

# A Survey on Mobile Data Offloading in Heterogeneous Networks

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**Abstract:** An extra ordinary increase in the mobile applications, data traffic is becoming a major issue in the network. With use of smart phones, laptops and tablets gradually increase the mobile data traffic. Now a day various solutions are available to recover this problem. Mobile data offloading and heterogeneous system is used for controlling data traffic and improves the performance, user mobility and coverage ratio. Mobile data offloading reduces difficulties on the cellular network and provide the solution with low cost. In this paper, we present a complete survey of Mobile data offloading techniques and extract the offloading functional requirements for today's mobile network.

**Keywords:** Mobile data offloading, heterogeneous system, user mobility, coverage ratio, cellular network.

## I. INTRODUCTION

Due to the smart phone usage the monthly mobile data traffic exceeds 10 exabyte's in 2016. The recent capacity of cellular network is not adequate to manage such an exponential data growth of mobile. This is very important to find alternative techniques to effectively solve mobile data traffic problem. The most significant solution is increase the capacity of network or upgrading the network. The capacity of network is increased by adding the number of base stations with small cell size like Femtocells and picocells . Mobile data offloading is also known as wifi offloading. Wifi offloading is complementary network technologies which transfers the original data to designated cellular networks and reduce the data band width on cellular network and release the other user's bandwidth. Wifi technology has several advantages while compared to a primary offloading technology. Wifi is able to provide similar data rates and achieves high energy competence than the cellular network. Wifi access points (APs ) [2] installed easily and quickly with a less amount of cost. Wifi offloading is the best solution to reduce mobile data traffic. Wifi data services are more efficient to cellular users. Wifi hot spots are extensively cheaper than upgrading the network. Many homes and workstation are installing the Wifi APs to reduce data traffic and lowest cost. The address of wifi offloading is time –to – capacity that provides the additional capacity to network.

### Types of Offloading

1. On the spot offloading
2. Delayed offloading

### On the spot offloading

On the spot offloading[10] provides the connectivity between wifi and on the spot data transfer. On the spot offloading is the common way of offloading where the wifi is not available then traffic is transmitted to the

cellular network. The benefits of on-spot-offloading are availability, performance and user mobility.

### Delay offloading

Delayed offloading the wifi is available then traffic is delayed to sometime threshold. Delayed offloading[19] provides the flexibility and performance gains to bother user and operator. Queuing analytic model and 2D Markov chain model produce the delayed offloading, average delay and performance such as deadlines.

### Key aspects of Wi-Fi offload

1. Implement the wifi offload solution by increasing the wifi footprint[15].
2. Enhancement and challenges of user equipment.
3. User interaction and authentication with network entities for charging and policy implementation.
4. Considerations of Seamless inter-network mobility.

### Wi-Fi offload - UMTS core network

UMTS[16] core network data traffic offload using wifi are depends on IWLAN. GPP system based Access Control and Charging, Service Continuity, Access to 3GPP CS Services, Common Billing and Customer Care are covered by IWLAN. User equipments are connected to UMTS RAN or WLAN RAN. 3GPP core network provide the authentication. The authentication is achieved without manual interference is main the aim of IWLAN. It is achieved by authentication protocols like SIM card. 3GPP network operators are very familiar with SIM based authentication. Currently the SIM based authentication done by WLAN networks. The 3GPP authentication protocols are EAP-SIM (Extensible Authentication Protocol-SIM), EAP-AKA (Extensible Authentication Protocol-Also Known As) and EAP-AKA" protocols. Another important aspect of wifi is mobility management. The mobility function is based on DSMIPv6.DSMIPv6 is

a protocol of mobility management and standard of IETF. Mobility protocol allows WLAN access to 3GPP access or vice versa.

**Drawback**

- 1) In the core network the policy and Qos management entities are not connected to Home Agent (HA).
- 2) UE is a single radio connection.

**Wi-Fi Offload - Evolved Packet Core network (EPC)**

EPC is tightly inter working[2] that provide the high level integration between cellular technologies and WLAN. EPC is a non 3 GPP stan. dard.EPC architecture is similar to IWLAN but it has additional functionality as Packet Data Network Gateway (PGW), Home Agent functionality. Policy and charging rule function (PCRF) is connected to different gateway function. Operator policies are equivalent to functional policy of PCRF. EPC mobility function is depends on 1) IP-flow basic or IP-flows with PDN. 2) Non – Seamless or Seamless described by 3GPP standard of TS 23.401. GTP protocol provide the Handover interfaces as S2a,S2b,S5 and Handover solution between the access networks as 3GPP and Non – 3GPP. TS 23.261 are used DSMIP protocol to provide the IP-Flow mobility. DSMIP allows different access networks to different IP-Flows.

**Hotspot**

Hotspot is the popular technology of Wi-Fi Association. It's also known as Wi-Fi certified Pass point. Hotspot 2.0 focuses on automatically discover the Access points that arrange the roaming connection with user home network. Hotspot 2.0[18] uses the seamless mobility for user WLAN to another WLAN or cellular WLAN to RAN.IEEE 802.11u, IEEE 802.1X, IEEE 802.11i, selected EAP methods are the enabling protocols are Hotspot. The pre-association dialog uses two enabling protocols as Access Network Query Protocol (ANQP) and Generic Advertisement Service (GAS) between the user equipment and network.

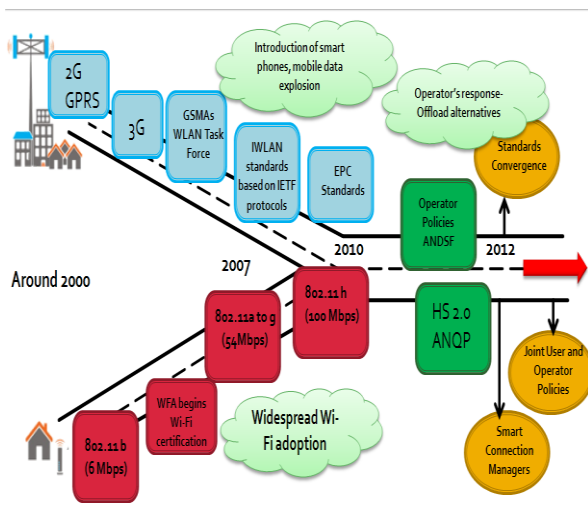


Figure.1 Wifi architecture

**II. HETEROGENEOUS NETWORKS TECHNOLOGIES**

Heterogeneous networks are increasing the capacity of mobile network. Heterogeneous network[4] is a collection of multiple radio access technologies, architectures, transmission solutions, and base stations of different transmission power. The design of Heterogeneous network is based on 3 perspectives: Demand perspective, supply perspective and Commercial Perspectives. Demand perspectives are traffic volumes, locations and data rate. Supply perspectives are radio environment, macro-cellular coverage, site availability. Commercial Perspectives are technology competition, business models, and marketing and pricing strategies. The different heterogeneous cellular network technologies are GPRS, EDGE, HSPA, LTE.

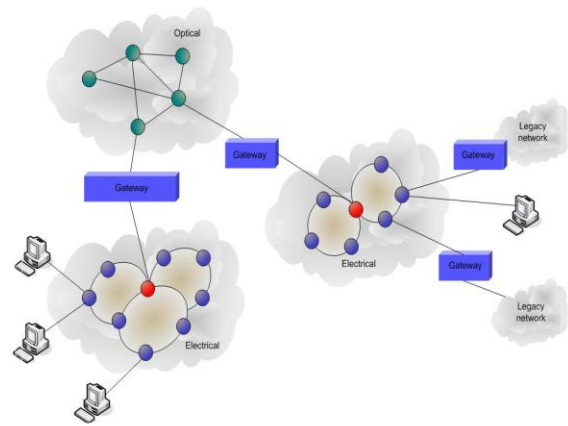


Figure.2 Heterogeneous cellular network

**LTE**

LTE technology[9] is IP based network which increases the loading on data packet and high data rates in networks. Data offloading is important to LTE Advanced (3GPP Release 10). LTE has two essential aspects. 1) LTE – Advanced provide the high data rates compared to 3 GPP release 8 /release 9 and increasing the EPC demands of data capacity.2) LTE – Advanced is an existing architecture, which needs a simple upgrades for install. Data usage is increasing between subscribers which affect the cellular networks. To recover this problem the 3GPP Release -10 is working on 3 areas such as LIPA, SIPTO and IFOM.

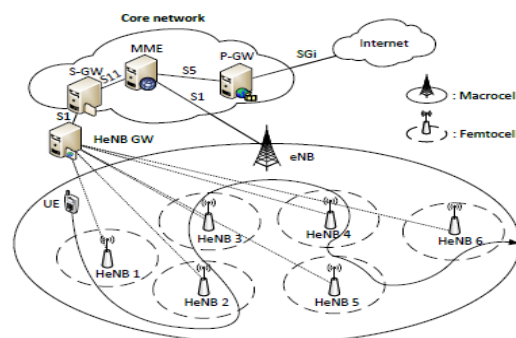


Figure.3 Architecture of LTA

**LIPA**

Local IP Access (LIPA)[13] is a simpler architecture connected to local networks. It is designed to manage the IP traffic. It mainly focus on local IP network to IP traffic locally. LIPA introduced by 3GPP Release-9, the functions and procedures are continued by 3 GPP releases 10. LIPA is handled by LIPA work item in 3GPP. LIPA is UE connected method to H (e) NB (Home node B or Home enodeB ) is capable of transferring the data between local network to same H(e)NB system without data transfer to macro network. LIPA is able to access the external network which is connected to local network. The LIPA function is network controlled function. LIPA is closely connected to Femtocells .LIPA is not suitable to access macro networks. To access the macro network it requires L-GW function

**SIPTO**

SIPTO Selected IP Traffic Offload (SIPTO)[11] is a network specified policy. It directly supports IP traffic offload to the internet. SIPTO is introduced by 3GPP Release 10. SIPTO is handling by SIPTO work item in 3GPP. SIPTO support Femto and macro network. SIPTO is a method of IP traffic on H (e) NB / cellular network. Cellular network gateway is closer to UE which reduces the system load. The function of SIPTO is network controlled function. The radio congestion is not supported by SIPTO offloading. SIPTO requires additional functionality for implementation. Traffic offload selection is based on operator policies.

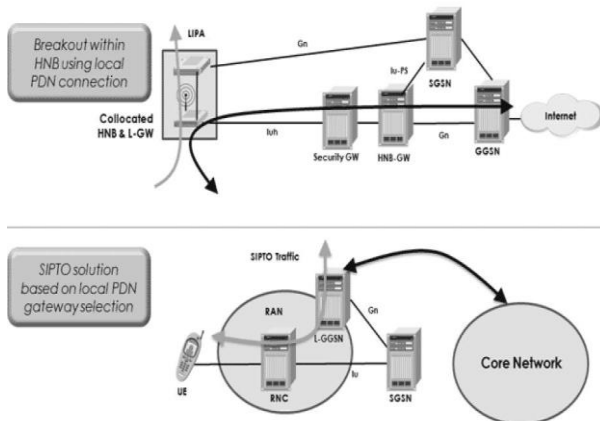


Figure.4 LIPA and SIPTO technologies

**IFOM**

IFOM is introduced by 3GPP Release 10. IFOM is handling the MAPIM[11][13] (Multi Access PDN Connectivity & IP Flow Mobility) work item in 3GPP. IFOM is a technique where the UE can add or delete the data sessions when ever access data offloading. Data offloading is highly transparent compared to LIPA and SIPTO. IFOM support the congestion of radio and core network but require the additional DSMIPv6 and Wifi. The implementation of IFOM is very difficulty compared to LIPA and SIPTO.

**GPRS**

The service of GPRS is packet based wireless communication. GPRS[8] data transfer rate is 56 k bps to 114 k bps. Mobile communication is based on Global system. The cost of GPRS service is less than service of circuit switch. The service of GPRS is 2.5 G and 3 G. The GPRS support the virtual private network (VPNs), blue tooth and packet based protocol of x.25 for providing the continuous private network service. GPRS structural design and mechanism is similar to GSM network but it has additional packet data transmission. So GPRS is called as Packet based mobile cellular network. GPRS require new Mobile Station (MS) for handling packet data. BSC require Packet Control Unit (PCU) and software upgrade. Physical and logical data interface is provided by PCU. The GGSN acts like router or an interface to external network. The SGSN is responsible for mobility management, mobile registration. The Combination of Sub Network Dependent Convergence Protocol (SNDPCP) and Logical Link Control (LLC) used in SGSN and the MS. The SNDPCP reduce the radio channel data load and packet encryption is providing by LLC. The GPRS allow the Quality of Service (QoS) like service precedence, Reliability, Delay and Throughput.

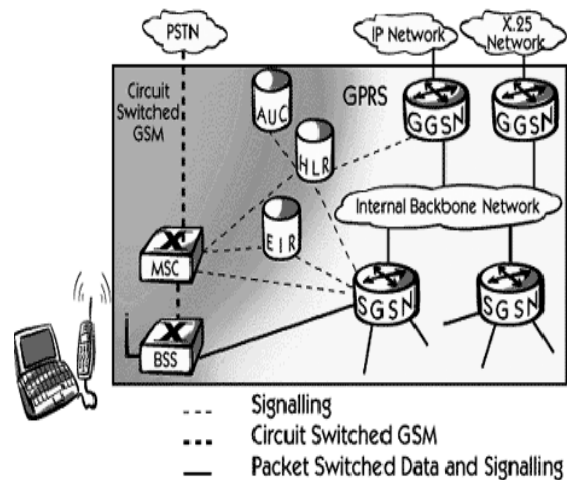


Figure.5 GPRS – Architecture

**EDGE**

EDGE (Enhanced Data rates for Global Evolution) is advanced technology of GSM radio access. EDGE[14] service is 2.75 G and the data rate is 384 Kbps . EDGE increases the throughput rate to 1.3 bps for down link and 653 kbps for up link also improves the efficiency of spectral. The EDGE is three time faster than GPRS system. The researchers support both network and phone.

**HSPA**

HSPA is a High Speed Packet Access. HSPA[26] is based on 3G technology and UMTS standards. It's otherwise known as 3.5 G.HSPA has the fast uploading and downloading capacity. The maximum speed of HSPA is 14 Mbps. The technology of HSPA is High Speed Uplink Packet Access (HSUPA), Evolved High Speed Packet

Access (HSPA+), High Speed Downlink Packet Access (HSDPA). HSDPA&HSUPA is a 4 G technology. Both [HSDPA&HSUPA][25] down load rate is 168Mbps. The two protocols of HSPA is high speed down link packet access (HSDPA) and high speed up link packet access (HSUPA) that are used to improve the performance of 3G utilize the WCDMA protocol. HSDPA allow the Universal Mobile Telecommunication System (UMTS) for achieve high data rate and capacity. HSDPA depends on shared channel transmission, multi-code transmission, hybrid automatic repeat request (HARQ), transmission time interval (TTI). HSUPA is an evolution of UMTS process. Packet scheduler is used by HSUPA. HSPA increase the packet data performance by upgrade the FDD and TDD. HSPA is a combination of HSDPA and Enhanced UL.

### III. ALGORITHM FOR HETEROGENEOUS NETWORK

#### RAT

RAT (Radio Access Technologies)[29] support the quality of service (QoS) and radio resources that provided by Common Radio Resource Management (CRRM). The major role of RAT is identifying the incoming call and verifies the incoming call is fit into the heterogeneous network. RAT guarantees the QoS for accepted call. The standard call admission control algorithm is suitable for homogeneous wireless network and they do not provide the solution for heterogeneous fitness problem. In the same coverage areas different RATs are coexisted in heterogeneous network. This problem is recovered by RAT selection algorithms that select the suitable RAT for requested calls. RAT selection algorithm focus on input (criteria), decision making (RAT algorithm) and output (admitted call).RAT selection algorithms are random based, load-balancing based, service-class based, service-cost based, path-loss based, policy based, layer based, non computational intelligence and computational-intelligence based.

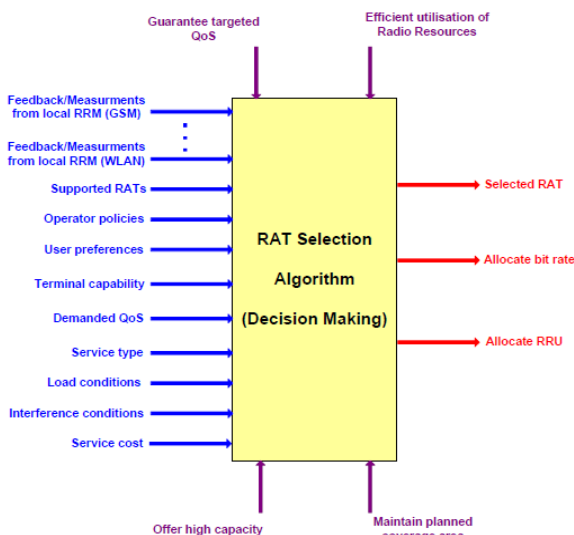


Figure 6.RAT Selection Algorithm

#### Greedy Algorithm

The greedy algorithms[22] contain two phases: 1) allocation phase and payment phase. The allocation phase select the access point and the mobile customer generates the maximum amount of offload data traffic. The payment phases first sort list the unused Access point (AP) and establish the price paid to the owner. The critical access point is referred and the price is assigned to the owner based on critical value. The time complexity of greedy algorithm is  $O(n^2m)$ .

#### Dynamic Load Balancing Algorithm

The Heterogeneous network load is balanced by Dynamic Load Balancing Algorithm (DLBA).DLBA[30] is also called as Adaptive algorithm. Reference Signal Received Power [RSRP] is detected in every Base Station cell by UEs . The difference between base stations is not considered when the detection is Macro Base Station [MBS] or Pico Base Station [PBS]. The HetNet access function is calculated by UEs and connects to the Base station.

#### SAW

SAW Simple Additive Weighting (SAW)[3] is also known as scoring method or weighted sum method or weighted linear combination. SAW is a simple and mufti attribute decision method. The SAW depends on weighted average method. The evaluation score is calculated for each scaled value with attribute weights assign by decision method by adding the product of all criteria. The requirement of SAW is objective identification, alternatives, sub objective weight, value of weighted partial preference, sensitive analysis. Normalized value is used to calculate the numerical attribute score. This value is matching the standardized scale.

#### FEMTOCELL

In cellular network the photocell is cells that contain Femto Base Station (FBS). FBS[28] is a low power Base Station normally installed through end Users.FBS provides the better radio coverage, increase the data capacity and mobile traffic - offload from macro cells. The function of Femtocells is standard spectrum. Femtocells Coverage area is up to a hundred meters and holds the active user up to 10.FBS is normally connected to cell phones and other devices like public transportation systems. In vehicular environment mobile Femtocells provide the enhanced cellular coverage and capacity. The FBS is connected to the Core Network (CN) by macro-BS or satellite communication.

#### PICO CELL

The small cellular base station is called as Pico cell. Pico cell[24] is also known as Access point base station or enterprise photocell. Small areas such as office, building are covered by Pico cell. Pico cells are connected to Base station controller. Pico cell heads are connected to Base station controller. The connection between Pico cell and Base station controller generally consists of in building

wiring or plesiochronous digital hierarchy (PDH)[E1/T1] links or Ethernet cabling. Resource management, hand over functions and Data sent to mobile switching center process are performed by Base station controller. The range of Pico cell is maximum 200 meters. Pico cell provide a small cell's concept for improving mobile user data throughput and mobile network capacity. The Pico cells are offered for technologies as GSM, LTE, ZTE, CDMA, and UMTS.

**Mobile Data Offload - Security Aspects**

Table 1. Mobile data offload – Security aspects

Sl. no	Key Aspects	Description
1	Confidentiality of user identify and device identity[1]	The confidentiality of User identity and device identity between core and UE that providing the frame work and protocol of EAP – AKA.
2	Authentication of Entity	The non-3GPP IP accesses are involved in Entity authentication. The network entity is authenticated by UE entity and UE Entity is authenticated by network entity is called as Mutual authentication
3	Confidentiality of User data and signaling data	MIP and DSMIP protocols provided confidentiality of user data and signaling data.
4	Roaming security	In the roaming security WAG like an anchor between Visited network and home network. The security mechanisms based on authentication policy.

**Challenges of Heterogeneous network**

Heterogeneous network has several challenges in various areas. The Heterogeneous networking devices[20] are supported by new access technologies such 3G, Ultra Wide Band (UWB) and WiMax. The major challenges in heterogeneous network are handover. Handover is important to handle the data packet at all layer and satisfied the seamless data transfer while the network resource might be mobile. Another major issue in heterogeneous network is QoS. The different wireless network has a changeable QoS. As a result affect the vertical handover and Qos connection. It is observed by

protocol stack. Changeable Qos also affect the network performance and transport services.

**IV. CONCLUSION**

This paper presented a survey on the different mobile data offloading in heterogeneous networks. This enables effectively handled the mobile data traffic in network environment. The mobile data offloading techniques and heterogeneous network techniques are combined to detect the data traffic and provide immediate response to the user. This result in the efficient detection and prevent the mobile traffic.

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