Algorithmic Aspects of Virtual Optical Network Embedding for Cloud Networks

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Outline

- Virtual Optical Network Embedding Problem (VONE)

- Performance Metrics

- Close-Related Problems to VONE

- VONE Problem Classification

Virtual Optical Network Embedding

- Main problem of network virtualization

- Assign physical network resources to virtual network requests

- Virtual node resource request: IT capacities (i.e., storage, computing)

- Virtual link request: connection between a virtual node pair

VONE: Modeling

- Physical network: modeled as undirected graph with bi-direction links

- Physical node: storage and computing capacities, location, elements of optical node architecture

- Physical link: bandwidth, length/latency, utilization cost, reliability

VONE: Modeling

- Virtual optical network: modeled as undirected graph

- Set of virtual nodes

- Set of virtual links

- Holding time (dynamic problems)

VONE: Sub-Problems

- Virtual node mapping

- Virtual link mapping

- Typically, one step at a time

VONE: Constraints

- Physical node/link resources
- No more than one virtual node in virtual network to same physical node (survivability)
- Wavelength continuity
- Spectrum contiguity
- Impairment

VONE: Objective Function

- Single-objective function

- Multi-objective function

Performance Metrics: Acceptance Ratio

- $Acceptance\ Ratio = \dfrac{\sum VON_{acc}}{\sum VON_{Tot}}$

- $Blocking\ Ratio = \dfrac{\sum VON_{Block}}{\sum VON_{Tot}}$

- $AR + BR = 1$

Performance Metrics: Embedding Cost

- $Cost_i^{Von} = \left(\gamma \sum_{N_P} c_{n,i}^P + \delta \sum_{L_P} B_{l,i}^P \right) HT_i$

- $Total\ Cost = \sum_{Acc} Cost_i^{Von}$

Performance Metrics: Embedding Revenue

- $Revenue_i^{Von} = \left(\alpha \sum_{N_V} c_{n,i}^V + \beta \sum_{L_V} B_{l,i}^V\right) HT_i$

- $Total\ Avenue = \sum_{Acc} Revenue_i^{Von}$

Other Performance Metrics

- Average virtual link length
- Maximum stress level
- Network/content connectivity
- Virtual network reliability
- Execution time

VONE Closed-Related Problems

- RWA, RSA

- Virtual network topology mapping: set of virtual nodes given

- Virtual infrastructure mapping: map set of connection demands

VONE: Classification

- Static: all requirements known a priori

- Dynamic: all requirements not known

Methods

- Exact methods: LP, ILP, MILP

- Heuristic methods

Research Issues: VONE

- Multi-Objective Approaches

- Multi-Domain Physical Networks

- Multicast Traffic

- Resilience

- Virtual Network Reconfiguration/Migration

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Back To Content Connectivity

- Set of virtual nodes requesting content in time basis

- Unknown and different Holding Time

- If two or more requests, which one to allocate first?

- We might not allocate a full virtual network but:
    - Set of nodes requesting content
    - Set of connections to content
    - Anycast, or multicast

SDN Survivability vs Content Connectivity

- SDN survivability share many common characteristics with content connectivity problem

References

[1] E. J. Dávalos, and B. Barán, "A Survey on Algorithmic Aspects of Virtual Optical Network Embedding for Cloud Networks," *IEEE Access*, vol. 6, pp. 20893-20906, 2018.

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