The Rise of Multi-Technology Small Cells
Mobile data consumption is growing at an incredible rate. Consumers around the world are eagerly purchasing smartphones and tablets and using those mobile devices to access bandwidth-hungry applications.

In its most recent Visual Networking Index (VNI), Cisco predicts that mobile data use will grow 13-fold over the next five years, hitting 11.2 exabytes per month by 2017.¹

For mobile operators, this rapid growth represents an enormous challenge. Their existing networks and wireless spectrum resources simply cannot keep up with rising customer demand.

To address this issue, the mobile industry has three primary options. First, they can address it by attempting to acquire more wireless spectrum, refarming existing spectrum, or utilizing unlicensed spectrum using carrier Wi-Fi. Many are currently attempting to do so, but these processes are usually long, complicated and costly.

Second, operators can implement optimization methods that help them use their existing networks and spectrum more efficiently. These methods include technologies such as multiple input/multiple output (MIMO) smart antennas, efficient interference management, advanced receivers and self-organizing network (SON) capabilities.

The third option, which is growing in popularity, is to deploy a hyperdense network of “small cells” to augment capacity in traffic hot spots and improve quality for end users. This technology has been the focus of a lot of industry buzz in recent years, but it’s now becoming a reality.

**SMALL-CELL EVOLUTION**

A “small cell” is just what it sounds like — a small cellular station that can handle traffic for a subset of users in a specific location. Small cells can be deployed indoors to improve call quality in places where coverage and signal quality are problematic. They can be used outdoors to extend coverage to rural or remote areas. And they can be installed in congested, highly populated areas to relieve some of the burden on the existing cellular infrastructure.

The small-cell category includes several different types of hardware, including femtocells, picocells and microcells. These differ in coverage area, deployment location and number of users served. (See chart on next page.)

Sprint deployed the first small cells in 2007 when it launched a femtocell program. In the years since, the category has expanded rapidly. According to Informa, the number

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of small cells deployed worldwide reached 6 million in November 2012, exceeding the
5.9 million macrocells in use for the first time. Not surprisingly, the same report found
that 95 percent of mobile operators surveyed believe that small cells are key for the
future of mobile networks.ii

But the small cells of the future will likely differ from those available today in one key
way. Currently, nearly all small cells support only one wireless technology — usually
either 3G or 4G LTE. The next generation of small cells will feature multiple technologies,
which will provide additional benefits for both carriers and end users.

THE MULTI-TECHNOLOGY SMALL-CELL OPPORTUNITY

Engineers are currently working on designs for small cells that will combine 3G with
Wi-Fi connectivity, or 4G with Wi-Fi, or even both 3G and 4G with Wi-Fi. Which combi-
nation operators choose to deploy will depend on the type of network they have in a
particular area, but the key will be the addition of Wi-Fi capabilities.

Because Wi-Fi operates on unlicensed frequencies, it’s essentially free for mobile
operators. Wi-Fi-capable small cells could relieve much of the burden on their stressed
cellular networks, leading to lower costs and improved user satisfaction. “Operators see
Wi-Fi as a very significant, very inexpensive way to off-load data,” said Jayanta Dey, VP
and head of R&D and consultancy, telecom equipment vertical, Wipro. “We believe that,
going forward, most of the small cells will offer integrated Wi-Fi.”

Multi-technology small cells also present an excellent opportunity for telecommunications equipment vendors. Market researchers at Infonetics predict that the market for
small-cell products will be worth $2.1 billion by 2016.iii And InStat believes the market
will be even larger — $14 billion by 2015.iv

<table>
<thead>
<tr>
<th>Deployment Location</th>
<th>Concurrent Users</th>
<th>Range</th>
<th>Frequency</th>
<th>Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home</td>
<td>4-8</td>
<td>300 m</td>
<td>5-10 MHz</td>
<td>&lt;10 Mbps</td>
</tr>
<tr>
<td>Enterprise</td>
<td>8-32</td>
<td>&lt; 1 km</td>
<td>10-20 MHz</td>
<td>&lt;100 Mbps</td>
</tr>
<tr>
<td>Public Hotspot (Indoor)</td>
<td>32-64</td>
<td>&lt; 1 km</td>
<td>10-20 MHz</td>
<td>&lt;100 Mbps</td>
</tr>
<tr>
<td>Public Hotspot (Outdoor)</td>
<td>32-256</td>
<td>2-3 km</td>
<td>20 MHz</td>
<td>&lt;100 Mbps</td>
</tr>
<tr>
<td>Rural</td>
<td>8-64</td>
<td>&lt;10 km</td>
<td>5-10 MHz</td>
<td>&lt;10 Mbps</td>
</tr>
<tr>
<td>Public Safety</td>
<td>32-64</td>
<td>&lt;30 km</td>
<td>5-10 MHz</td>
<td>&lt;10 Mbps</td>
</tr>
</tbody>
</table>

ii. Informa, Small Cell Market Status, Issue 4, December 2012
Market-Highlights.asp
iv. In-Stat, “More Than Just Femtocells, Small Cell Shipments’ Retail Value to Reach $14 Billion in 2015, Says NPD
For equipment vendors that get the right small-cell products to market quickly — and at attractive price points — the payoff could be substantial.

**CHALLENGES TO OVERCOME**

The race is on for manufacturers to design and produce the multi-technology small cells that the mobile industry desperately wants. But before vendors can bring those products to market, the mobile industry must first overcome some significant hurdles.

- **Product design.** Small cells come in a dizzying number of variants to serve many purposes. The category includes products for home users, enterprises and university campuses; indoor and outdoor public hotspots; rural areas; and public safety and defense. The multiple types of small cells include various form factors with different ranges and bandwidth capabilities, and they can support a variety of technologies (LTE, HSPA and Wi-Fi, as well as FDD and TDD mode). In addition, operators have a variety of carrier frequency bands and backhaul needs.

  The trick for equipment vendors will be identifying which products will offer the best combination of price and performance. And because many different vendors will likely offer small cells, companies will have to get those products to market in a timely manner if they want to compete.

  “There are multiple product variants supporting multiple deployment scenarios and configurations,” Dey explained. “There are multiple frequency variants and varying price points for these product variants. So equipment vendors must consider a multitude of factors to come up with a small-cell solution.”

- **Multilayer management.** When operators deploy small cells along with their macro stations, they end up with heterogeneous networks, also called HetNets, that pose significant management challenges. Equipment vendors must develop ways to deal with the interference that occurs when so many cell stations are deployed near each other. Many of the methods for handling the interference are being driven by standards bodies, but some vendors are also developing their own proprietary methodologies.

  In addition, operators need a way to coordinate traffic between the macro and small cells, and to determine when to connect to Wi-Fi and when to use other types of connections. Advanced SON technology will likely be key in overcoming these coordination and interference-management issues.

  Finally, vendors and operators will need effective interference and power management capabilities for small cells. This may involve small cells entering a dormant state to minimize interference and conserve energy when they are not in use. All of these management capabilities must be integrated into the software that runs the small cells.

- **Operational issues.** With macro base stations, mobile operators control the physical site where the stations are located, and they can perform maintenance as needed.
But with a large fleet of small cells, the operational picture looks very different. Small cells might be deployed on a light pole in a street, on the roof of a stadium or in a closet of an office building or home. Outdoor locations may require permission from municipal authorities for deployment or maintenance. Similarly, many indoor devices will be owned and deployed by enterprises and other private users, meaning that the operators will have no direct physical contact with the deployed small cells. And because it takes several small cells working in a coordinated manner across layers to create an effective HetNet, it would be cost prohibitive for operators to visit each location to perform maintenance, even if they could get access.

Given these new realities, operators will be looking for ways to reduce both capital expenses and operational expenses. Again, advanced SON techniques will come into play as this technology will enable networks to configure themselves, optimize themselves and even heal themselves. Operators will likely also look to shared models for small-cell location and deployment. And they’ll need to plan carefully for their deployment of the various types of small cells to minimize their capital expenditures.

In addition, operators also need to control the installation of Wi-Fi hotspots, perhaps by sharing them among multiple operators, as too many of them in the same hotspot will degrade the overall performance of the HetNets.

• **Backhaul.** Depending on where they are deployed, small cells will use a variety of mechanisms for connecting with backhaul. Whenever possible, operators will likely use their existing fiber or other existing backhaul infrastructure.

  However, Dey predicts, “The existing backhaul mechanisms will not be sufficient to address the small-cell deployment. Mobile operators will have to look out for new ways and new approaches. We think that wireless backhaul is going to play a greater role and it is going to give much more flexibility to operators to deploy the boxes in different environments.”

  To solve these challenges, operators will need small-cell solutions that incorporate different backhaul mechanisms, such as line-of-sight or non-line-of-site microwave, millimeter wave, 5 GHz Wi-Fi, FTTx or VDSL2. Depending on the deployment scenario, it may be more cost effective to have the backhaul integrated into the small-cell product.

**IMPLICATIONS**

Multi-technology small cells represent an important opportunity for the mobile industry. But significant challenges remain.

Experts recommend that manufacturers seek out partners that can help them navigate through the myriad of possible product variants to find those that will offer the best price-performance ratio. In particular, they should seek out a scalable software solution that can serve in multiple products, so that they don’t have to invest
in new software for every different small-cell product they design.

In addition, they’ll need an integrated solution—one where the hardware, software, RF and mechanical design work together to serve the needs of the operators and end users. Plus, their designs will need to be flexible and based on a plug-and-play architecture so that they can add capabilities as necessary for different operators and different locations.

Most importantly, equipment vendors need to begin working on this next generation of small cells today if they hope to compete in a market that is poised for rapid takeoff.
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