Survivability of Elastic Optical Datacenter Networks Based on Content Connectivity

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Group Meeting Presentation

Self-introduction

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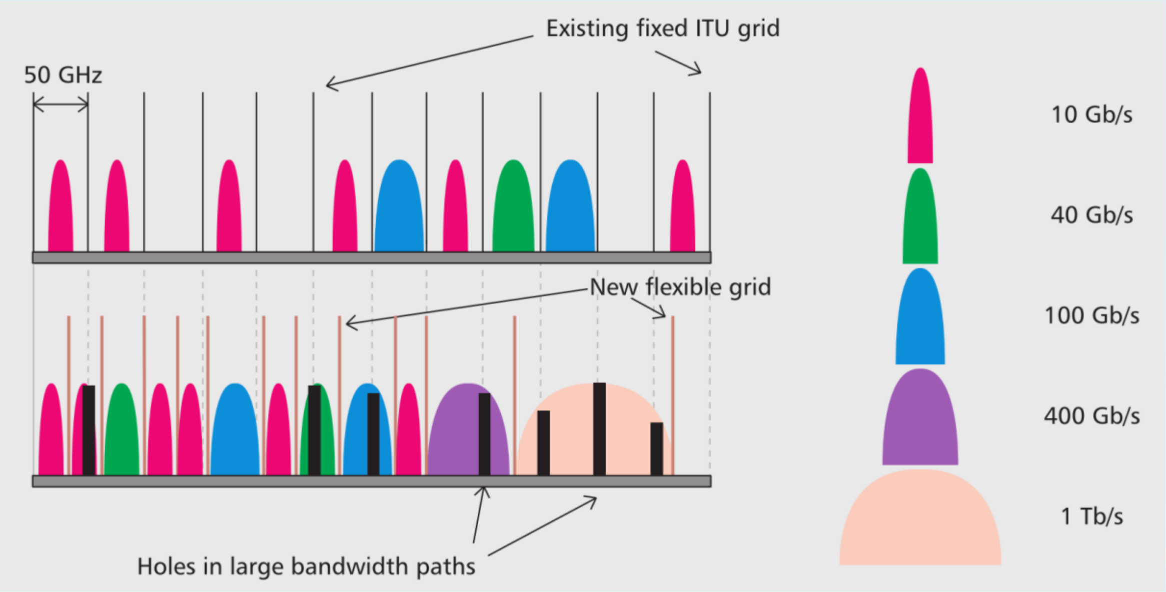
Research interests: Survivability of elastic optical datacenter networks, multicasting, virtual optical networks

Contents

1.1 Survivability of EODNs

- Elastic optical networks have **higher spectrum efficiency** with multi-carrier techniques
- EODNs has become a candidate for newly build optical interconnected datacenter networks to provision various high-bandwidth applications



1.1 Survivability of EODNs

- Elastic optical networks have **higher spectrum efficiency** with multi-carrier techniques
- EODNs has become a candidate for newly build optical interconnected datacenter networks to provision various high-bandwidth applications
- More **flexible** but also more **complicate** problems of spectrum allocation, modulation level selection…

- Optical network is fragile and easy to be broken by disasters
- Any fiber failure may cause a great loss of data and revenue (the capacity of a single fiber can reach Pb/s)

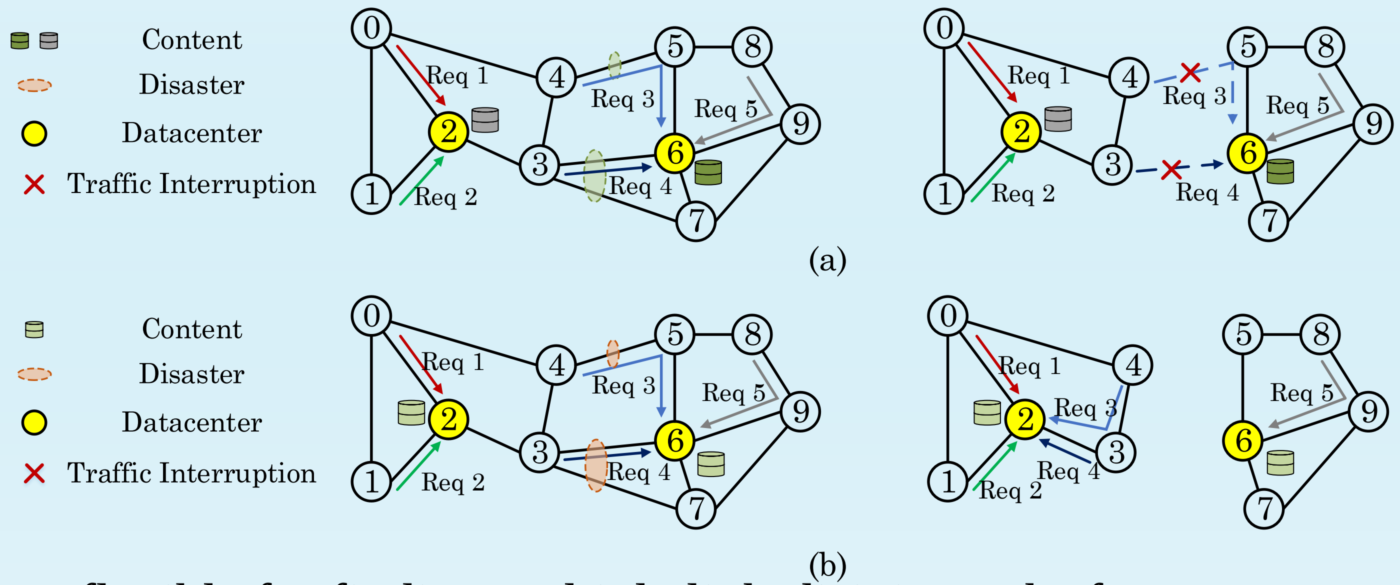
1.2 Survivability of EODNs

How to protect against a link failure?

- Protection or Restoration
- Sharing Protection vs Dedicated Protection
- Path-based (single path or multi-path) Protection, segment-based Protection, etc

- Multi-path protection method has higher spectrum efficiency.
- However, conventional multi-path protection for end-to-end connection relies on network connectivity.

1.3 Content Connectivity



- More flexible for finding multiple link-disjoint paths for a request
- Shorter distance of all optical paths
- Higher modulation level can be adopted
- …
- *At the cost of storage and bandwidth requirement for synchronization*

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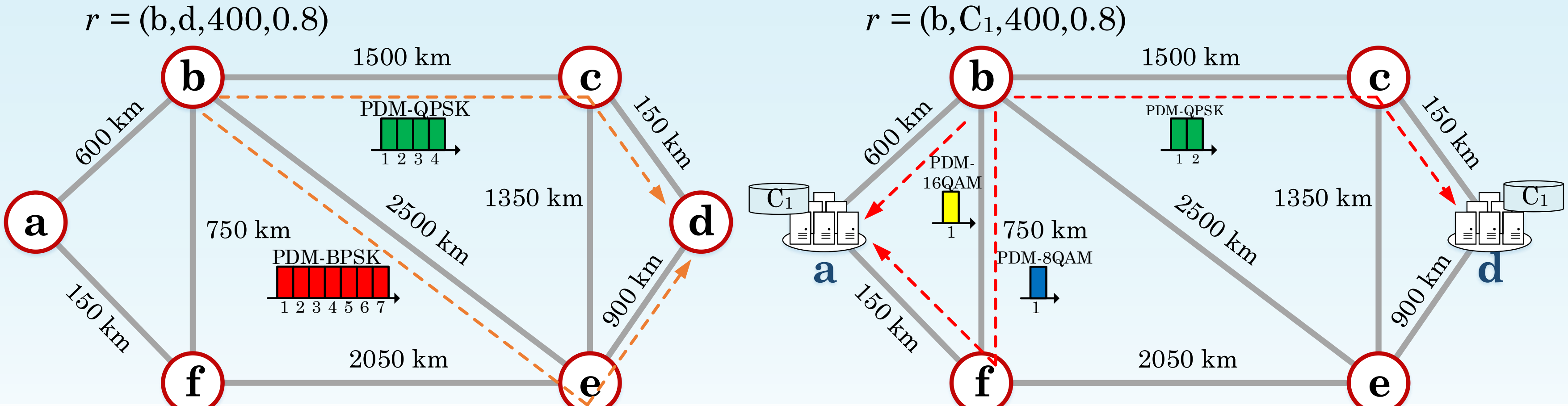
1.3 Content Connectivity

When a link failure occurs, a user can tolerate the reduced capacity as long as the essential service is guaranteed.

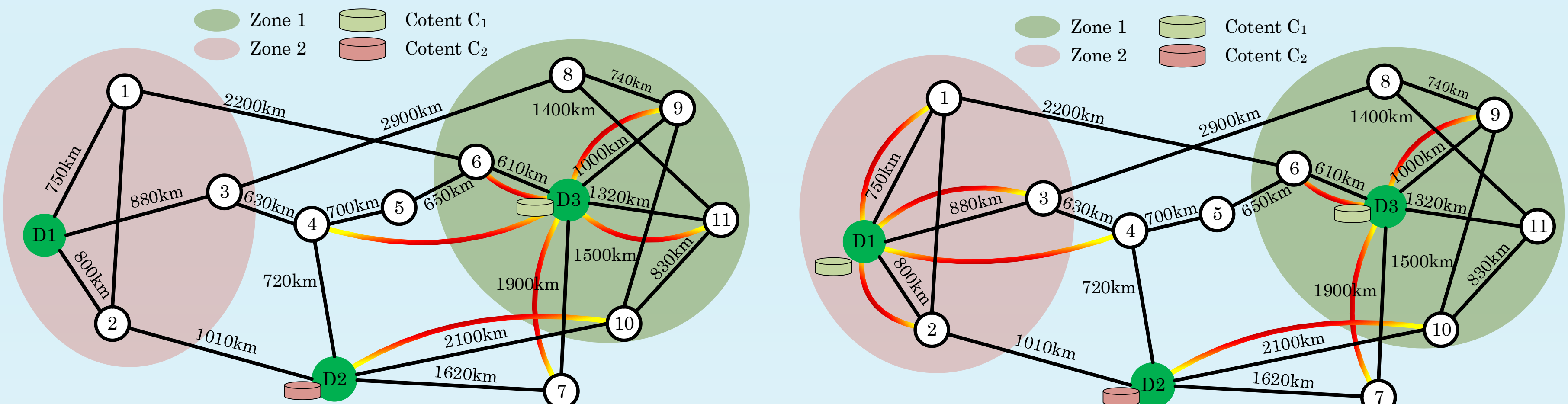
r = <*s*, *c*, *b*, *p*>, where *s* denotes the source node, *c* denotes the required content, *b* denotes the bandwidth demand, and *p* denotes the protection level .



(a) (b)

![UC Davis Networks Research Lab]

1.4 Dynamic Content Replacement



Stage Ⅰ   Stage Ⅱ

Stage I : users in Zone 1 request content C_1 intensively

Stage II: more users in Zone 2 begin to request content C_1

Waste of spectrum resource and higher latency

Content need to be dynamic replaced

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1.4 Dynamic Content Replacement

Trigger condition: $\frac{req_c}{req_{total}} \geq N \bullet \frac{R_c}{\sum_{c \in C} R_c} \quad \forall c \in C$

If the left side is greater than or equal to the right side,
the DCR algorithm is triggered

Calculate the number of replications for content:

Ideal replications for content *c* according to the request number:

$$\eta_c = \frac{req_c}{req_{total}} \bullet \sum_{c \in C} R_c^{\max}$$

The replication for each content has a limitation:

$$R_c' = \max\{m, \min\{\eta_c, R_c^{\max}\}\}$$

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1.4 Dynamic Content Replacement

Placing excess popular content in a datacenter will cause **resource contention**, as a result the datacenter should not be over load

Average cost of content *c*:

$$AV_c = \frac{\sum_{r \in T_c} b_r / C_{BPSK}}{R_c'} \quad \forall c \in C$$

b_r : the bandwidth demand of request *r*

C_{BPSK} :the base capacity of a spectrum slot with modulation format (BPSK)

The accumulated cost of content placed in a single datacenter should be limited to a threshold $TL_{threshold}$

$$\sum_{c \in C_d} AV_c \le TL_{threshold}$$

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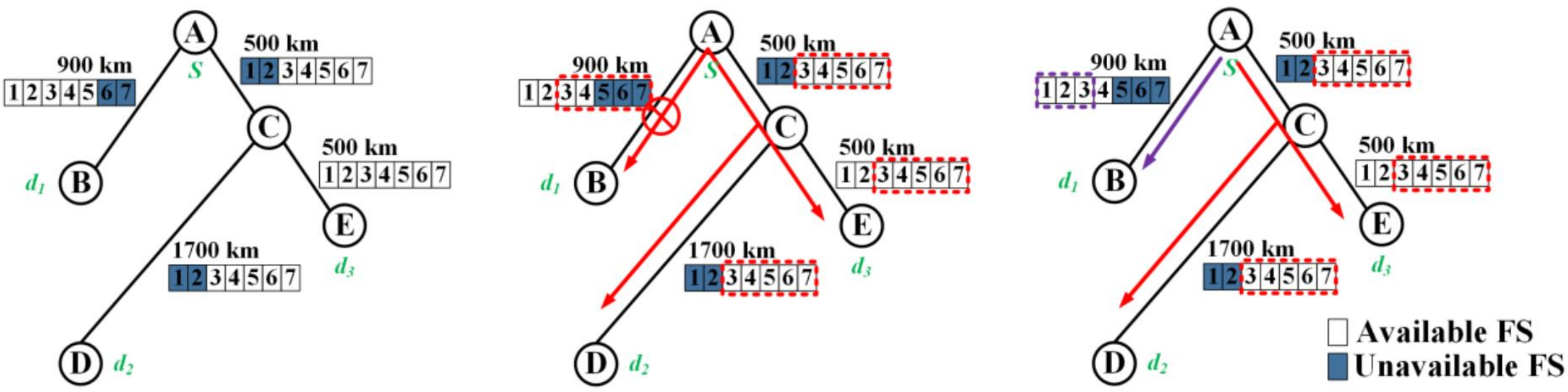
2 Survivable Multicast Provisioning

In optical networks, a light-tree rather than several light paths is conducted for a multicast request

Conventional single light-tree suffers from many shortages:

- Consuming too many regenerators to guarantee signal quality
- Low modulation level can be used $S_{m,n} = l_m / (\log_{10}(n)+1)$
- Inefficient spectrum usage and high blocking probability



Sub-light-tree Scheme

2 Survivable Multicast Provisioning

To protect a light-tree:

- Tree-based, path-based, and segment-based
- w/ sharing (self-sharing and cross-sharing) and w/o sharing

U = $\{U_2, U_3, U_4\}$

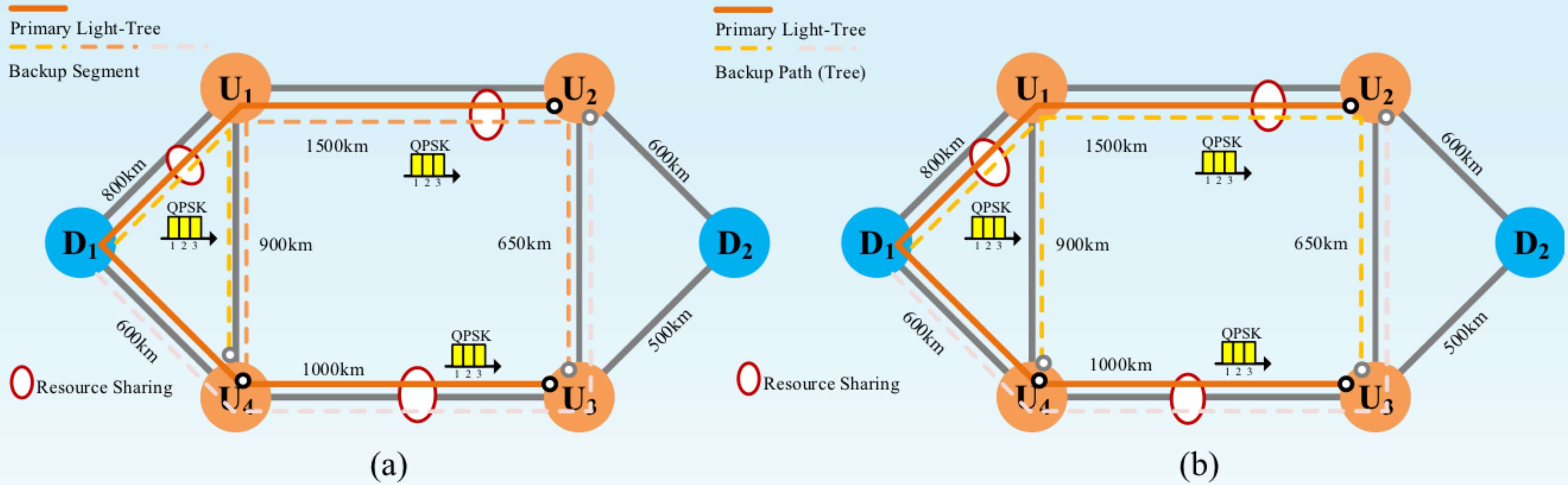


Fig. different survivable approaches for multicast request (a) segment-based (b) path-based

2 Survivable Multicast Provisioning

To protect a light-tree:

- Tree-based, path-based, and segment-based
- w/ sharing (self-sharing and cross-sharing) and w/o sharing

- Tree-based: Hard to find backup trees; high spectrum consuming and blocking probability
- Segment-based: Limited modulation-level selection due to spectrum contiguity and continuity constraints
- w/o sharing: Very low spectrum efficiency and high blocking probability

2 Survivable Multicast Provisioning

Distributed Sub-light-tree: In EODNs, the required multicast service is hosted in **multiple geographically distributed datacenters**.

MR_1={(B,C,F),b=1 FS}

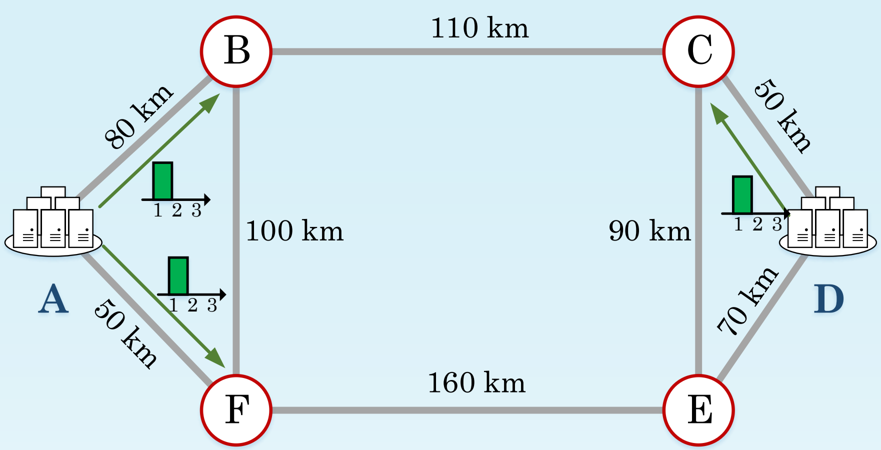


Fig.1 Primary distributed sub-light-tree

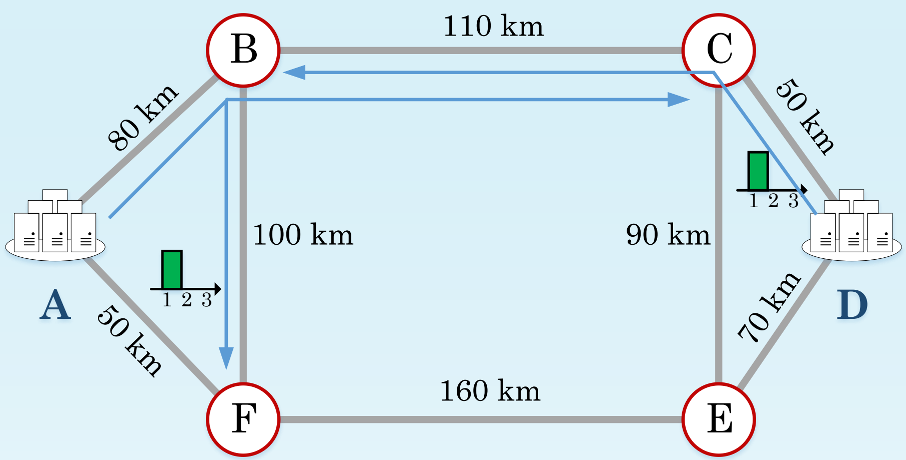


Fig. 2 Backup distributed sub-light-tree (self sharing)

Cross-sharing: The resource can be share between two backup paths of different multicast requests as long as the corresponding primary paths are disjoint.

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3 Machine Learning & Survivability

- Machine learning can process many factors at the same time and output the prior results
- About the survivability, the information of disaster, the request type, and other **realistic factors can be considered**
- Paths calculation and resource allocation can be conducted based on the **dynamic network states** and the information of **previous requests in the network**
- The controller of networks is strong enough to run such algorithms

Comments & Suggestions?

Thanks !