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Adaptive VNE Method Based on Yuragi Principle for Software Defined Infrastructure

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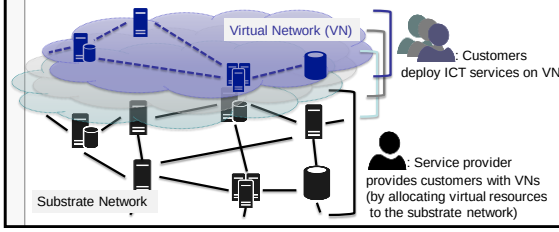
SDI (Software Defined Infrastructure)

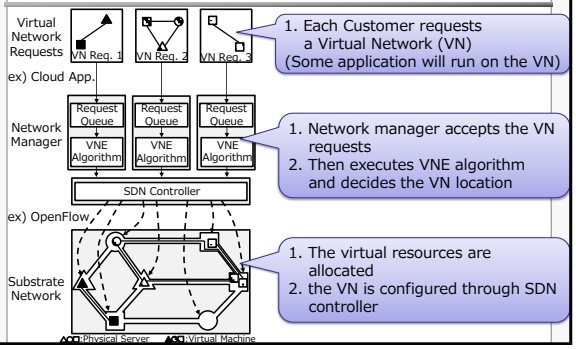
- **SDI provides virtualized infrastructures**
  - by slicing computing resources and network resources

Problem: strategy to control the assignment of physical resources to VNs

*Development and standardization of SDN/NFV technologies are also important



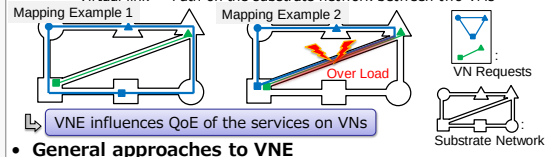
Service Model in SDI Frameworks



1. Each Customer requests a Virtual Network (VN) (Some application will run on the VN)
1. Network manager accepts the VN requests
2. Then executes VNE algorithm and decides the VN location
1. The virtual resources are allocated
2. the VN is configured through SDN controller

Resource Allocation Problem: (Dynamic) VNE

- **VNE (Virtual Network Embedding)**
  - Placement problem that maps VNs onto the substrate network
    - Virtual node → Virtual Machine (VM) on a physical server
    - Virtual link → Path on the substrate network between two VMs



VNE influences QoE of the services on VNs

- **General approaches to VNE**
  1. A central component identifies the current situation of networks
     - gathering traffic information and resource utilization of each VN
  2. Then, solves an optimization problem
     - e.g., minimizing resource utilization / maximizing revenue

Problems of the Conventional Approaches

- **The scale of network size gets larger**
- **The number of multiplexed VNs increases**

  - The identification of current situation gets complicated with enormous network information

・Occupation of link bandwidth
・Increase of delay
・Difficulty of solving the optimization problem

Some heuristic methods may ease this problem

calculation of optimization problem
Gathering network information
VN migration

***Flexible and immediate configuration is needed against VN request changes**

Purpose & Approach

- **Purpose of this research**
  - Proposal of a VNE method for large and uncertain SDI frameworks
    - The method works with little information to achieve scalability and adapts to environmental changes
- **Approach**
  - Extend the "Yuragi" based VN topology control method[7]
    - Yuragi: a Japanese word meaning a small perturbation
    - The method shows high adaptability to environmental fluctuations with restricted information on optical networks
  - Various matters must be considered for SDI frameworks
    - Node attribute
    - Computing performance on servers
    - VN multiplexing
    - etc.

Node attribute:
specific requirement of virtual node
ex) OS, RAID types
ex) for computing, for storage

[7] Y. Koizumi, et al., "Adaptive virtual network topology control based on attractor selection," *IEEE Journal of Lightwave Technology*, vol. 28, no. 11, pp. 1720--1731, June 2010.

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The VNE Method Based on "Yuragi" Principle

- **The method decides where (on which physical node n) to allocate virtual node of attribute k**
  - State variables $\mathbf{x} = (x_{kn})$ follows the dynamics below

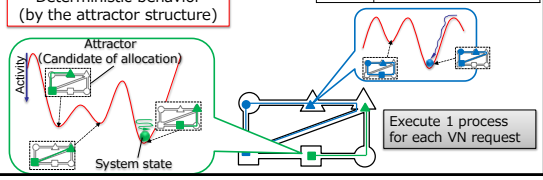
Activity (performance)

$$\frac{d\mathbf{x}}{dt} = \alpha \cdot f(\mathbf{x}) + \eta$$

Stochastic behavior

Deterministic behavior (by the attractor structure)

$x_{kn} > 0$	Get node n be a candidate
$x_{kn} < 0$	Exclude node n from the candidates
$x_{kn} = 0$	In case node n does not support attribute k



Execute 1 process for each VN request

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Evaluation

- **Evaluation measures**
  - Adaptability of Yuragi-based method
    - Whether the method achieves performance objective
  - Acceptance ratio of VN requests
  - The number of VN migration
- **A benchmark of the performance**
  - Greedy algorithm[11]: one of the heuristic VNE methods
    - aims to minimize utilization of node and link resources
    - embeds VM to the node with the most available resource
- **Comparison of information which needs gathering**

Yuragi	Observed delay on the single VN
Greedy	Resource utilization of both nodes and links over the substrate network Observed delay on the all VNs

[11] M. Yu, et al., "Rethinking virtual network embedding: Substrate support for path splitting and migration," *ACM SIGCOMM Computer Communication Review*, vol. 38, pp. 17--29, March 2008.

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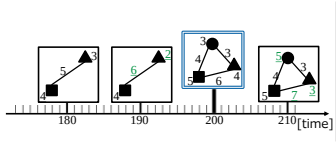
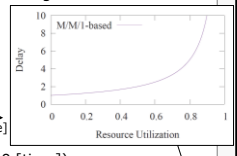
Simulation Environment

- **Substrate network (fixed): 50 nodes**
- **VN requests: 20 VNs (each has 2 to 5 virtual nodes)**
  - requiring capacities for CPU, Memory, Storage and Bandwidth





  - Resource requirements fluctuation (/10 [time])
  - Topological change (/100 [time])
- **Objective metric (activity): End-to-end delay**
  - delay in network + delay on virtual machines
  - (in the simulation,) modeled as a function of resource utilization

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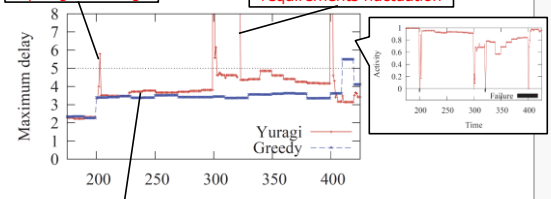
Observed Delay

- **The maximum delay on a VN out of the 20 requests**

Adapts to the topological change

Adapts to the requirements fluctuation



Maintains the state through the requirements fluctuation

Achieves the smaller delay than the target value

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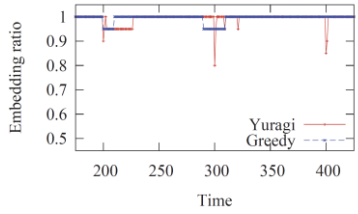
Embedding Ratio of VN Requests

- How many VNs are accepted out of the 20 requests
  - $= 1 - blocking\ ratio$



keep almost 95% to 100% acceptance excluding topological changes

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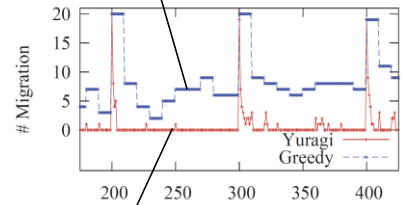
The Number of VN Migrations

- **The number of VNs whose location has been changed**

Pursues better delay with many migration



Keeps adaptable delay with less migration

Achieves adaptation with less VN migrations

Conclusion and Future Work

- **Work done**
  - Presented a VNE method based on Yuragi principle
    - The method decides the mapping of virtual node by attractor selection
  - Simulation results show the adaptability of the method
    - The method achieves small delay with less VN migration
- **Future work**
  - To execute more evaluation with different situation
    - Various delay models
    - Various topologies
    - Other objective metrics
    - Larger networks
  - To investigate a method of constructing the attractor structure
    - Better attractor structure will improve the convergence time and some performance