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A Survey on technical aspect of femtocell Networks

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Abstract: **The surest thanks to increase the system capability of a wireless link is by obtaining the transmitter and receiver nearer to every different, that creates the twin advantages of upper quality links and a lot of abstraction reprocess. in an exceedingly network with unsettled users, this inevitably involves deploying a lot of infrastructure, usually within the sort of microcells, hotspots, distributed antennas, or relays. A less costly various is that the recent idea of femtocells—also referred to as home base-stations—which area unit knowledge access points put in by home users to induce higher indoor voice and knowledge coverage. During this article, we tend to summary the technical and business arguments for femtocells, and describe the progressive on every front. We tend to conjointly describe the technical challenges facing femtocell networks, and provides some preliminary concepts for the way to beat them.**

IndexTerms: Femtocell, Infrastructure ,standardization ,QOS, Deployment ,Macrocell -

I. Introduction

The demand for higher knowledge rates in wireless networks is unrelenting, and has triggered the look and development of recent data-minded cellular standards like WiMAX (802.16e), 3GPP's High Speed Packet Access (HSPA) and LTE standards, and 3GPP2's EVDO and UMB standards. In parallel, Wi-Fi mesh networks are being developed to produce unsettled high- rate knowledge services in an exceedingly additional distributed fashion [1]. Though the Wi-Fi networks won't be able to support constant level of quality and coverage because the cellular standards, to be competitive for home and workplace use, cellular knowledge systems can have to be compelled to offer service roughly cherish that offered by Wi-Fi networks.

The growth in wireless capability is exemplified by this observation from Martin Cooper of Array communication: "The wireless capability has doubled each thirty months over the last 104 years". This interprets into associate close to million-fold capability increase since 1957. Breaking down these gains shows a 25x improvement from wider spectrum, a 5x improvement by dividing the spectrum into smaller slices, a 5x improvement by planning higher modulation schemes, and a whopping 1600x gain through reduced cell sizes and transmit distance. the large gains reaped from smaller cell Sizes arise from economical spatial employ of spectrum, or or else, the next space spectral potency [2]. The main drawback to the present continued micro-ization of cellular networks is that the network infrastructure for doing thus is pricey. A recent development square measure femtocells, additionally referred to as home base-stations, that square measure short vary, low value and low power base-stations, put in by the patron for higher indoor voice and knowledge reception. The user-installed device communicates with the cellular network over a broadband affiliation like line, cable electronic equipment, or a separate RF backhaul channel. Whereas typical approaches need dual-mode handsets to deliver each in-home and mobile services, associate in-home femtocell readying guarantees fastened mobile convergence with existing handsets. Compared to different techniques for increasing system capability, like distributed antenna systems [3] and microcells [4], the key advantage of femtocells is that there's little or no direct value to the service supplier. Table three provides a close comparison of the key traits of those 3 approaches. Studies on wireless usage show that over five hundredth of all voice calls [Airvana, 5] and over seventieth of information traffic originates inside [Picochip,5]. Voice networks square measure designed to tolerate low signal quality, since the specified rate for voice signals is incredibly low, on the order of ten kbps or less. knowledge networks, on the opposite hand, need a lot of higher signal quality so as to produce the multi-Mbps knowledge rates users have come back to expect. For indoor devices, significantly at the upper carrier frequencies doubtless to be deployed in several wireless broadband systems, attenuation losses can build high signal quality and thence high knowledge rates terribly tough to attain. This raises the plain question: why not encourage the end-user to put in a short- vary low-power link in these locations? this is often the essence of the win-win of the femtocell approach. The subscriber is pleased with the upper knowledge rates and reliability; the operator reduces the quantity on traffic on their high-ticket macrocell network, and might focus its resources on actually mobile users. To summarize, the key arguments in favor of femtocells square measure the subsequent.

Better coverage and capability. Thanks to their short transmit-receive distance, femtocells will greatly lower transmit power, prolong phone battery life, and come through the next signal-to- interference-plus-noise quantitative relation (SINR). These translate into improved reception—the questionable five-bar coverage—and higher capability. as a result of the reduced interference, additional users is packed into a given space within the same region of spectrum, so increasing the realm spectral potency [2], or equivalently, the overall range of active users per rate per unit space.

Improved macrocell liableness. If the traffic originating inside is absorbed into the femtocell networks over the science backbone, the macrocell SB will direct its resources towards providing higher reception for mobile users.

Cost edges. Femtocell deployments can cut back the operational and cost prices for operators. A typical urban macrocell prices upwards of $1K per month in website lease, and extra prices for electricity and backhaul. The macrocell network are stressed by the operational expenses, particularly once the subscriber growth doesn't match the increased demand for knowledge traffic [Airvana, 5]. The readying of femtocells can cut back the requirement for adding macro-BS towers. A recent study [6] shows that the operational expenses scale from $60K each year per macrocell to merely $200 each year per femtocell.

Reduced subscriber turnover. Poor in-building coverage causes client discontent, encouraging them to either switch operators or maintain a separate wired line whenever inside. the improved home coverage provided by femtocells can cut back motivation for home users to change carriers.

The goal of this text is to produce a summary for these end-user deployed infrastructure enhancements, and describe in additional detail however the higher than enhancements turn up. we tend to additionally describe the business and technical challenges that femtocells gift, and supply some concepts regarding the way to address them

II. Technical Aspects of Femtocells:

The capability potential of femtocells is verified apace from Shannon's law, that relates the wireless link capability (in bits/second) in an exceedingly information measure W Hertz to the Signal-to-Interference and Noise magnitude relation (SINR). The SINR may be a operate of the transmission powers of the required and officious transmitters, path losses and shadowing throughout terrestrial propagation. Path losses cause the transmitted signal to decay as $Ad^{-\alpha}$, wherever A may be a mounted loss,d is that the distance between

the transmitter and receiver, and α is that the path-loss exponent. The key to increasing capability is to reinforce reception between supposed transmitter-receiver pairs by minimizing d and α. at the same time, extra edges within the network-wide spacial utilise is obtained by—but not restricted to—exploiting diversity, and using interference cancellation, interference suppression and interference turning away techniques.

Femtocells change a reduced transmit power, whereas maintaining smart indoor coverage. Penetration losses insulate the femtocell from close femtocell transmissions. Presumptuous a set receive power target with a path-loss propagation model (no fading), and denoting α (resp. β) because the out of doors (resp. indoor) path-loss exponent, overlaying a region L2 with N femtocells ends up in a transmit power reduction of the order of [10(α-β) log10 L + five five log10 N] sound unit. as an example, selecting a cell dimension of L=1000 meters and N=50 femtocells, with equal path-loss exponents α=β=4, femtocells provides a transmit power saving of nearly thirty four sound unit. Once the indoor path-loss exponent is smaller, say selecting selecting, the transmit power savings increase to almost seventy seven sound unit.

To summarize, capability edges of femtocells ar attributed to:
1. Reduced distance between the femtocell and also the user, that ends up in a better received signal strength.
2. Lowered transmit power, and mitigation of interference from neighboring macrocell and femtocell users thanks to out of doors propagation and penetration losses.
3. As femtocells serve solely around 1-4 users, they will devote a bigger portion of their resources (transmit power & bandwidth) to every subscriber. A macrocell, on the opposite hand, features a larger coverage space (500m-1 kilometer radius), and a bigger range of users; providing Quality of Service (QoS) for information users is tougher. Points one & a pair of illustrate the twin enhancements in capability through hyperbolic signal strength and reduced interference. Purpose three shows that deploying femtocells can change a lot of economical usage of precious power and frequency resources. The belief here is that the wired broadband operator provides spare QoS over the backhaul. Otherwise backhaul capability limitations might scale back the indoor capability gains provided by femtocells.
Example. take into account a cellular OFDMA system with a hundred active users. One state of affairs consists of one macrocell serving all a hundred users at the same time, and also the alternative state of affairs consists of fifty femtocells, with 2 active users in every femtocell. Figure one illustrates the accumulative distribution operate of the normalized per user and total output (normalized by the general bandwidth), considering voice and information traffic. Simulations show an almost zero.6 b/s/Hz gain in normalized median user output in femtocell deployments for voice solely networks.

With information traffic, it's impossible for a macrocell to produce information services to any or all a hundred users at the same time thanks to the restricted transmission power and spectrum convenience per user. we tend to so take into account a somewhat pathological case, during which the macrocell invariably schedules the twenty strongest users for transmission. On the opposite hand, femtocells will transmit at the same time over the whole information measure. Compared to a macrocell, a femtocell readying shows a normalized user output gain equaling one.8 b/s/Hz and an enormous system wide median total output gain of nearly 250 b/s/Hz. This shows that the most important edges of femtocells ar a huge improvement within the system spacial spectral potency.

III. Business Aspects of Femtocells :

Even though femtocells supply savings in website lease, backhaul and electricity prices for the operator, they incur strategic investments. Operators ought to sharply value femtocells despite tight budgets and high producing prices, to contend with present Wi-Fi. For instance, the North Yankee operator Sprint charges a sponsored value of $49.99 per Airwave femtocell, for subscribing to a $30/month family set up. At an equivalent time, the options that femtocells need to offer square measure in many ways additional subtle than what's during a shopper grade Wi-Fi access purpose. The emergent femto vendors face value targets set by the mature high-volume Wi-Fi market and by the stress of the operators for stripped grant to cut back Return-on-Investment (ROI) time. Consequently, value problems square measure in most cases, the central issue driving the choice of solutions to every technical challenge.

Table one shows a prognostic value breakup during a femtocell network preparation, conducted by Airvana and Gartner [5]. On balance, it are often assumed that once one.5 years, operator investment are recovered, permitting future profits.

3.1 Current Standardization and Deployments

Given the aggressive cost challenges, standardization of requirements across customers is important to accomplish a low cost femtocell solution. Towards this end, a collaborative organization called the *Femto-Forum* comprised of operators and femtocell vendors was formed in 2007 with the objective of developing open standards for product interoperability.

Table 2 shows the current state of femtocell deployments. The North American operator Sprint, provides CDMA 1x EVDO services in Denver, Indianapolis and Tennessee; concurrently, a number of operators—Verizon and AT&T (USA), O2 Telefonica and Motorola (Europe) and Softbank (Japan)—are conducting femtocell trials prior to market. ABI Research [5] predicts 102 million users worldwide on more than 32 million femtocells by 2012.

IV **Technical Challenges**

This section overviews the key technical challenges facing femtocell networks.

1. Broadband Femtocells: Resource allocation, timing/synchronization and backhaul.
2. Voice Femtocells: Interference management in femtocells, allowing access to femtocells, handoffs, mobility and providing Emergency-911 services.
3. Network Infrastructure: Securely bridging the femtocell with the operator network over IP.

3.2 Physical and Medium Access layers: Broadband Femtocells

Confronting operators will be the dual problems of mitigating RF interference and efficiently allocating spectrum in femtocell networks. Interference mitigation will require innovative solutions since the low-cost target potentially necessitates scaled-down signal processing capabilities inside femtocells. The RF interference will arise from a) Macrocell to femtocell interference, b) Femtocell to femtocell interference and c) Femtocell to macrocell interference. The near-far effect—due to uneven distribution of receive power—is the main c and c), while femtocell to femtocell interference is relatively smaller due to low transmit power and penetration.

Challenge 1: How will a femtocell adapt to its surrounding environment and allocate spectrum in the presence of intra- and cross-tier interference?

The 3GPP LTE and WiMAX standards ensure intra-cell orthogonality among macrocellular users and mitigate inter-cell interference through fractional frequency reuse. Since femtocells will be placed by end consumers, the ad-hoc locations of femtocells will render centralized frequency planning difficult.

Owing to the absence of coordination between the macrocell and femtocells and between femtocells, decentralized spectrum allocation between macrocell and femtocell users is an open research problem, which can provide answers to the following questions.

- Should macrocell and femtocell users be orthogonal through bandwidth splitting? Is there an "optimal" splitting policy? How does this vary with the femtocell density?
- Alternatively, with shared bandwidth (i.e. universal frequency reuse), what fraction of the spectrum should the macrocell and femtocells assign their users?
- Which of these two schemes is "better" in various configurations?

Challenge 2: How will femtocells provide timing and synchronization?

Femtocells will require synchronization to align received signals to minimize multi-access interference, and to ensure a tolerable carrier offset. Synchronization is also required so that macrocell users can handoff to a femtocell or vice versa, which is made more difficult due to absence of centralized coordination between them. With an IP backhaul, femtocells will experience difficulty in obtaining a time base that is immune to packet jitter. For 4G OFDMA air interfaces, ranging procedures to achieve timing (~ 1 μs) and frequency accuracy (~250 ppb) [7]

[8] are needed for two reasons.

1. The inter-carrier interference arising from a carrier offset causes loss of sub-carrier orthogonality. Additionally, femtocells will have to compensate for frequency errors arising from the handset—which typically have poor oscillators.
2. 2.In TDD systems, femtocells will require an accurate reference for coordinating the absolute phases for forward and reverse link transmissions and bounding the timing drift.

Although both points apply to the macrocell BS as well, the low cost burden and difficulty of synchronizing over backhaul will make efficient synchronization especially important for femtocells. Network solutions such as the IEEE-1588 Precision Timing Protocol over IP—with potential timing accuracy of 100 ns—and self-adaptive timing recovery protocols (e.g. the G.8261 standard) are promising. Another possibility is equipping femtocells with GPS for synchronizing with the macrocell, which relies on maintaining stable indoor satellite reception and keeping low costs in a price sensitive unit. Finally, high precision oven-controlled crystal oscillators may be used inside femtocells, incurring additional cost and periodic calibration.

Challenge 3: How will backhaul provide acceptable QoS?

IP backhaul needs QoS for delay sensitive traffic, and providing service parity with macrocells. Additionally, it should provide sufficient capacity, to avoid creating a traffic bottleneck. While existing macrocell networks provide latency guarantees within 15 ms, current backhaul networks are not equipped to provide delay resiliency. Lack of net neutrality poses a serious concern, except in cases where the wireline backhaul provider is the same company or in a tight strategic relationship with the cellular operator.

Another issue arises when femtocells usage occurs when the backhaul is already being used for delivering Wi-Fi traffic. Trials by Telefonica [5] reveal that when users employed Wi-Fi, the femtocells experienced difficulty transferring data and even low bandwidth services like voice. This is especially important, considering that improved voice coverage is expected to be a main driver for femtocells.

3.3 Physical and Medium Access layers: Voice Femtocells

For voice users, an operator faces two choices: either allocate different frequency bands to macrocell and femtocell users to eliminate cross-tier interference, or alternatively, serving both macrocell and femtocell users in the same region of bandwidth, to maximize area spectral efficiency. Considering the scarce availability of radio resources and ease of deployment, using the same region of bandwidth is preferable, if at all possible.

Challenge 4: How will femtocells handle cross-tier interference?

CDMA networks (without femtocells) employ fast power control to compensate for path-loss, shadowing and fading, and to provide uniform coverage. When femtocells are added, power control creates **dead-zones** (Figure 2) leading to non-uniform coverage. On the reverse link, a cell edge macrocell user transmitting at maximum power causes unacceptable interference to nearby femtocells. Consequently, cell edge femtocells experience significantly higher interference compared to interior femtocells. On the forward link, at the cell edge—where femtocells are most needed—macrocell users are disrupted by nearby femtocell transmissions, since they suffer higher path-loss compared to cell interior users.

IV. Physical and Medium Access layers: Voice Femtocells

In this section overviews the key technical challenges facing femtocell networks.
1. Broadband Femtocells: Resource allocation, timing/synchronization and backhaul.
2. Voice Femtocells: Interference management in femtocells, permitting access to femtocells, handoffs, quality and providingEmergency-911services.
3. Network Infrastructure: firmly bridging the femtocell with the operator network over informatics.
1.1 Physical and Medium Access layers: Broadband Femtocells confronting operators are going to be the twin issues of mitigating RF interference and with efficiency allocating spectrum in femtocell networks. Interference mitigation would require innovative solutions since the affordable target probably necessitates scaled-down signal process capabilities within femtocells. The RF interference can arise from a) Macrocell to femtocell interference, b) Femtocell to femtocell interference and c) Femtocell to macrocell interference. The near-far effect—due to uneven distribution of receive power—is the most contributor for a) and c), whereas femtocell to femtocell interference is comparatively smaller thanks to low transmit power and penetration losses.

Challenge 1: however can a femtocell adapt to its close atmosphere and portion spectrum within the presence of intra- and cross-tier interference?

The 3GPP LTE and WiMAX standards guarantee intra-cell orthogonality among macro cellular users and mitigate inter-cell interference through fragmental frequency utilize. Since femtocells are going to be placed by finish customers, the ad-hoc locations of femtocells can render centralized frequency designing troublesome. Owing to the absence of coordination between the macrocell and femtocells and between femtocells, suburbanized spectrum allocation between macrocell And femtocell users is an open analysis drawback, which may offer answers to the subsequent queries.

• Should macrocell and femtocell users be orthogonal through information measure cacophonic? Is there an "optimal" splitting policy? However will this vary with the femtocell density?

• Alternatively, with shared information measure (i.e. universal frequency reuse), what fraction of the spectrum ought to the macrocell and femtocells assign their users?

•Which of those 2 schemes is "better" in varied configurations?

Challenge2: however can femtocells offer temporal order and synchronization?

Femtocells would require synchronization to align received signals to reduce multi-access interference, and to confirm a tolerable carrier offset. Synchronization is additionally needed in order that macrocell users will football play to a femtocell or contrariwise, that is formed harder thanks to absence of centralized coordination between them. With AN informatics backhaul, femtocells can expertise issue in getting a time base that's proof against packet interference. For 4G OFDMA air interfaces, move procedures to attain temporal order (~ one μs) and frequency accuracy (~250ppb)[7] [8] square measure required for2 reasons.

1. The inter-carrier interference arising from a carrier offset causes loss of sub-carrier orthogonality. in addition, femtocells can have to be compelled to make amends for frequency errors arising from the handset—which usually have poor oscillators.

2. In TDD systems, femtocells would require A correct reference for coordinating absolutely the phases for forward and reverse link transmissions and bounding the temporal order drift. Although each points apply to the macrocell SB yet, the low value burden and issue of synchronizing over backhaul can create economical synchronization particularly vital for femtocells. Network solutions like the IEEE-1588 exactitude temporal order Protocol over IP—with potential temporal order accuracy of one hundred ns—and self-adaptive temporal order recovery protocols (e.g. the G.8261 standard) square measure promising. Another risk is militarization femtocells with GPS for synchronizing with the macrocell, that depends on maintaining stable indoor satellite reception and keeping low prices during a worth sensitive unit. Finally, high exactitude oven-controlled crystal oscillators is also used within femtocells, acquisition further value and periodic standardization.

Challenge3: however can backhaul offer acceptable QOS

IP backhaul wants QoS for delay sensitive traffic, and providing service parity with macrocells? in addition, it ought to offer comfortable capability, to avoid making a traffic bottleneck. Whereas existing macrocell networks offer latency guarantees inside fifteen ms, current backhaul networks don't seem to be equipped to produce delay resiliency. Lack of internet neutrality poses a significant concern, except in cases wherever the wireline backhaul supplier is that the same company or during a tight strategic relationship with the cellular operator.

Another issue arises once femtocells usage happens once the backhaul is already getting used for delivering Wi-Fi traffic. Trials by Telefonica [5] reveal that once users used Wi-Fi, the femtocells seasoned issue transferring knowledge and even low information measure services like voice. this can be particularly vital, considering that improved voice coverage is predicted to be a main driver for femtocells.

1.2 Physical and Medium Access layers: Voice Femtocells

For voice users, AN operator faces 2 choices: either portion totally different frequency bands to macrocell and femtocell users to eliminate cross-tier interference, or instead, serving each macrocell and femtocell users within the same region of information measure, to maximise space spectral potency. Considering the scarce accessibility of radio resources and simple preparation, mistreatment constant region of information measure is preferred, if in the least attainable.

Challenge4: however can femtocells handle cross-tier interference?

CDMA networks (without femtocells) use quick power management to make amends for path-loss, shadowing and weakening, and to produce uniform coverage. once femtocells square measure side, power management creates dead-zones (Figure 2) resulting in non-uniform coverage. On the reverse link, a cell edge macrocell user transmittal at most power causes unacceptable interference to close femtocells. Consequently, cell edge femtocells expertise considerably higher interference compared to interior femtocells. On the forward link, at the cell edge—where femtocells square measure most needed—macrocell users square measure noncontiguous by close femtocell transmissions, since they suffer higher path-loss compared to cell interior users.

V Network Infrastructure :

In a femtocell setting, the operator can have to be compelled to offer a secure and climbable interface for the femtocell over information processing, at an inexpensive value. Ancient Radio Network Controllers (RNCs) area unit equipped to handle tens to many macrocells. However can they supply equal parity service to femtocells over theinternet?

Three network interfaces are planned, of that the IMS/SIP and UMA primarily based interfaces seem to be the architectures of alternative.Iu-b over IP: Existing RNCs connect with femtocells through customary Iu-CS (circuit-switched) and Iu-PS (packet-switched) interfaces gift in macrocell networks. The advantage is that the Capex is relatively low to that degree because the operator will leverage existing RNCs. The shortcomings area unit the dearth of quantifiability, which the interface isn't nevertheless standardized.

IMS/SIP: the net Media Sub-System/Session Initiation Protocol interface provides a core network residing between the femtocell and therefore the operator. The IMS interface converts subscriber traffic into information processing packets and employs phonation information processing (VoIP) mistreatment the SIP protocol, and coexists with the macrocell network. the most benefits area unit quantifiability and fast standardization. Disadvantages embrace the Capex for upgrade, and Opex in maintaining 2 separate core networks for the macrocell and femtocell severally.

RAN entranceway primarily based UMA: A Radio Access Network (RAN) entranceway exists between the information processing network and therefore the operator network, aggregating traffic from femtocells. This entranceway is connected to the operator network employing a customary Iu-PS/CS interface. Between the femtocell and therefore the RAN entranceway, the UMA (Unlicensed Mobile Access) protocol makes use of secure information processing tunneling for transporting the femtocell signals over the net. Current UMA-enabled services like T-Mobile's Hotspot@Home need dual-mode handsets for switch between in-home Wi-Fi and outside cellular access. Group action the UMA consumer within femtocells, instead of the mobile, would alter future deployments support use of heritage handsets.

RESEARCH METHODOLOGY

We now consider the key areas and tools for conducting further femtocell research, with the goal of designing efficient femtocell architectures.

5.1 Interference Management

Owing to the ad-hoc topology of femtocell locations, interference suppression techniques alone can prove ineffective in femtocell networks. serial Interference Cancellation—in that every user subtracts out the strongest neighboring interferers from their received signal—appears promising at the start, however cancellation errors quickly degrade its quality [12]. Consequently, associate interference shunning approach whereby users avoid instead of suppress mutual interference is a lot of probably to figure well in geography-dependent femtocell networks. The low value demand is probably going to influence the planning of low complexness femtocell baccalaureate receivers—simple matched filter process as an example—and low complexness transmission schemes for sensing close offered frequency channels to avoid collisions. In CDMA femtocell networks with universal frequency use, as an example, interference avoidance—through time-hopping and directional antennas—provides a 7x improvement in system capability [9], once macrocell and femtocell users share a typical information measure. Frequency- and Time-hopping. In GSM networks, the interference shunning offered through slow frequency hopping permits femtocell users and close sending macrocell users to avoid consistent mutual interference. Similarly, frequency-hopped OFDMA networks will use random sub-channel assignments so as to decrease the likelihood of persistent collision with neighboring femtocells.

In time-hopped CDMA, the CDMA length G Tc (G is that the process gain and Tc is that the chip period) is split into Nhop hopping slots, wherever every user indiscriminately selects a hopping slot for transmission and remains silent throughout the remaining slots. Random time-hopping reduces the common variety of officious users by an element of Hop, whereas trading-off the process gain. The exchange is that femtocells area unit accommodated by dynamic the manner associate existing CDMA macrocell network operates.

Directional Antennas within femtocells provide interference shunning, with zero protocol overhead, by proscribing radio interference among associate antenna sector. Providing an inexpensive cost and simple user preparation area unit the key challenges coping with this approach.

Adaptive Power management methods vary the femtocell receive power target counting on its location. industrial femtocells like Sprint's Airwave femtocell tackle cross-tier interference victimization associate "automatic adaptation" protocol that adjusts the femtocell transmit power. Over the forward link in closed access, Ericsson [13] has planned reducing interference to macrocell users by reducing the femtocell transmit power with increasing distance from the macro baccalaureate. The exchange is that the reduced home coverage at faraway femtocells. Over the reverse link in closed access, we propose providing the next receive power target to femtocell users relative to macrocell users [9], which is able to vary supported femtocell location.

Figure 03 shows the reductions within the outage likelihood for a femtocell user (the femto-macro receive power ratios area unit one and 10), in conjunction with interference shunning victimization CDMA time hopping and antenna sectoring. For open access, Kishore et al. [14] propose overcoming the near-far result by extending femtocell coverage—allow a user to speak to a macrocell providing their channel gain is appreciably higher—at the expense of enhanced interference between neighboring femtocells.

Multi-mode phones [7] switch protocols in closed-access systems for mitigating interference, for example, transmit in WCDMA mode within a femtocell, and revert to GSM mode otherwise.

5.2 MIMO FEMTO CELL Management

Multiple antennas at the transmitter and/or the receiver (MIMO) exploit the abstraction diversity of the wireless channel. Femtocells will perform temporal link adaptation through accommodative modulation and coding; to boot, MIMO abstraction link adaptation can modify a femtocell to modify between providing high information rates and sturdy transmission. High information rates area unit gettable by sending multiple abstraction streams (spatial multiplexing) over high SINR links. Over low SINR links, MIMO provides lustiness through open and control system diversity schemes like frame of reference codes and beam forming. fascinating area unit as for future analysis are a) link accommodative mode change for femtocells between diversity and abstraction multiplexing [15], b) analyzing the result of channel state info errors induced by co-channel interference on MIMO femtocell performance, c) the complexness limitations of MIMO femtocell receivers, which can be vital vs. macrocell receivers thanks to value issues, and d) channel models for MIMO femtocells, since the range characteristics is also terribly totally different from macrocells.

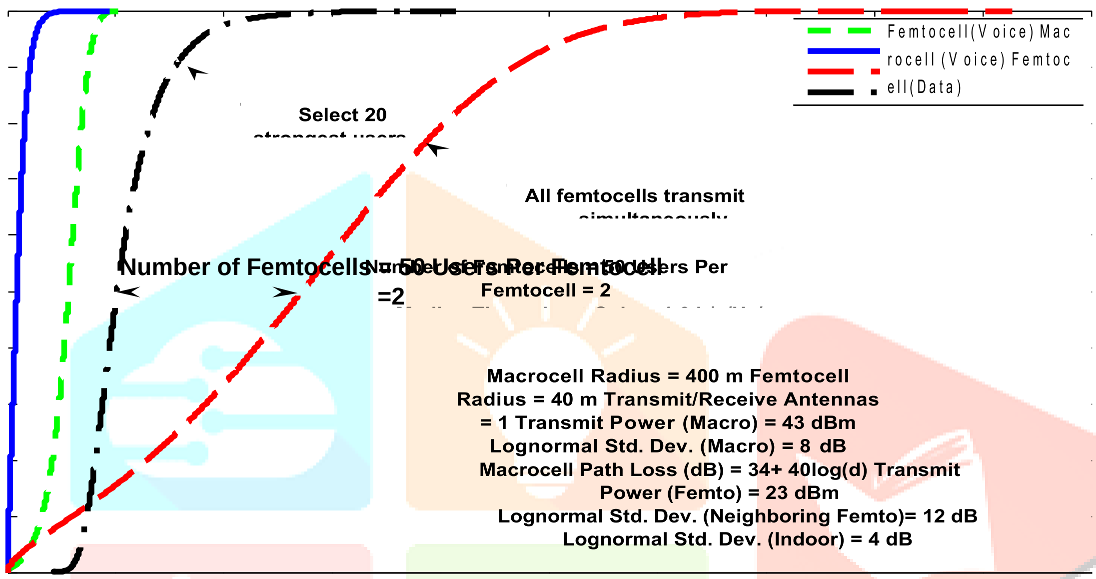
V. RESULTS AND DISCUSSION WITH CONCLUSION

VI Conclusion

Femtocells have the potential to supply top quality network access to indoor users at low price, whereas at the same time reducing the burden on the total system. This text has known the key advantages of femtocells, the technological and business challenges, and analysis opportunities. From a technical point of view, operators face challenges in providing an occasional price answer, whereas mitigating RF interference, providing QoS over the information processing backhaul, and maintaining quantifiability. From a business perspective, generating semi-permanent revenue growth and overcoming initial end user subsidies area unit key challenges.

Figure sand Tables

Figure 1: Femtocell vs. Macrocell Throughput



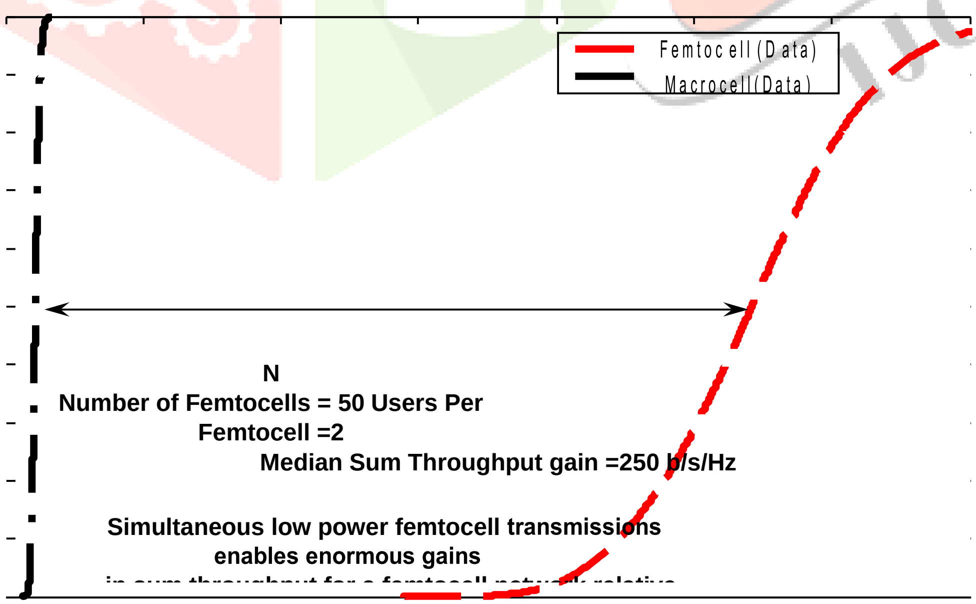


Figure 2: Dead zones in CDMA femtocell networks

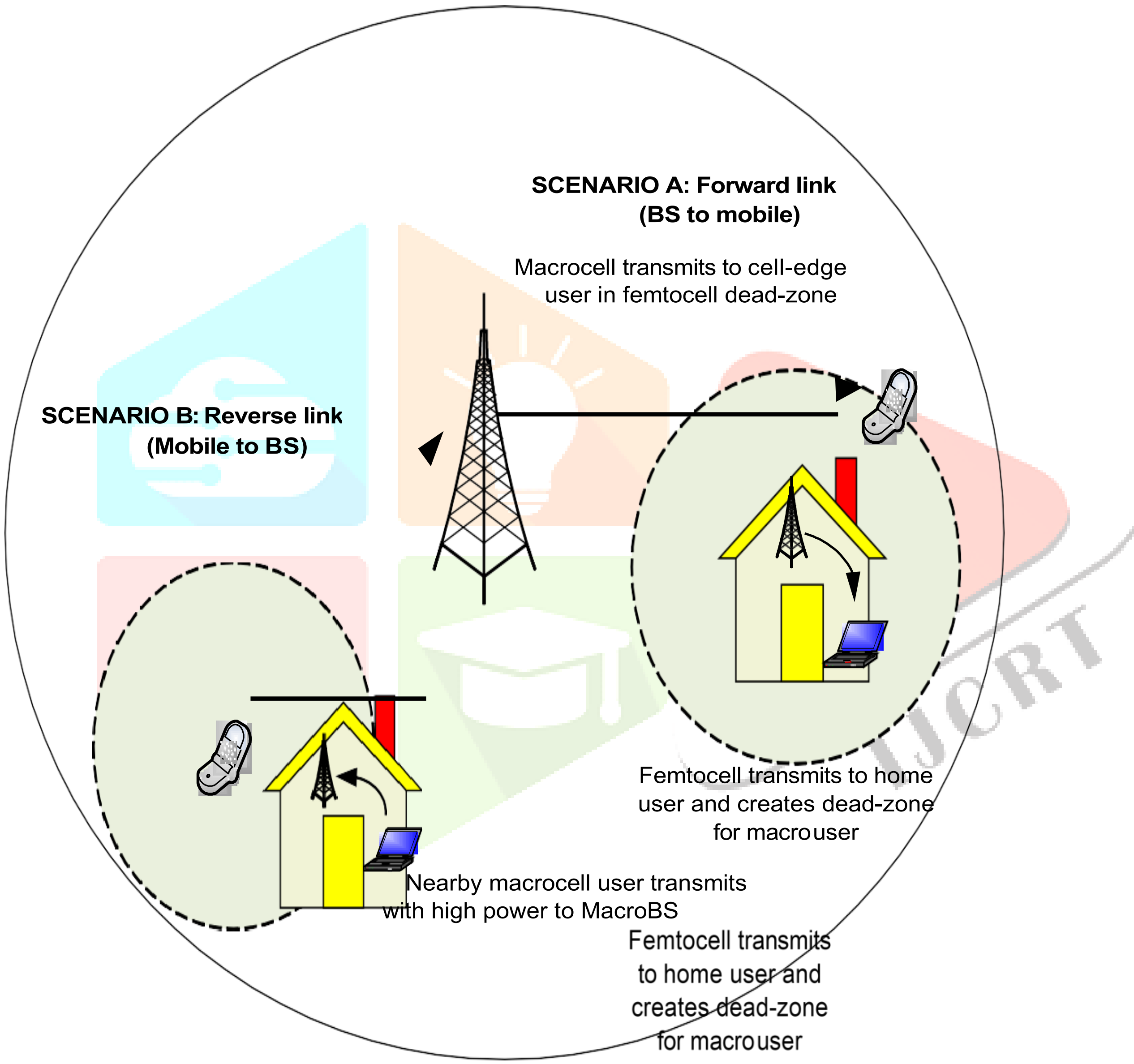


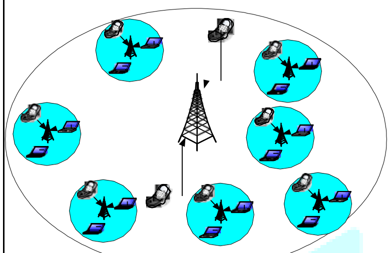
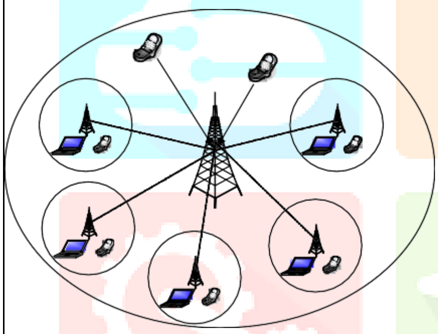
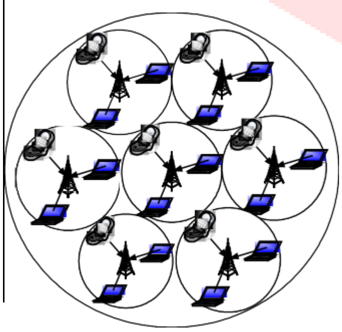
Table 1: Existing Femtocell Offerings

Table 2: Femtocells, Distributed Antennas and Microcells

Manufacturer	Partner/Operator	Region	Technology
Samsung (Ubicell)	Sprint (Airwave)	North America	a) IS-95, CDMA2000 1xEV-DO b) WCDMA
Air Walk Communications		North America	CDMA 1x RTT & 1x-EVDO
Ericsson		Europe	GSM/3GPP UMTS
Airvana	Nokia-Siemens		3GPP UMTS
Alcatel-Lucent		North America	3GPP UMTS
Axiom Wireless	Pico Chip	United Kingdom	a) 3GPP UMTS b) WiMAX
IP Access (Oyster)	Pico Chip	United Kingdom	3GPP UMTS
Ubiquity's (Zone gate)	Kineto wireless, Google	United Kingdom	3GPP UMTS/HSPA

Infrastructure	Expenses	Features
Femtocell: Consumer installed wireless data access point inside homes, which backhauls data through a broadband gateway (DSL/Cable/Ethernet/WiMAX) over the internet to the cellular operator network.	**Capex**. Subsidized femtocell hardware. **Opex.** a) Providing a scalable architecture to transport data over IP, b) Upgrading femtocells to newer standards.	**Benefits.** a) Lower cost, better coverage and prolonged handset battery life from shrinking cell- size, b) Capacity gain from higher SINR and dedicated BS to home subscribers and c) Reduced subscriber churn **Shortcomings.** a) Interference from nearby macro cell and femtocell transmissions limits capacity and b) Increased strain on backhaul from data traffic may affect throughput.

Table 3: Femtocells, Distributed Antennas and Microcells

Infrastructure	Expenses	Features
Femtocell: Consumer installed wireless data access point inside homes, which backhauls data through a broadband gateway (DSL/Cable/Ethernet/WiMAX) over the internet to the cellular operator network. 	**Capex.** Subsidized femtocell hardware. **Opex.** a) Providing a scalable architecture to transport data over IP, b) Upgrading femtocells to newer standards.	**Benefits.** a) [illegible] coverage and improved handset battery life [illegible] c) Higher SINR [illegible] d) Reduced subscriber churn. **Shortcomings.** a) Interference from nearby macrocell and femtocell transmissions limits capacity and b) Increased strain on backhaul from data traffic may affect throughput.
Distributed Antennas: Operator installed spatially separated antenna elements (AEs) connected to a Macro BS via a dedicated fiber/microwave backhaul link. 	**Capex.** AE & backhaul installation. **Opex.** AE maintenance and backhaul connection.	**Benefits.** a) Coverage improvement, b) Capacity gain by exploiting multiple AEs per macrocell user). **Shortcomings.** a) Does not solve the indoor coverage problem, b) RF interference in the same bandwidth from nearby AEs will diminish capacity and c) Backhaul deployment costs may be considerable.
Microcells: Operator installed cell-towers, which improve coverage in urban Areas with poor reception. 	**Capex.** Installing new cell-towers. **Opex.** Electricity, site lease and backhaul.	**Benefits.** a) System capacity gain from smaller cell size, b) Complete operator control. **Shortcomings.** a) Installation and maintenance of cell-towers is prohibitively expensive b) Does not completely solve indoor coverage problem.

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