A survey on recent trends in mobile data offloading techniques

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Abstract:

The mobile data traffic has grown exponentially due to availability of smart phones at affordable prices and wide internet usage. Today internet usage has become a necessity more than a luxury. The cellular operators are finding many ways to handle this traffic by upgrading cellular infrastructure which is expensive and through offloading mobile data traffic using femtocells and Wi-fi. Many researchers have provided cost effective and efficient solutions on mobile data offloading. We provide a survey on different mobile data offloading techniques by classifying them into homogeneous and heterogeneous offloading. This survey helps to find the technical aspects of different mobile offloading techniques and possible enhancements or benefits related to them.

Keywords: Mobile data offloading, wi-fi Aps, Femtocells, cellular networks

1.Introduction:

Due to Smartphone availability under $100 prices, there is a proliferous growth in availability of these devices in all developing countries which have added tremendously to the world's data traffic. The cisco global mobile data traffic says the data traffic has reached 7.2 exabytes per month in 2016 from 4.4 exabytes per month in 2015.It is forecasted that by 2021 mobile data traffic will reach 49.0 exabytes per month[1]. This report specifies on the indispensible need for cost efficient and feasible offloading techniques to relieve the cellular network from heavy data traffic load.

In 2016, 60% of mobile data traffic have been offloaded through wi-fi and femtocells . Many surveys have been conducted on different offloading techniques on 3g networks. Video streaming, video and audio downloads ,browsing, social networks and forwarding multimedia content through instant messaging services have contributed majorly to the mobile data traffic overload. Due to this problem the speed of most users go down from 3g to 2g as it is done by throttling connections voluntarily by cellular service providers. The cost of unlimited data plans is not affordable to all and because of that capped data usage plans have been provided by network operators.

Upgrading cellular infrastructure is expensive and the availability of spectrum is

scarce. To overcome these constraints complementary technologies like femtocells and wi-fi are used to offload mobile traffic from cellular network. There are considerable amount of solutions provided to offload mobile data traffic using users mobility patterns by selectively upgrading cellular infrastructure and through deploying low cost non-cellular infrastructure in an optimal way.

2.Related works

According to F.Rebecchi et al the offloading techniques are done through wi-fi access points and terminal to terminal offloading. In wi-fi based offloading when the users comes under the coverage of wi-fi hotspots the wifi data is enabled and mobile data flows through non spectral radio frequency. In terminal to terminal offloading a subset of mobile phones were chosen by the cellular network and data is passed to them .These mobile phones then using wi-fi and Bluetooth pass the information to the mobile phones in the same base station. He further classified offloading techniques into delayed and non delayed offloading based on Ap-based and Terminal to terminal strategy. His survey provides detailed account on different algorithms for mobile data offloading using delayed and non-delayed mechanisms[2]. A R pawar et al. provides solution to data offloading techniques through technologies like wi-fi ,femtocells(small cellular base station which uses licensed spectrum to cover indoor areas and cover areas where the cellular range is not strong which is a plug and play tool) , IP flow mobility(when multiple data flows happen in the mobile phone using cellular network and when the phone reaches a wi-fi hotspot, the data flow automatically changes to wi-fi network and when coming out of the hotspot range the data flow changes to cellular network), disruption tolerant networking(here the cellular network offload the common information like downloads to a subset of offload helpers who in turn propagate the data to other devices through short range device to device communication) and LTE small cell and Relay (it operates with both licensed and unlicensed spectrum by deploying LTE cells and wifi access points as a backhaul to the core network)[3] . Han et al propose mobile data offloading as one of the solution for accelerating content delivery as mobile bandwidth is comparatively low when compared with DSL and other wireline Networks. The team summarise on different techniques proposed by other researchers for offloading through opportunistic communications among devices and through metro scale wi-fi. They further summarise on network aggregation based data offloading techniques viz. Ptcp (group bandwidth of different networks by aggregating different radio interfaces), MAR(Mobile access router aggregates bandwidth of multiple WWAN networks and can be accessed by users through short range communication like wi-fi and Bluetooth) and Super aggregation(it aggregates radio interfaces but assigns each

with different tasks based on their link characteristics)[4].

3. Homogeneous offloading

Homogeneous offloading is upgrading cellular infrastructure without going for any supplementary technologies. Thus the cellular operator has control over the mobile offloading.

3.1.Delay tolerant based offloading

I.Trestian et al came with a concept of drop zones which is an up gradation of selective base station works using the mobility pattern of the nomadic users. The drop zones among the base stations are greedily selected which gives near optimal solutions. The drop zone mainly works based on the idea that lots of content generated are delayed before uploading. Example photos taken in mobile camera are not immediately uploaded to social network sites like facebook and flickr. The upload is delayed minimum for 10 hours and maximum for few days. So based on the delay timing the number of drop zones to be installed differs. Lower the delay higher the number of drop zones to be implemented. When delay time is high the user movement is high and thus less drop zones are required for uploading. The DropZone equipment is installed in the base station cellular network. Once the cell phone detects the drop zone, by sending packet and obtaining reply from special ip address such as 0.0.0.0 and the postponed content is uploaded. In this system the static users who majorly stay in one place say home will not be able to use drop zone unless their home is covered under drop zone area. When the drop zone area is congested at peak hours, not all users will be serviced by the same drop zone efficiently, so the users should be routed to nearby drop zones by considering their mobility pattern. A user interface with a limited upload or download for a particular drop zone and based on their mobility pattern showing nearby drop zones using app like google maps will help in providing such solution[5].

Wang et al adds a module called smart transfer to the android operating system to upload delay tolerant contents at a favorable network condition which is predicted using user profiles for individual users. For different kind of users the smart transfer adapts accordingly. The smart transfer framework contains three components, a profiler, scheduler and API as shown in Fig1. The profiler consist of time stamped log files, the scheduler generates a decision table using profiler information to determine when to initiate content transfer. The mobile apps contact the smart transfer framework through API and submit the contents to be uploaded with their delay tolerance rate. Here mobile data offloading takes place using cellular infrastructure up gradation alone. When the app senses high signal strength the data is offloaded in that base station[6].

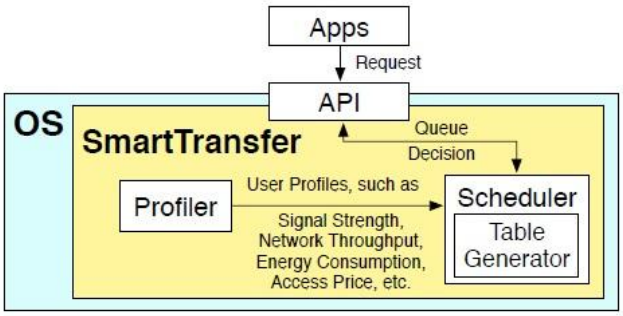

Fig1. Smart Transfer Framework [6]

3.2.Femtocells based offloading

Qutqut et al are the first to use the concept of offloading cellular operator traffic using femtocells with wi-fi as a backhaul through which the traffic is routed instead of the loaded macrocells. This offloads 50% of mobile traffic from cellular base station when the load is heavy[7].A R pawar et al also uses the similar technique[8].

4.Heterogeneous offloading

Heterogeneous offloading is done through supplementary technologies like wi-fi, D2D communications. Here we mainly focus on offloading techniques using wi-fi. Lee et al discuss about two types of wi-fi offloading, on the spot and delayed offloading. On the spot offloading opportunistically uses wifi access and delayed offloading waits for a fixed time and transfers all accumulated data when it move to the wifi access.

4.1.Prediction based offloading

Most offloading techniques use delayed transfers for content uploading and downloading. Some contents are time crucial and are to be uploaded at real time. Sometimes the mobile users are impatient to wait for a wi-fi connection to offload the contents. In such cases we need a balance between cost, delay and throughput. This balance or trade-off is realized through AMUSE(Adaptive bandwidth Management through User Empowerment), a functional prototype developed by Im et al. It is a user side, automated wi-fi offloading technique. When the user can't wait for wi-fi it allows the application to send or receive data using 3g network. When the application is delay tolerant and within a specified timeline if it get access to wi-fi , the data is offloaded there. If the timeline is crossed before reaching the wifi –spot, then the data is transferred through 3g network. AMUSE has an user interface through which the user can set the maximum 3g data usage and maximum dalay tolerances for different applications. The user interface has an app usage data history. It uses a bandwidth optimizer which makes offloading decisions for the user by predicting wi-fi availability at future times. It predicts wi-fi availability in future locations that the user is going to visit using time and location dependent probabilities. It works better then on the spot offloading algorithms as it delays contents for a fixed time and better than delayed offloading by shifting to cellular network when certain application sessions are not delay tolerant.

Thus delayed offloading delays all the applications irrespective of their session needs which is rectified in AMUSE[9].

4.2.Multi mode mobile data offloading:

Komnios et al. Introduces CEMMO(cost effective multi- mode offloading) which uses markov process for user mobility and connectivity prediction. Using this prediction, the data transfer request sent to the cellular operator contains certain parameters like DTI (delay tolerance indicator), data size,user probability to visit any other region and wifi- connectivity probabilities. CEMMO uses three modes of communication to offload mobile data traffic, they are Delay tolerant offloading (DTO), Peer assisted offloading (PAO) and transfer through 3G network. Many works have used DTO but here Success probability of using DTO and Success probability of using PAO is calculated to determine which transfer policy to use within DTI. The peer assisted offloading is a concept first time used in CEMMO where the source node send its data for upload through intermediaries. A storing region is setup where the source node sends the data to be uploades to the user nodes in the same region and replica of data is sent to all user nodes within the region. When any of the user node moves to near-by region containing wi-fi connectivity, it uploads the data. The cellular operator sends a notification to the source node that the data is uploaded and all other user nodes discards the replica when DTI expires. If the notification is not received by the sourec node within DTI time, then the data is sent through 3g network. Its offloading capacity is compared with DTO and on the spot offloading (OTSO). OTSO is opportunistically used. It offloads better than DTO in certain simulated conditions where the Wi-fi cost provided by cellular operator is nearly equal to 3g cost. Besides efficient offloading it saves energy consumption by avoiding frequent direction to energy – intensive 3g network[10].

4.3.Efficient ways of wi-fi Ap deployment

Dimetto et al focuses on efficient number of wi-fi Aps to be deployed to offload cellular traffic by opportunistic offloading using MaDNet architecture[11] .E.Bulut et al proposes an efficient offloading technique by better deployment of Aps to cover real time data traffic. The user area is divided into number of grid cells which is further subdivided into sub grid cells as a sub region of high density mobile request cell tower may not produce high data requests as a sub region of low density cell tower as shown in Fig 2. So Apps are deployed to small frames with high density mobile requests greedily within the large cell area which provides promising solution for future mobile data offloading [12].

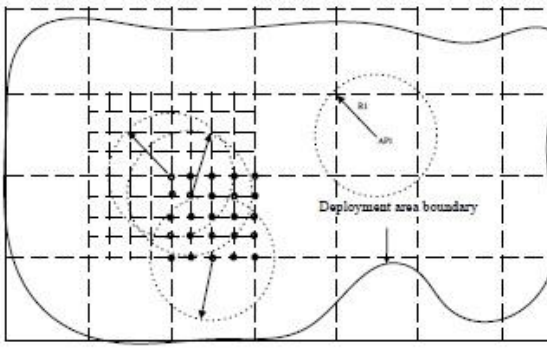

Fig 2. Efficient AP deployment in grid cell [12]

Conclusion:

This survey provides lot of mobile data offloading techniques that are mainly improvements over previous offloading techniques available. There are instances where Femtocells and WiFi which uses different spectral frequency are combined to provide mobile data offloading. Some techniques concentrate on tradeoffs between cost-throughput-delay in offloading. We have categorized offloading techniques based on improvement done to cellular infrastructure or using femtocells which uses the cellular spectrum of base station and other on offloading using supplementary technologies like wi-fi and device to device communication on Bluetooth. This survey focused on the recent improvements made over the existing offloading techniques and the benefits are discussed.

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Biography:

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