Management of managed self-organizing network in network virtualization environment

WTC 2012 @ Miyazaki, Japan

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Outline of Talk

- Background
- Problem Statement
- Proposal: Managed self-organization
- Evaluation
- Conclusion

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Overview of Managed Self-Organizing Network

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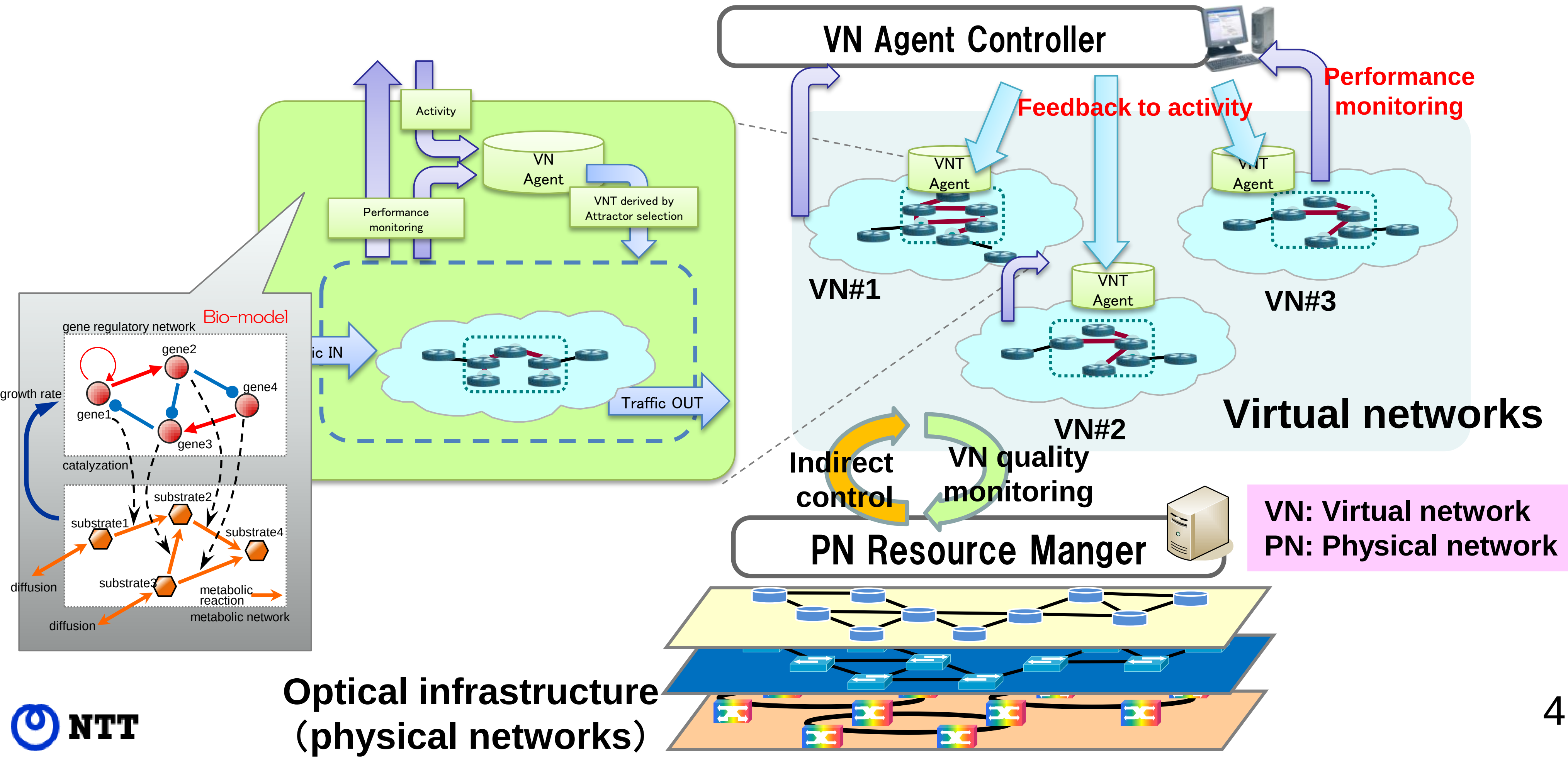
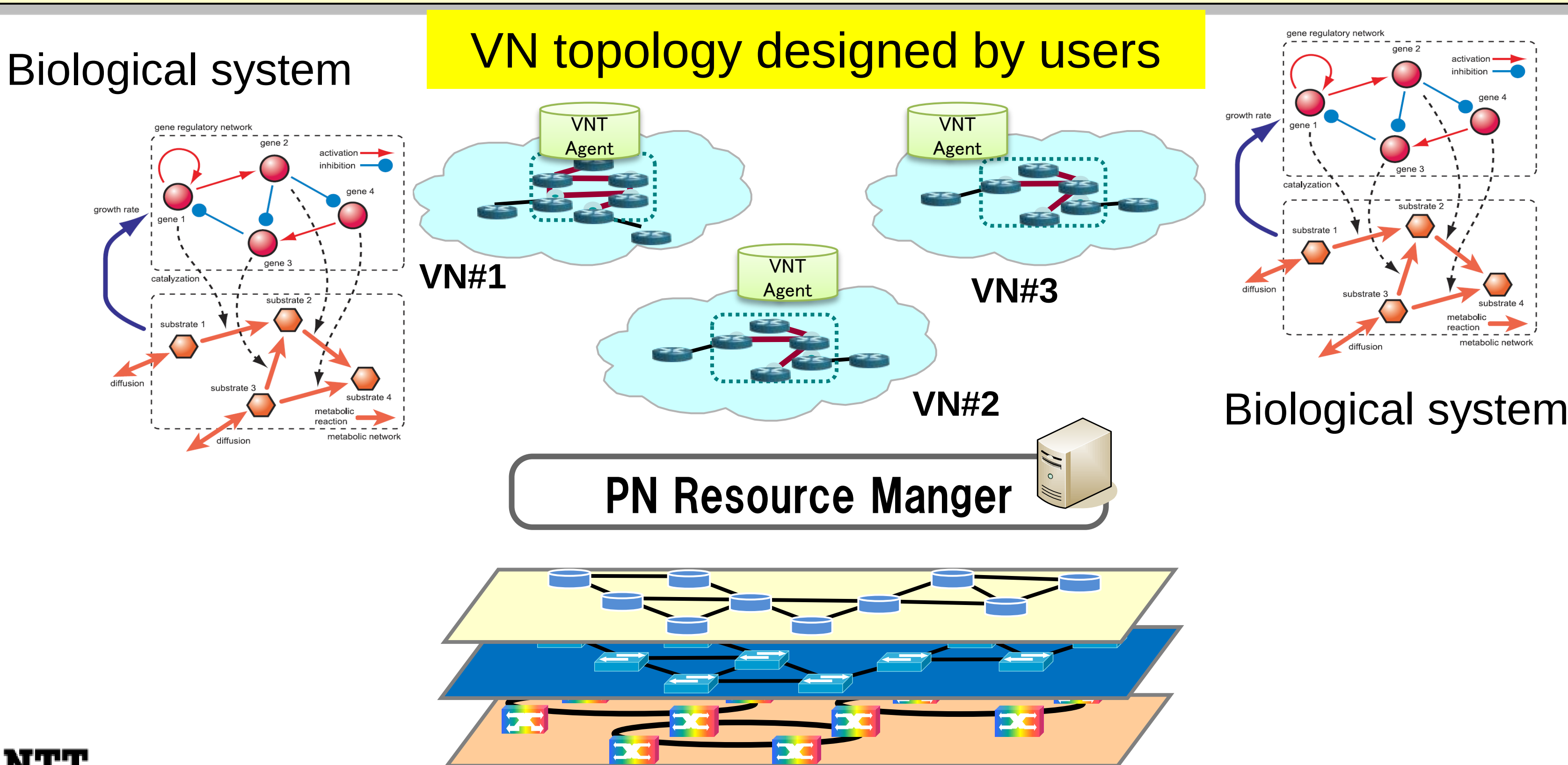
- **Aim:** Simplify management of network virtualization infrastructure through self-organization
- **Challenge:** Performance degradation due to resource contention
- **Proposal:** Architecture for stable accommodation self-organizing VNs



NTT

Background

- Network Virtualization provides controllability for users
- Users freely designs own topology for adaptability
- Introduce biology-inspired topology control scheme (=self-organization)



Adaptive VNT reconfiguration

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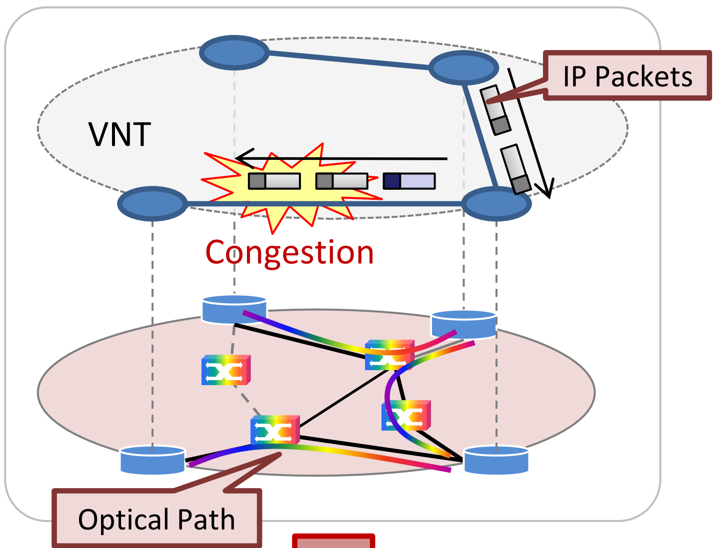
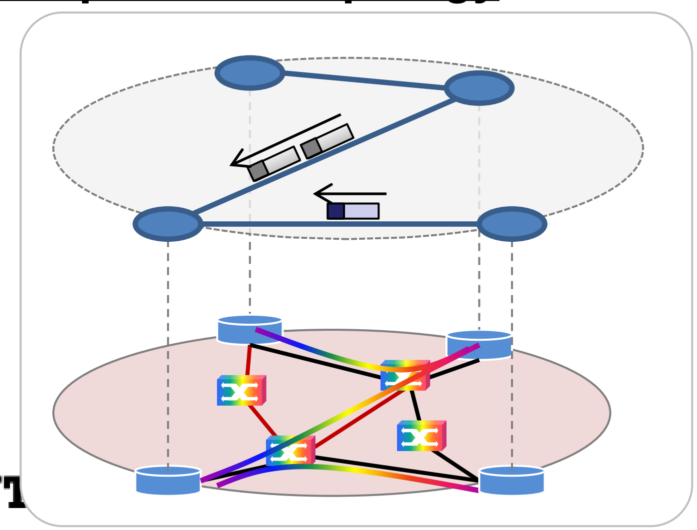
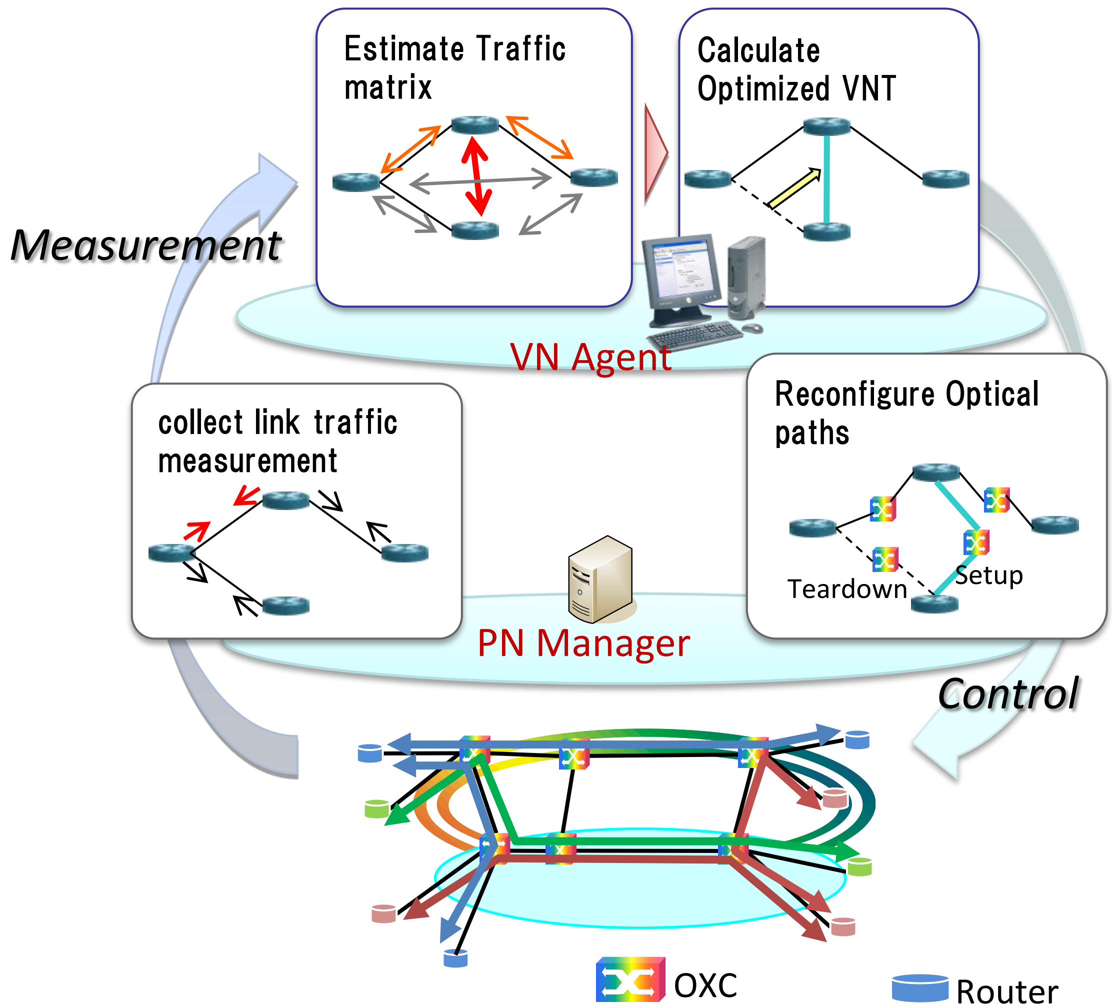
1. Initial Topology



1. Optimized Topology



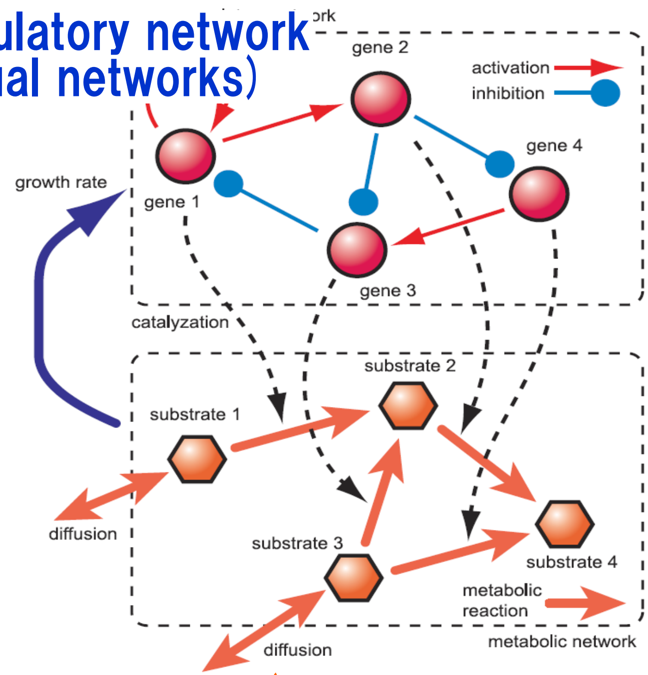
VNT: Virtual Network Topology



Background: Attractor selection-based control

1. Adaptability to unknown environmental changes
   - System finds attractor (=equilibrium point) through random search to adapt environmental changes.
2. Simplicity of control mechanism
   - Light-weight computation to find solutions
   - Works well with limited information.

Gene regulatory network (=Virtual networks)



Metabolic network (=Physical network)

Differential equation

$$\frac{dx_i}{dt} = f\left(\sum_{j=1}^{n} W_{ij} x_j - \theta\right) \cdot v_g - x_i v_g + \eta$$

[Kashiwagi2006] Kashiwagi et al.,"Adaptive Response of a Gene Network to Environmental Changes by Fitness-Induced Attractor Selection ," PLoS ONE, vol.1, 2006.

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Our goal

- Establish resource management architecture for accommodating numerous VNs.

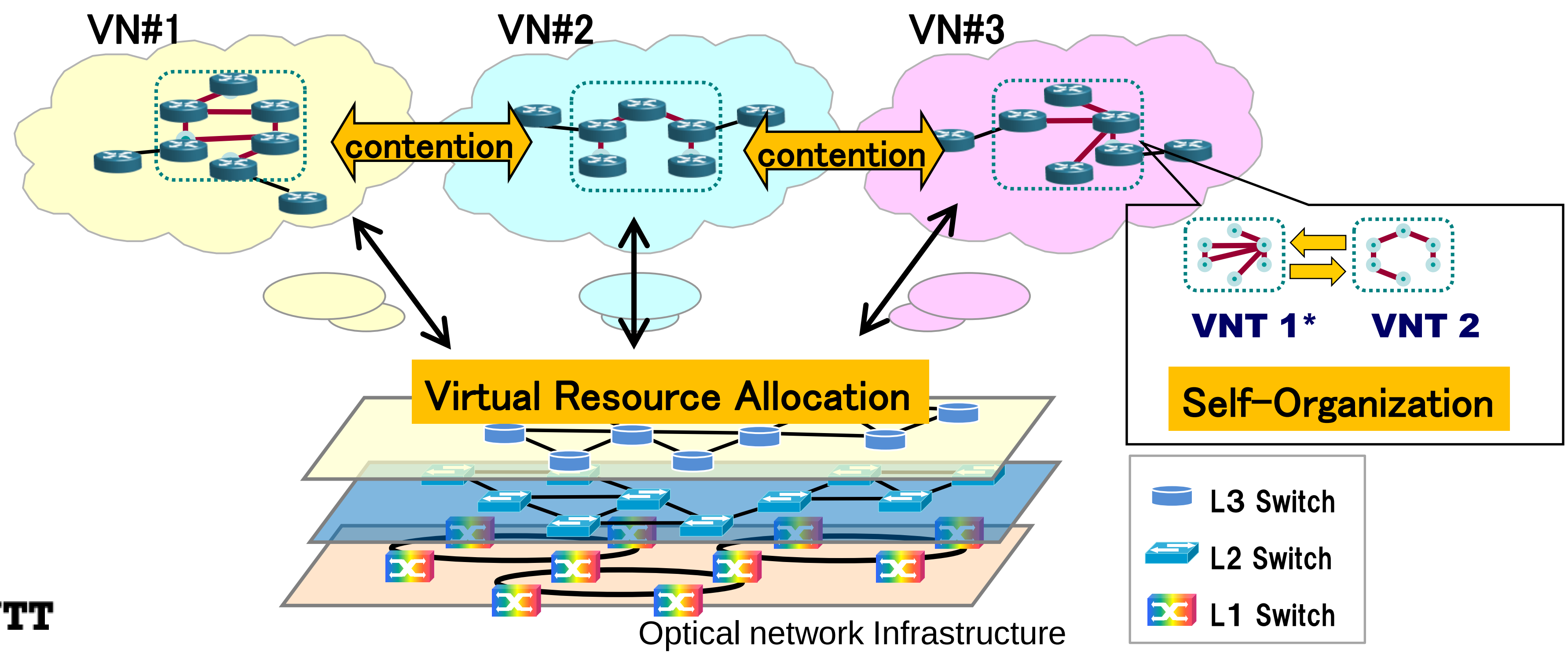
  Some Design Principles

  - Each VN is controlled according to self-organization for quick responsiveness.
    - VNs can freely aquire/delete virtual resources from PN for constructing optimal topology.
  - Minimal Control: Ensure enough scalability in terms of network size and the number of VNs.

Problem we are solving

- High-performance network virtualization over optical network infrastructure.
  - Wavelength path between two V-nodes fomrs virtual link in VNT.
  - Dedicated wavelength resource is allocated to each VN for hard isolation.
- *Key Question: Physical resource are limited. How to solve resource contention among numerous VNs?*
  - Introduce minimal intervention for stability.

  ⇒ Design simple management architecture for self-organizing VNs.



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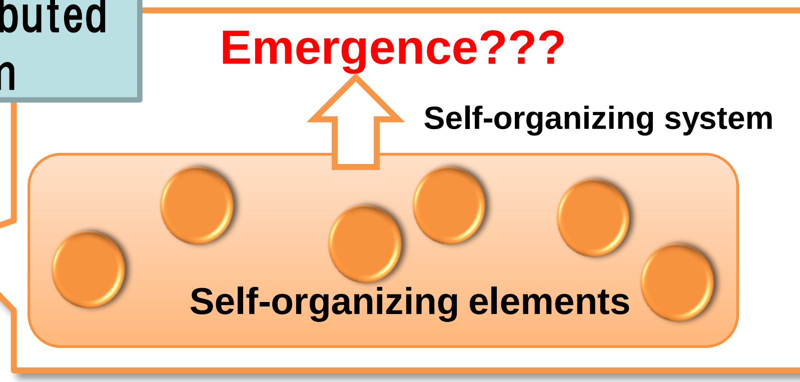
Our concept: Managed Self-Organizing System

- Limitations: Applying self-organization to multiple elements (i.e., VNs) can cause instability in case of emergency.
- Our solution: Introduce minimal control in resource allocation.

Fully distributed system

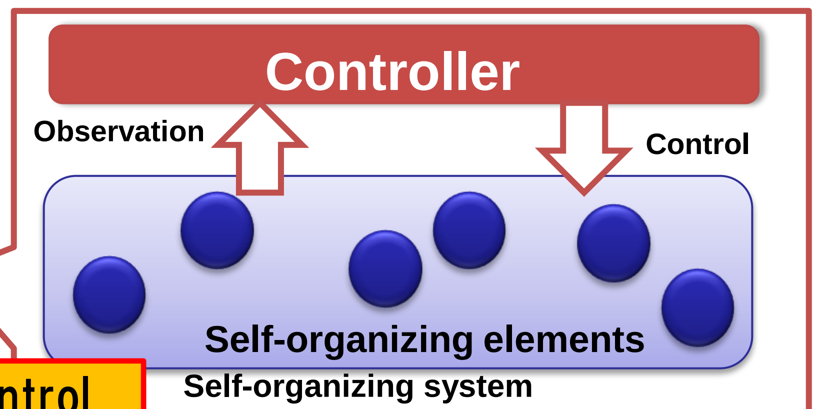


Self-Organizing System (SOS)

Has an ability to operate in a dynamically changing environment without centralized control.

Managed Self-Organizing System

Provides a range of operating regime by an external control while allowing a self-organization property

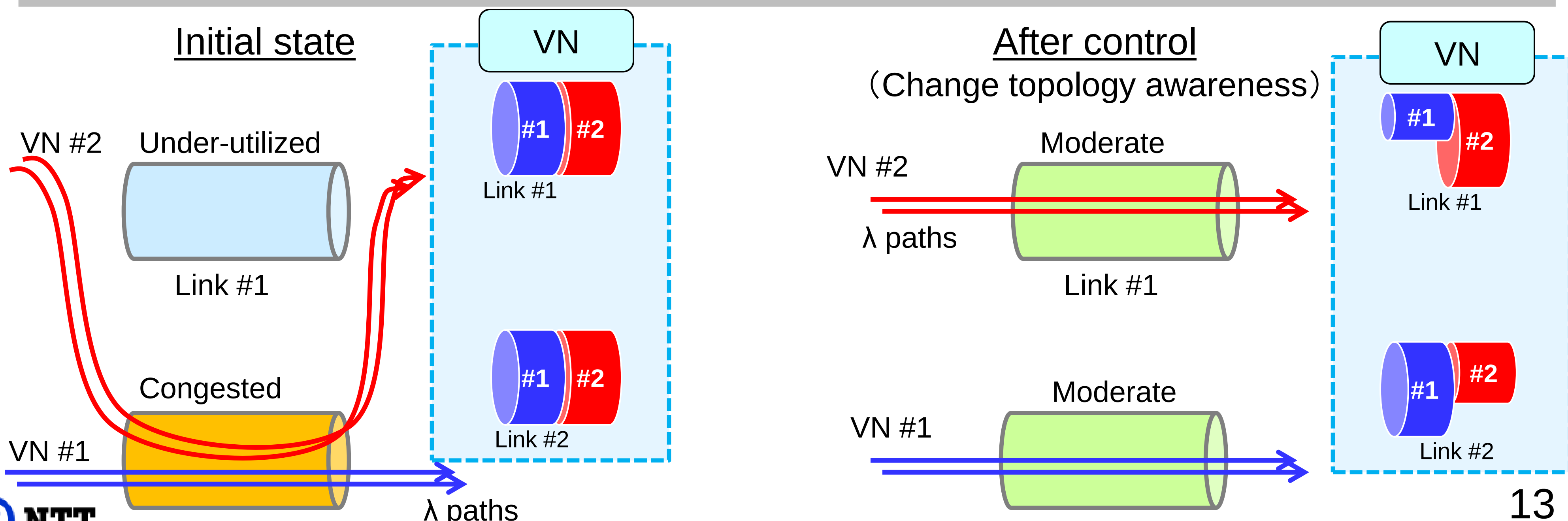


Hybrid control system

Design approach

- How to ensure scalability of resource management?
  - To accommodate hundreds of VNs, we should avoid fully centralized control.
  - Introduce indirect control for resolving resource contention among self-organizing VNs.
- Key observation for resource contention.
  - Same algorithm based on same information often cause synchronization.

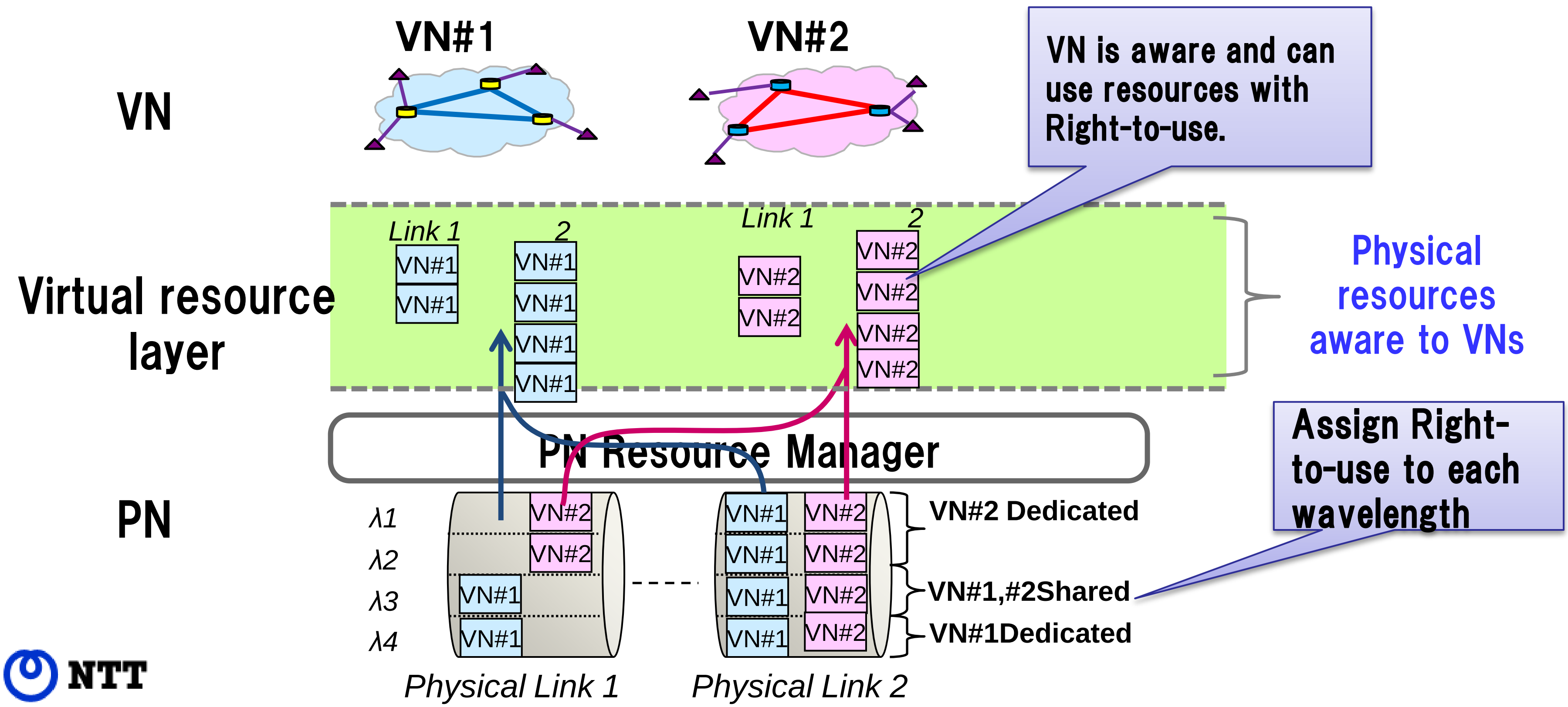
  ⇒ Inform different residual information to each VN for diversification.



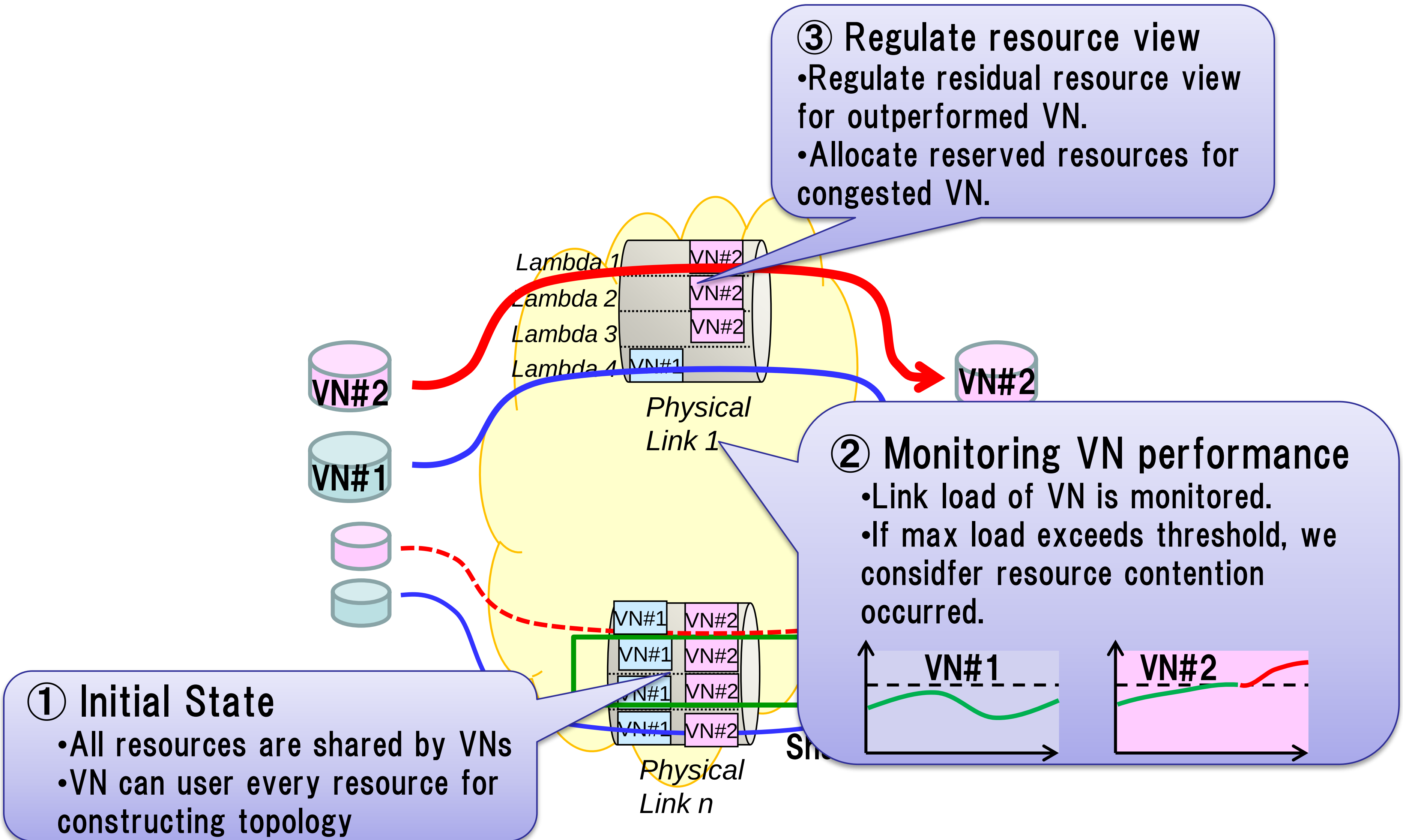
Resource management model

- Resource management system controls topology-awareness to each VN to avoid resource contention while allowing resource sharing to some resources.
  - Each VN utilize resources with "Right-to-use" privilege.
  - By combining resources with privilege, VN topology is created on-demand.

⇒ Virtual resource layer enables indirect control of self-organizing VNs.



Procedures for avoiding contention



VN: Virtual Network

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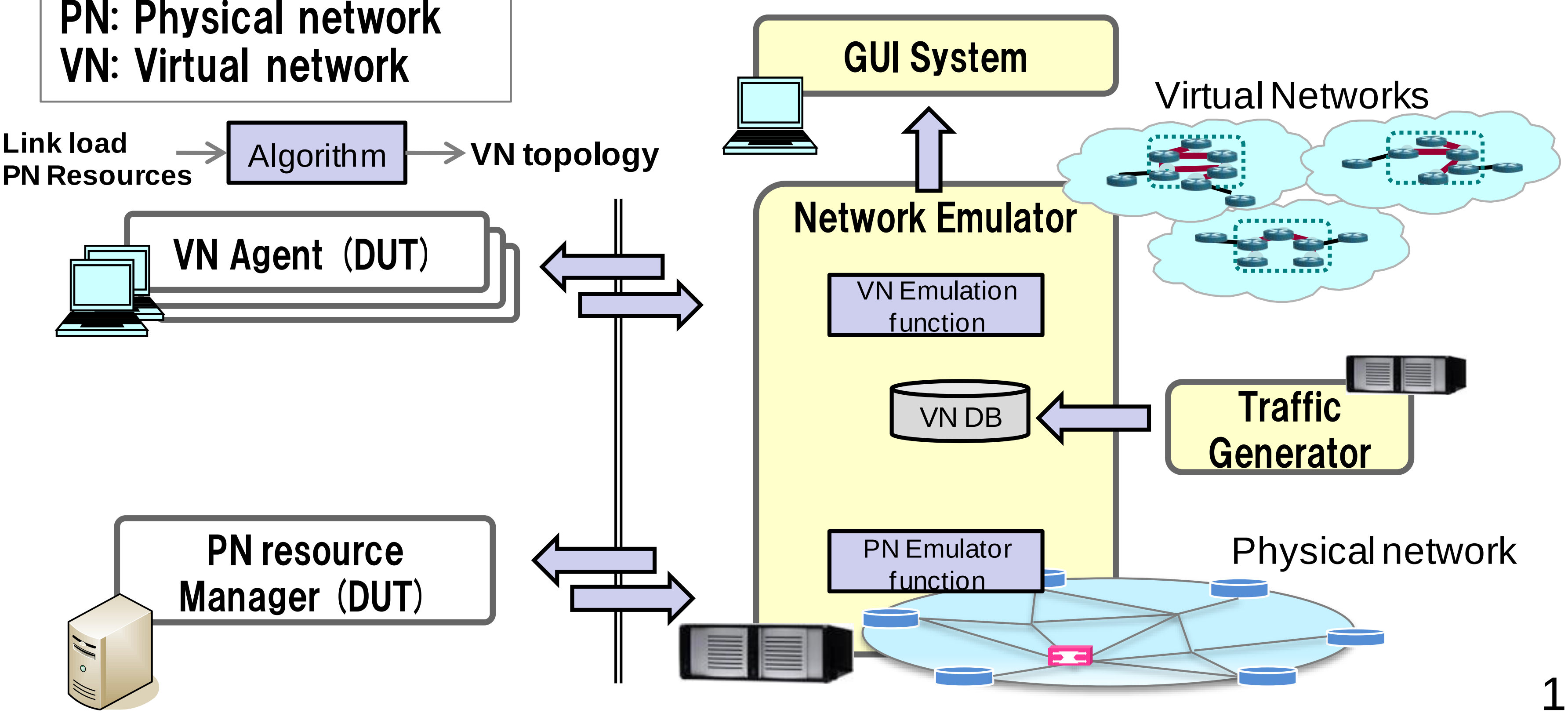
Experimental Demonstration

- Developed network emulating systems for demonstrating our architecture.
  - Simulate behavior of multiple self-organizing VNs.
  - Generate traffic demand changes and topological failures.

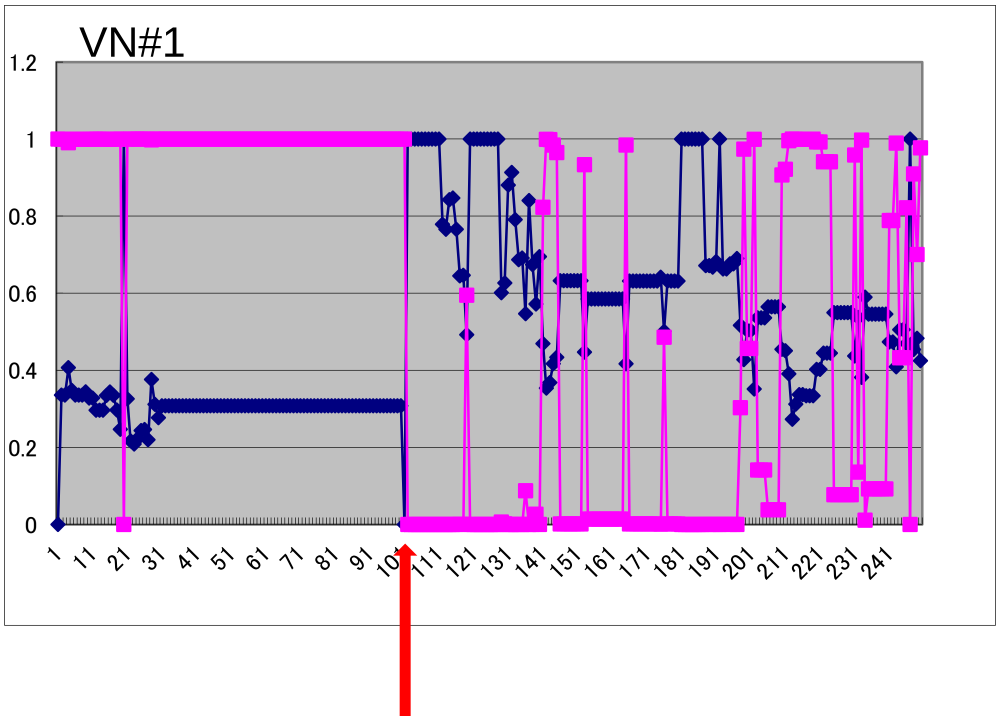
DUT: Device under test
PN: Physical network
VN: Virtual network



Result 3: Asymptotic behavior

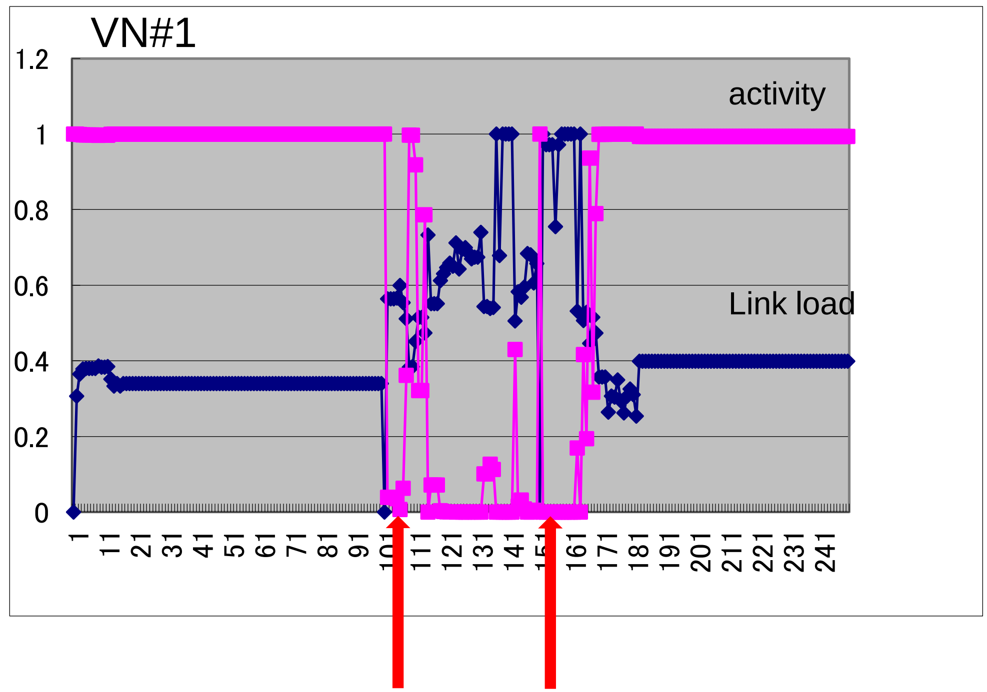
- Evaluate performance in simple 11-nodes Abilene topology.
  - SO fails to avoid resource contention.
  - Proposed mechanism quickly recovered performance by reallocating resources.

Completely Self-organized control



Traffic changes

Proposed (Managed SO control)



Traffic changes Resource reallocation

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Concluding remarks

- Summary:
  - Propose managed self-organizing network architecture
    - VNs controlled based on biological systems.
    - Require some mechanism for alleviating resource contention among VNs.
  - Basic idea is to regulate resource view for hot spot links
  - Simulation study demonstrated effectiveness of proposed algorithm
    - Quickly recovered performance due to sudden traffic change
- Future work:
  - Evaluate computation overhead of DRAMS.
  - Evaluation in large-scale network, more than 3 VNs.

Thank you for your attention

Acknowledgement **:**

This work was supported in part by the SCOPE (Strategic Information and Communications R&D Promotion Programme) of the Ministry of Internal Affairs and Communications, Japan.