Bandwidth Management Method for Heterogeneous Wireless Network

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Abstract: The integration of heterogeneous networks is a trend of Fourth Generation (4G) systems. But with more integrating network technologies, bandwidth management is more complicated. This paper proposes a bandwidth management method, called Bandwidth Management and Disposition (BMD). The BMD calculates the Reword Point (RP) to quantify the Mobile Host's (MH) requests, and calculates the Upgrade Rank (UR) or Downgrade Rank (DR) to quantify the upgraded or downgraded sequence of bandwidth, respectively. In the future, when a new service type or network technology is created, the proposed system functions also can be directly applied. This paper analyzes the BMD is more feasible than the other existed methods. The simulated results also demonstrate the functionality of the BMD. The incremental rate of achieved request is 12.52% and rate of bandwidth usage is 2.4% when the system with BMD. We conclude that the proposed system facilitates further development of wireless communication networks.

Keywords: bandwidth management, heterogeneous wireless network, hierarchical mobility management, Radio Access Technology (RAT), Reword Point (RP), Bandwidth Management and Disposition(BMD)

1 Introduction

Developments in new radio technologies and increased user demand are driving the deployment of a wide area of wireless networks, ranging from 802.11 networks for the local area, to third generation (3G) wireless communication for the wide area. With their complementary characteristics, these heterogeneous Radio Access Technologies (RATs) are expected to be integrated together for providing "Always Best Connections" to mobile users [1]. Driven by the desire for service “anywhere and anyway”, it is generally accepted that Fourth Generation (4G) wireless networks will be heterogeneous, integrating different networks to provide seamless Internet access for mobile users [2].

But the integration of heterogeneous networks causes complications in disposing bandwidth. New methods must be proposed to address this challenge of services offering to mobile users over an efficient and speedy bandwidth disposition. Many researches and methods have been proposed, for example, resource auctioning mechanisms [3], resource management for QoS support [2] and optimizing resources allocation by filtering operations and QoS classes [4]. However, these methods have some shortcomings when applied to the heterogeneous networks, as explained in the

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next section. We propose an efficient method for bandwidth disposition with heterogeneous networks.

In this paper, the bandwidth disposition problem is presented as a quantifiable function. The Bandwidth Management and Disposition (BMD) calculates the Reword Point (RP) to quantify the Mobile Host's (MH) requests, and calculates the Upgrade Rank (UR) or Downgrade Rank (DR) to quantify the upgraded or downgraded sequence of bandwidth, respectively. This method helps quickly to determine the efficient management of bandwidth. The simulated results also represent the performance of the proposed method.

The rest of this paper is structured as follows. The existed methods are described and discussed in section 2. Section 3 describes in detail the proposed method and analyzes in comparison with other methods. In Section 4, the performance of BMD is evaluated via simulation. Finally, we provide conclusions in Section 5.

2 Existed Methods

Many interworking architectures have been proposed to integrate heterogeneous networks, and many researchers have shifted their attention to the issue of resource management for heterogeneous networks. In this section, we shall introduce and analyze three different tactics for allocation bandwidth in heterogeneous networks.

2.1 Auction Mechanism

To create highly efficient resource utilization, Sallent et al. [3] presented a resource auction mechanism, Joint Radio Resource Management (JRRM) and spectrum auction, which creates a more efficient use of the available radio resources in heterogeneous wireless access networks. The scenarios offer services to the user over an efficient and ubiquitous radio access by means of coordinating the available Radio Access Technologies (RATs). The operator can adapt the RATs to result in a higher monetary gain according to the users' demand, and Auction Sequences (ASs) taking place in each cell are necessary to get this economical property. In turn, the user can express his urgency to get Radio Resource Goods (RRG) by his bid. Thus the ASs actively influence the users in bidding the RRG, in contrast to the Fixed Price Model (FPM).

The functional elements of the resource auctioning mechanism are depicted in Figure 1 [3]. To simplify the description, the introduction of each element is shown in [3].

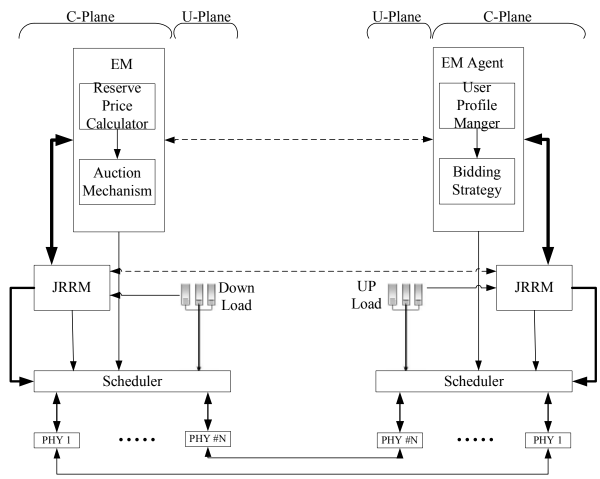

Fig.1: Auction System model

Two shortcomings of this method are conspicuous. First, the latency is increased due to the bid and comparison. The operator must to tell the user the situation of all RATs, so the user can determine the bid, and the bidder must then wait for the bids of other users or the expiration of auction. Second, it is obvious there are a large number of packets for bidding.

2.2 Resource Management for QoS Support

Song et al. [2] proposed a new admission strategy for integrating voice and data services. According to the characteristics of a cellular network and Wireless Local Area Networks (WLANs), the distinct features of voice and data traffic, the Quality of Service (QoS) requirements and user mobility patterns, the cellular network is preferred for voice service and WLANs for data service. Although the authors proposed the idea of division of labour, they deem the resource sharing between voice and data services. To properly apportion the total bandwidth between voice and data services in each network, the restricted access mechanism is used. Voice traffic is offered preemptive priority over data traffic and occupies up to a certain amount of bandwidth to meet its strict QoS requirements. The remaining bandwidth is dedicated to data traffic. Moreover, to achieve higher resource utilization by considering traffic dynamics, all unused bandwidth of voice traffic is shared equally by ongoing data flows.

This method has one shortcoming, which is that there is for much complexity as the system considers more and more heterogeneous networks. The flow chart in [2] is difficult to finish when the system integrates more service types and network systems.

2.3 Optimizing Resources Allocation by Filtering Operations and QoS Class

To optimize resource allocation, Ben Letaifa et al. [4] proposed a media tailoring mechanism which converts a video stream into a different representation that the client is more interested in or can handle better. The proposed approach is based on selection of the downloading bit-rate for each type of traffic flow which can be time-dependant, according to the dynamics of the link's traffic loads and users' requests. This mechanism provides a media adaptation for filtering between communication partners to tailor media streams to the network and end-systems capabilities. Media filters are entities that receive media streams at given qualities, and forward them to receivers at different quality levels after appropriate manipulation. Media filters therefore can be seen as a method to provide adapt for mobile user and heterogeneous capabilities of the network, the hardware platform and the application program.

Figure 2 [4] depicts only the one-way communication from the media servers to the mobile end-users (downstream). The filters are installed at the output ports of every router and server, as well as the radio network controllers Radio Network Controllers (RNCs) in the wireless network.

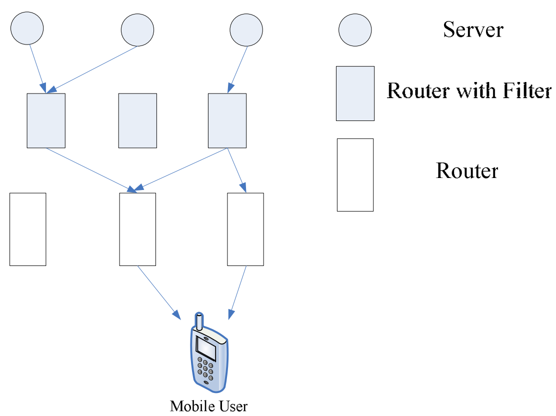

Fig.2: QoS Filtering Architecture

There are two shortcomings to this method. The first is that the service provider must set up the router with a filter, which is an extra cost. The second is the system needs to choose the best type of compressed video stream from the source to the terminal. However, the path from source to terminal usually has multiple hops, so some extraneous overheads are needed to calculate the best filtering video stream.

In addition, a lot of disposition methods are used in different network structure. It still can be as the target of studying. For fear of space, this paper is not described more. You can consult [5-7].

3 Bandwidth Management and Disposition

To improve the efficiency of bandwidth allocation, we designed a bandwidth management method called Bandwidth Management and Disposition (BMD). In this solution, we calculate the Reword Point (RP) to quantify the MH requests, and calculate the Upgraded Rank (UR) or Downgraded Rank (DR) to quantify the upgraded or downgraded sequence of bandwidth respectively. The computations of RP introduced in subsection 3.1; and the computations of UR and DR are introduced in subsection 3.2. Subsection 3.3 describes the procedure of the BMD. The analysis of BMD and other previous methods is illustrated in subsection 3.4.

3.1 Reword Point

We argue that the Reword Point (RP) is composed of the following metric attributes: profit of bandwidth per bit for this service (C), MH's velocity (V), transmissible rate of per request (R), priority of per request (P), network condition (N), QoS requirement (Q) and others (O). The RP could be measured via a function (1):

$$RP = f(C, V, R, P, N, Q, O) = aC + bV + cR + dP + eN + fQ + gO \quad (1)$$

where a, b, c, d, e, f, g are nonnegative real numbers describing the extent of a particular metric and it is assumed that

$$a, b, c, d, e, f, g \geq 0$$

The RP represents the level of gainable revenue for the service provider. The RP should be arranged in the order of descending power. The first one in this order will gain the first choice of bandwidth and then down in descending order.

3.2 Upgrade and Downgrade Rank

We argue that the UR or DR is a composition of the following metric attributes: increased profit (U), which increases bandwidth when starting upgrade or reduced profit (D) that gets the bandwidth back when starting downgrade; MH's velocity (V); transmissible rate of per request (R); priority of per request (P); network condition (N); QoS requirement (Q); and others (O). The UR and DR could be measured via function (2) and (3), respectively:

$$UR = f(U, R, P, N, Q, O) = hU + cR + dP + eN + fQ + gO \quad (2)$$

$$DR = f(D, R, P, N, Q, O) = hD + cR + dP + eN + fQ + gO \quad (3)$$

where h, b, c, d, e, f, g are nonnegative real numbers describing the extent of the particular metric and it is assumed that

$$h, b, c, d, e, f, g \geq 0.$$

The UR indicates the increase of revenue when MH's requests are upgraded, while the DR indicates the decrement of revenue when MH's requests are downgraded. All competitors are arranged in order by their UR or DR values. Both UR and DR orders are arranged in ascending power. The system starts to calculate the UR order when one MH releases its occupied bandwidth. The system starts to calculate DR order when an MH has insufficient bandwidth. In other words, the UR and DR orders do not coexist.

The occupied bandwidth of the first one in DR order will be returned firstly, and the others will follow in turn. The first one in this order indicates that the system has a reduced lowest revenue than the others in this order when the system decided to get bandwidth back. On the contrary, the last one in UR order will be allocated releasable bandwidth firstly since that will increase the maximum profit for the system. However, upgraded or downgraded bandwidth must to meet with MH demands as a restriction.

3.3 The procedure of BMD

The BMD can be divided into two parts. One is that an MH proposes a requirement bandwidth and the system does not have enough bandwidth; the other is that an MH releases its occupied bandwidth when it has finished its transmission. These are shown by Figure 3 and Figure 4, respectively.

Figure 3 shows the flow chart of BMD when an MH proposes its bandwidth request. MH first informs the Un and Ln of the system for a bandwidth request. The Un indicates the up-bound of bandwidth, while the Ln indicates the low-bound. The MH gains the Un bandwidth when the available bandwidth is more than a threshold, which implies that the system does not do any calculation when the bandwidth is sufficient. If it is not sufficient, the RP can be calculated by using Ln as the R for the function in eq.1 and be put into RP order. The highest RP gains the bandwidth firstly. The system changes the value of S when it disposes bandwidth or gets bandwidth back, where S indicates the maximum bandwidth that the system can get back. The system checks S before starting to calculate the DR order to avoid unnecessary degradation. The bandwidth of the first item in DR order will be returned first, and others in turn until the available bandwidth satisfies the MH request. MH waits a period of T for other users to release the occupied bandwidth when DR order is null and the bandwidth is still not enough for the MH. The system returns to check S after waiting a period of T.

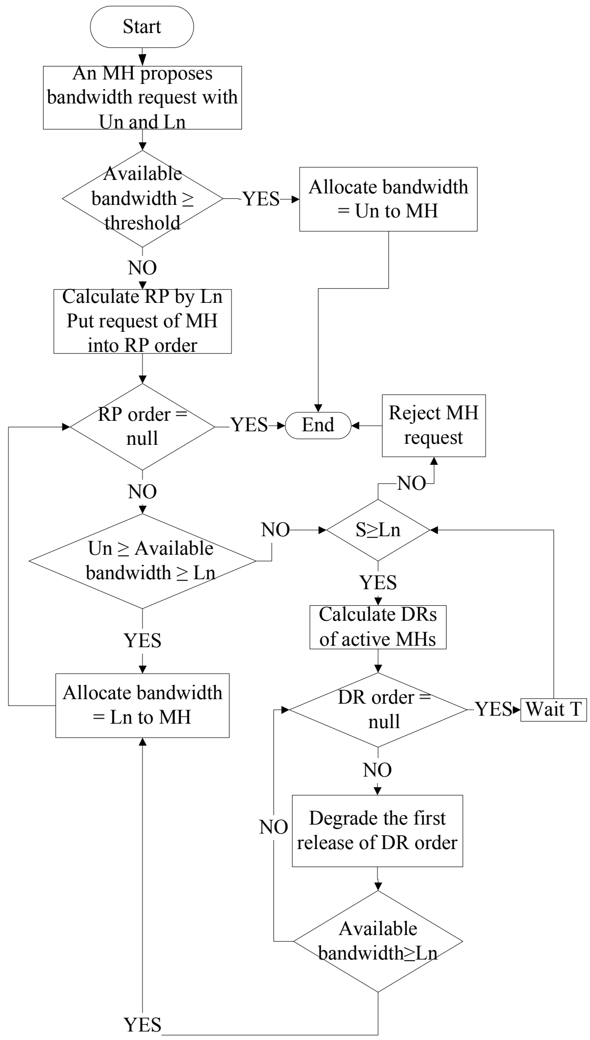

Fig.3: Flow chart of BMD when an MH requests service

In the contrary, the system calculates UR order to upgrade the bandwidth for ongoing requests when one MH releases its occupied bandwidth and there is no more MH waiting for bandwidth, as shown in Figure 4. The last item in UR order will be allocated releasable bandwidth firstly until the UR order or available bandwidth is null.

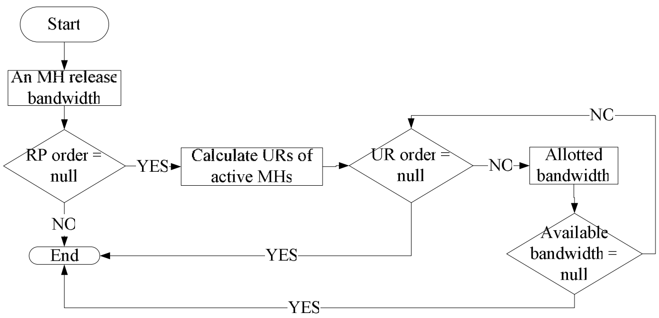

Fig.4: Flow chart of BMD when an MH releases its occupied

3.4 Analysis

This section compares our proposed mechanism with Auction, QoS support and filtering mechanism. We analyze the various factors such as latency, overhead expansibility, extra support and QoS flexibility.

In an auction mechanism, the bidder must to wait for the bids of other users or for the auction to expire, so the latency is higher. In addition, the forms of data packets are changed in the step of filtering mechanism, which will delay their transmission.

There are many packets for bidding when making a connection in an auction mechanism, so the connection overhead in an auction mechanism is larger than in other methods.

When there is new service type or network technology created, the flow chart needs to be major rewrited of the QoS support mechanism. Thus, the expansibility of the flow chart in a QoS support mechanism is lowest. The service provider needs to reinstall all filters when a new form of data packet is devised. Thus, the expansibility of the filtering mechanism is lower than Auction and BMD mechanism.

EM is the extra hardware support in an auction mechanism, where as a filter is the extra software/hardware supports in a filtering mechanism.

Operators propose a variant quantity of bandwidth for various requests in auction and BMD mechanism, but, a bandwidth quantity for one type request is immovable in the QoS support mechanism. Detailed analysis is consulted [8]. The analysis of the proposed method and existed methods is shown in Table 1.

Table 1: A contrast table

	Latency	Overhead	Expansibility	Hardware/ software Support	QoS Flexibility
Auction	High	High	High	Yes	Yes
QoS Support	Low	Low	Low	No	No
Filtering	Medial	Low	Medial	Yes	Maybe
BMD	Low	Low	High	No	Yes

4 Simulation

4.1 Simulation Parameters

We refer to the network architecture in [9]. For simplicity, we assume that all MNs have the same velocity and the conditions of all BSs are not different. The all parameters are as follows.

- C: Assume the rate of billing for all users is the same.
- V: Do not care it.
- R: MH proposes Un and Ln at random.
- P: Voice:1 Video:2 Data:3 (1>2>3)
- N: Do not care it.
- Q: Excellent:1, Good:2, Basic:3
- U/D: Assume the rate of for all users is the same.
- O: Do not care it, now.

When the service requires high R (High R indicates that it needs much bandwidth), it must have higher RP for increasing reward. When the service has low P (Low P indicates that it has high priority), it must have high RP for executing first and when the service's quality is low, it must have high RP for high bandwidth. So, P and Q are in inverse proportion to R in function (4). When the request has high priority, it must be downgraded, lastly. So, P is in inverse proportion to UR/DR in function (5.2). When the request occupied high bandwidth, it must be downgraded, firstly. High QoS occupied high bandwidth, so Q are in direct proportion to UR/DR in function (5), but pinned down by P. Thus, the formulas for above parameters are as follows:

$$RP = R + \frac{R}{P} + \frac{R}{Q} \quad (4)$$

$$UO = DO = \frac{1}{P} + \frac{Q}{P} \quad (5)$$

The transmission rates of the different service types and levels are from [10-12] and are shown as Table 2.

Table 2: The transmissible rates of the different requests

Application (kbit/s)	Excellent	Good	Basic
Voice	12.2		
Video	384	256	144
Data	100	50	10

The RP for Table 2 be calculated by eq.4 and shown as Table 3. The MH obtains 12.2 kb/s bandwidth when the service type is voice and the other obtains bandwidth in direct proportion to the RP. Since voice is still the largest amount, the priority of the voice serves to make its RP become great. Thus voice services will be served first.

Table 3: RP for Table1.

Quality Level	Excellent	Good	Basic
Voice	1000		
Video	960	512	264
Data	233	91	16

The UR and DR are calculated by the same formula (5) when the system needs the UR or DR order. The calculation opportunities of UR and DR are like those described in section 3.3.

4.2 Simulation Results

Requests are refused when there is insufficient bandwidth. The simulation tested the efficiency of BMD, and compared it to the situation with no BMD systems. The proposed BMD and the situation with no BMD systems are compared by observing the rate of achieved requests and the rate of bandwidth usage. This paper simulated the proposed system according to the increase in proportion of real-time services. The ratios of real-time to non-real-time were 2:8 and 9:1, as explained in [9].

Figure 5 shows the rates of achieved request. The dotted lines indicate that the system does not use BMD and dark lines indicate that the system uses BMD. All the rates increase to over 60% when the system uses BMD. In addition, the efficiency is manifest increase when the ratio of real-time requests and non-real-time requests increase. The proposed system increases the rate of achieved request approximately 7.09% when the ratios of real-time to non-real-time was 2:8, according to Figure 5.

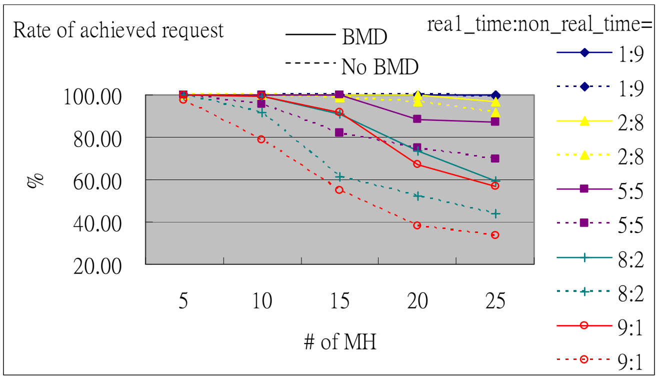

Fig.5: Rates of achieved request

Figure 6 shows the rates of bandwidth usage. When the numbers of MH is over 20, all the rates increase to over 70% with BMD. We observe that MH is 20, according to the simulation results in [9].

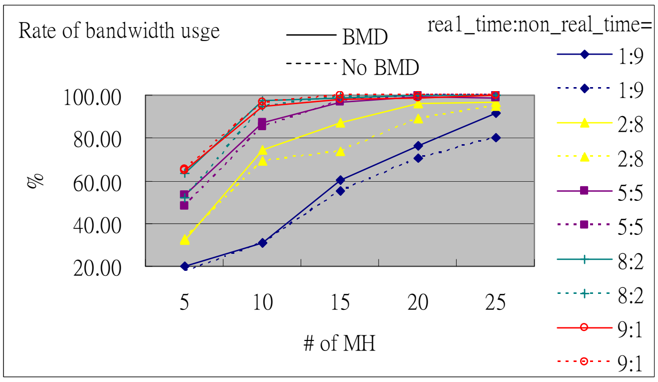

Fig.6: Rate of bandwidth usage

The two figures show that BMD can heighten the rate of achieved request and bandwidth usage. The incremental rate of achieved request is 12.52% and rate of bandwidth usage is 2.40% when the system with BMD.

Figure 7 compares the time of transmitted latency. The average latency of the proposed method is lower approximately 10.92ms than auction mechanism, and it is lower approximately 3.76ms than filtering mechanism according to the simulation. The simulation results show that the proposed system supports fine-fit resource management for 4G wireless network.

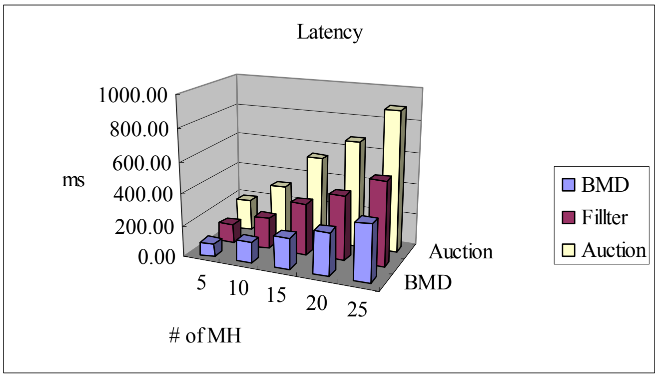

Fig.7: Time of transmitted latency

5 Conclusion and Future Work

This paper proposes a bandwidth management method, called BMD. The BMD includes RP, UR and DR functions. The BMD calculates the quantity of disposed bandwidth by RP function, and decides the upgraded/downgraded sequence of bandwidth by UR/DR function individually.

If the system has increased serviced types or network technologies in the future, the proposed functions are also applicable. The BMD makes faster decisions for disposing of bandwidth than the auction mechanism. The BMD is simpler than the flow chart in [4], especially for more heterogeneous networks. The BMD does not need to change the form of packets like the filter. According to simulation results, the BMD increases the rate of achieved request and rate of used bandwidth.

Further work will generate a scheme for reserving different bandwidth for handoff call in different cell [7]. Although minimizing the dropping of handoff calls is very desirable from the user’s point of view, this often comes at the expense of the bandwidth utilization, which is very undesirable from the service provider’s point of view. We expect to find a balance between these two. The other very important issue is that of load balancing of heterogeneous network [13]. We also try to make the load balancing between the adjacent cells.

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