8/17/2010

HARISHVADADA.WORDPRESS.COM

LTE & WiMAX Blog

Femtocells meet the Enterprise | hvadada

Femtocells have always intrigued me, why don't we have more of them? They provide indoor coverage to customers like me, and many advantages to the operator. So why are operators not giving them out for free with a DSL connection like Softbank in Japan? This is the 'new' paradigm for indoor coverage, last frontier not conquered by the wireless providers. In the US we have so much fiber underground that most operators can run fiber-to-home (FTH) and put up a Pico cell, albeit the Capex costs. I would think the only thing that is preventing the deluge of femtocells is the pricing, operator initiative and certain other factors like Interference mitigation, etc. Let us explore what they are, how they can be overcome and a balance between performance and efficiency.

Every RF engineer worth his salt has tried indoor solutions like repeaters, DAS systems and other indoor solutions and never got the optimal results. This has always been my pet peeve in the past, until Pico and Femtocells started to be the preferred solution for indoor coverage solutions. My first experience was with 2G Pico cells with Ethernet as the Abis, which was a 'new' thing at that time. With the advent of 4G all interfaces are IP and the transport is either IP-MPLS or PBB-TE, with IP addresses assigned to CPE's*. Femtocells now have a secondary purpose - offload traffic from the Macro cells in the network and help in de-congestion at Urban and dense Urban areas. With LTE and Self Organizing networks (SON), it can be used for self-configuration and self-optimization for the interference mitigation. According to recent studies 50 percent of phone calls and 70 percent of data services will take place indoors in the next years. Therefore, indoor coverage providing high data rates and quality of service (QoS) will soon be the gloating point for any network, capacity and not coverage will be king!

Challenges for FemtoCells

Femtocells will face several issues that still need to be addressed in order to guarantee interoperability with existing macrocells, including management and security. These are analyzed in the following.

Access Methods:
Femtocells can be configured in three ways to allow or restrict their usage by certain users -

Open access: All users are allowed to connect.
It has been shown that open access improves the overall capacity of the network, mainly because macrocell users can connect to nearby femtocells in locations where the macrocell coverage is deficient. From an interference viewpoint, this avoids femtocells behaving as interferers since outdoor users can

also connect to indoor femtocells. As a drawback, open access will increase the number of handoffs and signaling. Furthermore, with this type of access, security issues apply. Moreover, recent customer surveys shows that open access is commercially challenging for operators. This is because femtocells are paid for by subscribers, who are not keen to accept nonsubscribers as users of their own femtocells unless they obtain some kind of benefit/revenue.

Closed access: The femtocell allows only subscribed users to establish connections.
Closed access femtocells are thus more likely to be deployed in the home environment. However, this implies that power leaks through windows and doors will be sensed as interference by passing macrocell users, thus decreasing their signal quality. As will be shown, algorithms for the allocation of OFDMA subchannels can help to solve this problem.

Hybrid access: Nonsubscribers use only a limited amount of the femtocell resources.
Hybrid approaches allow the connectivity of nonsubscribers while restricting the amount of OFDMA subchannels that can be shared. In this way, most of the interference problems of closed access are eliminated while controlling the impact on the femtocell owner.

Time Synchronization:

Since femtocells are deployed by users, there is no centralized management of their radio resources. However, network time synchronization is necessary between macrocells and femtocells in order to minimize multi-access interference, as well as for the proper performance of handoffs. Without timing, transmission instants would vary between different cells. This could lead to the uplink period of some cells overlapping with the downlink of others, thus increasing intercell interference in the network. Since FAPs are aimed at the consumer electronics market, they are intended to attain low prices. The manufacture of low-cost femtocells equipped with high precision oscillators is not trivial, so other approaches need to be considered in order to achieve reliable time synchronization. The use of GPS receivers, which provide accurate timing over satellite links, has been proposed as a possible solution. However, their performance depends on the availability of GPS coverage inside user premises. Another solution is the use of the IEEE-1588 Precision Timing Protocol as a feasible method to achieve synchronization [6]. However, some modifications are necessary in order for it to perform efficiently over asymmetric backhaul links such as ADSL.

Physical Cell Identity:

Physical cell identity (PCI) is normally used to identify a cell for radio purposes; for example, camping/handoff procedures are simplified by explicitly providing the list of PCIs that mobile terminals have to monitor. Note that this list is usually known as the neighboring cell list (see below). The PCI of a cell does not need to be unique across the entire network; however, it must be unique on a local scale to avoid confusion with neighboring cells. This represents a challenge in femtocell networks, since they must select their PCIs dynamically after booting or changing their position in order to avoid collision with other macro/femtocells. Furthermore, in extensive femtocell deployments and due to the limited number of PCIs (e.g., 504 in LTE), the reuse of PCIs among femtocells in a given area may be unavoidable, thus causing PCI confusion.

Neighbor Cell List

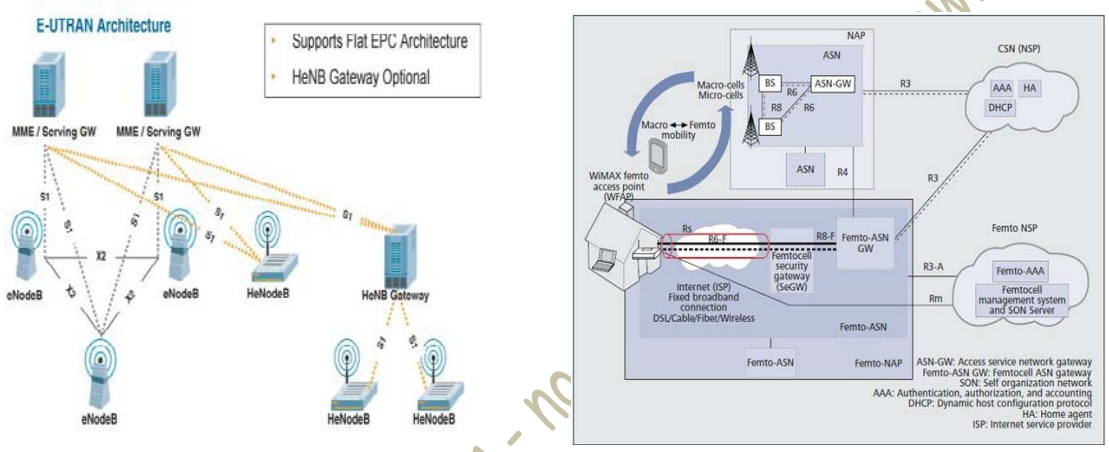
Since femtocells can be switched on/off or moved at any time, their neighbors vary often. Femtocells must thus be able to set up their neighboring cell list in a dynamic manner. Due to this, the relationships between femtocells must be handled differently than those between macro and femtocells. In addition, it is expected that the number of neighboring femtocells within a macrocell will grow beyond the 32 that

are currently considered in macrocells. Therefore, new techniques must be developed to allow macro and femtocells to support a larger number of neighboring cells and handle them rapidly.

Mobility Management

In macrocell networks, cell handoffs are triggered when users enter the coverage area of other cells. However, given the coverage size of open/hybrid access femtocells, this occurs more often than in the macrocell case, hence increasing network signaling. Different handoff management procedures are thus needed to allow nonsubscribers to camp for longer periods on nearby femtocells. Furthermore, a hierarchical cell structure (HCS) can also be used to distinguish between macro- and femtocells. In this way, the signaling across layers can be minimized as well as the neighboring cell list that users scan when performing a handoff.

Femto Architectures – 4G



LTE and WIMAX Femtocells

3GPP and WiMAX forum both have specified standards for Femtocells, and are looking forward for an aggressive push from operators for deployment of Femtocells. 3GPP Rel.9 has some extra functionality for Femtocells to support more efficiently HeNBs operation and to provide a better user experience. The key functionality added the Radio Access Network for HeNBs in Release 9 are:

- A novel Hybrid Cell concept
- Management of out-of-date CSG (Closed Subscriber Group) info
- Inbound Mobility (including proximity reports)
- Access Control
- Operation, Administration and Maintenance for HeNB
- Operator controlled CSG list
- RF Requirements for TDD and FDD.

WiMAX Femtocell has capabilities of a WiMAX macro-cell, other required features of a WiMAX Femtocell are the following:

- Spectrum: WFAP operates over licensed spectrum using standard WiMAX wireless air interface and protocol.

- Transport: WFAP uses transport network of subscribers' DSL, FTTH or cable-based broadband connection.
- Local Breakout: A WFAP should optionally support the capability to route incoming or outgoing traffic directly to the destination through the Internet Service Provider (ISP) network. This approach will bypass the WiMAX service provider network, thus offloading WiMAX service provider network and reducing the cost of service to the subscriber.
- Hand-over: A Femtocell solution should allow handovers between WFAP and WiMAX macro cells or with other adjacent WFAPs.
- Security: A Femtocell solution should use a secure channel of communication (for both control plane and data plane) with ASN Gateways in the core network. The core network must authenticate and authorize a WFAP before it starts offering services to MS/SS in its coverage area. A WFAP may authenticate the ASN Gateway with which it gets connected. A WFAP should keep its air interface disabled unless it is authenticated and authorized to start communication with the ASN Gateway in the core network. A Femtocell may support close subscriber group (CSG) database i.e. a list of subscribers allowed to access the WFAP, and its management.
- Network Synchronization: A WFAP should support mechanism to synchronize with external network to provide services that require strict air interface co-ordination. Some of the services are soft-handovers, support for idle mode paging, and multicast-broadcast (MCBCS) services.
- Quality of Service: A WFAP should support marking of incoming/outgoing packets with appropriate DSCP code, as configured by a service provider. This would allow support for defined service level agreements (SLAs) when the service is delivered through a WFAP.
- Manageability: A WFAP should implement DSL forum's defined TR069 protocol to allow an operator to remotely manage a WAFP. It must allow an operator to remotely disable/enable the air interface service.

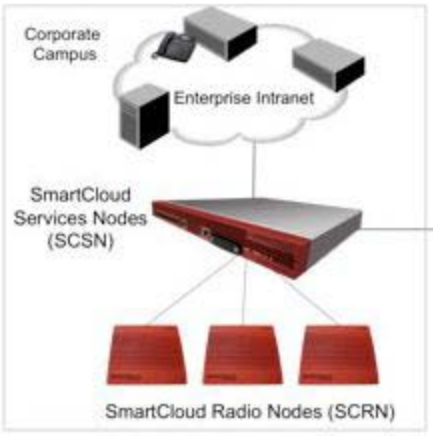
4G femtocells will take the lessons learnt from 2G and 3G solutions and take it to the next level by supporting Multi-RAT and Cognitive Radio functions.

Enterprise Wireless RAN – Spider Cloud

This will be a game-changer for operators looking to offer enterprise solutions to corporate customers – a RAT (Radio access Technology) agnostic offering that can customized for any set of cellular bands and technology. A company called Spider Cloud is offering this customized solution, with a multi-radio architecture that allows for a flexible upgrade path to higher user counts as well as the ability to support different radio access technology combinations on a single node. Though this idea might not be new in the Wi-Fi world but this will be a niche solution for indoor penetration inside Malls, Casinos and multi-storied office buildings who are corporate customers for any operator. The CAPEX/OPEX would be higher than a normal Femtocell but would benefit corporate customers in terms of coverage and security (VPN, Firewalls, etc)

They call this solution E-RAN (enterprise RAN) and consists of two nodes.

⇒ SmartCloud Services Node (SCSN)
⇒ SmartCloud Radio Node (SCRN)

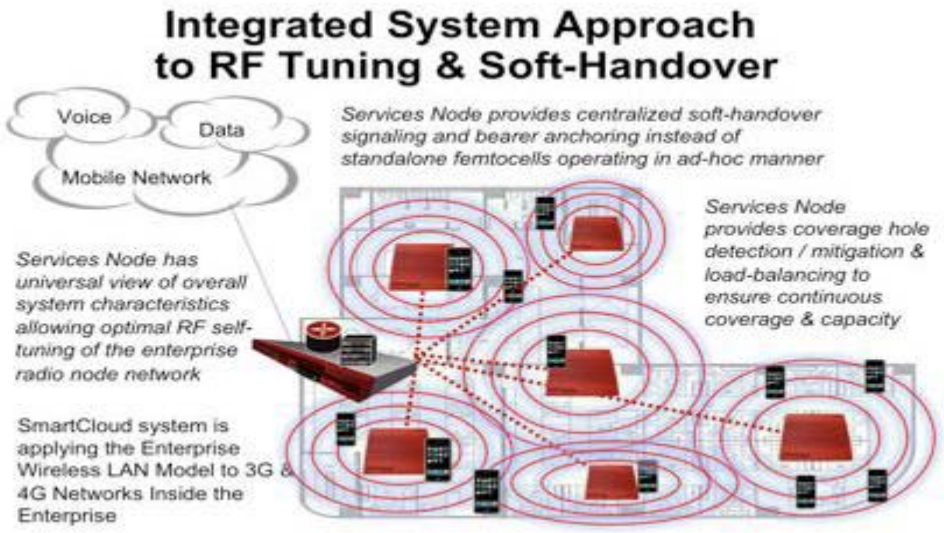


The SCSN is the central control point of the overall cluster of SmartCloud Radio Nodes (SCRN) deployed throughout the enterprise. The SCSN is a gateway appliance deployed directly inside the enterprise LAN that provides overall traffic aggregation and session management for all mobile sessions delivered through the SCRN radio nodes. In this context, the SCSN is analogous to the Enterprise Wi-Fi Switch where all radio node management functions are provided through a central control point.

The SCRN is a purpose-built small radius, high user capacity radio node. It has been custom developed by SpiderCloud Wireless through precision re-engineering of physical layer and media access control (PHY/MAC) characteristics in order to support increased user counts via a single node.

Unlike traditional small cell radio nodes, the SCRN supports a multi-radio architecture that allows for a flexible upgrade path to higher user counts as well as the ability to support different radio access technology combinations on a single node. This design allows the SCRN to provide access layer support in the delivery of universal wireless session management capabilities of the E-RAN solution.

RF Tuning and Mobility Features



SOURCE: http://www.spidercloud.com

RF management functions such as auto-configuration and self-tuning are executed centrally instead of in a peer-to-peer ad hoc manner. The SCSN is in a unique position to have universal knowledge of the RF propagation characteristics of the overall cluster of SCRN radio nodes deployed throughout the entire corporate campus. As a result, it can make dynamic RF tuning and optimization decisions based on the performance characteristics of the overall system.

Similarly, mobility management functions such as inter-radio node Soft-Handover are finally made possible through the E-RAN centralized Services Node architecture. Unlike existing indoor solutions, the E-RAN system has been designed to support Soft-Handover from the start. With E-RAN, the SCSN provides central management and coordination of each Soft-Handover mobility event between radio nodes. Through such centralized architecture, Soft-Handover events are most efficiently controlled, optimized, and anchored by the SCSN.

Conclusion

Wireless ecosystem has seen the most evolution in the last few years, and femtocells have made inroads into the home and the enterprise in different ways. Wi-Fi bubbles have been around the last 7-8 years in the enterprise and homes, with various enhancements to be able to do many functions among which are offloading the Macro network of data traffic, mesh networking to create backhauling of other RAT traffic, Voice-over-Wi-Fi, VOIP etc. Now there will be a big push for Femtocells as operators look for indoor solutions and ways to plug coverage holes, as they rollout 4G services and will be marketed under different names – small cell, sure signal, micro-bts, etc but they all mean the same. And a time will come when all operators will provide Femtocells for free and even bundle a DSL/Cable service together with it and the Femtocell will become a convergence device for providing other services like home automation, security, entertainment systems integrated into it, till then we will have to wait and watch how this ecosystem develops.

***CPE** – Customer Premises Equipment eg. Dongles, Laptops etc.