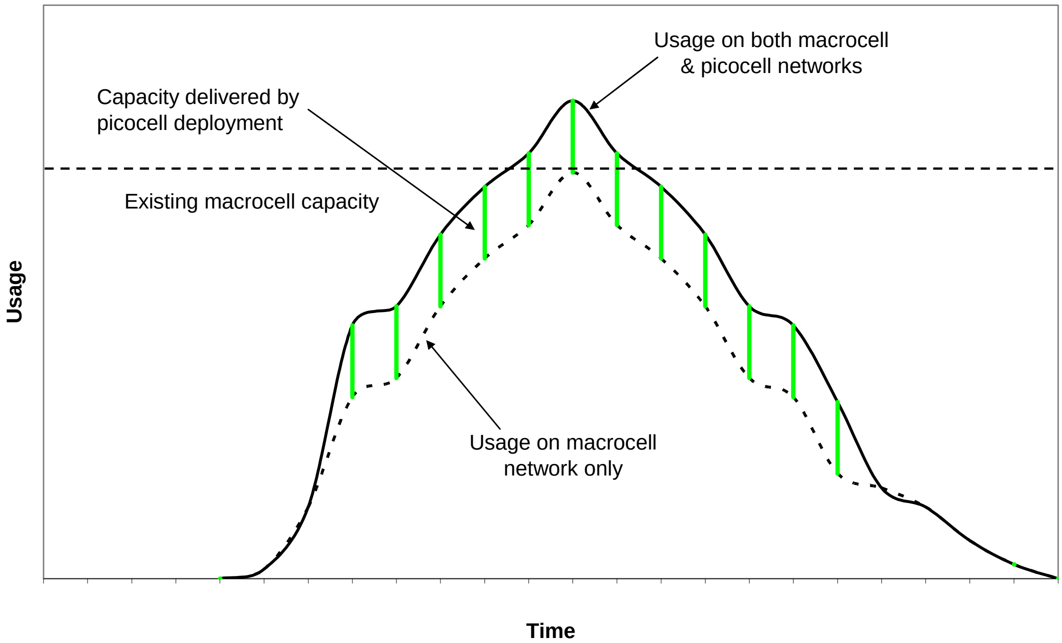
[1] Source: Analysys Research, 2006.

Figure 2 Typical network usage scenario with picocell deployment



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The benefits of deploying a picocell layer include:

- Lower cost of deployment versus the macrocell network.
- Highly targeted deployment (see Figure 3).
- Rapid rollout – no planning is required, and installation is quick and easy.
- Very low operational cost – the traffic is backhauled to the mobile operator's core network over an existing broadband link.
- Low power and interference – as the operational radius of a nanoGSM picocell is small (approximately 30m in a cluttered office environment), the power output is low and there is less interference with adjoining cell sites. This is becoming increasingly important as the macrocell footprint is reduced to deliver ever more capacity, and frequency reuse issues begin to limit the amount of spectrum available.

2.2 Macro Offload Model

The ip.access macro offload model addresses a number of benefits that nanoGSM picocells can bring including:

- Deployment cost savings (capex).
- Operating cost savings (opex).

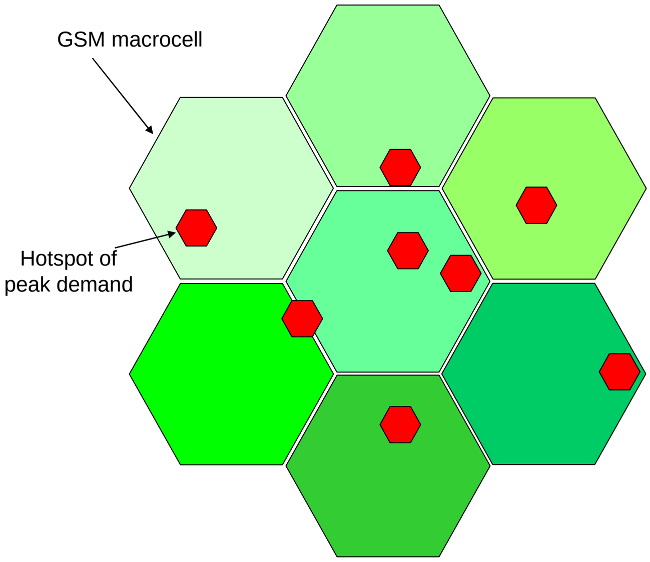
There are other benefits, both monetary and qualitative (e.g. rapid rollout), that are not directly addressed in the model.

The business case is established by comparing the cost of offloading a number of business users from the macro network onto the nanoGSM picocell layer over a particular area with the cost of installing additional macrocell capacity alone.

The following assumptions are made:

- Network capacity is increased sufficiently to just eliminate network busy signals in the peak hour – either by offloading users onto the picocell, or by upgrading the macro network.
- The macrocell network has no spare capacity in the vicinity.
- The area is designed to mimic a metropolitan or business district and the hotspots of peak demand are spread randomly throughout this area (see Figure 3).

Figure 3 Random hotspot distribution throughout a metropolitan/business district



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Beyond the number of users and the area targeted, the key variables explored in the model relate to usage and the macrocell network.

Usage seeks to determine total peak demand and is a function of the following inputs:

- The proportion of voice & data traffic that is generated from within the building (assumed to be 60%).
- Average mobile minutes of use and mobile data usage per customer per month.
- How much of the daily usage occurs in the busiest hour. This is used to determine the peak capacity requirement.

Based on the resulting peak demand, the number of picocells that need to be deployed can be calculated.

The macrocell input data is used to calculate:

- The number of existing macrocell sites within the area specified.

- The proportion of existing macrocell sites that can be upgraded.
- The cost of acquiring, upgrading and operating macrocell sites.

The number of macrocells required is dependent on the proportion of existing sites that can be upgraded and the coverage area. It is important to note that both coverage and capacity requirements drive the number of macrocells required. For example, if the number of additional macrocells required to meet end user demand is 2 but the number required to cover the area is 4 (assuming that the hotspots of peak demand are spread randomly throughout this area – see Figure 3), then coverage will be the determining factor.

It is assumed that existing cell sites are upgraded from a 3:3:3 to a 6:6:6 configuration; new sites are deployed with a 6:6:6 configuration.

2.3 Example Calculation

An operator providing mobile services in a densely populated urban area covering two square miles suffers capacity challenges, and wishes to offload the indoor mobile phone usage of 7,000 business users from its macro network.

These 7,000 business users on average each consume 800 voice minutes[2] and 5MB of data[3] per month.

The operator evaluates two solutions to this problem: extension of the macro network versus deployment of nanoGSM picocells from ip.access.

In the picocell proposal, the goal is to offload from the macro network 60 per cent of the voice and data usage of the 7,000 business users (i.e. the proportion of mobile voice/data usage made in-building). One fifth of their usage occurs during peak hour.

A diagram of the model flow is shown in Figure 5.

The total voice and data capacity needs of the 7,000 users requires the deployment of 9 new cell sites and 9 cell site upgrades[4]. It is assumed that only 50 per cent of the macro sites can be upgraded. In this deployment, coverage is the primary determinant of the number of macro cell sites required: whilst 10 macrocells are required to meet end user demand, based on macrocell spacing (2,000 feet) and the area targeted, 18 macrocells are required to deliver coverage at a cost of US$2.8m[5]. This assumes that customers are dispersed equally throughout the target area (see Figure 3).

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[2] Peak hourly voice usage: 800 minutes per month x 60% of call volumes connecting using a nanoGSM picocell = 480 minutes per month, or 22 minutes per day = 4 minutes during the busy hour = 0.07 Erlangs.

[3] Data is converted into a time equivalent, assuming a data rate of 9.6kb/s: 5MB per month x 60% of connectivity using a nanoGSM picocell = 3MB per month = 43 minutes per month = 2 minutes per day = 0.4 minutes during the busy hour = 0.007 Erlangs.

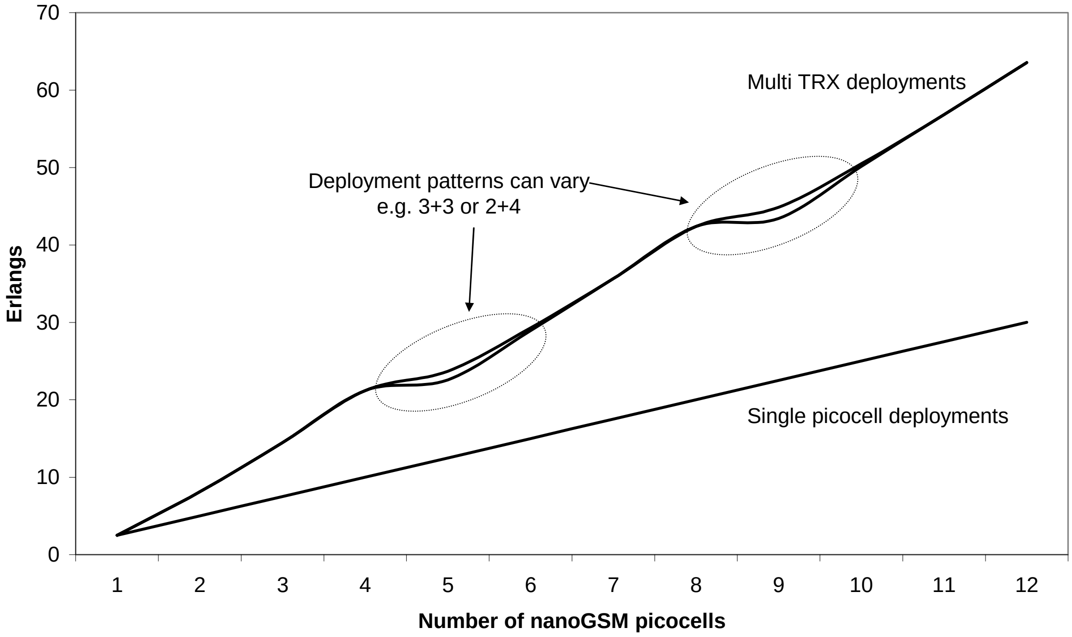
[4] A macrocell upgrade delivers 43.35 Erlangs (moving from a 3:3:3 to 6:6:6 configuration) and a new site delivers 105.6 Erlangs of additional capacity (6:6:6 configuration).

[5] Macrocell TRX cost & associated equipment: US$4,000; New macrocell site acquisition & build cost: US$200,000.

To achieve the same goal, 226 nanoGSM picocells[6] need to be deployed. The cost includes: nanoBTS picocell basestation unit costs, a pro rata share of the nanoBSC cost and OMC-R unit cost.

Note that this assumes the deployment of single nanoGSM picocells. However, a maximum of 4 nanoGSM picocells can be placed together in a multi TRX layout to boost capacity (and enhance the business case) considerably (see Figure 4). For example, if nanoGSM picocells were deployed in dual-TRX configurations, only 70 nanoGSM picocells would be required, reducing the deployment costs by 47 per cent.

Figure 4 Capacity scaling with multiple nanoGSM picocells[7]



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Note that the picocell deployment pattern can vary - as shown by the line splitting - and have an impact on capacity. For example, 5 picocells could be deployed in a 3+3 or 4+2 layout.

Monthly operational costs for the nanoGSM layer are dominated by DSL backhaul. However, if the customer funds the DSL rather than the operator, the business case is improved considerably. For a macrocell deployment, the monthly operational cost is higher and comprises T1 backhaul[8], site rental[9], power and cooling.

Depreciating the costs (capex & opex) over a period ranging from 7 to 10 years[10], the annual cost for a nanoGSM deployment versus the equivalent macrocell deployment can be calculated.

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[6] A single nanoGSM picocell delivers 2.5 Erlangs (assuming a 1% blocking ratio).

[7] A maximum of 4 nanoGSM picocells can be placed together in a multi TRX layout and can boost capacity considerably. Using the current example calculation, a single picocell can support 31 users. However, 2 nanoGSM picocells placed together will support 101 users.

[8] T1 backhaul is calculated by determining the minimum number of T1 lines needed to carry the total throughput from the additional macrocell deployment. This assumes that T1 lines are shared between macrocells.

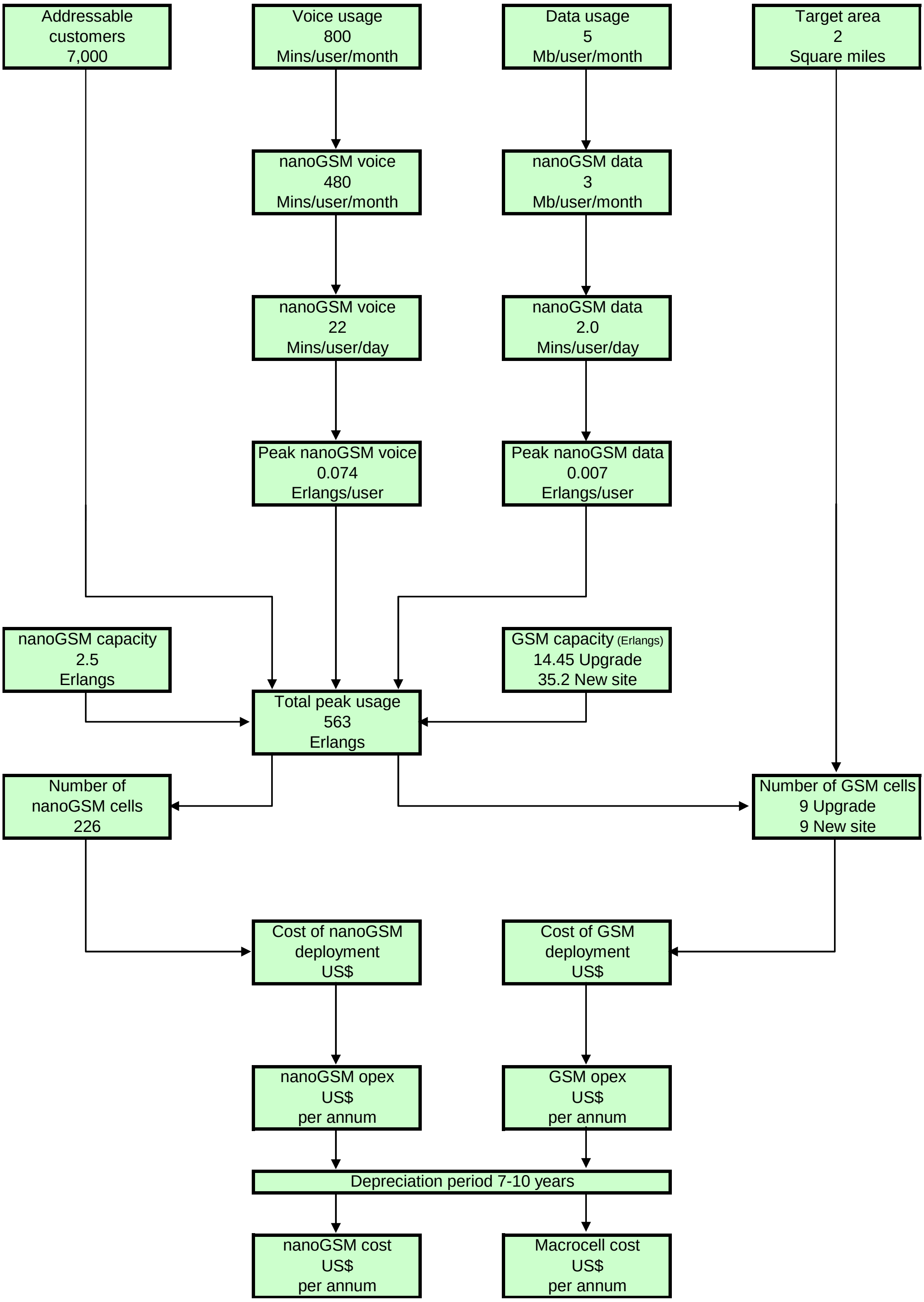
[9] Annual macrocell site rental: US$20,000.

[10] Depreciation rates: macrocell site - 10 years; macrocell equipment - 7 years; nanoGSM network equipment - 7 years; nanoBTS picocell basestation - 7 years.

In this example, a nanoGSM picocell deployment would result in an annual saving of US$339k, or 53 per cent versus a macrocell deployment.

The Macro Offload model is available in spreadsheet form for analysis of different scenarios. Please contact ip.access for further details.

Figure 5 Macro offload model flow summary



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3 Enterprise In-Building Coverage

Delivering high-quality mobile services inside buildings is a tough challenge for the macro network because walls attenuate the radio signal.

With current industry estimates of the proportion of voice & data traffic that is made from within the building at around 60 per cent, it is clear that without investment in an effective in-building coverage strategy, operators will be limiting their ability to grow the business customer base, increase usage and generate additional service revenue.

For example, a business mobile user with no in-building coverage whose monthly bill is US$60 could be expected to spend an additional US$90 per month[11].

3.1 Enterprise In-Building Coverage Model

The ip.access enterprise in-building coverage model addresses the cost of deploying nanoGSM picocells in an in-building environment:

There are other benefits, both monetary and qualitative (e.g. increased customer usage and take-up, and macrocell capacity savings), that are not directly addressed in the model.

The business case is established by calculating the cost of deploying and operating an enterprise in-building picocell network over a standard contract period.

The number of picocell users represents not only the number of operator business customers within the enterprise but also the number of the operator's other customers (this includes not only private users but also users who are refunded for business calls, often known as prosumers) which can also benefit from improved in-building coverage.

Usage seeks to determine total peak demand and is a function of the following inputs:

- The proportion of voice & data traffic that is generated from within the building (assumed to be 60%).
- Average mobile minutes of use and mobile data usage per customer per month.
- How much of the daily usage occurs in the busiest hour. This is used to determine the peak capacity requirement.

Based on the resulting peak demand, the number of picocells that need to be deployed to meet end user demand can be calculated.

However, the number of picocells required is also dependent on the size of the deployment. It is important to note, therefore, that both coverage and capacity requirements drive the number of picocells needed.

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[11] This assumes that in-building usage accounts for 60 per cent of total mobile usage and that existing fixed line usage is transferred to mobile.

3.2 Example Calculation

An enterprise with 200 employees operating in a 15,000 square feet facility is suffering coverage problems and is likely to churn.

The enterprise has 50 business mobile users, and an additional 27 consumer users on the same network (based on 90 per cent mobile market penetration and 20 per cent operator market share). Average mobile usage amongst this group is 500 minutes of voice[12] and 5MB of data[13] per month (both incoming and outgoing calls). Monthly average revenue per user (ARPU) is assumed to be US$60.

60 per cent of usage occurs within the building and 20 per cent of usage occurs during the peak hour.

A diagram of the model flow is shown in Figure 6.

Two nanoGSM cells are required to achieve full coverage of the premises, based on a rectangular floor layout and an operational range of a nanoGSM cell of 30 meters.

Based on the usage assumptions (total voice and data usage for 77 business and consumer users), two picocells[14] are required to meet the in-building capacity requirements.

In this deployment, coverage and capacity are both determinants of the number of nanoGSM cells required:

- 2 picocells need to be deployed to ensure sufficient capacity.
- 2 picocells cells are required to offer sufficient coverage.

The deployment cost includes: nanoBTS picocell basestation unit costs, a pro rata share of nanoBSC cost, OMC-R unit cost and installation.

Annual operating costs include DSL line rental and support costs. However, if the customer funds the DSL rather than the operator, the business case is improved considerably.

By depreciating the hardware and installation costs over the 3 year contract period and including annual operating expenses, the cost for an enterprise nanoGSM deployment equates to US$7 per user per month and could be underwritten by either:

- A 12 per cent pro rata increase in voice and data usage.
- The addition of a further 10 business mobile users with a monthly ARPU of US$60.

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[12] Peak hourly voice usage: 500 minutes per month x 60% of call volumes connecting using a nanoGSM picocell = 300 minutes per month = or 14 minutes per day = 2.8 minutes during the busy hour = 0.046 Erlangs.
[13] Data is converted into a time equivalent, assuming a data rate of 9.6kb/s: 5MB per month x 60% of connectivity using a nanoGSM picocell = 3MB per month = 42 minutes per month = 1.9 minutes per day = 0.4 minutes during the busy hour = 0.006 Erlangs.
[14] A single nanoGSM picocell delivers 2.5 Erlangs (assuming a 1% blocking ratio). 2 nanoGSM picocells placed together deliver 8.1 Erlangs.

As the hardware can be readily redeployed to other locations, the cost can be depreciated over its working lifetime rather than the contract duration[15]. If such a method of cost accounting were used, the business case would be improved considerably. For example, by depreciating the hardware cost over a period of 7 years rather than 3 years, the cost per user is reduced by 26 per cent to US$6 per month.

3.3 Picocells vs. Repeaters

Along with picocells, repeater/DAS (distributed antenna system) is the most common solution to address in-building coverage. Repeaters amplify the outside cellular signal, which is then distributed throughout the building using indoor antennae (known as DAS).

Using the example business case, the cost of a repeater deployment is somewhat more expensive than the cost of a picocell deployment (US$9 per user month vs. US$7 for a nanoGSM picocell deployment, based on a repeater cost of US$12,000 and the cost of the internal antennae installation of US$0.80 per square foot).

Furthermore, repeaters suffer from a number of drawbacks including:

- Extends existing macrocell coverage only, offering no additional capacity. This creates network planning issues and, if the macrocell was already operating at close to capacity, additional macrocell capacity may be required.
- Dependent on a mobile signal from a macrocell from outside the building. This limits the number of in-building locations where repeaters can be deployed. Picocells, on the other hand, are able to extend network coverage where none previously existed, using the existing broadband link to backhaul traffic to the mobile operator's core network.
- Installation requires cabling throughout the building and creates tenant disruption.
- Solution is a permanent installation and cannot readily be redeployed. Picocells can be redeployed easily and their cost can therefore be depreciated over their working lifetime rather than the contract duration. If such a method of cost accounting were used in the business case calculation, the annual cost would be reduced (see above). In the business model, the picocell cost has been depreciated over the contract duration (3 years).
- Only able to offer location based tariffs based on the footprint of the macrocell resulting in revenue leakage. Picocells can be used to deliver targeted "office zone" tariffs, making the mobile phone competitive with the fixed line telephone. Thus, picocells have the potential to play a significant disruptive role in Fixed Mobile Substitution (FMS).

Whilst the benefits of picocells versus repeaters outlined above have not been modelled, their inclusion would have a sizeable impact on the business case. For example, using the business case illustration above, if we include the cost of replacing the macrocell capacity that has been 'redirected' by the repeater into the building, the cost of a repeater deployment increases by over 25 per cent.

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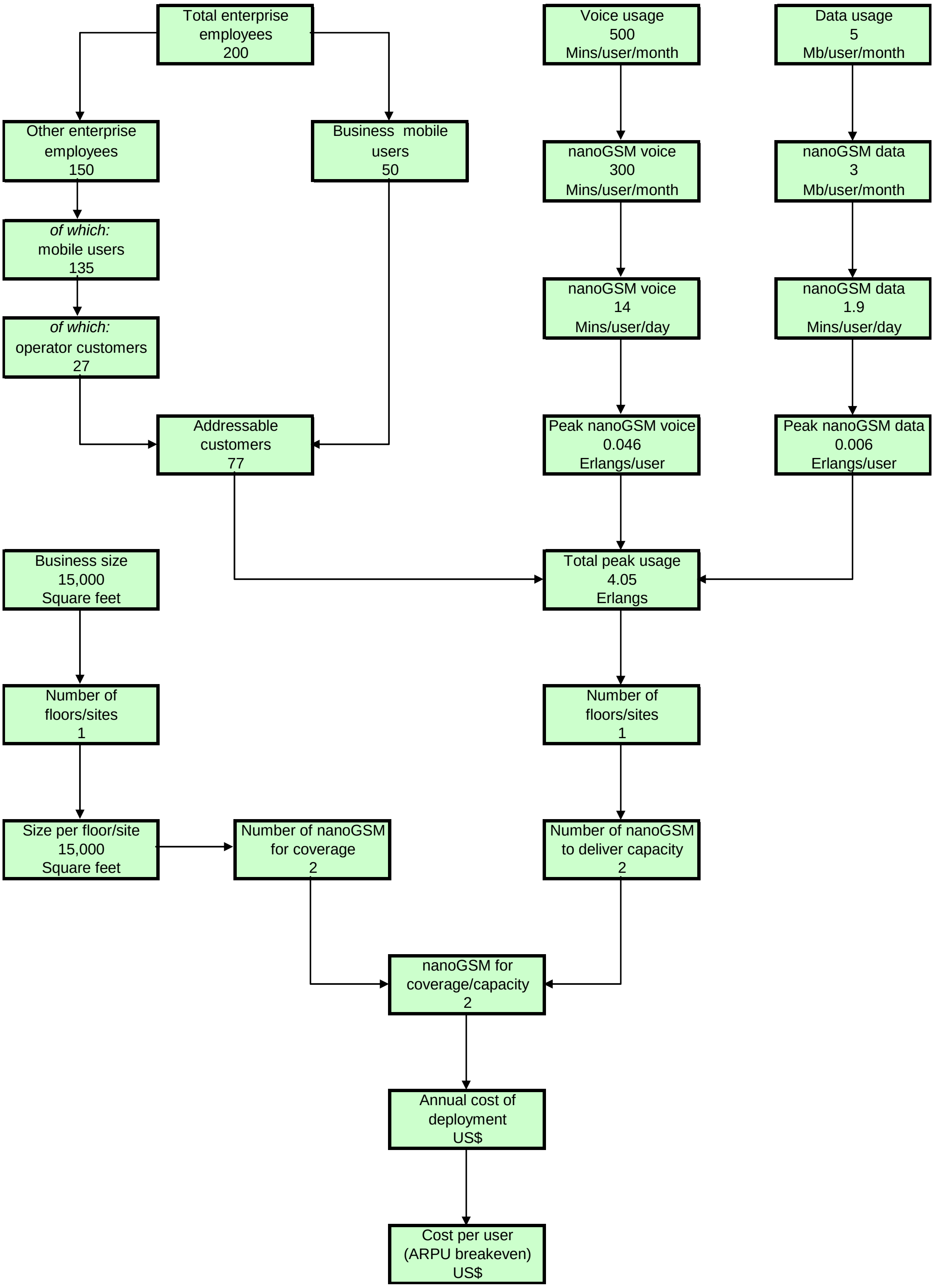
[15] Note that under IFRS (International Financial Reporting Standards), the cost of network infrastructure is written off over the duration of their estimated useful life.

Picocells, therefore, represent a more flexible solution to providing in-building coverage and offer a number of additional benefits, both monetary and quantitative, versus repeater deployments.

The Enterprise In-building Coverage model is available in spreadsheet form for analysis of different scenarios. Please contact ip.access for further details.

Figure 6 Enterprise coverage model flow summary



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