Cambridge Industries Group (CIG)

White Paper for Small Cell Solution Overview

V0.2

1. Small Cell Application Overview

The growth of smartphones has multiplied mobile data consumption, and capacity has become an issue of key importance. Because of congestion in the network, with both dropped data and voice sessions, users' experiences are degraded. Purchasing additional spectrum, which is a finite resource, is impractical for cost and timing reasons. One of the most efficient ways to improve capacity within a network is to reduce the cell size radius, and place the cell sites closer to each other, resulting in a more densely packed network of smaller cells. Microcells, picocells, and femtocells are each a subset of small cells. There are economic advantages, as well as network advantages to deploying small cells.

Macrocells are the original, wide area high power base stations which cover areas up to about 20 miles radius (more in specific situation). In urban areas, a separate layer of microcells is installed to provide the capacity and in-building penetration needed, taking the load off the macro cellular network. For office buildings and shopping malls with extremely high demand, even smaller cell sites are used. All three types of cell operate in a very similar way, and are actively managed and configured by the mobile network operator. Each cell is configured with neighbor lists, so that mobile phones can switch over to an appropriate nearby cell and continue their conversation without interruption.

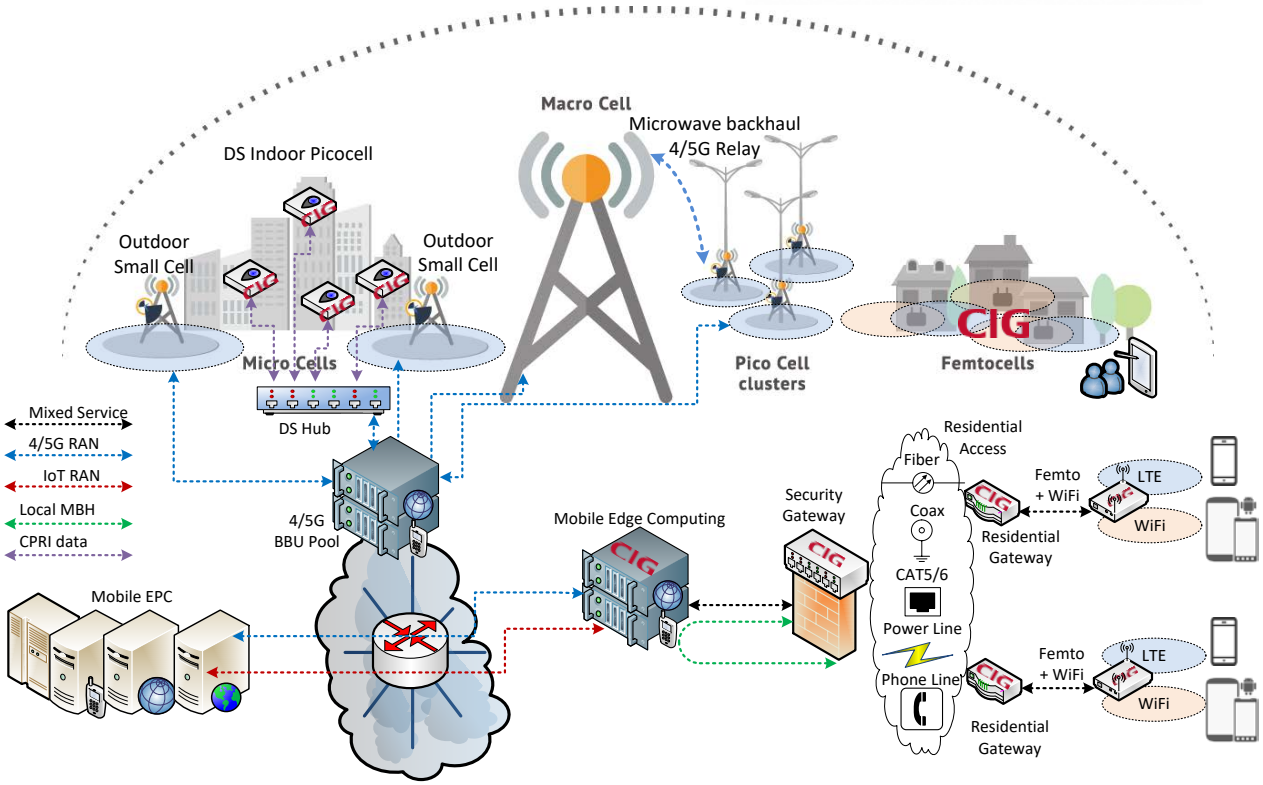
A picocell is a small cellular base station typically covering a small area, such as in-building (offices, shopping malls, train stations, stock exchanges, etc.), or more recently in-aircraft. In cellular networks, picocells are typically used to extend coverage to indoor areas where outdoor signals do not reach well, or to add network capacity in areas with very dense phone usage, such as train stations or stadiums. Picocells provide coverage and capacity in areas difficult or expensive to reach using the more traditional macrocell approach. Picocells are normally installed and maintained directly by the network operator, who would pay for site rental, power and fixed network connections back their switching center.

A femtocell is a small, low-power cellular base station, typically designed for use in a home or small business. A broader term which is more widespread in the industry is small cell, with femtocell as a subset. It connects to the service provider’s network via broadband (such as DSL or cable); current designs typically support 16 active mobile users in a residential setting. A femtocell allows service providers to extend service coverage indoors or at the cell edge, especially where access would otherwise be limited or unavailable. CIG SC-100 family Femto is addressing this market.

Femtocells differ from picocells because they are intended to be much more autonomous. They are self-installed by the end user in their home or office, primarily for their own benefit. Femtocells automatically determine which frequency and power levels to operate at, rather than being directed from a centrally determined master plan. This allows the network to adapt automatically as new femtocells are added or moved without the need for a complete frequency re-plan.

Aspect	Pico cell	Femtocell
Installation	Operator	Customer
Transmission to operator's network	Operator	Customer
Frequency/radio parameters	Centrally planned	Locally determined
Site rental	Operator	Customer

Typically the range of a standard base station may be up to 32 kilometres, a microcell is less than two kilometers wide, a picocell is 200 meters or less, and a femtocell is in the order of 10 meters.



2. Integration of WiFi

Under pressure from more users, more devices and more applications, mobile networks have to transport higher traffic loads. The increase in traffic load will continue over the coming years and is profoundly changing how mobile operators plan, deploy and operate mobile networks, and charge for access.

Mobile operators are integrating Wi-Fi within their core network and can manage cellular and Wi-Fi traffic effectively using the same tools to support the same services on both interfaces. We envision a deployment model in which locations with the higher traffic levels (e.g., dense metro areas, stadiums, airports) benefit from small cells with Wi-Fi, but in which small cells with a lower traffic load (e.g., in suburban areas) and a wider range may not warrant the addition of Wi-Fi. Similarly, in residential and most enterprise locations, i.e. the major application of SC101, Wi-Fi offload will necessarily remain a complementary tool and play a huge role because it has a low cost-per-bit and sufficient spectrum to support high throughput rates to subscribers as WiFi uses license-exempt spectrum.

Actually, CIG SC-100 family is more suitable for the solution known as LTE + Wi-Fi Link Aggregation (LWA). With LWA, the LTE data payload is split and some traffic is tunneled over Wi-Fi and the rest is sent natively over LTE. This can greatly enhance the performance of an LTE service. With LWA, Wi-Fi runs in the unlicensed bands and LTE runs in the licensed bands, and the two radio technologies are combined to offer a compelling user experience. Both technologies are allowed to do what they do best, and LTE no longer needs to perform any unnatural acts.

Unlike the deployment of LTE in unlicensed spectrum, which requires all new network hardware and all new smartphones, LWA could be enabled with a straightforward software upgrade allowing smartphones to power-up both radios and split the data plane traffic so some LTE traffic is tunneled over Wi-Fi and the rest runs natively over LTE. The traffic that flows over Wi-Fi is collected at the Wi-Fi access point and then tunneled back to the LTE small cell, which effectively anchors the session. The flows are combined at the LTE small cell and then sent on to the evolved packet core (EPC) and from there to the Internet.

The big advantage of this approach is that all Wi-Fi traffic can benefit from the services provided by the

mobile operator's EPC. These services include billing, deep packet inspection, lawful intercept, policy, authentication and the list goes on. If the LTE signal is lost, this service will drop and the user can reinitiate an Internet connection over Wi-Fi. This approach is somewhat similar to multi-link or multi-path TCP, except that the traffic is combined in the cellular RAN rather than back in the Internet.

3. CIG Femto Product Overview

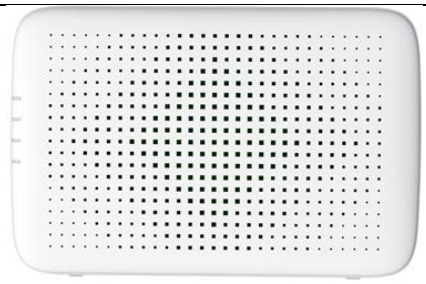
This following table specifies the hardware features and requirements for CMCC Band 40 Indoor TDD LTE Femto WiFi cell.

Model	Enclosure	Features

SC-101	To be updated 	o Chipset: FSM9016(Baseband)+ FTR8930(RFIC)+ AR9287(802.11n)
		o Band 40 TDD LTE (2320~2370MHz)
		o DL 150/UL75 Mbps @ 20MHz
		o 16 users, 8 users/TTI (4 DL + 4 UL)
		o 802.11n 2.4G 2x2 WiFi
		o 802.11ac 5G 2x2 WiFi (Reserved)
		o 5x Integrated antennas
		  o 2 for Band 40 LTE
		  o 2 for 2.4G WiFi
		  o 1 for Network Listen (HB,MB&LB)
		o Network listen for synchronization and interference management
		  o Band 3: 1805~1880MHz
		  o Band 8: 925~960MHz
		  o Band 38: 2570~2620MHz
		  o Band 39: 1880~1920MHz
		  o Band 40: 2320~2370MHz
		o 1x GPS interface (MCX connector) 5V@20ma
		o 1 x GE uplink + 2xGE LAN
		o 1 x 12V DC power input;
		o 1 x Reset button
		o 1x USIM interface (reserved)
		o 9x LEDs for visual indicators (PWR, Internet, Service, WAN, LAN1, LAN2, LTE User, WiFi, GPS)
		o Support both desktop and wall mount

The following table specifies the hardware features and requirements for CIG Indoor FDD/TDD LTE Femto cell.

Model	Enclosure	Features

SC-100	 	o Chipset: FSM9016(Baseband)+ FTR8930(RFIC)
		o Versatile design for different band options
		  o Band 7 FDD LTE
		  o Band 3 FDD LTE
		  o Band 40 TDD LTE
		  o Band 41 FDD LTE
		  o HW ready for Band 1,2,4,9,10 FDD LTE
		o DL 150/UL75 Mbps @ 20MHz
		o 16 users, 8 users/TTI (4 DL + 4 UL)
		o 3x Integrated antennas
		  o 2 for Bandx LTE
		  o 1 for Network Listen
		o Network listen for synchronization and interference management
		  o Band 1: 2110~2170MHz
		  o Band 3: 1805~1880MHz
		  o Band 7: 2620~2690MHz
		  o Band 8: 925~960MHz
		  o Band 20: 791~821MHz
		o 1 x GE uplink
		o 1x GPS interface (SMA connector) 5V@20ma
		o 1 x 12V DC power input;
		o 1 x Reset button
		o 4x LEDs for visual indicators (PWR, Internet, Service, LTE User)
		o Anti-tamper protection
		o Support both desktop and wall mount
		o White and Black enclosure for different customers

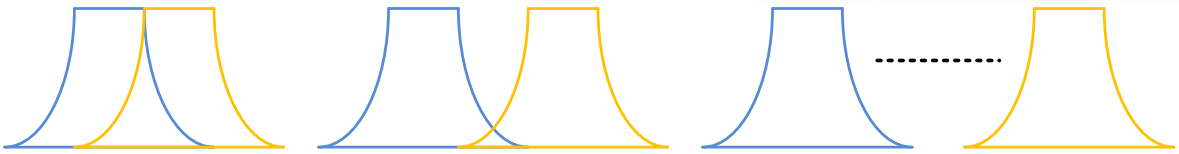
4. Carrier Aggregation (CA) and Multiple Bands

Carrier aggregation offers successively higher peak data rates as well as better broadband experience across the coverage area. The data rates scale with the amount of spectrum allowing 3GPP Rel 10 to support up to 5 carriers with up to 100 MHz of spectrum . Qualcomm SC commercial solutions can support up to 2 carriers with peak data rates up to 300 Mbps (Cat 6). Qualcomm mobile commercial solutions can support up to 3 carriers with peak data rates up to 450 Mbps (Cat 5).

Increased data rates of carrier aggregation can be traded off to get higher capacity for bursty applications, such as web browsing, streaming, social media apps and others, meaning operators can choose a higher capacity for the same user experience, better user experience for the same capacity, or both.

Two Carrier aggregations have been requested by several customers (incl. CMCC) @ Tx Power 21~27 dBm per carrier. Three types of down link carrier aggregation types are shown as following (only 20MHz BW is discussed here)

- Contiguous CA: two carriers are located at the adjacent channel
- Non Contiguous CA: two carriers are located with some guard channel (only 1 channel and 2 channel guard band is discussed here)
- Inter band Non Contiguous CA: two carriers are located in different band (refer to more than 2 channels guard band for convenience of discussion)



Contiguous CA Non Contiguous CA Inter-band Non Contiguous CA

There are also 2 different antenna options for CA implementation:

- Different carrier use separate antenna (aka. 4T4R) vs. Different carrier use same antenna (aka. 2T2R)

In SC-2xx family provides a competitive solution for the 2T2R solution with support of contiguous and non-contiguous CA.

5. Picocell Product Overview

The following table specifies the hardware features and requirements for CMCC Band40 indoor TDD LTE Picocell.

Model	Enclosure	Features
SC-200		o Chipset: FSM9955(Baseband)+ FTR8900(RFIC)2x for dual cell o Band 40 TDD LTE (2320~2370MHz) o Cat 6 (DL 150/UL75 Mbps) @ 20MHz; o 128 users, 32 users/TTI (16 DL + 16 UL) o Either 2x integrated B40 LTE Omni antenna or 2x SMA external antenna interface o 1 for Network Listen (HB,MB&LB) o Network listen for synchronization and interference management o Band 3: 1805~1880MHz o Band 8: 925~960MHz o Band 34: 2010~2025MHz o Band 38: 2570~2620MHz o Band 39: 1880~1920MHz o Band 40: 2320~2370MHz o 1x GPS interface (MCX connector) 5V@20ma for cable loss o 1 x GE uplink (RJ45/SFP) with PoE power supplier o 1 x GE port for local traffic o 48V auxiliary DC input o 1 x Reset button o 7x LEDs for visual indicators (PWR, Internet, Service, WAN, LAN,LTE User, GPS) o 1x USIM interface o IP30 water resistance o Support both ceiling and wall mount

6. CBRS band application

On April 17 2015, a new Citizens Broadband Radio Service for shared wireless broadband use of the 3550-3700 MHz band (3.5 GHz Band) is established. Rules governing the Citizens Broadband Radio Service are found in Part 96 of the Commission's rules.

The key points of Citizens Broadband Radio Service is summarized in following sections. Firstly, what is the

CBRS Band? The Citizen's Broadband Radio Service will encompass the band of spectrum from 3550 MHz to 3700 MHz. To date, only the 3650-3700 MHz portion of the band has been accessible to non-federal operators using a non-exclusive licensing process, leading to what has been commonly referred to as a "lite" or "quasi" license for the 3.65 GHz band. (This licensing process requires cooperation between operators in the same area to avoid interference issues).

The new CBRS band will open up an additional 150 MHz of spectrum, employing a 3-tier access/licensing model. A groundbreaking Spectrum Allocation System (SAS) will be used to improve availability of the spectrum for all users.

Three different Access Tiers

Incumbent Access - This highest tier is intended to protect and yield highest priority to incumbent Federal users (military ground stations, government, etc...) that have and continue to occupy portions of the band. Incumbent Access users will be protected from PAL and GAA users by the SAS.

Priority Access Licenses (PAL) - Up to 7 of these 10 MHz spectrum blocks per census tract will be awarded to the highest bidders. If there is no competition, then the prices will be very low. PAL users will be protected from GAA users by the SAS.

General Authorized Access (GAA) - Opportunistic spectrum usage. "License by Rule" (no license required as long as the rules are being followed). Unprotected from higher tiers.

7. Outdoor Picocell Product Overview

The following table specifies the hardware features and requirements for Band42/43 outdoor TDD LTE Picocell.

Model	Enclosure	Features
SC-200		• Chipset: FSM9955(Baseband)+ FTR8950(RFIC) →2x for carrier aggregation • CBRS focus (3550~3700MHz) • Band 42 TDD LTE (3400~3600MHz) • Band 43 TDD LTE (3600~3800MHz) • Cat 6 (DL 150/UL75 Mbps) @ 20MHz; • Carrier aggregation (DL 300/UL150 Mbps) • 128 users, 32 users/TTI (16 DL + 16 UL) • 2x external LTE antennas • Omni antenna: horizontal beamwidth of 360°. • 1x GPS interface (N-type connector) 5V@20ma for cable loss • Network listen for synchronization and interference management • Band 42: 3400~3600MHz • Band 43: 3600~3800MHz • 1 x GE uplink with PoE power supplier • Support of 802.3at and PoE++ • 1 x GE port for local management • 1 x Reset button • 5x LEDs for visual indicators • (PWR, Internet, Service, LTE User, GPS) • Support both pole and wall mount • IP67 water resistance • Product Operating Temperature Rage: -40°C ~ +55°C