RADIO FREQUENCY SYSTEMS
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Understanding Small Cell Backhaul: Challenges and Solutions

Written by Asad Zoberi, Product Manager, RFS

January 2014

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Executive Summary

With the rollout of LTE and other next-gen wireless services coupled with the growing number of wireless users, carriers are approaching the limits of available spectrum, particularly in urban areas where data traffic is often most concentrated. As a result, these carriers are increasingly moving towards small cells to increase network capacity, expand the edges of the network to include areas where service was previously unavailable or unreliable, provide superior indoor and outdoor wireless coverage, and make better use of the spectrum.

Naturally, when new small cell sites are added, seamless user experience and high performance are critical, and electrical radiation patterns must be closely analyzed. Cost-efficiency is also a natural concern. Backhauling becomes a key consideration but can also present a lot of challenges. While integration of the antenna and electronics/outdoor unit (ODU) is imperative, small cells have to maintain a very low visual impact and integrate well into their surroundings.

This article will explore the need for small cell backhaul and the challenges faced by mobile operators, as well as look at the viable technology options that are emerging to enable sites that are aesthetically pleasing without sacrificing performance or becoming cost-prohibitive.

Mobile data traffic is expected to grow 13-fold between 2012 and 2017, to a staggering 10+ exabytes per month

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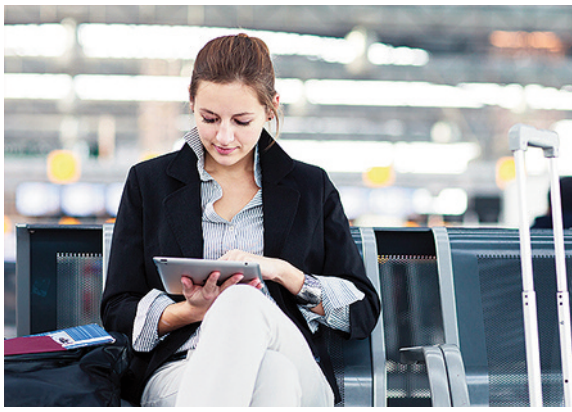
Why Small Cells?

Mobile data consumption has been increasing at an explosive rate and is likely to continue to do so for the foreseeable future. For example, according to Cisco's 2013 Visual Networking Index Global Mobile Data Traffic Forecast[1], mobile data traffic is expected to grow 13-fold between 2012 and 2017, to a staggering 10+ exabytes per month.

With the rollout of LTE and other next-gen wireless services coupled with the growing number of wireless users, carriers are approaching the limits of available spectrum, particularly in urban areas where data traffic is often most concentrated. As a result, these carriers are increasingly moving towards small cells to increase network capacity, expand the edges of the network to include areas where service was previously unavailable or unreliable, provide superior indoor and outdoor wireless coverage, and make better use of the spectrum.



By adding small cells – which may be femtocells, picocells, microcells or metrocells – mobile operators are able to offload a significant amount of traffic from the macro network in order to increase network capacity without having to add new macro sites, which are much more cost-prohibitive and complex to install. This creates a heterogeneous network or "Hetnet" by creating a mix of a macro layer and a small cell layer. Because small cells are reasonably priced and make for easy installation almost anywhere, they are an ideal choice for providing coverage to small populations such as a single building, a city block, or even a rural village. Most MNOs anticipate a ratio of three to six small cells per macro (even more for some.)

According to forecasts by ABI Research, outdoor small cells will reach 500,000 units in 2013 and over 3.5 million units by 2018[2]. In terms of revenue numbers, Infonetics Research expects the small cell market as a whole to reach $750M by the end of 2013 and to grow at a 48% 5-year CAGR to reach $2.4B in 2017[3].

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Small Cell Backhaul Challenges

Naturally, when new small cell sites are added, seamless user experience and high performance are critical, and electrical radiation patterns must be closely analyzed. Cost-efficiency is also a natural concern. Backhauling becomes a key consideration, particularly given the high range of wireless frequencies in the typical scenarios.

One of the primary backhaul challenges is that while integration of the antenna and electronics/outdoor unit (ODU) is imperative, small cells have to maintain a very low visual impact and integrate well into their surroundings (such as on a utility pole) as traditional large antennas with apparent parabolic shapes are not typically welcomed by the public in highly visible areas. Thus, it can be difficult to identify an ideal location for the backhaul provider to provide access. This often requires that the mobile operator and backhaul provider consolidate technology and work together to find a solution that remains aesthetically pleasing while ensuring that the small cell's reliability is on par with that of the macro network – and that the mobile user will have the same seamless experience whether on the macro network or the small cell.

Challenge of small cell backhauling: Very low visual impact

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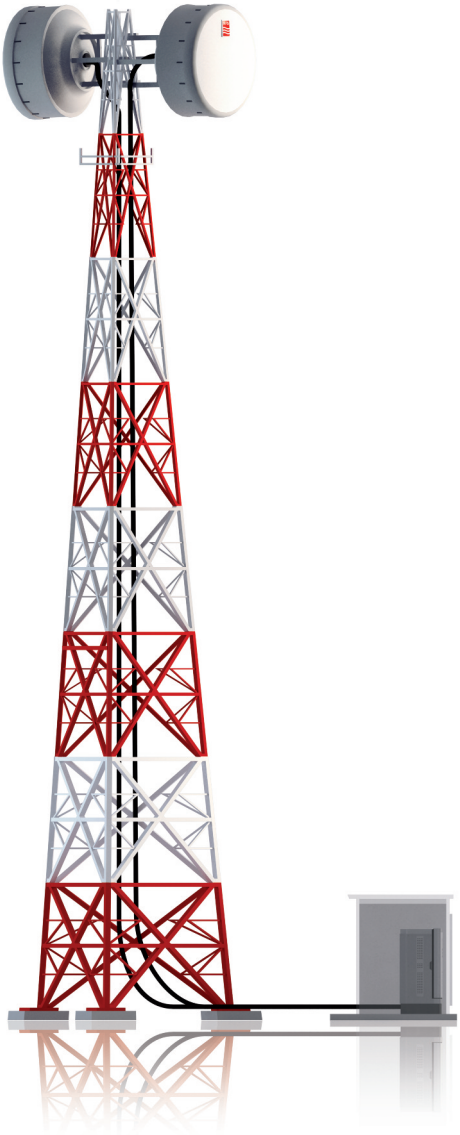
Backhaul Options

There are a range of backhaul solutions that can address the wide variety of small cell uses. For high-performance microwave backhaul, traditional line of sight (LOS) and non-line of sight (NLOS) propagation offer two approaches that provide a viable alternative to fiber or copper backhaul, which can be costly and impractical given the location of small cells and the need to maintain a low visual impact. However, a direct line of sight does not always exist between nodes and LOS typically requires parabolic dishes which could prove aesthetically unsuitable at many small cell locations. NLOS microwave point-to-point and/or point-to-multi-point wireless may be necessary in this respect – and requires less intrusive equipment – but there has been some concern that it is prone to 5-10 ms latency, which is problematic for common real-time applications. However, findings by Ericsson reported in the February 2013 *Ericsson Review*[4] support that NLOS can in fact be a viable solution for small cell backhaul. Because small cells are only intended as short-distance solutions, the high-system gain that supports targeted link distance and mitigates fading with traditional LOS backhaul can instead be used to compensate for NLOS propagation losses.



While NLOS may sometimes be suitable for the <6GHz spectrum, this part of the spectrum is too limited and/or cost prohibitive for the needs of many operators. Thus, backhaul solutions also need to be considered for small cells operating on higher frequencies of the spectrum, which are less constraining to data usage. More and more operators are looking at these higher frequencies as part of their long term strategy. This includes:

- **Traditional LOS 6-42GHz Bands** – Several issues may limit the usage of these frequencies for small cell backhauling, including difficulty to reach acceptable gain while reducing product size, complex licensing requirements, limited throughput and spectrum congestion.
- **60GHz V-Band** – This high frequency spectrum is particularly advantageous because it has low or no spectrum cost thanks to its "license exempt" status and there is a good amount of spectrum available in the 60-80 GHz range. Interference is limited

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and high frequency reuse is possible in this portion of the spectrum because high signal loss in this frequency band attenuates interfering signals and the maximum range is constrained to around one mile or less – a sufficient distance for small cell backhaul links. Point-to-point links can achieve data throughput rates up to1Gbps, which meet or exceed the needs of most multi-mode small cells.

- **70/90GHz E-Band** – E-band backhaul equipment benefits from higher data capacities than 60GHz but under the current FCC standards requires a larger dish (1ft) antenna. The ETSI Class 3 standard is also compatible with E-Band for small cells. Several radio manufacturers are working on developing higher capacity and more economical radio platforms that would most likely increase usage of this band for small cell applications.

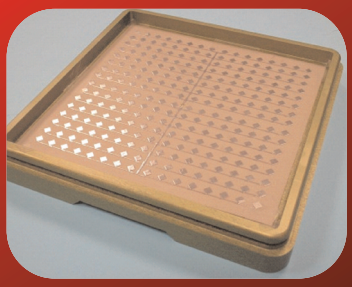
The RFS Solution: Small Form Antennas (SFA)

Backhaul can seem like a daunting process that can potentially deter operators from deploying small cells, but this does not have to be the case. RFS has launched a development program called SFA (Small Form Antennas) to study technologies in the aforementioned high frequency bands and address the common challenges of small cell backhaul in order to successfully integrate antennas and electronics that have a low visual impact and enable small cell microwave radio components to look like a single part.

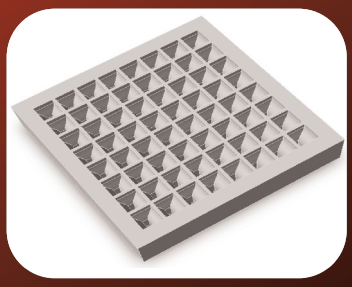
RFS has studied several backhaul technologies, including:

- **Microstrip / PCB** – These antennas can be very flat – like a circuit board – and visually pleasing. However, performance issues have been reported with PCBs. In addition, these antennas can be cost prohibitive.
- **Horn Array** – These antennas, while not as flat as PCBs, are optimized for higher frequencies (60 and 80GHz). One major disadvantage with these antennas is that a horn array for each frequency band has to be a separate design, making it likely not as cost competitive.

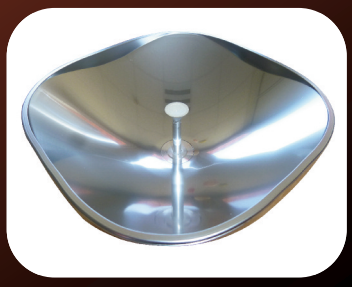
Several technologies have been studied including:



Microstrip / PCB



Horn Array



Ultra-Small Parabolic

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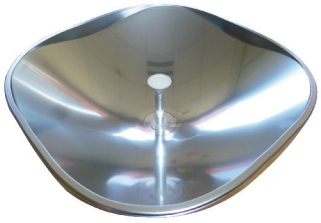
- **Ultra-Small Parabolic** – These antennas target a wide frequency range from 23GHz to 80GHz with one reflector for 60/80GHz and one reflector for 23/42GHz. In terms of performance, cost and appearance, ultra-small antennas are the superior option for small cell backhaul. Another important consideration for small cell antennas is integration with the electronics which can be easily achieved with Ultra-Small Parabolic antennas.



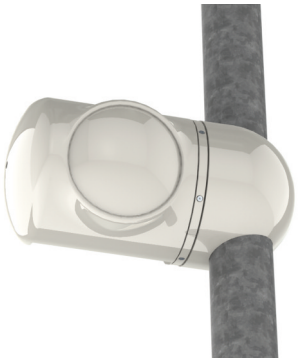
Ultra-Small Parabolic

InvisiLine™ Series* of Small Cell Backhaul Antennas

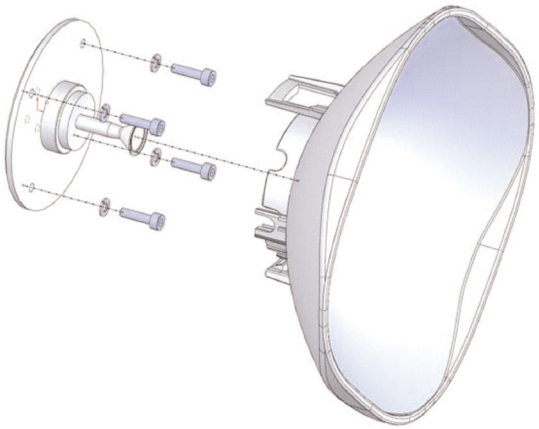
RFS is currently launching a 60GHz antenna for small cell backhaul, which includes many significant features such as a very light weight, a small size and a low cost, all while maintaining excellent performance. Additionally, an 80GHz antenna for small cell backhaul will be available from RFS in early 2014.

Radio Integration

RFS is further innovating in the area of the packaging structure* for small cell backhaul, with a focus on camouflaging the two components to look more natural and emotionally transparent in the landscape, including options such as different shapes, hidden mounting structures and different colors to ensure as much transparency as possible.



Complete Camouflage Solutions



Extremely easy ODU antenna integration

***Patents pending on several RFS designs at the time of printing**

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Conclusion

In conclusion, though it can seem like a challenge to conduct small cell backhaul -- while maintaining a site that is aesthetically pleasing, without sacrificing performance or becoming cost-prohibitive -- there are in fact viable options. RFS is at the forefront of exploring and designing antenna technologies* that enable backhaul for small cells operating in diverse ranges of the high frequency spectrum. The ultimate result will be a seamless experience for the mobile user as they are transitioned from the macro network to the small cell, while freeing up additional spectrum for the mobile operator to support increasing data traffic demands.

Company profile

Radio Frequency Systems (RFS) is a global designer and manufacturer of cable, antenna and tower systems, plus active and passive RF conditioning modules, providing total-package solutions for outdoor and indoor wireless infrastructure.

RFS serves OEMs, distributors, system integrators, operators and installers in the broadcast, wireless communications, land-mobile and microwave market sectors. As an ISO compliant organization with manufacturing and customer service facilities that span the globe, RFS offers cutting-edge engineering capabilities, superior field support and innovative product design. RFS is a leader in wireless infrastructure.

***Patents pending on several RFS designs at the time of printing**

[1] http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.html

[2] https://www.abiresearch.com/press/market-gets-primed-to-rollout-half-a-million-outdo

[3] Small Cell Equipment Biannual Worldwide and Regional Market Size and Forecasts: 2nd Edition, Infonetics Research

[4] http://www.ericsson.com/res/thecompany/docs/publications/ericsson_review/2013/er-nlos-microwave-backhaul.pdf