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SURVEY ARTICLE

A Survey Paper on Multi-Homed Services Satisfying QoS in Heterogeneous Wireless Access Networks

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Abstract: Multi-homed services in heterogeneous wireless access networks are quite popular nowadays, which results in the increased usage of multi-interfaced devices. In a networking environment with the presence of both single and multi-homed network for Resource Allocation, the best available wireless access network at its location is assigned for the single network and all the available bandwidth is utilized by the multi-homing network. Fair Queuing with Deficit Round-Robin, provides fair sharing of network resources. Use of available multiple paths with minimized end-to-end delays and packet reordering between the source and destination are provided by Effective Delay Controlled Load Distribution. Due to the wide usage of multi-homed services, battery drain is the major problem. Thus, Dynamic Load Distribution and Packet Reordering, meets the Quality of Service (QoS) under delay-constraints resulting in Power-Efficiency (reduces power consumption).

Keywords: Heterogeneous Wireless Access Networks, Load Distribution, Delay Minimization, Packet Reordering, Power Consumption

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I. INTRODUCTION

Multi-homing refers to a computer or device connected to more than one computer network with different access capabilities, to increase the reliability of an internet protocol network, such as a user served by more than one internet service provider. For multi-homed services, with effective radio resource allocation [1] for the networks connected to the devices, available bandwidth can be utilized efficiently from each of the available wireless access networks. Fairly allocation of resources [2] among the networks in a multi-homed environment can reduce the contention of resources. For the transmission of packets from source to destination with the presence of multiple paths between them, each of the available multiple paths can be utilized effectively to minimize the delay during the packet transmission resulting in load distribution with effective delay control in multipath networks [3] and along with packet reordering [4] can result in the reduced power consumption meeting QoS requirements.

II. LITERATURE SURVEY

1. Decentralized Radio Resource Allocation

In a heterogeneous wireless access medium, radio resource allocation provides mechanisms for the allocation of bandwidth and call admission control in order to satisfy the Quality of Service (QoS) requirements for efficient utilization of available bandwidth from these available heterogeneous wireless access networks.

1.1 Two types of Services

In a heterogeneous wireless access medium, radio resource allocation provides two types of services namely,

- Single-network service
- Multi-homing service

1.1.1 Single-Network Service

A mobile terminal (MT) is assigned the available best optimal wireless access network in its location in a single-network service, where the available bandwidth from the best assigned wireless access network is utilized [5], based upon the received signal strength [6] or the bandwidth available [7].

The drawback of using single network service is that, if the assigned network to the mobile terminal (MT) at its location does not satisfy the bandwidth required by the incoming call, the call is blocked resulting in increased call blocking rate. Thus multi-homing service is preferred.

1.1.2 Multi-homing Service

For multi-homing services [8], a mobile terminal (MT) utilizes the required bandwidth from all the available wireless access networks in its location using its multi-homing capability.

The advantage is that, available resources from different networks are aggregated together to provide service to the required data rate requested by the application.

Even with multi-homing capability on the MT, using multi-homing services requires the presence of sufficient energy at the mobile terminal. In case of scarcity of energy at the MT, service from multi-homing can be switched to single-network and thus the unwanted services/interfaces can be turned off so as to save energy.

The radio resource allocation algorithm supports both the single-network and multi-homing services with a constant bit rate and variable bit rate services.

1.2 CORA and DSRA Algorithms

Two algorithms are used for radio resource allocation.

- Centralized optimal resource allocation (CORA) algorithm
- Decentralized sub-optimal resource allocation (DSRA) algorithm

1.2.1 CORA Algorithm

In Centralized optimal resource allocation algorithm [9], different networks operations are controlled by a central resource manager [10] for both single and multi-homing networks. The central resource manager is provided with the information's such as service type, service class, and home network through the Base Stations/Access Points (BSs/APs) using multi-homing capability. Based on these information's, the central resource manager determines the maximum and minimum required bandwidth for the MTs.

The issues of CORA algorithm are,

- Maintenance and operation of the central resource manager will be handled by which network.

- Required changes in the structure of networks to adapt to the structure of the central resource manager.
- Single point of failure of the central resource manager.

1.2.2 DSRA Algorithm

For efficient resource allocation and call admission control, decentralized sub-optimal resource allocation algorithm is used for both single and multi-homing networks based on the arrival and departure rate of the call to reduce the call blocking rate, opted for different networks operated by different service providers. On call traffic prediction and network cooperation, DSRA algorithm provides efficient resource allocation switching between single and multi-homed services, thus utilizing the available bandwidth to service the requested bandwidth for the applications in MTs.

2. Fair Queuing with Deficit Round-Robin

A technique that allows the flow (stream of packets) to pass through the network device with sharing of network resources to be fair is called Fair Queuing (FQ). In older techniques, it takes O(log(n)) to process a packet. But using fair queuing with deficit round-robin [2], it takes O(1) to process a packet. Normally the packets are queued during transmission using First Come First Served (FCFS) queuing services.

2.1 Nagle's Solution

Nagle [11] identified each flow that is about to pass through the network device using source and destination address and uses separate queue for each flow and services them in a round-robin fashion.

The issues with Nagles's solution are,

- If the packet arrival rate from source is high, then the number of queues for the flows, increases drastically resulting in the dropping of packets.
- Size of the packet is not considered.

2.2 Fair Queuing

Problem with Nagle's solution is solved by an algorithm called bit-by-bit round-robin (BR). In BR, the transmission of flows takes place bit by bit in a round-robin fashion.

The issue is that, bit-by-bit transfer of flows takes long time and is very expensive.

2.3 Stochastic Fair Queuing

In stochastic fair queuing (SFQ) [12], the incoming packets are mapped to their corresponding queues using hashing techniques with queues services in a round-robin fashion. If the buffer size is large, flow collision is reduced fairly.

The advantage is that,

- Number of queues are less than the number of flows since flows hashing to the same bucket are put into same queue instead of a separate queue per flow.

The drawbacks includes,

- Hashing may result in collision of flows.
- Packet size is not considered.
- Small buffer size may result in dropping of packets at the end of the queue.

2.4 Deficit Round-Robin

Unfairness in the queues being serviced in a round-robin fashion in constant time are due to the flows with different packet sizes. Deficit Round-Robin (DRR) uses stochastic fair queuing (SFQ) to assign the flows to the queues and processes/services the queues in a round-robin fashion in constant time.

The difference in how round-robin and deficit round robin works is that, the quantum remaining in a round or not carry forwarded to the next round in round-robin technique, whereas in deficit round-robin, the quantum remaining in previous round are carry forwarded and added to the quantum in the next round efficiently.

Fig. 1 depicts the operations of deficit round-robin. The queue consists of two packets. One packet of size 65 and other packet of size 75 with quantum size of 70. Initially DC value is set to the quantum size.

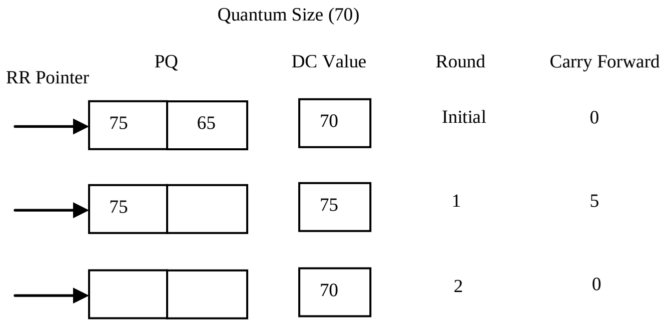

Fig. 1. Deficit Round-Robin

where RR Pointer is Round-Robin Pointer, PQ is Packet Queue, DC Value is Deficit Counter Value.

In 1st round, first packet of size 65 is transmitted and thus 5 of quantum size is carry forwarded to the second round. In the 2nd round, the next packet is transmitted based on the quantum size added with carry forwarded value. Then next queue is processed. In the fig 1. Only one queue is showed.

Various figures of merit to measure the fair queuing algorithms are fairness measure (FM) and work. FM measures the fairness in servicing the queues. Work measures time taken to service a queue fairly.

The advantages of deficit round-robin are,

- Handles flows with different packet sizes.
- Implemented at low cost.
- As the number of flows increases the throughput is perfectly fair even with random packet sizes per flows.
- Regardless of different traffic patterns, DRR achieves perfect fairness.

3. Effective Delay Controlled Load Distribution

To provide service for the real-time applications and multimedia applications, network capacity and Quality of Service (QoS) constraints are the major demands. In heterogeneous wireless access networks with the presence of multiple paths, effective data transmission [3] is made possible. Inefficient load distribution in multiple paths results in load imbalance and packet reordering problems. Before assigning load to each path in the network of multipaths, capacity of paths such as bandwidth and buffer size have to be determined. Load imbalance may result in imperfect load distribution across multiple paths in the network. On receiving of all packets at the destination from multiple paths in the network, requires packet reordering. If all the packets are received at the destination within the receive timeout period, transmission is successful and packet delay is avoided. Else would result in loss of packets and packet delay. Higher the packet delay, higher the risk of packet reordering. Packet delay is nothing but the end-to-end delay time and packet reordering recovery time.

3.1 Round-Robin Based Schemes

In Deficit Round-Robin (DRR) [13], at each round the deficit counter is incremented by the quantum been carry forwarded from the previous round. Similarly on choosing a path for the transmission of packets, deficit counter is decremented by the packet size. If the deficit counter (DC) holds positive value, then same path is used for packet transmission, else different path will be chosen. If the deficit counters of all the paths are not positive, then a new round is started.

Merits: Efficient load balancing, Starvation free.

Demerits: Inability to maintain per-flow packet reordering.

3.2 Least Loaded Based Schemes

In least loaded based schemes [14], [15], [16] the path with small queue size is served first by the least loaded server.

Demerits: Order of the tasks is not considered which may result in packet reordering problem.

3.3 Flow Based Schemes

Direct Hashing (DH), Table Based Hashing (TH) [17], [18], [19] and Fast Switching (FS) [20] are the various flow based schemes. In DH and TH, based on the packet identifier information obtained from the packet header which is usually the destination address, flows are assigned the paths. In FS, based on flow-path mapping, packets belonging to same flow are passed in same path and if packets of different flow are encountered, different path is chosen.

Demerits: In load distribution across multiple paths in the networks, variations in size of the flow may result in load imbalance problem.

3.4 FBS with Adaptive Load Balancing / Distribution

Load Distribution over Multipath (LDM) [21], Load Balancing for Parallel Forwarding (LBPF) [22] and Flowlet Aware Routing Engine (FLARE) [23] are the various flow based schemes (FBS) with adaptive load balancing.

3.4.1 LDM

In LDM, the paths are chosen based on the path utilization and hop count. The smaller the hop count in the path and lower been utilized, the higher the probability of the path to be selected for transmission of packets.

Demerits: Load imbalance may result due to different flow sizes.

3.4.2 LBPF

LBPF is similar to the DH, in addition it considers the traffic rate of each flow.

Merits: Load imbalance is mitigated.

Demerits: Expensive packet reordering.

3.4.3 FLARE

A flow is split into several subflows, and each subflow is called a flowlet. Based upon the interarrival time and round trip delay of the arriving packets, the packets arriving with in the interarrival time are passed through the same flowlet, else a new flowlet is chosen.

Solutions obtained from flare are,

- Load imbalance is reduced with expensive packet reordering.
- Packet reordering is reduced with high load imbalance.

3.5 DCLD

In Delay Controlled Load Distribution (DCLD) [24], a traffic splitting vector is used to distribute the incoming traffic across multiple paths.

Demerits: DCLD does not work well under different traffic conditions.

3.6 EDCLD

Effective Delay Controlled Load Distribution (EDLCD) [3], considers the input traffic rate and instantaneous queue size and determines the traffic splitting vector without additional overhead for distributing the load across multiple paths in the network as shown in Fig.2.

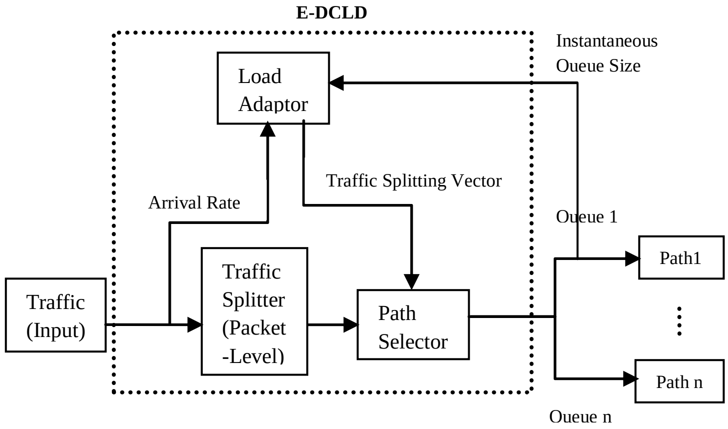

Fig. 2. E-DCLD Model

LLF has very low end-to-end delay based on the queue size whereas FS has large end-to-end delay but load balance is achieved which is not in achieved in LLF. SRR and LLF have high risk of packet reordering than E-DCLD.

The merits of E-DCLD over other algorithms are,

- End-to-end delay is reduced which in turn results in the reduction of both packet delay variation and risk of packet reordering without additional network overhead.
- Since the risk of packet reordering is reduced and is small, packet recovery process also seem to be small.

4. Power Efficient Load Distribution for Multi-homed Services with Sleep-Mode over Heterogeneous Wireless Access Networks

Frequent and long duration usage of multi-interfaced devices causes battery drain in the MTs connected with different types of interfaces such as WiMAX and WLAN, even though sleep mode is employed in the interfaces. To meet the Quality of Service (QoS) requirements under delay constraints, dynamic load distribution [4] is performed to reduce the power consumption.

Reliability and load balancing [1] are the benefits of multi-homing for heterogeneous wireless access networks. Load imbalance and packet reordering are the major problems. Sleep mode is employed in the Medium Access Control (MAC) layer to reduce power consumption [25].

Greedy's with and without packet reordering algorithm is used to achieve the efficient packed reordering at the destination. In Greedy's with packet reordering, reordering of received packets are done at the Medium Access Control (MAC) level. In Greedy's without packet reordering, the received packets are not reordered at the MAC level and hence after the reception of all the packets at the destination, sorting of the packets are done which results in reduced delay and efficient power consumption.

III. CONCLUSION AND PROPOSED WORK

In the paper, the survey is about why multi-homing services with decentralized radio resource allocation are being used and Fair queuing with deficit round robin does efficient assigning of flows to the queues to be serviced by the network and Efficient Delay controlled Load Distribution, distributes the load across multiple paths in a multipath heterogeneous wireless access network with reduced end-to-end delays, packet delay variations and also lowers the packet reordering risk by reducing the packet reordering recovery time.

In a heterogeneous wireless access network with multi-homed services been enabled, the proposed work is to implement the concept of dynamic splitting load distribution and efficient packet reordering (with packet reordering and without packet reordering) in the multi-homed environment to reduce the power consumption while satisfying the quality of service (QoS) constraints.

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