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Enhanced Dynamic Bandwidth Aggregation for Remote Data Transfer Using Concurrent Multipath in Wireless Network

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ABSTRACT

The increasing growth of internet and advanced wireless technologies leads to millions of people to exploit mobile devices, which revolutionized the way of accessing digital information. Most people use mobile data access and data transfer remotely using wireless technologies namely 802.11, *Wi-Fi*, GSM, 3G, WiMax through various network interfaces provided for laptop, notebook, tablet and smart-phone. Many of the multimedia applications like video streaming, online gaming are demanding high bandwidth. The existing mobile devices are using single network interface for data transmission at a time. The restriction on the usage of these available interfaces on the user device as one interface at a time will put a limitation on the flexibility and better utilization. The requirement demand can be met by formation of high speed larger logical link using individual low bandwidth links, thereby reducing the delay and ensuring the reliability of data by using multiple paths in wireless network. This paper proposes dynamic bandwidth aggregation system for remote data transfer through concurrent multipath to achieve increased transmission throughput and reliability.

Index Terms: Aggregation, Bandwidth, Interface, Multipath.

1. INTRODUCTION

With the rapid development of technology and communication networks, mobile devices are becoming more popular for access of information, video streaming, and online gaming. Today millions of people are having rich, digital content access at the fingertips by using mobile devices, smart-phones and tablets. These modern mobile devices are equipped with multiple network interfaces such as 802.11, *Wi-Fi*, GSM, 3G, WiMax, LTE and through various network interfaces for the devices like laptop, notebook, tablet and smart-phone.

Nowadays many of the Internet and multimedia applications like video streaming [10], online gaming, high definition (HD) video services are demanding high bandwidth. The existing wireless technologies differ in terms of services provided such as bandwidth, coverage, price and quality of service support. The existing mobile devices are using single network interface for data transmission at a time. The restriction on the usage of these available resources on interfaces on the user device as one interface [25] at a time will put a limitation on the flexibility and better utilization. The use of multiple interfaces simultaneously, can improve quality and provide support for applications requiring high bandwidth [20]. The bandwidth of an individual interface is not sufficient to meet the required demand. An idea of aggregating the individual low bandwidth links to form a high speedy larger logical link can satisfy the demand there by reducing the delay and ensuring the reliability of data by using alternate communication paths in the heterogeneous wireless network (HWN). HWN is a wireless communication network where internet services can be

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accessed through multiple wireless technologies like WiFi, WiMAX, GSM etc[1-3]. Bandwidth aggregation in heterogeneous wireless network will provide many of benefits for real time applications.

2. BANDWIDTH AGGREGATION AND RELATED WORK

Bandwidth aggregation can be defined as the process of gathering and combining offered bandwidth from the available network interfaces to create a high speed logical link. This link can be used by the applications which require high bandwidth. Maximum utilization of network interfaces can be made by using bandwidth aggregation. Some of the benefits Heterogeneous wireless network with two different access interfaces namely GSM, WiFi and WiMax that are connected through the Internet Protocol is as shown in figure 1 to represent overview of architecture to support bandwidth aggregation through concurrent multipath transfer [24,28]. A multimode terminal, when it is in the overlapping region of these access technologies, can use them simultaneously. Efficient aggregated bandwidth is not utilized by multimode terminals due to varying delay, characteristics of bandwidth of different access technologies. In real time applications, reordering of packets lead to delays, leading to reduction in throughput [7, 8, 21]. However there are many benefits of using bandwidth aggregation [26]. One of them is throughput. Video streaming [30], online gaming, teleconferencing and many more internet applications demand for higher bandwidth. The bandwidth of single access interface is inadequate to support demanding video applications. Increase throughput can be accomplished by using bandwidth aggregation. In bandwidth aggregation multiple paths or channels are used for transmission of data. If any one of the path fails during transmission, the data traffic can be switched to the other unused connection paths. Thus bandwidth aggregation provides increase in reliability. A multimode device can use various wireless technologies simultaneously to provide different range of bandwidths and each technology is being operated independently. Thus bandwidth aggregation increases resource sharing by integration of the limited channel resources available.

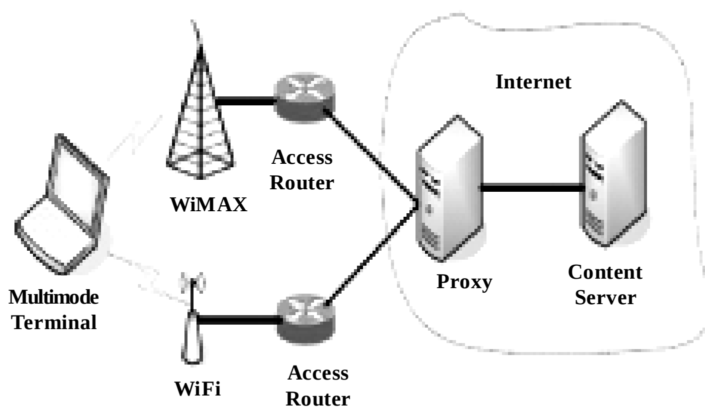

Figure 1: Architecture for bandwidth aggregation

When a client requests for a media stream, proxy server fetches it from Media stream server. A proxy server is connected to multiple paths in network. Each path in network is independent and has specific transmission speed being characterized by following properties [1].

a) Available bandwidth: the number of bits transferred in unit time

b) Round trip time: the total amount of time for sending the data packet and the time for receiving the acknowledgement of that packet

c) The path loss rate: the probability that the packet gets lost in that path Based on the above mentioned factors, transmission capacity for each path is assigned so as to obtain a total optimum throughput. However end-to-end delay of each path varies. While transferring of packets in concurrent multipath, there are more chances of packets arriving as out of order. Therefore the packet scheduling scheme

[11, 12, 13, 15, 27] is suggested to arrange the transmission sequence so as to minimize the delay caused due to reordering of packets [29] at the receiver [9]. The output at the receiver is generated by reordering of packets received through multi paths. This not only aggregates the available bandwidth of multi paths, but also reduces the delay due to reordering of packets at the receiver.

There are mainly two types of bandwidth aggregation namely adaptive and Non-adaptive bandwidth aggregation.

Non-adaptive Bandwidth aggregation: These are basically static links. Static links can be designed and implemented at protocol stacks of different network layers.

Adaptive band bandwidth aggregation: Selection of interfaces is made dynamically based on network dynamics and traffic [14]. The network traffic is characterized by delay, available bandwidth and path loss rate which are considered for making a decision for scheduling of packets. It provides better throughput and link utilization over Non-adaptive bandwidth aggregation. Bandwidth aggregation can be applied to protocol stacks of application, transport, network and link network layer.

Bandwidth aggregation is one of the research areas from many years. Several solutions are given by researchers to provide the service of bandwidth aggregation, Bandwidth aggregation solutions [18] are implemented at different layers of network protocol stack, namely at application layer, transport layer, network layer and link layer [4-6].

Application layer solutions: Improvement in performance and reliability can be enhanced by de-multiplexing data over multiple heterogeneous paths. However this leads to higher complexity at application network layer in view of requirement of handling multiple interfaces at application layer. Application layer solutions are implemented as a middleware between the application and transport layers. Handling multiple interfaces and distributing the different application data across them is taken care by middleware. This middleware may be either transparent or nontransparent. Transparent middleware uses the same interface and semantics as that of transport layer used for the application. This middleware also guarantees the same semantics provided by the traditional transport layer. Non-transparent middleware facilitate the applications with simple API for using multiple network interfaces which require modifications to the applications in order to make use of available interfaces.

Application layer approaches also make use of existing protocols such as http for video-playback. Using http range requests and pipelining in employing bandwidth aggregation by making updates at the client side application layer without server-side changes or updates in the network is proposed [15]. A connection-level scheduling granularity approach is used [16] to enable bandwidth aggregation over existing internet servers and the world-wide web. An approach that works with connection level scheduling granularity but can switch to packet-level scheduling if both ends support it is proposed in paper [17].

Transport layer solutions: TCP [22] and stream control transmission protocol (SCTP) are used in tandem / combination to achieve concurrent multipath transfer (CMT) in heterogeneous access network, as SCTP [23,30] adapts to multi-streaming [28], multi-homing and further it can transmit segments of the application layer via multiple links. However reordering of packets is mandatory at receiver as TCP and SCTP are not adaptive to reordering.

Network layer solutions: Network layer [31] based bandwidth aggregation supports packet level traffic distribution over multiple interfaces. Scheduling of data packets at different interfaces is an important parameter to be considered for bandwidth aggregation. Earliest Delivery Path First (EDPF) scheduling algorithm and packet-pair scheduling for TCP application uses a network proxy which is responsible for parallel transmission over multiple interfaces and reassembling the packets received at receiver [4, 15]. A mobile host (MH) connected to network vide multiple interfaces acquires a fixed IP address from network proxy to directly communicate with the remote server.

Data link layer solutions: Link layer bandwidth aggregation makes a single logical channel with larger capacity by bundling multiple data link channels, for improved performance, Generic link layer (GLL) with multiple radios is used for communicating with a destination node. Cognitive convergence layer (CCL) in which creation of a single virtual link layer interface between higher layers and the underlying real link layer interfaces. Traffic distribution policy is implemented at the sender and a reorder mechanism at the receiver. However, link layer bandwidth aggregation requires special hardware and software, that are limited to local domains.

3. PROPOSED WORK AND RESULTS

A simulated version of multi path environment is set up where multiple machines are connected amongst a wireless local area network. These specific machines are depicted as heterogeneous wireless network mode. Individual machines will have their own transmission rates. The paths along specific machines constitute for concurrent multipath transfer. Aggregation on multipath is done to get accumulated bandwidth. Fig. 1 shows high-level overview of architecture to support bandwidth aggregation through concurrent multipath transfer.

Module1: Creating GUI Frameworks A GUI framework at proxy server is created depicting the multipath environment. It also incorporates mouse click buttons for various user I/O operations. Login screen for admin is created and verified for authentication. Another GUI framework at client side is created enabling end user to send request for desired file. Login screen for user is created and verified for authentication.

Module 2: Network Generation Since this is a simulation process, we first connect multiple PCs in a Wireless Local Area Network. Some of the machines will be acting as medium of transport such as wifi or WiMax and have unique transmission speeds. One of the machines will act as a proxy server for hosting the data packets and other would be the client.

Module 3: Forwarding of Packets When a client requests for a media stream, proxy server fetches it from Media stream server. A proxy server is connected to multiple paths in network. Each path in network is independent and is being characterized by following properties

The available bandwidth : the number of bits transferred in unit time. – The round trip time :the total amount of time taken to send the data packet as well as receive the acknowledgment of that packet.

Module 4: Reordering of Packets

The end-to-end delay of each path varies. While transferring of packets in concurrent multipath, there are more chances of getting packets as out of order. Therefore the packet scheduling scheme is suggested to arrange the transmission sequence so as to minimize the delay caused due to reordering of packets at the receiver [11]. The output at the receiver is generated by reordering of packets received through multi paths. This not only aggregates the available bandwidth of multi paths, but also reduces the delay caused due to reordering of packets at the receiver [20]. As we have performed compression before sending, decompression is done after receiving so as to regain the original data.

The aim of this work is to

- Increase transmission throughput by transferring data through concurrent multi paths.
- Increase resource sharing by integration of the limited channel resources available.
- To increase the reliability by providing alternate path to transfer data.

Results are measured with the following performance parameters.

Packet Delivery Rate: The percentage of packets received by the client with respect to the number of packets sent by proxy server is calculated as packet delivery rate. Comparison of packet delivery rate is as shown in Fig. 2 and it shows 20-30 percent increase in packet delivery rate in the proposed system.

Effective Loss Rate: The number of packets lost during transmission as well as number of packets received after deadline time constitute for effective loss rate. A comparison of packet loss rate is as shown in Fig: 3.

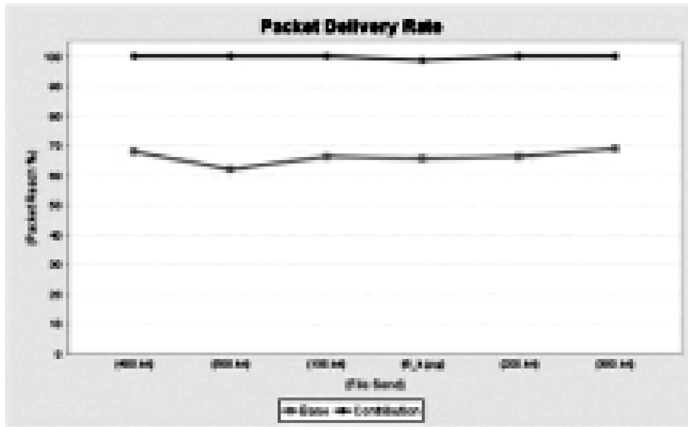

Figure 2: Comparison of Packet delivery rate

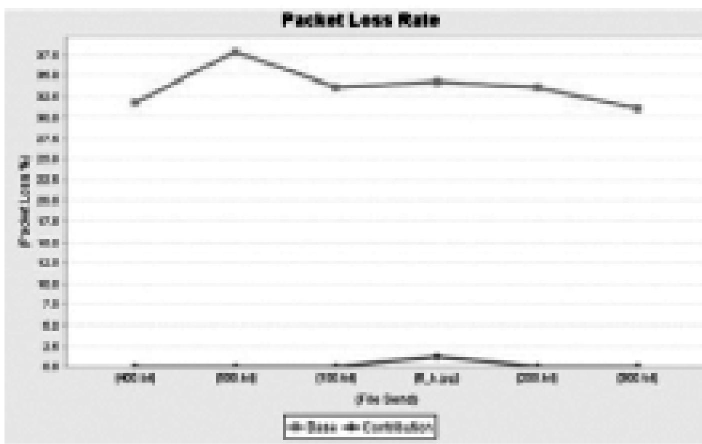

Figure 3: Comparison of packet loss rate

Transmission Time: The time taken to transmit a complete data file is the transmission time. Here as the file id divided into packets and sent along multipath, transmission time is reduced. As we are incorporating compression of file, it further reduces the transmission time. Transmission of various data files of different

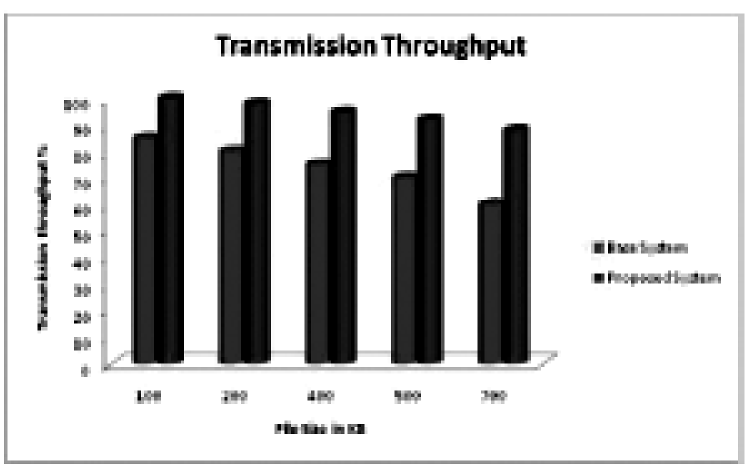

Figure 4: Comparison of transmission throughput

sizes and measure the different parameters considered in previous section. The files varying in size as around 100KB, 200KB, 300KB, 400KB, 500KB, 700KB are considered and transmitted. Transmission throughput percentage is calculated as percentage of ratio of total number of bytes received to total number of bytes sent. The graph that gives comparison of Base System with Concurrent Multi Path (CMT) and Proposed System incorporating CMT with compression is as depicted in Fig 4.

4. CONCLUSION

Bandwidth aggregation approaches are proposed so that a multimode terminal equipped with multiple network interfaces can access through concurrent multi paths. Bandwidth aggregation services can bring in significant improvements in performance over conventional single interface use by providing increased throughput, resource sharing and reliability. A larger logical link with high bandwidth can be created by aggregating multiple lower bandwidth links so as to meet the demands of applications requiring higher bandwidth. A dynamic bandwidth aggregation approach is at transport layer of network. Base stations are deployed between proxy server and client. Packet forwarding is done at server and packet reordering is done at client. Compression/Decompression is implemented to enhance transmission throughput as well as better QoS. Hence bandwidth aggregation is attained by aggregating the low bandwidth channels and thereby increased transmission throughput is achieved.

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