Survey paper on Heterogeneous Wireless Ad-hoc Networks for enhancement of Coverage area in Cellular networks

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Abstract- Data traffic is growing significantly due to proliferation of smart phones and tablets and has an adverse effect on radio access links and the backhaul infrastructure of mobile operator’s network. LTE and other advanced techniques offers higher data traffic throughput than allocated bandwidths. The combined capacities of even these networks is not sufficient to meet projected future capacity demands and the conventional solution is to increase the capacity of LTE mobile networks which includes splitting macro-cells or adding more sites. Both of these solutions require high capital and operational expenditures. Mobile operators are seeking a new and cost effective ways of increasing both indoor and outdoor coverage for improving overall network capacity. In this paper we present a survey of different techniques for enhancement and improvement of coverage area in cellular networks using heterogeneous wireless ad-hoc networks.

Introduction
Capacity may be a limitation depending on the backhaul and intelligent network management between cells. Seamless connectivity and roaming between cellular networks is very essential. Better coverage area can be improved by increasing more channels with minimal interference and at reduced costs. The easiest way to increase the system capacity of a wireless link is to locate the transmitter and receiver as close to each other as possible thus creating mutual benefits for both uplink and downlink quality. Microcells and nano cells have been currently used to increase the coverage of indoors and subway tunnels despite their high costs of installation. In order to increase the quality of the wireless services, this paper mainly focuses on many effective solutions such as Wi-Fi, Repeaters, Femtocells, Picocells, Distributed Antenna Systems, Hybrid solutions. These solutions are small, low-cost base stations located in the small places such as houses and offices. The maximum allowed transmit power is low compared to transmit power of a macro cell base station. Thus, the subscribers’ demands of higher data rates with low delays are granted by small cell deployment. The operator may reduce the
amount of traffic on the expensive macro cell network and can focus on outdoor mobile users.

Different techniques for enhancement and improvement of coverage area in cellular networks.

1. Wi-Fi: Wi-Fi is a popular option for improving indoor mobile services but has been limited to providing data services unless the user is happy to make use of Over The Top alternatives to cellular voice and messaging such as Skype. It includes features for roaming between their cellular and carrier Wi-Fi network. Full cellular voice and SMS services with handover between cellular and Wi-Fi networks is not yet supported in carrier Wi-Fi but is being worked on and eventually will be included. Operator launches of applications to deliver voice and SMS services via Wi-Fi is evidence of progress in this area.

1.1 Self-provided Wi-Fi
Self-provided Wi-Fi is a term employed to distinguish between the various types of Wi-Fi offerings currently in the wireless market. It offers

![Fig 1.1 Self-provided Wi-Fi](image)

wireless access to a user's fixed line broadband connection (i.e. a data connection) to the user's mobile and other Wi-Fi enabled devices using a simple box or access point that is plugged into their broadband connection. In other words, this is the type of Wi-Fi that has been deployed for many years in homes and businesses, for which the consumer buys their own Wi-Fi access point (widely available online or from major home electronics devices retail outlets) and installs it themselves.

**Advantages:**
1. Better data rates (depending on broadband connection)
2. Improved data service availability (depending on where they install their access point)
3. Improved mobile phone battery life.
4. Reduced costs for mobile data services as using Wi-Fi will not come out of their monthly data allowance for their operator

1.2 Carrier Wi-Fi
The concept of Carrier Wi-Fi or Service Provider Wi-Fi comes as a result of the need of operators to face various challenges associated with consumer's demands and technical issues:
1. Increase in signalling traffic due to smart phones
2. Very large growth in mobile data
3. Lack of spectrum and inability to rapidly deploy new cell sites
4. A shift from outdoor consumption to indoor
5. Consumer services on mobile devices getting more and more difficult to be separated
This carrier-grade solution uses licence exempt spectrum to offload data traffic and help operators to deliver new services, providing a platform for business and service innovation for them. Some of the benefits for consumers as foreseen using this technology include:

1. Easy connectivity
2. Seamless authentication and roaming between cellular and carrier Wi-Fi networks and intra Wi-Fi access point roaming
3. Session continuity
4. Application transparency
5. Consistent user experience

2. Repeaters:
Traditional consumer Repeaters are signal “boosters.” They potentially cause harmful interference which limits their deployment. Operator deployed Repeaters are still widely used for large buildings and are sometimes combined with a DAS system if a coverage only solution is required. A new group of repeater emerging is the intelligent repeater which includes some improvements over traditional consumer Repeaters to tackle interference issues. Crucially Repeaters of all types rely on a good outdoor signal to boost into the target building and so are not useful in areas a long way from existing sites with no outdoor or indoor signal.

2.1 Traditional consumer Repeaters –
These tend to be small, low cost, bi-directional amplifier units that the user can place on their window ledge to pick up a “donor” mobile signal which is then “boosted” and retransmitted into the building. In car repeater units are also available. This is due to interference concerns to the macro cellular network which are much greater in these devices than in operator deployed Repeaters as:

1. These units tend to be broadband units working across a number of operators
2. The operator has no direct control over where the unit is used and its settings
3. The low cost and small form factor of the unit means that the same level of skilled installation and setup associated with operator deployed Repeaters to minimise interference cannot be achieved.

2.2 Intelligent Repeaters –
Generally the low cost and small form factor of these units means that there is not good isolation between the two opposite facing antennas in the unit which in turn limits the amplification that can be achieved without having feedback issues. This combined with the placement of the unit on a window ledge rather than having an antenna external to the building will limit the levels of service improvement achieved.
antennas which are linked by a 5GHz radio link (i.e. the same licence exempt band as used by the most recent Wi-Fi devices). The outdoor “donor” signal is picked up by the donor box, digitised and transmitted to the mobile unit via the 5GHz link and then retransmitted by the mobile unit. This allows the donor unit to be located near a window and the mobile unit to be positioned at where the coverage improvement is required. This evolution of traditional consumer repeaters has notably been approved by some network operators and aims to minimise interference to the macro cellular network by:

1. Using intelligent power control
2. Having good isolation between the donor and indoor antenna as these are in separate boxes
3. Repeating the signal from within the building rather than on the window which isolates the indoor signal from the outdoor macro cellular network better.

Femtocells:
Femtocells are low cost cellular base stations that can be installed by the end user by plugging it into power and their broadband connection similarly to a Wi-Fi access point. They have been deployed commercially by all mobile operators, targeted on particular groups of consumers. An important benefit is that these provide all cellular services including voice and SMS, but these are usually provided as part of the user’s mobile subscription.

Advantages:
1. Better availability and quality of cellular voice, SMS and data services in the building
2. Better cellular data rates
3. Improved mobile phone battery life
4. Simple to set up, with little or no configuration required.
5. Potentially reduced mobile costs if operators choose to bill consumers for femtocell traffic differently to their usual monthly data allowance, where they use femtocells.

Limitations:
1. The consumer must provide (and pay for) an adequate broadband connection to make the femtocell work.
2. The user must have a 3G handset

4. Picocells:
Picocells are similar to femtocells but cover larger areas and target bigger SME buildings and can be used in a network to cover some larger enterprise buildings. They promise to provide a solution to the gap in solutions for mid and large scale enterprises as technical, cost and deployment challenges are addressed.

Advantages:
1. Better availability and quality of cellular voice, SMS and data services in the building
2. Better cellular data rates
3. Improved mobile phone battery life
4. Potentially reduced mobile costs if operators choose to bill consumers for picocell traffic differently to their usual monthly data allowance.
5. Potentially specialised indoor services might be offered from the operator via picocells but these are not yet widely available.

Limitations:
1. The building owner or business will likely have to provide (and pay for) a broadband connection to make the picocells solution work.
2. Capacity may be a limitation depending on the backhaul and intelligence of the picocells network in managing users between cells.

5. Distributed Antenna Systems (DAS):
Distributed Antenna Systems (DAS) are an infrastructure of cables, amplifiers and antennas installed within a building to distribute mobile signals in analogue form throughout it typically from a dedicated high-capacity base station, but sometimes from a repeater or small cells. This is costly to plan and install and so only suitable for large high capacity buildings or corporate buildings where the value of the overall account to an operator can justify the high capital investment in the infrastructure, but allow relatively straightforward support for multiple operators. Distributed base station solutions are an evolution of DAS which distribute signals digitally and include more intelligence to dynamically adjust capacity to the areas of a building that need it at any time. Again these are high end installations for big high capacity venues.

6. Hybrid solutions: Hybrid solutions also promise to make a major impact, with for example femtocells, picocells and Wi-Fi promising to provide complementary capabilities, and an increasing degree
of integration between these technologies is evident in the marketplace.

**Conclusion:** In this paper we present a survey of different techniques such as Wi-Fi, Repeaters, Femtocells, Picocells, Distributed Antenna Systems, Hybrid solutions, for enhancement and improvement of coverage area in cellular networks using heterogeneous wireless ad-hoc networks.

**References:**


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