DragonWave
www.dragonwaveinc.com

Microwave Journal
Frequency Matters.

Small Cell Wireless Backhaul for 4G – Underlying technology Enablers

Eric Boch

Article

August 26, 2013

Abstract

The cellular industry seems to be buzzing with "small cell" fever. Within the general thrust of implementing small cell outdoor cellular networks, backhaul is seen as one of the major barriers to deployment[1]. The market for equipment used to provide backhaul to these sites can be generally evaluated by the number of micro-cellular base stations that are forecasted, along with an assessment of whether they'd be backhauled using various, more likely backhaul technologies (i.e. fiber or wireless).

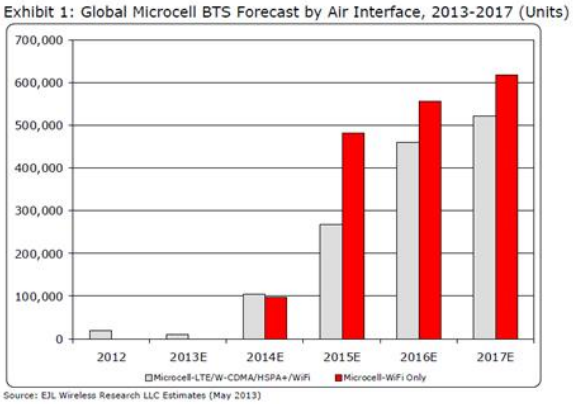

Figure 1 - Global MicroCell Base Station forecast (Source = ELJ Wireless Research, Global Microcell Base Station Market Analysis and Forecast, 2013-2017, May 2013

[1] Operator survey data from Small Cell Forum (2014) indicates that small cell backhaul is of the highest concern to operators

The Market forecast data shown above relates to micro-cellular base station “units”. In order to assess the market sizing for wireless backhaul, the data needs to be further reduced as follows;

1. Indoor vs outdoor deployments
    a. Difficult to assess this split
    b. There are certainly many operators deploying in-home (femto-cell) and in building (pico-cell) solutions in an effort to provide indoor coverage and/or offload the outdoor (macro-cellular) network. These indoor deployments also offer the operator some option to market additional services to their enterprise customers
2. Fiber vs wireless backhaul
    a. Most of the outdoor sites will be situated on non-traditional sites which will doubtfully be exposed to convenient fiber drops (i.e. steet/Traffic light poles, bus shelters, small store-fronts, advertising billboards, etc.)
    b. Based on fiber penetration information related to fiber-to-the curb (FTTC), and fiber-to-the-building (FTTB), fiber penetration to these outdoor microcell host sites can be expected to be negligible

Although the split in indoor-vs-outdoor small cells is difficult to assess, it’s likely that wireless backhaul will play a key roll in outdoor small cell backhaul deployment scenarios. There are a number of short range wireless backhaul solutions that have respective pros and cons. These include:

1. Millimeter-Wave unlicensed technologies – i.e. 60 GHz (V-band)
    - Widespread availability, unlicensed, high capacity
2. Millimeter-Wave licensed technologies – i.e. 70/80 GHz (E-band)
    - Reasonably widespread availability, licensed/light-licensed, needs large antennas in some geographical regions
3. Licensed Common-Carrier bands (6 – 60 GHz)

- Globally available, widely used for macro-cellular backhaul, usually doesn't allow for very small antennas (i.e. << 30cm dia)

4. Unlicensed Microwave bands (i.e. 24 GHz ISM)
    - Short range, available in NA & Europe
5. Area Licensed Microwave bands (i.e. 24 & 38 GHz DEMS, 28 GHz LMDS, 42 GHZ MVDS)
    - Operator has to pay for area license, different bands available in various geographies, can use very small antennas
6. Licensed sub-6GHz bands (i.e. 2.6 GHz, 3.5 GHz and 4.9 GHz)
    - Limited spectrum available, may compete with RAN spectrum demands
7. Unlicensed sub-6GHz bands (i.e. 2.4 GHz & 5.8 GHz)
    - Globally available, usually heavily cluttered with users/interference, difficult to assert availability or reliability performance (interference)

Further wireless backhaul market assessment Information from Infonetics Research[2] suggests that of the choices outlined above, millimeter wave technology may play a dominant role in the outdoor small cell backhaul market. Their findings show:

- Deployments of outdoor small cells will be driven largely by mobile operators' need to enhance saturated macro-cellular networks in urban, high-traffic areas and improve the mobile broadband experience
- Wireless microwave technologies, licensed millimeter wave accounts for the largest portion of outdoor small cell backhaul revenue
- Outdoor small cell backhaul connections are expected to reach 656,000 in 2017

[2] Infonetics Research, summary excerpts from *Small Cell Mobile Backhaul Equipment* report, Dec 2013

- Though North America originally led the outdoor small cell charge, it's expected that regional revenue share will shift to Asia Pacific and EMEA by 2017
- A cumulative $3.6 billion will be spent worldwide on outdoor small cell backhaul equipment over the 5 years from 2013 to 2017, with the market kicking into high gear in 2015
- Additionally, over $43 billion being spent on macro-cell backhaul equipment during the same 5-year period (see Macro-cell Mobile Backhaul Equipment and Services report)

Since outdoor small cell deployments are largely expected to be in cluttered, street-level environments, there is often concern about wireless radio link planning success, particularly where clear Line-of-Sight (LoS) may be a challenge to obtain. The wireless backhaul community's use of LoS, "near-LoS" (nLoS) and "non-LoS" (NLoS) leads to a further complication that arises when proponents of one or the other argue that a given band is "nLOS" or "NLoS" capable or not. It is also important to determine exactly what these terms mean. For example, it is entirely possible to operate radio links at high frequencies (i.e. 28GHz, 60GHz) in non-LoS modes using reflected link topologies in dense downtown/urban environments[3].

Technology Thrusts at Play

The industry sees the general idea of "small cell" deployments as a mechanism for dealing with the scarcity of useful RAN spectrum. Cellular end-user bandwidth demands are escalating at a pace which outstrips the capabilities of the RAN interfaces (i.e. 3G, 4G) to the point where small cell networking solutions appear to be increasingly necessary. Currently, while expected deployment volumes of small cells is being debated, there does appear to be a consensus that the volumes will be much larger than those associated with today's macro-cellular networks. Focusing on the outdoor segment, where wireless backhaul would likely play a large role, the anticipated deployments drive some or all of the following projections:

- Deployment outdoors at low elevations will require small, lightweight, integrated electronics solutions

[3] DragonWave 60GHz field measurements, Ericsson 28GHz field measurements

- Equipment industrial design (ergonomics) can be very important
    - Mounting on Street Light Poles (SLPs) or Traffic Light Poles (TLPs) requires careful consideration of weight & wind loading limitations of these host sites
- Large volumes and the "smaller" site scenario will demand massively lower cost equipment than was previously palatable in the macro-cellular scenario
- Deployed equipment requires self-installation and self-alignment functionality in order to minimize installation time and cost
    - Interference control is vital[4]
- Power saving operating modes are important
- Integrated management solutions are needed (RAN, switching, backhaul)
    - Network configuration (and reconfiguration)
    - End-to-end management (OAM, path management, IPSec path and key management)

Impacts to Wireless Backhaul Enabling Technologies

Outdoor small cell wireless backhaul products are expected to be highly integrated solutions, offering a wide range of advanced networking features that may include:

- Ethernet OAM (IEEE 802.1p, 802.3q)
- Carrier grade Ethernet functionality (i.e. MEF ELine, ELAN, ETree)
- Support of networking synchronization (i.e. IEEE 1588 V2 TC and/or BC)
- Network Synchronous operation (SyncE, management thereof)

[4] When considering wireless backhaul, a significant problem arises when backhaul beams are "randomly" implemented/pointed, potentially causing interference in neighboring network infrastructure. This problem becomes more acute when lower frequencies are used, because their propagation attributes generally allow them to cause a broader/aggravated interference scenario

- VC tunneling support (i.e. MPLS)
- Network security (i.e. IPsec)

But what about the RF layer? Beyond cost reduction and multi-function integration, what innovations are required? There are key considerations that need to be addressed. For example:

- Although short ranges are involved, losses associated with blocked, diffracted or reflected paths drive a requirement for high system gain
    - The need for optimized Power Amplifiers with integrated facilities for linearization and Digital Pre-Distortion feedback
- Complex multipath-laden operating environments demand;
    - Complex, adaptive modem solutions
    - robust [antenna] spatial filtering capability
- Deployment densities drive requirements for low side/back-lobe antenna designs
    - Care must be taken to consider the global requirements for radiated pattern masks in the various operating bands and geographic regions. This can be particularly challenging when considering electronically steerable antennas in some bands
- Packaging demands for outdoor small cell require low-heat (i.e. low power consumption) designs with high power-added efficiencies.
    - Features which allow for power conservation during off-hours, or during “stable” RF channel periods is also very valuable
- Electronic beam steering (and or null steering) can be used for a number of possible networking benefits;
    - Self-installation and peer-finding
    - Compensation for mounting site motion (i.e. street light pole twist & sway)

- Self-re-organization, self-healing
- Selection of alternate nLoS paths
- Spatial filtering of sources of interference
- This suggests a need for phased array technologies
    - Integrated multi-channel RF front-end devices
    - Low cost antenna arrays
    - Ability to easily adapt designs to conformal, ergonomically –acceptable housing shapes.

Summary

After thorough investigation and analysis of market drivers and forecasts, it's clear that wireless technology is a logical fit for outdoor small cell backhaul. Although it is also clear that no single solution can address the many complexities and technological hurdles that need to be overcome to add reliable carrier-grade, small cell wireless backhaul to existing networks. In order to achieve an optimized application of wireless technology to this market, a number of identified, underlying technology solutions need to be employed at the wireless component and antenna supply chain layer.

View this Article Online

http://www.microwavejournal.com/articles/22881-small-cell-wireless-backhaul-for-4g-underlying-technology-enablers