Next generation IP network control based on traffic engineering

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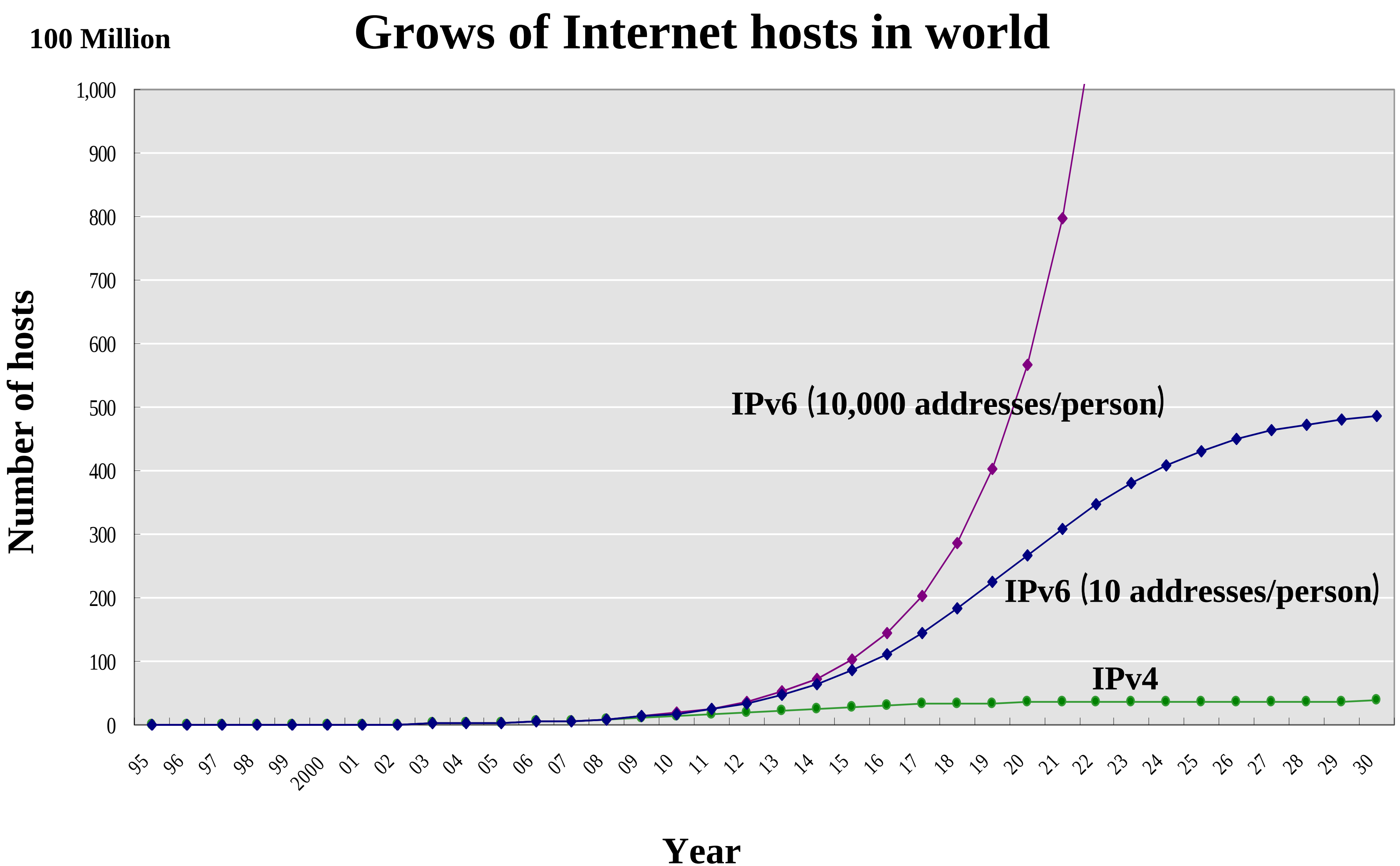
Motivation

Network management becomes more important and more complex.

What are major difficulties?

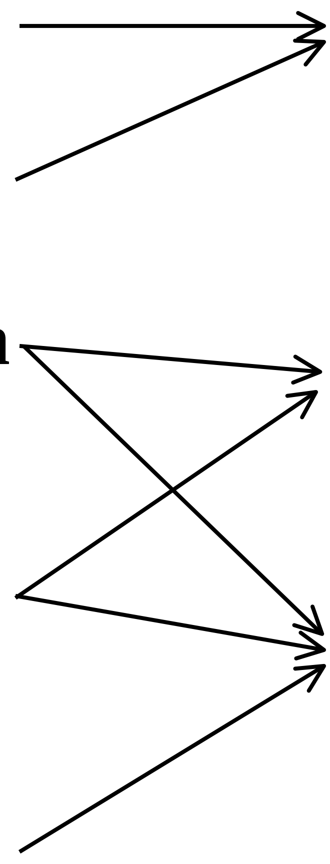
- The number of terminals and nodes will become very large. For example 50 times in 10 years.
- IP is basically connectionless, so it is difficult to control QoS.
- Control in IP world is distributed control.
- Various networks based on various technologies coexist. (ISDN, ATM, FR, IP)
- In ubiquitous computing era, there are many kinds of terminals and networks.

Estimation on growth of Internet hosts



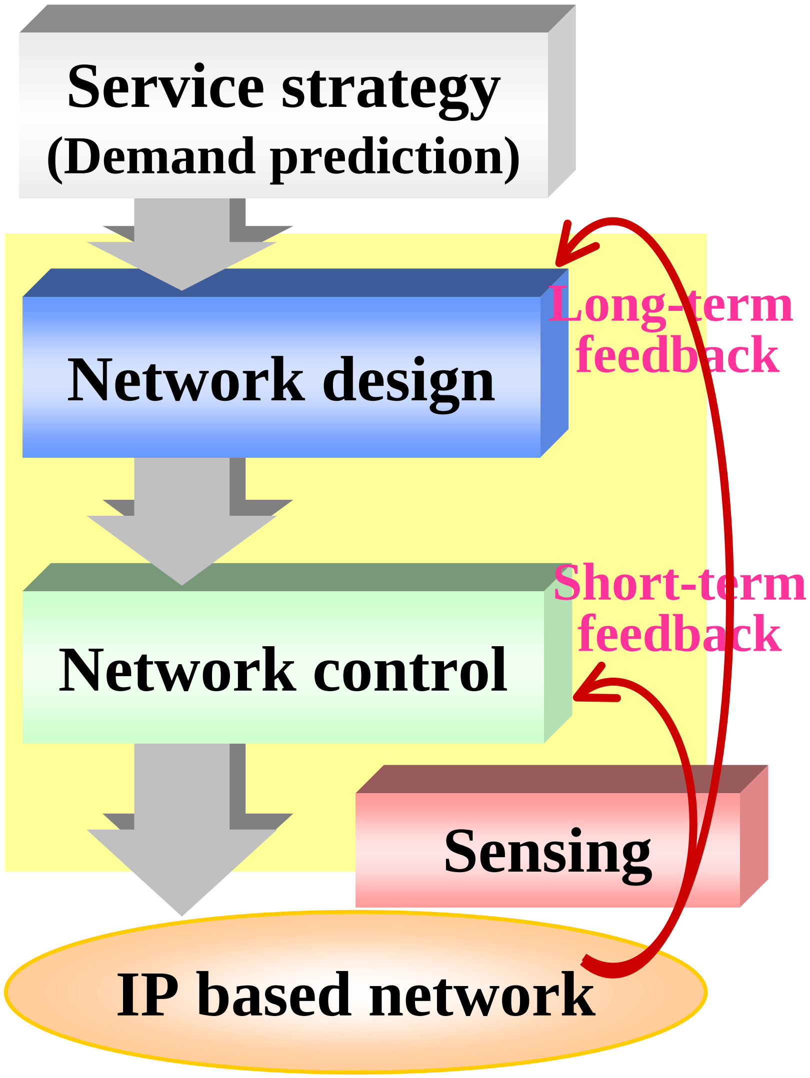
Requirements on network control and management

- **Simple operation**
- **Quick reaction**
- **Flexible connection set-up**
- **Efficient resource usage**
- **Robust for change**



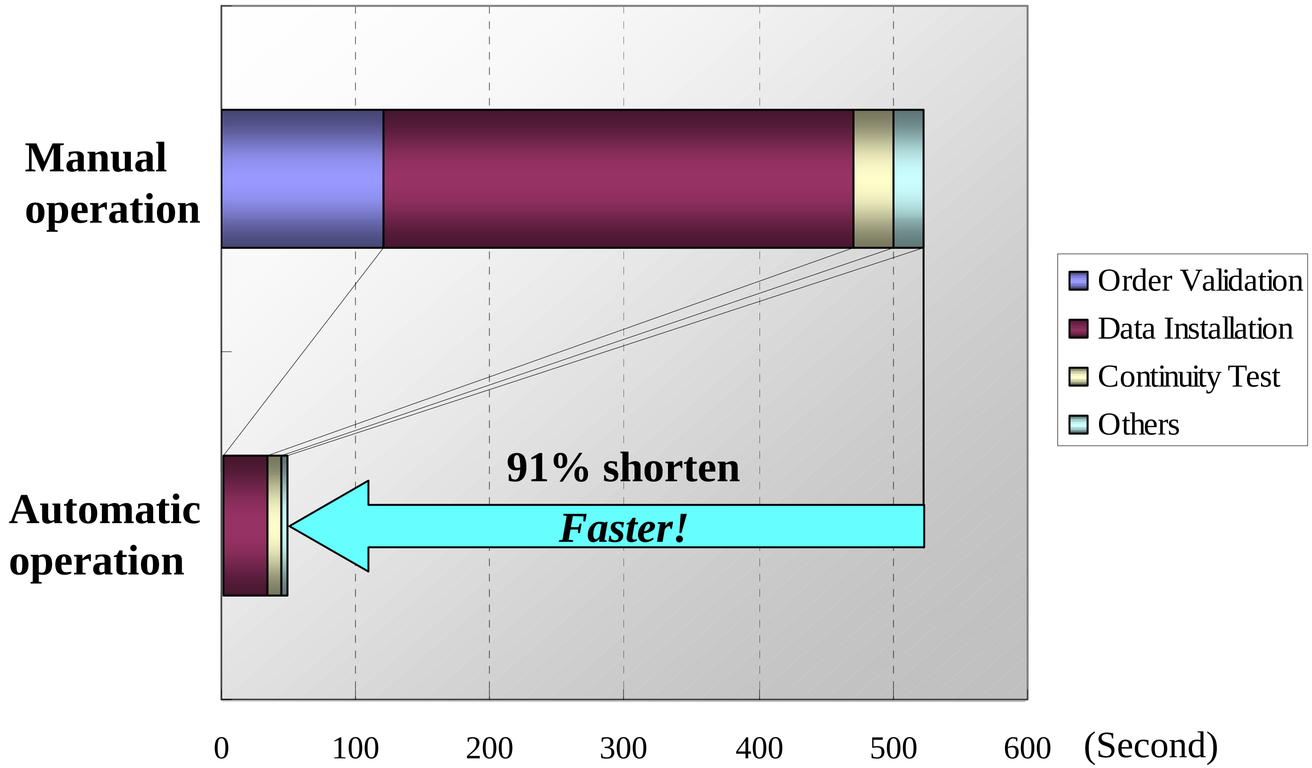
- **Systemized and automatic network operation**
- **On demand resource allocation**
- **Optimization over all network using feedback control**

Systemized and automatic network operation



- Quick reaction
  - for user's request
  - for faults/miss operation
  - for demand change
- Reduction of operation cost
- Optimization of resource allocation
  - re-routing based on short-term feedback
  - re-design based on long-term feedback

Effect of automatic operation
- Example : path provisioning -

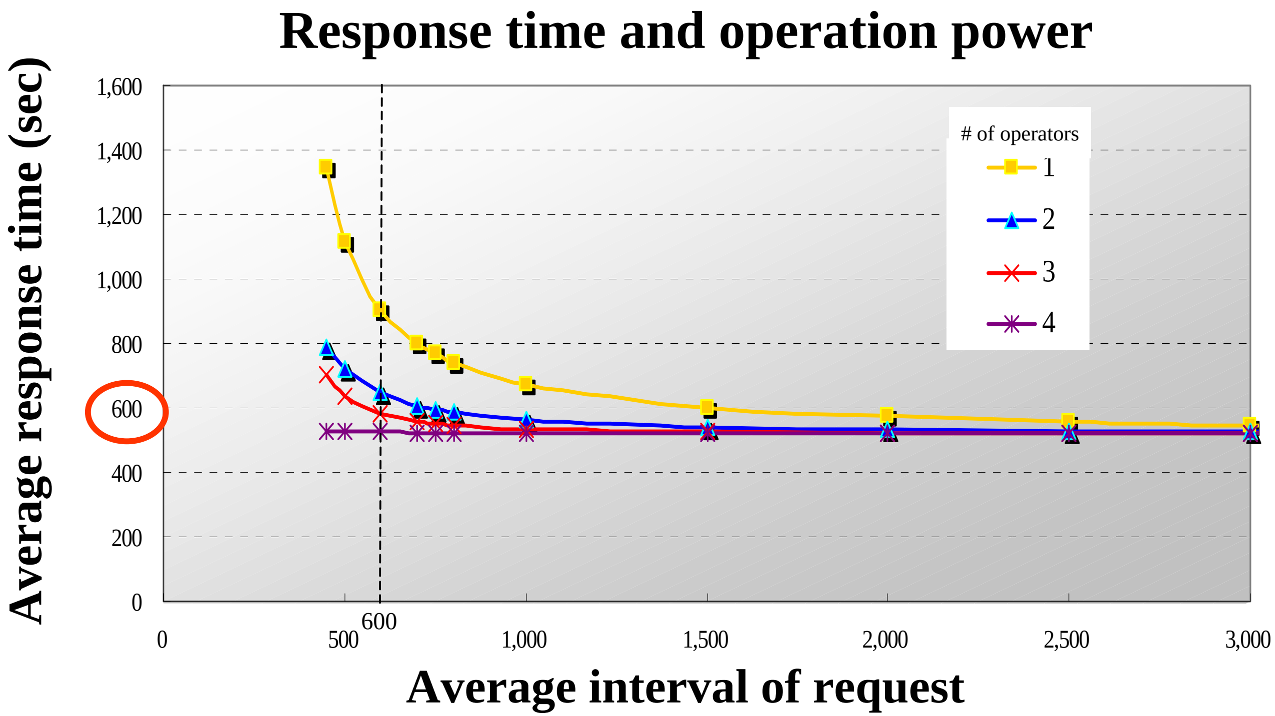


The provisioning time can become 1/10.
This can lead to the big reduction of OPEX.

Effect of automatic provisioning

Assumption : processing time

- **Manual : 523sec**
- **Automatic : 49sec**



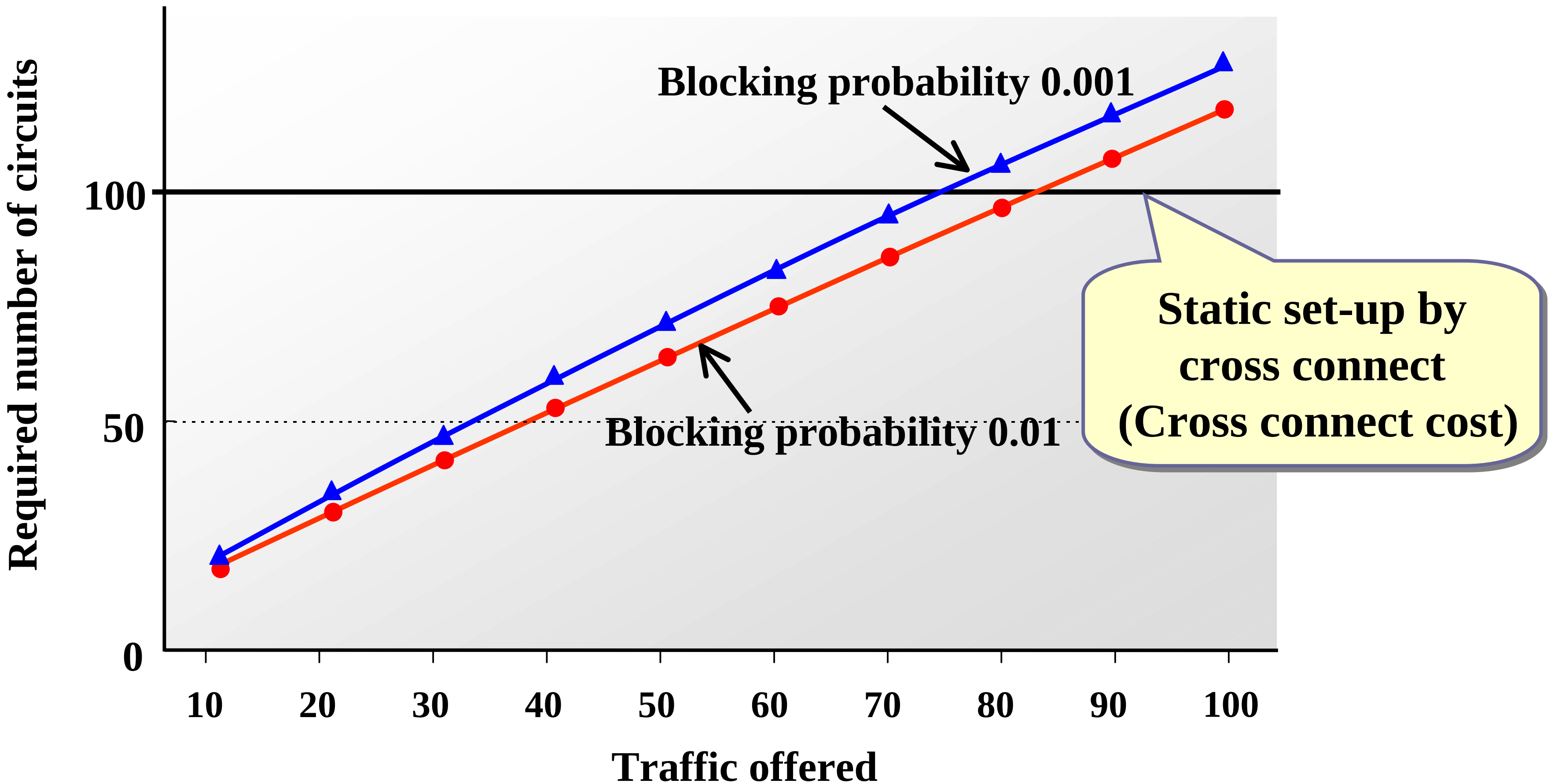
For request every 600s,

- **Average response times are 905s by manual and 94s by automatic system.**

If response time is required to be within 600second, 3 times of current operator is required.

Effect of dynamic resource allocation

In the case of small traffic, the number of required circuits by dynamic set-up is smaller than that by static setup.



What is traffic engineering?

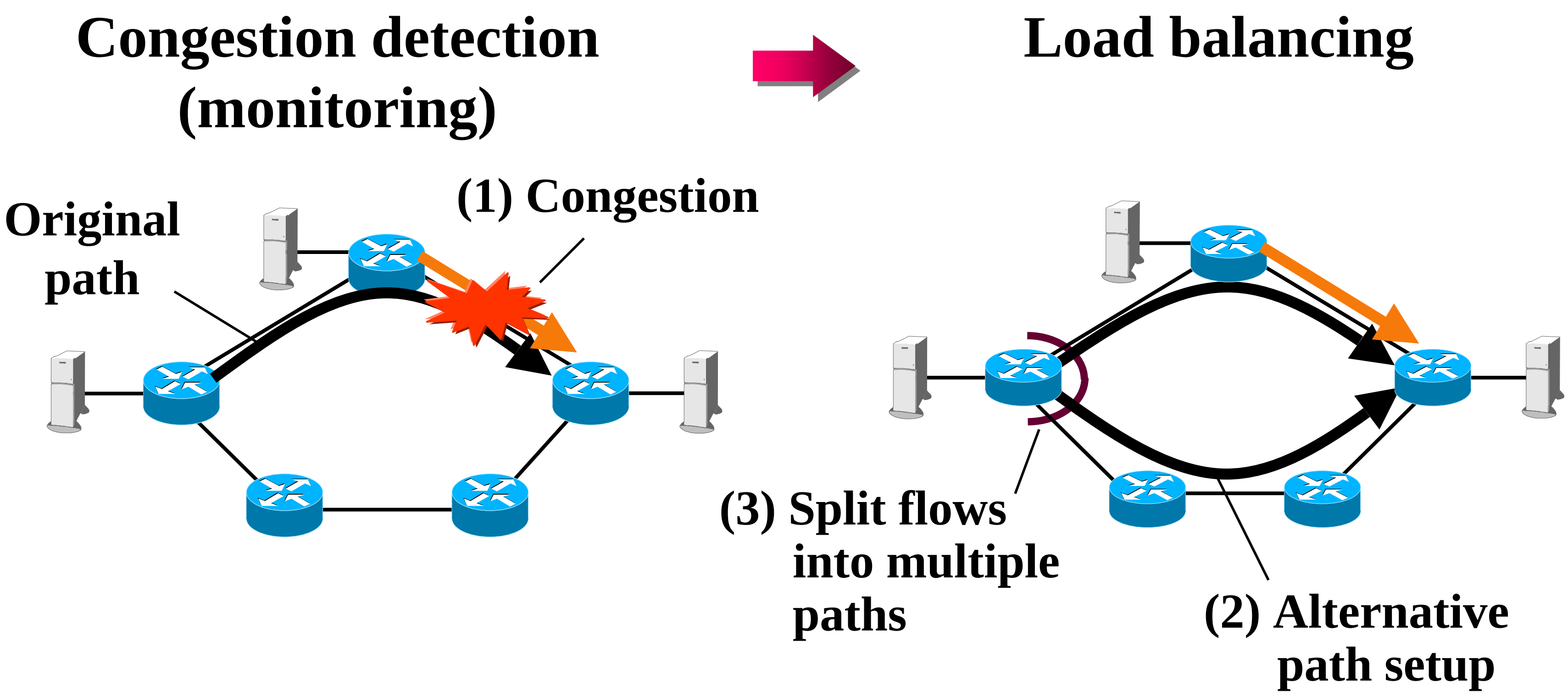
- **RFC3272, "Overview and Principles of Internet Traffic Engineering"**
  - **“Internet traffic engineering is defined as that aspect of Internet network engineering dealing with the issue of performance evaluation and performance optimization of operational IP networks.”**
- **RFC2702, "Requirements for Traffic Engineering Over MPLS"**
  - **“A major goal of Internet Traffic Engineering is to facilitate efficient and reliable network operations while simultaneously optimizing network resource utilization and traffic performance.”**

Our goal of traffic engineering (TE)

- **In order to enhance tolerance of traffic variation, TE dynamically uses multiple routes whole network as two or three-dimensional space and dynamically controls traffic, and maximizes performance of the network.**
- **TE is based on feedback control and optimum route selection among multiple possible routes by a metric based on operator's strategy and user's requirement.**

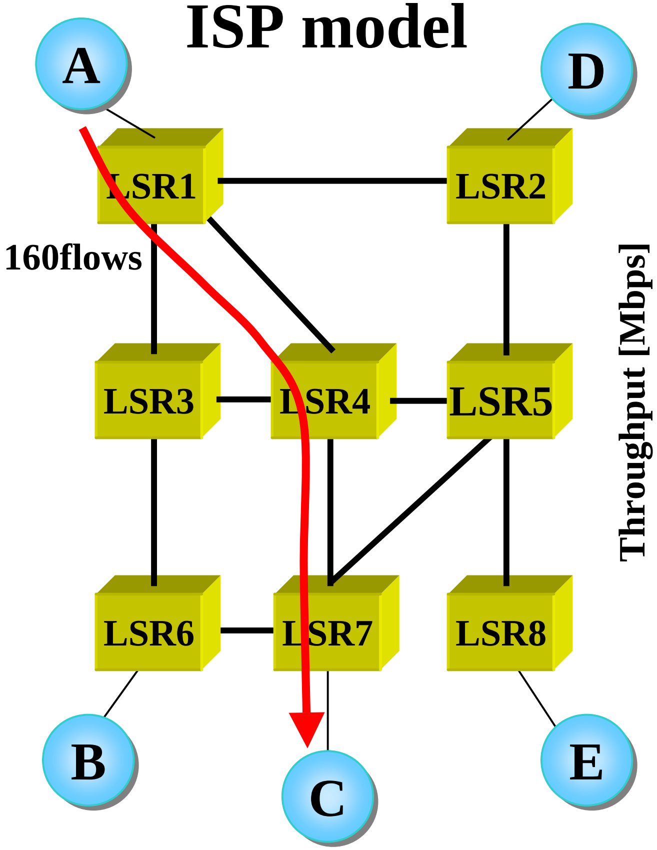
Typical example of TE
- Dynamic load balancing -

- Achieves highly reliable network
- Enables efficient use of bandwidth resources

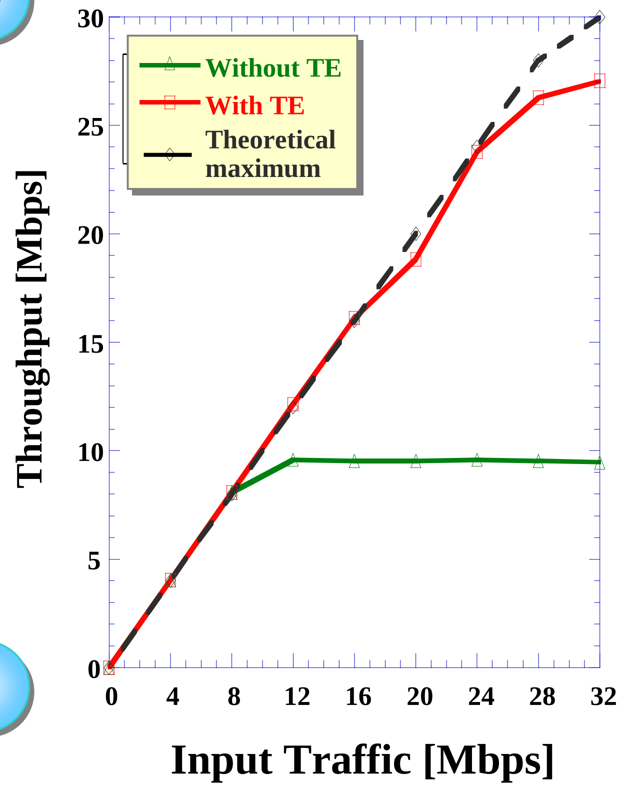


Effect of dynamic load balancing

ISP model

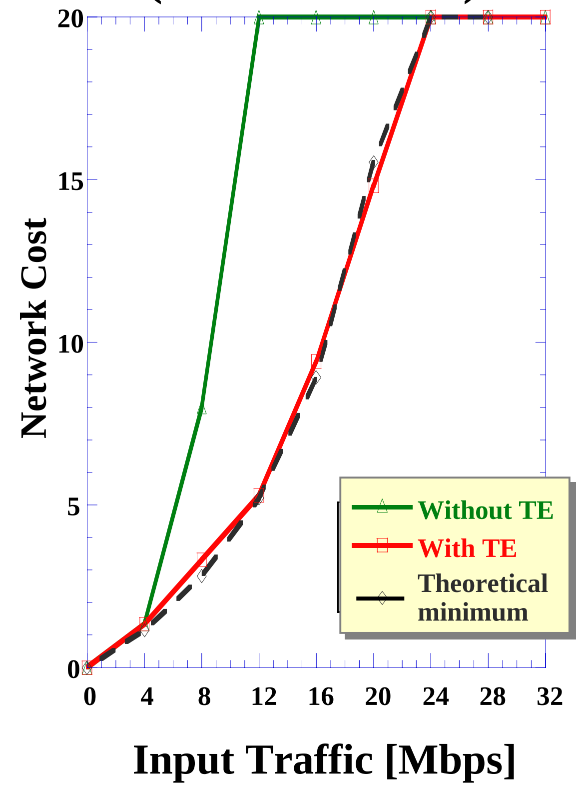


Throughput

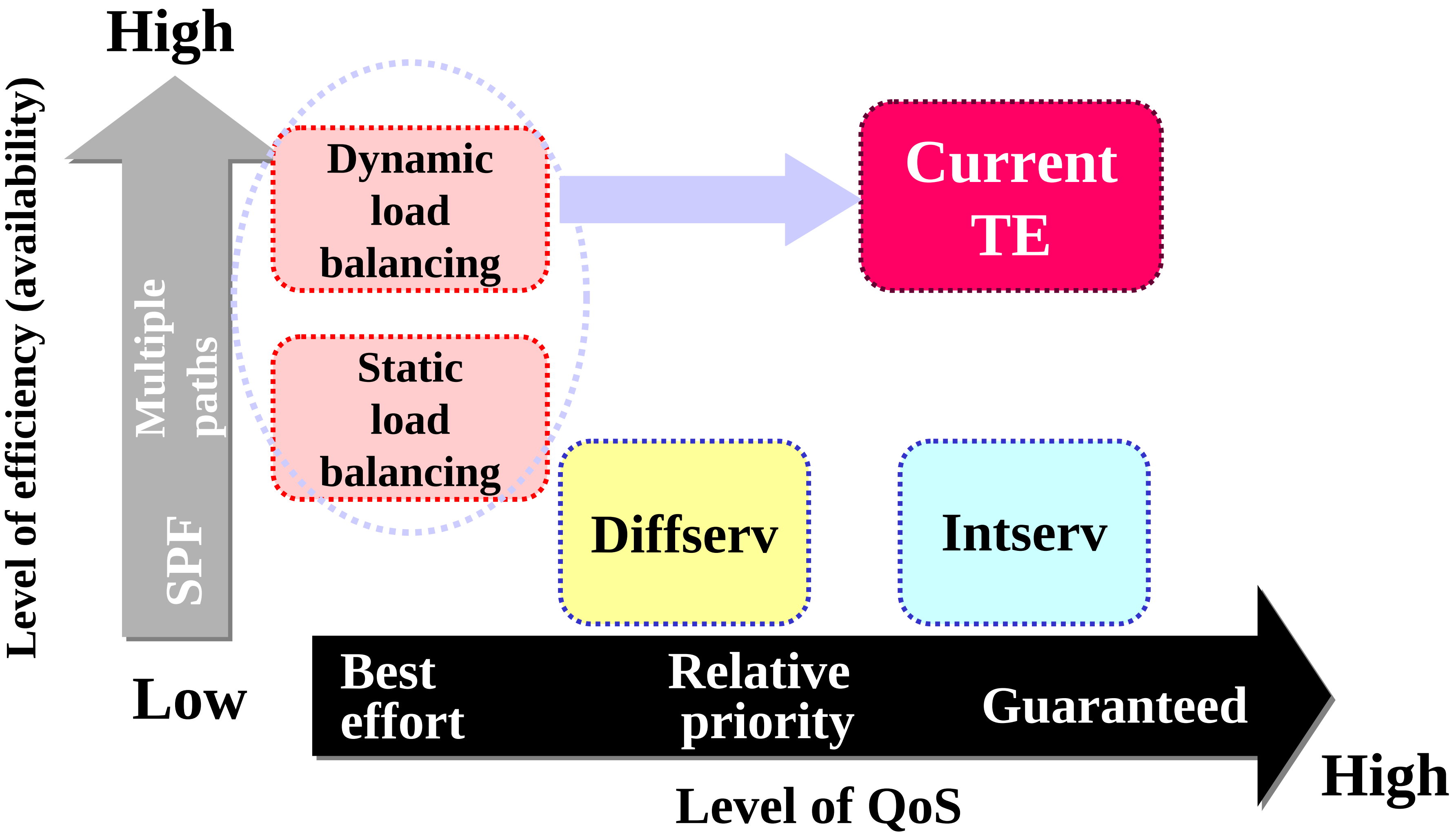


Queuing delay

(Network cost)

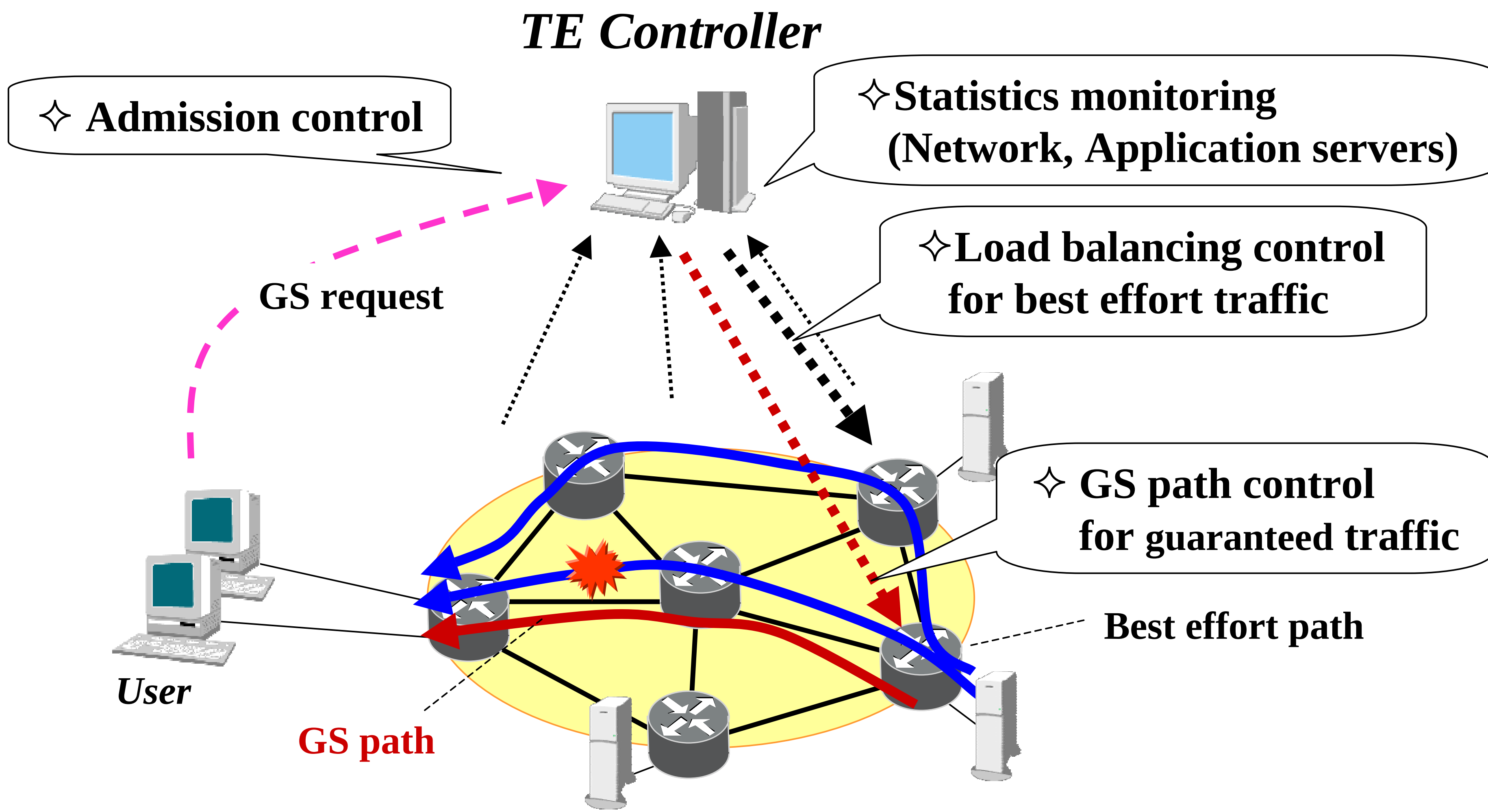


Our approach on TE



QoS : quality of service
SPF : shortest path first

Proposed architecture for QoS control based on TE



GS : Guaranteed Service

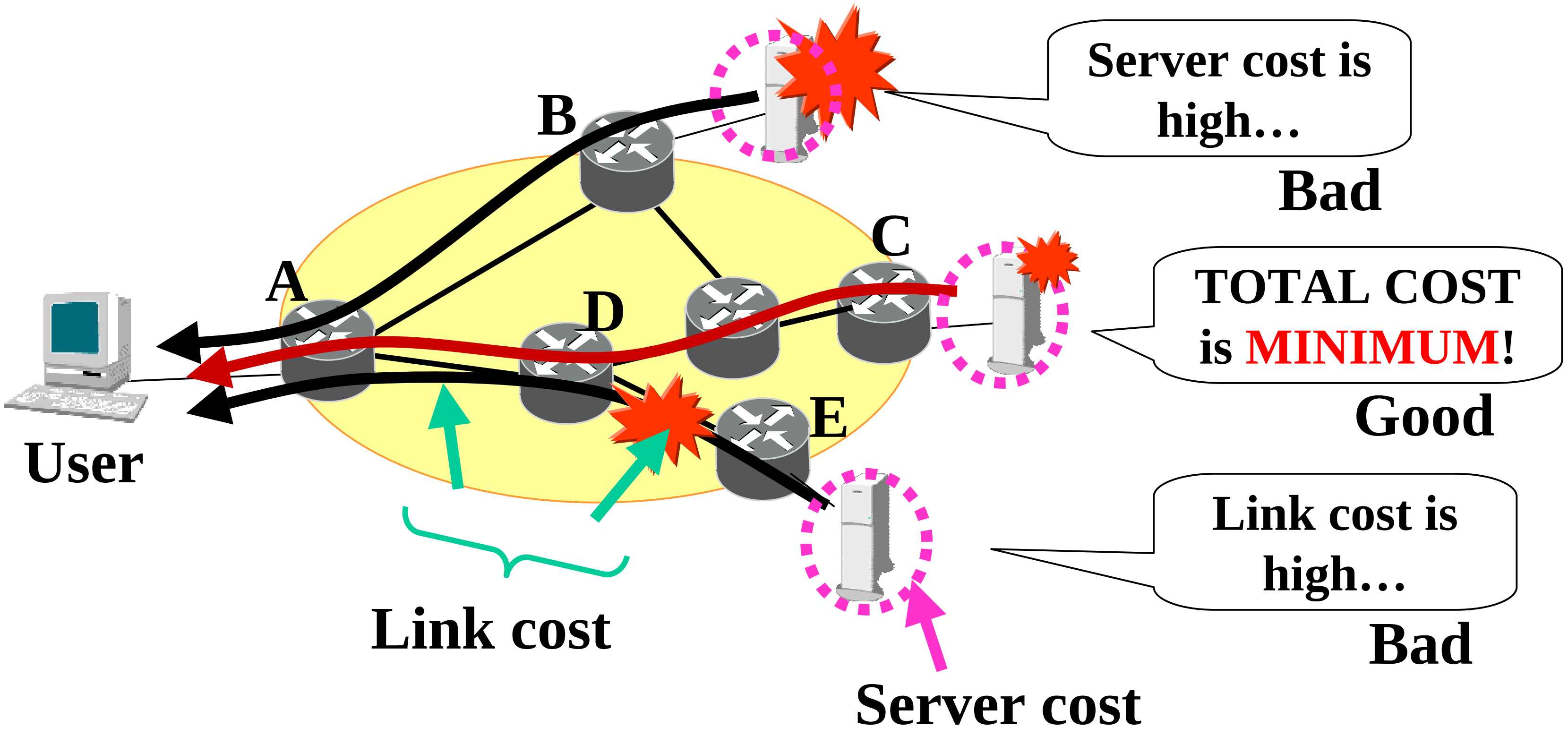
QoS routing algorithm

- **Minimize total cost of link and server**

  $$Total\_cost = server\_cost + \sum link\_cost$$

  Link_cost = 1/available bandwidth

  Server_cost = 1/available output rate



Our QoS control based on TE

Based technologies:

- Calculation of minimum cost route using Dijkstra's algorithm considering requirement and traffic statistics
- Constraint-based routing (initial target is MPLS)

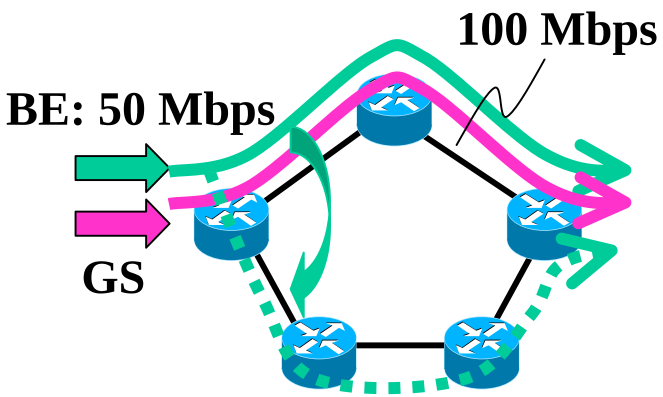
Features:

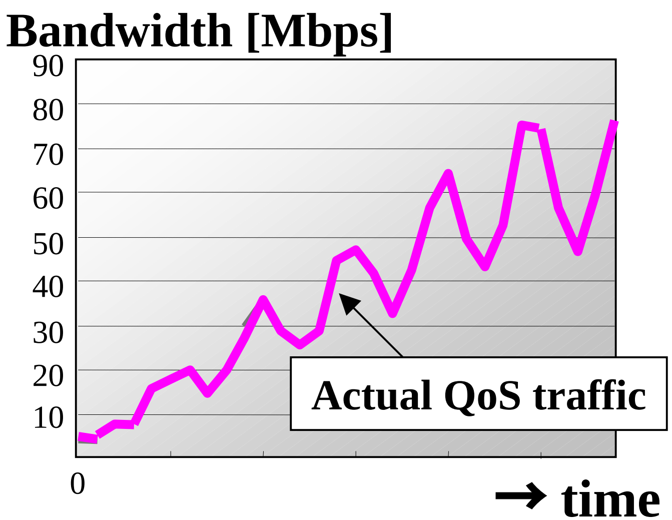
- Optimum GS path can be established on demand base considering loads on both links and server
- Performance of BE traffic can be maintained by dynamic load balance even when GS traffic pushes out BE

- Various QoS services can be provided on demand base
- This can dynamically and efficiently allocate resource by following network status. (High availability and robust)
- This can be a base for SLA and usage based charge

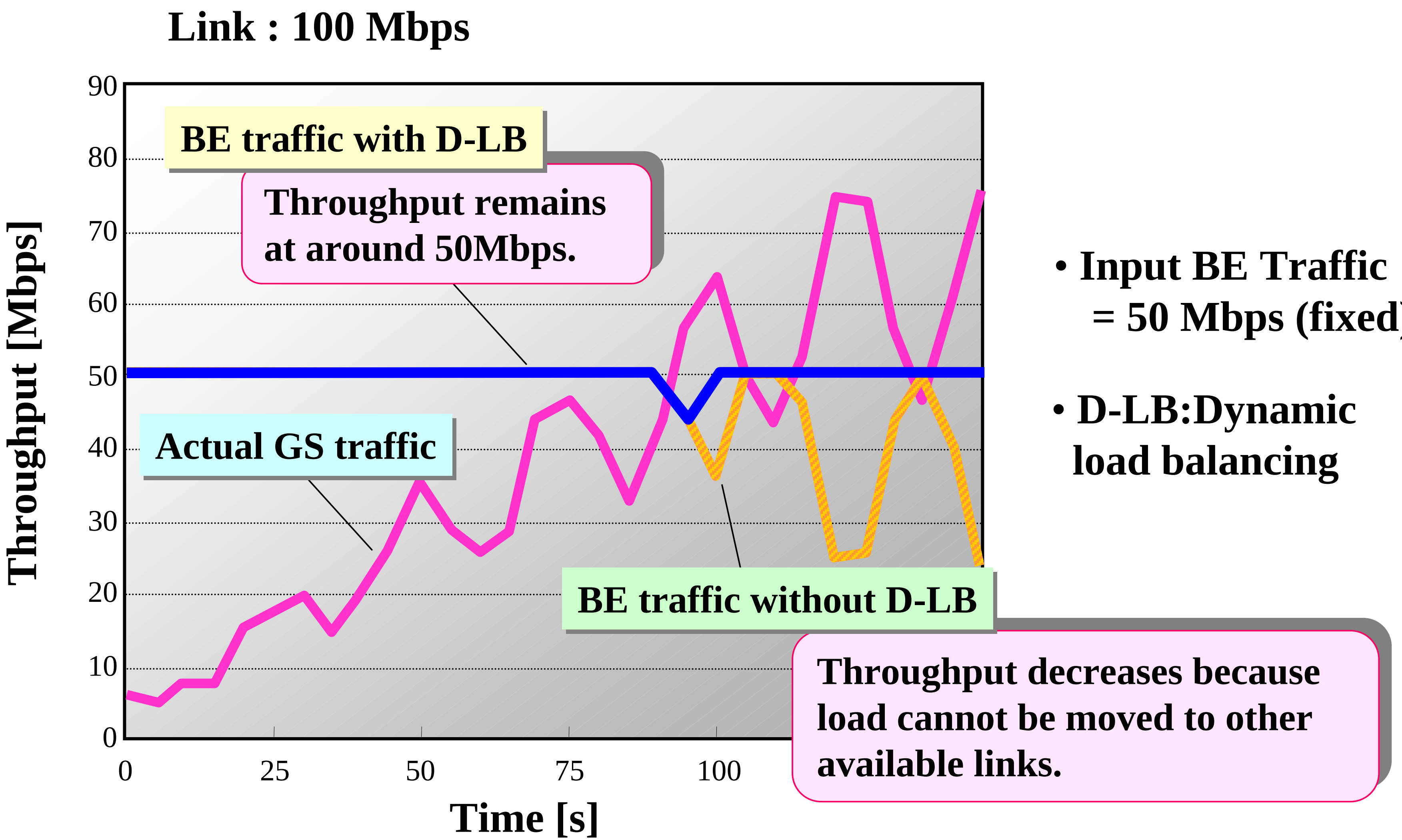
Evaluation of dynamic load balancing
- metric, model and conditions -

- **Metric**
  Throughput of best effort (BE) traffic
- **Model**
  5-node-ring model with 100-Mbps links
- **Conditions**
  - **50-Mbps BE traffic**
  - **Bandwidth reserved for GS traffic is increased to 80 Mbps**
  - **Actual amount of GS traffic fluctuates**
  - **Congestion detection conditions**
    - ✓ **Actual (GS+BE) traffic > 80 Mbps**





Evaluation of dynamic load balancing
- results -



- **Input BE Traffic = 50 Mbps (fixed)**
- **D-LB:Dynamic load balancing**

Evaluation of QoS routing : Metrics

- **Metrics**
  - **Number of GS requests accepted**
  - **Average number of hops in GS paths**
- **Comparison with existing techniques**
  - **LSL (lowest server load) method:**

    1st.step : Select server with lowest load

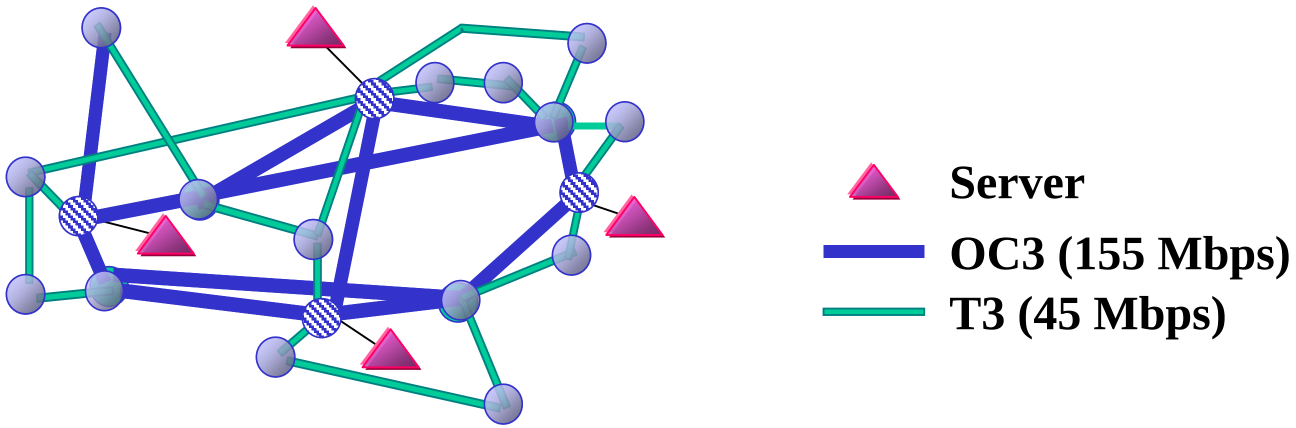
    2nd.step : Select minimum cost route to server
  - **DNS (domain name server) method:**

    1st.step : Select the nearest server first

    2nd.step : Select minimum cost route to the server

Evaluation of QoS routing : Model

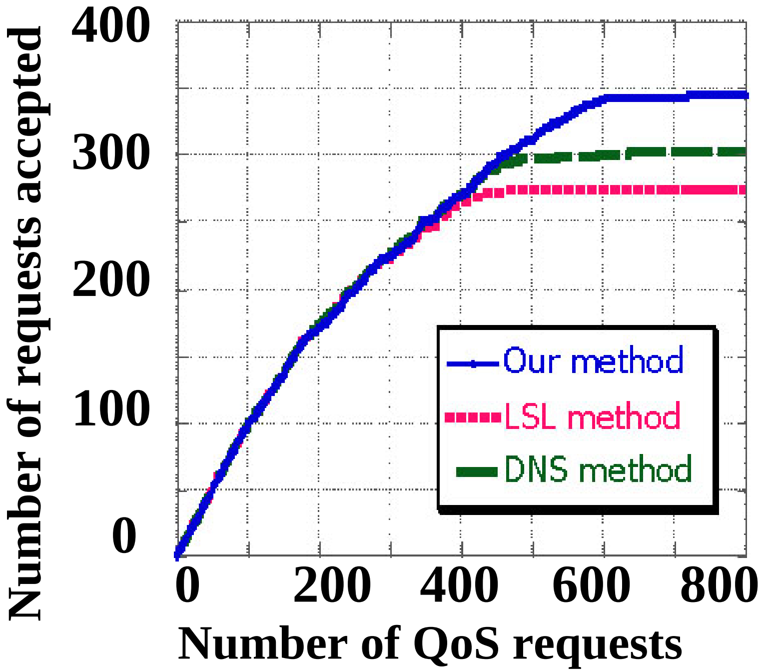
- **Simulation model**
  - ISP network, 19 nodes
  - 4 application servers (capacity of 500Mbps)
  - 1-10 Mbps bandwidth-guaranteed requests
  - Requests generated at random position
  - Not release GS path

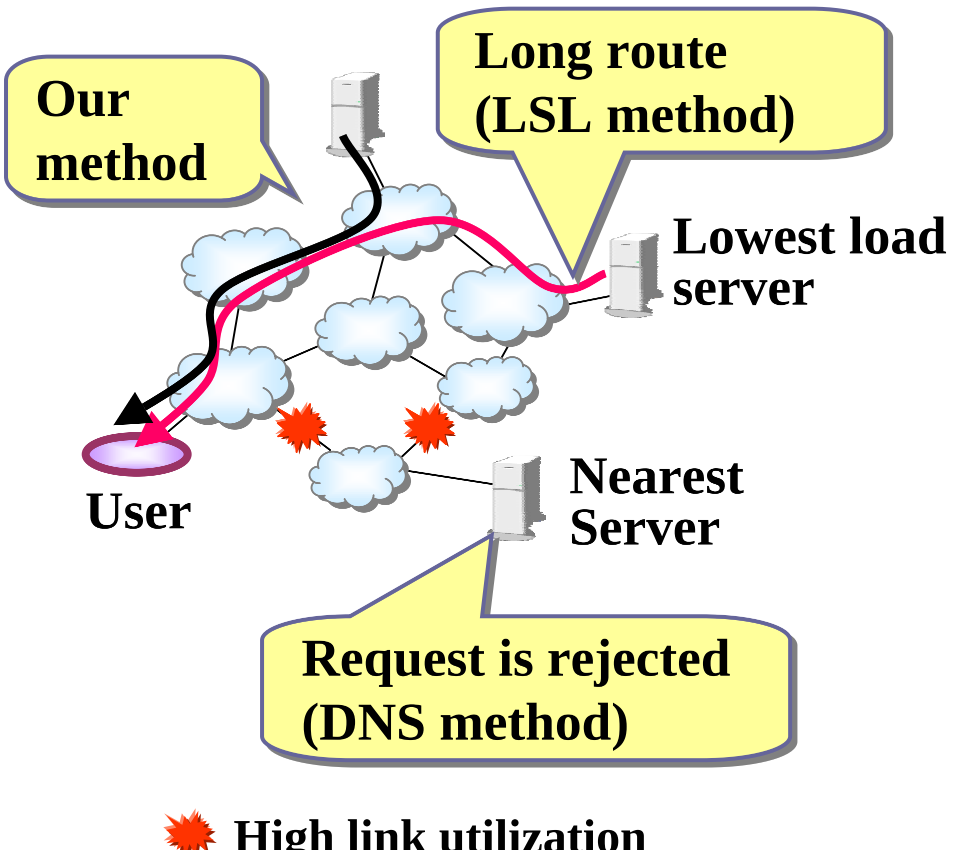


Evaluation of QoS routing : Results (1)

- **Effect of QoS routing considering both server and network loads**

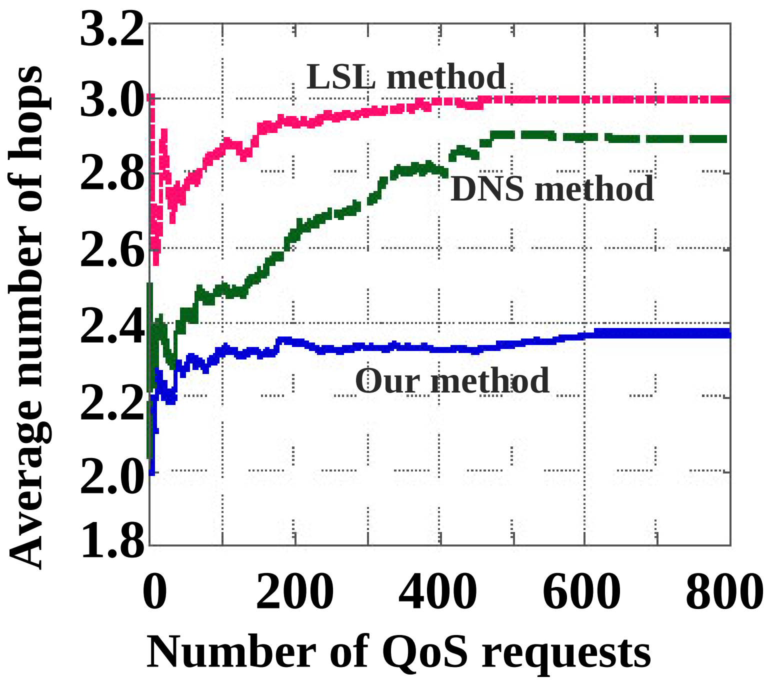
(Effect 1) Achieve lower blocking probability

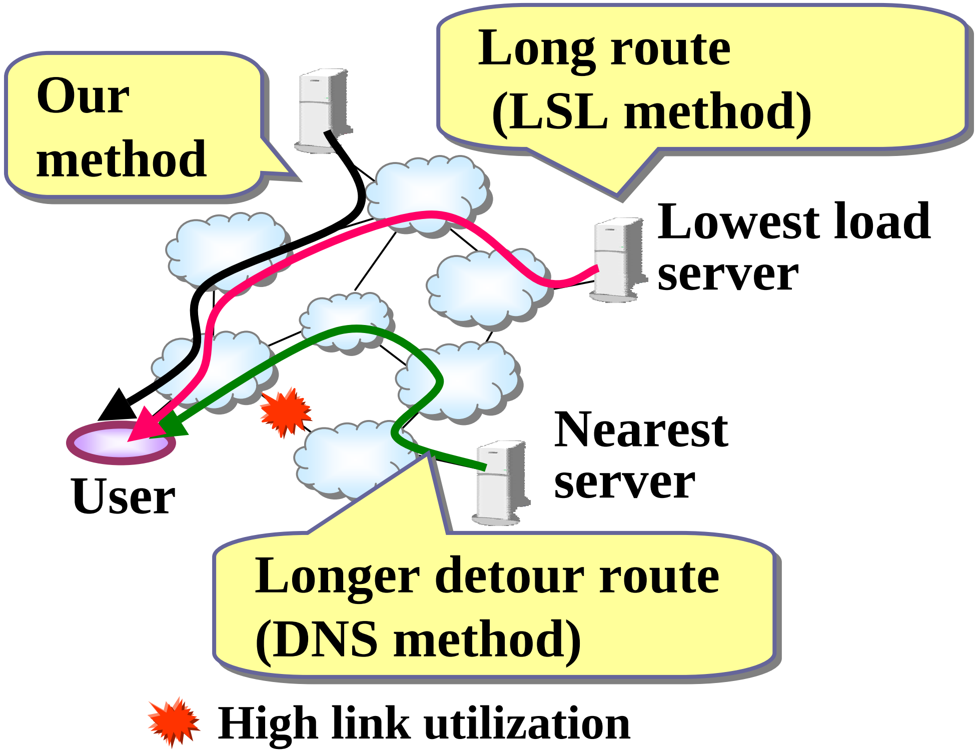




Evaluation of QoS routing : Results (2)

(Effect 2) Provide route with lowest number of hops

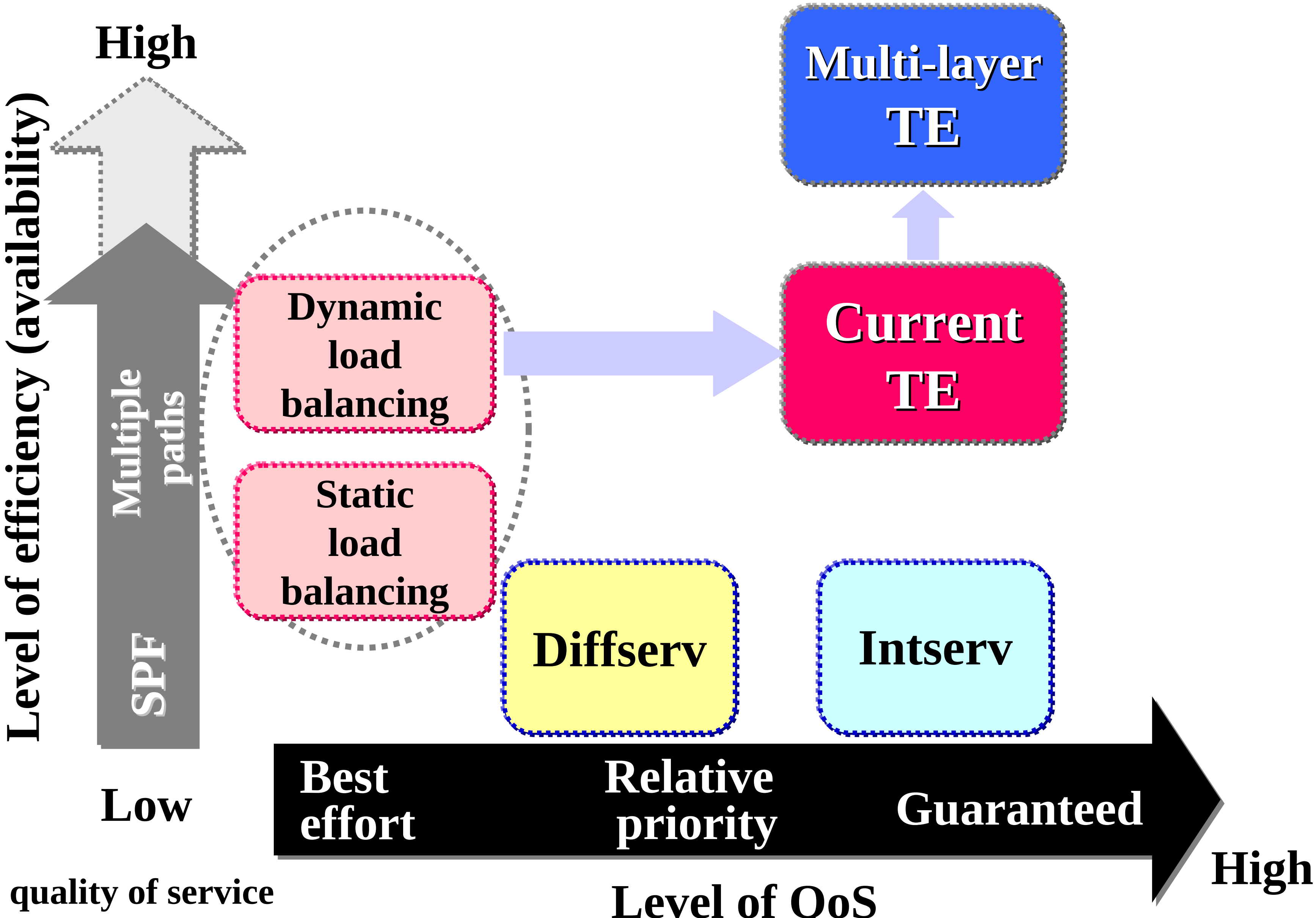




Our method

- Accommodates many more requests
- Achieve efficient resource utilization

Our approach of TE



QoS : quality of service
SPF : shortest path first

Summary

- **Network management becomes more important and complex because of a huge number of nodes and heterogeneous environment in ubiquitous computing era.**
- **Key features of next generation IP network control & management are**
  - **Systemized and automatic network operation.**
  - **On demand dynamic resource allocation.**
  - **Optimized route search with robustness.**
- **Traffic engineering is one of core technologies.**

Acknowledgement :

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Thank You!