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Dynamic bandwidth slicing for service migration in passive optical network based mobile backhaul

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Fig. 1: (a) The traditional dynamic bandwidth allocation algorithm and (b) the proposed dynamic bandwidth slicing algorithm.

arrives, which requires multiple polling cycles to be transmitted. As a consequence, non-migrated data $N2$ at ONU_1 that arrive after $M1$, have to wait and experience high latency. In the proposed DBS algorithm (see Fig. 1(b)), the cycle time can be dynamically divided into several slices, which are provisioned to different kind of traffic. The proposed DBS algorithm is also based on the report and grant mechanism. If there is no migrated data to be transmitted in the polling cycle, the proposed DBS algorithm performs in the same way as the classical DBA algorithm. Once service migration occurs, the resource controller located at the OLT calculates the lengths of the slices for both migrated and non-migrated traffic according to the information included in the report messages, namely the size and deadline for the migrated data. The granted time slots for Slice 1 ($SL1$) are allocated to the migrated data according to the ascending order of the deadline for finishing migration. In Slice 2 ($SL2$) the time slots are granted for the non-migrated traffic and are proportional to the requested time slots. Note that the same principle as the proposed DBS can also be used in the downstream. The pseudocode of the proposed DBS is presented in Fig. 2, while the corresponding parameters are explained in Table 1.

3. Performance evaluation

The proposed DBS algorithm is evaluated by numerical simulations with MATLAB in terms of average migration delay of migrated data as well as average packet latency and jitter of non-migrated traffic. We consider a TWDM-PON having the time slots for each wavelength scheduled separately, i.e., separate time and wavelength scheduling [8]. The performance of the proposed DBS is tested based on EPON protocol. The interleaved polling with adaptive cycle time (IPACT) is used as the benchmark [9]. The number of ONUs for one PON is 8, while the round-trip time is 200 us corresponding to the fiber reach of 20 km. The packet processing time at OLT is 0.2 ms and the maximum polling cycle

Table 1: List of Symbols.

Symbol	Descriptions
RN_i	Requested time slot for non-migrated data at the i^{th} ONU
$R_{i,j}$	Requested time slot for the migrated data generated by the j^{th} service migration at the i^{th} ONU
$D_{i,j}$	Deadline for completely migrating the data generated by the j^{th} service migration at the i^{th} ONU
$RF_{i,j}$	Granted time slot for the migrated data generated by the j^{th} service migration from the i^{th} ONU
C_{max}	Maximum length of polling cycle time
N	Number of the ONUs in one PON
K_i	Number of the service migrations at the i^{th} ONU
BR	Transmission time for sending each report and grant message
BG	Guard time between two time slots

DBS Algorithm

1. **Input:** $RN_i, R_{i,j}, D_{i,j}$
2. $RF_{i,j} \leftarrow R_{i,j} / \lceil D_{i,j} / C_{max} \rceil$
3. $\alpha \leftarrow C_{max} - \sum_i (BR_i + BG_i)$
4. $SL1 \leftarrow \text{Minimize} (\sum_i \sum_j^{K_i} RF_{i,j}, \alpha)$
5. $SL2 \leftarrow \text{Minimize} (\sum_i RN_i, C_{max} - SL1)$
6. sort $(RF_{i,j})$ according to the ascending order of $D_{i,j}$
7. $B_allocated \leftarrow 0$
8. **while** $B_allocated \leq SL1$
9. **for** i from 1 to N
10. **for** j from 1 to K_i
11. $ONU_i \leftarrow RF_{i,j}$
12. $B_allocated \leftarrow B_allocated + RF_{i,j}$
13. $\beta \leftarrow SL2 / \sum_i RN_i$
14. **for** i from 1 to N
15. $ONU_i \leftarrow \beta \times RN_i$

Fig. 2: The pseudocode of the proposed dynamic bandwidth slicing algorithm.

Fig. 3: (a) Average migration delay of the migrated data, (b) average latency and (c) jitter of non-migrated data.

is 2 ms [7, 9]. The size of report and grant messages is 64 bytes, while the guard time is 1 μ s. The line rate is 10Gbit/s for both the upstream and downstream. The non-migrated traffic arrives according to Poisson process, and its packet size is uniformly distributed between 64 to 1518 bytes. The Poisson arrivals of service migration is also assumed, and the size of migrated data generated by one service migration is uniformly distributed between 10 and 100 Mbits, which can be fragmented by several 1518-byte Ethernet frames [6, 9]. We assume that the buffer size in each ONU is 50 Mbytes, and the simulation time is 100 seconds. Two cases with different migrated traffic load (MTL), i.e., MTL = 0.1 and 0.3, are tested. For the proposed DBS algorithm, the impact of different deadlines (D) for the migrated data is also investigated. Fig. 3(a) shows the average migration delay as a function of the non-migration traffic load for both the benchmark and DBS. In the benchmark, the average migration delay slightly increases with the non-migration traffic load (NTL). Due to FCFS, once the migrated data arrives, it is served immediately regardless of the requirements on deadline. Therefore, the migration delay is pretty low. In the DBS, the average migration delay is 500 ms when D is set to 0.5 s, while it is 1000 ms for D=1 s, regardless of the MTL. It implies that the required deadline for migration data can be satisfied. Fig. 3(b) shows the average packet delay of the non-migrated traffic. The higher the MTL is, the larger the average packet delay is. However, compared with the benchmark, the average packet latency for the DBS is significantly lower (30% for MTL=0.1 and 50% for MTL =0.3 when D=0.5 s). In contrast to the latency, the jitter improvement of the non-migrated data is more obvious. As shown in Fig. 3(c), a reduction by a factor of 10 can be achieved by using the proposed DBS algorithm. Furthermore, when D becomes larger, the packet latency and jitter of the non-migrated data in the DBS can be further decreased. For instance, the average packet latency decreases up to 60%, when D increases from 0.5 s to 1 s.

4. Conclusions

We proposed a dynamic bandwidth slicing algorithm, in which the data generated by service migration in the FeRANs is properly handled. Simulation results reveal that the packet latency and jitter of the non-migrated data can be significantly reduced by partitioning large-size migrated data into smaller pieces while its migration delay constraint is still satisfied. Moreover, with a more relaxed migration delay constraint, the impact on non-migrated data can be further reduced when the proposed DBS algorithm is employed.

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6. References

- [1] M. Chiang et al., "Fog and IoT: an overview of research opportunities," IEEE Internet of Things Journal, vol. 3, no. 6, pp. 854-864(2016).
- [2] J. Li et al., "Resource management in fog enhanced radio access network to support real-time vehicular services," Proc. ICPEC, Madrid (2017).
- [3] M. Jia et al., "Cloudlet load balancing in wireless metropolitan area networks," Proc. INFOCOM, San Francisco (2016).
- [4] A. Ashok et al., "Enabling vehicular application using cloud services through adaptive computation offloading," Proc. VNC, Columbus (2016).
- [5] "5G automotive vision" 5G-PPP white paper (2015).
- [6] X. Sun et al., "Adaptive avatar handoff in the cloudlet network," IEEE Transaction Cloud computing, vol. PP, no. 99(2016).
- [7] J. Li et al., "Optical transport network architecture enabling ultra-low latency for communications among base stations," Proc. OFC Los Angeles (2017).
- [8] A. Dixit et al., "Energy efficiency DBA algorithms for TWDM-PONs," Proc. ICTON, Budapest (2015).
- [9] G. Kramer et al., "IPACT: A Dynamic Protocol for an Ethernet PON (EPON)" IEEE Com. Mag., vol. 40, no. 2, pp. 74-80 (2002).