Mobile Data Offloading Techniques and Related Issues

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Abstract— **From last few years there is development of smart devices and popularity of social media and Internet gaming has created a large amount of data traffic over cellular networks. Due to increase in data traffic congestion and less frequent packet transmission will be experienced in traditional network. Therefore, telecom operators should have traffic offloading mechanisms that will help in managing their network load and capacity more efficiently. So different innovative techniques have present to manage data traffic such as Wi-Fi, LTE Small Cell and Relay, femtocells, DTN-based Network, and IP flow mobility. This paper includes different data offload strategies and considers the issues and benefits related with each of them.**

Keywords- **Data offloading, Wi-Fi, LTE Small Cell relay, femtocells, disruption tolerant network**

I. INTRODUCTION

Current cellular networks are experiencing an explosive growth in data traffic and this traffic creating burden on network This growth is result of smart devices, data-hungry mobile apps (for example online social networks ,Internet gaming, video streaming), According to Cisco's Global Visual Networking Index (VNI), since 2007, global mobile data traffic is doubling every year. It is estimated that this rate of growth will even increase more over the next few years [1]. Simultaneously, the number of mobile subscribers and mobile devices has significantly increased in the last few years and it is expected to exceed with world's population. The Global mobile data traffic is expected to grow to 10.8 Exabyte (1 exa = 1018) per month by 2016, this figure is an 18-fold increase over 2011 [1]. Social networking, video and internet gaming creates tremendous strain on the networks. As data traffic reduces network capacity so there is need of techniques which will reduce congestion in network, mobile data offloading. An intuitive approach is to leverage the unused bandwidth across different wireless technologies, we consider mobile data offloading as the use of a complementary wireless technology to transfer data originally targeted to flow through the cellular network, in order to improve some key performance indicators [2]. Mobile data offloading is innovative techniques for reducing strain on macro cell. Mobile data offloading used to reduce congestion and make better use of available network resources. Main objective of Mobile data offloading is to reduce the cost and to have transmission capacity for hungry services on the mobile network. It is useful to maintain quality of service (QoS) for customers.

Key factors to manage networks include:

1. Radio Spectrum Utilization

Operators have limited and expensive Spectrum. Operators need to plan the effective utilization of their radio resources as number of connected devices continues to increase. This can be done by offloading data between licensed and unlicensed spectrum.

2. Controlling CAPEX

Operators need to focus on core and access network investments only in those areas that offer the strongest potential returns.

3. Backhaul Network Optimization

The increase in data traffic creating backhaul bottlenecks and causing strain to the operator radio access networks. As traffic is continues to increase there is need to design and implement an efficient backhaul system to transport the data from the access to the core network.

4. Transactional Load Management

In order to optimize bandwidth it is important for operators to keep the signaling and transactional load to a minimum, with increasing number of devices. Data traffic patterns depend upon the type of device, its form factor, time of the day, type of application and even the density of users in a particular location.

Manuscript received April, 2015.

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Data traffic offload can help operators reduce the traffic on their radio spectrum lowering the operating load on base stations. It also provides an opportunity for service providers to charge users for offload solutions such as small cells, while helping customer reduce their usage costs by offloading data to alternate networks [3].

In this paper we cover the existing mobile data offloading solutions. Wi-Fi and femtocell are recent technologies. Other techniques are explained in brief with limitations and benefits of each solution.

II. SOLUTIONS FOR MOBILE DATA OFFLOADING

A. Mobile Data Offloading Via Wi-Fi

Wi-Fi stands for ―wireless fidelity. It is based on IEEE 802.11 standards. Mainly it is used for broadband access in an indoor environments. Wi-Fi provides higher data rates but with limited coverage and mobility compared to conventional mobile communication technologies like Universal Mobile Telecommunications System (UMTS), high-speed packet access (HSPA), and Long Term Evolution (LTE). This is low cost and easy to install method. It is used to manage data traffic growth at reduced costs. Wi-Fi hotspot is that they operate over unlicensed spectrum. , Building of Wi-Fi hotspot is easier and cost effective than large network deployments. The effectiveness depends upon the duration for which the user remains in the coverage area. The longer a user stays in Wi-Fi coverage area greater the benefits are of data offload. The data traffic to be shifted from expensive licensed bands to free unlicensed bands up to 2.4 GHz and 5 GHz. The main approaches for operators to offload data traffic onto Wi-Fi networks, which are depending on the level of integration between Wi-Fi and cellular networks [4].

It is categorized in two types unmanaged data offloading and An integrated data offloading. In unmanaged data offloading data is transparently moved onto the Wi-Fi network, whenever they are in Wi-Fi coverage. This technique does not require any network equipment. But it has some drawbacks first, the operator loses visibility and control of its subscribers whenever they are on the Wi-Fi network. Second, the operator is unable to deliver any subscribed contents such as corporate VPN, ringtones, etc. A managed data offloading approach can be adopted by operators who do not want to lose control of their subscribers. This is achieved by placing an intelligent session-aware gateway [5].

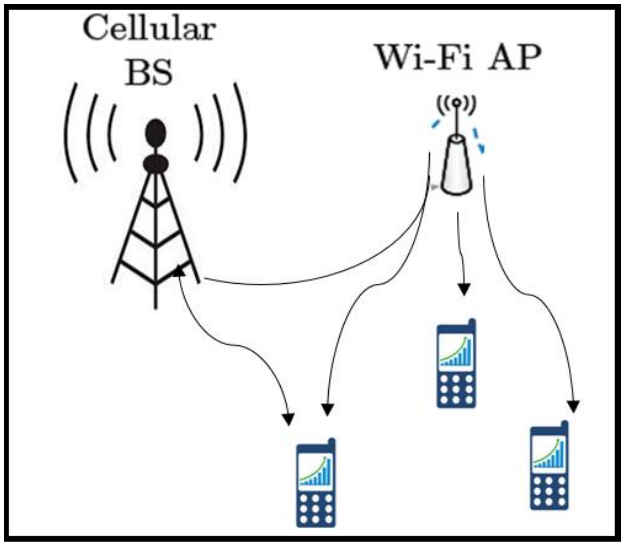
In integrated data offloading

This approach provides the operator with full control over subscribers as well as the ability to deliver any subscribed content while the users are on the Wi-Fi network. For coupling cellular and Wi-Fi networks there are two architectures: loose coupling and tight coupling. In loose coupling, the networks are independent, no major cooperation is require between them and, in a tight coupling system, the Networks share a common core and majority of network functions such as vertical [6].

B. Mobile Data Offloading Via LTE Small Cell and Relay

This method is similar to Wi-Fi, LTE Small Cell works both on licensed as well as unlicensed spectrum as it offload data traffic from the core network and saving radio spectrum.

LTE Small Cell are connected to the radio network and provide higher coverage. they require low power and are



useful to offload data in high density and high traffic areas.

This solution is deployed and managed by the operator, it is suitable with long-term strategy of mobile operators. Wi-Fi hotspots and LTE small cells will co-exist to address selective offload of data from various devices.

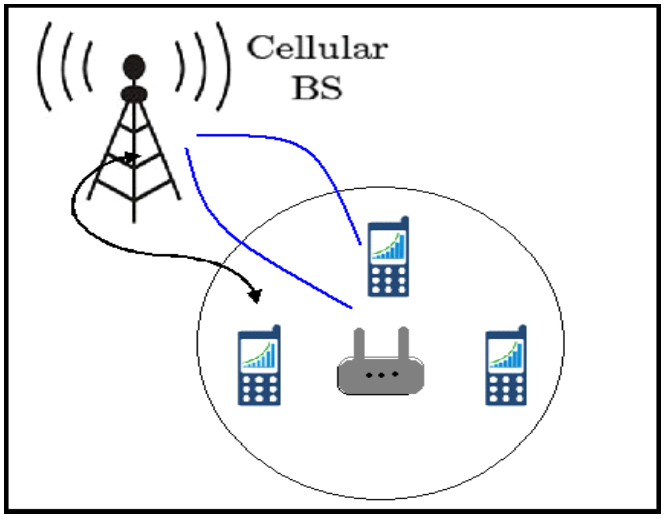


Figure 2. Mobile data offloading using LTE small cells.

C. Mobile Data Offloading Via IP Flow Mobility

IP flow mobility [7] is a recently standardized technology in the Internet Engineering Task Force (IETF). Operator can shift a single IP flow to a different radio access without disrupting any ongoing communication. For example,

Consider a user connected to a cellular base station having multiple simultaneous flows a voice call and a file download moving into the coverage of a Wi-Fi hotspot. The network, upon detection of the Wi-Fi access, decides to shift the file download on the Wi-Fi network. If the user leaves the Wi-Fi coverage just for a single time, the file download is seamlessly shifted back to the cellular network. This IP flow mobility provides operators with a better data traffic management solution by selectively offloading heavy users and thus reduce congestion on their networks. Using this user also get its benefit because he is able to enjoy high bandwidth connections and a better experience.

D. Mobile Data Offloading Via Disruption Tolerant Networking (DTN)

Disruption Tolerant Networking is used to offload data traffic from cellular networks with high capacity and free device-to-device i.e. D2D Operator has to look for dedicated device to reduce the strain on their core networks and improve efficiency. In DTN-based mobile data offloading system, some chosen users that is helpers. They will have to participate in the offloading. Incentives for these users can be provided by using some micro-payment scheme, or the operator have ability to offer the participants a reduced cost for the service or they can offer better quality of service [8],[9]. The multiple-type mobile data offloading scheme should have to consider. There are two types of nodes in the system, known as offloading helper and mobile data subscriber. The service provider first chooses some users that are willing to participate in data offloading by itself. When it has a set of mobile data items which is required to be deliver or to be downloaded, the storage allocation decision is made, and it then transmits the mobile data to these chosen helpers through the cellular network according to the storage allocation policy they have. These offloading helpers then further propagate the data to other subscribers that are interested in the data by short range device-to-device communication.

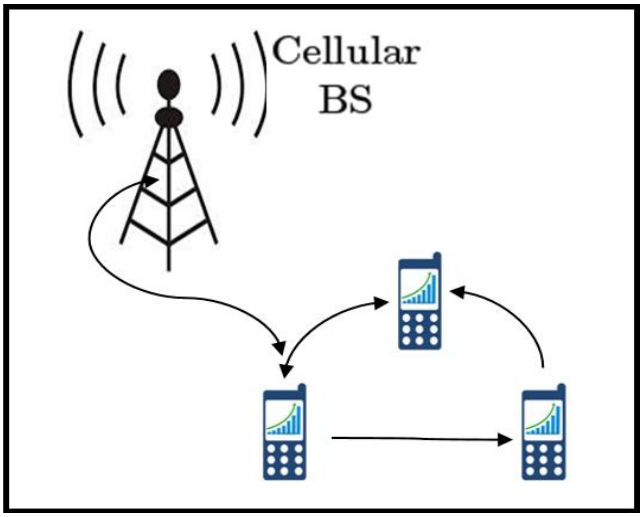


Figure 3. Mobile Data Offloading Via Disruption Tolerant Networking

E. Mobile Data Offloading Via Femtocells

A Femtocell is a small cellular base station designed for use in residential or small business environments. It connects to the service provider's network via broadband (such as DSL or cable) and typically supports 2 to 5 mobile phones in a residential setting. A Femtocell allows service providers to extend service coverage inside of our home without the need for expensive cellular towers. It allows the service provider to extend service coverage in areas where access would be limited or unavailable. Femtocells improve both coverage and capacity, especially indoors. The concept of femtocells is applicable to all are standard GSM, wideband code-division multiple access (WCDMA), World-Wide Interoperability for Microwave Access (WiMAX), and LTE. Data offloading through femtocells is effective because, the usage occurs primarily 55 percent in the home and 26 percent occurs in the office [11]. Thus, the operators get the opportunity to offload heavy users through femtocells very easily. Femtocells represent an operator deployed and managed service, and hence provide a seamless experience to users. Femtocells are able to deploy quickly and easy to manage [10].

In femtocell environments is connected to the user's broadband connection, then over the Internet and to the operator's cellular network or other Internet destinations. Whenever a subscriber comes into the coverage of femtocell, the user equipment (UE) automatically associates itself with femtocell. Traffic flows through the femtocell and the subscriber's broadband connection. The femtocell offloads both the Node and the radio network controller (RNC), which reduces the load on the macro cellular network. Standard IP traffic offload (SIPTO) [12], is a new standard, currently under development. This technique will enables the operator to offload certain types of traffic at a network node close to the UE's location. The current standardization process mainly considers two types of policies for offloading which is based on: access point name (APN) and deep packet inspection (DPI) [5].

The Wi-Fi operates in unlicensed bands, operators have access to much larger free spectrum to cater for any size of Wi-Fi deployment, on the other hand, Femtocells require planning as they operate in licensed and limited spectrum bands. Femtocells can capture 100 percent of traffic, whether it is voice or data, and it is not bother about whether it originates from a feature phone, smart phone, or a laptop, but this is not possible in the case of Wi-Fi. Another one is that, femtocells can provide guaranteed QoS using licensed bands, whereas Wi-Fi cannot guarantee about QoS. In orthogonal multiple access, the choices of access mode are Highly dependent on the cellular user density. Different Access modes are presented as per [13].

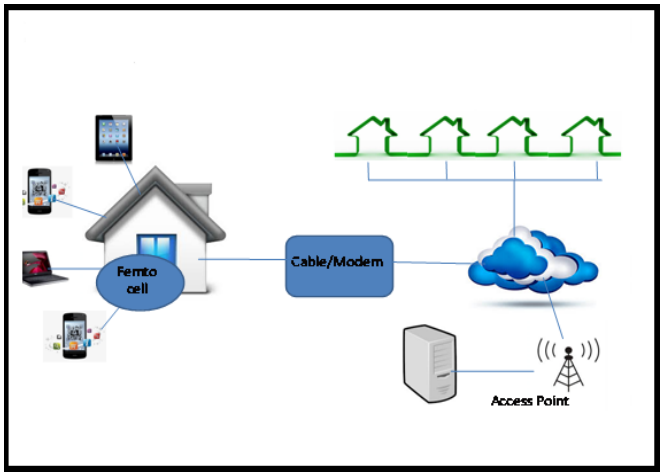


Figure 4. Mobile Data Offloading Via Femtocells.

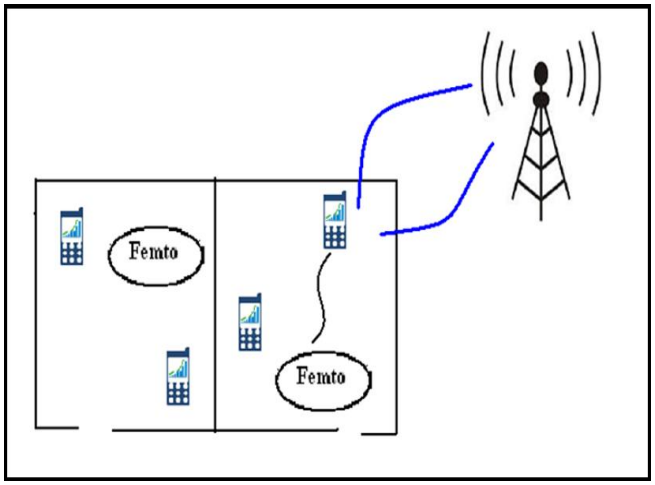


Figure. 5. Cross-Tier Intererence for the Downlink and Uplink

FEMTO ACCESS TYPES

A. Open Access

Open Access illuminates interference and provides a better Overall network performance in terms of QoS and throughput [4], because all available resources are shared between users. However, the number of handovers and signaling in the network is increased heavily.

B. Closed Access

This is used only for Closed Subscriber Group (CSG) users. However, the system operator will set a different service levels for the needs of CSG users.
In this case, management is more complex.

C. Hybrid Access

Hybrid Access mode allows particular outside users to access a femtocell. The conditions of access to a femtocell by an outside user can be defined by each operator separately and entry to any guest or new user can be requested by the owner. In hybrid mode, non-CSG service can only get limited service [14]. These access modes are used in mobility management.

FEMTOCELL INTERFERENCE INSTALLING

Femtocells where more than one femtocell may co-exists and many users may enter femtocells' coverage, leads to major interference challenges [15]. There are two types of interferences that occur in two-tier femtocell network architecture (central macrocell with OFDMA femtocells). Co-tier interference: This type of interference occurs among network elements that belong to the same tier in the network. Co-tier interference occurs between neighboring femtocells use the same sub channels. Cross-tier interference: This type of interference occurs among network elements that belong to the different tiers of the network, i.e., interference between femtocells and macrocells [16].

III. ISSUES IN MOBILE DATA OFFLOADING

LTE small has complexities in installation which can adversely impact capital and operating expenditures. An advantage of LTE small cells is that they can be easily deployed with low skilled workers.
There are some key challenges that arise while implementing a data offloading solution, especially offloading through Wi-Fi. Service providers must require consistent user experience and service continuity. This includes providing a transparent login across different networks which avoids disruptions in service continuity. A subscriber's authentication data is required to be present in the home location registry (HLR) in case of 3GPP networks, which cannot be accessed easily through non-3GPP networks such as Wi-Fi [5].
The Wi-Fi network does not have QoS guarantees, a QoS-driven vertical handover from Wi-Fi to 3GPP networks, which is essential in order to ensure the QoS for users, especially when the Wi-Fi network is experiencing congestion. The network cannot force a device to switch on the Wi-Fi interface. This creates challenges for those operators who want to implement a Wi-Fi offloading solution. But currently no outdoor Wi-Fi planning tools are available in the market, creating challenges in optimal deployment of outdoor Wi-Fi access points. Also, if we want Wi-Fi offloading solutions on a large scale then it is necessary to address roaming agreements between different Wi- Fi networks. For femtocells, a major challenge is interference management. By deploying femtocell a two-tier network is created, which result in creating interference either of co-tier or cross-tier An important challenge in mobile data offloading, in deriving offloading solution is to distinguish between different user segments and network conditions [11]. Wi-Fi network uses unlicensed spectrum and consume low power. It is useful for selective data offloads. It lower setup and Maintenance costs. Main challenge is limited coverage,

interference management and Security problems.
D2D data offloading is easy to setup it can be connected either on Wi-Fi Macro network. It is used to reduce interference signaling load. It is efficiently used for efficient management of data exchanges and Bandwidth. Security is main issue in D2D data offloading.

IV. CONCLUSION

This paper surveys of the current state of mobile data offloading. Data offloading used for smart data traffic management and to reduce congestion from their networks .Service providers are struggling to manage the data traffic explosion. There are many commercially available offloading options such as Wi-Fi offload, LTE small cells / relay nodes, femtocells, IP flow mobility, DTN-based Network, etc. Simultaneously data hungry applications are increasing so, it is extremely important that operators start evaluating their capacity and networking requirements so as to manage data traffic. Service providers must use different types of offload solutions to heighten quality of service and improving customer experience. Femto cell has interference problem and Wi-Fi has security problems so we can use Integrated Femto and Wi-Fi so as to have Improved Service Performance and Interference Management.

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