White Paper

The Future of Infrastructure: Compact Base Stations

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June 2010

Introduction

There is little question that cellular phones have had a huge impact on how we work, live, and how we conduct business. Initially, cellphones were about voice communications, allowing almost anyone anywhere to communicate with others, even in developing countries with little wired infrastructure. In the last few years, the cellular revolution has been slowly evolving by adding high-speed wireless broadband to the mix, first in the form of third-generation (3G) data services, and soon by what are being called fourth-generation (4G) data services—superfast broadband exceeding the data speed available via DSL, cable, and satellite broadband services. Within the next few years, most of us living on the planet will have access to the Internet, streaming video, and other broadband services via wireless.

With this change in wireless services offered, has come a profound change in the way that wireless operators must engineer their networks for 3G, which will further support the drive to 4G. These changes affect everything from backhaul and the core network, to the base station itself and how entire networks are designed, deployed, and maintained. No longer is a network of macro base stations spaced 5 or more miles apart and supplied with T1 backhaul sufficient to provide data services to subscribers that are demanding faster data speeds and much more data than ever in the past. A new type of infrastructure deployment is required for 4G, and the base station at the forefront of this new deployment is the compact base station.

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The Evolution of the Cellular Network

To fully understand and appreciate how the cellular network has evolved and how it will need to evolve further in the future, one has to understand why the current network was built the way it was in the first place.

The first cellular networks were deployed across the US and throughout the world in the 70s, 80s, and 90s, and the goal of these networks was to provide coverage over as large an area as possible. To accomplish this, operators installed macro base stations with cellular towers. Macro base stations are typically installed in a temperature-controlled shelter, and contain 3 or 4 racks: 1 for power, 1 or 2 for baseband processing, and 1 for RF. Depending on the technology used, and frequency, most towers could provide voice service to many hundred voice subscribers over an area of 50 sq. miles or more. In general most cell towers used three sectors, although six sectors were used at times in very densely populated areas, and single sectors were used in areas with quite low population densities.

This type of wide cell tower spacing worked well for voice for several reasons.

- A subscriber on a voice network uses only a small amount of data at a rate of only 10–15Kbps. This means than an operator, even with limited spectrum, can still deploy towers with large footprints and provide a capacity of several hundred subscribers or more within each tower.
- The most expensive and time-consuming aspect of installing a macro base station and tower is acquiring the land and getting the zoning approval to install the tower. Since macro base stations have a wide area of coverage, fewer of them are required to cover a given area.
- Getting backhaul, both wireless and wireline, to a macro base station can be costly. By minimizing the number of cell sites required, backhaul costs can be reduced.

In 2001, NTT DoCoMo launched the first 3G network, and the next year, Verizon in the US and operators around the world launched their 3G networks. While first-generation and second-generation networks were all about voice, 3G was about data. GSM wireless operators upgrading their cellular networks to 3G with the addition of a WCDMA base station would almost always install them at the same locations as their existing GSM base stations. This made perfect sense because the towers were in place, as were the base station enclosures and backup power supply, so installations went smoothly. CDMA operators, in most cases, had the luxury of upgrading their current 2G base stations to 3G, further reducing upgrade costs, but also meaning that their 2G and 3G base stations would be co-located.

Initially, operators had their 3G networks up pretty quickly, but it was soon very apparent that the network of macrocell base stations that operators used for 2G voice was not an ideal topology for 3G data. The problems that operators faced with subscribers were the following:

- Many dead spots. Signal levels that had been adequate for a voice call were now inadequate for a 3G data connection—at least a connection that offered anything approaching what could be called broadband. While a voice connection can be very tolerant of dropouts, a 3G data connection requires not only a stronger signal but also a more consistent signal. Dead spots are also a problem indoors when a signal, because it is too weak or at too high a frequency, has trouble penetrating a building. Low frequencies, those generally under 1GHz tend to have a much easier time penetrating buildings than frequencies typically used for 3G—over 1.8GHz.

- Slow connection speeds. While a poor signal can slow a wireless data connection as the connection falls to less and less complex and more and more robust modulation schemes, another problem with connecting wirelessly is when the distance between the user and base station becomes too large. As the distance from the user to the base station increases, the latency of the signal also increases, slowing down total data rates.
- Poor system capacity. This is probably the largest problem with using a macrocell network for 3G. The reason for this has to do with the laws of physics and the spectrum allocation owned by wireless operators. Within a cell, total throughput for all subscribers combined is limited to the amount of spectrum owned by the operator, and the technology employed. To generalize, the greater the number of subscribers sharing the resources of one cell, the slower the data rate that each will experience. If a large cell is split into four smaller cells, the total capacity of these four cells could be up to four times as great as the total capacity of the larger cell. Therefore, all else being equal, a greater number of smaller cells produce a much higher capacity than one large cell.

Operators deploying 3G tackled the problems listed above in a variety of ways, ultimately by placing more antennas closer to subscribers. Some of the solutions that wireless operators have deployed for their 3G networks include:

- Distributed antenna systems (DAS): A distributed antenna system employs a macro or micro base station the same as a conventional cellular site would with a cellular tower antenna, but instead of the large antenna, fiber-optic cables are used to distribute the base station's signals to a group of antennas placed outdoors or indoors throughout a large building like an airport, shopping mall, or hospital. The multiple cells of a distributed antenna don't add capacity when compared to a cell tower, but they do reduce dead spots, and get the antennas closer to the subscribers. Often multiple operators will share the cost of installing a DAS, since a DAS system can be used simultaneously by multiple operators each using a different technology and frequency. Distributed antenna systems, however, can be quite expensive to install and operate, so usually they are only feasible if several operators can share the expense of installing and operating these systems.
- Remote radio heads (RRH): Like a distributed antenna system, a system employing remote radio heads has a micro or macro base station. But unlike a single antenna base station site, the radios and associated antennas for the base station are separated from the base station via fiber. An additional antenna and radio might be local to the base station as well. Remote radio heads can be used to offer diversity for a base station and/or it can support access from many locations. It's common in high-rise buildings, for example, to install a base station in the basement, and then provide remote radio heads on multiple floors of the building. Remote heads are used in many other locations as well, including train stations, shopping malls, hospitals, etc. and in many of the same situations as distributed antenna systems, except remote radio heads give an operator much more flexibility in the design of the network. Unlike distributed antenna systems, however, base stations with remote radio heads are typically owned by a single operator, not shared among

several operators. Remote radio heads are typically used for outdoor coverage, but they can be used for indoor coverage as well, or even for a combination of outdoor and indoor.

- Picocells: Picocells are small base stations deployed by operators where coverage holes exist or to provide focused coverage either indoors or out. Picocells are a good alternative for operators who want to get their base stations closer to users, but as opposed to micro or macrocells, picocells have limited capacity due to their small cell size and limited output power.

These coverage and capacity solutions used by operators each have several pros and cons. Remote radio head solutions and distributed antenna systems both require a large enclosure to house the macro or micro station. Many times this enclosure needs environmental controls, such as air conditioning and a backup power source, such as batteries and possibly a generator, all of which add to the cost. For the DAS system, this enclosure may need to house equipment from three or four operators, which again can add to the cost.

A solution involving picocells is also not without challenges. Since traditional picocells have a relatively low capacity and smaller coverage area, many of them are required, and if the number of picocells grows too quickly, getting backhaul to them all quickly can get expensive. If wired Ethernet is already at the site, the costs are relatively low, but if wireless backhaul is required, costs can grow quickly because separate backhaul equipment must usually be added at each traditional picocell location.

While none of the existing 3G coverage and capacity solutions are ideal in all respects, operators have been forced to use such solutions to solve their 3G problems.

Table 1. Traditional Base Station Types

Traditional BTS Type	MacroBTS	MicroBTS	PicoBTS
Application	**Outdoor Coverage**		**Indoor Coverage**
Range	0.5 – 22 miles	0.25 – 3 miles	SMB/Floor
Sectors	3 – 6	1 – 3	1
Power Out	10 – 20 W	2 – 4 W	250 mW
Subs/Sector	> 200	< 200	8 – 25
RF - Tx/Rx	2x2, 4x4	2x2	1x1
PA Type	Discrete PAs		

Source: In-Stat, 5/2010

The Infrastructure Needed for 4G

New 4G technology works fundamentally different from 3G technology, so deploying 4G network presents an even greater challenge for wireless operators than did 3G. Operators deploying 4G technology (WiMAX and LTE) typically have the same problems that they experienced deploying 3G technologies, only to a greater extent. For example, many operators are deploying 4G technologies on higher frequency spectrum than 3G, where it becomes even more difficult to penetrate buildings. In addition, 4G technologies are using orthogonal frequency-division multiplexing (OFDM) technology which not only works better with high-multipath environments, but actually benefits from a high level of multipath. For operators, this means they must deploy infrastructure equipment with multiple antennas in each sector providing both receive and transmit diversity.

Because of the challenges of deploying 4G, wireless operators have had to totally rethink how they would deploy their networks. On one-hand, operators have spent billions of dollars deploying 2G and 3G technologies, so they want to make use of existing infrastructure, such as towers, backup power, bunkers, and all other rights-of-way that have taken them years to acquire and build. But on the other-hand, the types of base stations and the layout of these base stations that worked for 2G and 3G need to undergo a fundamental overhaul for 4G.

The solution for operators is a new family of base stations, which is the subject of this paper—the compact base station. As the name implies, compact base stations have the same capacity as existing base stations do, but due to rapid advances in semiconductor technology, these base stations are many times smaller and much more power efficient than conventional base stations.

For wireless operators with 4G networks to deploy, the compact base station couldn't have arrived too soon. While traditional base stations with very large power amplifiers will still be used by operators in the deployment of 4G, the new compact base station family of products will be used in a variety of situations where traditional large base station products just would not be feasible because of their large physical size, cooling requirements, or high cost. Some of the locations now possible because of the compact base station include the top of lighting poles, the sides of buildings, indoor locations, including business locations, or just about any location where power and networking is available. In fact, many compact base stations will also include support and power amplification for wireless backhaul, making even a networking connection unnecessary.

Exactly What Are Compact Base Stations?

A compact BTS is a family of base stations with the capabilities of a traditional base station, but in an ultra-compact, single-enclosure form factor. Such base stations have only become available recently because of the increasingly high degree of integration and sophistication of system-on-chip (SoC) silicon used to build these base stations. Unlike the evolution of the computer, the reduction in size of micro and macro base stations has occurred at a much slower pace, due to complexity and the many diverse processing requirements of the base station systems themselves.

A traditional base station includes physical layer (PHY)), media access controller (MAC), and control plane layers, as well as the digital radio sub-system (radio head) that drives the power amplifier (PA). A single-enclosure base station needs to contain all of these same processing components—but in a much smaller package. Modern multi-core SoC architectures employ the integration of multiple DSP, RISC, and CPU cores, augmented with HW acceleration cores, targeting the processing layers of entire base station systems—thus enabling the ultra-compact form factors discussed in this paper.

Table 2. Compact BTS Characteristics

Compact BTS Class of Equipment				
Application	**Macrocells**	**Microcells**	**Picocells**	**Indoor PicoAPs**
General	Single-enclosure BTS, size and cost reduced by use of SoC technology. Contains all BTS components such as control layers, MAC and PHY, as well as all RF-related sub-systems, such as digital radio design (DFE), and analog RF and PA.			
Spec	Size, weight, and power consumption are driven by the heat dissipation of the integrated PA. (Compact BTSs are passively cooled and never require an air-conditioned shelter or cabinet.)			
Power Consumption	Up to ~170W	50W to 120W	25W to 60W	10W to 25W
Antenna Options	Discrete Antennas Multi-Sector Options	Discrete Antennas Multi-Sector Options	Integrated Antennas Multi-Sector Options	Integrated Antennas Single Sector
Physical Form Factor	Same as RRH	Similar to Small RRH	Compact Access Point	Indoor Access Point
RF – Tx/Rx	2x2 – 8x8	2x2 – 4x4	4x4	4x4
Mounting Locations	Dependent on actual Compact BTS Equipment Form Factor (size, weight, power consumption). (Compact BTSs are passively cooled and never require an air-conditioned shelter or cabinet.)			
	Tower, roof tops	Tower, roof tops, side walls	Side walls, lamp posts, traffic lights, poles, MSO cable strands, etc.	Floors, SMB, MTU, etc.
Operational	Controlled and monitored remotely, same MTBF as an equivalent RRH.			
Multi-Protocol	Software-defined architecture supporting multiple, simultaneous technologies including HSPA, LTE, WiMAX.			
Self-Backhaul, Relay	Hub Functionality	Hub Functionality	Self-Backhaul for Metrozone Deployments	Yes
Subscribers	Flexible—driven by RF location, cell size, local market demography.			
Subs per Sector	> 200	< 200	< 100	< 50
Cost	$8K – $12K	$5K – $10K	$2K – $5K	$350 – $1K

Source: In-Stat, 5/2010

In the end, the compact BTS components with the most system impact may well be the power amplifiers (PAs), which have not seen the same size reduction or miniaturization, mainly due to the fact that PAs are not digital processor-driven components. Outdoor mobile infrastructure does require the use of high-power RF signals to drive required minimum cell sizes, and this requirement will become more prevalent, as wider and wider 4G channels are employed for higher sector capacity. High-power radio sub-systems utilize high-output PAs that dissipate significant amounts of input power as heat, thereby dictating the size and choice of materials for the system enclosure.

To satisfy passive cooling requirements for single-enclosure compact base stations, the stringent management of PA efficiency, i.e., minimizing heat dissipation is a key processing capability—a mandatory requirement for the SoCs used to build compact BTS equipment.

Compact BTS need to come in several types and form-factors, matched up with location-specific requirements for various cell sizes, regulatory stipulations and physical requirements. In most cases, compact base stations will have the same capacity and capabilities as their traditional counterparts. However, in cases of lower wattage power amplifiers, that would dictate a smaller cell size, which happens to align almost perfectly with the needs of wireless operators deploying 4G solutions.

The emergence of the compact base station class of products has occurred because wireless operators require them and because sophisticated SoC technology now makes them possible. In the coming years, operators will increasingly rely upon these products and many operators have used the early versions of these products for their WiMAX deployments. For LTE, their numbers will grow rapidly due to the large number of operators, worldwide, who are planning, or have already started to deploy LTE.

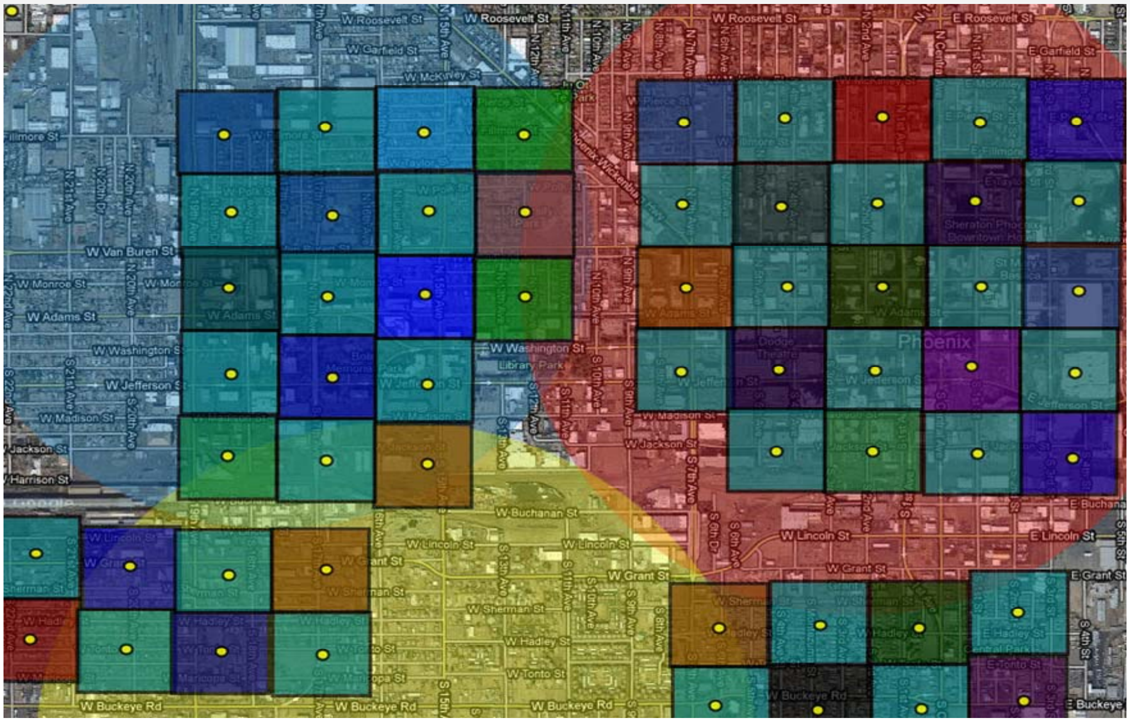
Table 3. 4G Compact BTS Family w/Traditional Macrocell Overlay

BTS Type	Traditional	Compact BTS			
Cell Type	**MacroBTS**	**MacroBTS**	**MicroBTS**	**PicoBTS**	**PicoAP**
Application	Outdoor Coverage				Indoor Coverage
Range	0.5 – 22 miles		0.25 – 3 miles	0.1 – 0.6 miles	SMB/Floor
Sectors	4 – 8	1 – 6			1
Power Out	20 – 80 W	20 – 80 W	5 – 20 W	1 – 5 W	4 x 250 mW
Subs/Sector	> 200		< 200	< 100	< 50
RF - Tx/Rx	2x2 – 8x8		2x2 – 4x4	4x4	
PA Type	Discrete PAs			PA - IC	

Source: In-Stat, 5/2010

Wireless operators, have looked at compact base stations cautiously in the past, predominantly because, in the past, integrated single-box BTS products were still very heavy, bulky, and expensive, and quite limited in performance. On the other hand, operators have spent billions of dollars deploying hundreds of thousands of macro sites, and want to reap the benefits of those investments for as long as possible. Hence, both layers of deployment will co-exist for a long time—a macrocell overlay, based on existing cell sites, and the new micro and picocell underlays, consisting of compact BTSs deployed in new sites, with the task to provide much greater capacity density.

Figure 1. Macro Network with Compact BTS Overlay



Source: In-Stat, 5/2010

Compact base stations have the capacity of a micro cell, or in some cases, even a full macrocell, but with a small size that can be mounted on a streetlight, the side of a building, or in a small enclosure on or in a building. No rewiring is required because compact base stations typically can use existing and available power sources and no large enclosure needs to be built or maintained due to their very small footprint. While at first it may seem that they will be harder to service being on a light pole or the side of a building, this is typically not the case. The MTBF (mean time between failures) for power amplifiers used in remote radio heads, distributed antenna systems—and now also in compact base stations—is typically orders of magnitudes lower than the MTBF for the emerging class of base station SoCs. Therefore, adding the SoC to any given radio design, e.g. suitable for building or light pole deployments, doesn't significantly decrease the MTBF of the base station system. In fact, in many cases these SoCs will actually replace digital radio front-end components, e.g. FPGAs, effectively reducing the BOM count and thus increasing overall system HW reliability.

The Challenges for Compact Base Stations

While compact base stations offer many advantages to wireless operators, and wireless operators have no choice but to adopt them if they are going to provide subscribers with the capacity and data speeds which they seek, this isn't to say that compact base stations don't face challenges; they do.

For one, operators have worked with large infrastructure manufacturers, like Ericsson, Nokia-Siemens, Alcatel-Lucent, Huawei, and others, since back in the 2G days. When 3G was deployed, most operators used the same vendors they had for 2G, and when 4G is deployed, it's likely the same will be true, but the problem has been that the large infrastructure manufacturers have been slow to embrace the compact base station concept, largely because they fear it could cannibalize its other, very profitable, product lines. While most tier-one infrastructure manufacturers have, in fact, started to develop compact base stations (especially for LTE), 2nd and 3rd tier infrastructure manufacturers and startups, like Purewave, and Alvarion, are much further along and many of these companies are trialing or already selling such products. Ultimately, it will be the wireless operators themselves that will drive demand for the compact base station class of products, as it ultimately will be the least expensive and quickest way for them to get fast data rates and high-capacity solutions to their customers.

The second challenge in getting compact base stations deployed is that operators are just now rolling out their 4G networks or starting to plan them, and while they want to provide high data rates and a lot of capacity, their real priority is about coverage before all else and wide coverage requires cell towers. Still some operators, like many that have deployed WiMAX, have taken a combination stance, deploying both large cells on towers for coverage and smaller cells in densely populated areas. For Clearwire, for example, this has slowed their rate of deployment some, but deploying a more complete network gives early adopters and the press a better chance to evaluate a network that not everyone may be familiar with. If the early press and word-of-mouth advertising an early network receives is not positive because data rates are slow, others may be less apt to subscribe to the service. We can't forget the negative publicity that AT&T Wireless experienced when their network wasn't fully up to the task of supporting millions of high-profile and vocal iPhone users. AT&T has spent billions of dollars since to upgrade its network to the point where it's very solid today, but negative press can take a long time to dissipate.

The final obstacle for operators wanting to deploy compact base stations is that these base stations are just starting to appear. While WiMAX versions have existed for a short time, most LTE versions, or products supporting multiple technologies, such as WCDMA & LTE, or TD-LTE and WiMAX, are still in development. However, with the silicon products on the way from companies like MindSpeed and DesignArt Networks, In-Stat believes it will only be a matter of time before a wide variety of products start hitting the market.

Compact Base Station Forecasts

There are two types of markets that compact base stations will occupy; First, because they are cheaper and potentially much smaller than the infrastructure that has existed in the past, many of the early compact base stations have replaced, and will continue to replace, older existing models of base stations in the traditional markets where base stations are currently used. Second, compact base stations will occupy new markets for wireless operators that haven't previously existed because traditional base stations were either too expensive, too large, or both.

Table 4. Worldwide Compact BTS—Traditional Markets, 2010–2015 (Units)

Traditional Segments	2010	2011	2012	2013	2014	2015	CAGR
Compact MacroBTS	524	3,049	9,843	22,957	44,265	77,132	171.4%
y/y growth		481.7%	222.8%	133.2%	92.8%	74.3%	
Compact MicroBTS	849	8,008	32,814	105,248	275,024	629,939	275.0%
y/y growth		843.3%	309.8%	220.7%	161.3%	129.0%	
Distributed Compact BTS - RRH	156,218	211,979	279,946	364,238	374,753	318,334	15.3%
y/y growth		35.7%	32.1%	30.1%	2.9%	-15.1%	
Compact Indoor Pico	3,300	7,500	12,900	23,200	43,560	78,350	88.4%
y/y growth		127.3%	72.0%	79.8%	87.8%	79.9%	
Total Traditional Compact	**160,891**	**230,537**	**335,504**	**515,643**	**737,602**	**1,103,755**	**47.0%**
y/y growth		43.3%	45.5%	53.7%	43.0%	49.6%	

Source: In-Stat, 5/2010

Table 4, above, contains the forecast for compact base stations used in traditional base station segments for 3G, WiMAX, and LTE. These segments are the route that 3G and 4G infrastructures have been, and will continue to be, deployed by most operators, with the difference being that instead of an operator deploying large macro and micro base stations, the operator can instead deploy a single-box compact base station in its place.

Table 5. Worldwide Compact BTS—New Markets, 2010–2015 (Units)

Metrozone Segments	2010	2011	2012	2013	2014	2015	CAGR
Metropolitan PicoBTS	7,400	137,812	411,185	1,536,166	2,995,346	4,792,553	265.0%
y/y growth		1762.3%	198.4%	273.6%	95.0%	60.0%	
Rural/WISP Coverage	78,707	89,201	101,883	115,659	138,553	159,336	15.1%
y/y growth		13.3%	14.2%	13.5%	19.8%	15.0%	
Total Compact Metrozone	**86,107**	**227,013**	**513,068**	**1,651,825**	**3,133,898**	**4,951,889**	**124.9%**
y/y growth		163.6%	126.0%	222.0%	89.7%	58.0%	

Source: In-Stat, 5/2010

Table 5, above, contains forecasts for compact base stations used in new applications that will be enabled by the new paradigm shift, which compact base stations enable. Included in this forecast are forecasts for 3G, WiMAX, and LTE compact base stations, but for the vast majority of applications that these base stations will enable, the technology used by these base stations will be either WiMAX or LTE.

The Metropolitan PicoBTS category represents those compact base stations that will be used for capacity fill-in and, overall, will represent roughly 79% of all compact base station deployments in 2015.

Most operators with existing 3G infrastructures will initially deploy 4G technology (WiMAX and LTE) using conventional macro or micro stations at their existing 3G sites first, providing a quick way to provide 4G coverage. Then, as the number of subscribers escalates, along with their data usage needs, operators will use compact base stations for a metropolitan overlay to provide the capacity and higher data rates required in these situations.

Yet another new market for compact base stations will be brought about by Greenfield deployments in developing countries and operators in rural areas. These wireless operators will benefit from the low-cost and small size that compact base stations offer, providing wireless broadband coverage to areas previously without any coverage. These operators will use compact base stations, with wireless backhaul, to quickly deploy coverage to large areas at a low cost, typically for fixed-wireless applications, which would not have been possible before because of the high cost and large size of previous infrastructures. Areas in countries, such as India, Africa, and China, will be the largest beneficiaries of this technology, allowing the people in these areas to join the broadband revolution for the first time—based on wireless infrastructure. Systems of this type will also be deployed in more developed regions of the world, such as in the US, but in remote rural areas not yet served by other wireless systems.

Table 6. Worldwide Compact BTS—All Markets, 2010–2015 (Units)

Total Compact BTS	2010	2011	2012	2013	2014	2015	CAGR
Total Compact	**246,999**	**457,550**	**848,571**	**2,167,468**	**3,871,500**	**6,055,644**	**89.6%**
y/y growth		85.2%	85.5%	155.4%	78.6%	56.4%	

Source: In-Stat, 5/2010

Table 6, above, contains the total In-Stat forecast for compact base stations used for 3G, WiMAX, and LTE. As this forecast shows, In-Stat feels that the market for compact base stations will be very bright, and the reasons are clear; compact base stations are inexpensive, when compared to most existing infrastructure solutions, and they are the only way in which wireless operators will be able to provide the capacity and speed which subscribers require, at a cost that operators can afford. Conventional macrocells are great for providing wide-area coverage, and they will remain very viable for 4G, but smaller cells will be required for populated areas that have higher capacity needs. In addition, compact base stations will make it economically feasible to provide wireless broadband coverage to rural and remote areas, where it hasn't previously been feasible.

Overall, from 2010 to 2015, In-Stat forecasts that the number of compact base stations will grow at a compound annual growth rate of over 89%. While this rate may seem high for an infrastructure product, early rollouts of WiMAX by Greenfield operators have proven how fast compact base stations can be adopted by operators where reduced cost and ease of deployment are important criteria.

Company Profiles

AirWalk Communications

Located in Richardson, TX, AirWalk Communications manufactures home femtocells, but the company also makes larger microcell base stations supporting CDMA2000 1xEV-DO Rev. A and CDMA2000 1xRTT products.

Alvarion

Alvarion is a leading WiMAX equipment manufacturer located in Sunnyvale, CA that also has offices in Africa, Brazil, Italy, Japan, Spain, the United Kingdom, and a few additional locations. Its wide geographical orientation mirrors its wide range of products, covering all aspects of WiMAX infrastructure. Alvarion's BreezeMAX line of base stations would fit into the compact base station class, with their BreezeMAX Macro Outdoor base station being their carrier-class WiMAX 802.16e outdoor offering.

DesignArt Networks

Located in Israel, DesignArt Networks is a fabless semiconductor manufacturer focused on the compact base station market. The company's SoCs are not only powerful enough to create a multi-sector micro base station with a single chip, but in doing so, they have enough processing power left for fully integrated wireless backhaul support using the same chip. The recently announced DAN3000 SoC platform supports concurrent operation of 2G, 3G, and 4G services, including HSPA, WiMAX, and LTE Advanced. The DAN3000 is scheduled to sample to customers Q3 of 2010.

ip.access

Located in Cambourne, Cambridge, in the United Kingdom, ip.access manufacturers home femtocells, as well as operator-installed picocells. For the most part, these picocells are used indoors by operators for difficult reception problems, such as retail stores, underground facilities, high-rise buildings, business parks, and shopping malls. Currently, ip.access manufactures GSM and WCDMA/HSPA picocells.

Mindspeed

Mindspeed is a fabless semiconductor manufacturer located in the US. The company is involved in several types of product areas, including baseband processors used in compact base station products. The company's latest product, the 750MHz Transcede 4020, supports multiple technologies, including WCDMA, LTE, TD-SCDMA, and WiMAX 802.16d/e/m.

Percello

Percello is a fabless semiconductor company, located in Israel that has been targeting the femtocell space. While the company continues to stay focused on the femtocell space, it is also working on developing two future chips for larger LTE base stations that potentially can be used in public spaces. The PRC7000 supports two transmit and two receive antennas and can support dozens of simultaneous users up to UE category 4. The PRC9000 is a dual-mode (UMTS/HSPA + LTE) SoC chip incorporating much of the same characteristics as the PRC7000, but adds 5.76 Mbps HSUPA support for up to UE category 6, and 21.6Mbps HSDPA support for up to UE category 14. While both the PRC7000 and PRC9000 are much more powerful than current femtocells, they would only produce a low-end type, single-chip compact base station product.

PicoChip

PicoChip is a fabless semiconductor manufacturer located in the United Kingdom. PicoChip has been predominately involved in the femtocell space, but recently is has been working on creating products that can support 32 or more simultaneous users, and the company continues to add power to its chips.

Purewave

Purewave, located in Mountain View, California, is a privately held company that sells compact, outdoor base stations of the type discussed in this report. The company currently only sells WiMAX base stations, but, in the future, it plans to support other technologies as well, such as LTE. The Quantum 6000 is representative of these types of base stations. The 6000 supports up to 6 transmit and 6 receive antennas, and supports both 5MHz and 10MHz channel size over 802.16e.

Summary

As wireless operators move from deploying 2G systems to 3G and 4G systems, the ideal type of infrastructure for each system has changed and evolved. While 2G, voice-centric infrastructures called for macrocells with cellular towers, 3G systems used these macrocells, as well as supplemented them with distributed antenna systems, remote radio head systems, and picocell base stations. With 4G, wireless operators are again going to be forced to rethink how they deploy infrastructure, and for these networks, smaller cells with more powerful base stations are what fit the bill.

Existing rack-type macro or micro base stations could be used for the smaller cells that 4G requires, but this would be extremely costly, and besides, just finding the space and having the ability to rent the land for these larger base stations is really unrealistic. Instead, a new category of base stations will be used—compact base stations. Based on highly integrated SoC solutions, this type of base stations has only existed for a short time because it required advanced silicon-level integration, multi-core SoC design, and the use of very powerful, targeted processor cores, all of which have only been available in a single package for a very short time. Still, more and more solutions are appearing, to the point where In-Stat feels that the compact base station segment will become a significant element in the deployment of the emerging 4G infrastructure.

In addition to providing metropolitan high data rates and coverage, compact base stations, being much less expensive and requiring very little real estate, will displace the use of larger, more costly, older infrastructure in many new installations. Compact base stations will enable wireless operators to deploy networks in emerging economies and rural areas for fixed-wireless and mobile offerings where, previously, the cost of building broadband infrastructure would have been prohibitive. In this case, compact base stations will open up entire new markets, which were impossible to target in the past.

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