Achieving Plasticity in WDM networks: Application of Biological Evolutionary Model to Network Design

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VNT (Virtual Network Topology) control

- VNT control reconfigures VNT in accordance with traffic changes
  - by establishing or tearing-down lightpaths
  - to lower link utilization

Research Background

- VNT control against traffic fluctuation
  - Some VNT control methods have showed good performance, such as keeping link utilization lower
  - VNT control method based on attractor selection\(^1\) shows high adaptability to unexpected traffic demand changes

- Shortage of resources caused by traffic growth
  - The VNT control may fail to obtain a good VNT

Network Design against Traffic Growth

**Purpose:** Add physical resources, e.g., transceivers in order to improve the adaptability of VNT control

- A good network design, or reinforcement of physical resources can accommodate future unknown traffic demands
- Optimization toward the present traffic may be bad for the future traffic

An Effect of Adding Transceivers

- We consider a method of adding transceivers
  - Selection of IP-routers where transceivers should be added
  - Adding a transceiver results in a new lightpath available

**Key:** The transceivers distribution has effect on available VNTs
**Approach: Achieving a Biological Plasticity**

- A plasticity, i.e., a changeability to environmental fluctuation is a basic characteristic in evolution

**Physical topology:**
- Simulation environment

**Evaluate traffic demand and link utilization:**
- Traffic demand model: Initially, each nodes has traffic demand about 15% more traffic patterns
- Add a transceiver to the selected node
- If there remains another transceiver, go back to Step 1
- Otherwise, finish

**Proposed Method of Adding Transceivers**

**Step.1:**
- Select a node to add a transceiver
  - Temporarily add a transceiver to one node
  - Evaluate the plasticity by using the biological model
  - Repeat [1.1-1.3] for another node

**Step.2:**
- Temporarily add a transceiver and evaluate the plasticity
- Add a transceiver to the selected node
  - If there remains another transceiver, go back to Step 1
  - Otherwise, finish

**Applying a Genetic Evolutionary Model**

- Evaluate the plasticity by computational simulation in case some transceivers were added to some nodes

**Evaluation**

- Simulation environment:
  - Physical topology:
    - Initially, each nodes has 2 + its degree transceivers
    - Traffic demand model:
      - $T_{VNT}(t) = m + r_{VNT}(t-1)$
      - Increase linearly
      - $T_{VNT}(t) = T_{VNT}(t-1) + k \times \sigma_{VNT}(t)$

- Method for comparison:
  - An ad-hoc design based on a heuristic method

**Performance against Traffic Changes**

- Proposal method accommodates CCDF
  - The distribution of link utilization for 1000 patterns of traffic changes
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**Performance against Noise Strength**

- Proposal method with VNT control is adaptable even under drastic traffic fluctuation

Both designs achieve 100% success rate

The proposed design achieves plasticity

The ad-hoc design cannot handle various traffic patterns

**Conclusion and Future Work**

- **Proposal**
  - We proposed a design method of WDM network, which determines a set of IP-routers where transceivers should be added
  - The proposed method is inspired from biological evolution so that the network can obtain plasticity

- **Computer simulation**
  - Simulation showed the proposed method makes VNT control more adaptive against unexpected traffic fluctuations

- **Future work**
  - Evaluation on other physical topologies
  - Extension of the method so that it should add other resources not only transceivers of a node but also links between nodes

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