Scheme for Optical Network Recovery Schedule to Restore Virtual Networks after a Disaster

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Telecommunication Networks in Disasters

After disaster occurs, what should network operators do?

Post-Disaster Technologies

Traffic Engineering

- Content-Connectivity
  - Temporary

- Degraded Service
  - Temporary

Network Engineering

- Emergency Communication
  - Temporary

- Repair Failures
  - Permanent

“Scheme for optical Network Recovery Schedule to Restore Virtual Networks after a Disaster”, C. Ma, et al.
Earthquake Recovery in Wenchuan

- Failures in Disaster:
  - Numerous Failures
    - 4,000 telecommunication offices
  - Limited Teams

Problem

How to make the recovery schedule for each team?

Outline

1. Backgrounds
2. Problem and Solution
3. Simulation Results
4. Conclusions
Problem Statement

• Input
  ▪ physical networks
  ▪ virtual networks
  ▪ mapping relationship
  ▪ disaster (failed components)

• Output
  ▪ Recovery schedule

“Scheme for optical Network Recovery Schedule to Restore Virtual Networks after a Disaster”, C. Ma, et, al.
Recovery Process

Metrics

- Failed virtual links (FVL)
- Un-full virtual networks (UVN)
-Disconnected virtual networks (DVN)

Schedule: (B,F), (E,F), (B,C)

Total damage: 2+1+0 = 3
ILP Model

Constraints

Statements of Physical Links

\[ \sum_{k=1}^{K} y_{ij,k} = 1 \quad \forall (i,j) \in E^D \]

\[ \sum_{(i,j) \in E^D} y_{ij,k} = 2 \quad \forall k \in \{1,\ldots,K\} \]

\[ y_{ij,k} = y_{ij,k} \quad \forall k \in \{1,\ldots,K\}, (i,j) \in E^D \]

\[ c_{ij,k} = \begin{cases} 0 & \forall k \in \{1,\ldots,K\}, (i,j) \in E^D \end{cases} \]

\[ c_{ij,k} = \sum_{k' \in \{1,\ldots,K\}} y_{ij,k'} \quad \forall k \in \{1,\ldots,K\}, (i,j) \in E^D \]

Damage of UVN

\[ f_{s,k} = \sum_{m,n \in E^V_s} l_{(m,n),s,k} \quad \forall s \in \{1,\ldots,S\}, k \in \{1,\ldots,K\} \]

Objectives

Minimum DVN

\[ \min \sum_{k \in \{1,\ldots,K\}} \sum_{s \in \{1,\ldots,S\}} r_{s,k} \]

Minimum UVN

\[ \min \sum_{k \in \{1,\ldots,K\}} \sum_{s \in \{1,\ldots,S\}} f_{s,k} \]

Minimum FVL

\[ \min \sum_{k \in \{1,\ldots,K\}} \sum_{s \in \{1,\ldots,S\}} \sum_{m,n} l_{(m,n),s,k} \]

Damage of DVN

\[ \sum_{(m,n) \in E^D} x_{(p,q)(m,n),k} = \sum_{(m,n) \in E^D} x_{(p,q)(m,n),k} = \]

\[ \begin{cases} 1 & \text{if } n = p \\ -1 & \text{if } n = q \\ 0 & \text{otherwise} \end{cases} \quad \forall p, q, m \in V^V_s, p \neq q, (m,n) \in E^V_s, k \in \{1,\ldots,K\} \]

Damage of FVL

\[ r_{s,k} = \sum_{p \in V_s} \sum_{q \in V_s} \sum_{m,n \in E^V_s} x_{(p,q)(m,n),k} \quad \forall s \in \{1,\ldots,S\}, k \in \{1,\ldots,K\} \]
Simulation

- Modified NSFNet topology
- Two disaster areas with 7 failures each
- Ten virtual networks
  - Four virtual nodes, which are randomly mapped to physical network
Results of OFC

Disaster Area D1

|------|-----------------------------------|

*Disconnected virtual networks (DVN)  *Un-full virtual networks (UVN)  *Failed virtual links (FVL)

All the objectives get their optimal results.
Results after OFC

- Repair and traveling times are dynamic changed.
- Multiple algorithms (Dynamic Programming, Greedy Algorithm, Simulated Annealing) are proposed.
Conclusions

• We investigated the recovery schedule of virtual networks after disaster and proposed a mathematic solution for it.

• We proposed and compared different recovery objectives, and showed that each objective can lead to its optimal result.

• **Work after OFC:**
  - Repair time and traveling time to failure locations will be dynamic changed.
  - Heuristic algorithms will be introduced and compared to the problem.
Thanks!

Q&A