An Offset Differential Assembly Method at the Edge of OBS Network	Phương pháp lập burst phân biệt offset tại biên của mạng OBS

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Abstract	Tóm tắt
Traditional burst assembly method only differ service class priority by increasing extra offset time so as to assure QoS at Optical Burst Switching (OBS) core node which increases all network delay extremely, especially for optical network with many hops and large radius. In order to take full advantage of flexible buffer and control function of electronics device and optical large capacity predominance, it is desired to process real-time traffic at edge ingress node and guarantee delay fairness under small enough delay and QoS based on offset time differentiation for various classes. To achieve lower assembly delay at OBS edge node and offset time based QoS guarantee at core node, this paper proposes an approach called Prediction and Offset QoS Assembly (POQA) to improve existing burst assembly mechanism at edge node. POQA method takes into account the delay fairness and QoS-based offset time adequately. The ratios of assembly time and offset time are introduced to make a delay and offset differentiation among various traffic classes. Assembly delay, burst size, burst utilization and length error of various classes are compared under different offered load. Moreover, in contrast with traditional time assembly method, simulation results show that POQA method can achieve a significant improvement in terms of burst delay and utilization and realize the delay fairness and offset time QoS differentiation under different traffic offered load.	Phương pháp lập burst truyền thống chỉ phân biệt độ ưu tiên lớp dịch vụ bằng cách tăng thời gian offset phụ để đảm bảo QoS tại nút lõi Chuyển Mạch Chùm Quang (OBS), điều này làm tăng mạnh độ trễ mạng tổng thể, đặc biệt đối với các mạng quang học có nhiều hop và bán kính lớn. Để khai thác triệt để ưu điểm của bộ đệm linh hoạt và chức năng điều khiển của thiết bị điện tử và dung lượng quang học lớn, chúng ta cần xử lý lưu lượng thời gian thực tại nút biên vào và đảm bảo công bằng độ trễ trong điều kiện trễ nhỏ và QoS dựa trên phân biệt thời gian offset đối với các lớp khác nhau. Để đạt độ trễ lập burst thấp hơn tại nút biên OBS và đảm bảo QoS dựa trên thời gian offset tại nút lõi, bài báo này đề xuất một phương pháp có tên là Lập Burst QoS Dự Đoán và Dịch Chuyển (POQA) để cải thiện cơ chế lập burst hiện tại tại nút biên. Phương pháp POQA xét đến sự công bằng độ trễ và thời gian offset dựa trên QoS. Chúng tôi đưa vào khái niệm tỷ số thời gian lập burst và thời gian offset để tạo trễ và phân biệt offset trong các lớp lưu lượng khác nhau. Độ trễ lập burst, kích thước burst, khả năng tận dụng burst và sai số chiều dài của các lớp khác nhau được so sánh trong các lưu lượng đầu vào khác nhau. Hơn nữa, trái ngược với phương pháp lập burst thời gian truyền thống, kết quả mô phỏng chứng tỏ rằng phương pháp POQA có thể cải thiện đáng kể độ trễ burst và khả năng sử dụng burst và thực hiện ngang bằng độ trễ và phân biệt QoS thời gian offset trong các lưu lượng đầu vào khác nhau.
Keywords: Quality of Service (QoS),	Từ khóa: Chất lượng dịch vụ (QoS), dự

prediction, offset time, delay fairness, burst assembly 1. Introduction Burst photonic networks employing optical burst switching (OBS) technology are considered to be promising candidates for building the next generation photonic Internet. In OBS network [1], control information carried by control wavelength channel is decoupled from data channel. There is an offset time between the control packet and the data burst. Each ingress edge node aggregates the arrival packets at a lower line speed and then generates optical bursts. Bursts are disassembled into packets at egress edge nodes. The intermediate optical core nodes use optical control packet arriving beforehand to configure optical switching matrix during offset time so that optical data burst can pass core nodes directly without OEO conversion. The traffic aggregation, control packet generation and output optical packet features directly influence the performance of core optical networks. Burst assembly and JET offset time management policy are two important issues in OBS network. In traditional assembly schemes called Time Assembly (TA) [2, 3], control packet is sent after a burst is completely generated. Burst assembly and offset time produces extra assembly delay which is the sum of all electronic packets burstification buffer time from their arrival to transmission. An optical burst must wait assembly time and offset time to transmit which is too large compared with end-to-end propagating delay. This method decreases	đoán, thời gian offset, công bằng độ trễ, lập burst [redacted] [redacted]

the OBS network utilization drastically and makes high priority real-time service intolerable. Electronic assembly delay at edge node exerts a deteriorative influence on core network. The studies of delay reduction on traffic prediction appear in [4, 5] at burst assembly edge node. Linear prediction method is used to reduce burst latency. However the prediction precision of the existing method fluctuates with offset time and assembly time and the prediction methods may generate large estimate error, which deteriorates the performance of OBS network extremely. Furthermore the existing assembly method does not consider delay fairness of differentiate service. High priority class must guarantee small delay, while low priority service can tolerate bigger delay. Then QoS at core node with no delay fairness becomes meaningless. On the other hand, traditional method only differ service class priority by increasing extra offset time so as to assure QoS at core node which increases all network delay extremely, especially for optical network with many hops and large radius.

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In order to take full advantage of flexible buffer and control function of electronics device and optical large capacity predominance, it is desired to process real-time traffic at edge ingress node and guarantee delay fairness under small enough delay and QoS based on offset time differentiation for various classes. In this paper, we propose an effective Prediction and Offset QoS Assembly (POQA) method for self-similar traffic to

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improve existing assembly mechanism at edge node. Simulation results show that POQA method can achieve a significant improvement in terms of burst delay and utilization and realize the delay fairness and offset time QoS differentiation under various traffic offered load. The rest of this paper is organized as follows. Section 2 describes the assembly system model on assembly and offset time at OBS edge node, and in section 3, we propose the POQA algorithm. In section 4, we explain the performance evaluation of the POQA method and numerical results are shown. Finally, conclusions are presented in section 5.

2. System model

The POQA model employs JET protocol [6]. Burst assembly time lies on many factors consisting of the number of accessing sources, the offered load, service classes, bit rate and network capacity etc. Moreover assembly time decides the burst size. In view of current optical switching and control packet processing speed, offset time ranges from several hundred microseconds to millisecond magnitude. In the traditional OBS system, edge node will not send control packet until the whole burst generates shown in fig. 1(a). Then after an offset time, burst is sent to OBS network. Fig. 1(b) depicts that every burst of POQA model can reduce the delay of an offset time. The prediction time and offset time compose burst assembly time. Black packets denote the actual arrival traffic during prediction time, and grid packets represent the predicting traffic that will arrive in offset time. Each burst

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length is estimated in the prediction time according to the past p-order burst length value and current traffic. At the end of prediction time, edge node estimates burst length and sends control packet to core network. When assembly is over, we compare the estimate value with the actual burst length and obtain the length estimate error for the next adaptive length estimation.

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Fig. 2 Burst assembly time differentiation and offset QoS

Multiple self-similar traffic sources access OBS ingress edge node, and then different packets from every source are classified into each burst queue for electronic buffer in terms of QoS priority and output port. POQA mechanism is applied in each burst queue and burst length estimation is executed as described in fig. 1(b). Fig. 2 depicts POQA burst assembly time and offset time differentiation of four classes in our scheme. The bias rectangle denotes different burst offset time for four classes. High priority service class0 has the longer offset time than low priority class1-3. The ratio of them is fixed in our assumption such as 6:4:3:2. White rectangle represents burst assembly time with the ratio of 2:3:4:5 from class0 to class3 which comprises the offset time identical with fig. 1(b). Therefore high priority traffic achieves a smaller burst assembly time for delay fairness and a longer offset time for QoS guarantee in core network.

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3. Algorithm

Based on normalized MMSEP algorithm for self-similar traffic described in [7],

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POQA interpolates a current traffic weight in prediction time to improve the estimation performance of real-time traffic. The event that the first packet in the corresponding queue arrives triggers Adaptive Auto-Regressive (AAR) linear filter. POQA uses the past p-order burst actual length, adaptive coefficients and current arrival traffic in prediction time to estimate the burst length on-line. We consider the following four steps to explain the POQA:

Step 1 Set burst assembly time differentiation Ta‘ and offset time To‘ i=0, 1, 2, 3 for the service assembly queue of four classes shown in fig. 2.

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Step 2 The first packet arrival at the corresponding port and service class assembly queue triggers the related AAR linear filter. Simultaneously, the previous prediction value of burst length L(n) is used to calculate the error e(n)=l(n)-L(n) and weight w(i) i=0,.. .p-1 in (2). Afterward, burst assembly queue pass the current arrival traffic l(n+1) to AAR filter.

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Step 3 POQA calls the past p-order burst length value l(n-I),I=0, p-1, and combines w(i) with current arrival traffic l(n+1) to estimate the burst length L(n+1). Expression (1) and (2) give POQA one-step burst length prediction value L(n+1). The coefficient w(-1) is the weight of current arrival traffic l(n+1),which is the ratio weight of assembly time Ta‘ to current prediction time Ta‘ - To‘ . The coefficients w(i) are initialized to Weight, i=0, .p-1 and a to 1-Weight in (1). Set ^ to 1 for a fast

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convergence in (2).	
Step 4 POQA sends control packet with L(n+1) at the end of prediction time. When the data burst assembly completes, POQA calculates length error e(n)= l(n+1)-L(n+1) to decide whether to execute void filling when e(n)<0 or segment residual packets to the next assembly burst in this queue when e(n)>0. Then after optical burst routing and wavelength assignment, data burst with estimate size L(n+1) is multiplexed into optical fiber for transmission.	[redacted]
From the above description, we can see that POQA algorithm has two important features: First, normalized MMSEP algorithm is a self-similar traffic oriented estimate method. It is fit for IP and Ethernet centric data network now.	[redacted]
Adaptive linear prediction is adopted by introducing current traffic weight in prediction time which can not only enhance the real-time traffic prediction precision but also decrease latency of each assembly burst pertaining to different traffic class. Second, burst assembly time and offset time differentiation guarantee traffic class delay fairness, burst size, length error differentiation and offset time based QoS without extra offset delay in OBS core network. 4. Performance evaluation To evaluate performance of our method, we undertake simulations in a network environment with the following	[redacted]

assumptions: (1) Forty 100Mbps Ethernet sources access the edge node. Hurst parameter of packet inter-arrival process is 0.9; (2) every self-similar source generates packets of which the length follows Pareto distributed with the range from 64 bytes to 1518 bytes. The shape parameter of Pareto distribution is 1.4; (3) we use four service classes 0, 1, 2 and 3 to stand for different priority traffic. The burst assembly time of classes is 0.4, 0.6, 0.8 and 1ms and the offset time of classes is 0.3, 0.2, 0.15 and 0.1ms from class0 to class3 respectively. (4) The number of egress edge nodes is 15. The order of the AAR linear filter is four.

The observed evaluate characters of all classes are average delay, average burst utilization, average burst length error and average burst size. In fig. 3, we draw the plot of POQA average burst delay versus load of all class traffic. We observe that assembly delay becomes large almost linearly along with the offered load increased due to the more packets arrival in every burst assembly time. Meanwhile through comparison, it is easy to find out that the assembly delay of higher priority traffic is always smaller than that of lower priority traffic. Class0 obtains the smallest burst assembly delay and class3 the longest. This indicates that POQA scheme realizes delay fairness and offset time QoS for various classes. Fig. 4 describes the POQA average burst size versus offered load of different classes. As the load increases, burst size of all traffic class increase with evident differentiation. Burst size turn large from class0 to class3 owning to the increasing

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assembly time.

Fig. 5 Length error versus load

Fig. 5 plots POQA average length error (i.e. the ratio of estimate error length to average burst length) under different offered load. Length error decreases with the augment of load. Meanwhile unlike delay fairness, since high priority class has relative small burst assembly time and large offset time resulting in inaccurate prediction, length estimate error of higher priority class is bigger than that of lower priority class.

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Fig. 6 compares the average delay of Time Assembly and our ADaptive POQA method according to offered load. The average delay of POQA is much smaller than TA and they both increase linearly with load and maintain a very strict delay differentiation among four classes. This illustrates that POQA approach achieves delay fairness and very small delay with QoS-based offset time.

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Fig. 7 and fig. 8 compare the average burst size and burst utilization of AD and TA respectively under various load. Burst size of AD is larger than TA and low priority traffic is smaller than high priority traffic in AD and TA methods. The burst utilization is defined as the sum of the total data estimate packet time over burst assembly time. The burst utilization of TA and AD both increase steadily as the offered load turns large. Furthermore, we discover that average burst utilization increases from classO to class 3 with

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offered load in TA, while decreases from classO to class3 in AD. TA is always much lower than AD under any load for all classes.	[redacted]
Above comparison implies that POQA method can execute perfect prediction for the self-similar traffic, then decrease assembly delay and achieve delay fairness and QoS-based offset time differentiation in spite of introducing the assembly mechanism of the last residual packets being inserted to the next burst. Since the real Internet traffic can be best modeled by self-similar process, the results strongly verify the adaptive feature of our POQA method. The improvement of assembly delay, burst utilization and QoS offset time differentiation at edge node release the rigorous demand of end-to-end delay for real-time traffic, and furthermore enhance the throughput efficiency and provide QoS guarantee in core OBS networks.	[redacted]
5. Conclusion In this paper, a Prediction and Offset QoS Assembly method is proposed and demonstrated to be effective at the edge node of OBS networks. Furthermore POQA method obtains the delay fairness and QoS-based offset time adequately. The ratios of assembly time and offset time are introduced to make a delay and offset differentiation among various traffic classes. Through the comparison of assembly delay, burst size and burst utilization of various classes with the	[redacted]

traditional TA method, POQA adaptively changes the burst prediction length and then reduces the assembly delay at edge node under various offered load. Simulation results of different traffic classes under our network condition show that, POQA can adaptively accommodate the change of traffic load, assembly and offset time and achieve a significant improvement in terms of burst delay and utilization and realize the delay fairness and offset time QoS differentiation.	[redacted]