CHR Solutions

# The Case for Small Cells

*A Whitepaper*

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## OVERVIEW & HISTORY

The face of mobile networks has changed, forever. In the beginning coverage was the order of the day. The original cell towers for public mobile networks were placed miles apart providing coverage for vast acres.

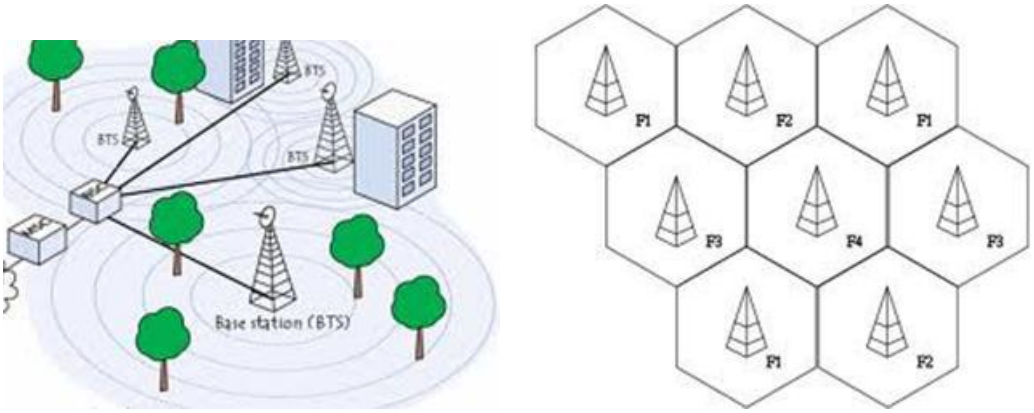



Figure 1 - Traditional 2G Macro cellular network design (Source: Small Cell Forum)

The first engineering issue faced was capacity. In areas of higher density, such as larger cities, only a limited number of simultaneous phone calls were possible. Traditional analog cell networks evolved to digital where the existing limited and precious resource, spectrum, could be used by simultaneous voice callers by using Time Division Duplexing (TDD) in the case of GSM delivering a 4X capacity increase and in the case of Code Division Multiple Access (CDMA) networks claiming a 10x capacity increase over analog cellular systems. Still not enough as mobile subscribers continued to grow at exponential rates.

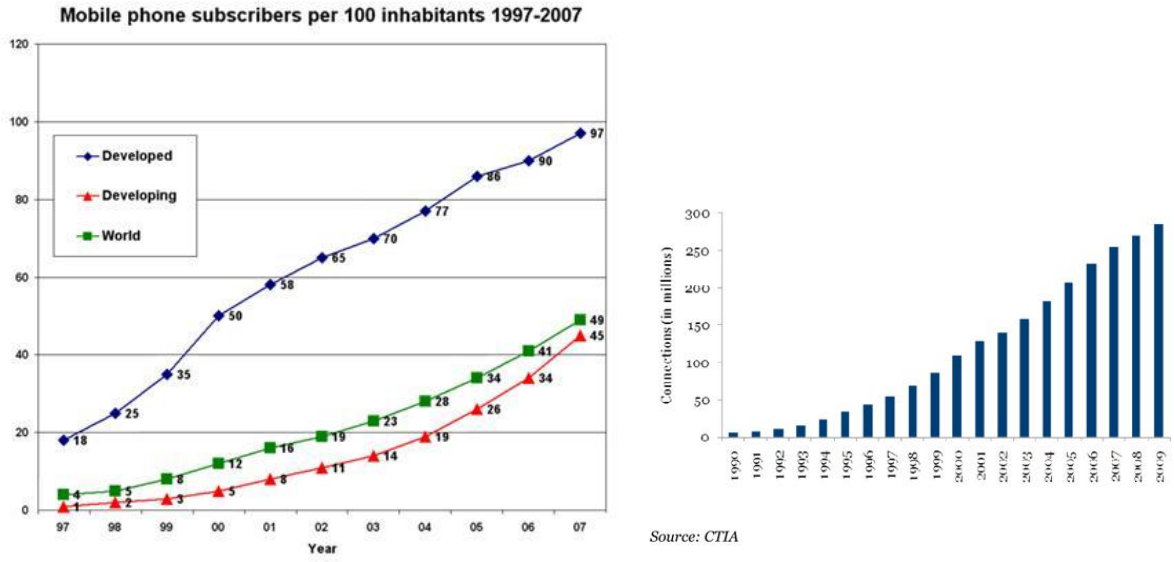



Figure 2 - The growth of Mobile Networks in terms of subscribers

The killer application for the first couple of decades of public mobile networks was voice with data peaking at a paltry 9600 bits per second for 2G wireless systems.

Sectorization and smart antenna technology at the outdoor macro base stations was introduced to add additional capacity. In addition, cell splitting to increase the number of cells in a given area are all methods to add additional capacity to the network.

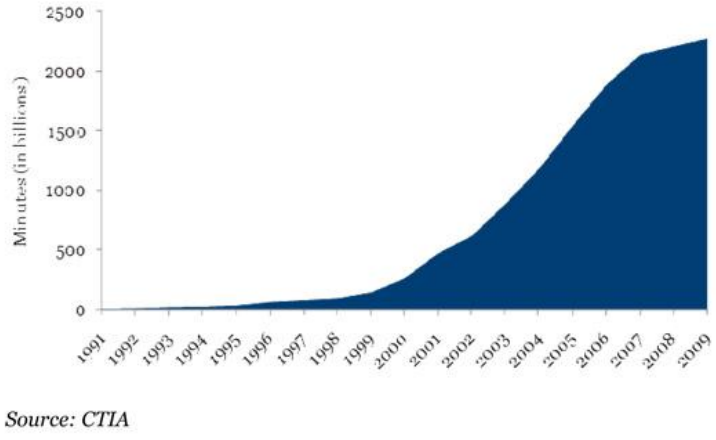



Figure 3 - Increase in minutes of use (voice)

While voice (and text) is still important, data has become the dominant factor driving the increase in capacity needs by mobile operators.

In addition, original mobile networks were designed to support users moving at 70 miles per hour. However, currently close to 80% of all mobile traffic occurs indoors. Basic physics of wireless propagation tells us that when wireless signals propagate through walls they lose approximately 10dB which is 10 times of their power levels compared to the outside signal!

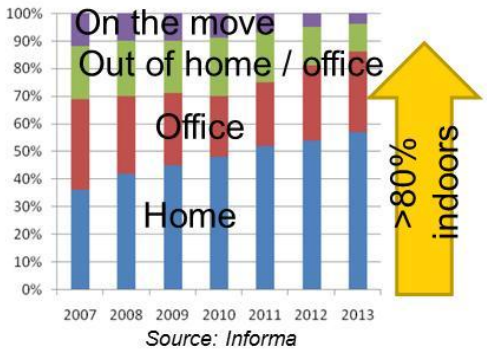



Figure 4 – Shift from outdoor mobile to indoor stationary

The introduction of 3G technologies such as WCDMA and CDMA2000 not only provided for significant increases in voice capacity, but also introduced the capability for broadband data speeds over wireless mobile networks. This has laid the foundation for a major industry shift. Since that time data speeds have grown to approach 100 Megabits per second with HSPA+, CDMA EV-DO and now with LTE and 4G technologies. That is the good news. However, as data capabilities have increased so have consumer appetites for data.

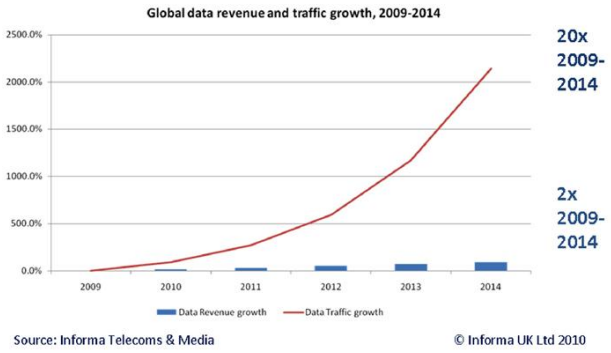



Figure 5 – Global Data Revenue and Traffic Growth

One of the issues for mobile operators is that the growth of data is much faster than the growth in revenue from data. This is creating an increase in cost without a balance increase in profit. The following graph shows a commonly accepted forecast from Cisco on the pending exponential rise of data traffic in mobile networks.

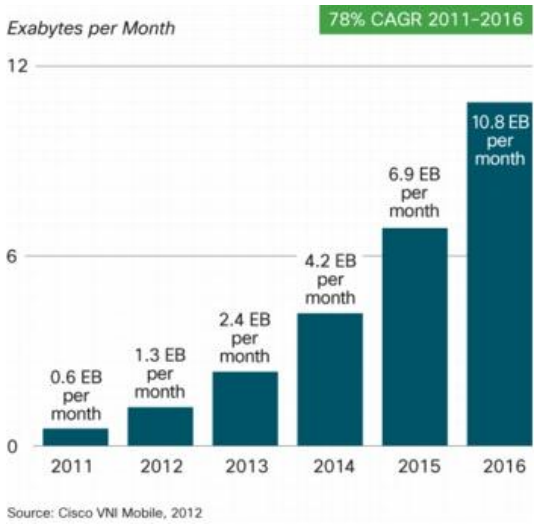



Figure 6 - Increase in Mobile Data

How can mobile operators deal with this insatiable appetite for data from Mobile consumers?

The following chart shows the increase in capacity over time in the wireless industry. It is interesting to note that the majority of capacity increases have come from frequency re-use such as using smaller cells.

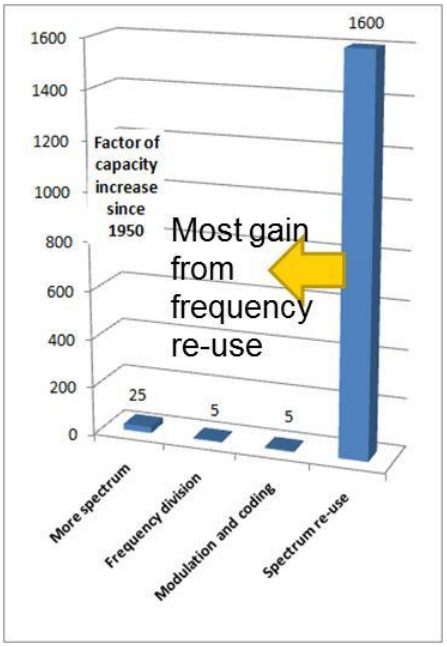


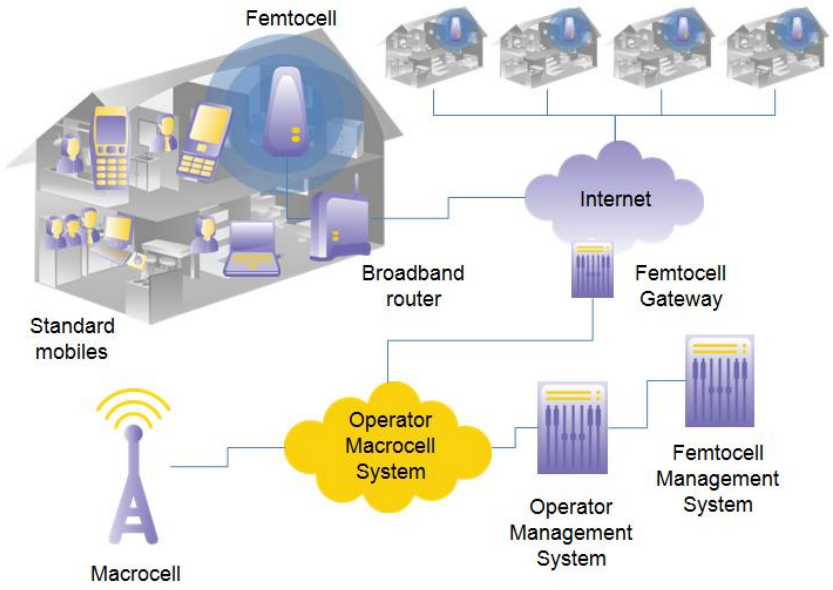

Figure 7 - Capacity increases over time (Source: Cooper's Law)

One other interesting factor to note is that in 3G networks the largest monthly operating expense for most mobile operators is the cost of backhaul circuits that connect their outdoor macro base stations to their core networks delivering wireless voice, text and data services to their customers. Some estimates place these backhaul OpEx costs at 40% - 60% of overall Operating Expenses. Pretty significant!

Not to mention the high costs of site acquisition, dealing with local government bodies and fighting to limit "unsightly" cell towers from their communities. NIMBY – "*Not in my back yard*" is a familiar saying in the industry for those that have to manage the complex negotiations and costs of not only acquiring, negotiating and building out new sites to add precious capacity to wireless networks that are over-maxed.

The provision of spectrum at higher frequencies (such as 1,900 MHz for PCS versus 800 MHz for Cellular) only made problems worse for many traditional cellular mobile providers who were hoping to leverage their existing cell sites for their new technology upgrade. Basic physics tells us that higher frequency signals do not travel as far, they are also attenuated further when going through building materials such as roofs, walls and interior walls. This created coverage holes and the need to add more macro sites in between an existing macro design (tricky!). In addition, when CDMA (WCDMA) cells get loaded with capacity they tend to breathe i.e. shrink. Thus, making coverage problems worse.

# THE INTRODUCTION OF SMALL CELLS




The Small Cell

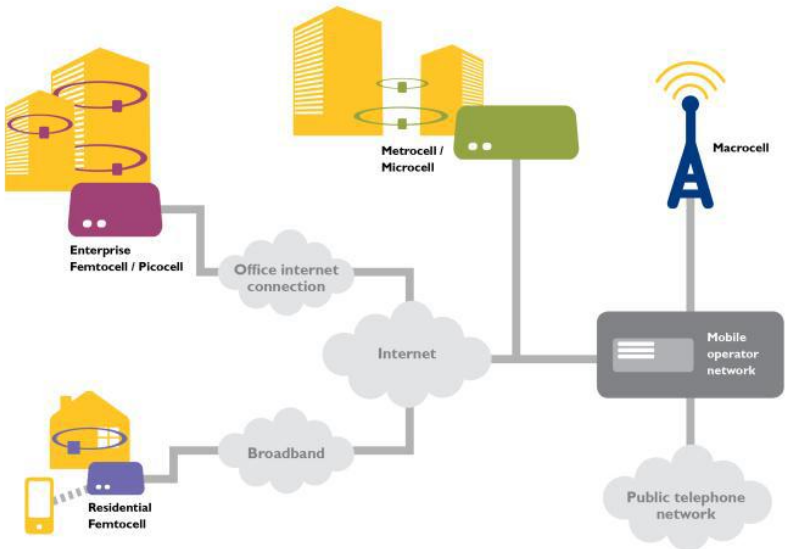



Figure 8 – Basic picture of small cell topology (Source: Small Cell Forum)

All of these technology and market dynamics have created the need for small cells. The original outdoor radio base stations were the size of a large refrigerator. Over time they have integrated down to smaller and smaller form factors and lower costs. The introduction and mass proliferation of Wi-Fi technology has led the way for a whole new way of thinking for cellular. With the introduction of Femtocells we are now seeing 3G radio base stations the size and form factor of Wi-Fi access points.

There are many business, consumer and economic benefits of small cells.

Femtocell technology was standardized by 3GPP (GSM, HSPA and LTE) in 2009. The majority of definition for 3G Femtocells called HomeNodeB in the standard is defined in GSM Release 8 which was published in May of 2009. Similarly, cdma2000 standardized Femtocells were published by 3GPP2 also in 2009. Since that time we have seen commercial launches by over 60 global mobile network operators. Informa and ABI analysts state that over 4 Million Femtocell units have shipped already and they are forecasting that over 40 million units will ship by 2014. In fact, Informa estimates that by 2016 almost 90% of all mobile base stations will be small cells! Wow! Already there are more 3G Femtocells than 3G Macrocells in the USA and globally. Estimates are that by the end of this year there will be more small cells deployed than all types of macro base stations. Thus the face of mobile networks has already changed and is expected to change even further in the very near future!

One of the big economic benefits of Small Cells is that they can use commercial grade Internet backhaul. This delivers significant economic benefits for mobile network operators. Consumers and business owners benefit by receiving better coverage. Some operators are even sharing the benefits by offering unlimited voice and/or data plans or lower tiered FemtoZone pricing. New services are also enabled by small cells, leveraging their unique presence and rich location capabilities.

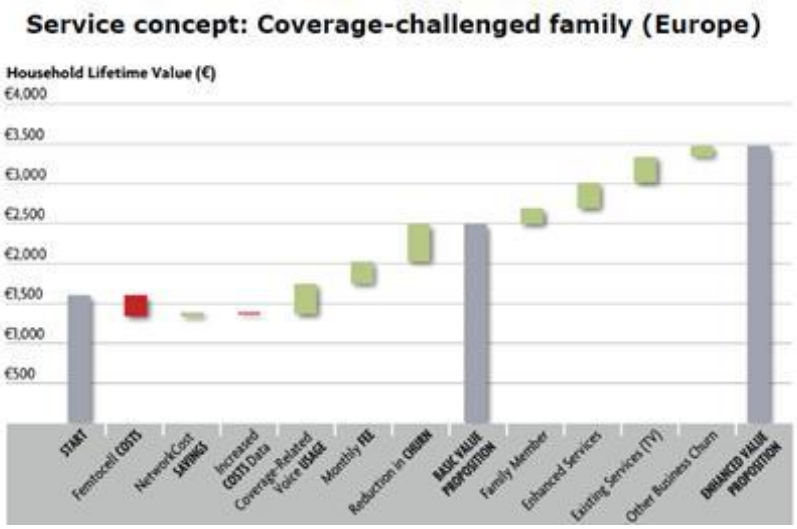



Figure 9 – Business Case Modeling Tool Example (Source: Signals Research)

The initial deployments of 2G & 3G small cells were designed to provide coverage in places where there was a broadband connection. It is a known fact that the biggest reason why consumers churn is due to poor coverage. Studies have shown that in the USA as many as 30% of consumers suffer a coverage problem at home or at work. Currently many installations of small cells are targeted to address this coverage issue.

Now, we are also seeing Femtocells evolving into Enterprise, Outdoor (Metro, Micro, Picocell) and Rural applications. The economics of small cells are so powerful that the original Femto chipsets are now being used in these larger, higher power and higher capacity cell types, replacing expensive and noise generating Distributed Antenna Systems (DAS) in hotels, office buildings, airports and shopping malls— providing brilliant five bar coverage while adding capacity (rather than robbing) to the network.

We are also seeing Small Cells being used more and more for data off-load. Figure 6 above showed the massive growth in data happening in the market today. Wi-Fi is currently in almost 100% of all smart phones. Many operators have invested in Integrated Wireless LAN systems that allow data traffic to offload to known Wi-Fi systems when they are available. This overcomes the usability of traditional Wi-Fi networks that require SSID, User Log In and WPSK Password which is not user friendly for non-technical users. Leveraging seamless, carrier class Wi-Fi for data off-load has become an extremely fast growing market to address an emergency situation commonly referred to as the “data tsunami”, by mobile network operators.

Original Integrated Wireless Local Area Network (I-WLAN) systems were never widely deployed since they required a client (software) on the wireless handset for them to work. This turned out to be too cumbersome for the marketplace.

Modern systems being deployed today leverage integrated AAA capability to determine that users are (paying) subscribers and allow their data traffic to roam automatically onto the lower cost (carrier owned or partner provided) Wi-Fi networks.

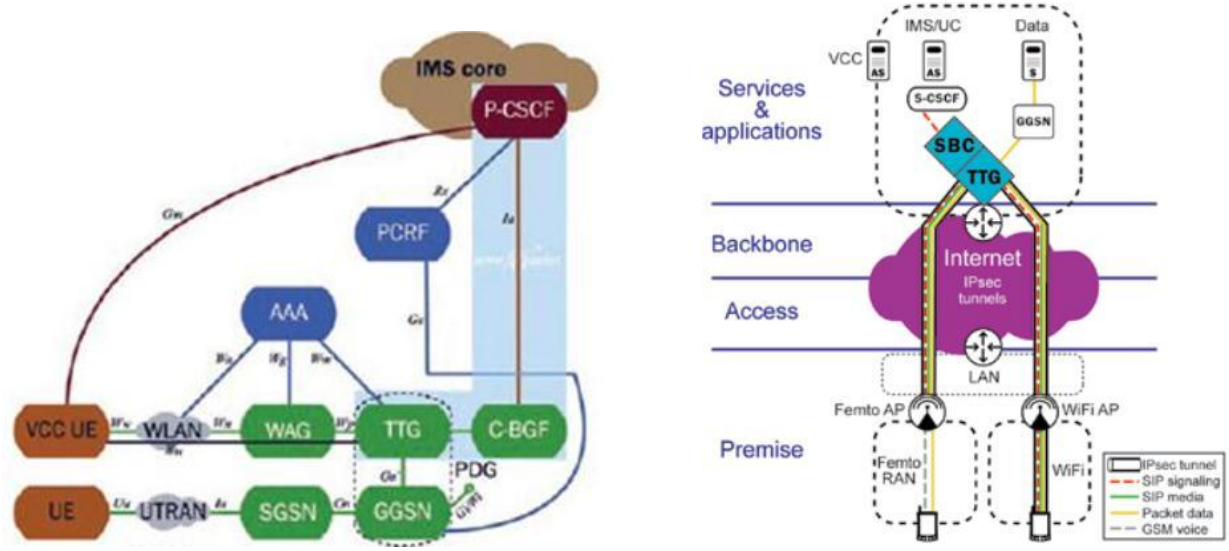



Figure 10 – Wi-Fi offload systems (Source: Small Cell Forum)

Another benefit of small cells for data off-load is that a Wi-Fi client is not required and the battery only needs to power one radio. The off-load also works for feature phones that may not have a Wi-Fi and in cases when the consumer has the Wi-Fi radio turned OFF on their device.

Next generation systems: LTE also known as 4G, by definition operates as a higher order modulation technology to be able to deliver 100 Megabits per second (Mbps) service over a given frequency band. However, basic physics tells us that higher order modulations do not propagate as far resulting in peak rates near the center of the cell but less than 4G experiences near cell edges. The significantly high modulations that allow 4G LTE to operate close to the theoretical limit of wireless physics does not propagate over a significant distance. Therefore, by definition 4G LTE is inherently a small cell technology.

An emerging trend is to have dual mode, dual technology access points that utilize one physical hardware integrating 3G, 4G and LTE all in the same box. More sophisticated systems enable intelligent off-load where the network can decide to deliver service over the best method. For example, streaming video over LTE; voice over 3G and large file download

over Wi-Fi. In addition, the network has the knowledge of the traffic patterns—in a crowded public Wi-Fi environment routing the traffic over 3G or vice versa, thus optimizing the user experience and providing the most efficient service delivery from an overall network perspective.

Additionally, significant CapEx savings can be realized by using small cells to help deliver initial 4G service coverage–thus, deferring the purchase and deployment of more expensive Macrocells. A large range, high power coverage network can be deployed using Macro sites and then as subscribers sign up for 4G service, they can be provided a small cell at home and at work to allow for the optimum user experience. Signals Research released a business case modeling tool that showed based on the time value of money (NPV) savings alone realized, this approach can be used to completely pay for the much less expensive small cells (Figure 10). It also creates a situation where mobile operators can match costs to revenues by accelerating the time to commercial service offerings. This value is in contrast to the more traditional "if we build it, they will come" approach of previous generation technologies.

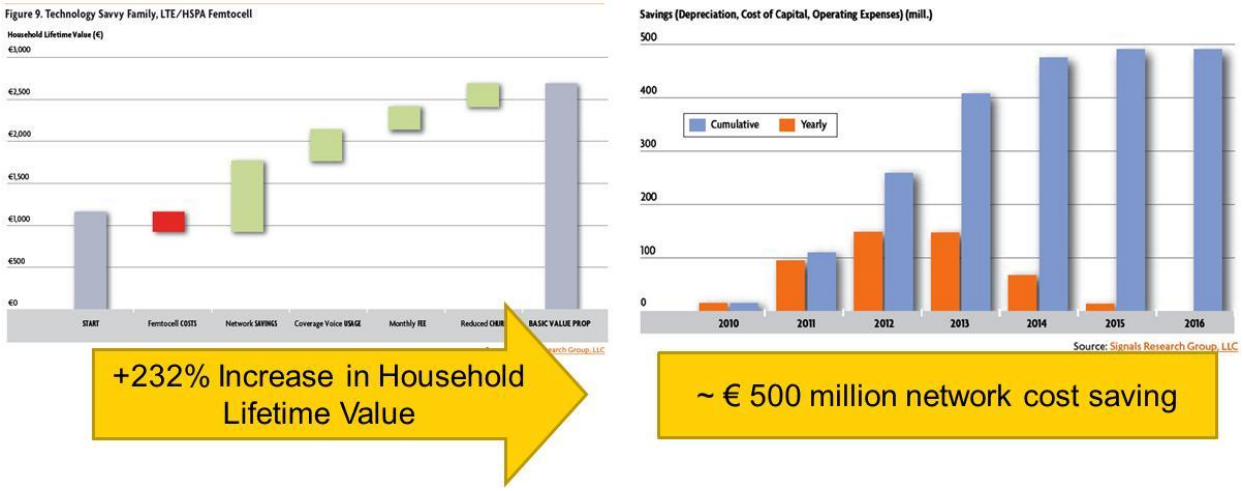



Figure 11 - LTE Business Case for Small Cells (Source: Signals Research)

## IMPORTANCE OF WIRELESS BACKHAUL

Now that we have all these high capacity (100MBps) 4G small cells out there, how do we connect them to the network? Mindspeed, an industry leader in Small Cell chips recently announced that it will take approximately 40,000 small cells to cover Barcelona, Spain. This creates a need to think differently about backhaul. While fiber rings are extremely well deployed, in many cases the fiber is not where the access point needs to be located for the best wireless service. Digging new cable infrastructure is too expensive for each of these small cells. Point-to-point, mesh and wireless backhaul technologies are extremely important to deliver a network that meets coverage, capacity and cost needs to deliver the expected user experience as well as an acceptable business case for the mobile operator.

Figure 12 – Wireless Backhaul

This disruptive move to small cells to increase capacity, therefore, requires a corollary disruptive need for small cell backhaul. While fiber capacities are required to deliver the necessary bandwidth for 100 Megabit cell sites, we recognized that availability of fiber may be an issue. While fiber backhaul is the right choice in some instances, in other cases point-to-point, point-to-multi-point and wireless backhaul systems are more efficient as well as cost effective.

This means that the shift to small cells is also requiring a move to new ways to think about backhaul compared to the traditional T1/E1 Fiber cable that was used previously.

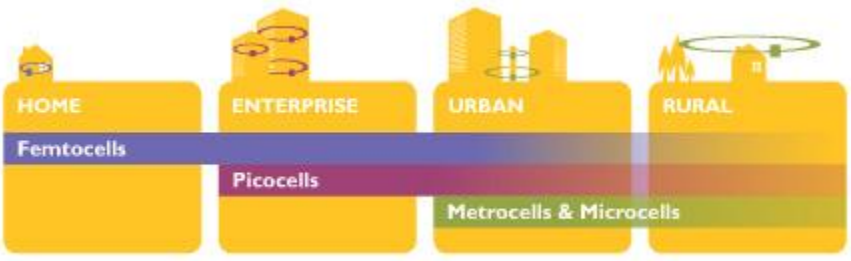
## RURAL APPLICATIONS

Today, small cells are also being used to provide service to rural and less inhabited areas. The superior economics of Femto technology are now being applied to Pico, Macro and Micro cells using the same chip sets there were originally designed for high volume, low cost Femto access points. These larger cells are combined with higher power transmitters and outdoor enclosures to economically provide coverage and service to previously under-served areas. In these cases fiber, point-to-point or even satellite backhaul is used to deliver core network connectivity to these cells.

## DISASTER RECOVERY

In other cases, small cells are now being used to deliver “cell on wheels” quickly to disaster stricken areas. When the powerful earthquake and resulting Tsunami hit Japan last year over 80% of the macro cell towers were not operating. Also, there was no power to run the towers and no fuel to power generators. Mobile Network operator Softbank was able to drive in small cells using satellite backhaul to restore service and connectivity to this disaster stricken area. A similar solution was also used in Thailand after flooding devastated a large area of the country. Small cells are a valuable tool to be prepared in case disaster strikes—allowing for quick and reliable restoration of service to needy consumers and emergency personal.

## CONCLUSION




In conclusion, the face of wireless networks has changed forever. The use of Small Cells is the latest evolution to deliver the best possible user experience and satisfy the ever growing consumer appetite for data. CHR recognizes this trend and fundamental shift in network topologies for our customers. We have studied the topography of this new environment and now offer a full suite of solutions for our customers. From strategic planning and network design to managed services and network monetization—we enable our clients to select the deployment and business model that best fits their unique needs while leveraging the economies of scale, best practices and innovative technologies of the rapidly evolving wireless business.

For more than 75 years, CHR has been the largest, single-source provider of business process outsourcing, engineering services, software solutions, and technology managed services to communications service providers across the globe. Our team of industry experts from multi-faceted disciplines helps clients grow revenues and improve operations. CHR's local presence, national network and global reach provide the scale and skill to elevate your business. Our clients include: telephone, Internet, cable TV and wireless providers and city municipalities. We employ more than 500 team members with eleven offices and two network operating centers in five states and two countries.

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