Mobile Data Offloading Using Femtocell

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***Abstract*—Developing smart devices and tremendous use of social networking sites has raised a problem of data traffic. To mitigate this issue femtocell are expected in indoor environment. In this paper we have explained data offloading using femtocell via Wi-Fi (Wireless Fidelity) access point. Femtocell are responsible for intra and inter cell interference and increase in energy consumption on entire network in this approach we are making femtocell base station self-configurable in order to make it energy efficient and to reduce interference by adjusting cell radius. As there is no information exchange in macro cell base station and femtocell base station so this is practically suitable for large deployment.**

***Keywords*— Smart Device, Femtocell, Wi-Fi , Data Offloading.**

I. INTRODUCTION

In past few years, increasing smart phone usage created data traffic. This is because of higher demand for social networking sites, entertainment services along with these there is higher demand for full HD (High Definition) screen from user side creating greater stress on network reducing capacity. Mobile users in overloaded network experiences low data transmission and low quality of service hence there is need mitigate network congestion and enhance its capacity this can be done using data offloading technique".

Mobile data offloading: An intuitive approach is to leverage the unused bandwidth across different wireless technologies." It is used as a complementary wireless technology to transfer data originally targeted to flow through the cellular network [3].

In this paper, we propose energy efficient data offloading using self-configurable femtocell. We propose to use femtocell base station in indoor environment to have better coverage and Wi-Fi access point is used as backhaul. Smart devices are connected to femtocell base station instead of macro cell base station. Data traffic is routed through cellular network through Wi-Fi. This helps to reduce strain on network. Macro cell base station is operated and installed by operator however femtocell are by user. This causes interference problem. Unnecessary active mode of femtocell consume more power so our proposed system deals with power reduction and interference cancellation. There is no information exchange in macro cell base station and femtocell base station so this is practically suitable for large deployment and best for simple and practical application. There are several solutions that can be used for traffic management are explained as follows.

II. RELATED WORK

One of the data offloading solution showed that, An Integration of Wi-Fi with cellular network is used to offload data. Here the performance is evaluated at different degrees using loose coupling and tight coupling and also very tight coupling. Main focus of this study is session continuity and issue occurred during handover. Tight coupling is used to overcome this issue. This paper dose not considers Interference issues [2].

Wi-Fi offloading in dense urban deployment is studied in [4][7], writer has proposed three deployment algorithms namely, Traffic Centric, Outage Centric and Uniform Random Algorithm depending on traffic density, number of users and strain on macro base station. This concludes that a user throughput increase with increase in access point density. Indoor Wi-Fi deployment reduce the network outage generated from indoor but this does not consider outer users. Here comparison is made Wi-Fi offloading against femtocell offloading. Wi-Fi offloading is good for higher throughput than femtocell[7] .Example [9] has demonstrated an integration of 3G /LTE(Long Term Evaluation) and Wi-Fi network, here small cells transmit on both licensed and unlicensed band .Integration of LTE and Wi-Fi network is helpful to improve users throughput. No interference, mobility is considered. In NESTO (Network Selection and Traffic Offloading) system the technology specially designed for android mobiles. NESTO provides "ABC" solution that is always connected and provide energy efficient, bandwidth maximization technique good for full dual mode [5][10].

Smart phone energizer is energy efficient technique to provide energy saving up to 40 %to 56%.It is also designed to reduce execution time. For above purpose it uses two modes namely, learning mode and prediction mode [11].Another approach is data offloading for femtocell using cloud computing, this is helpful for energy saving of femtocell device and also mobile device. Femtocell consume more power in data processing, data encryption and hardware authentication. Here above process are offloaded to cloud and power is consumed. This approach is able to traffic management according to interference and mobility via internet. This model consider network security [12].Integration of 3G and WLAN (Wireless Local Area Network) is used to make offload seamlessly. This model consider handover security management. Here we are getting better QoS and improved network performance [14].

Wi-Fi access point and base station uses orthogonal frequency .In example[15] interference issue is not present as it uses successive interference cancellation technology either for Wi-Fi access point or base station or at both[15].Offloading data through Wi-Fi and femtocell , the agreement of mobile network and access point owner is required. To overcome this issue [16], has proposed system integration among one MNO (Mobile Network Operator) and multiple APOs (Access Points) by bargaining system. Proximity based offloading describes methodology of directly connecting client on close proximity that is: device to device communication. This method helpful in reducing power consumed by client and improve capacity of LTE environment [17].Offloading SMS through email reception via internet uses Wi-Fi technology. This reduces SMS congestion. This also improves delay delivery.

Apart from this, Femtocell are deployed to have better coverage area in indoor environment. Femtocells are low power base station having coverage area of few meters. Femto core is connected to cellular network through broadband cable such as DSL (Digital subscriber line) or separate radio frequency channel. It is easy to install no information exchange between macro base station and femto base station. It operates in licenses frequency band [1]. Another technology Wi-Fi operate in unlicensed frequency band. Wi-Fi uses large bandwidth so it can be more promising solution. As every smart device has inbuilt Wi-Fi, no user device up gradation is required. Wi-Fi routers are cheaper and it requires low infrastructure cost.[13][15]. So we are using data offloading in femtocell using Wi-Fi as backhaul.

III. Proposed System

Femtocells are installed by users and macro cell are by operator hence there may be chance of interference. Interference is basically of two types, Femto-to-femto interference and Femto-to-macro interference. In places where the macro cell and femtocell network utilize the same frequency band, the femtocell can create interference with the macro cell. Femtocell consume more power so there is need of saving energy. In this article, we propose to use set of FBS (Femtocell Base station) in heavy traffic area such as public places, multinational companies with single macro base station. Both FBS and MBS (Mobile Base Station) assumed to operate using OFDMA (Orthogonal Frequency Division Multiplexing). Model consist of femtocell and Wi-Fi coverage area with Wi-Fi access point as a backhaul. Mobile devices are directly connected to FBS instead of macro base station. To reduce load on macro base station, mobile data traffic in femtocell coverage area is offloaded through Wi-Fi. This offloading is easy, No need to modify network infrastructure. As femtocell that are connected to macro cell base station will not offload much data traffic so voice and data traffic remains unsolved problem [18]. So we are using Wi-Fi as backhaul for femtocell offloading. Wi-Fi network are mostly used by cellular operator to enhance network capacity and offload traffic.

In example [18] battery life is major issue for mobile devices because connecting through Wi-Fi require more power than connecting to cellular network [22], and we know that installation of femtocell by user causes intra cell and inter cell interference. Here we focus to deal with femto-femto interference and power consumption.

Our algorithm perform self-configuration to reduce power consumption and interference. Our objectives are 1) Relieve load on macro base station. 2) Improve overall network capacity and maximize total coverage within specific area of femtocell. 3) Improve QoS(Quality of Service) by reducing femto-femto interference. 4) Reduce total power consumption of femtocell base station and make FBS and mobile user energy efficient. All this can be achieved by using self-configurable and self-optimizing femtocell coverage area by adjusting cell radius according to received signal strength by FBS.

IV. System Architectire

A.Components

Our framework consist of UEs, set of FBS, macro BS, Wi-Fi access point(Wi-Fi coverage) with Wi-Fi transmitter.

SD: Any smart device having cellular interference. Consider set of user equipment's SD={ SD1, SD2, SD3,...........}

FBS- Consider set of FBS deployed in public places that can serves up to 60 users. It is preconfigured to accessible Wi-Fi access point.

Macro cell BS- Regular MBS for cellular coverage.

Wi-Fi Transmitter - An antenna installed in environment to connect Wi-Fi access point.

B.Decission Parameters

FBS parameters are used to control power are explained as follows, Noise level on uplink frequency is level of uplink frequency band measured by FBS due to transmission of each active user linked to any base station present in macro cell area. Wideband SINR (Signal to Interference plus Noise Ratio) measured by each users connected to FBS.

C. Operational Steps

Power control mode of FBS are Sleep mode and Active mode. In Sleep mode FBS is in power saving mode it switches off FBS power (UPLINK_NOISE<=THRESHOLD_NOISE).

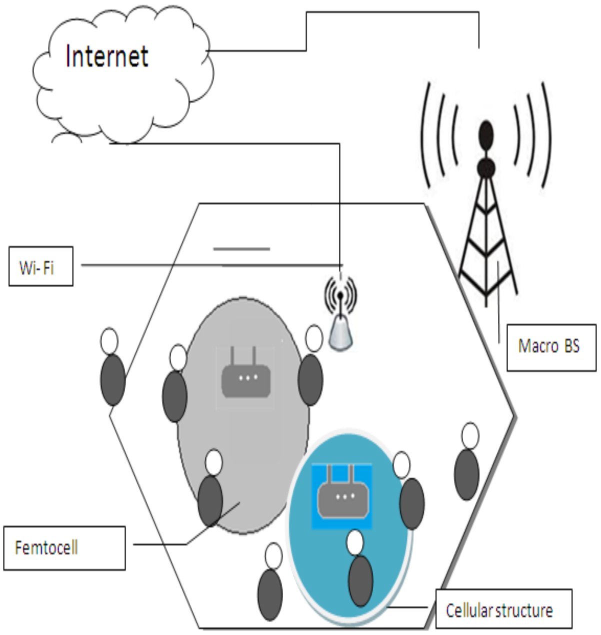


Figure 1: Architecture of system

Depending on onsite traffic demand and received signal strength FBS goes in Active mode (UPLINK_NOISE >THRESHOLD_ NOISE).To reduce interference cell radius is adjusted using Received signal strength.

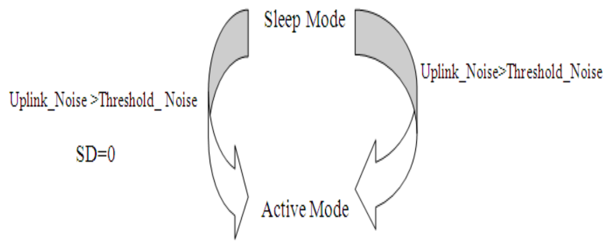
Power Control and Interference Cancellation Listen Mode

When SD comes in sensing range of sniffer connected to MBS, sniffer detects rise of received noise power. THRESHOLD_ NOISE is threshold value used to avoid unreasonable activation of idle femtocell.

Initial Power Setting-

When sniffer detect rise in received noise power that is UPLINK_NOISE<=THRESHOLD_ NOISE, FBS switches on its transmission and associated processing providing cell coverage with initial radius R_i.

Here FBS sets initial transmit power to such a value that a user located at edge of femtocell with radius $R_i n_i$ receives, same power by nearby MBS.FBS check UPLINK_NOISE, SINR and compare them with threshold values and go find optimal configuration situation. Meanwhile FBS adjust its radius depending on RSSI, In case user suffer from high level of interference due to overlapping coverage area of adjacent FBS, FBS dynamically decrease power I and thus (coverage) while, if no SD is connected to FBS, FBS switches to sleep mode (UPLINK_NOISE < THRESHOLD_ NOISE) .Here power consumption is decided based on site traffic demand and accepted SINR level of currently connected users.



In Active mode for data offloading following steps are as follows shown in Figure 2: (1) Trigger stage, (2) Classify stage, (3)stage and (4) Offload stage.

In the Triggering stage, when SD_i enters the coverage of FBS; a trigger to offload will be initiated based on a predefined network condition (e.g. FBS's RSSI(Received Signal Strength)). When the trigger condition is satisfied, the SD_i sends a request to be transferred to FBS.

In the Classification stage, the serving macro-BS receives the request of the SD_i then checks its status. The status of a SD is "idle" when it has neither a voice call nor a data session, and is "active" when it has either. If the status of SD_i is idle, it remains connected to the serving macro-BS. However, if its status is active, the macro-BS will then check if SD_i has a voice call or a data session. For a voice call, the SD_i remains connected to the macro-BS. Yet, if it has a data session, the macro-BS will classify the users' data request in different classes based on the applications priority, where Cn has the highest priority in C. For example, video streaming users will be given the highest class Cn, while HTTP users will be given the lowest priority C0, and so on.

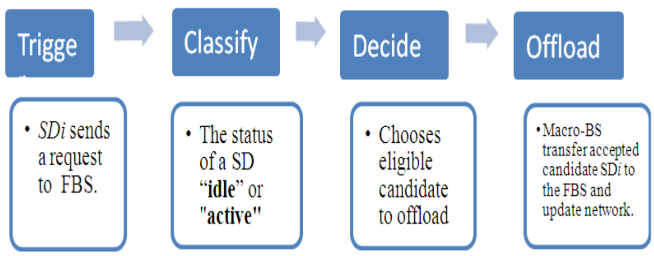


Figure 2 : Operational steps

In the Decision stage, after the FBS receives a candidate user SD_i to offload, it chooses which eligible candidate user to offload from the macro-BS based on two conditions. First, the current number of smart devices connected to FBS i.e SD_f should be less than the maximum number, $SD_{fmax,}$ a FBS can accommodate simultaneously.

In the offloading stage, the macro-BS will transfer the accepted candidate SD_i i to the FBS and update the network. There are some cases where Wi-Fi coverage is not available or the signal strength degrades below a certain threshold. Then the FBS will ask the macro-BS to transfer the set of users associated with it.

We consider framework consisting of regular macro BS at 300 m2 and set of FBS i.e. 5 installed in public place, the environment of 60X 40 m2 should have Wi-Fi transmitter, Wi-Fi access point as backhaul. FBS can serve max 60 users. FBS's received signal strength indicator is triggering condition as in any cellular network smart device should communicate with BS that has highest RSSI. So when a smart device enters in FBS coverage it will sense the FBS's higher RSSI due to short distance between smart device and FBS, smart devices will report FBS's RSSI to serving macro BS and send request req_i.

Algorithm 1: Power consumption and interference cancellation mode

1. FBS in sleep mode
2. If UPLINK_NOISE < THRESHOLD_ NOISE then
   FBS come in active mode
3. Smart device send request to FSB
4. FBS measure received signal strength and accordingly set femtocell radius
5. Endif
6. End

Algorithm 2: Classification at micro-BS

Input: *Req_i*: a request by SD_i to switch to FBS

1. Receive a Req_i from a SD_i
2. **If** SD_i is active **then**
3. **If** the SD_i has a voice call **then**
4. Ignore // i.e. keep connected to the MBS
5. **Else if**
6. C_i = Classify SD_i based on application types
7. **If** (**Decide** (Req_i) = = Accept) **then**
8. Transfer SD_i to the FBS
9. **Else**
10. Ignore
11. **Endif**
12. **Endif**
13. **Else**
14. Ignore
15. **Endif**
16. **End**

Algorithm 3: Decision at FBS

Decide ($DReq_i$)

Input: $DReq_i$: is a data user request from a SD_i associated with its C_i

Output: Accept/Reject: message sent to MBS to transfer/keep a SD_i

Initialize: SD_f –User connected to FBS
SD_{fmax}- Maximum user connected to FBS

1. Receive a $DReq_i$ from MBS of SD_i
2. **If** $SD_f < SD_{fmax}$ **then**
3. Accept SD_i
4. $SD_f = SD_f + 1$
5. **Elseif** $SD_f = SD_{fmax}$ **then**
6. **Reject** SD_i
7. **If Wi-Fi coverage is not found then**
8. transfer SD_i to the MBS
9. **Else**
10. Offload
11. **Endif**
12. **Endif**
13. **Endif**
14. **End**

V. Conclusion

Femtocells and Wi-Fi networks are seen as promising solutions to enhancing coverage and capacity, and offloading traffic in currently overburdened cellular networks. In this paper, we propose a data offloading framework for cellular operators by utilizing mobile femtocells and Wi-Fi. Our proposed framework utilizes urban Wi-Fi APs to be used as backhauls for FBSs installed in public places .Using Wi-Fi AP we are offloading data traffic using FBS .This increase network capacity and reduce strain on macro cell base station. We used interference cancellation method and power consumption modes for making system suitable for practical deployment environment.

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