

# CONCURRENT MULTI-PATH REAL –TIME TRANSMISSION CONTROL PROTOCOL

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## Abstract:

Next generation wireless communication networks are featured with heterogeneity where multiple wireless technologies exist together. In the intersection of coverage areas of these different technologies, receiver having multiple interfaces can access them concurrently so as to improve the performance and this prompts bandwidth aggregation. A larger logical link can be created by aggregating low bandwidth links. The same link can be used by a multimode terminal for applications that are demanding high-bandwidth. Advantages of bandwidth aggregation and the challenges that are faced in attaining bandwidth aggregation are discussed in this paper. An overview of the architecture, different approaches and bandwidth aggregation techniques employed in various layers of network are highlighted.

**Keywords:** Bandwidth aggregation; concurrent multi path transfer; heterogeneous wireless network.

## 1. INTRODUCTION

With the rapid growth of Internet, the advancement of technology and reduced cost of electronic components, more and more number of users are using the mobile data access and data transfer by using various network interfaces for the devices like laptop, notebook, tablet and smart-phone using various wireless technologies like 802.11, Bluetooth, GSM,3G, WiMax etc.[17][18] The existing wireless technologies differ in terms of services provided like bandwidth, coverage, price, quality of service support. If there is a restriction on the usage of these available resources with interfaces on the user device as one interface at a time, then imposes limitation on the flexibility and better utilization. So by using multiple interfaces simultaneously, can improve quality and provide support for applications requiring high bandwidth [18]. Further delay can be reduced when alternate path of communications are kept alive enhancing the reliability of data. Heterogeneous Wireless Network (HWN) is a wireless communication network where Internet services can be accessed through multiple wireless technologies like WiFi, WiMAX, GSM etc[5][6][9]. Nowadays many of the Internet applications are demanding high bandwidth. The bandwidth of an individual technology is not sufficient to meet the current demand. Hence by aggregating the individual low bandwidth links, form a high speedy larger logical link. Bandwidth aggregation in heterogeneous wireless network will provide many of benefits for real time applications.

## 2. METHODOLOGY

The bandwidth aggregation in wireless networks can be defined as the aggregation of bandwidth offered by individual links of multiple technologies to form a high speedy larger logical link. The accumulated bandwidth from multiple wireless interfaces can create a high bandwidth larger logical link. This has several performance benefits as described below.

- **Increased throughput:** Many internet applications like video streaming services (example: YouTube, teleconferencing, online gaming etc) demand high bandwidth. The bandwidth of existing individual technologies is inadequate to support throughput demanding video applications. Hence bandwidth aggregation provides the increased transmission throughput to meet the requirement.
- **Resource sharing:** 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.
- **Reliability:** Attaining bandwidth aggregation through concurrent multipath transfer of data provides greater reliability. Multiple paths or channels are available for the transmission. At any instance, if any path fails, then there is availability of other path for the transmission. Thus bandwidth aggregation can bring in increase in reliability of communication system.

### 3. PROPOSED SCHEME

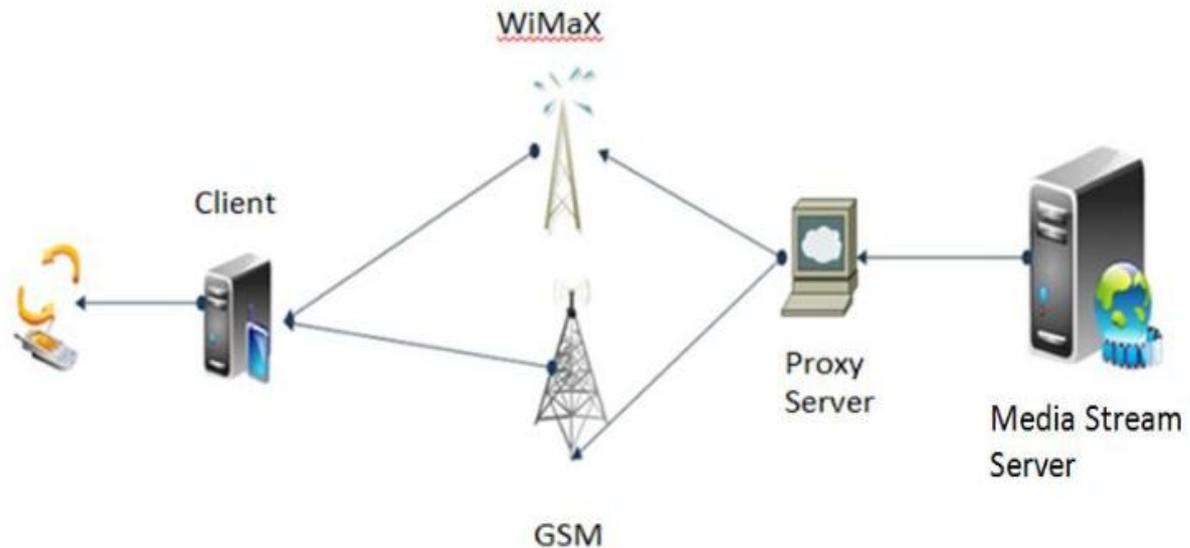
The aggregated bandwidth can bring in significant benefits in the form of increased throughput, resource sharing and increased reliability as discussed in section I. However there are some challenges that need to be addressed while attaining the bandwidth aggregation. The challenges that are faced are: Packet reordering, delay and more battery power consumption. In heterogeneous wireless networks, the packet reordering is caused due to simultaneous transmission of packets across concurrent multi paths. Each of the paths has different end-to-end delays and transmission speed resulting into arrival of packets at the receiver as out of the intended order. The reordering of the packets affects adversely on performance of any real time application. Packet reordering occurs when the order of the packets received by the receiver is not same as the order of the packets sent by the sender [9].



**Fig.1. Packet Reordering**

That is, the sequence of the packet which is arriving is lower than the sequence of the packet that has already arrived at receiver as illustrated in fig 1. The end-to-end delay is increased due to the time consumed in reordering of the packets. Due to this delay, some of the packets of real time applications miss their corresponding deadlines and get discarded. Packet reordering and the delay caused by it can also affect the Transmission Control Protocol (TCP). TCP allows reordering of packets by maximum of two positions of reordering and corrects by inbuilt re-sequencing mechanism [21]. However beyond two positions of reordering is regarded as packet loss and thus reducing the transmission window size. Consequently the application throughput may drop rapidly leading to the underutilization of accumulated bandwidth capacity. This affects a lot to the video streaming

applications that have stringent quality of service (QoS) requirements. Thus for an efficient bandwidth aggregation, it is a must to incorporate the mechanism for



**Fig.2. Overview architecture to support bandwidth aggregation**

packet reordering and minimizing the delay caused due to it. Battery power consumption is always a key issue with handheld devices. More amount of power is consumed by handheld devices during its operation as well as at idle periods. The battery power consumption is increased more when a terminal is equipped with multiple wireless interfaces. The operational lifetime of terminal is reduced leading to the risk of premature transmission termination. For ensuring uninterrupted concurrent multipath transfer of data, it is a must to incorporate a mechanism for minimizing the terminal's battery power consumption. Fig 2 shows high-level overview of architecture to support bandwidth aggregation through concurrent multipath transfer. The figure depicts heterogeneous wireless network with two wireless interfaces say (WiMax and GSM). When the coverage areas of these wireless technologies overlap, a multimode device in this area can use them simultaneously [15]. 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].

- The available bandwidth – the number of bits transferred in unit time
- The round trip time – the total amount of time for sending the data packet and the time for receiving the acknowledgement of that packet
- 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 is suggested to arrange the transmission sequence so as to minimize the delay caused due to reordering of packets at the receiver. 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.

#### 4. ANALYSIS

A survey of bandwidth aggregation solutions addressed at various layers of network protocol stack such as Application layer, Transport layer, Network layer and Link layer is discussed in [4]. Here is a brief look at bandwidth aggregation techniques employed in various layers of network.

##### **A. Application Layer:**

An application layer protocol for bandwidth aggregation in mobile devices is suggested in [2]. In this paper, a protocol for aggregating WiFi and 3G wireless links on mobile devices is suggested. An algorithm is proposed that can transfer wireless data over both WiFi and 3G interfaces with the aim of minimum battery energy consumption. This service is made simple by providing a mobile application in the mobile devices that is independent of operating system and network protocol stack. In general, application layer bandwidth aggregation mechanism use a middleware for sending packets over multiple interfaces at sender as well as for collecting the received packets in proper sequence at receiver side. Thus a middleware mechanism to be deployed at both sender and receiver side for optimal operation, this limits the widespread uses of application layer bandwidth aggregation approach.

##### **B. Transport Layer:**

Stream Control Transmission Protocol (SCTP) is the standard protocol at transport layer of network to enable concurrent multipath transfer (CMT) in heterogeneous access network. A distortion aware CMT solution (CMT- DA) for video streaming is provided in [1]. The CMT-DA solution uses estimating path status, allocating flow rate also delay and loss controlled retransmission to have quality of service (QoS) in real time video streaming in multiple wireless interfaces [14]. In this paper, transmission of video streaming is done using the SCTP association [7] from source to a destination node. SCTP transmission involves the sockets. [10] The video is encoded and further encoded data is then divided into several chunks and sent over multipaths. The receiver receives the packets in a receiving buffer and reorders to restore the original video to be given to the upper layer applications. The transport layer mechanisms for bandwidth aggregation require adaptations at node as well as remote server, this limits deployment to specific applications.

##### **C. Network Layer:**

An important aspect of bandwidth aggregation mechanism is scheduling of data packets onto different interfaces. A network layer solution for bandwidth aggregation is given by proposing a well known Earliest Delivery Path First (EDPF) scheduling algorithm [15]. A packet-pair scheduling for TCP application was also proposed [17]. Both the approaches involve a network proxy, providing various services like bandwidth aggregation, resource sharing and mobility support to client by accessing multiple network interfaces. Network proxy is responsible for concurrent transmission of data over multi paths and also assembling the packets received at receiver.

#### CONCLUSION

Bandwidth aggregation approaches are proposed so that a multimode terminal equipped with multiple network interfaces can access through concurrent multi paths [20]. Bandwidth aggregation services can bring in significant improvements in performance over conventional

single interface use by providing increased throughput, resource sharing and reliability. By the aggregation of existing lower bandwidth links so as to create a larger logical link, can serve the applications demanding high bandwidth. This paper presents a survey of bandwidth aggregation approaches developed to have concurrent multipath transfer across multiple wireless technologies simultaneously. In future, the wireless communication networks would be the convergent of various access networks, incorporating diverse transmission features and capabilities. Bandwidth aggregation is facilitated in multihomed mobile terminals for increased transmission throughput and enhanced reliability.

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