Quality of Service in Optical Telecommunication Networks

Periodic Summary & Future Research Ideas

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@Networks Lab Group Meeting

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Tsinghua University

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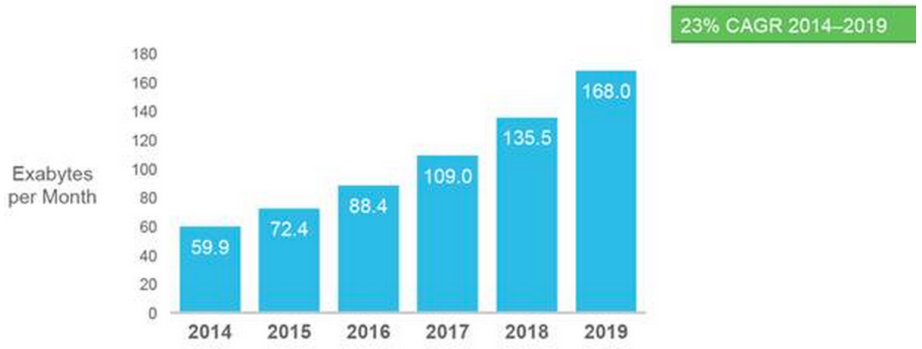
Outline

- Background
- Preemptive Service Degradation for Blocking Cancellation in Multi-layer Networks
- On-line Latency Reduction for Coordinated Multi-Point in C-RAN

Background

- Traffic load is increasing rapidly, now and future.



Source: Cisco VNI Global IP Traffic Forecast, 2014–2019

Background

- Tidal traffic may influence the Quality of Service in peak hours.
- Service degradation provides a efficient way to eliminate the blocking, which means that the traffic can still be routed with degraded serving rate.

Background

- The majority of network traffic is delay-sensitive but degradation-tolerant (video), or delay-insensitive (Web data, file sharing), which makes possible to apply service degradation.

Fig. 2, Global IP Traffic by Application Category
Source: Cisco VNI Global IP Traffic Forecast, 2014–2019

Proposal 1:

Preemptive Service Degradation for Blocking Cancellation in Multi-layer Networks

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outline

- Background
- Static planning
- Dynamic algorithm

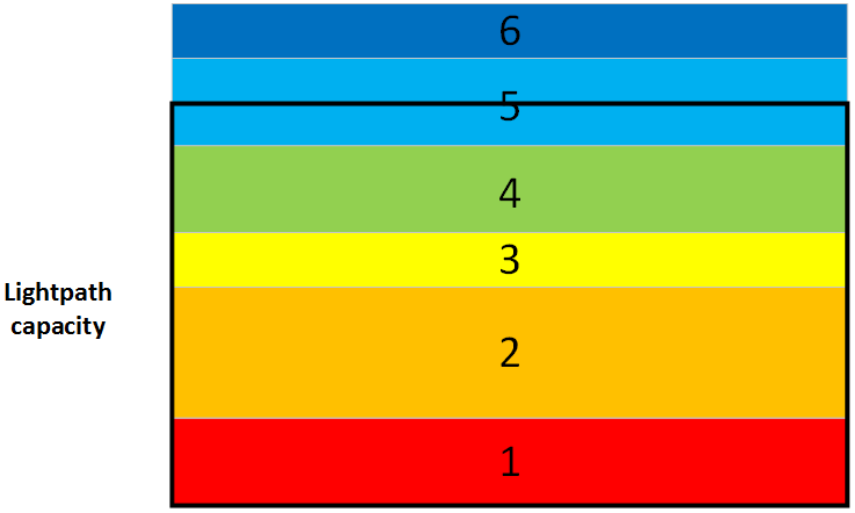
Background

- Given certain traffic profile, how to provsion the lightpath most efficiently.
- As the extended holding time may influence the following the traffic, thus, we should try to make it as short as possible.
- The goal is to decrease the blocking probability to zero.

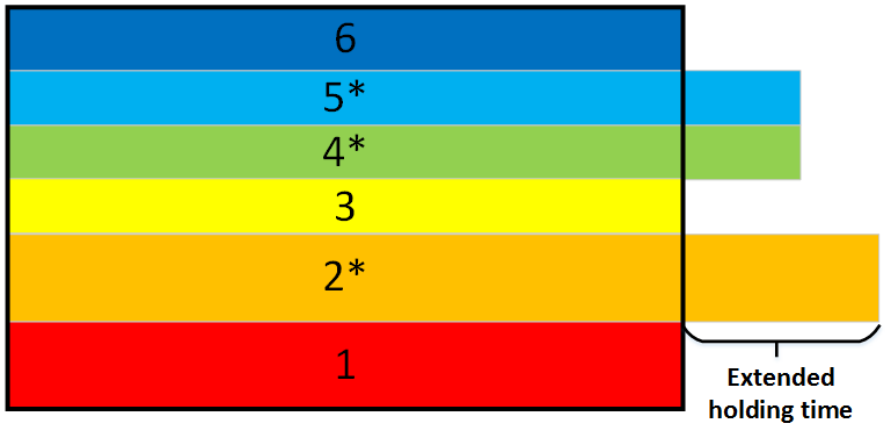
outline

- Background
- Static planning
- Dynamic algorithm

Schematic graph in static planning



Original scheme: 5 and 6 blocked



Preemptive Degradation scheme: no blocking

In Network Planning Stage

- **Preemptive Degradation Optimization Problem**
- Objective:
  - Minimize the overall extended holding time
- Given:
  - Traffic profile
  - Network topology as well as its resources
  - The maximum delay for each traffic request

In Network Planning Stage

- **Preemptive Degradation Optimization Problem**
- Constraints:
  - All traffic requests must be routed
  - Traffic grooming constraints
  - The delay of degraded traffic should not exceed its max delay
- Output:
  - The actual bandwidth of each traffic request

Expected result analysis

- Analyze the relationship between:
  - amount of traffic given vs. number of affected traffic
  - amount of traffic given vs. overall extended holding time

outline

- Background
- Static planning
- Dynamic algorithm

Dynamic algorithm

- When considering dynamic scenario, we have two questions to answer:
  - How to degrade?

    How much bandwidth degradation should we execute?
  - Which to degrade?

    Which traffic should we choose to degrade?

How to degrade?

- **Degrade one traffic**

  When the network capacity is constrained, we degrade one of the existing traffic (or the new traffic) to accommodate the new traffic.

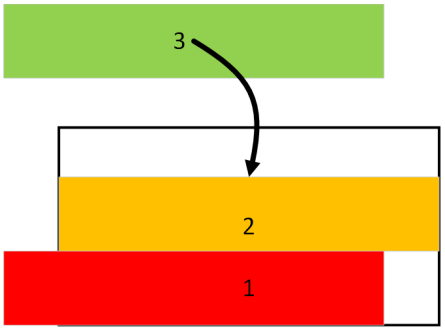
- **Degrade several traffic**

  When the network capacity is constrained, we degrade several existing traffic (as well as the new traffic) to accommodate the new traffic.

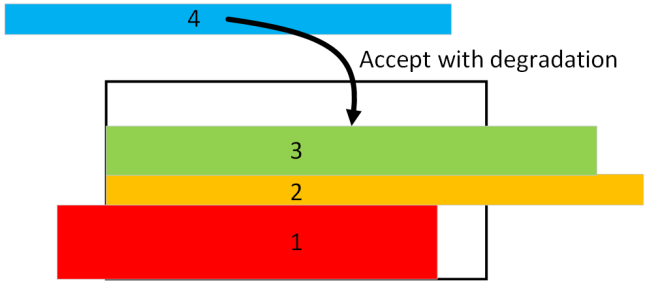
How to degrade?

- **Trade-off in degradation scale:**

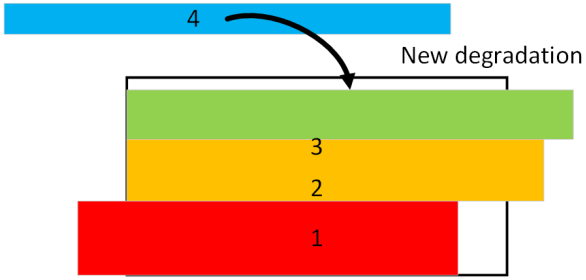
  If the degradation scale is large, then when the next traffic arrives, we do not need to degrade once again, thus in this way we lower the times of degradation, however, this will result in longer extended holding time. So this trade-off need further analysis.



How to degrade traffic request #3?



Longer extended time,
Less frequent degradation



Shorter extended time,
more frequent degradation

Which to degrade?

- **minimize the number of affected connections**

  We should try to use the minimum number of degraded requests to accommodate the arriving one. We will degrade the same traffic until it can not be further degraded.

- **minimize the degradation extent in each request**

  We should try to degrade the existing requests to the minimum extent and minimize the average extended holding times due to degradation. We will degrade different traffic at different times and avoid using two times of degradation on the same traffic.

Which to degrade?

- **Define a degradation cost: Combine the degradation approaches and decide by the Degradation Cost:**

  Degradation Cost of one traffic = extended holding times * degraded bandwidth

  So by this cost we can evaluate different kinds of degradation strategies, and find out which performs better.

Proposal 2:

On-line Latency Reduction for Coordinated Multi-Point in C-RAN

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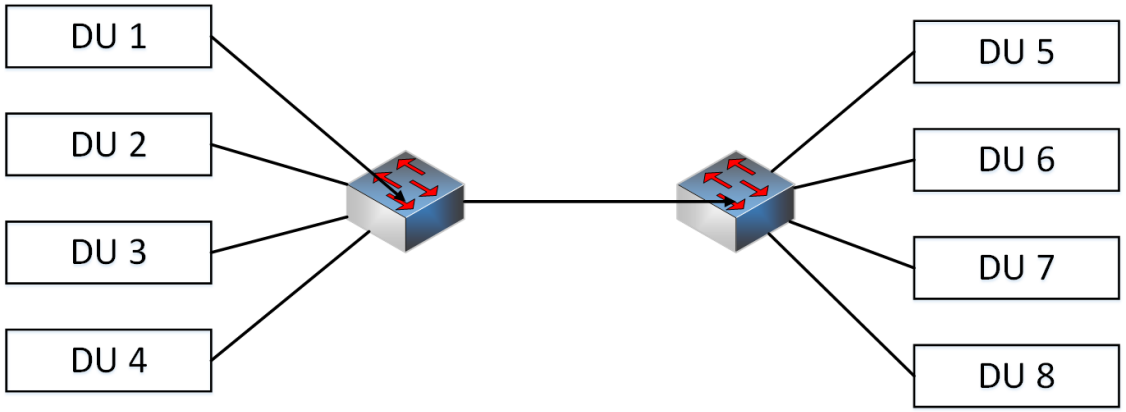
outline

- Problem analysis
- Dynamic algorithm

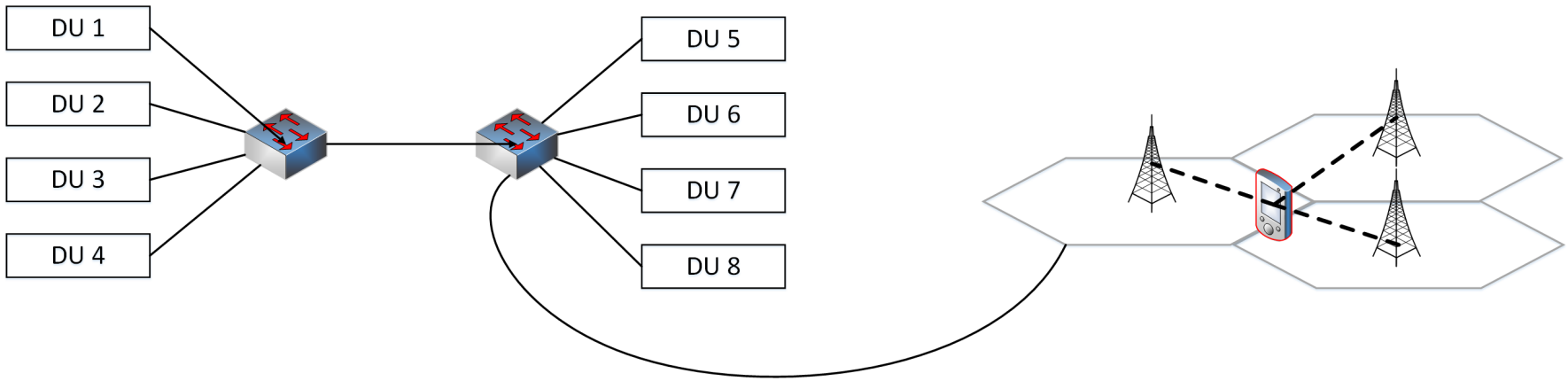
Architecture

In C-RAN the DU is a centralized processing center, supporting the remote base stations. The DU servers can be linked with some sort of architecture.



Architecture

Coordinated Multi-Point is an emerging technology to provide better Quality of Service in the border of cells. A mobile terminal can receive transmissions from several base stations.



Architecture

For any architecture, we use a matrix to abstract them:

Inter-DU cost matrix:

$$\begin{bmatrix} c_{11} & \cdots & c_{1n} \\ \vdots & \ddots & \vdots \\ c_{n1} & \cdots & c_{nn} \end{bmatrix}, \; c_{nm} = c_{mn}$$

Problem analysis

We consider traffic request in the form of CoMP

For traffic arrivals:

Where to merge the arriving traffic?

For traffic departures:

When to re-formulate the CoMP

outline

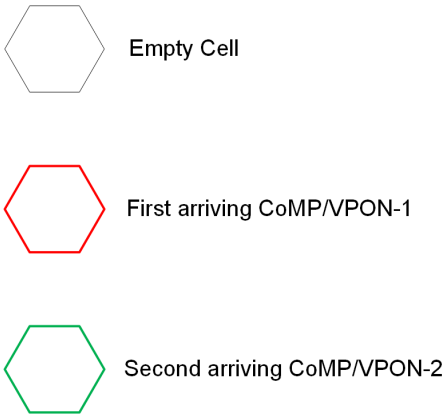
- Static planning
- On-line algorithm

For traffic arrivals

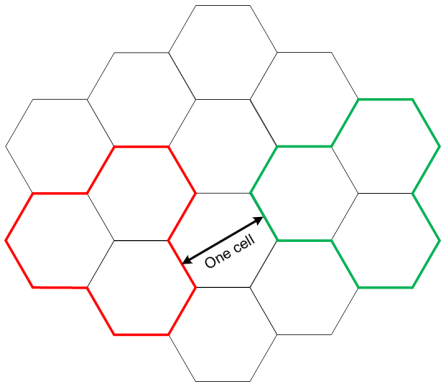
- For traffic arrivals:

  Formulate the two CoMPs into two VPONs.
  Merge the two CoMPs into one VPON.
  Merge the two CoMPs into one VPON.
  Merge the arriving CoMP with the existing VPON which has smaller size.
  Merge the arriving CoMP with the overlayed VPON.
  If possible, combine the two VPONs into one VPON, else, move the smaller one to a DU which has smaller(or zero) costs communicating with the larger VPON.
  If possible, combine the three VPONs into one VPON, else, move the smaller two to a DU which has smaller(or zero) costs communicating with the largest VPON.

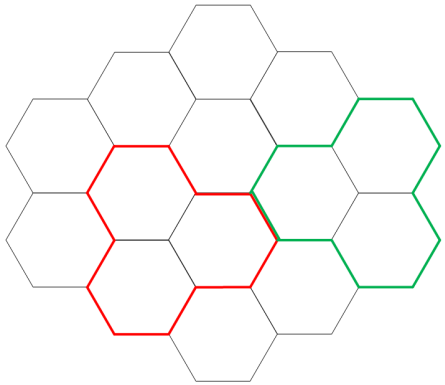
For traffic arrivals



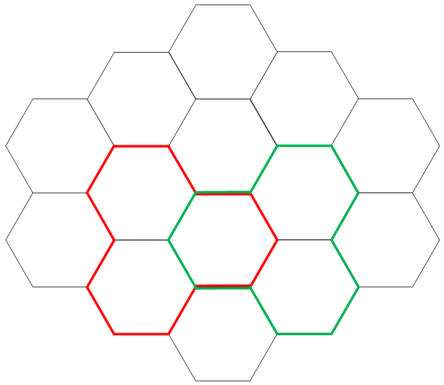
Sparse Distribution



(1) Two adjacent arriving CoMP without any overlap



(2) Two adjacent arriving CoMP with edge-overlap



(3) Two adjacent arriving CoMP with cell-overlap

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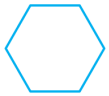
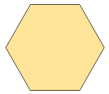
For traffic arrivals

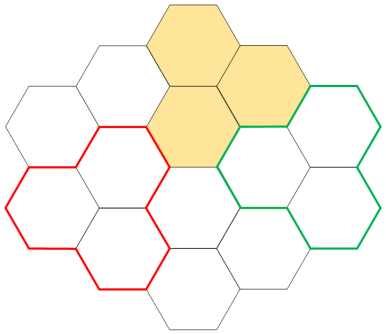


VPON-3

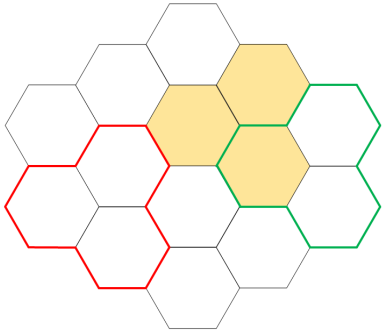


Current arriving CoMP

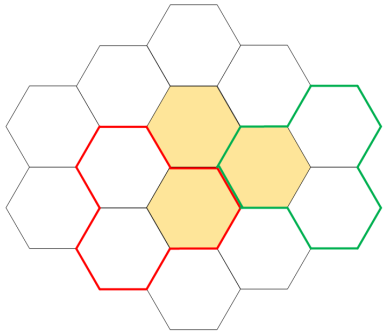
Dense Distribution



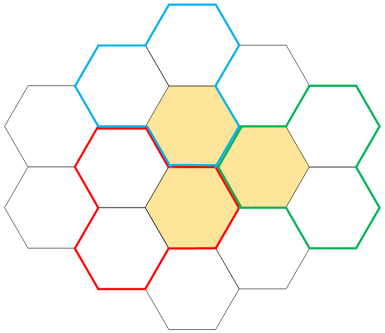
(4) Zero cell-overlap, several edge-overlays



(5) One VPON cell-overlay



(6) Two VPON cell-overlaps



(7) Three VPON cell-overlaps

For traffic departures

- For traffic departures:

  If one cell has no CoMP, release it from VPON.

Thank you for listening!

Any comments or questions?

It is really a nice time here in Networks Lab in UC Davis, with Bis, Charles, Massimo, and all you guys here.

Thank you!

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