Scientific Journal of Impact Factor(SJIF): 3.134

e-ISSN(O): 2348-4470
p-ISSN(P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 2, Issue 5, May -2015

A Survey on Load Balancing in Mobile P2P System in 3G Cellular Network

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Abstract — *The idea of traffic localization is applied in mobile peer to peer (MP2P) system in WLAN networks still be effective to reduce the cross cell traffic. But, the idea of traffic localization is applied in cellular networks; it will not be effective and even encounter problems. So traffic localization in mobile P2P system in cellular networks actually makes no sense to reduce cross cell traffic. Moreover, in cellular networks the overall radio link bandwidth in each cell is limited. Thus too many peers choosing from single cell would degrade the peer performance because bandwidth allocation for each peer would be small. So, for peer selection optimization in mobile P2P system in cellular networks, cell load must be taken into account. That is peer selection should achieve load balance on the cell. So, in this paper we describe various peer selection algorithms for load balancing in mobile P2P system in cellular network.*

Keywords- *MP2P, 3G Cellular Network, Peer Selection, Load Balance*

I. INTRODUCTION

Cellular Networks have been around since the 1980s and each year their subscribers increase at a very fast rate. First generation (1G) networks were the first cellular networks introduced in the 1980s. They were only capable of transmitting voice at speeds of about 9.6 kbps maximum. 1G system had some limitations such as no support for encryption, poor sound quality and inefficient use of the spectrum due to their analog nature. Second generation (2G) cellular networks also known as personal communication services (PCS) introduced the concept of digital modulation meaning that voice was converted into digital code, and then into analog (radio) signals. Being digital, they overcame certain limitations of 1G system. Although 2G systems were a great improvement from 1G, they were only used for voice communication. The Third generation (3G) standard is currently being pushed as the next global standard for cellular communications. It will provide services such as fast Internet surfing, advanced value added services and video telephony [1].

The aim of 3G network is to provide a worldwide standard and a common frequency band for mobile networking. The bandwidth and location information available to 3G devices gives rise to applications not previously available to mobile phone users. Some applications are Mobile TV, Video on demand, Video conferencing, Telemedicine, Location-based services, Global Roaming.

P2P [2] application has recently become very popular in fixed Internet. Peer to Peer services, like file sharing and communication services are well known for most of the fixed internet. P2P protocols allow peers to connect directly to each other without any interference from a central server. This enables many kinds of P2P applications. First, P2P networks can be used for example for traffic-intensive file sharing, since the heavy traffic is between the peers and there is no central server limiting the total traffic in the network. Second, there is P2P Internet telephony that is analogous to the first application. Here, the voice or video streams correspond to the files. Third, P2P networks can be used also for less traffic-intensive information search and sharing purposes. BitTorent is a new generation of peer to peer file sharing system and has become the most popular for file sharing [3]. One of the key issues in P2P technologies is peer selection, which means choosing other peers for data transmission for the requesting peer. Peer selection has great influence on peer performance and traffic distribution in the whole network. Traditional P2P networks treat all the peers equally and the peers which have the requested data copies will be selected randomly by the DHT algorithms [4]. This kind of peer selection ignores the underlying network information and thus may bring huge cross-ISP or cross-domain network traffic, which will put great burden on Internet backbone bandwidth. So, some algorithms or mechanisms have been proposed for optimizing peer selection in P2P networks. In, Bittorrent clients try to find the total content copies stored by all intrdomain peers. If the intra-domain peers have 100% of the requested data, the clients will stop trying to connect the peers in outside domains. Clients can also select peers using the algorithm proposed in [5] by taking the following factors into account: the hop count, RTT, and link bandwidth between the requesting peer and the other peers. This kind of algorithm can also reduce the cross-domain network traffic.

The idea of traffic localization applies to mobile P2P systems in cellular networks. Since it may reduce cross cell traffic. When idea of traffic localization is applied in mobile P2P system in WLAN cellular networks still be effective to reduce the cross cell traffic, since each AP can be seen as a switch in LAN and peers in the same cell can connect to each other directly through the Ap. But when idea of traffic localization is applied in mobile P2P systems in 3G cellular

network, it will not be effective and even encounter problems. In 3G cellular networks, peers in the same cell cannot connect to each other through the 3G base station, all traffic pass through GGSN (Gateway GPRS Support Node), which is responsible for connecting multiple cell to each other over IP, so traffic localization in mobile P2P systems in 3G cellular networks actually makes no sense to reduce cross cell traffic.
Moreover, in 3G cellular networks the overall radio link bandwidth in each cell is limited. Thus too many peers choosing from single cell would degrade the peer performance because bandwidth allocation for each peer would be small. So, for peer selection optimization in mobile P2P systems in 3G cellular networks, cell load must be taken into account, and number of peers chosen from a single cell should be limited. That is peer selection should achieve load balance on the cell.

The rest of this paper is organized as follows. In section II describe the architecture of 3G cellular Network. We describe different peer selection for load balancing in cellular Network such as UTAPS algorithm, A novel Peer Selection algorithm based on FPCD, Random Peer Selection, PSANIC algorithm, CFLB algorithm, and DBaT algorithm in section III. Finally, we summaries our paper in section IV.

II. ARCHITECTURE OF 3G CELLULAR NETWORK

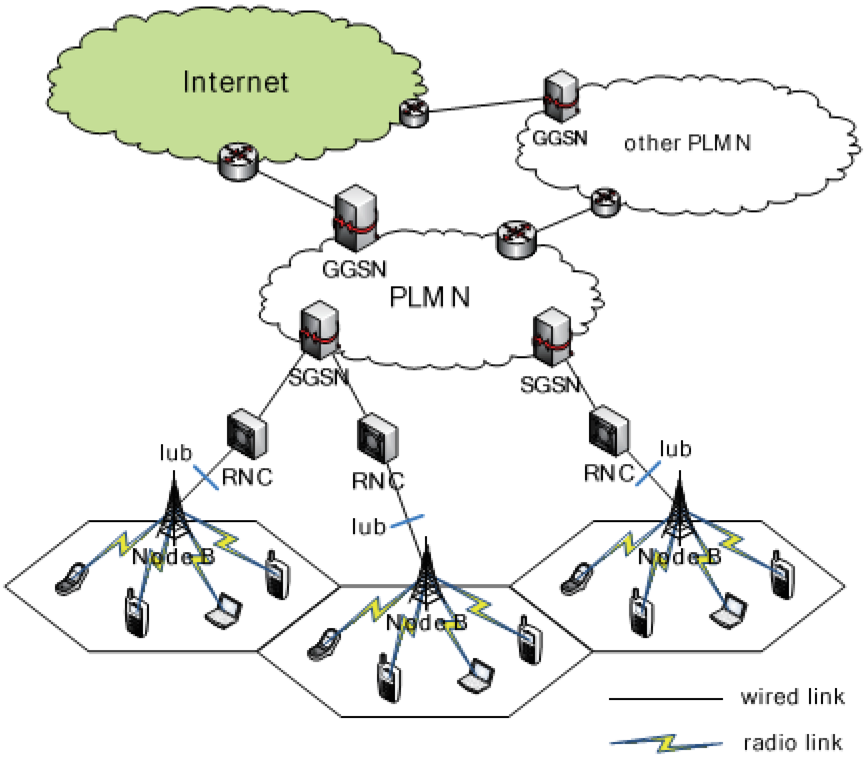


Fig.1. Architecture of 3G cellular network [10]

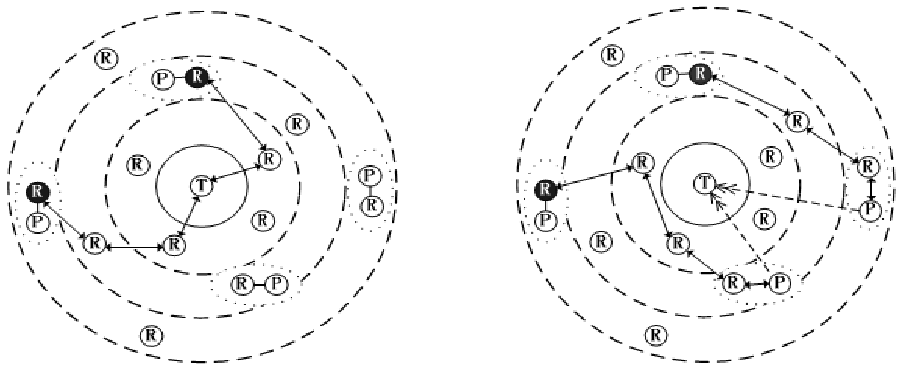
Fig.1. shows the architecture of a 3G cellular network. A 3G cellular network is mainly composed of two parts: the RAN (Radio Access Networks) and the PLMN (Public Land Mobile-communication Network). RAN implements a radio access technology and PLMN providing land mobile telecommunications services to the public. An RAN comprises an RNC (Radio Network Controller), some Node Bs (base station in 3G cellular networks) and some lub interfaces between the Node Bs and the RNC. RNC is responsible for controlling the Node Bs that are connected to it. Each Node B covers a certain area, which is usually called as a cell. The total radio link bandwidth provided by a Node B is limited. For example, this value is 2Mbps in WCDMA systems. A PLMN is also called as the Core Network in 3G cellular networks. In fact, A PLMN can be divided into two parts: the CS domain (Circuit Switched domain) and the PS domain (Packet-Switched domain). Since in 3G cellular networks the CS domain is used for voice services and has nothing to do with data services, so only present the PS domain in Figure. The PS domain in a PLMN is mainly composed of some SGSNs and some GGSNs. A SGSN holds the location information of each mobile device in its service area, and its main function is to forward IP packets for these mobile devices. A GGSN is used for connecting a PLMN to exterior data networks such as Internet, with the main function of IP data packaging and routing. In mobile P2P systems in 3G cellular networks, a tracker, which can be either a ptracker or an itracker, is deployed in each PLMN. The tracker connects with GGSN and SGSNs in the same PLMN, maintains information of all peers in the PLMN, and is responsible for returning a peer list to the mobile device which has sent a data request to the tracker.

III. PEER SELECTION ALGORITHMS

3.1 UTAPS algorithm

An Underlying Topology Aware Peer Selection (UTAPS) algorithm [6] wh ich could select peers by taking the knowledge of underlying topology into consideration .so, UTAPS algorithm selects Peer within small hop count and low round trip time (RTT) range by utilizing the knowledge of underlying topology. There are two main parts of UTAPS: inferring the underlying topology and peer selection based on the inferred underlying topology. So, UTAPS algorithm achieve better individual performance in download time and efficient use of resources in ISP's backbone in sense of traffic injected into ISP network.

3.1.1 Underlying topology inferring. The paradigm of inferring the underlying topology is illustrated in Fig.2. First use network tomography technique to infer the underlying topology. This is a straightforward step in which a tool as Traceroute is used. Each time when a new peer joins, the tracker traceroutes the new peer and gets some knowledge (e.g. the router's IP address, the RTT and hops from some peer to the router) of the underlying IP topology (Fig.2 (a)). With the number of peers increasing, the tracker acquires more accurate information of the underlying IP topology.
But, in the underlying IP network, a router may have many interfaces with different IP address; therefore, and by Traceroute, we can find these different IP addresses but cannot tell whether they belong to the same router. To solve this problem, the most straightforward way is taking different addresses as different routers. Generally, there are many peers are attached to a single router's interface (subnet). Peer selection algorithm can work well by returning peers which are close In UTAPS algorithm, by synthesizing the information from peer tracerouting peer and tracker tracerouting peer, the tracker can tell the accurately relationship between interface and router in most cases. Since the file delivery is directly occurred between peers, peers also traceroute the peers in the peer list returned by the tracker and then report the results to tracker for optimal purpose (Fig.2 (b)). In Fig.2 the nodes in the dash ellipse are peers attached to the same router. Based on the knowledge of underlying topology, tracker utilizes the topology information from the 'sights' for each router. The sight of a router contains other routers which are within certain hops or RTTs. More specifically, the sight of a router represents what it can 'see' within certain hops or RTTs.



(a) Traceroute from tracker (b) Traceroute from Peer

Fig.2 paradigm of inferring the underlying topology [6]

3.1.2 Peer selection. Different ways or sequences of utilizing the RTT sights and hop-sights of router can lead to different instances of peer selection algorithms. Hence, get a family of peer selection algorithms. This family of heuristics for peer selection tries to accelerate the file delivery by reducing RTT (by finding peers with small RTT) and reduce the cross-ISP traffic (by selecting peers within small hops).

3.2 A novel peer selection based on FPCD

BT traffic is main component in P2P traffic. In order to control the BT-like P2P traffic and reduce their bandwidth occupancy at some key location such as gateway, in this paper, a peer selection algorithm based on file piece convergence degree (FPCD) is brought forward [7], which takes BT as an example. Applying this algorithm, BT-like P2P traffic between networks can be controlled and reduced heavily. In this way, the traffic congestion between networks brought by BT-like P2P downloading will be alleviated greatly.

BT system is made of tracker, downloader and seed. Tracker returns a peers list for each peer to help it finding other peers. A file that will be transferred in BT system is cut into some pieces which have the fixed size, and each piece is cut into some blocks. The information about the file and tracker is put into a file whose suffix name is 'torrent'. The peer selection algorithm in BT system is determined by piece selection algorithm, namely, 'Rarest First' and 'Strict Priority' algorithm.

During the downloading process, peer *A* which was selected at random from peers in BT system continues to receive the 'have' message from its neighbors. We call the pieces needed to be downloaded as the interested pieces. Peer *A* has a counter which is used to count the numbers of 'have' message for every interested piece. When peer *A* receives a 'have' message, the corresponding counter adds 1. The piece which has the minimum 'have' message number will be chosen to download. That is to say, the corresponding peer will be chosen to download. That is called 'Rarest First'. During downloading process, peer *A* records the pieces which have been downloading, the blocks of these pieces are requested firstly, this is called 'Strict Priority'. BT keeps sending several requests (usually 5) in pipelining way at the same time. Each request asks for downloading a block.

3.3 Random peer selection

According to the Bit Torrent file distribution system, a peer that wants to download a file (i.e. a leecher) gets a random list of peers (i.e. potential seeders) from an application tracker. It selects its seeder randomly from that list. Sometimes a downloading leecher does not find expected content from its selected seeders and then it seeks another set of seeders with help from the tracker. The basic responsibility of a tracker is to maintain the list of participating seeders and provide support for them. In other words, in this selection algorithm a seeder has been chosen randomly without consulting the network layer.The main advantage of the random algorithm is that the leecher needs no information about the underlying network. This allows the P2P client to be very simple. However, it results in decreased application performance and poor utilization of the network resources, because the number of ISP hops between the leecher and the seeder can be arbitrary [8].

3.4 PSANIC algorithms

P2P technology can transmit data more efficiently and make better use of network resources, things like file sharing and Instant Communication become much easier and convenient in P2P environment. Traffic of P2P applications occupies much of bandwidth in bottleneck links, non-P2P applications may be severely harmed due to lack of bandwidth. To conquer this problem, previous algorithms mainly focused on blocking the P2P traffic to benefit the ISPs, or optimizing peer selection algorithms which can only benefit the P2P applications but ignore the influence to the network. But, PSANIC (A Peer Selection Algorithm with Consideration of Both Network Topology Information and Node Capability in P2P Network) algorithm is to optimize peer selection in P2P networks with consideration of not only network topology information but also node capability [9].

Definition of cost, which is determined by the node network information from the source node to the destination one and node capability, is the key for our sorting and selection. Thus, give attention to both alleviating the network workload and improving the P2P performance.

Definition 1: The total cost from the source node to the destination node can be defined as follows:

$$Cost = \delta 1 \times C_{net\_info} + \delta 2 \times C_{node} \quad (1)$$

Where, C_{net_info} is the cost calculated according to the node network information,

C_{node} is the cost depending on the node capability.

Δ1 and δ2 are the weight coefficients which can be adjusted and depends on the negotiation between P2P and ISPs.

The two terms presented in (1) are explained in part *A* and part *B* separately:

A. Cost determined by node network information

The network information includes two aspects: the AS where the object node locates in and the type for the node access to the Internet. Thus the C_{net_info} should be calculated in both of these two aspects. It is reasonable to assume that parameters for node access are almost the same because these intra-AS nodes have the same PoP and media access mode. Definitions for cost based on these two aspects are shown as below:

Definition 2: The cost between AS for request node and AS (Autonomous System) for candidate node, which depends on the link status, can be defined as follows:

$$CE_{ij} = \frac{\mu_1}{Bandwidth_{ij}^{eq}} + \mu_2 + \sum_i^j Delay + \mu_3 + \sum_i^j Hop \quad (2)$$

Where, CE_{ij} represents the cost just depending on the link status information between AS I and AS j.

$Bandwidth_{ij}^{eq}$ represents the equivalent bandwidth between AS *I* and AS *j*.

$\sum_i^j Delay$ represents the total delay from the source AS *I* to destination AS *j*

$\sum_i^j Hop$ represents the number of the router/switcher hops from source AS *I* to destination AS *j*

μ_1, μ_2 and μ_3 which can be determined through the negotiation between different P2P applications and ISPs, are the weight coefficients to calculate CE, and they reflect the importance of different parameters.

Definition 3: The cost for node I which belongs to certain AS accessing to the Internet can be defined as follows:

$$CP_i = \frac{n_1}{Bandwidth_i^{AC}} + n_2 + Delay_i^{AC} + n_3 + Lost_i^{AC} \quad (3)$$

Where, CP_i represents the cost for nodes which belong to AS I accessing to the Internet.

$Bandwidth_i^{AC}$ is presented for the access bandwidth of nodes which belong to AS *i*.

$Delay_i^{AC}$ represents the delay for nodes which belong to AS *I* accessing to the Internet.

$Lost_i^{AC}$ represents the packet loss rate for nodes which belong to AS *I* accessing to the Internet.

Like μ_1, μ_2 and μ_3 mentioned above, n_1 , n_2 and n_3 are also the weight coefficients for different access parameters and they reflect the importance of them.

Besides the cost of links between different Ass in the core network, the access cost Cpi for the source node I and the access cost CP_j for destination node j.

Definition 4: The total cost Cnet _ info, which based on the node network information between AS I where the request node locates in and AS j where the object nodes locate in, could be defined as follows:

$$C_{net\_info} = CE_{ij} + CP_i + CP_j \quad (4)$$

B. Cost determined by node capability

Although the nodes in the same AS have almost the same access information, the number of connected sessions may be different and change along with the time. In other words, the available bandwidth and the data transferring delay may be different among these candidate nodes. Thus their capabilities are different. If the P2P redirector wants to get the intra-nodes information of their connected session numbers to calculate the node capability.

Definition 5: The cost determined by node capability can be defined as follows:

$$C_{node} = \frac{\gamma_1 * NUM_{Total}}{(NUM_{Total} - NUM_{Con}) * Bandwidth_i^{AC}} + \frac{\gamma_2 + SegSize + NUM_{Total}}{(NUM_{Total} - NUM_{Con}) * Bandwidth_i^{AC}} \quad (5)$$

Where, The first term in formula (8) shows the cost due to the available bandwidth. The second term in this formula shows the cost due to the data segment's transferring delay.

NUM_{Total} represents the maximum session number of nodes and NUM_{Con} represents the connected session number.

SegSize represents the size of data segment which need to upload to other nodes.

γ_1 and γ_2 are the weight coefficients.

After getting the C_{net_info} and calculating the cost of node capability, will get the total cost for a candidate node. We can select the less key nodes as the response nodes. Because the total cost takes both the network information and node capability into account, we have found the balance between reducing the AS-cross traffic and optimizing the node performance.

3.5 CFLB algorithms

A peer selection algorithm named CFLB (Cell First for Load Balancing) [10] for mobile P2P systems in 3G cellular networks always chooses a peer with the highest available uplink bandwidth from a cell with the lowest traffic load until the number of peers is reached. CFLB algorithm, which is implemented at the tracker in a PLMN in 3G cellular networks and works after the peers holding the requested data copies have been found by the tracker. Moreover, before the CFLB algorithm works, the tracker must be aware of the following information: the location and available uplink bandwidth of each peer it has found, and the traffic load on each cell that these peers are located in. Such information can be obtained from GGSN and SGSN, which hold the information of each mobile device and cell in the PLMN. Specifically, the available uplink bandwidth of each peer can be measured statistically by the network or reported by the peer itself. Assuming that the tracker needs to choose *n* peers from *m* peers that hold the requested data copies (*n* < *m*), the CFLB algorithm will work in the following steps:

1) Make a list of the cells that the *m* peers are located in, and the list is arranged in ascending order of traffic load on each cell;
2) Choose a cell with the lowest traffic load in the list;
3) Choose a peer with the highest available uplink bandwidth in the cell chosen in step 2);
4) Recalculate the traffic load on the cell chosen in step 2) according to the available uplink bandwidth of the peer chosen in step 3);
5) Repeat step 1) to step 4) until *n*, the requested number of peers, is reached.

With the help of CFLB the tracker can select appropriate peers for load balancing while assuring favorable peer performance. After the CFLB algorithm is performed the traffic load on the cells in a PLMN is remarkably more balanced and CFLB algorithm can also achieve better peer performance.

3.6 DBaT algorithms

In mobile cellular networks, the bottleneck of file transfer speed is usually the downlink bandwidth of the receiver rather than the uplink bandwidth of the senders .This is because the sum of the uplink bandwidth of multiple serving peers is often greater than the downlink bandwidth of a requesting peer. So, for peer selection in P2P file sharing systems over mobile cellular networks, it is unnecessary to always choose peers with high uplink bandwidth. Motivation is that, since the file transfer speed is limited by the requesting peer's downlink bandwidth, some other performance indicator such as load balance on cells should be focused on.

In P2P file sharing systems the requesting peer's demand can be divided into two cases, one is that the requesting peer demands a lower bound of the sum of the selected peers' uplink bandwidth and the other is that the requesting peer demands a certain number of selected peers We consider the two cases both and two algorithms for the two cases respectively. The first one is named DBaT-B (Downlink Bandwidth as Target, Bandwidth satisfied), and the second one is named DBaT-N (Downlink Bandwidth as Target, Number satisfied). Major features of our algorithms can be described as follows. DBaT algorithms First, they take the requesting peer's downlink bandwidth as the target of the sum of the selected peers' uplink bandwidth. Second, they choose a cell with the lowest traffic load before choosing each peer. Difference of the two algorithms lies in using different criteria in each peer selection round to satisfy the different demand. Moreover, we also provide a Fuzzy Cognitive Map (FCM) [11] that can be used in our algorithms to estimate peers' service ability according to multiple influential factors [12].

IV. SUMMARY

In this paper, a survey of various peer selection algorithms for load balancing in mobile peer to peer system in 3G cellular network was given. This paper also describes the architecture of 3G cellular network. First, describe UTAPS algorithm which selects Peer within small hop count and low round trip time (RTT) range by utilizing the knowledge of underlying topology. The novel peer selection algorithm based on FPCD in BT system is determined by piece selection algorithm, namely, 'Rarest First' and 'Strict Priority' algorithm. RS algorithm select peers randomly and needs no information about the underlying network. PSANIC (A Peer Selection Algorithm with Consideration of Both Network Topology Information and Node Capability in P2P Network) algorithm is to optimize peer selection in P2P networks with consideration of not only network topology information but also node capability. CFLB algorithm always chooses a peer with the highest available uplink bandwidth from a cell with the lowest traffic load until the number of peers is reached. DBaT algorithms First, they take the requesting peer's downlink bandwidth as the target of the sum of the selected peers' uplink bandwidth. Second, they choose a cell with the lowest traffic load before choosing each peer.

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