Slice-Aware Service Restoration with Recovery Trucks for Optical Metro-Access Networks

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Introduction

User demands and services are evolving...

A new generation of optical metro networks is needed to turn the vision of “Smart Cities” into reality

• From a rigid ring-based aggregation infrastructure to a composite network-and-computing ecosystem to support next-generation 5G services

• Several technical enablers:
  ▪ Increased reconfigurability enabled by SDN
  ▪ Integration of optical and wireless access networks
  ▪ Metro nodes becoming edge data centers (edge computing)
  ▪ Network slicing to logically partition network, computing, and storage resources
  ▪ …
Metro-Access Networks

User demands and services are evolving...

*so is the network*

- 75% of total metro traffic is terminated within the metro network, as video, data and web content is increasingly generated at the metro networks
Evolution of Metro-Access Networks

*Edge computing and SDN*
Evolution of Metro-Access Networks

Network Slicing

This transformation calls for trustworthy, high-availability, and sliceable next-generation metro-area networks that are resilient against disasters
Recovery for Metro-Access Networks

• Post-disaster recovery in metro access is different from that in core networks
  • Too expensive for disaster resiliency
  • Much less redundant than core

• After disaster, utmost priority: minimize service downtime (recover network asap)
  • Slice re-provisioning may not be possible with available resources and considering locality of services
  • Control plane managing the slices can also be affected by disasters

Utilize equipment for "temporary relief/service" only in case of disaster instead of preplanning lot of redundant capacity
Rapid network recovery using deployable recovery units

- In the post-disaster phase, recovery trucks can provide both repair and temporary relief/service while repair work is going on.

"Slice-aware" routing and deployment strategy to minimize downtime penalty and ensure fast restoration of important slices.
Slice-Aware Service Restoration

• Model the problem based on classical *vehicle routing problem*

• Recovery trucks provide both repair and *temporary relief/service* while repair work is going on (unlike general network recovery)

• Develop a “slice-aware” routing and deployment strategy for heterogeneous recovery trucks to heterogeneous failure sites

   Minimize downtime *penalty* - fast restoration of important slices
Slice-Aware Service Restoration with Recovery Trucks
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Slice-Aware Service Restoration with Recovery Trucks

• Given: network topology, set of network slices, set of failed nodes, set of heterogeneous trucks

• Output
  • Routes for recovery trucks

• Objective: Minimize service disruption penalty of slices

• Solution Approach
  • Mathematical model (MILP)
Compared schemes

• Deployment schemes to be compared

  • Slice-aware service restoration with temporary service (minimize penalty)
  • Slice-unaware service restoration with temporary service (minimize travel time)
  • Slice-aware service restoration without temporary service (repair only)
Simulation Setup
## Results

<table>
<thead>
<tr>
<th></th>
<th>Slice-aware</th>
<th>Slice-unaware</th>
<th>Slice-aware w/o temp. relief</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulative penalty</td>
<td>29.04</td>
<td>41.09</td>
<td>47.88</td>
</tr>
</tbody>
</table>

- 29% savings in penalty
- 38% savings in penalty
Results

- **60% reduction in service disruption penalty**
- **46% service-restoration time savings**
Conclusion

• Our slice-aware service-restoration approach can achieve significant reduction in service-disruption penalty and savings in service-restoration time in a post-disaster optical metro-access networks