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Simplification of Service Functions Based on Growth in Scale of Networks

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Outline of presentation

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- **Background of research**
  Evolution of service functions together with network growth
  （Diversification and simplification）
- **Simplification of service functions based on growth in scale of networks**
  Growth of traffic volume, Growth of topology, Necessity of decentralized manner, Increase of fault patterns
- **Simulation model for simplification of service functions**
  Priory control for path routing, Load balancing between multi-paths
  Reduction in processing delay due to simplification of service functions
  User's feedback based on satisfaction rate of required quality
- **Simulation results of simplification of service functions**
  Feasibility of simplifying service functions,
  Effect of simplification on network evolution
- **Summary and future works**

Background of research

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Deployment of a new generation of network infrastructure

- Diversification of service functions due to network openness
- **Simplification of service functions for scalable self-organized network**

Simplification of service functions based on growth in scale of network itself

- Priority control for path routing（Based on topology growth）
- Load balancing between multi-paths（Based on traffic growth）

- Feasibility of simplifying service functions

- Effect of simplification on network evolution

Principles of simplification -1

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Growth of traffic volume

⇒ Effect of statistical multiplexing

- Priority control for packet transfer
- **Load balancing between multi-paths**

Growth of topology

⇒ Small-world property

- **Priority control for path routing**
- Reliable data transfer
- Data gathering through network

⇒ Reduction in clustering coefficient

- Message flooding

Principles of simplification -2

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Necessity of decentralized manner

⇒ Uneven arrangement of traffic flows

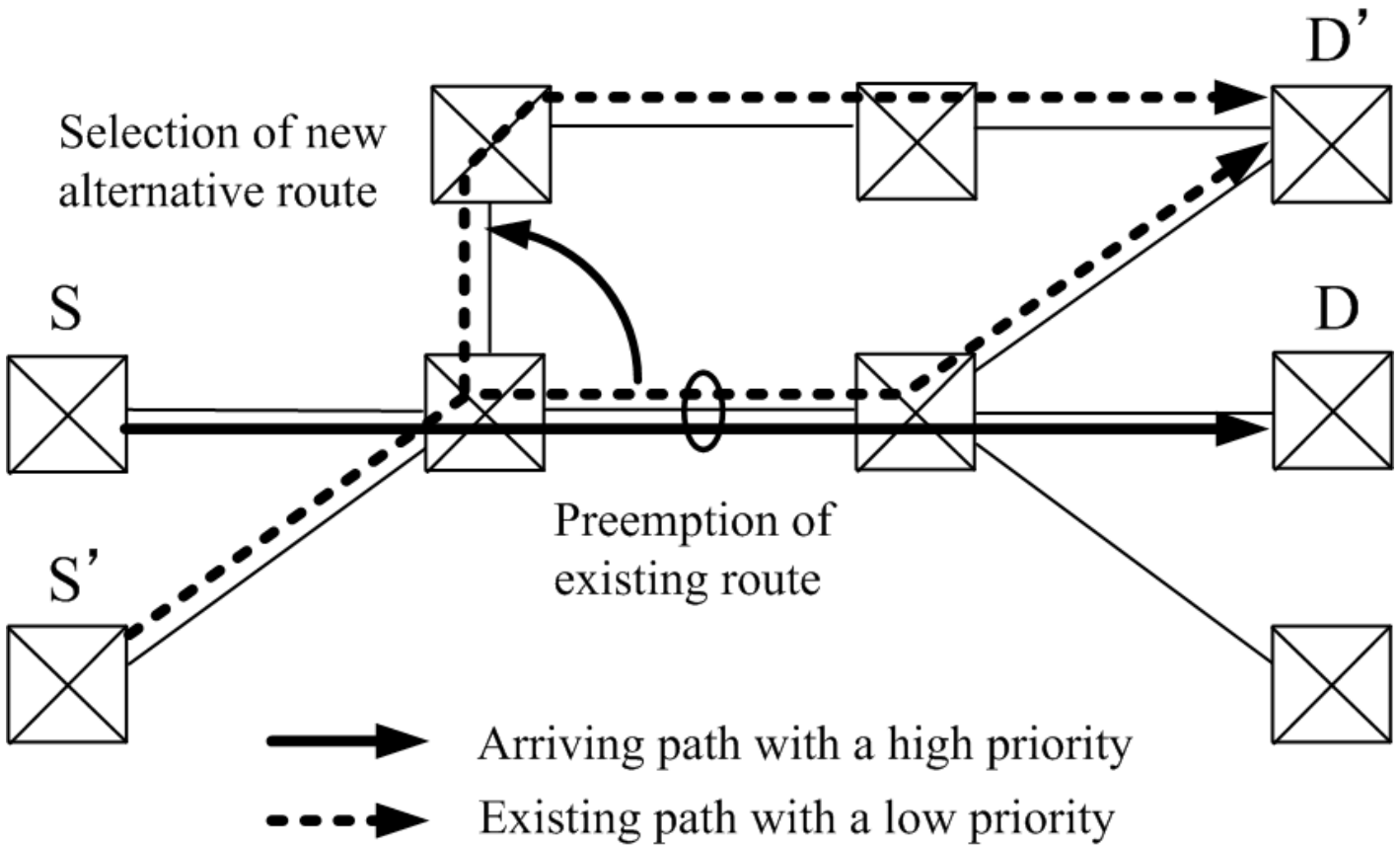
- Priority control for packet transfer
- **Priority control for path routing**

Increase of fault patterns

⇒ Rapid increase in number of combinations

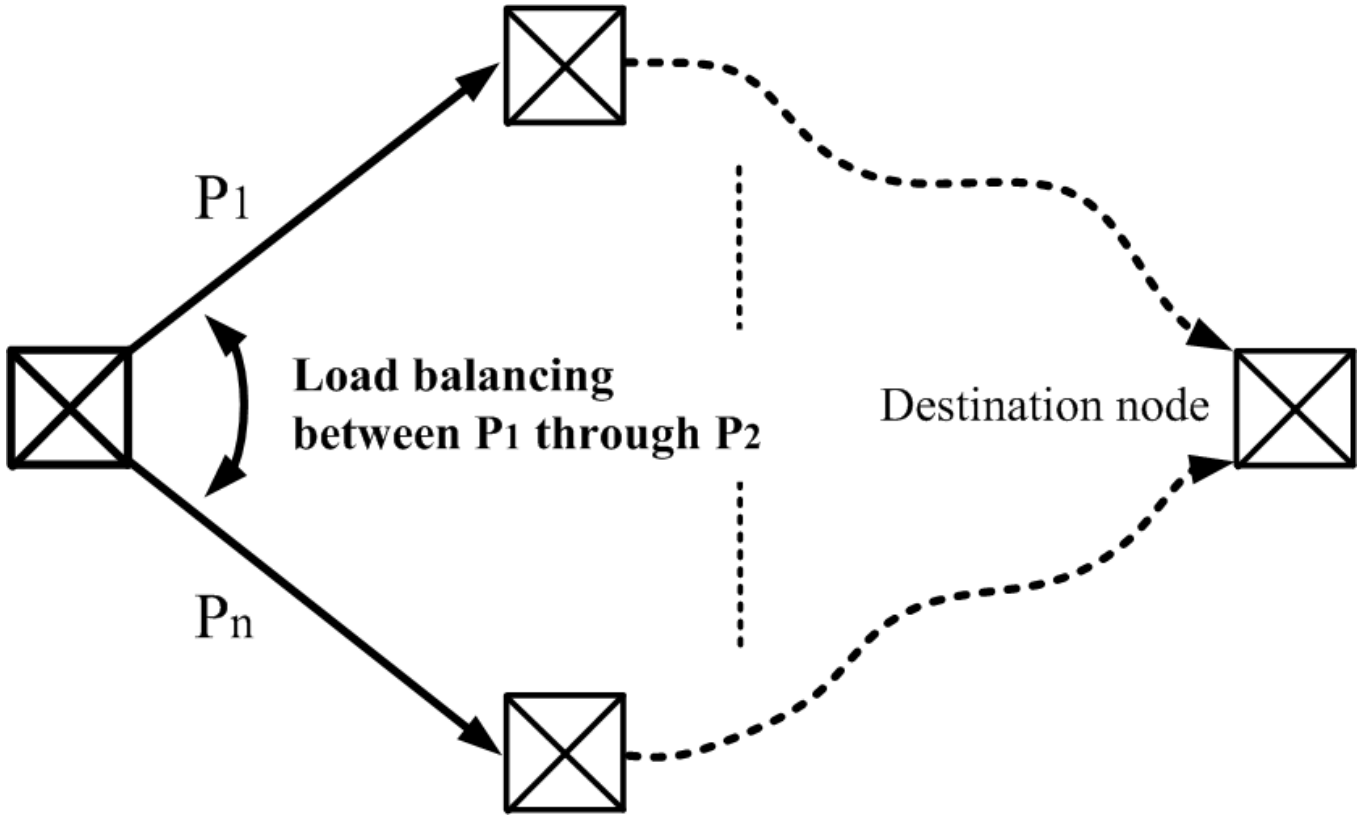
- Fault detection and localization by monitoring paths

Priority control for path routing



Simplification ⇒ **Reduction in number of priority classes**

Load balancing between multi-paths



Least load path selection ➡ **Random path selection**

Simulation model

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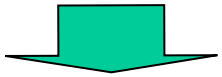
Repeat of the following processes at each term

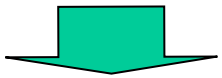
Traffic volume scenario, Node attachment scenario



Traffic flow arrangement according to priority classes

（Objective）Minimization of cost for link capacity expansion and new link installation

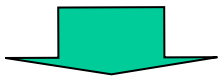
（Constraint）Maximum link utilization rate



Decision of nodes where random multi-path selection is adopted

（Objective）Maximization of nodes where random multi-path selection is adopted

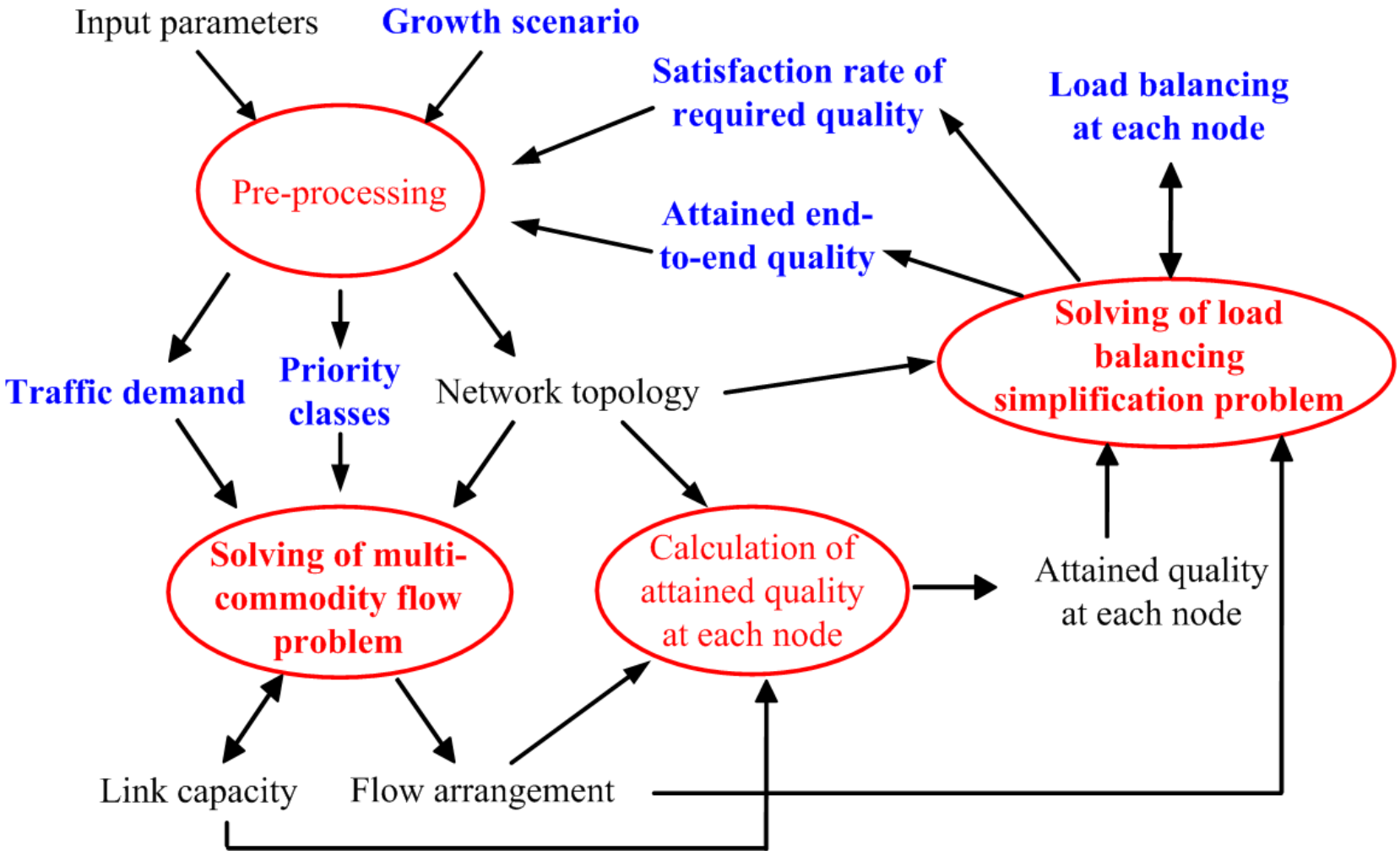
（Constraint）Minimum satisfaction rate of required quality



Reduction in number of priority classes based on attained end-to-end quality at each class

User’s feedback based on satisfaction rate of required quality（Feedback portion of applied traffic volume in the next term）

Flow chart for simulation model



Premises of evaluation -1

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Simulation time	0 → 40	Cost ratio of existing and new links	1 : 5
Number of nodes	10 → 50	Ratio of traffic volume for class integration	0.95
Maximum link utilization rate	0.8	**Minimum satisfaction rate of required quality**	0.95

- Basic portion of applied traffic volume

  → Exponential increase, 100 times during 40 terms

- More than given ratio of traffic volume in a certain priority class attains end-to-end quality higher than required quality in a higher priority class

  → **Two priority classes are integrated**

- Satisfaction rate of required quality at each traffic demand

  → More than 0.7: Increase of traffic volume in the next term

  Less than 0.3 : Decrease of traffic volume in the next term

Premises of evaluation -2

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Calculation of end-to-end attained quality

- Packet transfer quality (delay) at each outgoing link

  Least load path selection : Sojourn time in M/M/S model

  → Random path selection : Sojourn time in M/M/1 model

- Processing quality (delay) at each node

→

Number of priority classes	5	4	3	2	1
Least load path selection	1.12	0.11	0.10	0.09	0.08
Random path selection	0.08	0.07	0.06	0.05	0.04

Required quality at each priority class

Priority class	1	2	3	4	5
Required quality	0.195	0.215	0.385	0.40	0.42

End-to-end attained quality

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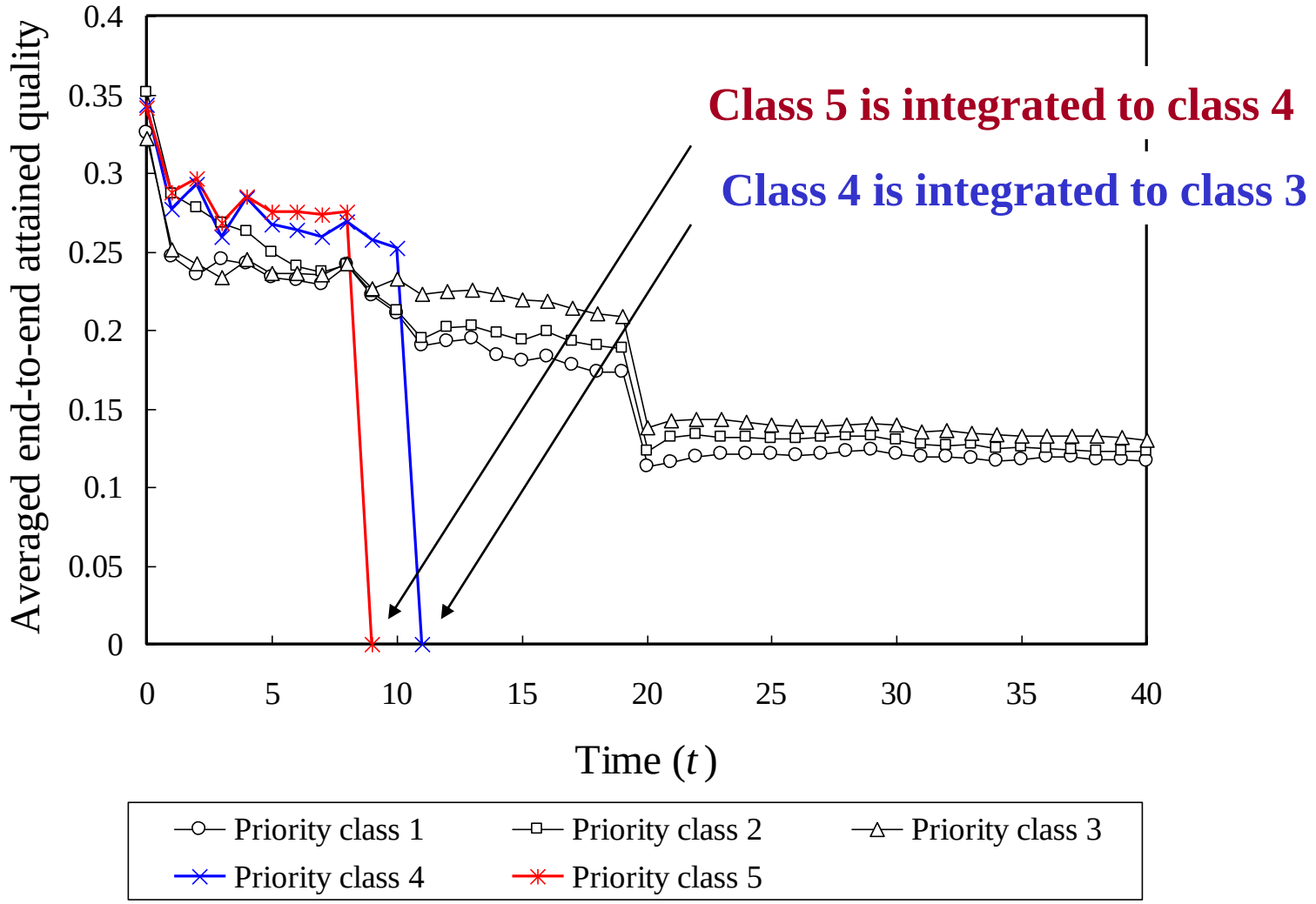

Number of nodes

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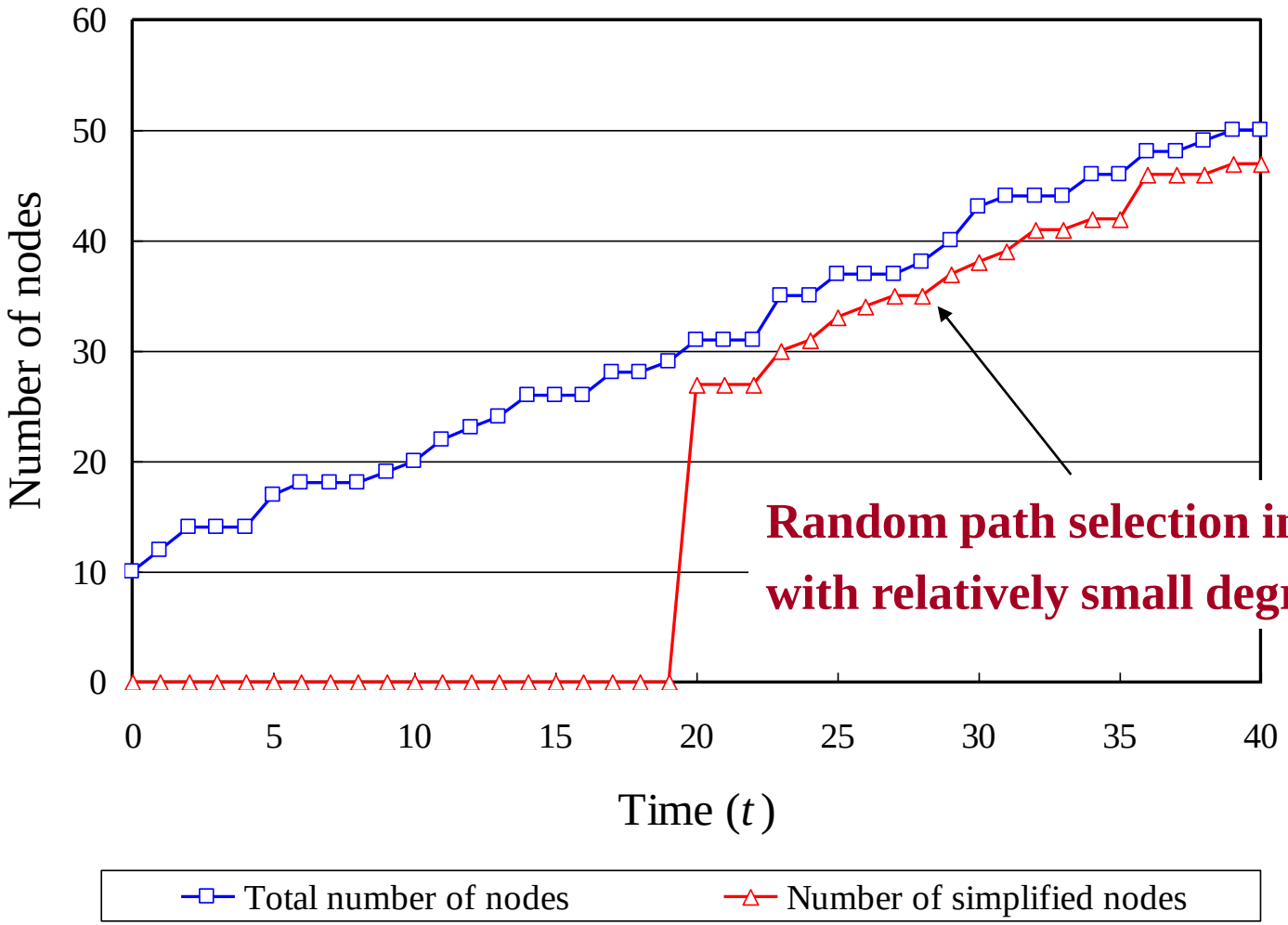

Total applied traffic volume

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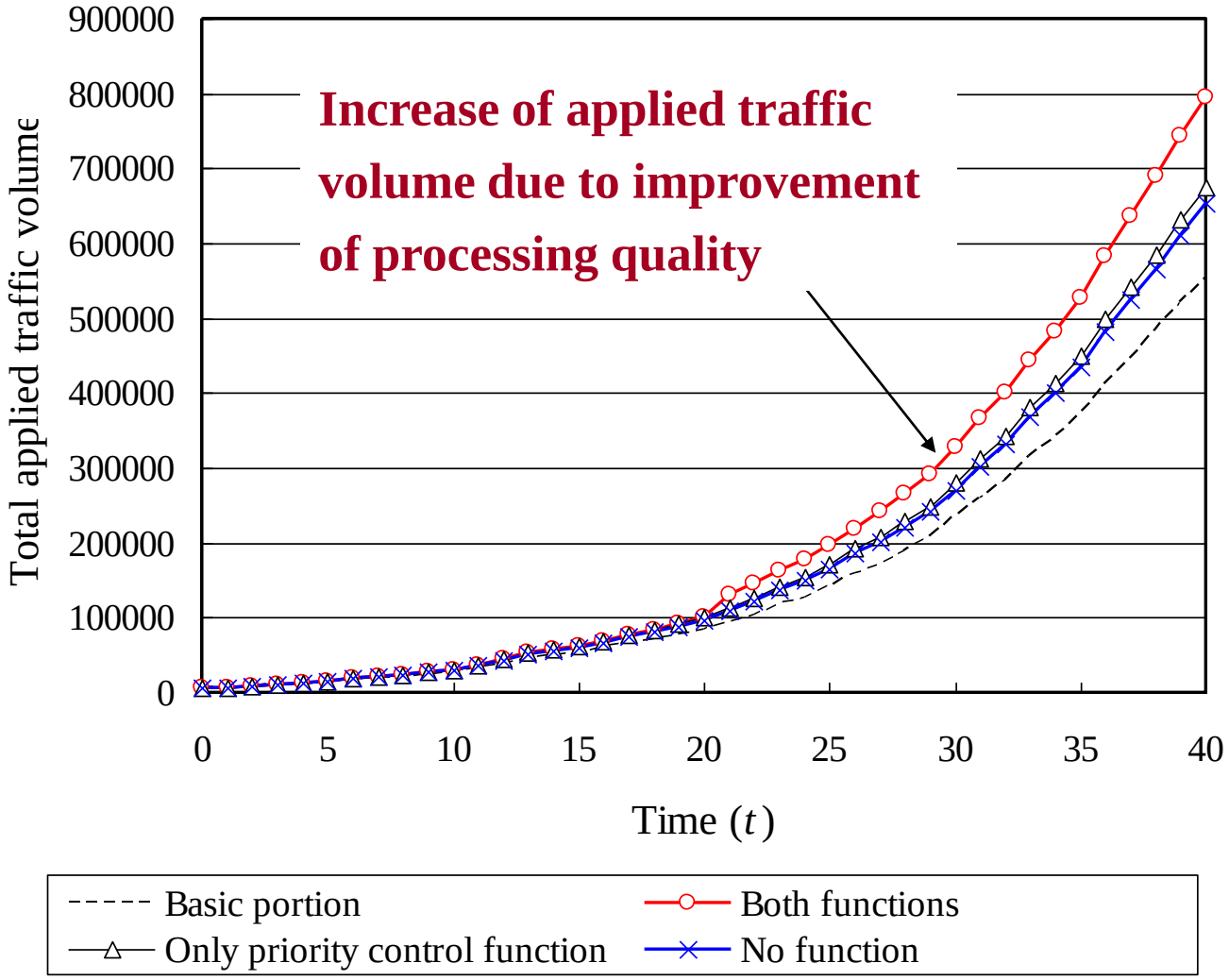

Total link capacity

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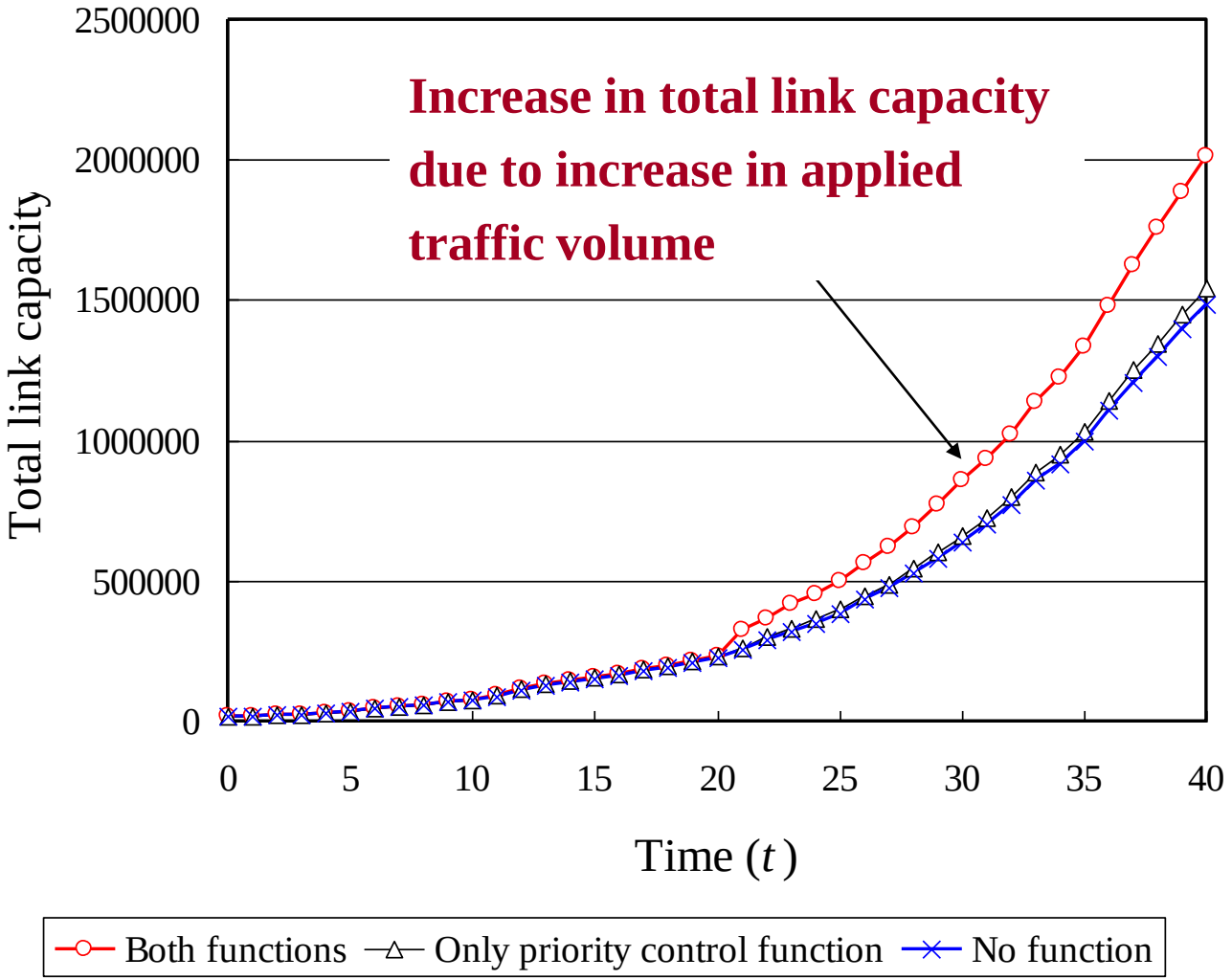

Summary and future works

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Simplification of service functions based on growth in scale of evolving network

- Capital investment in proportion to applied traffic volume
  - ⇒ Effect of statistical multiplexing, growth of network topology
  - ⇒ **Reduction in number of priority classes,**
  - ⇒ **Random selection between multi-paths**
- User's demand feedback according to satisfaction rate of required quality
  - ⇒ Improvement of processing quality at each node
  - ⇒ **Increase of operator's revenue due to acceleration of network evolution**

Future works

- Sophistication of simulation model involving other simplification examples
- Investigation on decentralized simplification mechanism