Two-color Grants for 100G EPON Channel Bonding

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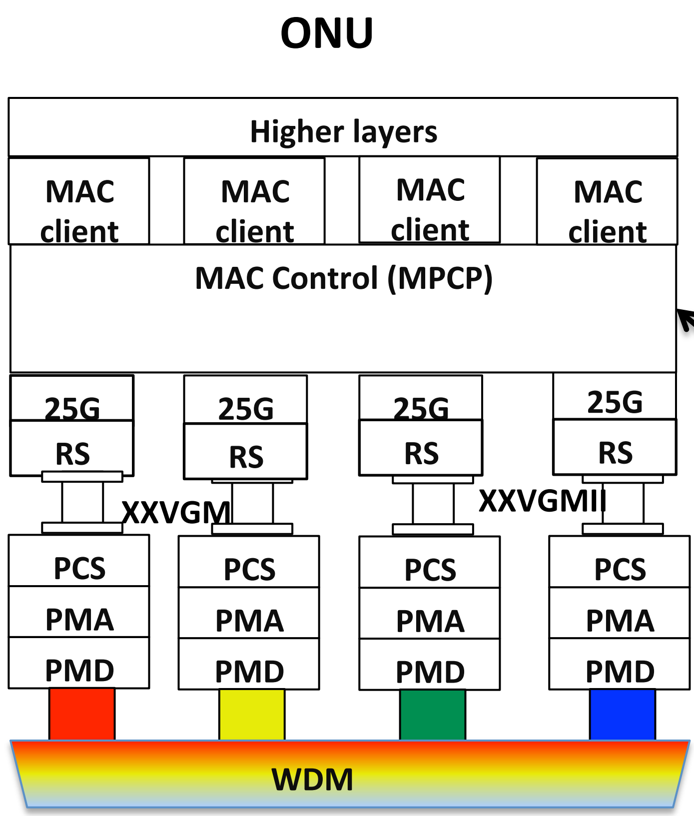
Outline

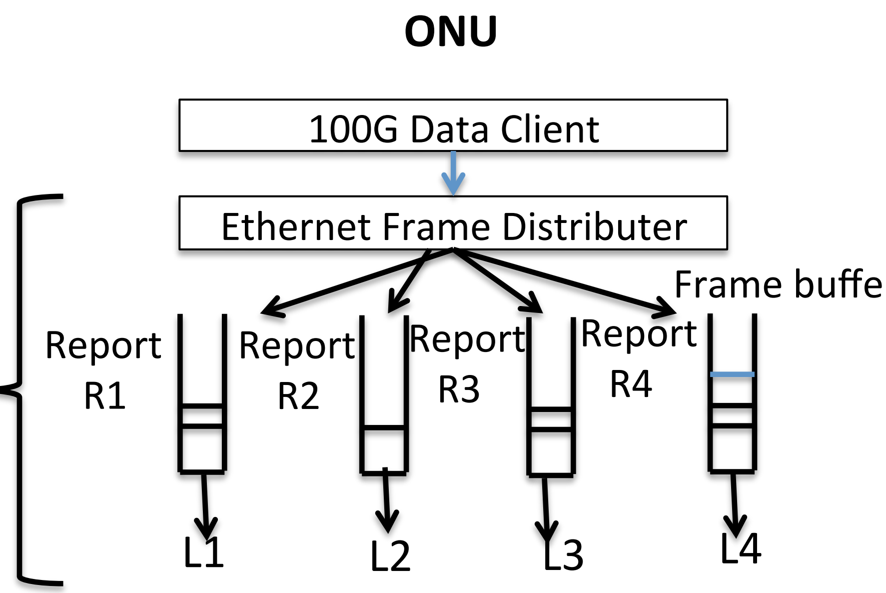
- ONU controlled frame distribution for upstream channel bonding
- OLT controlled data distribution for upstream channel bonding
- Equal sub-grant and fixed sub-grant
- Two-color grants

Background

- 2D scheduling with Frame-boundary-aware MPCP is discussed in dai_3ca_01_0716
- Frame-boundary-aware MPCP needs new field in MPCP report
- This contribution discuss another approach for completeness

ONU Controlled Frame Distribution in Channel Bonding





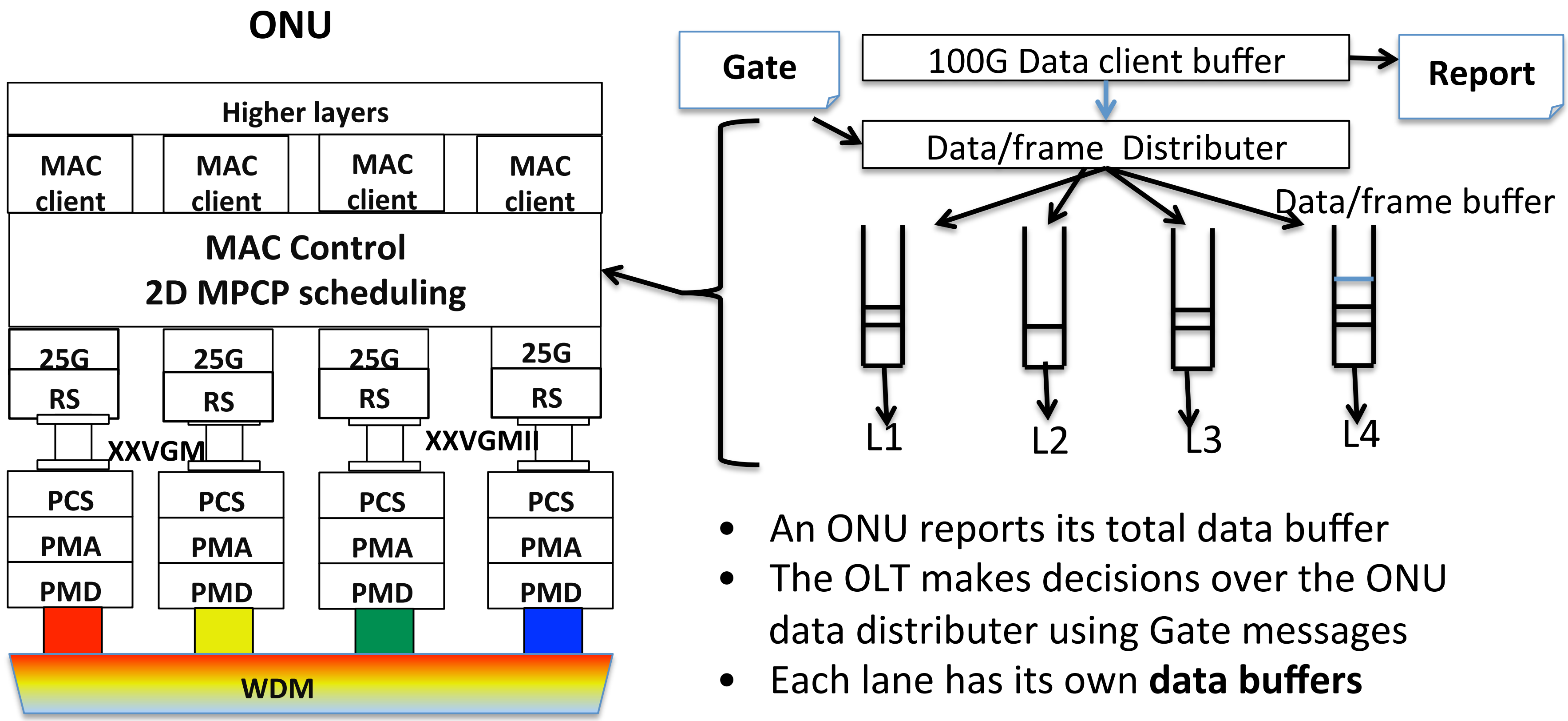
- OLT doesn’t control frame distribution
- ONU frame distributer makes decisions
- Each lane has its own **frame buffers**

- From the scheduler point, each lane has it’s own scheduler
- It essentially has four 1D schedulers

ONU Controlled Channel Bonding (continuous)

- Frame fragmentation can be avoided
- However, it introduces a new problem of frame reordering.
- Since there are 4 independent scheduling domains, frame arriving orders at the OLT will be random, therefore, large frame buffers are needed at OLT to reorder the received frames
- Delay is another concern

OLT Controlled Data Distribution in Channel Bonding



- An ONU reports its total data buffer
- The OLT makes decisions over the ONU data distributer using Gate messages
- Each lane has its own **data buffers**

- From the scheduler point, it is a 2D scheduling system
- An ONU reports its data client buffer to be distributed to lanes
- The Gate driven lane distribution is generally data distribution rather than frame distribution
- Fragmentation will happen in general

2D Scheduling for variable length frames

- Ethernet frames are variable in lengths.
- The 2D scheduling mechanism works for variable length frames
- In 4-channel 100G EPON, a 2D scheduler divides the total grant N request by an ONU into n_j sub-grants for each available channel ch_j
- The 2D scheduler has no knowledge of the frames structure behind the ONU's report
- The length of a sub-grant n_j may NOT equal the length of the Ethernet frames to be distributed to the ch_j

n_j x TQ $\neq$ Length of frames to be distributed to ch_j.

Grants and sub-grants

- Assuming a multi-channel ONU requests bandwidth = N x TQ
- The 2D scheduler assigns N grants to the ONU
- The scheduler then needs to divide the N grants into n_j sub-grants

$$N = \sum_j n_j ,$$

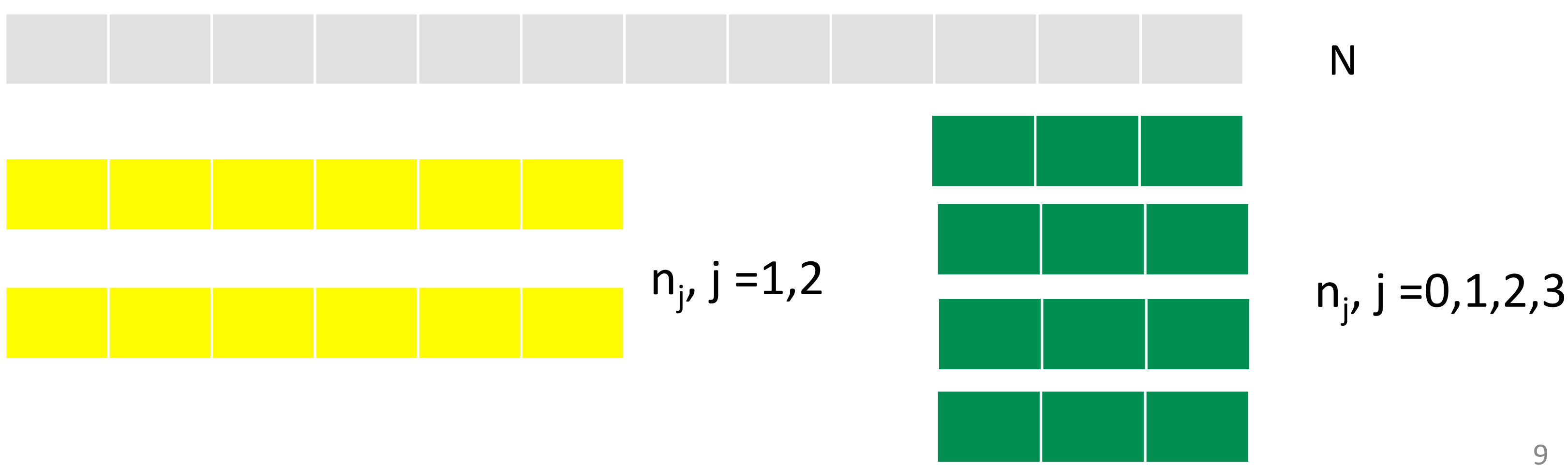
How big is a sub-grant?

- The absolute minimum sub-grant = 1 TQ (1G, 10G EPON spec.)
- The minimum sub-grant for a 1522 byte Ethernet frame = 31 TQ (assuming 25Gb/s rate)
- There is not a maximum grant size in theory, but there are practical limits which are not important for the problem here

Equal size sub-grant

- A 2D scheduler determines the total grants N based on the ONU report
- The scheduler then divides the total grants N with the number of active lanes to get the sub-grants

$n_j = N/(\#\text{of lanes})$ — $j = 0,1,2,3$ for 100G ONU; $j = 1,2$ for 50G ONU



Rules for equal size sub-grant

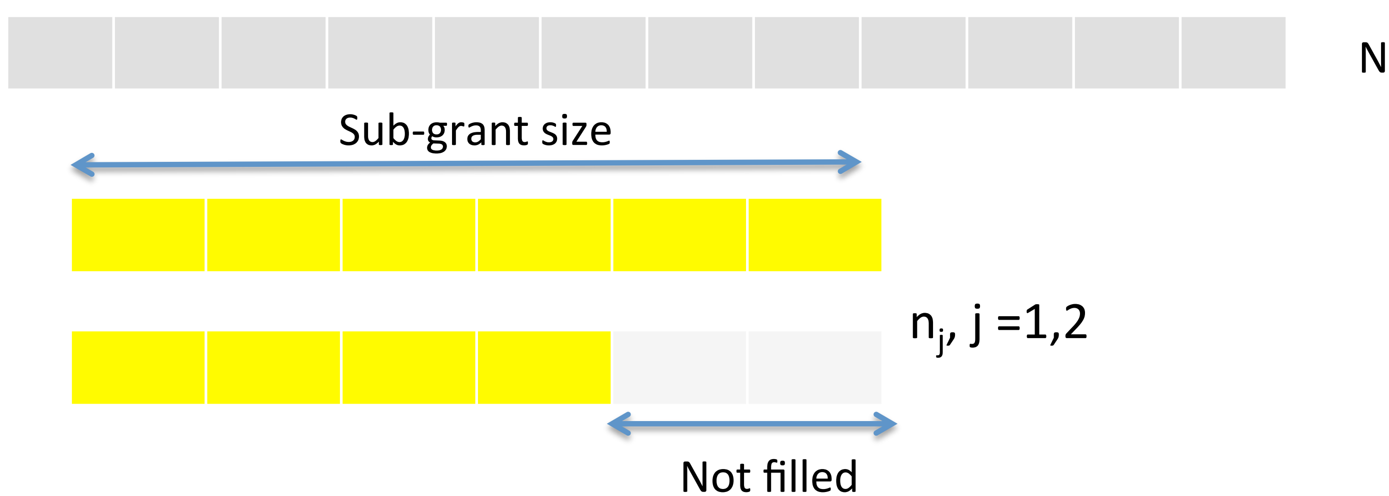
- A 2D scheduler assigns n_j to each available channels
- If the total grant N is small, for example, NxTQ < 1522 bytes, the scheduler should schedule the entire N to the first available channel
- Fragmentation will happen in general

Fixed size sub-grant

- The 2D scheduler determines the total grants N based on the ONU report
- The 100G EPON standard specifies a standard sub-grant size S

TQ =< S <= 31 TQ

50 bytes =< S x TQ <= 1522 bytes



Fixed size sub-grant - Rules

- A sub-grant S acts as a container
- The minimum size of S is one TQ
- A 2D scheduler assigns sub-grant S to each available channel until total grants >= N
- Smaller S causes more fragmentations, and bigger S may lose some efficiency. The last S may be half empty)
- If choosing S = 31 TQ (1522 bytes), fragmentation may be avoided, but will be inefficient for small packets

Equal size or Fixed size sub-grants?

- Both equal size and fixed size sub-grants may cause fragmentation in general
- Fixed size sub-grants may be quicker in processing frame distribution since the container S is pre-defined
- However, finding and agreeing upon an optimized S may be a challenge

$$50 \text{ bytes} =< S \times TQ <= 1522 \text{ bytes}$$

Minimum Optimized? Maximum

Two-color grants

In order to avoid fragmentation and at same time use simple fixed sub-grants with accepted efficiency, we define Two-color grants:

Red grant n_r = TQ

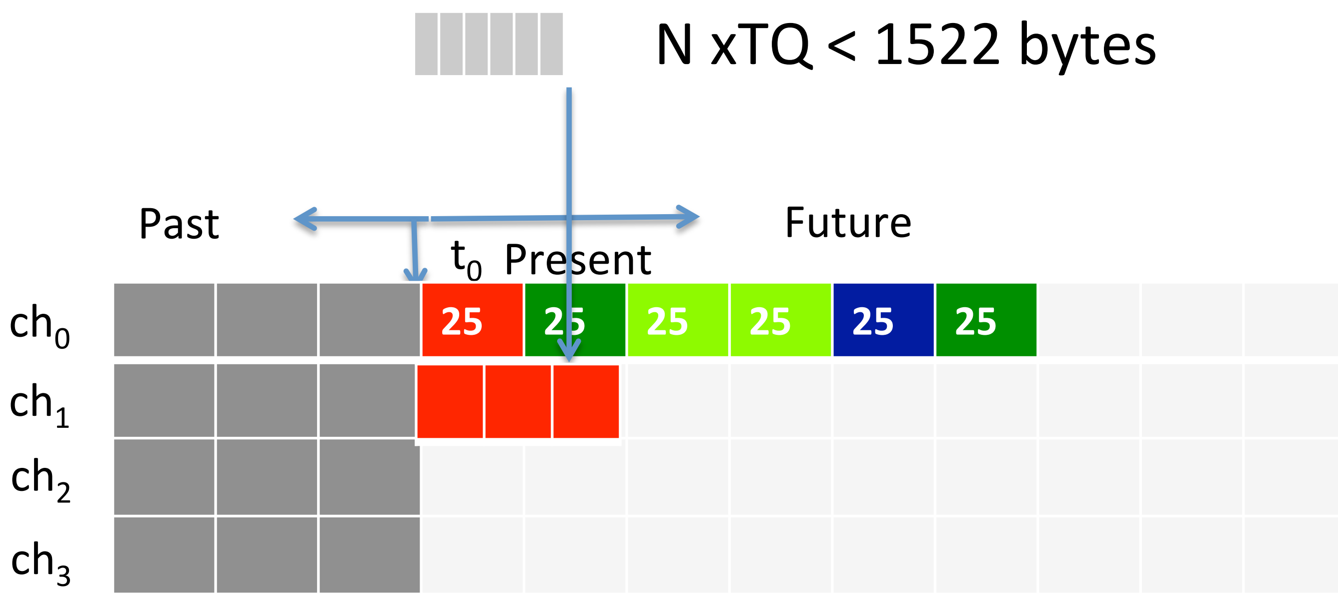
Green grant n_g = 31 TQ

- Red grants are for small packets, such as 64 bytes and 74 bytes frames.
- Green grants are for maximum Ethernet frames, such as 1522 bytes frame
- Fragmentations could be avoided with additional rules
- Balance efficiency and no-fragmentation requirements

Two-color grant -Rules

1. If report N xTQ < 1522 bytes, schedule the first available channel with multiple Red grants with n x n_r >=N
2. If report N x TQ >= 1522, schedule the first available channel with a Green grant, and subsequent available channels with Green grants until total granted bandwidths >= N
3. A frame distributer at ONU distributes data to the lane buffer in the unit of natural Ethernet frames, ie., variable length frames <= 1522 bytes

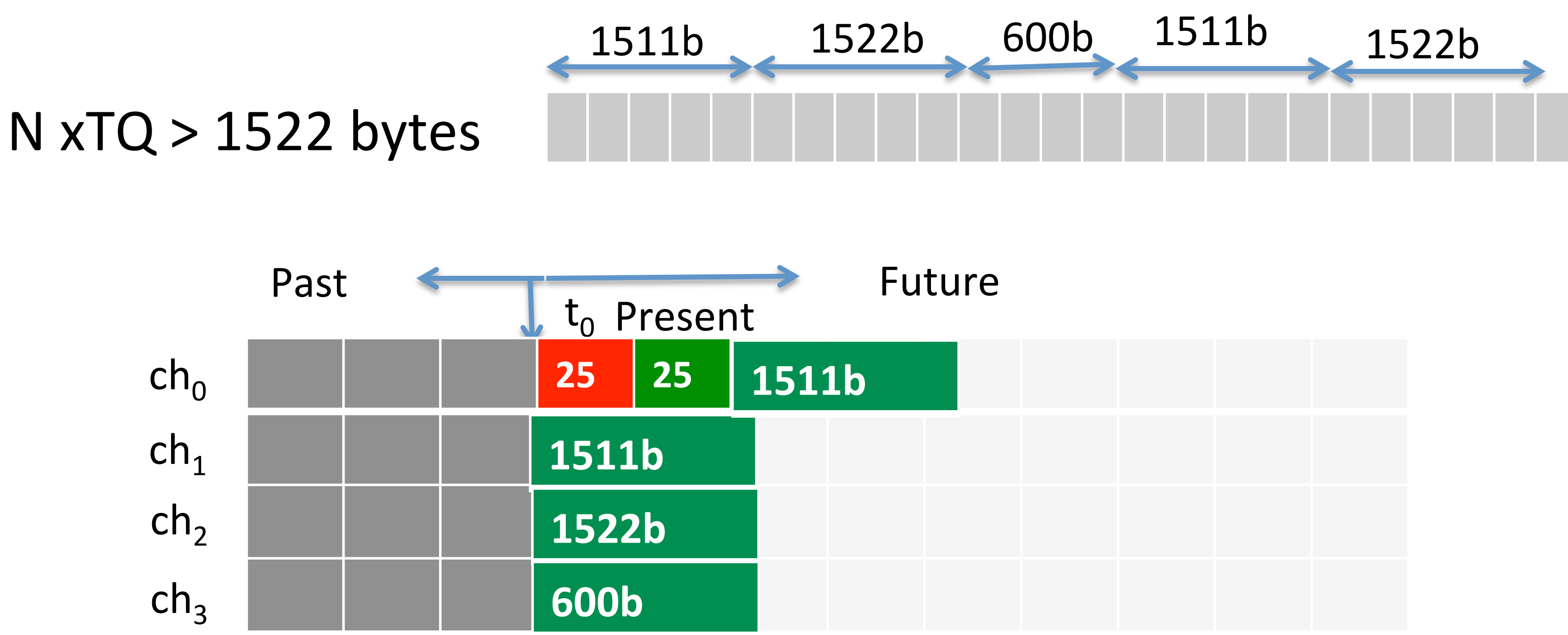
Two-color grant Example 1



Rule 1: If report N xTQ < 1522 bytes, schedule the first available channel with multiple Red grants with $n \times n_r >= N$

- No need to distribute small packets to multiple channels
- Avoid fragmentation

Two-color grant Example 2



Rule 2: If report N x TQ >= 1522 bytes, schedule the first available channel with a Green grant, and subsequent available channels with Green grants until total granted bandwidths >= N

Rule 3: The frame distributer at ONU distributes data to the lane buffer in the unit of natural Ethernet frames …

Justifications for Two-color grants

Possible applications for symmetric 100G EPON

- Connections between satellite data centers with main data center
- Connections between small data centers for backup
- Network connections between regional Headends with main Headend
- …

If 100G/50G upstream capacities are needed, it is reasonable to expect a large amount of Ethernet frames to be of maximum lengths. Two-color grants provides balance of efficiency with no-fragmentation requirements.

Conclusion

- **Equal size sub-grants and fixed size sub-grants cause frame fragmentations in general.**
- **Two-color grants provide balance of efficiency with no-fragmentation requirements.**

Thanks

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