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Research on Media Stream Transmission Based on Back-pressure in Mobile Wireless Network

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Abstract

With the development of smart-phone devices, media stream transmission is bound to make wireless network communication resources that are in short supply cause greater pressure. Due to the user's move in the media stream transmission process in the mobile wireless network, it may be possible to lead to the following questions: the established connection is interrupted; the effect in data transmission structure becomes poor or invalid; wireless connection changes more frequently. All these problems will directly result in the QoS of media stream transmission. Back pressure algorithm is a control method which is firstly proposed by Tassinlas and Ephremides in the control theory. We choose back pressure algorithm as the basic research method of mobile media stream transmission because of the conclusion that back pressure algorithm can make the network load balance and maximize network utilization. According to the above problem, the article proposes the back-pressure algorithm guaranteeing deadline, and the proposed algorithm can well guarantee deadline of packet transmission. It not only can remove the packets which are redundant or staying too long time in the network, but also can make network throughput optimal. And in order to speed up the network's convergence speed and improve user's satisfaction index. We proposed cluster-based back pressure algorithm guaranteeing deadline.

Keywords: *QoS; network load balancing; network utilization; throughput*

1. Introduction

At present, mobile devices which are represented by smart-phone with high ability develop rapidly, and sales of smart-phone are more than 17000 singly in the year 2009. Experts think that the number of mobile devices such as smart-phone would be more than computers by the end of 2011, and in accordance with the this speed the number of these mobile devices will increase significantly in the future [1]. Mobile devices will soon be the subjects of Internet communication, so mobile devices and mobile communication environment will become the basic working environment of computing applications in the future. Now the people are very willing to put their shooting video and other media files share on the network, and transmit with each other between friends in social network [2-3]. The result of sharing massive high quality video files in the network need transmit very large amounts of streaming media data in wireless network, which make wireless network communication resources that are in short supply cause greater pressure. Many Internet service providers start to take some measures (such as charging the users with a large amount of data money) to contain a large amount of streaming media data uploaded [4].This approach can obtain effect, but it is in order to reduce the using effect of users on the system at the cost of. From a long-term point of view, this is a kind of unwise choice. Simultaneously, it is likely to lead to the following questions due to the user's move in the streaming media transmission process in the mobile environment: the

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established connection is interrupted; the effect about data transmission structure becomes poor or invalid; wireless connection changes more frequently. All these problems will directly lead to the QoS of streaming media transmission. Therefore, it is very important to guarantee the deadline for packet transmission the same time that alleviates the wireless network bandwidth pressure.

In view of the user generated content, the article [5] proposed a Taming method, which actually designs appropriate upload location and upload the opportunity to reduce the pressure of communications based on the characteristics of generating and uploading streaming media data from users.

In addition to using the characteristics of the data transmission requirements to effectively upgrade the capability of the service system, the common ways to reduce pressure of communication are: using correlation of transmission content; reducing load to achieve the Shannon Capacity of wireless channel on the changing channel. Actually these three aspects constitute the three basic methods to alleviate the pressure of the wireless communication: upgrading communication service ability, reducing the amount of data transferred, making full use of the channel resources. These three aspects constitute the main research work in the field of wireless communications at present. In view of uplink transmission of streaming media data from the users, how to take advantage of the relationship between the transmission content to reduce the amount of data transferred is the important content in the study of WMSN (Wireless Multimedia Sensor Network) [6-7]. Although the same method based on condition entropy coding can also be used in this project, the Camera unlike WMSN in mobile environment is unified deployment and fully cooperation, so we need deal the existing processing method with in-depth transformation to apply to mobile streaming media transmission process [8-9]. To make full use of the wireless channel of dynamic resources in this research, Gudipati et al proposed a high efficient and beautiful comprehensive solution in paper [10], and it can obtain good effect. But more serious defect existing in the above research is: not considering the deadline of packet transferred, so streaming media communication with stringent QoS requirements such as the deadline so on, is the main work of this study.

The rest of this paper is organized as following. In Section II, we introduce back pressure algorithm. In Section III, we detail the proposed back pressure algorithm guaranteeing deadline about streaming media transmission, and experiment result and analysis are presented in Section IV. Conclusion and future work are given in Section V.

2. Back Pressure Algorithm

Back pressure algorithm is a control method which is proposed by Leandros Tassinlas and Anthony Ephremides in IEEE Transaction on Automatic Control in the year 1992 [11]. It mainly manifest in routing scheduling scheme based on the back pressure numerical in network transmission system. The Figure 1 shows the basic idea of back pressure in the network, which back pressure value on the link (if link l1 on BP = 2) is the queue length of the link tail minus queue length of the link header (in this case 6-4 = 2). The core idea of back pressure algorithm is to select the collections whose sum of the back pressure value is the largest from all feasible scheduling link set to schedule. As an example shown in figure 1, under the constraints of wireless half-duplex transmission, {l1, l4} and {l2, l3} are two feasible scheduling link sets, and the sum of back pressure value corresponding to two sets is 5 and 1 respectively, so obviously it should select {l1, l4} to schedule. The intuitive idea of back pressure is to choose the links with the most stressful pressure and firstly uninstall the pressure on these links. Apparently when a node has multiple neighbor nodes, as in the Figure

1, the header node of l1 and l2 has two neighbors, and we select the link with bigger back pressure numerical as well as actually choose the neighbor node load in the light (corresponding to the queue length is shorter)to transmit. Clearly it can have the effect of load balancing, and can give full play to the communication capability of each node and link to complete the task of communication. A lot of research results are proved: routing scheduling strategy based on back pressure can achieve the largest utilization of network communication ability, and the conclusion is applicable to solve communication bandwidth pressure problems of stream media data upload in the wireless network [12-13]. So we choose back pressure algorithm as the basic research methods of mobile streaming media transmission.

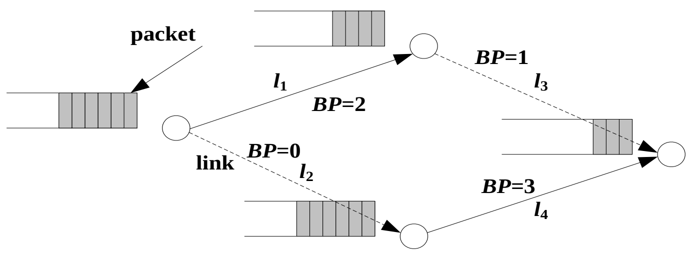

Figure 1. The Basic Idea of Back Pressure

3. Back Pressure Algorithm Guaranteeing Deadline

3.1. Basic Model

We let G= (*N*, *L*) denote a network, where *N* denotes a collection of nodes in the network, and *L* denotes a collection of direct links. Here, we assume that | *N* |=N, | *L* |=L. Let (*m*, *n*) denote the link from node *m* to node *n*. μ_{mn} denotes the transmission rate on link (*m*, *n*), $\mu = \{\mu_{mn}\}$ denotes transmission rate vector set on the link. If all the links in the specified link vector by μ can transmit simultaneously, we claim that link vector μ is obtainable. Let Γ denote all the obtainable vector sets of link rate.

About the communication in the network, we let *f* denote a flow, let *s*(*f*) denote the source node of flow *f*, let *d*(*f*) denote the destination node of flow *f*, and let *F* denote the set of all the flows. Let *N*(*f*, *j*) denote the *j*th node n_j of flow *f*, where n_j is the node in the network. Let Q_f denote the queue length of flow *f*. Let T_f denote the staying time which the packet of flow *f* stays in the network, and we regard T_f as a parameter of flow *f*. We let $\mu_f(t)$ denote the number of packets injected by *f*, and assume that $\mu_f(t)$ is i.i.d. Let $Q_a^{(c)}(t)$ denote the number of *c* resource at the node *a* at the time *t*, $A_a^{(c)}(t)$ denote the number of packets which arrive at node *a* and send to node *c* finally at time *t*, $\mu_{ab}(t)$ denote the transmission rate on link (*a*, *b*) at time *t*, $S(t)$ denote the network topology at time *t*, and $\Gamma_{S(t)}$ denote all the obtainable vector sets of link rate under topology $S(t)$. We use $Q_{l(f,j)}^{(f)}(t)$ to denote the queue length of flow *f* in *j*th node at time *t*.

The goal of back pressure algorithm guaranteeing deadline is to solve the following problems:

(1) $\max \boldsymbol{\mu} \cdot \boldsymbol{\omega}$

(2) s.t. : $\begin{cases} \boldsymbol{\mu} \in \Gamma_{S(t)} \\ \mathrm{T}_f \geq T, Q^{(f)}_{l(f,j)}(t)=0, j=1,2,...,length(f) \end{cases}$

Let $\boldsymbol{\mu}$ denote the obtainable transmission rate matrix, $\boldsymbol{\omega}$ denote the weight matrix on the link, and $length(f)$ denote the number of node which flow *f* routes from source to destination. $\max \boldsymbol{\mu} \cdot \boldsymbol{\omega}$ is also to maximize the number of packet which is sent successful, the above question can convert to following question(satisfy the same constraint):

$$\max \sum_{a=1}^{N} \sum_{b=1}^{N} \mu_{ab}(t) W_{ab}(t) \tag{1}$$

where,

$$W_{ab}(t) = \max[Q_a^{(c)}(t) - Q_b^{(c)}(t), 0] \tag{2}$$

3.2. Flow Control Theory

This paper considers the flow control with the deadline constraint, and all packages must be converted in the prescribed deadline. Flow control theory is introduced as follows.

We use $f = (s(f), ..., d(f), \mathrm{T}_f)$ to denote a flow with deadline T_f parameter. We assume that the deadline in the network is *T*. Due to traditional back pressure algorithm can achieve stable, we calculate the value of T_f respectively in *F* when the network achieve stable. The method of calculating T_f is as follows:

$$\mathrm{T}_f(t) = \frac{Q_f}{\mu_f(t)} = \frac{\sum_{j=1}^{length(f)} Q^{(f)}_{l(f,j)}(t)}{\mu_f(t)} \tag{3}$$

Then we take the following decisions:

(1) If $\mathrm{T}_f \geq T$, then,

$Q^{(f)}_{l(f,j)}(t) = 0,\ j = 1, 2, ..., length(f)$

(2) Else calling the traditional back pressure algorithm for the leave schedule sets.

For example is as shown in Figure 2.

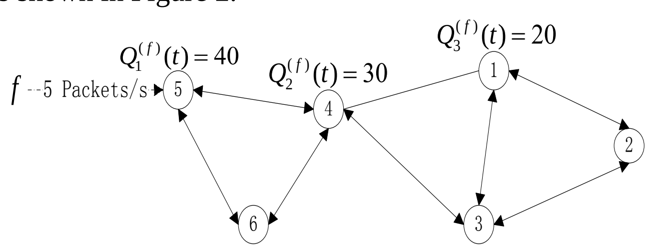

Figure 2. Flow Control Theory

We define a flow $f = (5, 4, 1, 2, \mathrm{T}_f)$, and *f* sends packets to node 5 at the rate of 5 packets per second. We assume that the deadline is 10 seconds. When network achieve the stable, the number of packet at every node in f is 4, 3, and 2 respectively. Then T_f = (40+30+20)/5=18s>T=10s, so we remove the packets from the network, that is $Q_j^{(f)}(t)$ =0, j=1, 2, 3.

3.3. Algorithm and the Stability Proof

Back pressure algorithm guaranteeing deadline focuses on researching how to maximize transmission capacity of wireless network where the delay time $d(p)$ which packet is sent from source to destination with satisfies $d(p) \leq T$. The solution of the paper is that we dominate the rates which flow to nodes $N(s) = \{n_1, n_2, \ldots, n_k\}$ at source node s. The detail is as shown in Figure 3. The main idea of algorithm design is that we calculate the T_f for every flow f from s to d through n_i. Due to traditional back pressure algorithm can make queue achieve stability, when queue is stable, the queue length Q_{f_i} and flowing rate $\mu_{f_i}(t)$ satisfies Little theorem of stable queuing system:

$$Q_{f_i} = \mu_{f_i}(t) \times \mathrm{T}_{f_i} \tag{4}$$

In this theorem, T_{f_i} denotes the stay time that a packet stays in the queue. Therefore, $\mathrm{T}_{f_i} \leq T$ if and only if $Q_{f_i} / \mu_{f_i}(t) \leq T$. It is this principle that results in the statement (3) in Figure 3.

Let 1_Φ denote indicator function with condition Φ. If condition Φ sets up, then $1_\Phi = 1$, else $1_\Phi = 0$. The following condition sets up for given back pressure algorithm.

$$\begin{aligned} Q_{l(f,j)}^{(f)}(t+1) &= Q_{N(f,j)}^{(f)}(t+1) \\ &= Q_{l(f,j)}^{(f)}(t) + 1_{j\neq 1} V_{N(f,j-1)N(f,j)}(t) - V_{N(f,j)N(f,j+1)}(t) + 1_{j=1}\mu_f(t) \\ &= Q_{l(f,j)}^{(f)}(t) + 1_{j\neq 1} V_{n_{j-1}n_j}(t) - V_{n_j n_{j+1}}(t) + 1_{j=1}\mu_f(t) \end{aligned} \tag{5}$$

We use $V_{ab}(t)$ to denote the number of actually transmitting packet, $\mu_{ab}(t)$ denote the transmission rate, and $u_{ab}(t)$ denote the unused transmission rate from node a to node b at time t. The relationship of these is as follows:

$$V_{ab}(t) = \mu_{ab}(t) - u_{ab}(t) \tag{6}$$

Algorithm : back pressure algorithm guaranteeing deadline
Input : G= (N,L), source node s, $N(s) = \{n_1, n_2, \ldots, n_k\}$, destination node d
Output : Routing/scheduling strategy

(1) Find a flow $f_i = (s, n_i, \ldots, d)$ for every $n_i \in N(s)$ starting from node s.
(2) Measure queue length Q_{f_i} and input rate $\mu_{f_i}(t)$ of f_i for every f_i
(3) If $Q_{f_i} / \mu_{f_i}(t) \geq T$, then remove these schedule sets from $\langle s, n_i \rangle$.
(4) Call traditional back pressure for leaving schedule sets.

Figure 3. Back Pressure Algorithm Guaranteeing Deadline

Theorem 1: Back pressure algorithm guaranteeing deadline can make the network system achieve stability.

Proof: First, it is easy to verify that $Q_s^{(d)}(t)$ is Markovian since back pressure algorithm guaranteeing deadline makes routing and scheduling based on the queue lengths and link state at time *t*. Define Lyapunov functions:

$$V(t) = \sum_{\forall s,d \in N} [Q_s^{(d)}(t)]^2 \geq 0$$

$$V^{'}(t) = \sum_{\forall s,d \in N} [Q_s^{(d)'}(t)]^2 \geq 0$$

Due to traditional back pressure algorithm can make network system achieve stability, so $\frac{V^{'}(t+1) - V^{'}(t)}{\Delta t} \leq 0$ sets up, then $V^{'}(t+1) - V^{'}(t) \leq 0$. Since deadline constraint, the relationship between $Q_s^{(d)'}(t)$ and $Q_s^{(d)}(t)$ is as follows:

$$Q_s^{(d)'}(t) = Q_s^{(d)}(t) + \sum_{\forall f \in F} \sum_{T_f \geq T} Q_f(t)$$

$$Q_s^{(d)'}(t+1) = Q_s^{(d)}(t+1) + \sum_{\forall f \in F} \sum_{T_f \geq T} Q_f(t+1)$$

Then,

$$\begin{aligned}
&V^{'}(t+1) - V^{'}(t) \\
&= \sum_{\forall s,d \in N} [Q_s^{(d)'}(t+1)]^2 - \sum_{\forall s,d \in N} [Q_s^{(d)'}(t)]^2 \\
&= \sum_{\forall s,d \in N} ([Q_s^{(d)'}(t+1)]^2 - [Q_s^{(d)'}(t)]^2) \\
&= \sum_{\forall s,d \in N} ([Q_s^{(d)'}(t+1) + Q_s^{(d)'}(t)][Q_s^{(d)'}(t+1) - Q_s^{(d)'}(t)]) \\
&\geq \sum_{\forall s,d \in N} ([Q_s^{(d)}(t+1) + Q_s^{(d)}(t)][Q_s^{(d)'}(t+1) - Q_s^{(d)'}(t)]) \leq 0
\end{aligned}$$

and,

$$\begin{aligned}
&Q_s^{(d)'}(t+1) - Q_s^{(d)'}(t) \\
&= Q_s^{(d)}(t+1) - Q_s^{(d)}(t) + \sum_{\forall f \in F} \sum_{T_f \geq T} Q_f(t+1) - \sum_{\forall f \in F} \sum_{T_f \geq T} Q_f(t) \\
&= Q_s^{(d)}(t+1) - Q_s^{(d)}(t) + (\sum_{\forall f \in F} \sum_{T_f < T} Q_f(t+1) - \sum_{\forall f \in F} \sum_{T_f < T} Q_f(t))
\end{aligned}$$

We assume that $\forall \Delta t > 0$, the network topology $S(t)$ doesn't change, then,

$$\begin{aligned}
&Q_s^{(d)'}(t+1) - Q_s^{(d)'}(t) \\
&= Q_s^{(d)}(t+1) - Q_s^{(d)}(t) + \sum_{\forall f \in F} \sum_{T_f < T} (Q_f(t+1) - Q_f(t)) \\
&= Q_s^{(d)}(t+1) - Q_s^{(d)}(t) + \sum_{\forall f \in F} \sum_{T_f \geq T} \sum_{i=1,(n_j,d) \in f}^{N} (\mu_f(t) - V_{n_j d}(t))
\end{aligned}$$

When $T_f \geq T$ sets up, $\mu_f(t) > V_{n_j d}(t)$ sets up, then,

$$Q_s^{(d)'}(t+1) - Q_s^{(d)'}(t) > Q_s^{(d)}(t+1) - Q_s^{(d)}(t)$$

So,

$$
\begin{aligned}
& V^{'}(t+1) - V^{'}(t) \\
& > \sum_{\forall s,d \in N} ([Q_s^{(d)}(t+1) + Q_s^{(d)}(t)][Q_s^{(d)}(t+1) - Q_s^{(d)}(t)]) \\
& = V(t+1) - V(t) \le 0
\end{aligned}
$$

That is that $\frac{V(t+1)-V(t)}{\Delta t} \le 0$ sets up. Therefore, back pressure algorithm guaranteeing deadline can make the network system achieve stability.

4. Cluster-Based Back Pressure Algorithm Guaranteeing Deadline

In back pressure algorithm of distributed network transmission in the large network, convergence speed may be slow, which to a certain extent reduces customer's satisfaction index of streaming media data transmission. To speed up the convergence rate of the streaming media transmission, this part puts forward a cluster-based back pressure algorithm guaranteeing deadline, this algorithm may not make the throughput optimal at some point, but it can speed up the network's convergence speed, and improve user's satisfaction index.

4.1. Clustering in the Network and Model Definition

First of all, we should consider the mobile node in the network clustering. About clustering algorithm in the network, many top academic journals have published a large number of relevant academic achievements. Paper uses the minimum cluster head change algorithm, namely minimum ID algorithm combined with the most generous algorithm. The core idea of algorithm is to select the node with the largest degree of network topology nodes as the cluster head. When there are multiple nodes with the largest degree, the node with smallest ID is chosen as the cluster head node. We call the nodes gateway nodes which they belong to multiple clusters at the same time. Gateway nodes are responsible for the data transmission between two neighboring clusters. At every moment, every node in the network will broadcast its own ID and degree information, so that when change happens in network topology, the system can cluster again.

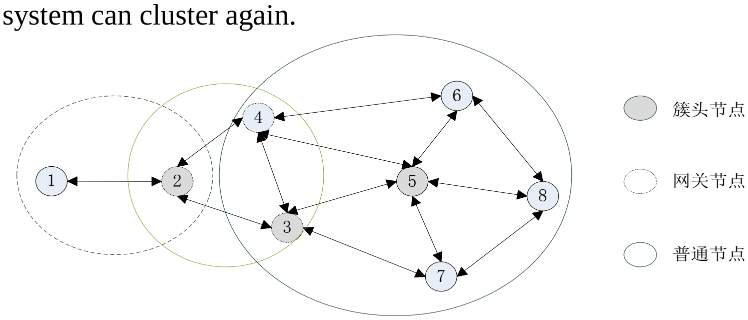

Figure 4. Clustering in the Network

For example, as shown in Figure 4, in accordance with the minimum cluster change algorithm, we firstly select node 5 as the cluster head node because of the largest degree 5 of node 5. And all nodes adjacent with node 5 will cluster a cluster. For node 2, the degrees of its adjacent nodes 3, 4 are both 4, so we choose node 3 with ID smaller as the cluster head node, and clustering results is as shown in Figure 4. In Figure 4, node 2 and 4 are the gateway nodes.

We let $C(n)$ denote the cluster which contains node n, B_C denote gateway nodes of cluster C. For some of these discussions, communication controller, namely cluster node, at every time requires dynamic shunt in the source node s for the flow $f=(s,d)$. If the source node s and destination node d in different clusters, each packet of the flow $f=(s,d)$ before delivered to the target node need to pass some gateway nodes to forward. In this case, the cluster head nodes need to decide to choose a gateway node to forward. Define:

$$Q_s^{r,d}(t)=Q_s^{(r)}(t)+\hat{Q}_r^{(d)}(t) \quad (7)$$

$Q_s^{r,d}(t)$ denotes congestion degree that the source node s forwards packets to the destination node d through each gateway node r of the cluster $C(d)$, where $\hat{Q}_r^{(d)}(t)$ denotes queue length that packets need be forwarded through gateway node r after the rectification, and the specific calculation method is below. If the source node s is a internal node of cluster $C(d)$, the packages of the flow $f=(s,d)$ can be sent to the destination node directly without forwarding through the gateway node. Therefore, to define:

$$Q_s^{0,d}(t)=Q_s^{(d)}(t) \quad s,d\in C(d)$$
$$Q_s^{0,d}(t)=\infty \quad s\notin C(d)$$

4.2. Cluster-based Back Pressure Algorithm Guaranteeing Deadline

Cluster-based back pressure algorithm is mainly divided into the following steps:

(1) Shunt and gateway node selection

At time t, node s shunts into $A_s^{r,d}(t)$ for packets $A_s^{(d)}(t)$ flowing into node s, where $A_s^{r,d}(t)$ denotes the number of packets that are injected from the source node s through the gateway node r forwarding to the destination node d. When node s and d are in the same cluster, the packets of node s can be directly forwarded to destination node d, otherwise the cluster head node will calculate the value of $Q_s^{r,d}(t)$, and choose the small gateway r with the smaller value of $Q_s^{r,d}(t)$ to forward packets, model expresses as:

$$A_s^{r,d}(t)=\begin{cases}A_s^d(t) \ , \ r=r^* \\ 0 \qquad , \ r\neq r^*\end{cases}, \text{ where } r^*=\arg\min_{r=\{0\}\cup B_{C(d)}} Q_s^{r,d}(t) \quad (8)$$

When $r^*>0$, r^* denotes the gateway node with the smallest congestion degree. $r^*=0$ denotes that the packets can directly delivered to destination node.

(2) Rectifier

Gateway node r will hold a real queue and a queue after rectifier for each destination node in the cluster $C(r)$. Let $\hat{Q}_r^{(d)}(t)$ denote a queue after rectifier, and the calculation method is as follows:

$$\hat{Q}_r^{(d)}(t)=\sum_{s:f(s,d)\in F} A_s^{r,d}(t) \quad (9)$$

(3) The back pressure scheduling

At every time, the cluster node can calculate the value of $\boldsymbol{\mu}(t)$ through solving the following question:

$$\boldsymbol{\mu}(t)=\arg\max_{\boldsymbol{\mu}\in\Gamma_{S(t)}}\sum_{a=1}^{N}\sum_{b=1}^{N}\mu_{ab}(t)W_{ab}(t) \tag{10}$$

Where, $W_{ab}(t)=\max[Q_a^{c(t)}(t)-Q_b^{c(t)}(t),0]$, $c(t)=\begin{cases}\arg\max\limits_{r\in\cup_C B_C}(Q_a^{(r)}(t)-Q_b^{(r)}(t)) & ,b\in\cup_C B_C\\ \arg\max\limits_{c\in N}(Q_a^{(c)}(t)-Q_b^{(c)}(t)) & ,\text{otherwise}\end{cases}$.

After obtaining $\mu_{ab}(t)$ and $c(t)$, node *a* can send the packets in the queue $c(t)$ to node b at the rate $\mu_{ab}(t)$ through the link (*a*, *b*). If $c(t)\neq b$, the packets can be stored into the queue $c(t)$ at node *b*. If $c(t)=b$, the packets in the queue $c(t)$ at node *a* can be sent to node *b* or forwarded to other cluster through gateway node *b*.

Cluster-based back pressure algorithm guaranteeing deadline is as shown in Figure 5.

Algorithm: Cluster-based back pressure algorithm guaranteeing deadline Input: G= （N,L） , source node s, $N(s)=\{n_1, n_2, \ldots, n_k\}$, destination node d Output: Routing/scheduling strategy
(1) Use minimum cluster head change algorithm to cluster. (2) Find a flow $f_i=(s, n_i, \ldots, d)$ for every $n_i\in N(s)$ starting from node s. (3) Measure queue length Q_{f_i} and input rate $\mu_{f_i}(t)$ of f_i for every f_i (4) If $Q_{f_i}/\mu_{f_i}(t)\geq T$, then remove these schedule sets from $<s, n_i>$. (5) Call cluster-based back pressure algorithm for leaving schedule sets.

Figure 5.Cluster-based Back Pressure Algorithm Guaranteeing Deadline

5. Simulations

We consider the network with 64 nodes as shown in Figure 6.The connection between two nodes is said a communication link, and all links of transmission capacity for two-way transmission at the rate of 1 packet/time slot. Assume that all links are orthogonal, so the link can transmit simultaneously. At the same time assume that link transmission delay is zero.

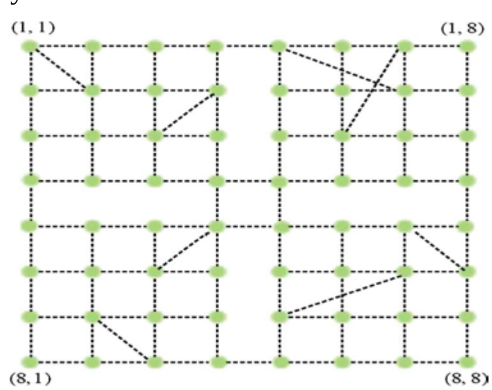

Figure 6. Network Topology of Simulation

We create eight data flows in the network such as Table 1.The fixed transmission rate of each flow is 1 packet/time slot. The traditional back pressure algorithm and back pressure algorithm guaranteeing deadline are simulated as follows.

Table 1.Flow in the Network

Flow ID	（Source, Destination）
1	（（1,3），（2,5））
2	（（2,3），（2,7））
3	（（2,2），（1,6））
4	（（3,4），（2,7））
5	（（1,1），（1,7））
6	（（4,3），（5,4））
7	（（4,6），（6,6））
8	（（5,3），（5,6））

We study the total queue length at each node, and we also study the packet loss rate and throughput of the network. Figure 7 shows the queue length increases with the time t. Figure 8 shows the throughput of the network, and it indicates that back pressure algorithm guaranteeing deadline can maximize network utilization the same time guarantee deadline. Due to back pressure algorithm guaranteeing deadline can remove the packets which can't satisfy the requirement of deadline, packet loss rate is higher than that in back pressure algorithm as shown in Figure 9.

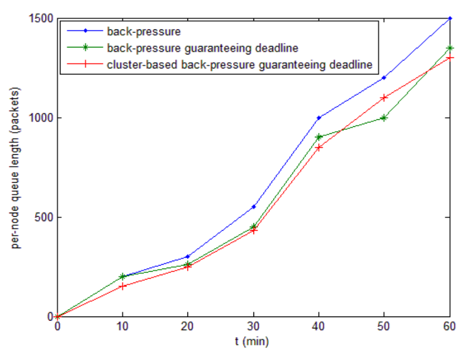

Figure 7. Per-node Queue Length

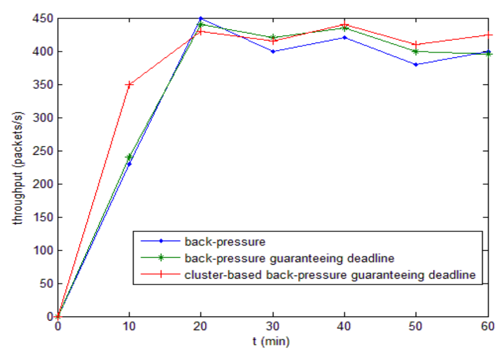

Figure 8. Throughput in the Network

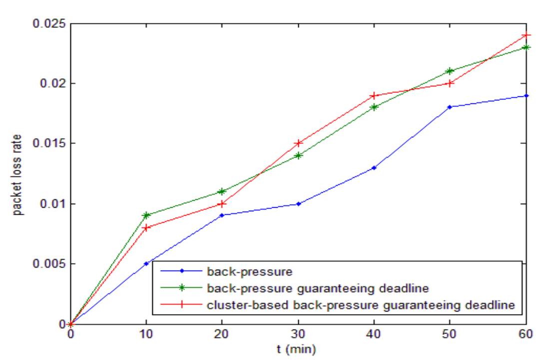

Figure 9. Packet Loss Rate with Vary Time t

6. Conclusion and Future Work

This paper has proposed the back pressure algorithm guaranteeing deadline and cluster-based back pressure algorithm guaranteeing deadline in mobile wireless network. We proofed the algorithm's stability in mobile wireless network through the Lyapunov method. And we also tested the performance of the algorithm through the experiments based on NS2. In a word, the algorithm can make network throughput optimal the same time guarantee deadline. And cluster-based back pressure algorithm guaranteeing deadline can speed up the network's convergence speed. But the algorithm can still exist many problems, such as higher point to point transmission delay and so on. We need do more research in the future.

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