Compositional Traffic in Networks on Chip

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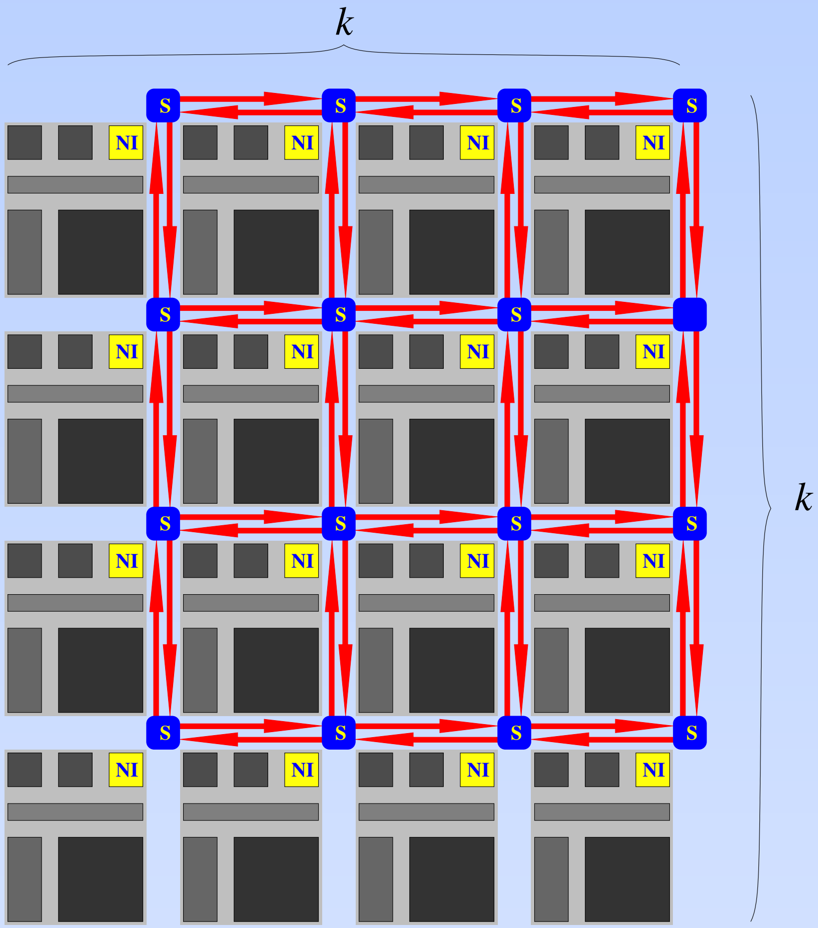
BEC 2006

Overview

- Scalability of meshes and k-ary n-cubes
- Traffic contracts
- Composition of traffic contracts

Scalability of Meshes

Scalability of Meshes



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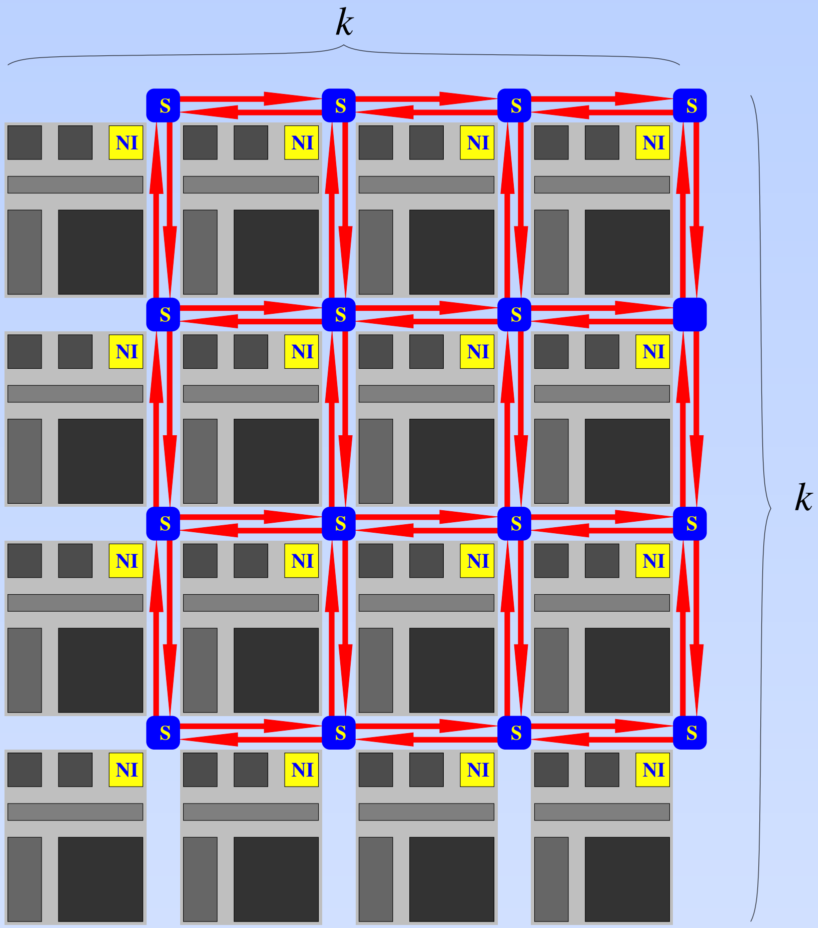
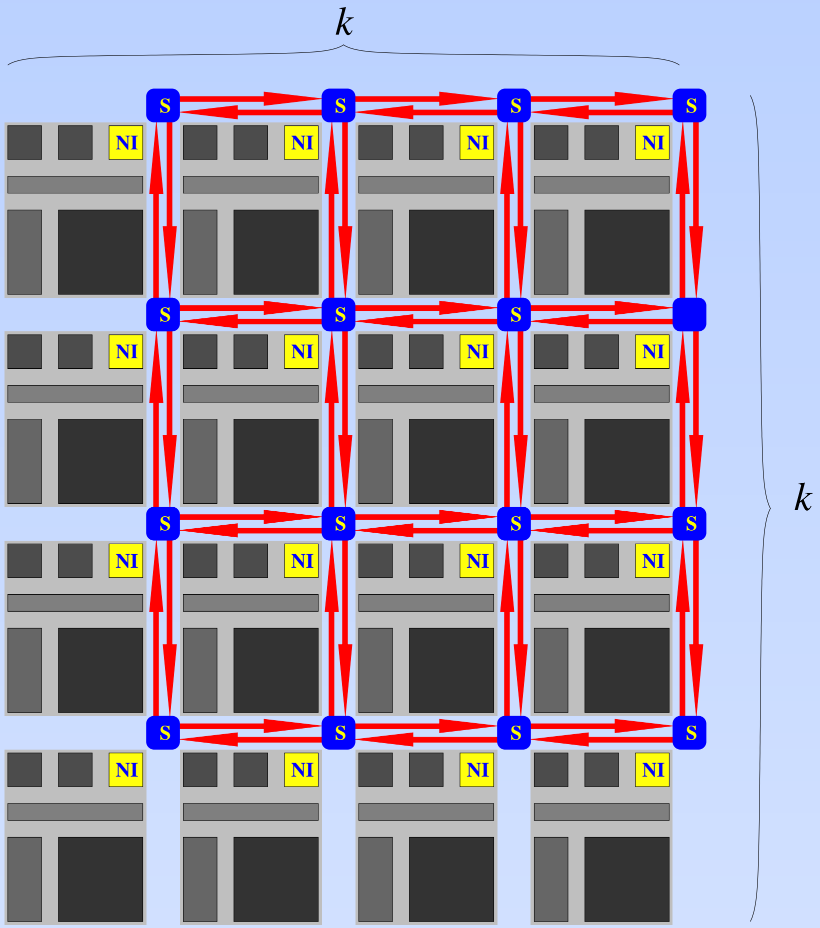


Under uniform traffic:

Scalability of Meshes



Under uniform traffic:

average distance: $2/3k$

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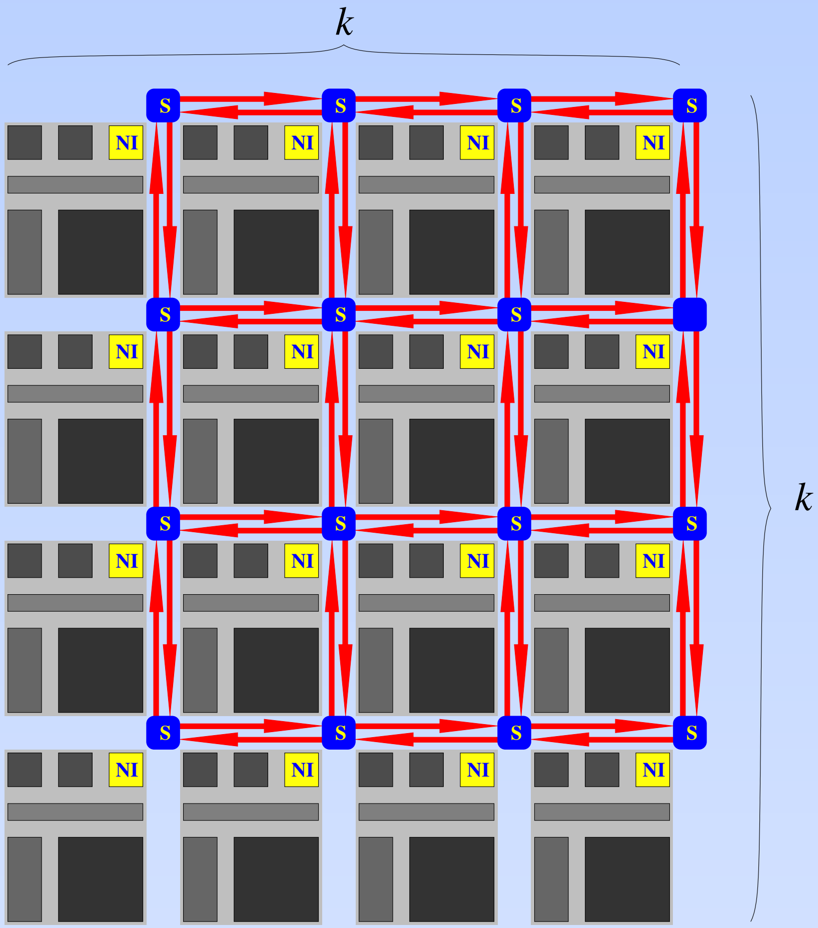

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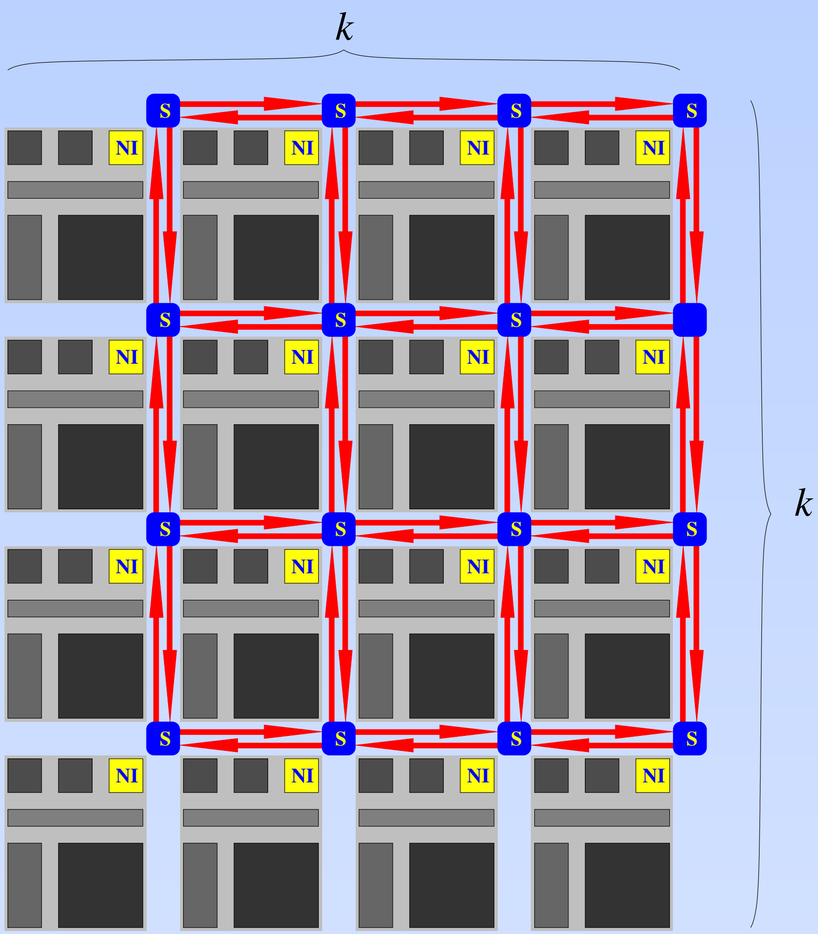

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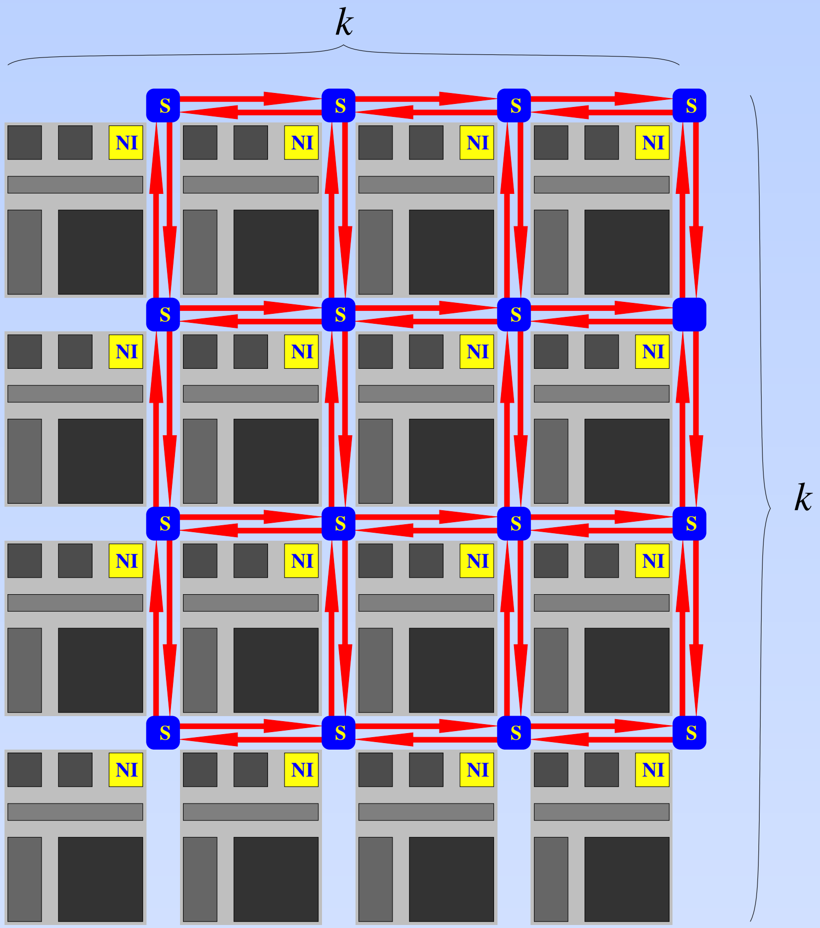

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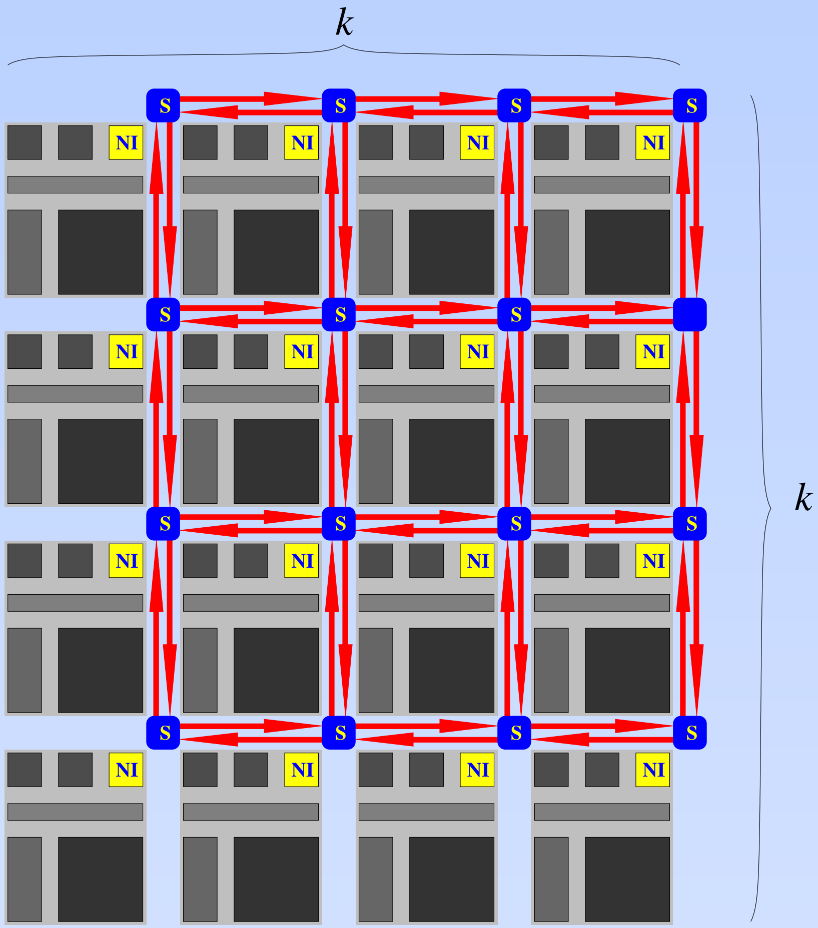

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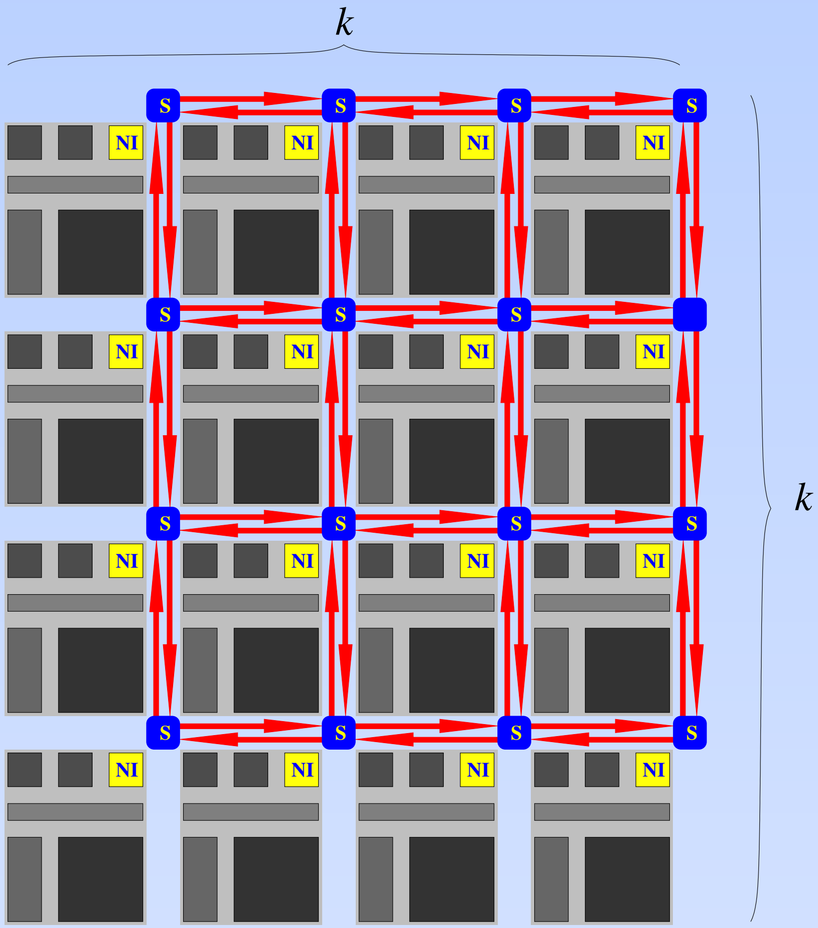

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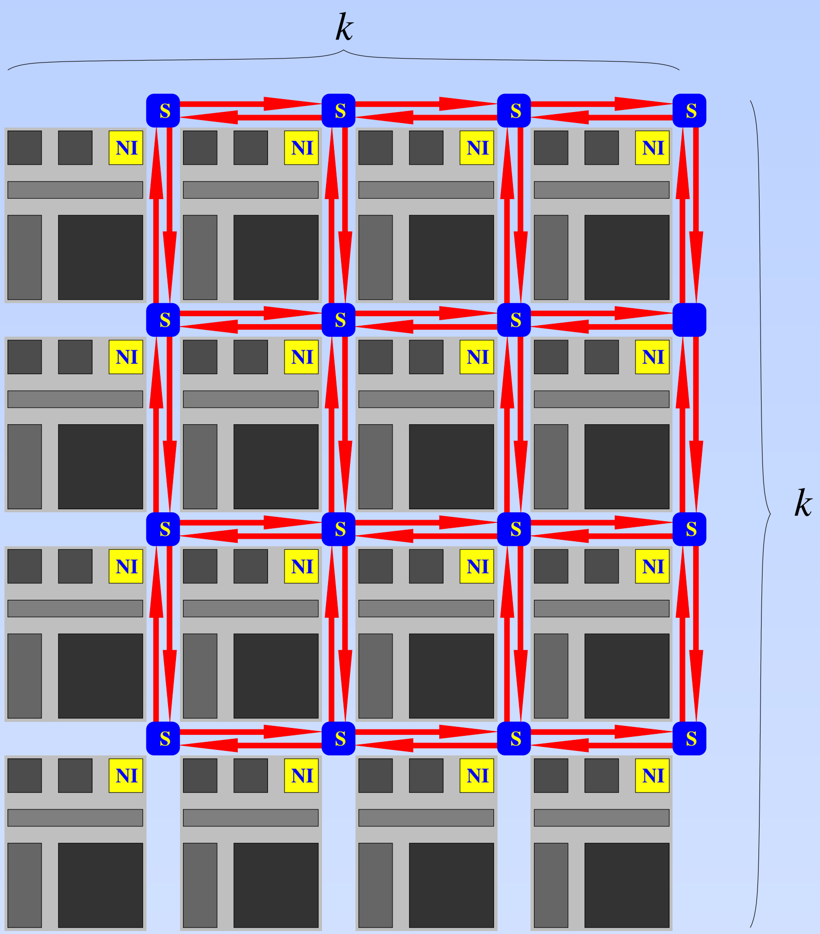

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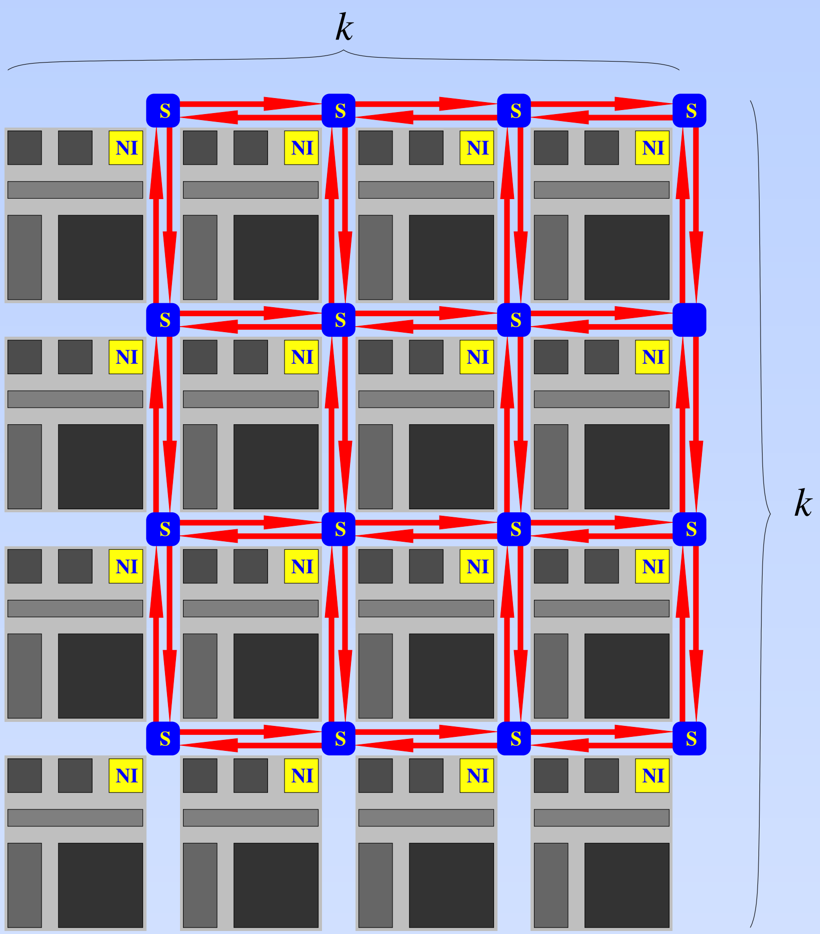

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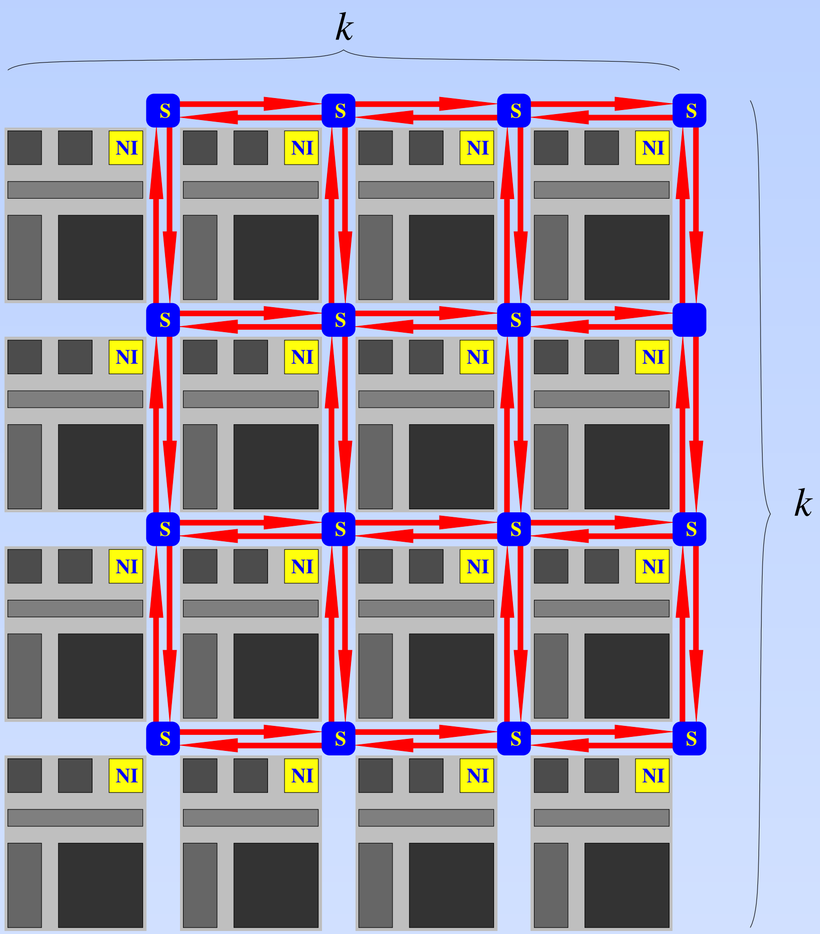
$$p = \frac{6(k-1)}{k^2}$$

Scalability of Meshes



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k	p
2	1.5
3	1.33
4	1.125
5	0.96
10	0.54

Scalability of Meshes

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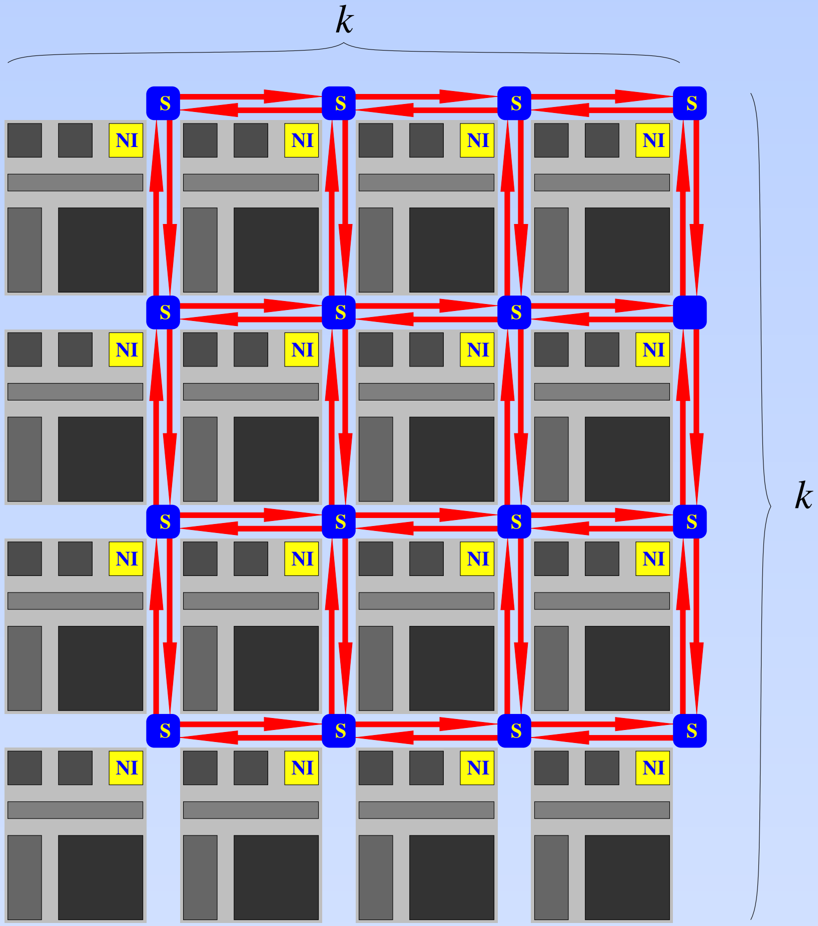

Under uniform traffic and bisection constraints:

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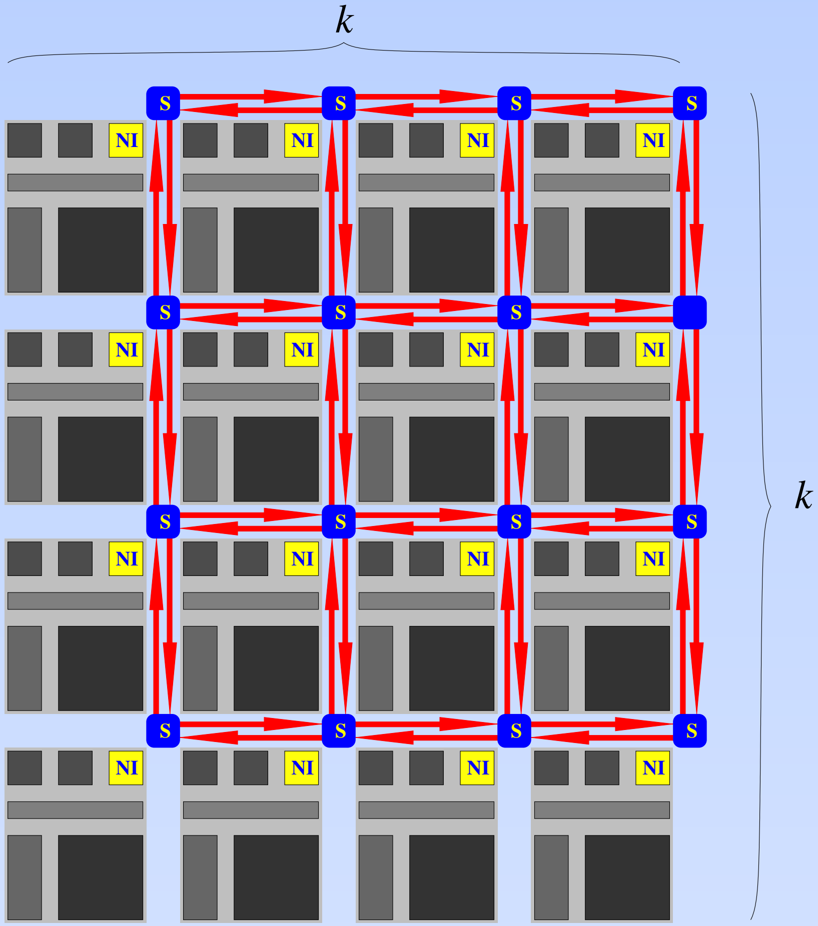

Under uniform traffic and bisection constraints:

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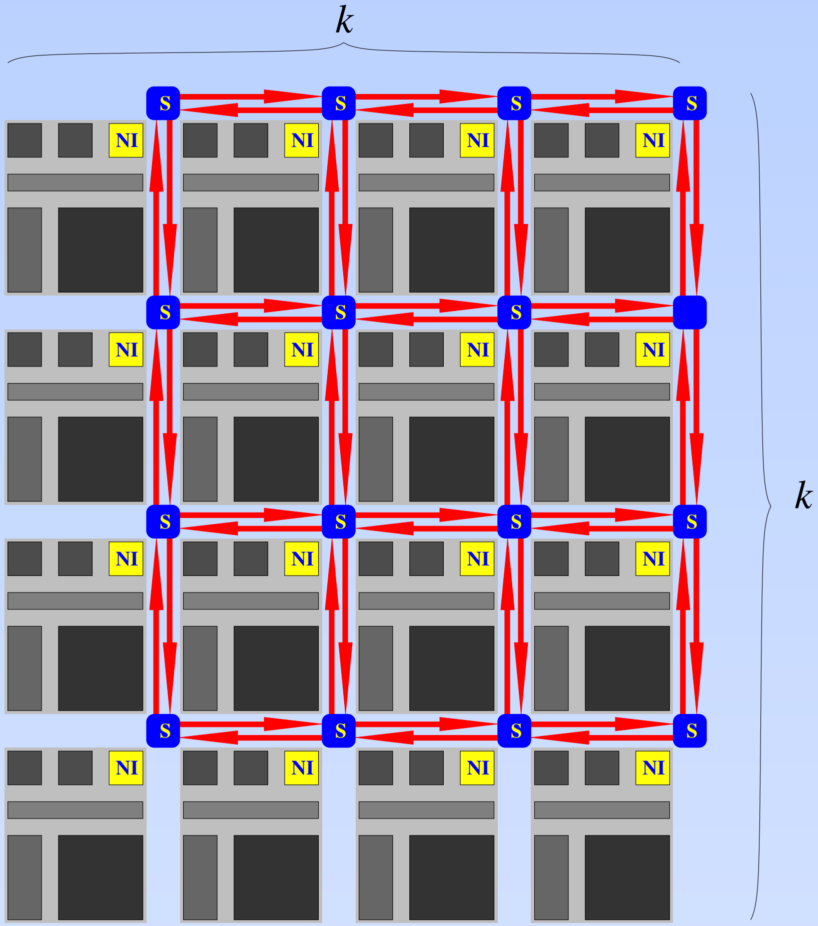

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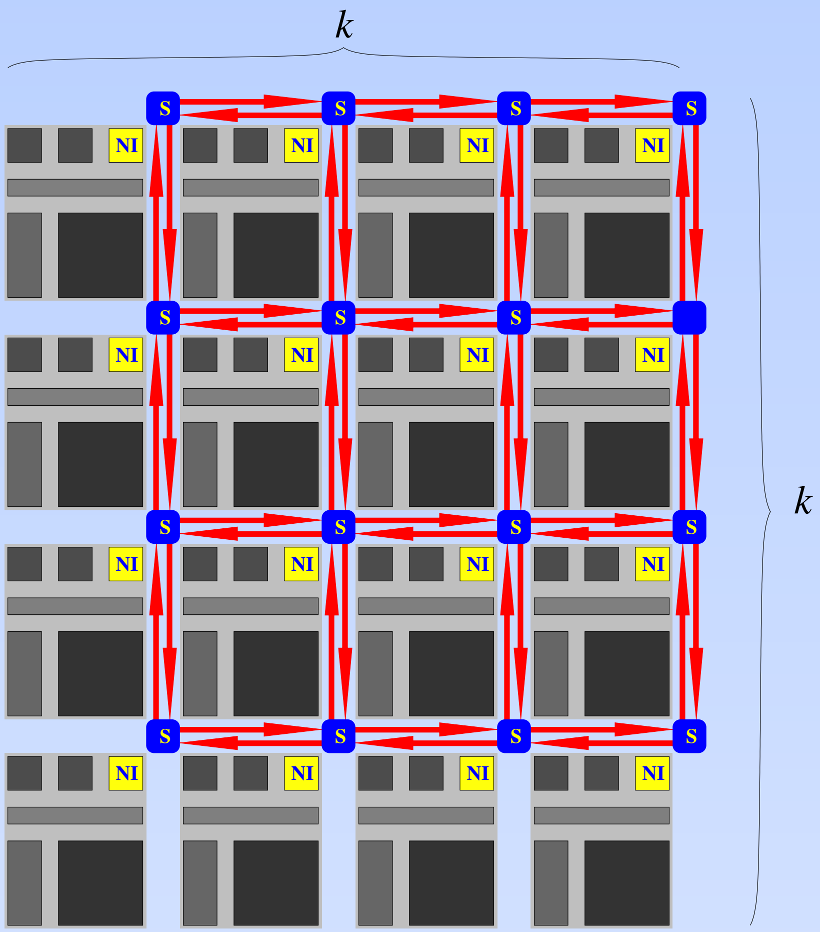

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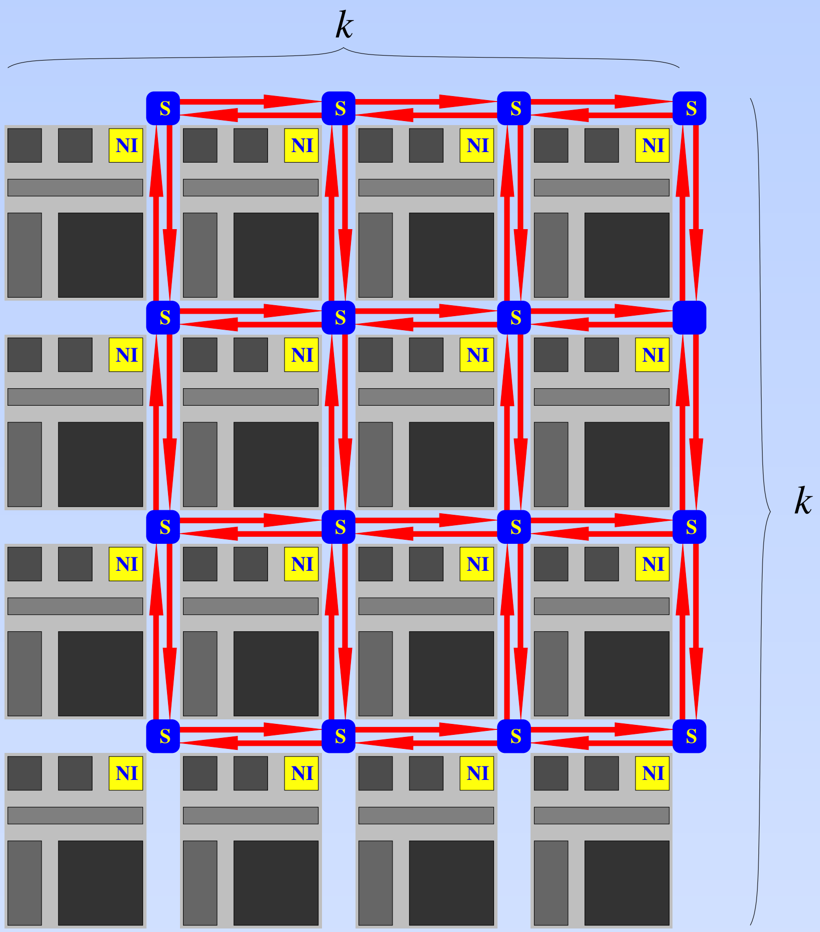

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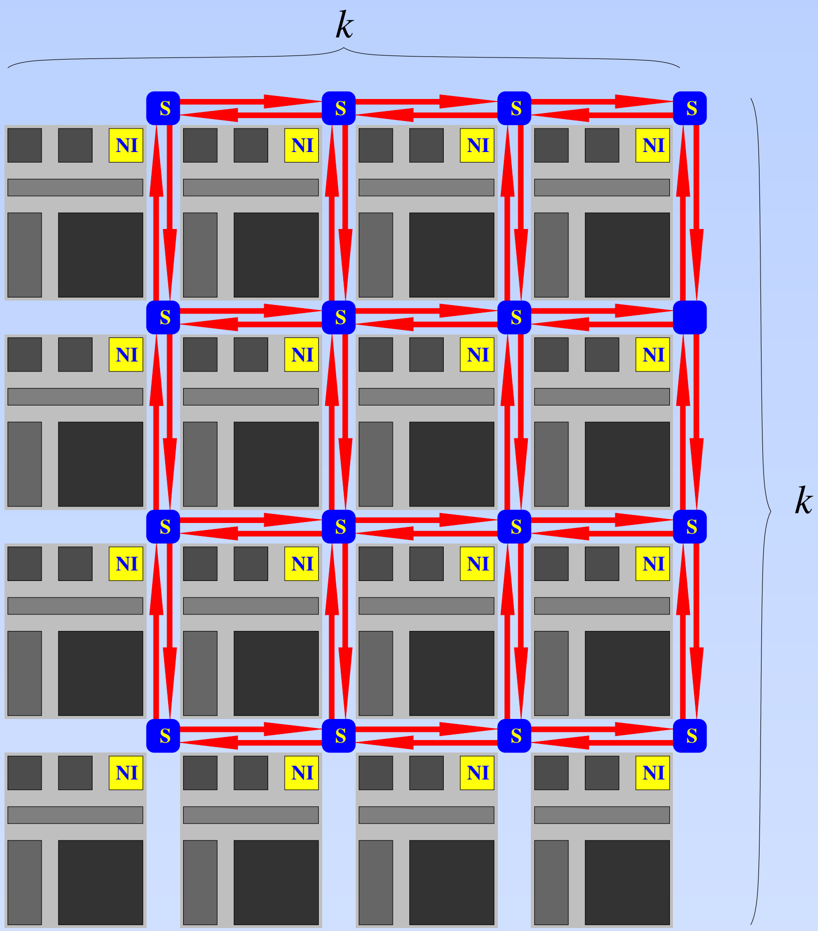

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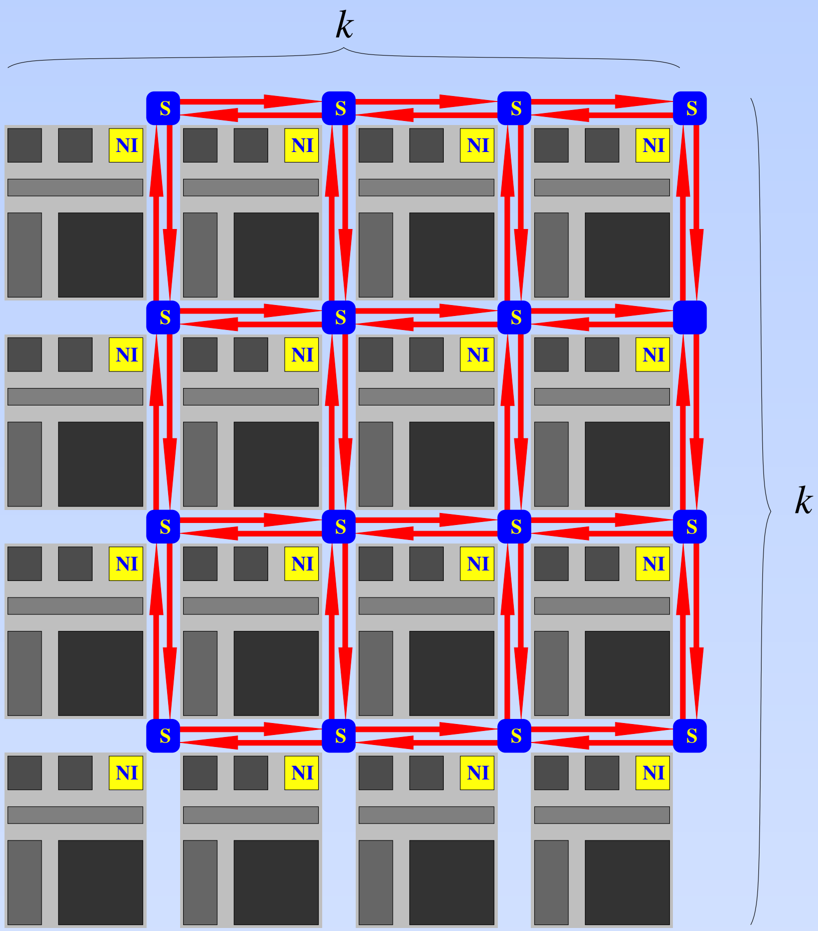

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k	p
2	2
3	1.33
4	1
5	0.8
10	0.4

Scalability of k-ary n-cubes

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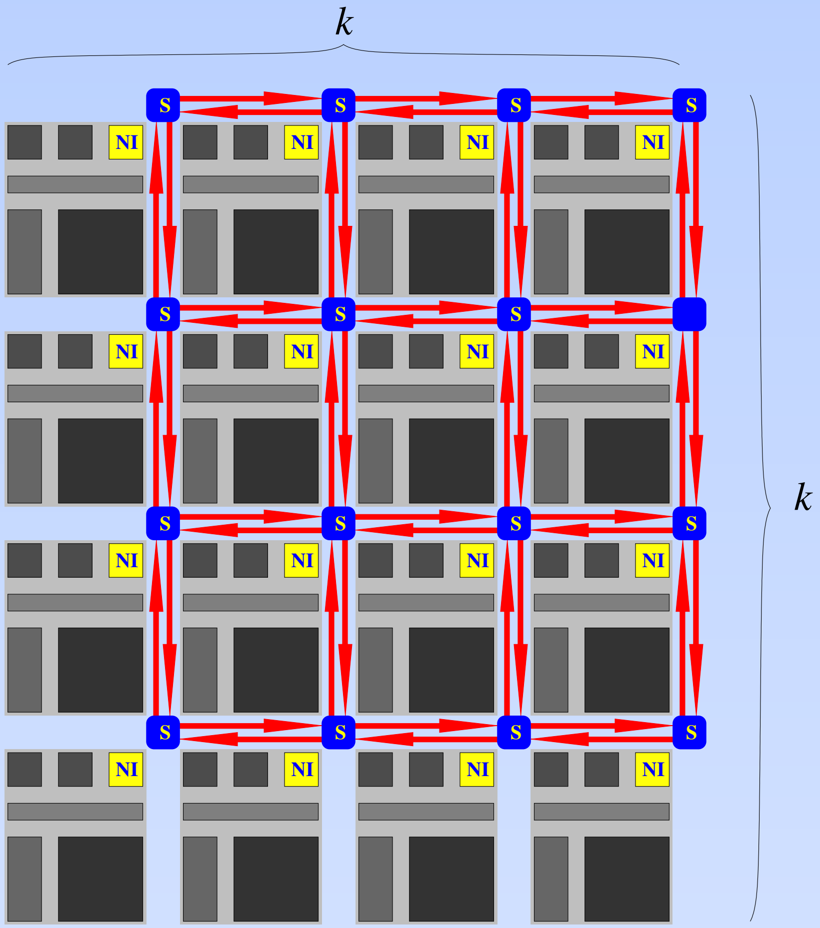

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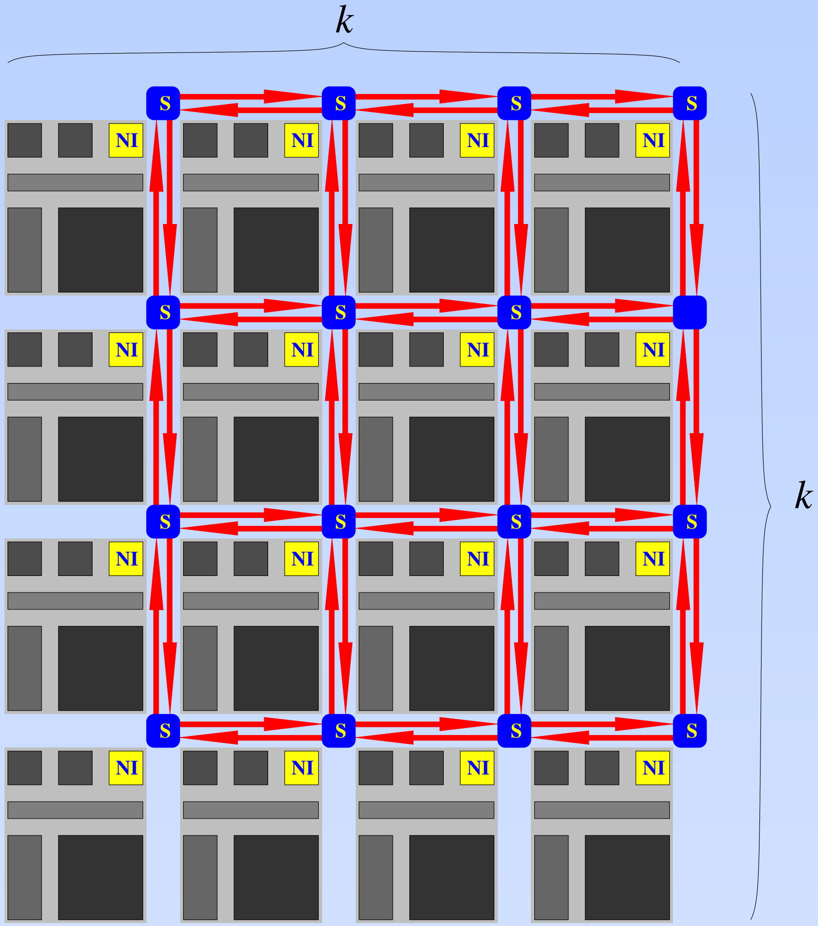

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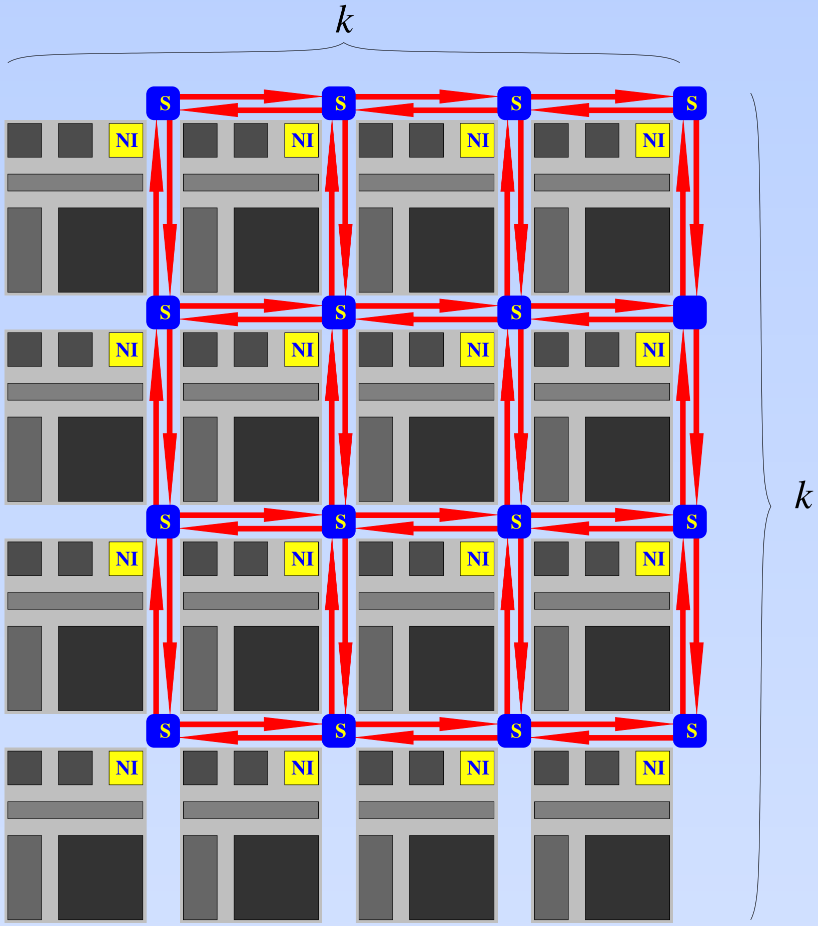

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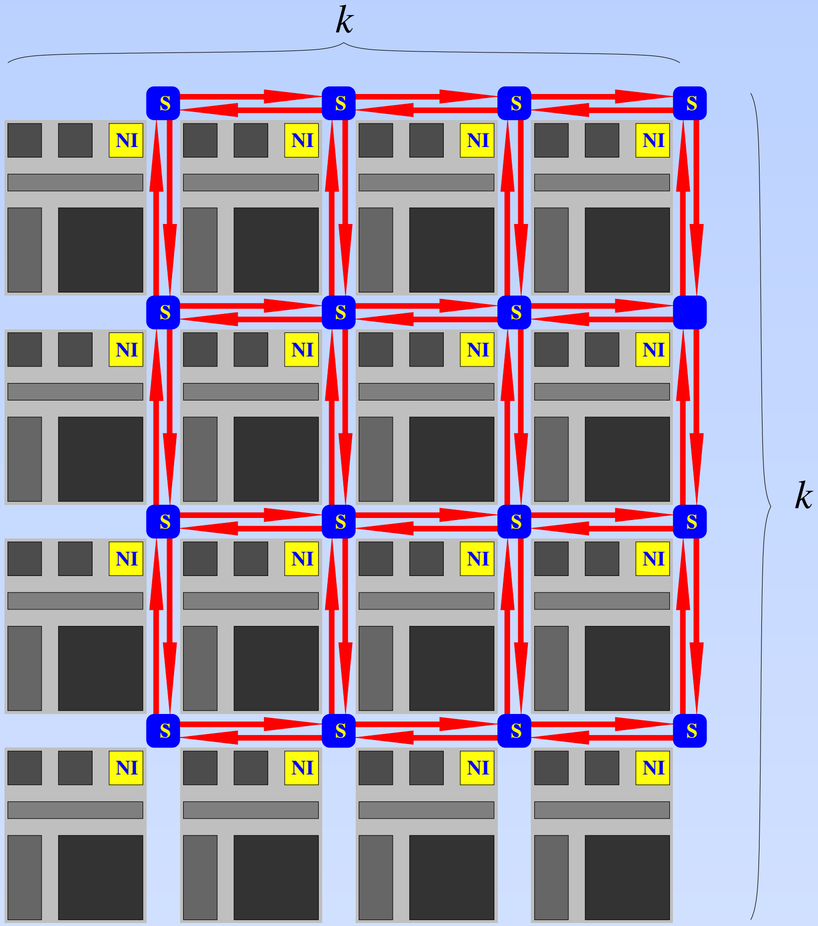

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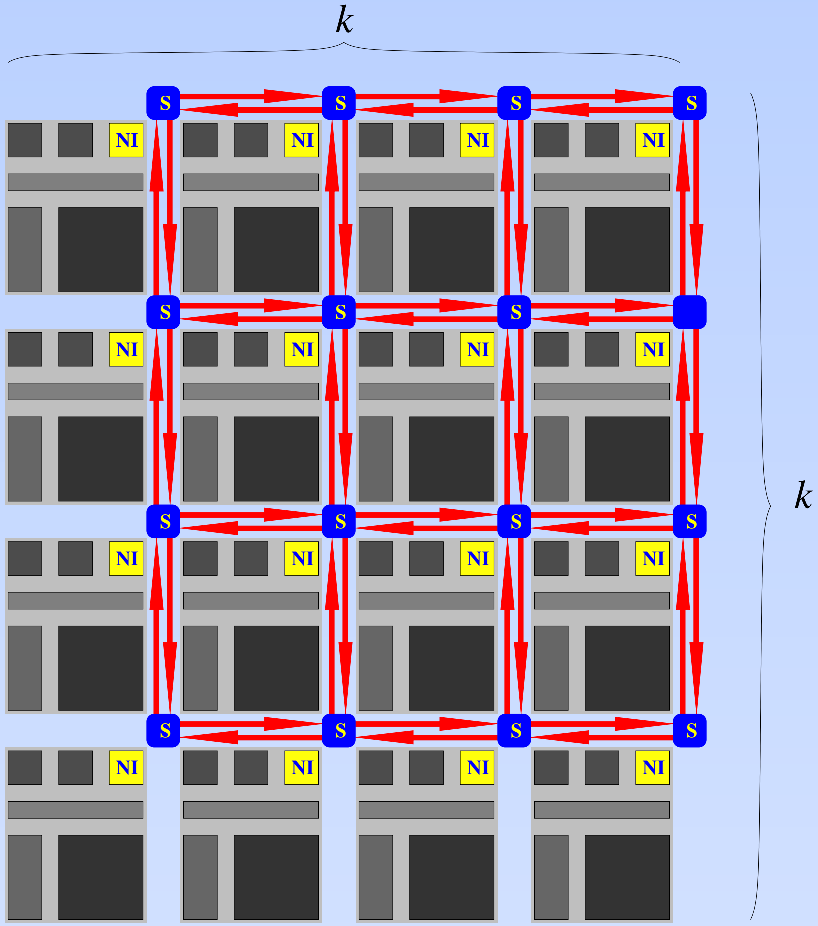

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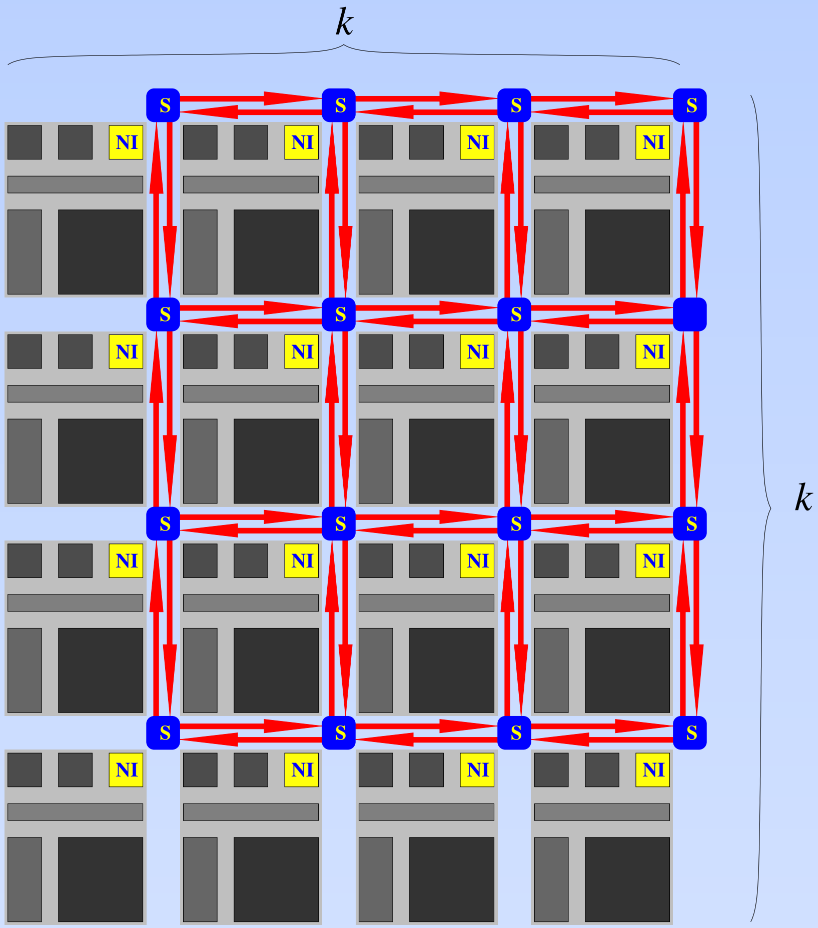

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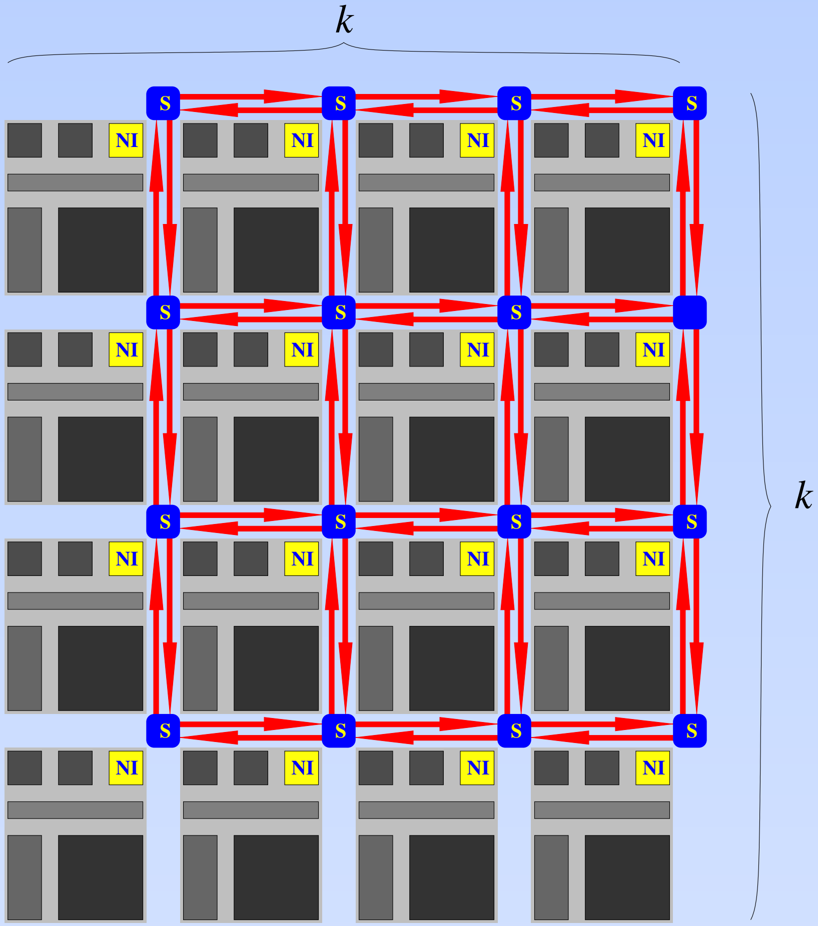

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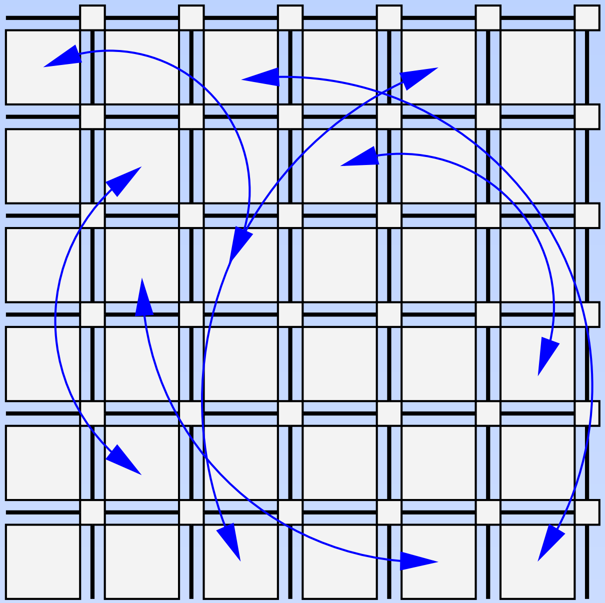
Efficient Composition Leads to Scalable Solutions



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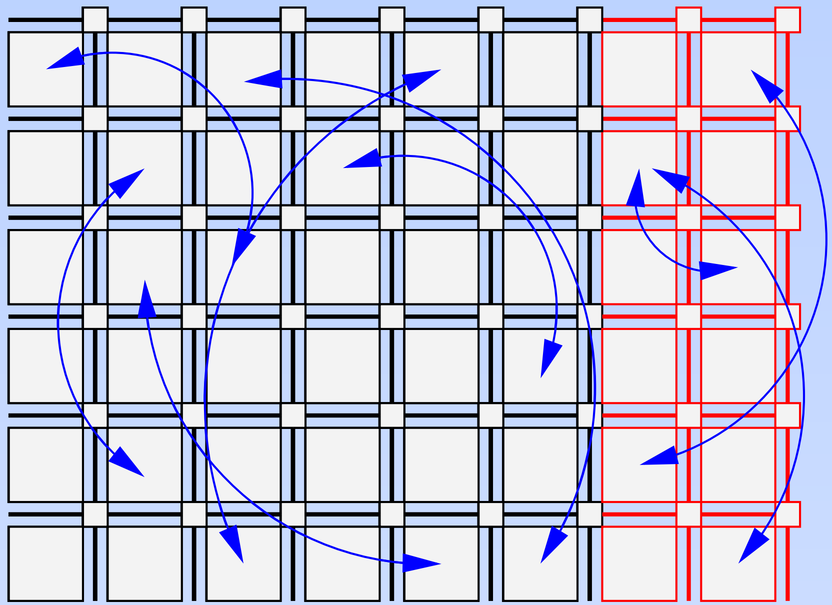

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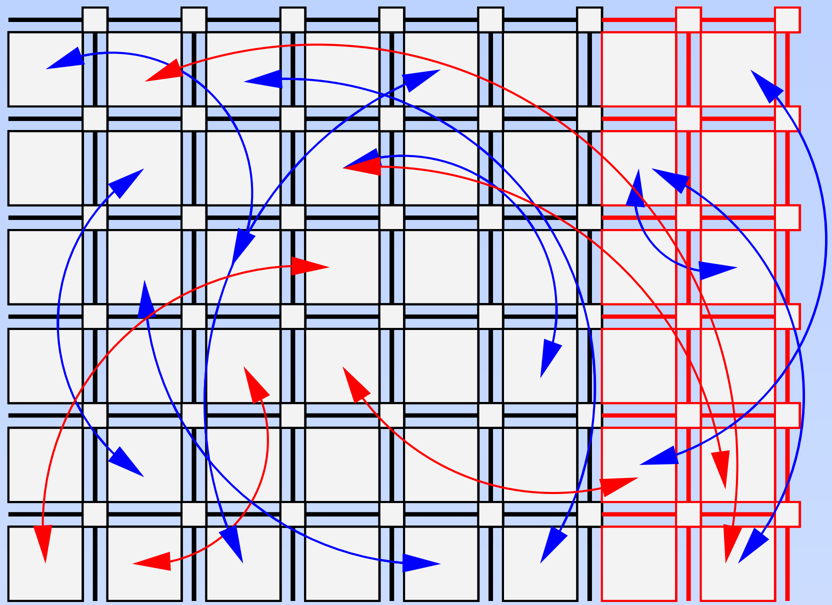

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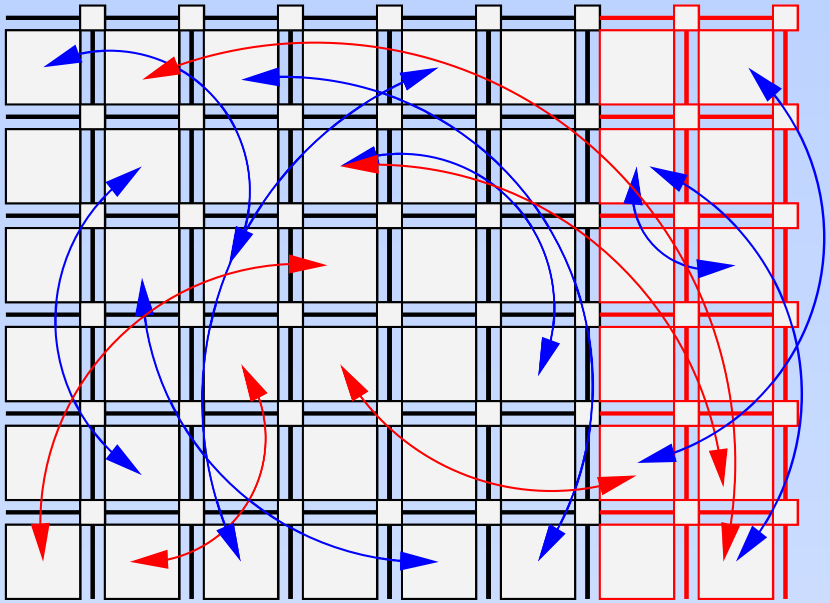

- Composition of Functionality with predictable performance
- Composition of Functions in network nodes
- Composition of Traffic

Traffic Contract between Resource and Network

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Resource		Network	
Obligation	Benefit	Obligation	Benefit

Traffic Contract between Resource and Network

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• limit outgoing traffic • consume incoming traffic with guaranteed delay bounds			

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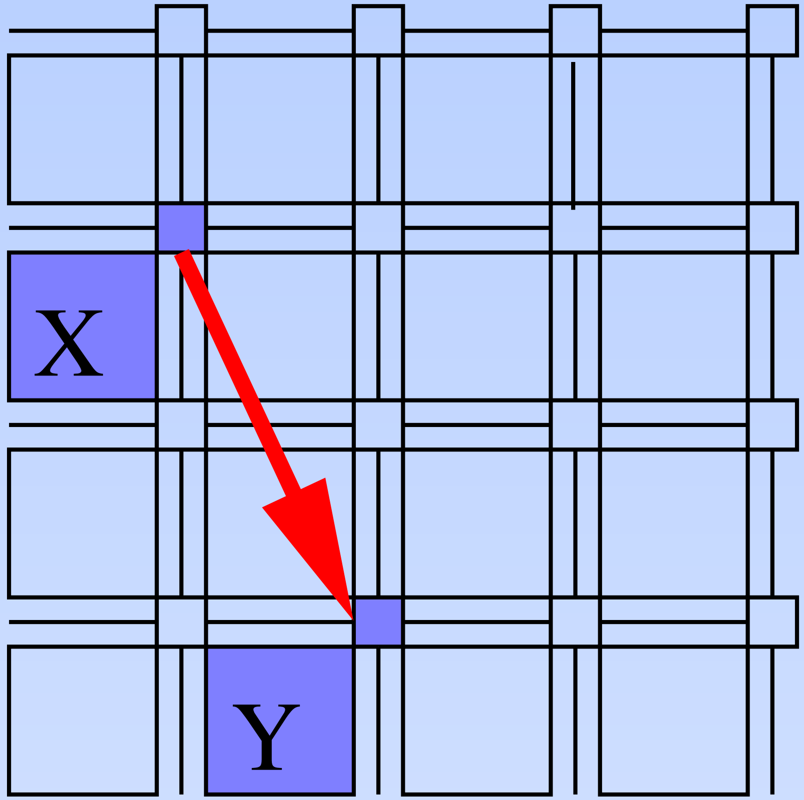
Traffic Budget Based Contract



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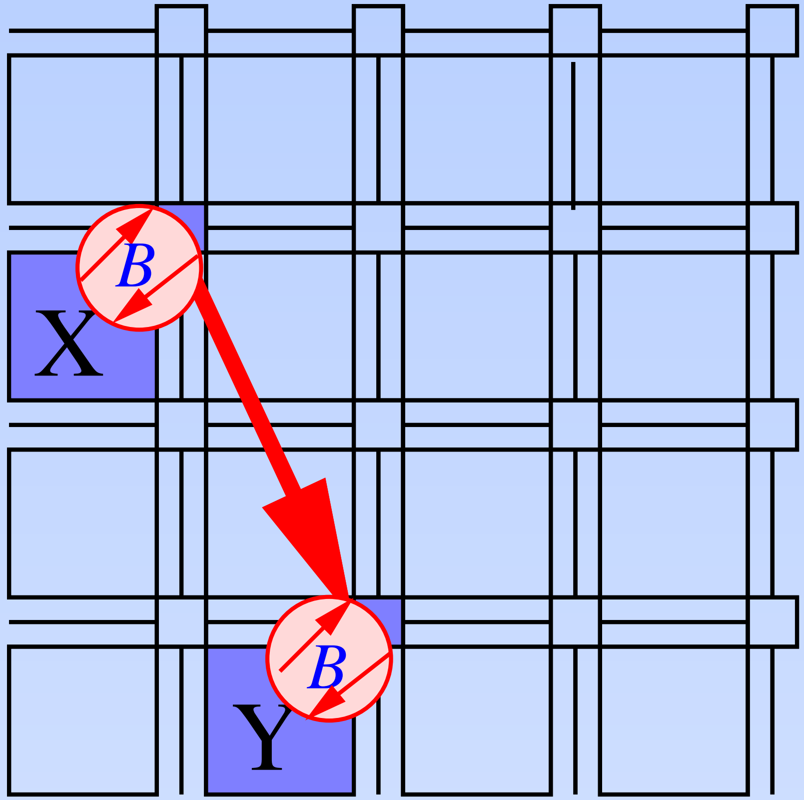

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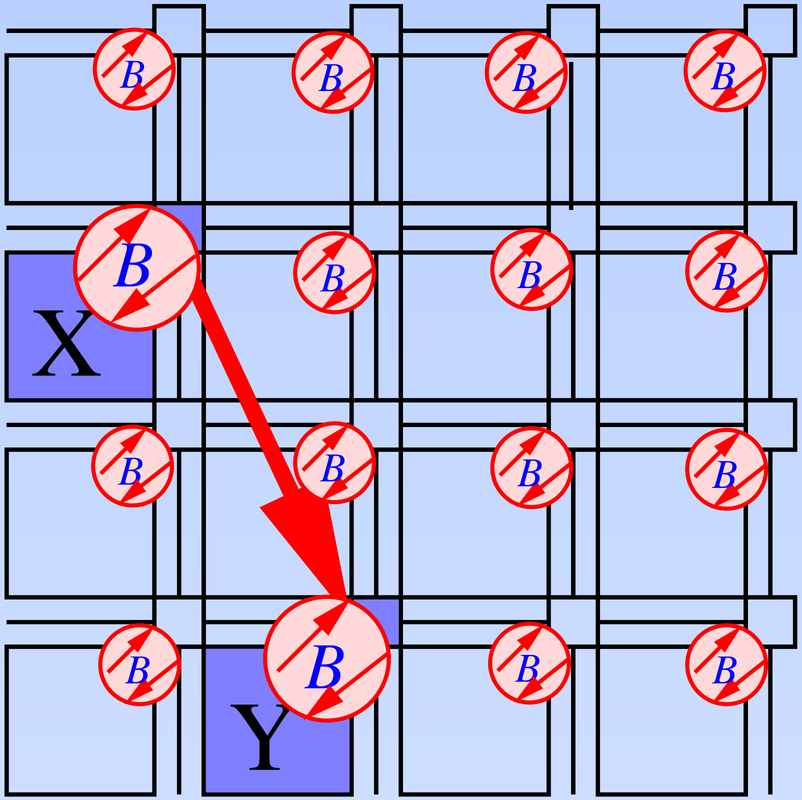

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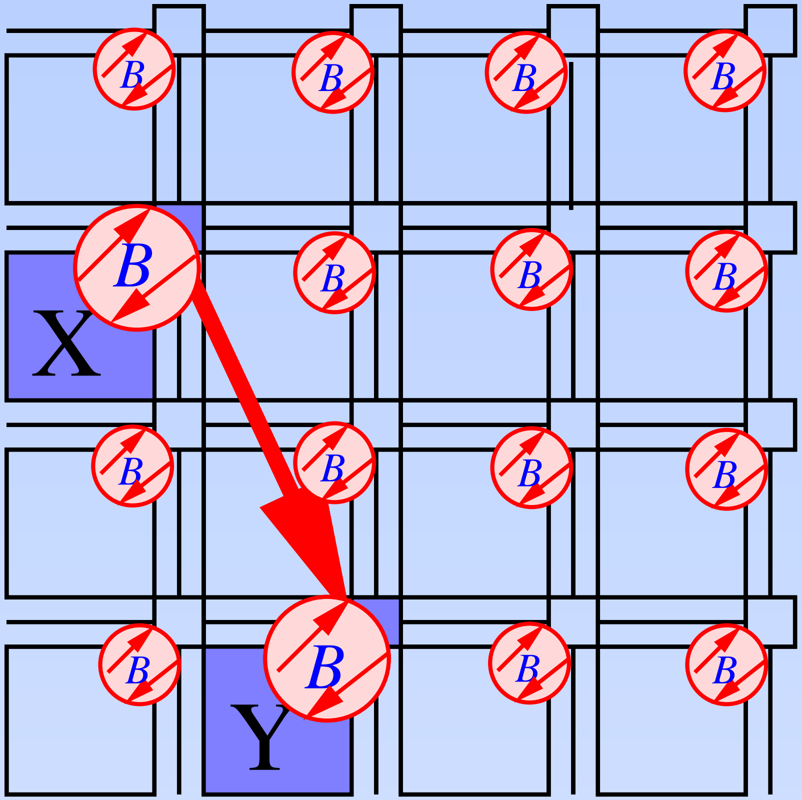
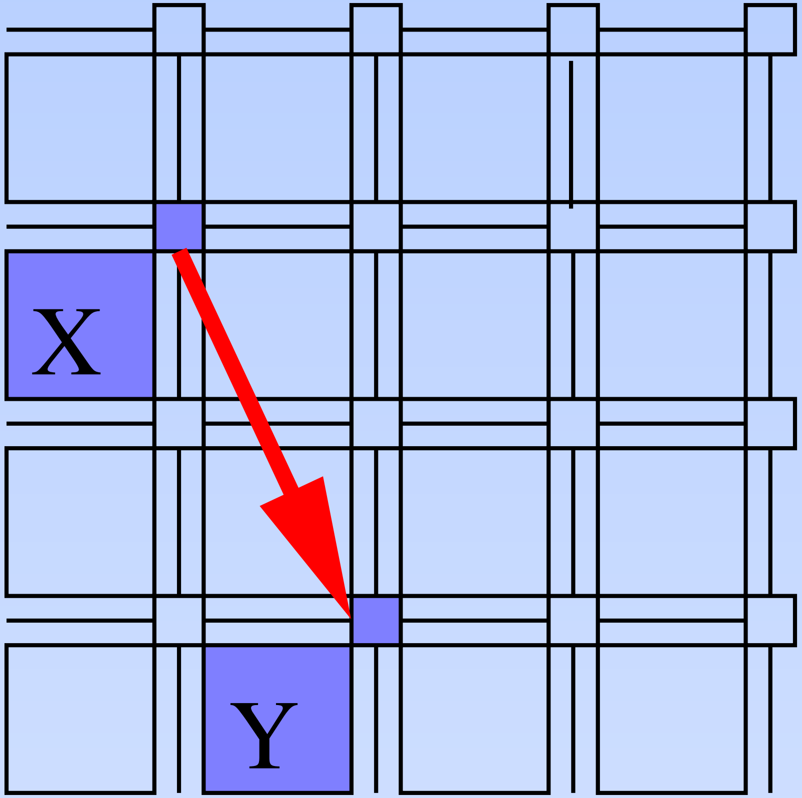


- Resource based budget allocation
- Assigning budgets is based on network global analysis
- Using budgets is a resource local decision
- Opening new end-to-end connections within budgets is local

Link Allocation Based Contract



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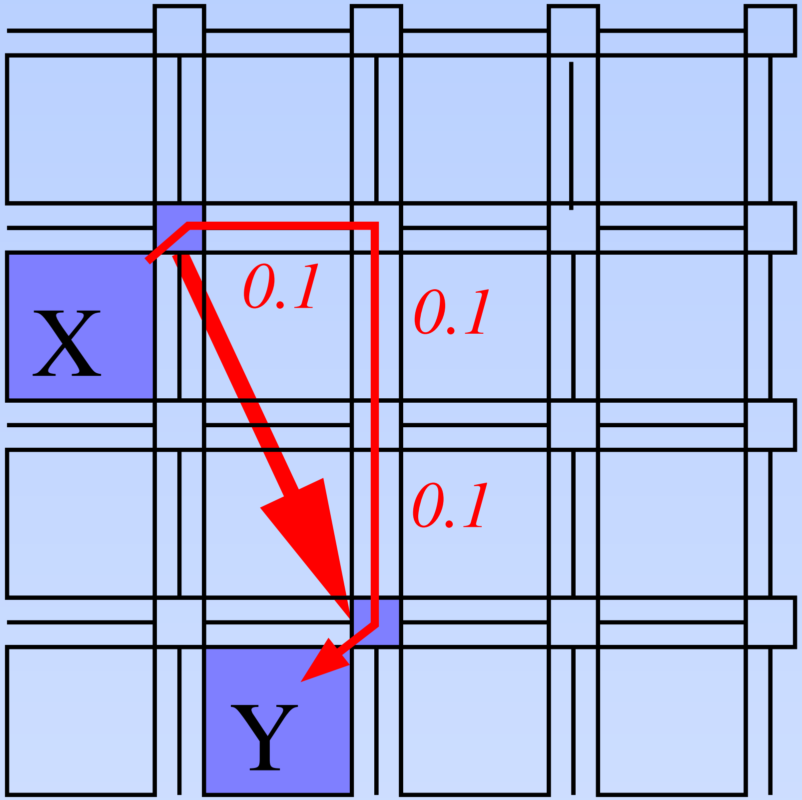

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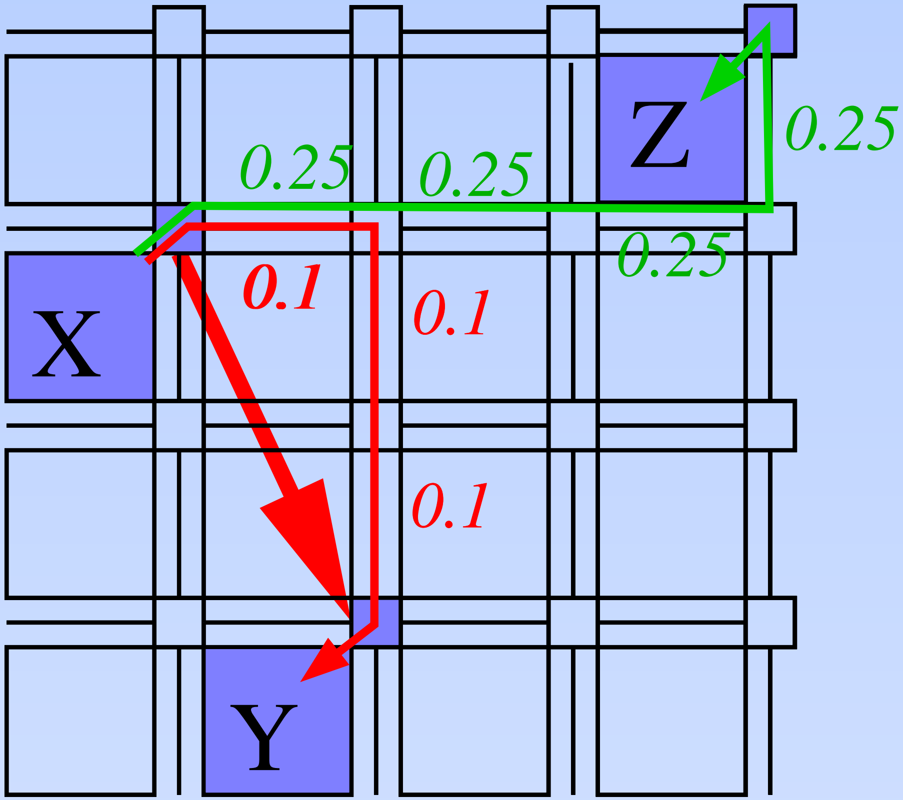

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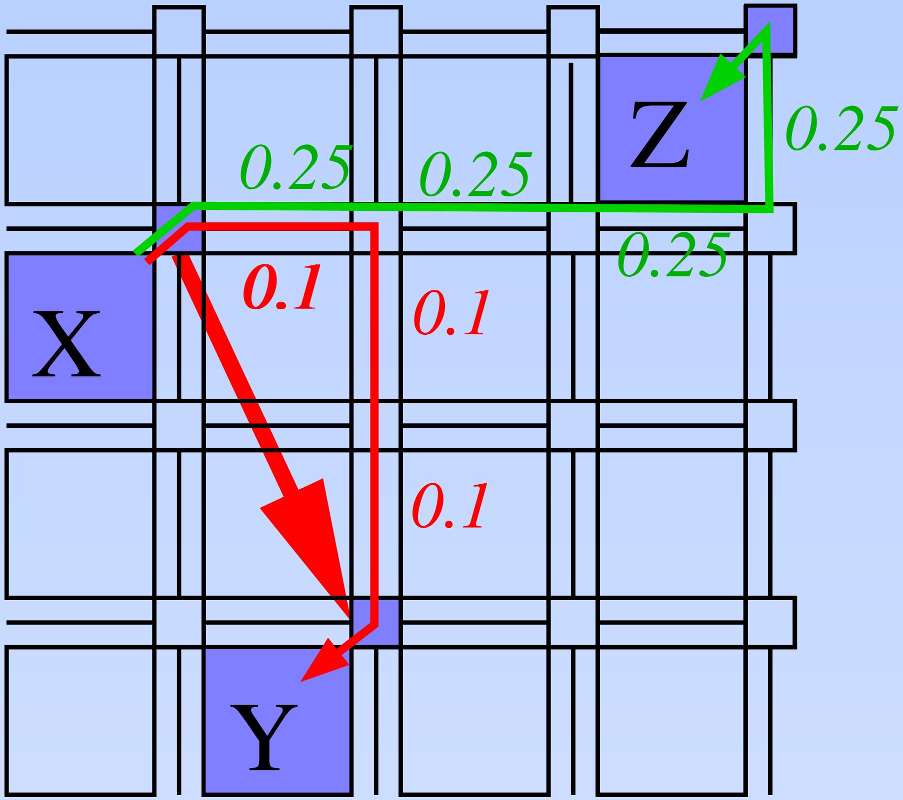
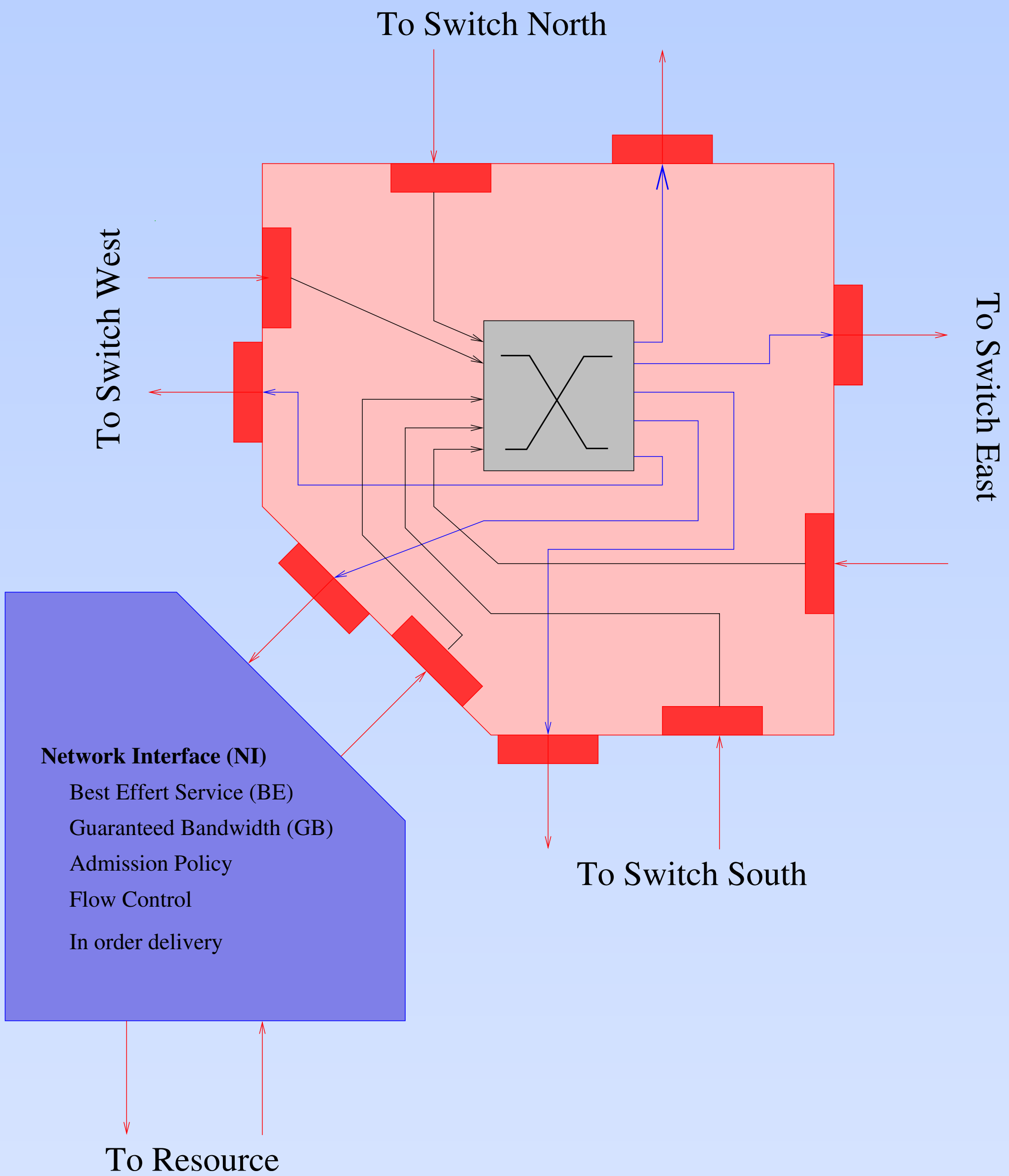


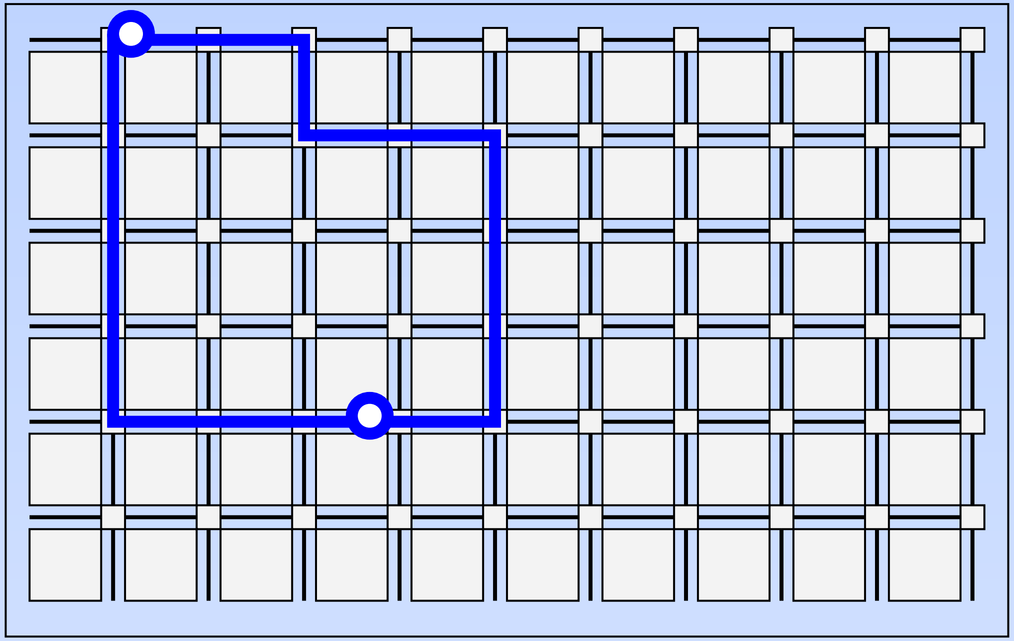
- Link based traffic allocation
- Allocating links is based on network global analysis
- Using allocated links is a resource local decision
- Opening new end-to-end connections requires global analysis

Nostrum Characteristics



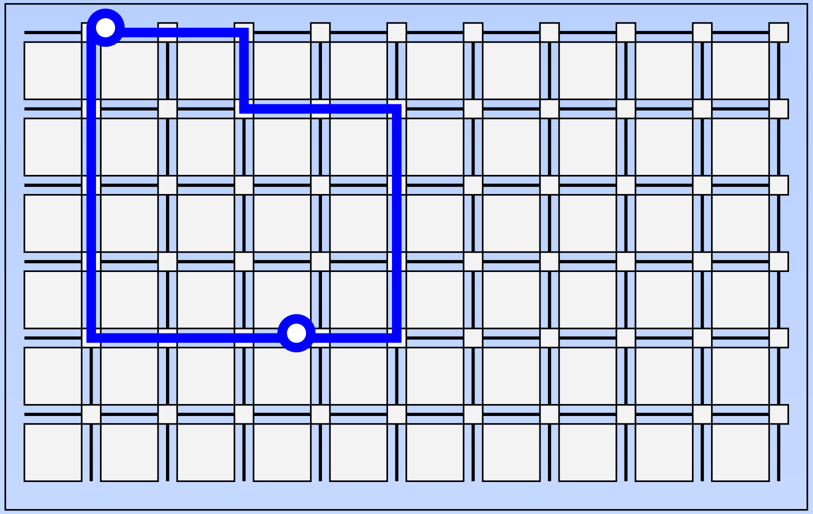
- Adaptive, hot potato routing
- No buffering in switches
- Access policy and buffering in the network interface
- Wide links
- Pseudo-synchronous network operation
- Best Effort service
- Guaranteed Bandwidth service based on virtual circuits

Nostrum Communication Services



- Best Effort:
  - On congestion packets are deflected
  - Higher Priority:
    - Older Packets
    - Shorter distance to destination
- Guaranteed Bandwidth
  - Virtual Circuits (VC)
  - Looping containers reserve resources

GB Traffic Composition



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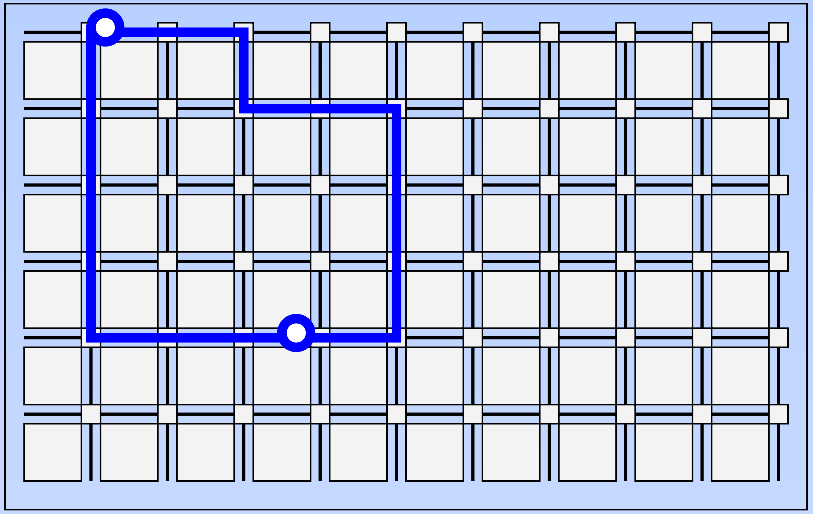

Load and performance is considered within a time window W cycles.

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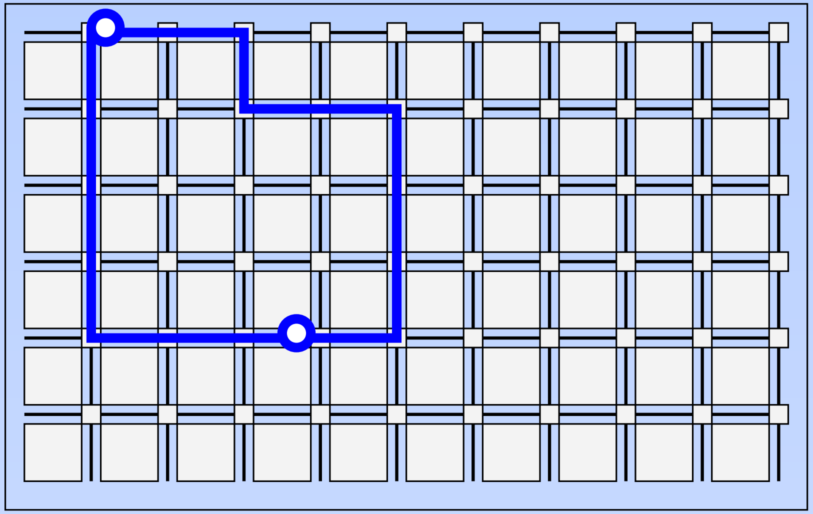

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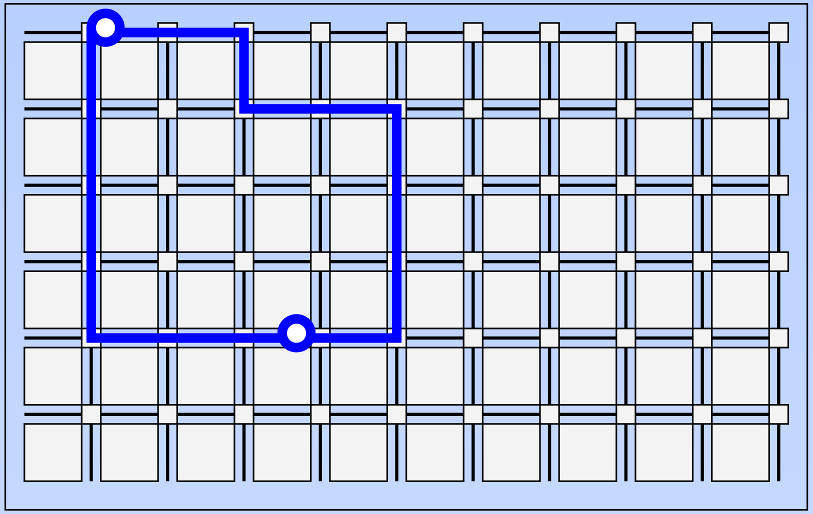

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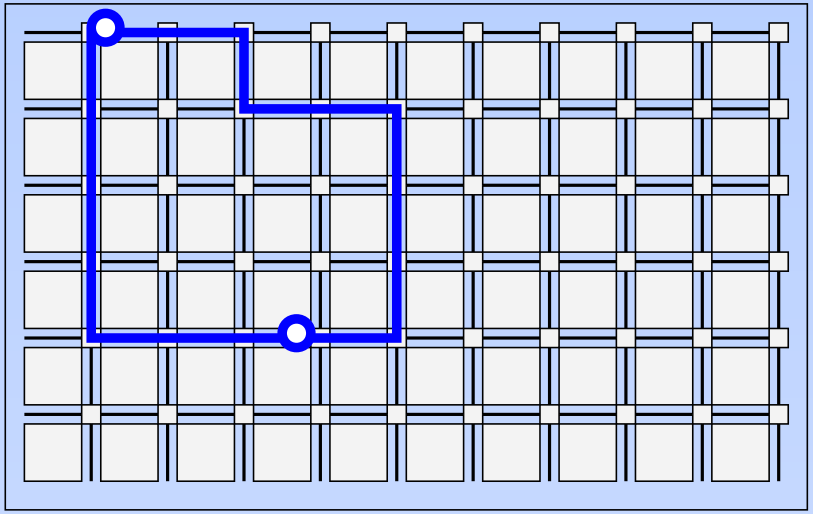

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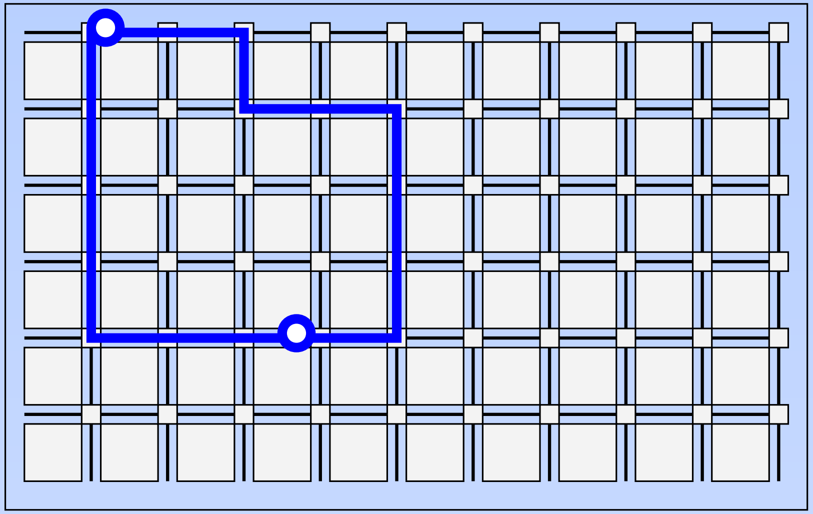

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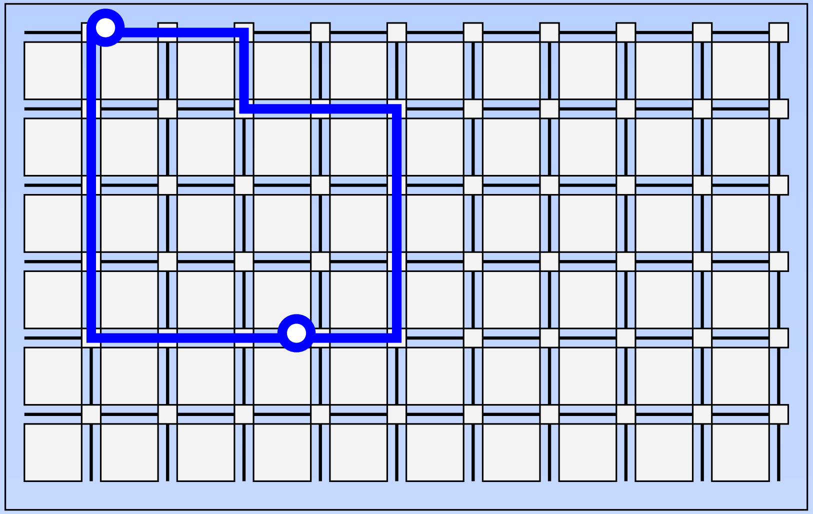

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Traffic Constraints:

$$\sum_k V_k \leq CG_{\mathrm{VC}} \leq WL$$

$$\sum_k v_{i,k} \leq CL_{\mathrm{VC}} \leq W \quad \text{for all links } i$$

Properties of GB Traffic

c_k: number of containers in the VC k;
len_k: the length of the VC in cycles.
$\mathrm{maxInit}_k$: maximum time between two containers.

Properties of GB Traffic

Bandwidth:

$$BW_k = \frac{c_k}{\mathrm{len}_k} \quad \frac{\text{packets}}{\text{cycle}}$$

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Maximum Latency:

$$\mathrm{maxLat}_k = \mathrm{maxInit}_k + \mathrm{len}_k$$

c_k: number of containers in the VC k;
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Properties of GB Traffic

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$$\delta = \frac{\text{sum of traveling time of all packets}}{\text{sum of shortest path of all packets}}$$

Constraints for BE Traffic - Resources

$$\begin{aligned}\sum_{h \in H_r^o} E_h &\leq B_r^o \\ \sum_{h \in H_r^i} E_h &\leq B_r^i \\ \sum_r B_r^o = \sum_r B_r^i &\leq CG_{\mathrm{BE}}\end{aligned}$$

E_h: Network load due to channel h
H_r^o: Set of outgoing channels in resource r
H_r^i: Set of ingoing channels in resource r
B_r^o: Outgoing traffic budget for resource r
B_r^i: Incoming traffic budget for resource r
CG_{BE}: Global constraint on BE traffic

Properties of BE Traffic

Under incoming and outgoing resource budget constraints;
n_h: number of emitted packets in each window on channel h;
d_h: shortest distance on channel h;
D: diameter of the network;
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Properties of BE Traffic

Bandwidth:

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Nostrum Traffic Contract Summary

Traffic Constraints:

$$\sum_k V_k \leq CG_{\mathrm{VC}} \leq WL$$

$$\sum_k v_{i,k} \leq CL_{\mathrm{VC}} \leq W$$

$$\sum_{h \in H_r^o} E_h \leq B_r^o$$

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Traffic Properties:

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- result in communication performance characteristics for a NoC platform
- allow for composition of traffic with predictable performance
- imply requirements for service users (nodes, applications) and service providers (communication network, component implementations)