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Proactive Dynamic Calendar Allocation Scheme for 5G/B5G Transport Network Slicing Based Flexible Ethernet

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ABSTRACT

This paper proposed a proactive calendar allocation scheme that enhances utilization for optical network resource and provides differentiated service for network slicing. The simulation shows utilization improvement from 72.8% to 81.2% under the evaluated scenario.

MOTIVATION

Flexible Ethernet (FlexE) implements TDM on top of the Ethernet to decouple media access control (MAC) rates and physical layer (PHY) interface capacities.

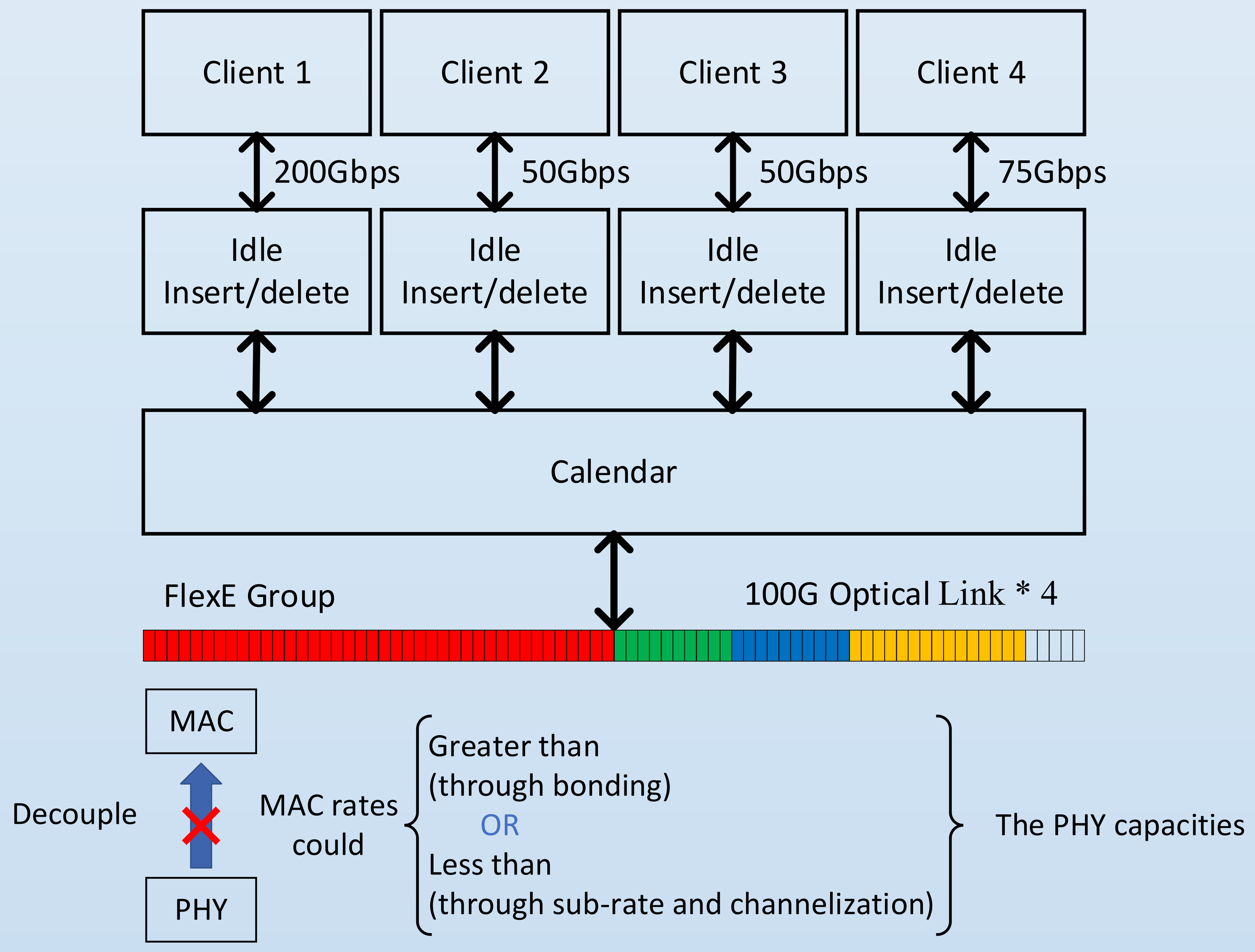

Fig.1: FlexE architecture

The decoupling of MAC and PHY relaxes limits on the rate of MAC. The MAC rates could greater than (through bonding) or less than (through sub-rate and channelization) the PHY capacities.

Due to the above advantages, FlexE has been used in several applications such as 5G/B5G optical transport networks.

However, FlexE does not meet the requirement of network slicing which is considered as one of the most innovative aspects of 5G networks.

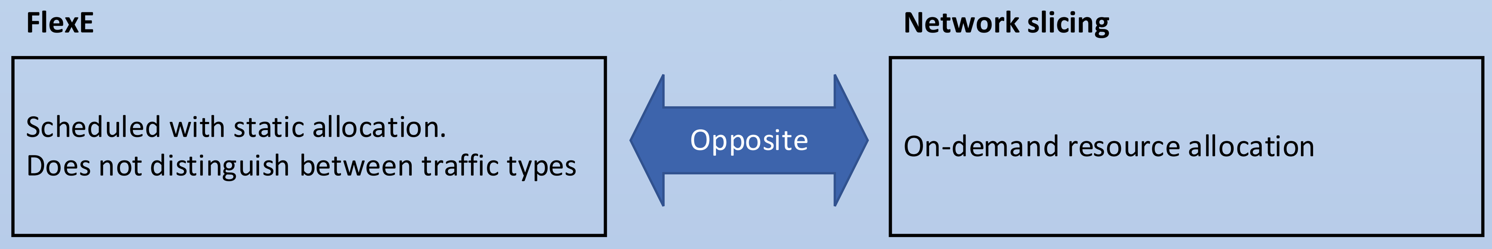

Fig.2: FlexE and network slicing are opposites

This will result in underutilization of network resource. The slots allocated conservatively based on peak traffic assumptions often have large over-provisioned bandwidth. The static allocation of slots prevents the adaptation for time-varying traffic

Thus, dynamic slot allocation scheme is needed to meet diverse requirements in terms of bandwidth and E2E latency.

- The allocation of slot could be adapted over time instead of allocating a constant number of resources to reduce resource overprovisioning.
- The allocation scheme should take into consider the service priority. The scheme should guarantee the QoS of services and meet the requirement of network slicing.

This paper proposes a proactive dynamic calendar allocation scheme for FlexE. Simulation result shows utilization improvement from 72.8% to 81.2% under the evaluated scenario.

METHOD

FlexE uses a shim layer that is placed between the MAC and PHY layers to decouple the MAC client rates and PHY capacities. Each FlexE client presents a 64B/66B encoded bit-stream to the FlexE shim. The FlexE group is composed of N FlexE Instances, typically 100Gbps optical transport network. The FlexE clients carried over a FlexE group are mapped and reverse mapped by the FlexE shim layer. The shim allows for flexible data rate allocation through bonding, sub-rates and channelization. Through the above three capabilities, FlexE shim layer distributes 66B blocks from the client into PHY instances sequentially. A calendar model is used to assign positions of 66B blocks on the FlexE group.

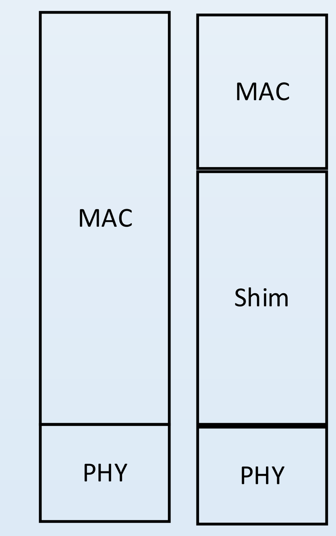

Fig.3: Layer model of FlexE

The proposed scheme assigns service according to the priority and predicted bandwidth in each allocation configuration cycle. The proposed scheme has 3 steps:

1. Static slots are reserved for delay sensitive services in high priority.

The reserved slots are evenly distributed throughout D blocks in PHY. Slot reservation could guarantee the bandwidth and delay jitter for delay sensitive services. Slots will be allocated as even as possible. In other words, the scheme tries to get the interval of slots as close as possible.

2. The calendar model predicts bandwidth demand of best effort service in low priority.

History traffic data is collected for the bandwidth prediction. The future bandwidth demand could be predicted by a deep learning based short-term traffic prediction approach.

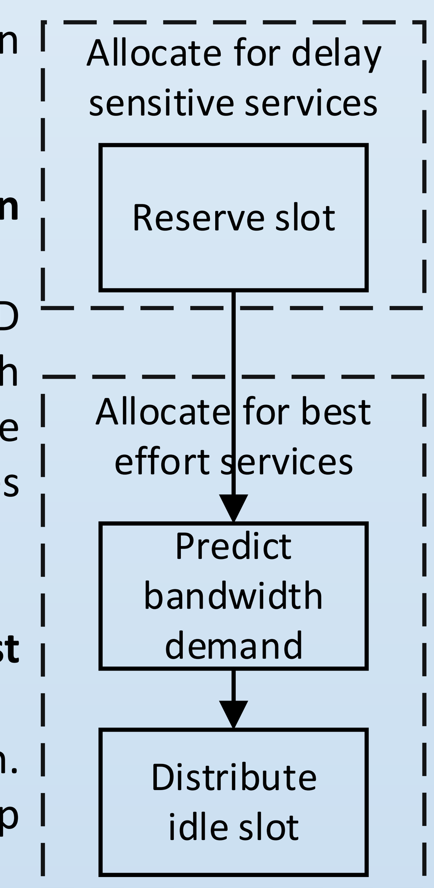

Fig.4: Steps of scheme

3. **Idle slots are allocated to best effort service according to the predicted bandwidth.** An old first algorithm (OFA) is designed to distribute slot resource for best effort service.

The old first algorithm polls and distributes each idle slot in turn until there are no bits in the buffer. OFA follows the caching time (longest to shortest) to assign slot in turn. The client with the maximum caching time will get the front slots. It means that the client with longer caching time will get more chance to transmit. The OFA could decrease the waiting time of traffic data. This could uplift the experience of client.

SIMULATION

Utilization:

Most of the time, utilization of OFA compares higher with that of TRA in Fig.5 (a). The average utilization has been improved from 72.8% to 81.2%. The on-demand provision of slots could improve the resource utilization.

The proposed scheme had a good utilization in different traffic loads in Fig. 5(b). As the traffic load increased, the resource utilization increased. The traffic with bigger load generates more data which may fit closer to the fixed granularity of bandwidth. In other words, the idle bandwidth in slots is smaller.

The proposed scheme had a good utilization in different client numbers in Fig. 2(c). As the number of clients increased, the resource utilization decreased. The bandwidth demand of a single client may be smaller than the granularity of bandwidth. This mismatch may decrease the total utilization.

Latency:

The shorter latency is provided by the proposed algorithm in Table Ⅰ. The average delay is decreased from 111us to 94us. Note that, the end-to-end delay is formed by lots of parts. This paper only focuses on the delay of FlexE shim.

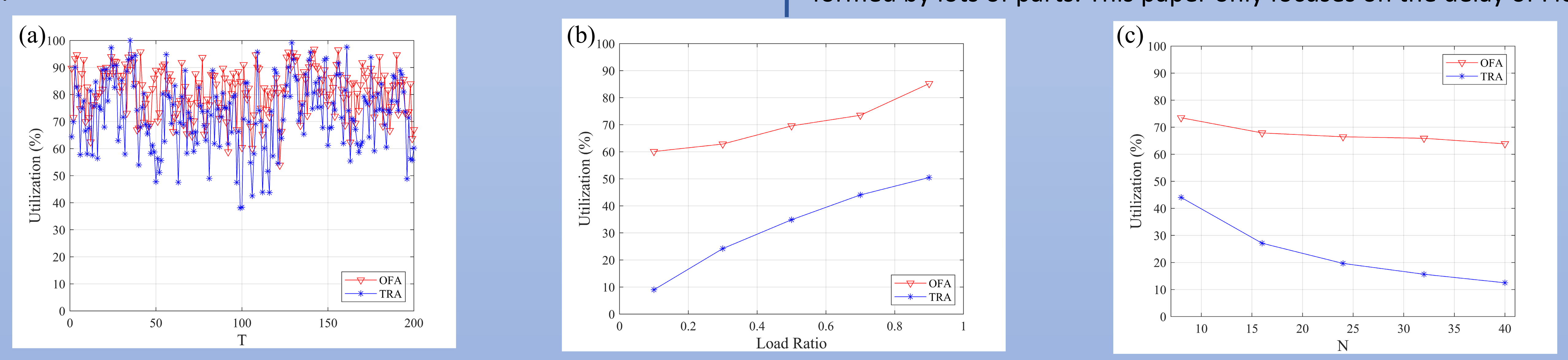

Fig.5: Results (a) Utilization in allocation configuration cycles. (b) Utilization in different traffic load. (c) Utilization in different number of clients.

TABLE I
Delay Of Each client By OFA And TRA

Client No.	1	2	3	4	5	6	7	8	Mean
Delay of OFA	100.6014	80.86581	124.8437	146.0022	119.5941	58.95438	62.72201	65.21119	94.84934
Delay of TRA	111.3152	101.249	152.9873	192.4643	127.0054	59.33016	64.45942	81.47905	111.2862

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