An Autonomic Active queue management mechanism to improve multimedia flow deliver quality

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Abstract

In order to provide better quality of service to the multimedia applications in Mobile Ad Hoc Network (MANETs), where its resource is limited and changed dynamically, in this paper we introduce an Active Queue management mechanism with autonomic attributes, named Autonomic Active Queue Management (AAQM). With the rapid development of network services and network technologies, the users requirements of network mainly the QoS are to improve. Whereas the traditional Active Queue Management (AQM) mechanisms are not adequate to provide QoS guarantee to multimedia video traffics effectively. AAQM tries to adjust its network behaviour and optimize the overall network performance according to network and service condition information.

Keywords-autonomic network; active queue management; QoS; multimedia application

I.INTRODUCTION

Autonomic network is a research hotspot in future network architectures. It is capable of introducing the autonomic features to network entities to solve the increasing complexity of network management and control. Due to the simplicity and scalability of DiffServ architecture, it obtains researches widely. Therefore, it is a reasonable way to introduce the autonomic mechanisms to DiffServ components, optimizing the network performance by dynamically adjusting the network behaviour according to the real-time condition information. Mobile ad-hoc network (MANET) is a collection of mobile nodes, which form a wireless network without the use of an existing infrastructure. MANET’s are usually characterized by mobility of nodes and communication over multiple hops. Hence, MANET links are short lived and the topology is very dynamic

To provide QoS for video applications, two major approaches have been proposed. They are end system based approach and network based approach respectively. In the end system based approach, the end system is in charge of providing QoS. These methods have obtained widely research. But the complexity and overhead of end system are increased greatly. While in the network based approach, the routers are in charge of QoS provision. DiffServ related technologies have been applied to network video. A representative technique is to carry out buffer management.

As a mechanism to support congestion control at intermediate routers, the active queue management is a hotpot in network research. Sally Floyd [2] firstly proposed Random Early Detection (RED) at 1993. At the same time a new direction of network research is also put forward, which is Active Queue Management (AQM).IETF RFC2309[3] suggested to adopt AQM mechanism at routers, which became a research hotpot. The basic idea of AQM is to avoid congestion before the buffer is full by means of dropping packets in advance.

These queue management mechanism randomly dropping packets are relatively effective in reducing packet loss. But in MPEG4 encoded multimedia applications, there is no simple relation between packet loss and video quality perceived at the receiver. Due to the dependency between video frames, even a small packet loss may cause many successively delivered packets with no use in practice, which will seriously impact the video quality. Because the resource in MANETs is limited and varying, while large bandwidth is needed by video application, it is unavoidable that lots of video packets have to drop. To reduce the loss of video stream delivery quality and effectively drop video packets, we will introduce autonomic mechanism to queue management mechanism, dynamically adjusting the discarding operation according to the network environment and video feature information.

The rest of the paper is constructed as follows, section 2 discusses the related works; section 3 will describe the proposed AAQM in detail; section 4 presents the simulation analysis results; section 5 concludes the paper.

II. RELATED WORKS

Autonomic network is a research field of the future Internet architecture. The concept of autonomic network is derived from autonomic computing.

of research projects are being carried out in this field, such as ANA[6], BIONETS[7], Haggle[8] and EFIPSANS[9]. The main target of the research is to add autonomic attributes to network elements, simplifying the network management and control. Autonomic attributes such as self-management, self-configuration, self-optimization, self-aware, self-adaptability are realized based on feedback control loop. The autonomic mechanisms can dynamically adjust network behavior according to varying network environment and optimize the overall network performance. The autonomic mechanism is suitable for future heterogeneous and complex network.

The AQM in wireless network where is easy to loss packets has not been widely studied. It is prefer to choose end system based approach to improve the video flow quality. The end system based approach is relatively effective, but it increases the complexity and overhead of the end systems greatly. It is expected to adopt simple and effective queue management approach to provide QoS by network centric method.

There is rarely research focus on exploiting the active queue management mechanism to improve the video delivery quality. Most AQM mechanisms drop packets randomly without differentiating their importance. The traditional queue management without considering the packets' importance is not suitable for multimedia flow, which will damage the video flow quality seriously.

The available queue management algorithms which are able to differentiated packet priorities include RIO[13], Weighted RED(WRED)[14], WRED with Thresholds(WRT)[15], and so on. But the priorities are not divided by video packets' importance.

In [10], a rate based RIO algorithm, named Rb-RIO, is proposed. It classifies packets of I frame, P frame and B frame to three priority classes. I frame packet has smaller drop probability compared with other packets. [11] proposed a priority dropping mechanism, which mapped I frame, P frame and B frame packets of MPEG4 hierarchical video flow architecture to different drop priorities of WRED, which is called REDN3.

III. AUTONOMIC ACTIVE QUEUE MECHANISM

The methods with differentiating video packet importance usually just take into account the difference of frame type. But simply mapping packets to different dropping priorities according to frame type and setting fixed parameters for corresponding priority may not obtain the optimal performance. We should make full use of the packet feature information caused by the video encode process to optimize the queue management operation.

We introduce autonomic mechanism to our queue management design. Autonomic attributes such as self-configuration and self-adaptation are realized base on Network environment conditions will change with time dynamically. The length of node's queue is changing according to traffic rate and link bandwidth. The queue management mechanism will collect this network context.

feedback control loop. The feedback loop is based on context information collected. And the context information used in our mechanism includes network context and service context. We use the context information to dynamically configure and adjust the packet dropping operation information to judge the congestion condition. Network context information is monitored by wireless nodes. And the service context information is recorded in the packet header according to their video compression character by source end. When the packet travels in network, nodes are able to abstract the service context information directly from packet header. The service context information, for example video compress character information, such as frame type, frame situation and frame size are abstracted from the IP packet header, and it will determine the configuration of the queue management mechanism parameters.

The self-configuration and self-adaptation autonomic attributes are realized base on a feedback loop. In the feedback loop, the network and service context is collected through the collecting step. Then the congestion level is judged according to the network context information. And the configuration is determined based on the service context. Finally execute corresponding configuration and adjustment. The feedback loop will adaptively adjust the network behavior and optimize the overall network performance.

Source operation

In the MPEG4 encoded video flow, each frame in a Group of Pictures(GOP) with different encode method has different impact on the video reconstruction quality at the receiver. MPEG4 encodes video data to three types of compression frames, they are I frame, P frame and B frame respectively. I frame is encoded in an intra-frame way, so it can decode independently. P and B frames are encoded in inter-frame way, so they need relative frames to decode. We can get the frame importance comparison result in each GOP. I frame is the reference frame to all the frames in the GOP, so I frame has the highest importance. P frames at the front part has higher importance than the P frames at the rear part in each GOP. And B frame is encoded with prediction encoding; its data amount almost reflects the approximation between the B frame and the prediction frame. Therefore, we can consider that B frame with larger size is more important than smaller one. In summary, the frames in each GOP ordered by importance from high to low are I frame, the P frame at the front part, the P frame at the rear part, B frame with large size, and B frame with small size respectively.

The service context information means the character information generated by the video compression, including video frame type, frame number, frame size and so on. These character information generated by the source video codec are recorded into the packet header. We add several fields into the IP header, including frame type, the number of P frame in GOP, the max P frame number, B frame size and the max B frame size, named f_type, f_seq, PN, f_size and BS respectively. For f_type filed, 0 means I frame, 1 means P frame, and 2 means B frame. The number of P frame is the P frame predicted sequence number in GOP, which is between 1 and PN. And the f_size field records the B frame size.

TABLE I. PACKET PRIORITY MAPPING

priority	**packet type**	**priority index**
class 1	packet carrying I frame data	001
class 2	packet carrying the former part P frame data in GOP	010
class 3	packet carr ying the latter part P frame data in GOP	011
class 4	packet carr ing lager size B frame data	100
class 5	packet carrying smaller size B frame data	101

The source end divides the video packets into five priorities according to the video compression character information. Additionally we add another filed into IP header, named PI(priority index). The priority dividing table is shown in table I. The packet importance decreases from class1 to class5.

B. Queue management operation

The collecting operation of autonomic loop monitors the queue length to estimate the network congestion situation. The average queue length and real time queue length are used as congestion metric. The interface queue of wireless node for video packets is a FIFO queue in our design. But in the internal queue structure, packets are directly mapping to five virtual queues(VQ) according to their priority indexes(PI) recorded by the source end. Packet drop priority increases from VQ1 to VQ5. The algorithm uses the highest drop priority dropping method. If packet dropping needed, the arriving packet will enter into its corresponding virtual queue, and the first packet of the highest drop priority virtual queue will be dropped.

Parameters in the RED and WRED queue management algorithms are static. The parameter maxp is set as a fixed value. But in our design, the maxp is able to adjust according to the packet's service context information. The original maxp for I, P and B frame are maxp_i, maxp_p and maxp_b respectively. But the maxp_p is able to be adjusted according to the P frame number. The maxp is adjusted according to P number as

$$maxp = maxp\_i + (maxp\_p - maxp\_i) * a * (No./PN) \quad (1)$$

in which, a is a small const.

And the maxp_b is adjusted according to the B frame size, as

$$maxp = maxp\_p + (maxp\_b - maxp\_p) * b * PS/size \quad (2)$$

in which, b is another small const.

If the average queue length qa is less than the small threshold th_min, then enter the arrival packet into the queue. If qa is larger than the large threshold th_max, then enter the arrival packet to its corresponding queue, and drop the first packet in the highest drop priority virtual queue. If qa is between the two thresholds, then calculate a drop probability, enter the arrival packet, and discard the drop target packet with the probability. The probability calculated is the drop probability of the first packet of the highest drop priority virtual queue.

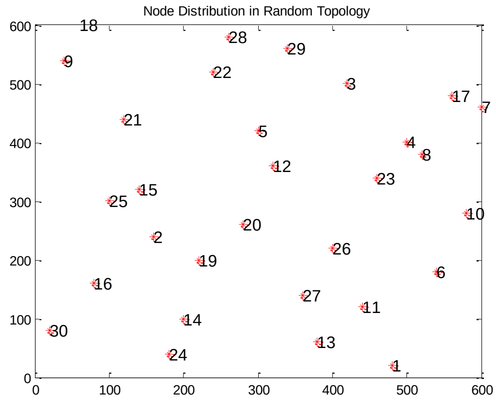
The pseudo-code of the AAQM algorithm is shown in Table II:

TABLE II. PSEUDO-CODE OF AAQM ALGORITHM

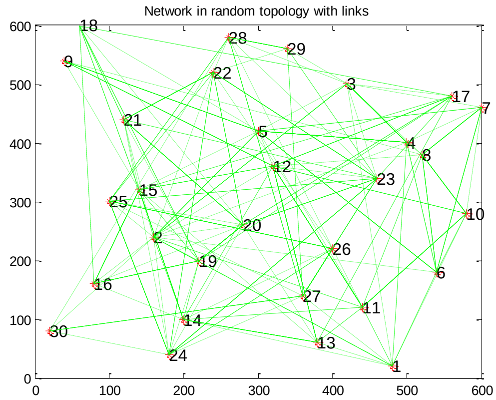
```
calculate the average queue length qa and get the current queue length qc
mapping the arrival packet to corresponding virtual queue
        according to PI

//adjust maxp parameter
if the arrival packet carrying I frame data
    maxp = maxp_i
else if the arrival packet carrying P frame data
        maxp = maxp_i + (maxp_p – maxp_i) * a * (No./N)
    else
        maxp = maxp_p + (maxp_b – maxp_p) * b * PS/size

 //caculate the drop probability
 if ((qa >= th_max) || (qc = qlim ))
      enter the arrival packet to its corresponding virtual queue
      drop the packet with highest drop priority
 else
      if (qa < th_min)
          enter the arrival packet into its corresponding virtual queue
      else
          p = maxp * (qa – th_min ) / (th_max – th_min)
          randomize a number u
          if ( u<= p )
              enter the arrival packet to its corresponding virtual queue
              drop the packet with highest drop priority
          else
              enter the arrival packet into its corresponding queue
```

IV. SIMULATION

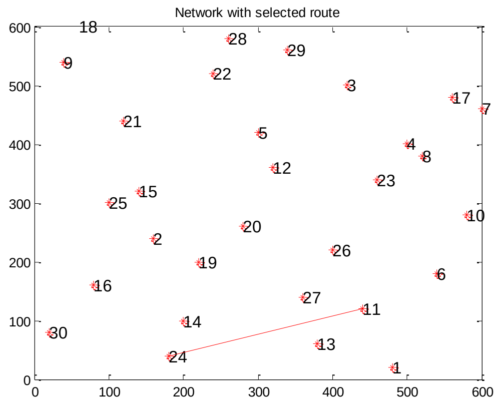
It also gives the comparative analysis for the proposed AAQM with the WRED by evaluation of PSNR for the recovered video using AAQM and WRED. In this part, we use simulation to compare the performance of the proposed AAQM algorithm with WRED in Manet's scenario. The queue management algorithm is applied on the wireless interface queue. There are 30 wireless nodes move randomly in a given1000x1000 m2 square. We use the matlab to generate the MANET scenario. Video sequences are in the .avi format. The simulation operation follows Doctor Chih-HengKe'smethod [12]. We encoded the video into MPEG4 formatted file, and transmitted through the network shown below. Finally compare the file after transmission with the original file, and calculate the PSNR(Peak Signal-to-Noise Ratio) value. PSNR is one of the most widespread objective metrics to assess the application-level QoS of video transmissions. The wireless bandwidth is set as 11Mb. Node communication radius is set as 300m. The length of interface queue is set 100.The two queue management algorithms are simulated using the same parameter value. WRED is used as [11] described, video packets are divided into three priorities according to their frame type.



In this work to evaluate the proposed approach we had considered a network having 30 nodes. The area of the network considered is 600 m^2.In this network the nodes are distributedin random fashion. The x-axis denotes length of the network along horizontal direction and the y-axis denotes the length along the vertical direction



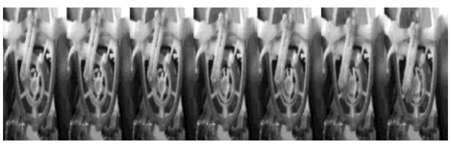
The above figures shows the complete links provided from each and every node to each and every node. For this purpose the distance from node to node has to be evaluated. Then only the links are going to be plotted by comparing it with the network range. Thus to provide a link between two nodes the distance between that two nodes should be less than the network range.



The above figure shows the path established between two nodes. Here the node 21 is considered as source node and the node 11 is considered as destination node. To establish the path between these two nodes first the source node has to send the request packet to destination node then the destination node has to be acknowledge an acknowledgement to source. If the source receives the acknowledge from the given destination node then the path is said to be established. Then only the communication for information transfer is going to be occurred between those two nodes.

Original Video sequence

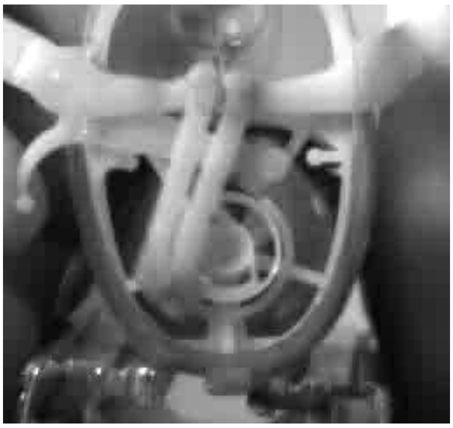
The above figure represents the original video sequence taken to process through the selected path between source node and destination node. The given video file format is qcif.yuv. The two algorithms are applied on this video one by one and the performance is analyzed by evaluating the PSNR for obtained video at destination



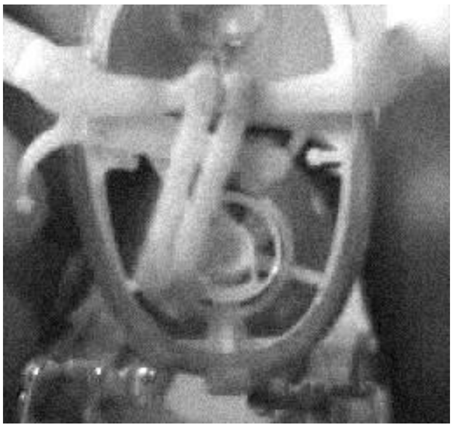
Generally a video file is considered as a group of images (frames). So to process any operation on an video in the first stage we have to extract the frames from it. The above figure denotes the extracted frames for the given video sequence in the fig12.

The these frames are divided into I frame, P frame and B frame respectively and these are processed through the selected path between source node and destination node by applying the both weighted random early detection and AAQM one by one. The recovered video sequences after processing through the selected path using AAQM and WRED is shown in fig

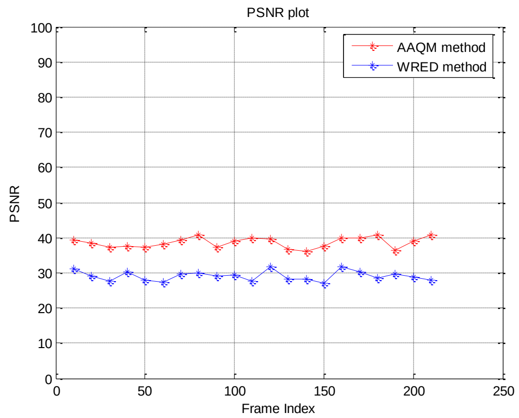
Recovered Video sequence using AAQM method



Recovered Video sequence using WRED method



The above figure denotes the recovered video sequence using WRED method. From the figure it is clear that the recovered video sequence by WRED has some distortions compared to the video in the, recovered using AAQM. From this visual analysis we can conclude that the proposed approach is efficient.



The above figure denotes the PSNR plot for the proposed approach and also fr previous approach. First to evaluate the numerical analysis we have to evaluate the mean square error between the original video and recovered video. Then the PSNR can be evaluated by applying the logarithm for that MSE. The formulae for MSE and PSNR evaluation are shown below.

$$MSE=\frac{1}{n}\sum_{i=1}^{n}(\hat{y}_i - y_i)^2$$

Where $\hat{y}_i$the recovered video is sequence and y_i is the original video sequence.

PSNR=10*log(MSE)

Conclusions

In this work a new queue management scheme is proposed to improve the multimedia flow delivery quality in mobile Adhoc networks. For such purpose we introduced the autonomic attributes to queue management algorithm. The mechanism is capable of configuring and adjusting dynamically according to network and service context information. In AAQM, multimedia video packets are divided into several drop priority levels according to their service context, further taking into account the video compression characteristic information. The simulation performed in Mat lab is compared the performance of the proposed AAQM with WRED when transmitting MPEG4 formatted video flow. The result shows that AAQM can protect important video packets and reduce the impact of packet loss on video quality effectively.

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