The Network Layer

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Outline

- Basic network-layer architecture of a datagram network
- Introduction to forwarding
- Introduction to routing
- General architecture of a router
- Switching fabric and queuing
- Internet network-layer protocol
- The Internet protocol (IP)
- Fragmentation

Application Level

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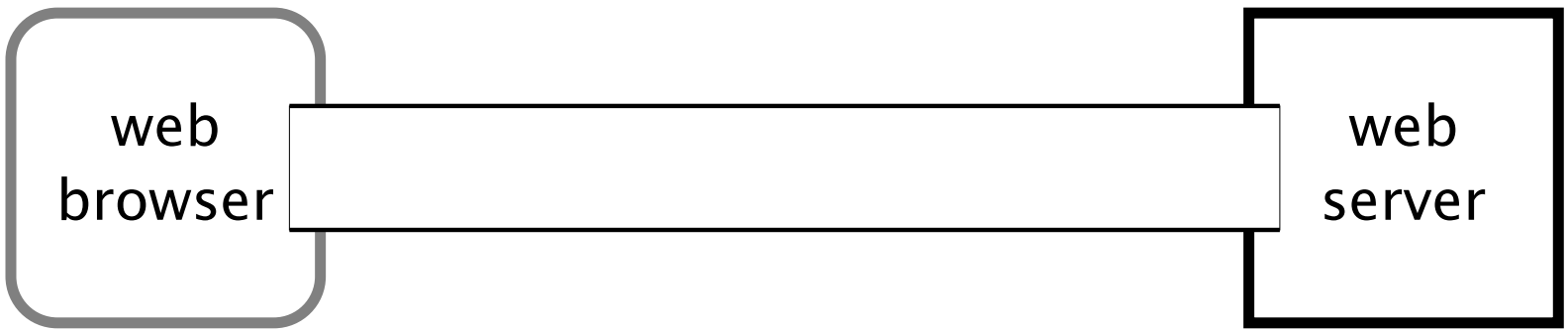

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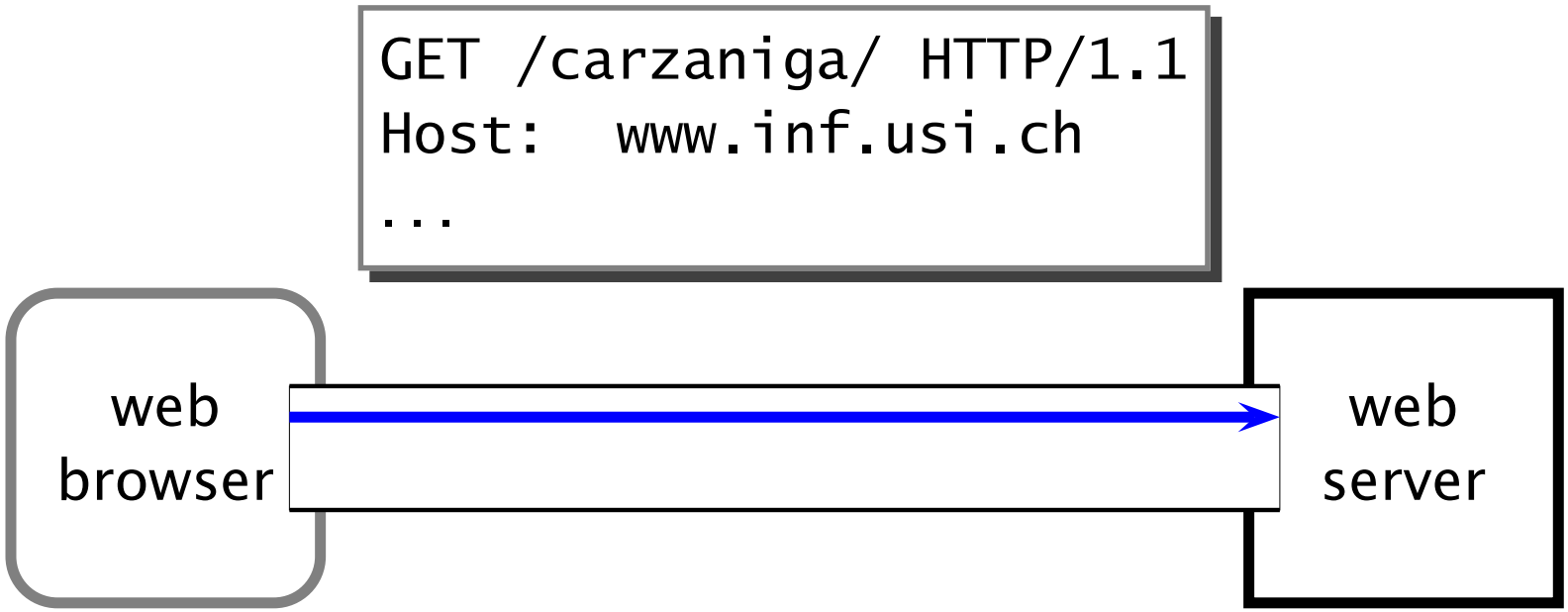

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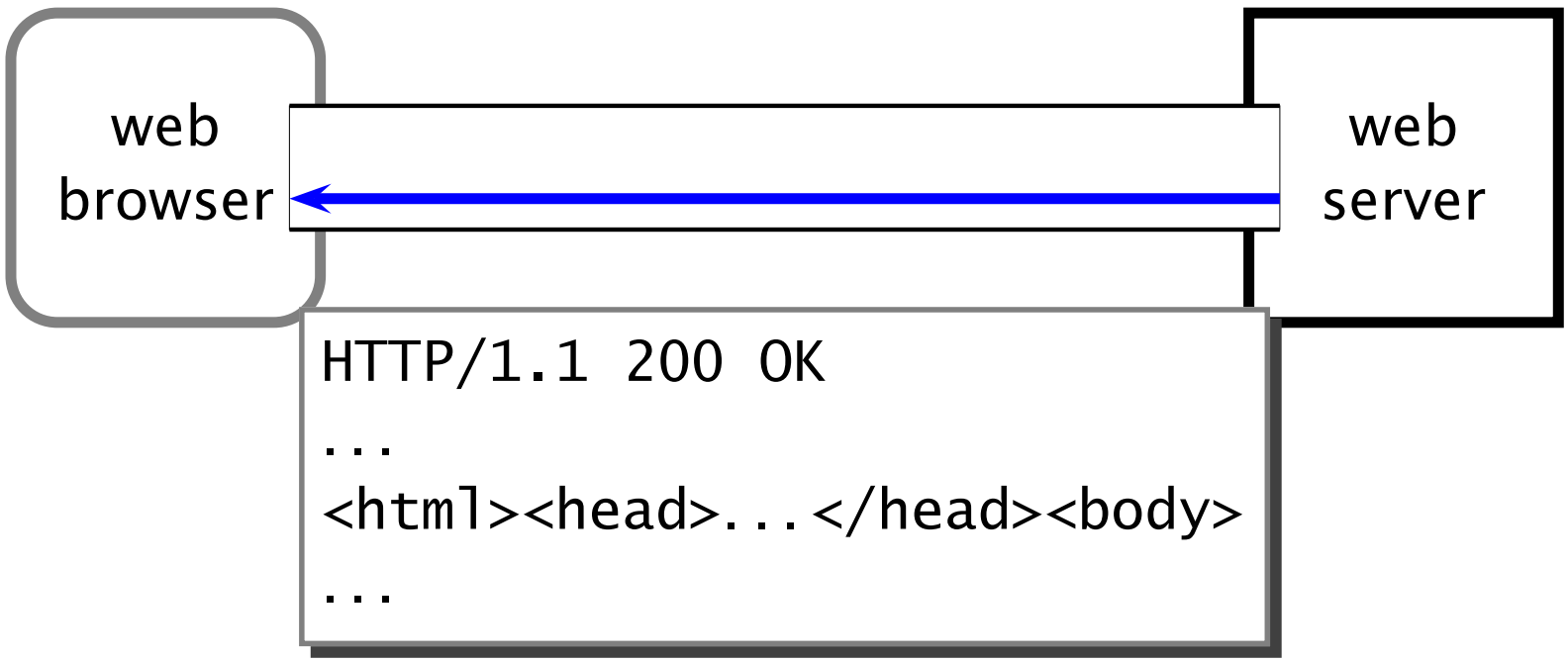

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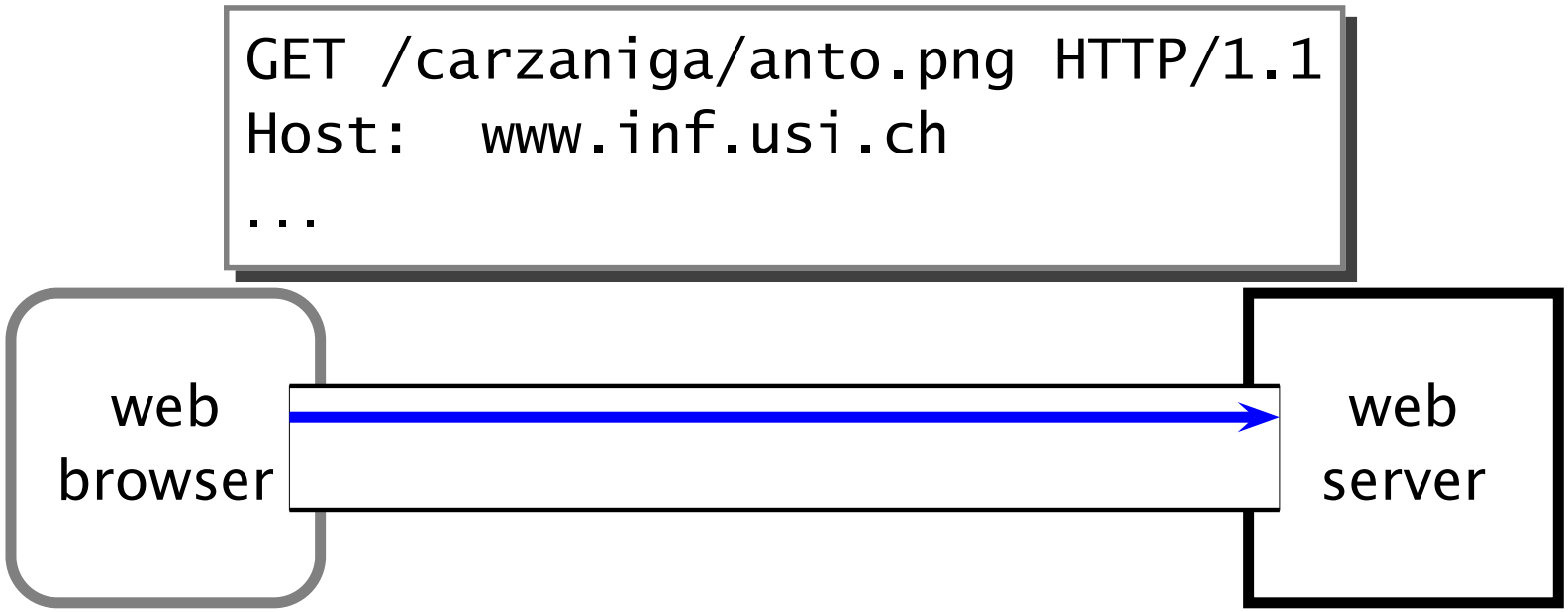

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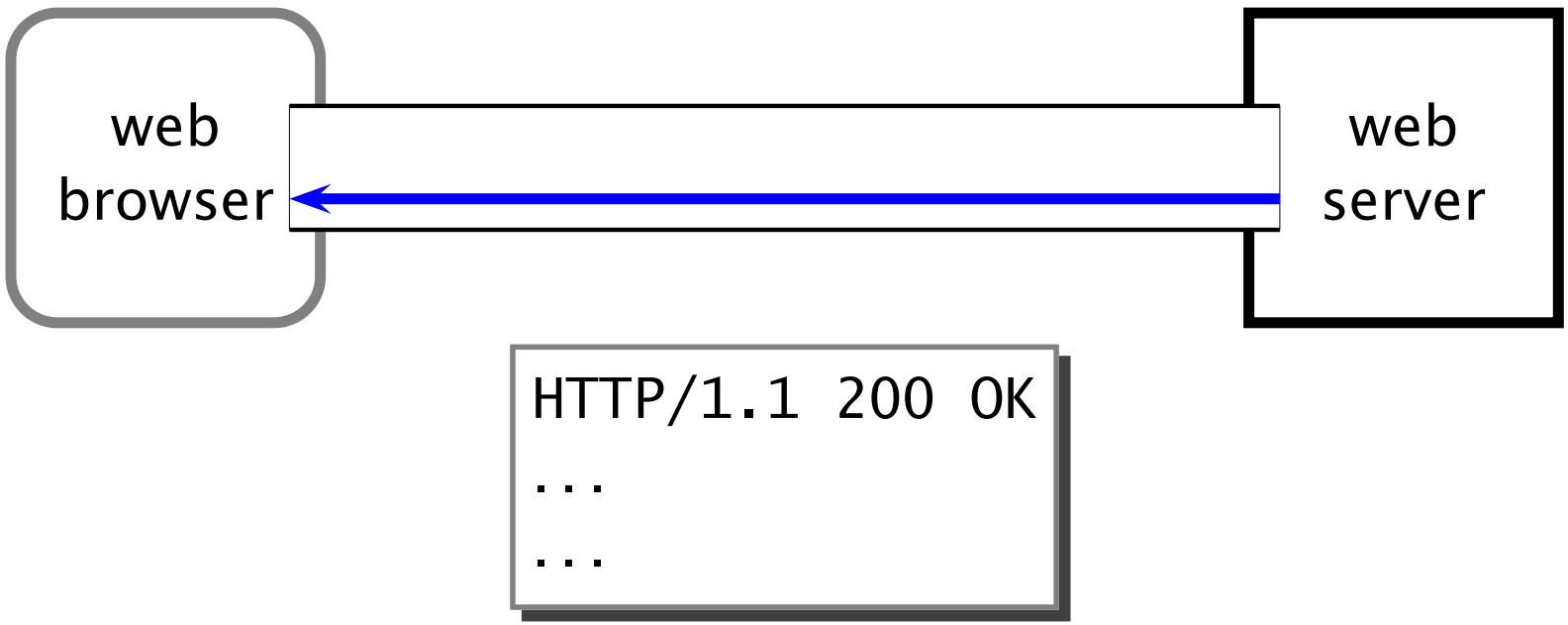

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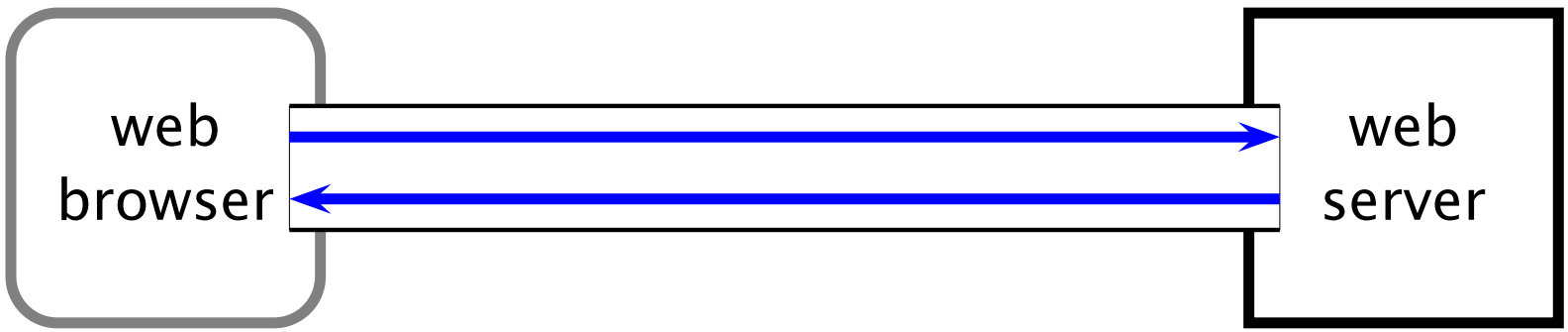

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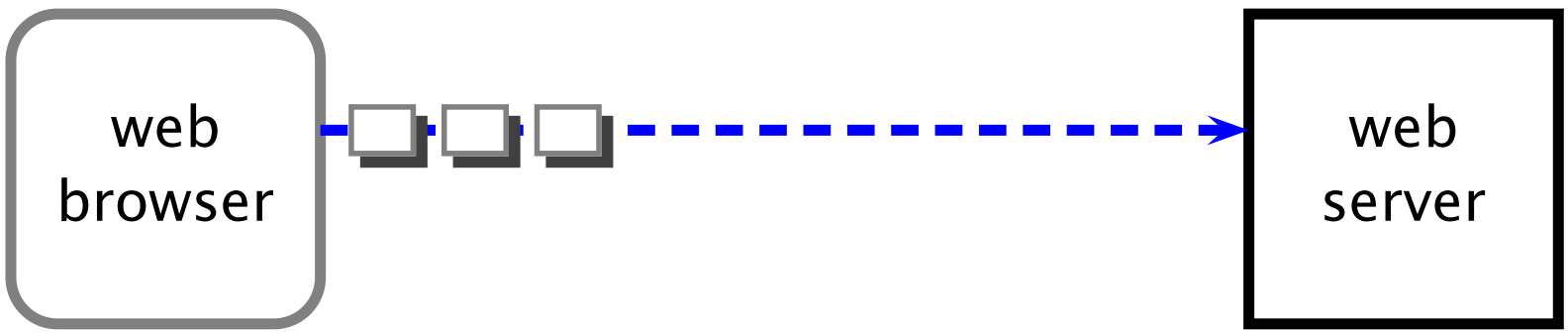

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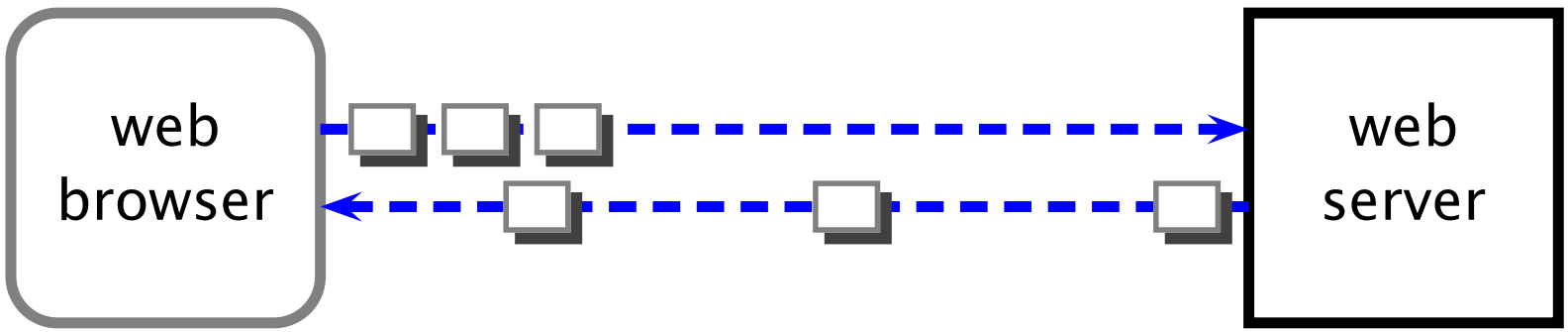

Network Layer

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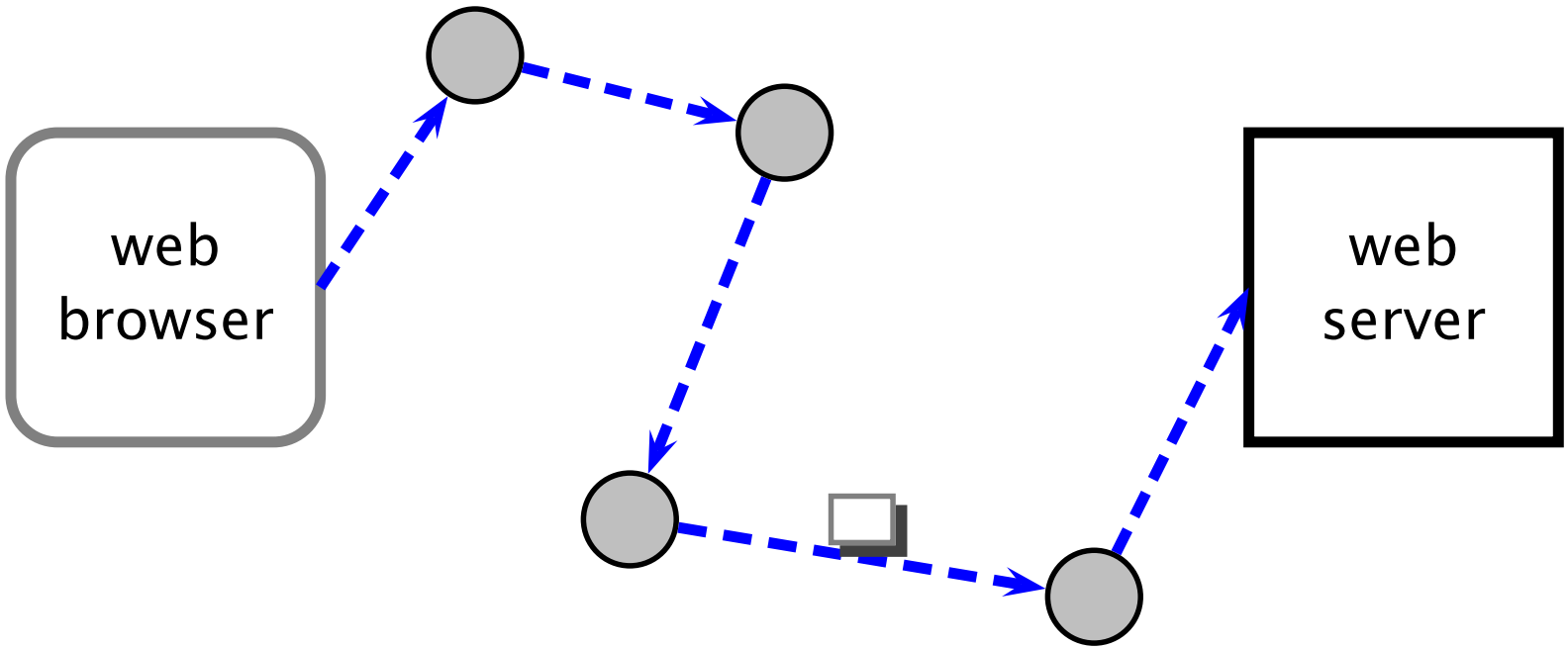

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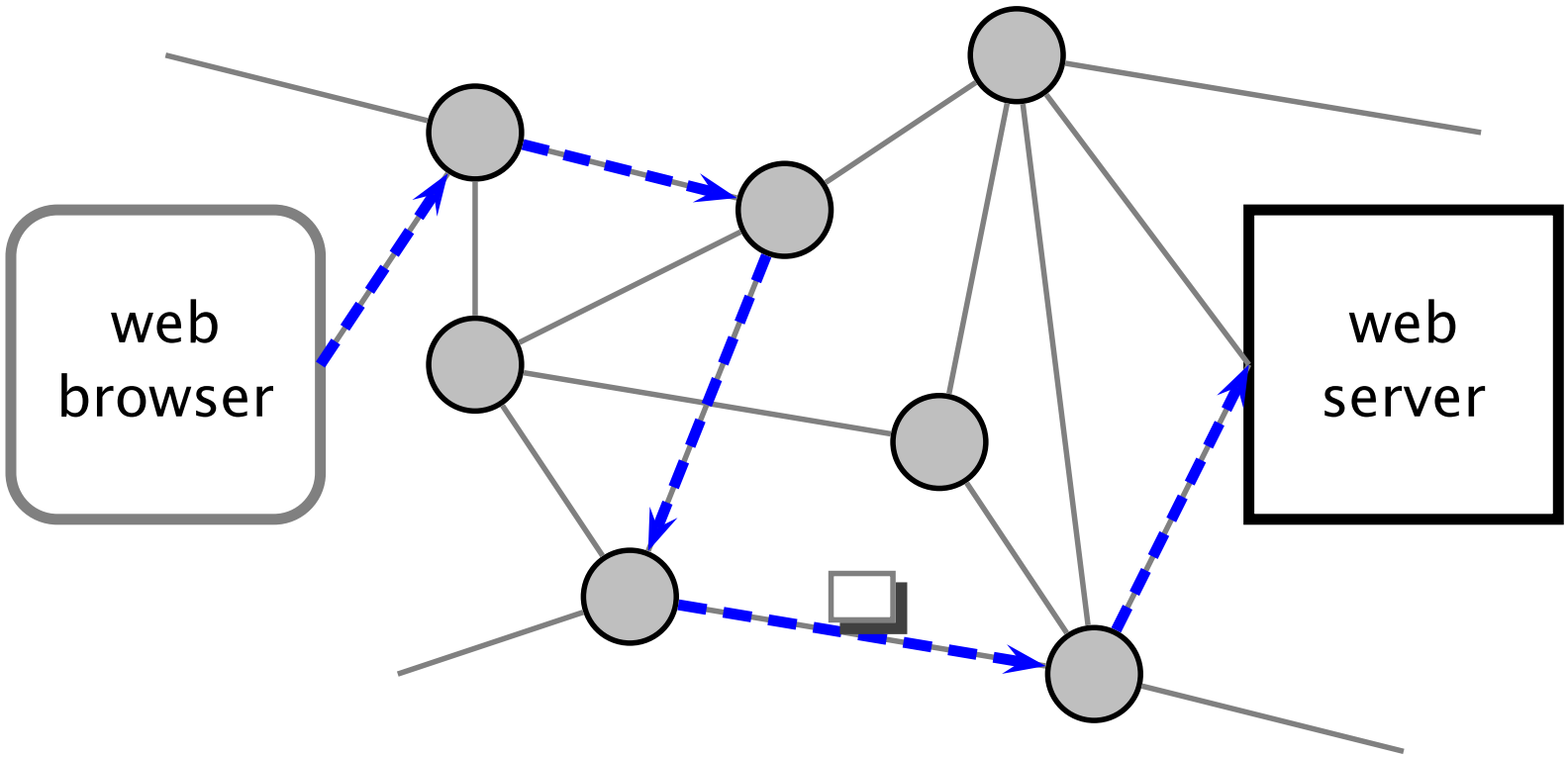

Router

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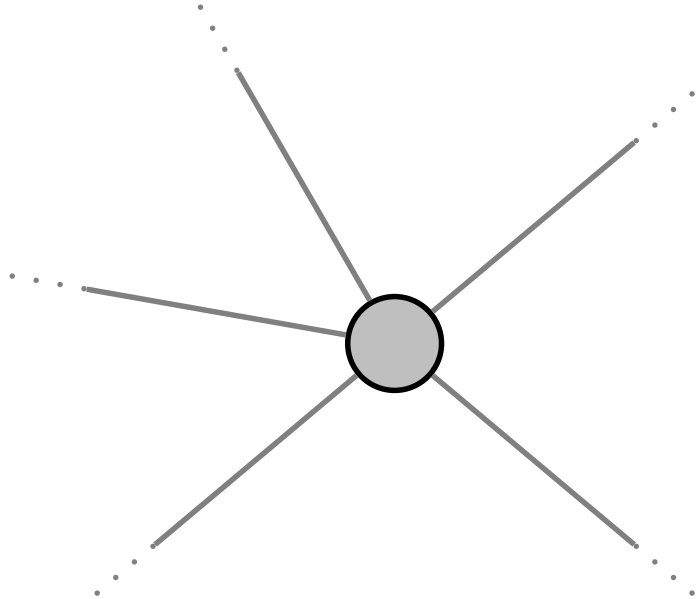

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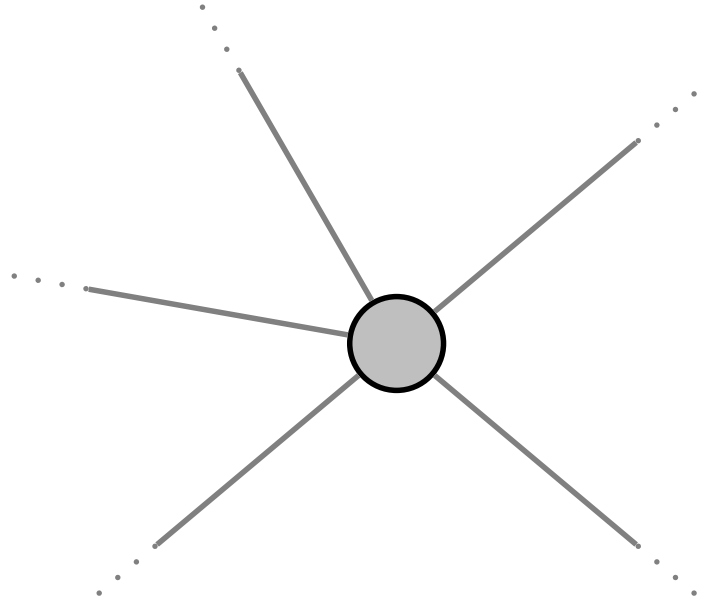

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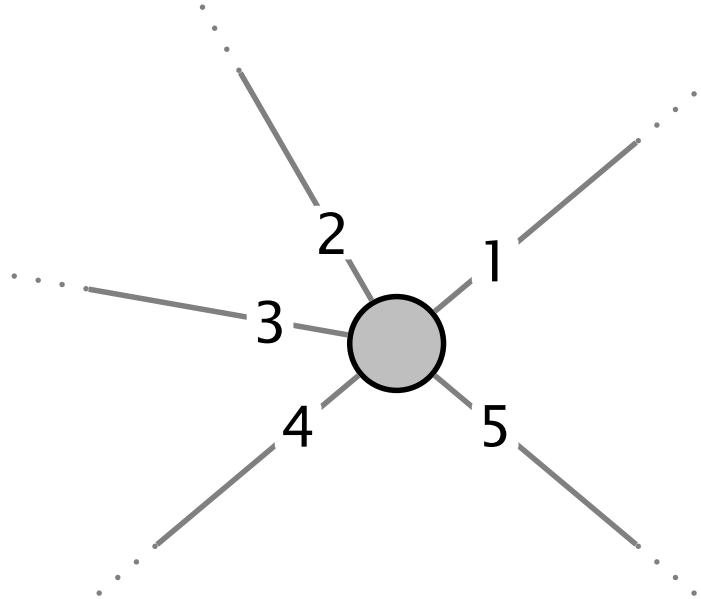

- Fundamental component of the network layer
- A *node in a graph*
- A finite set of input/output (physical) connections
  - a.k.a., *interfaces* or *ports*

Focus: “Datagram” Networks

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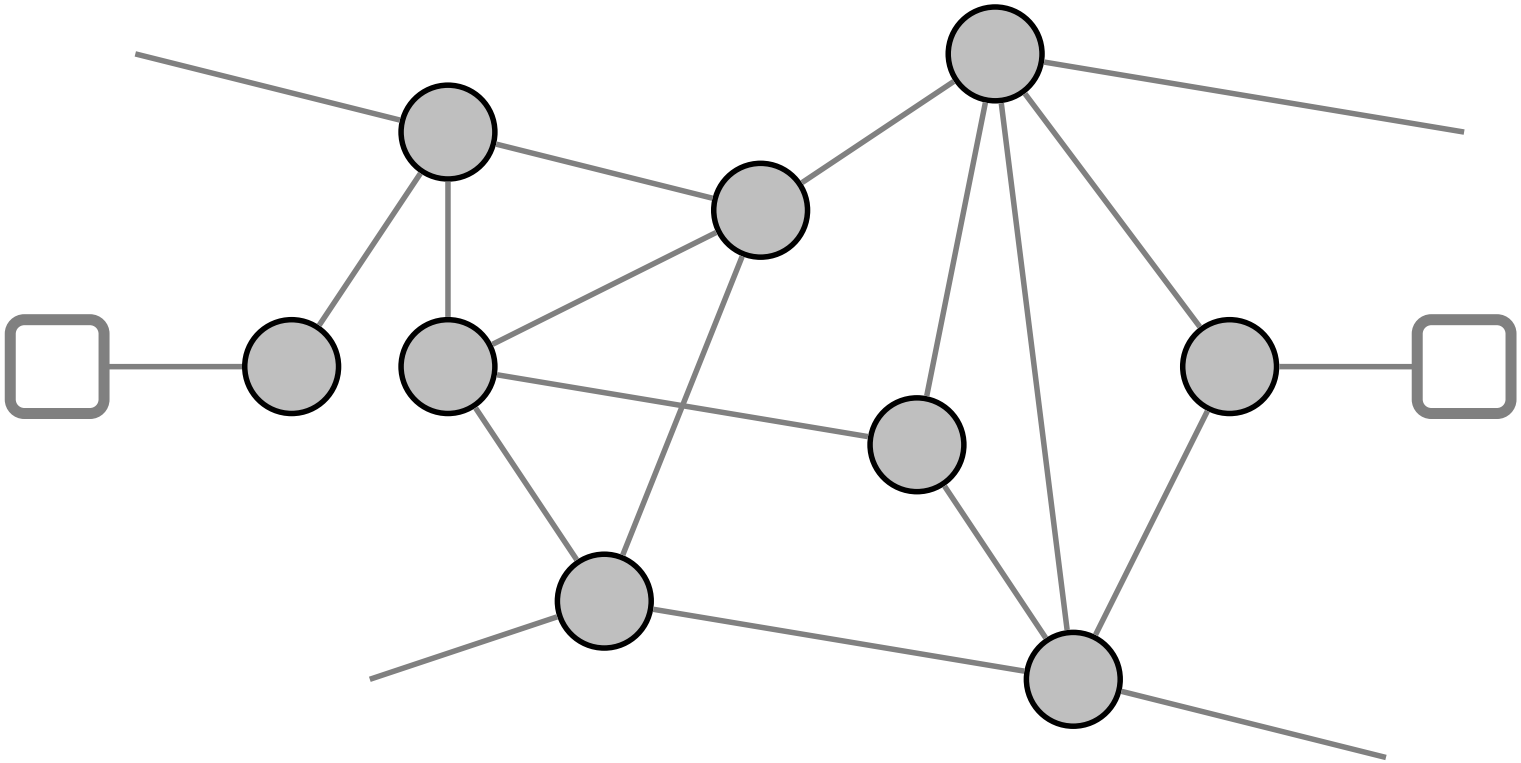

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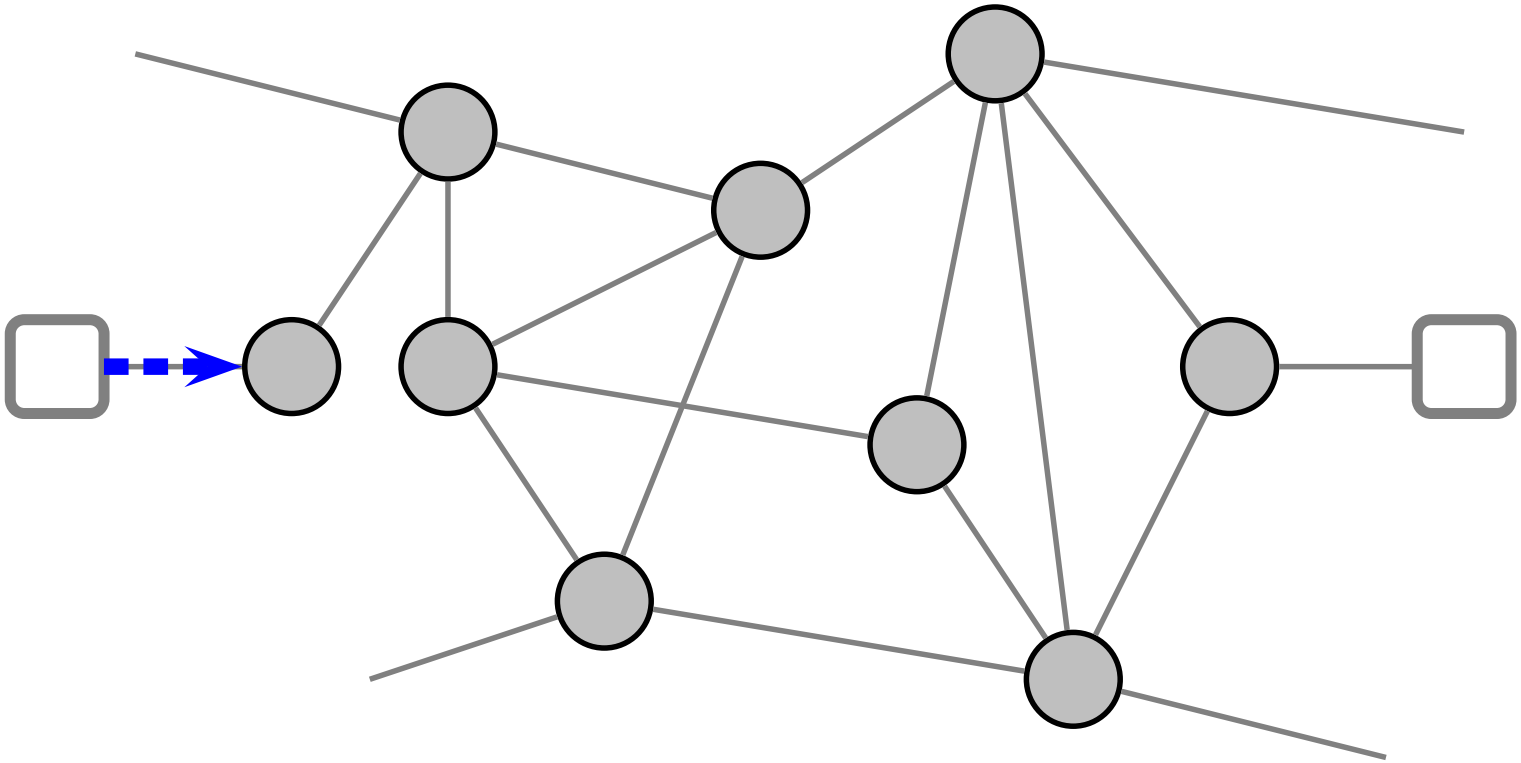

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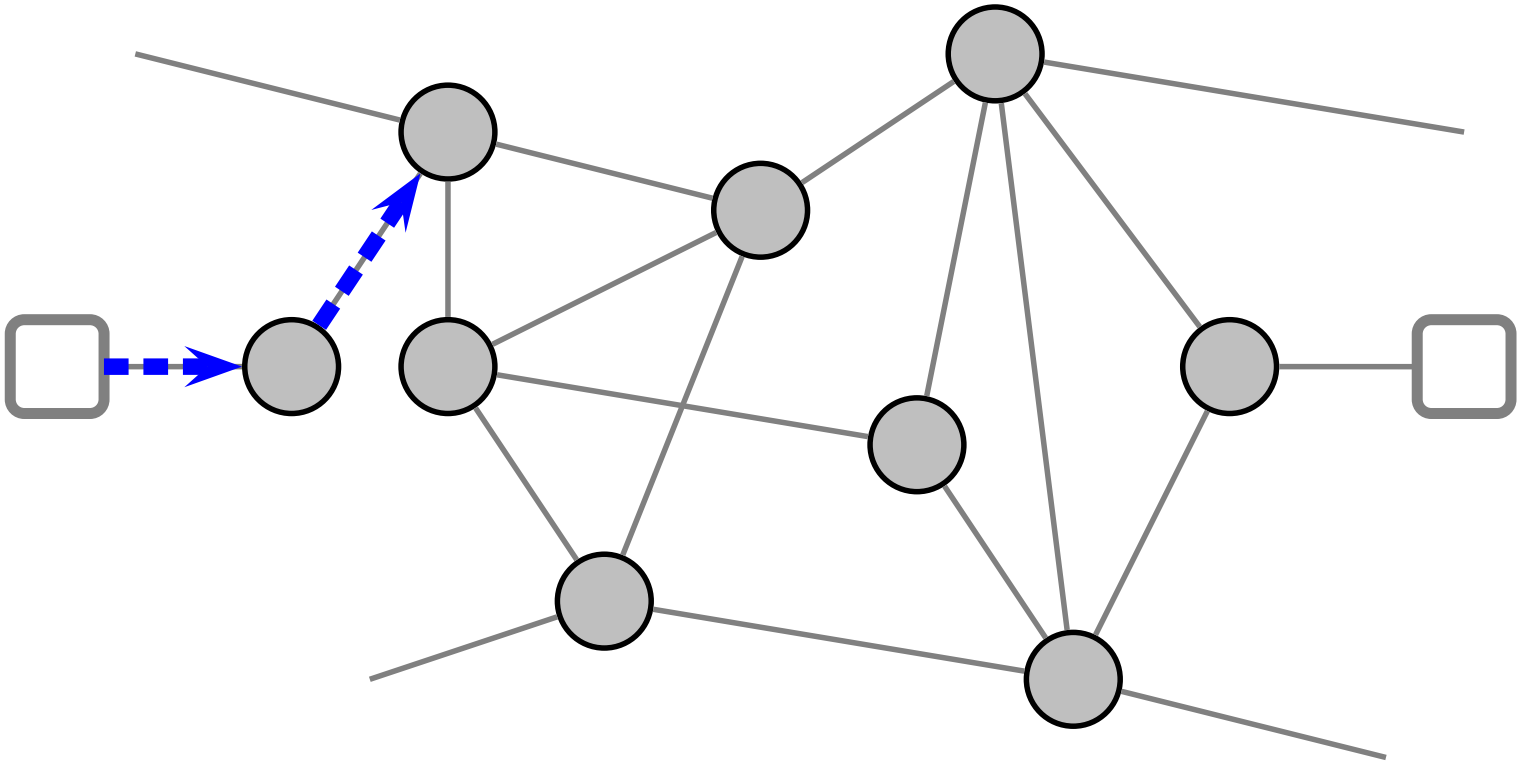

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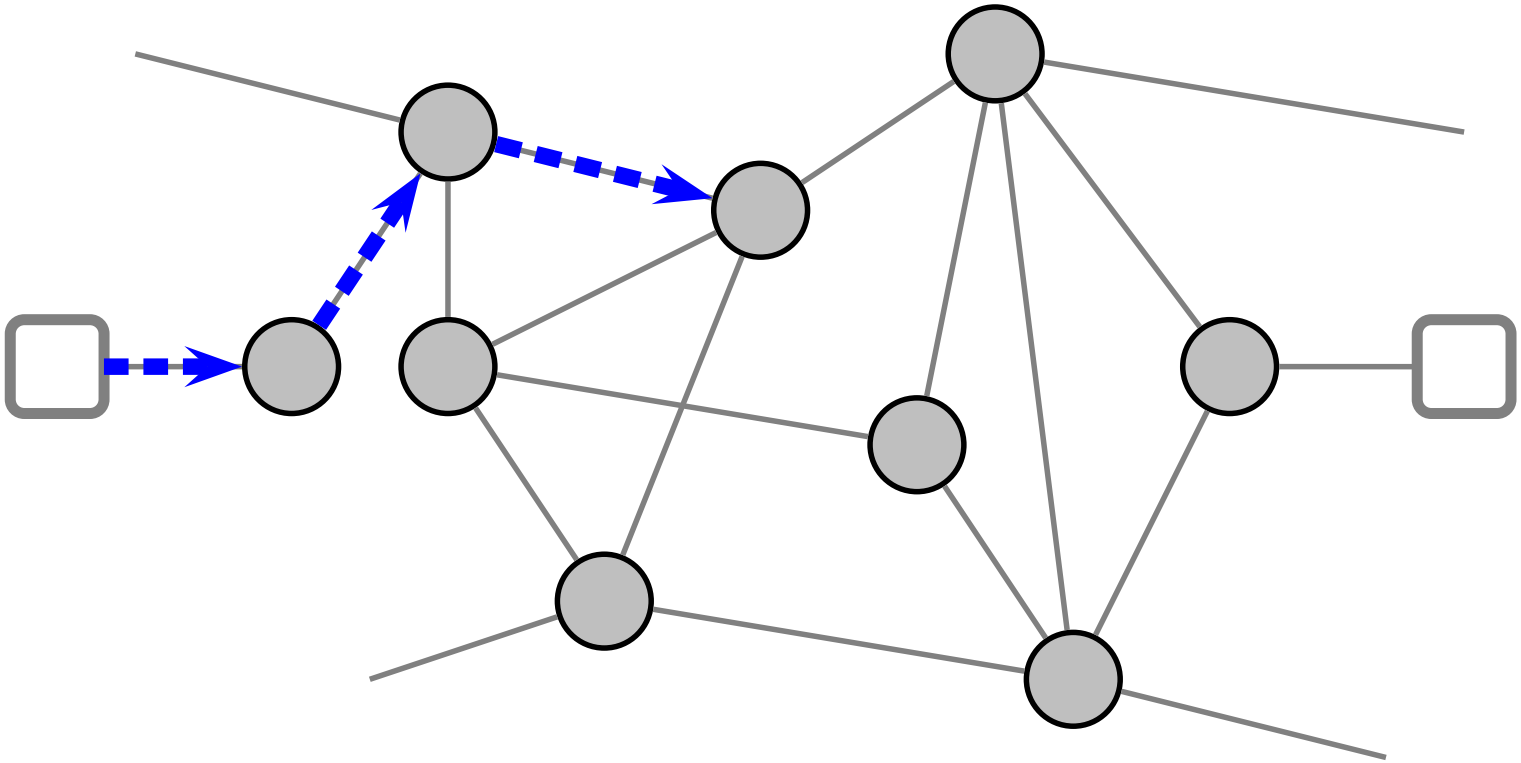

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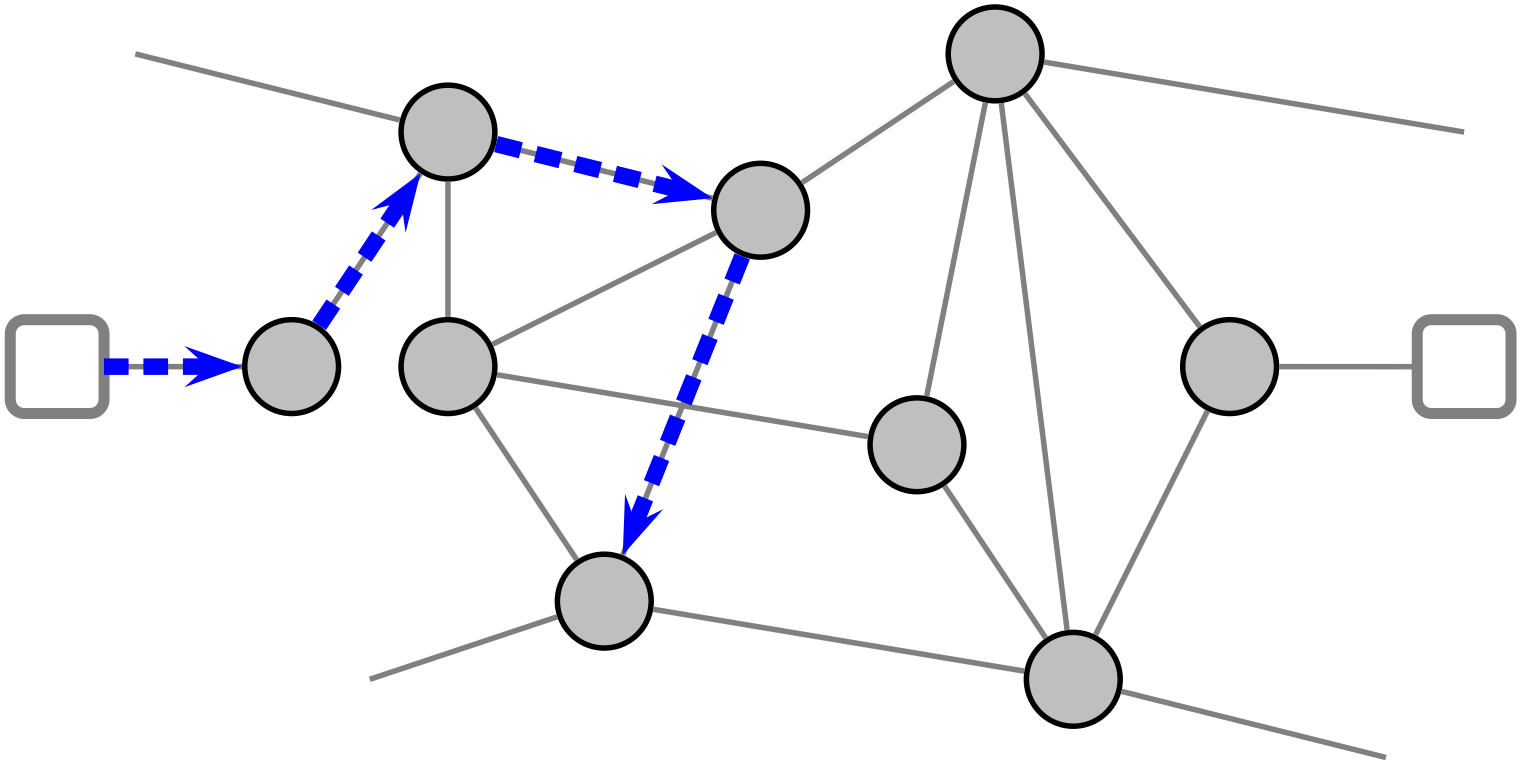

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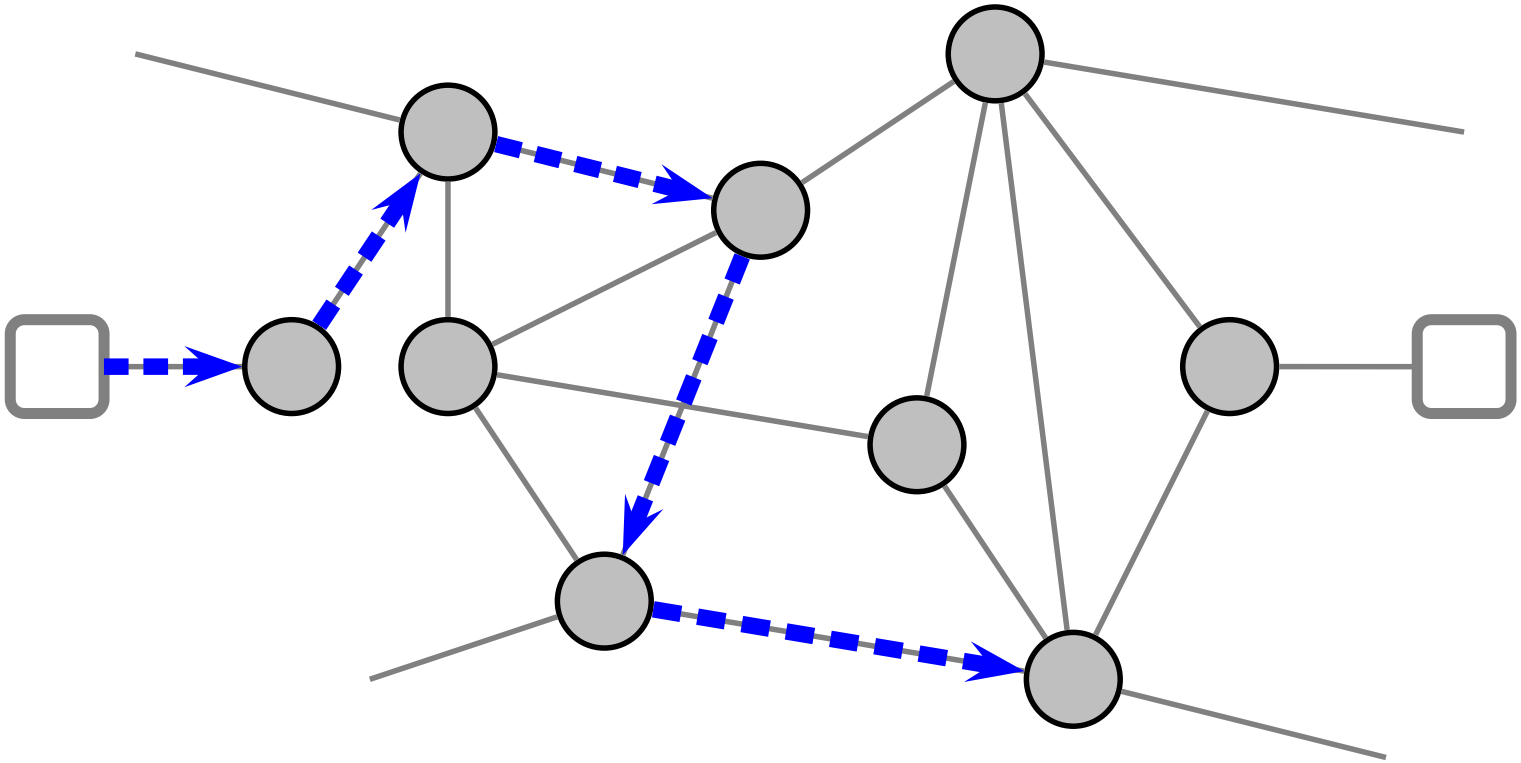

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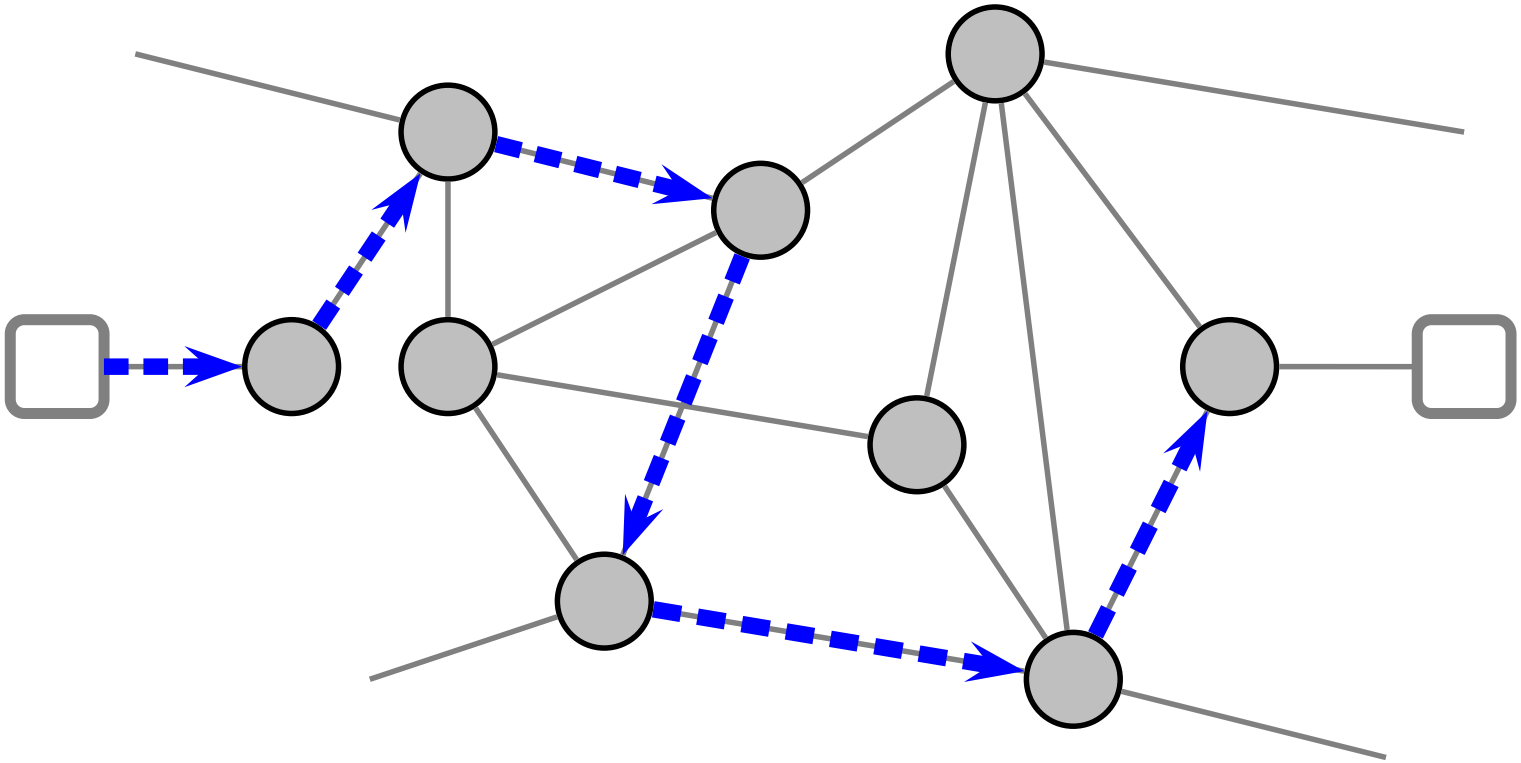

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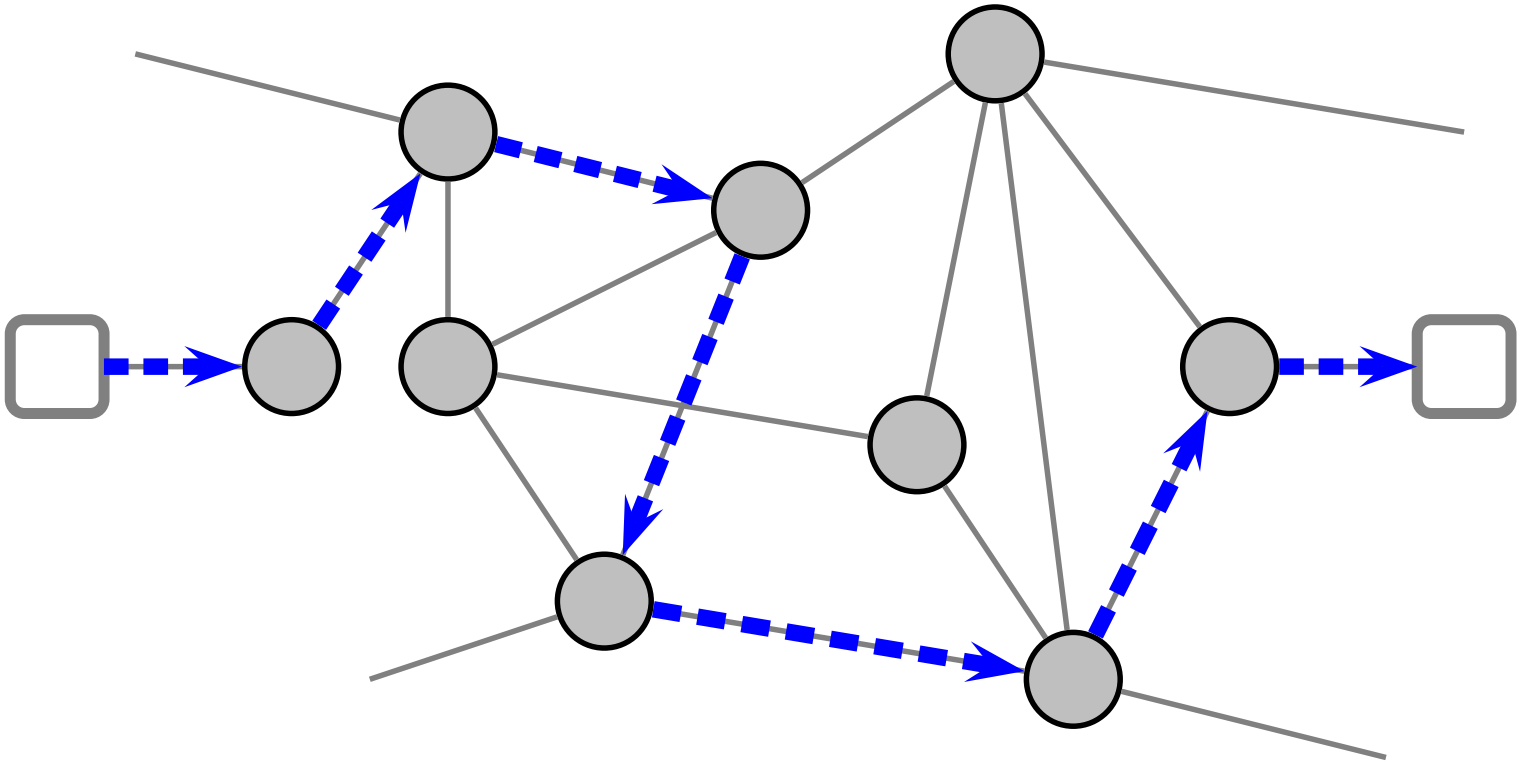

- Potentially *multiple paths* for the same source/destination

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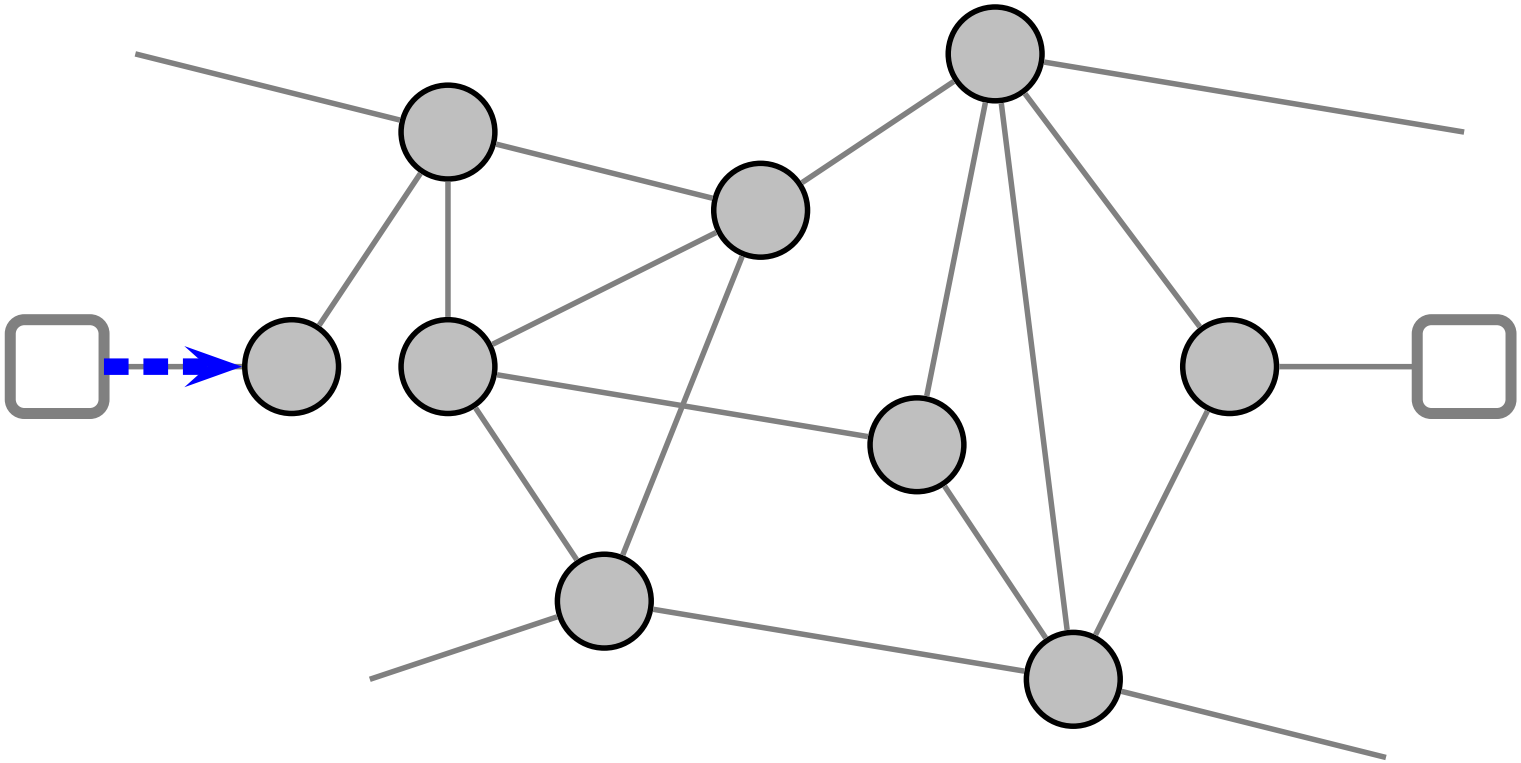

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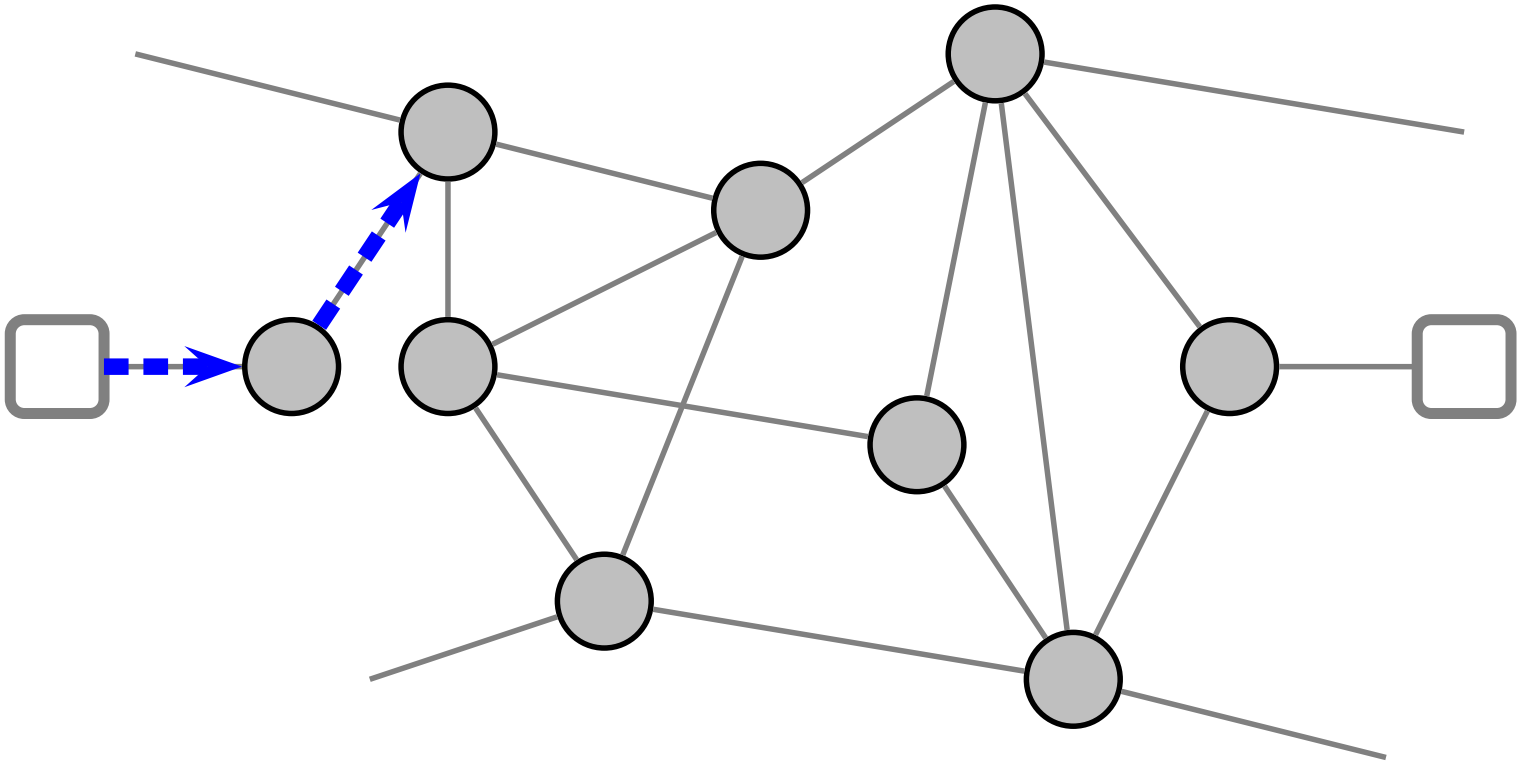

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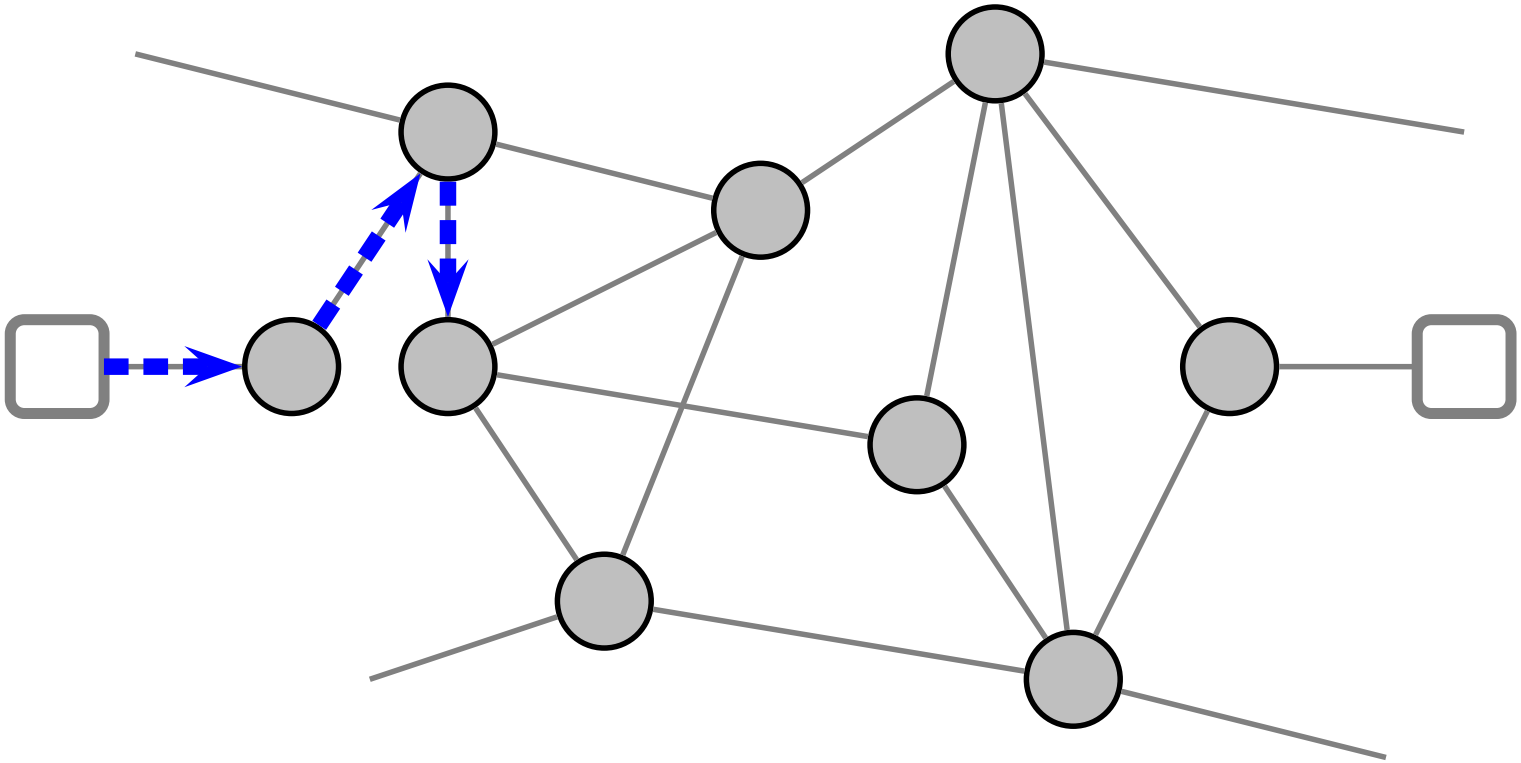

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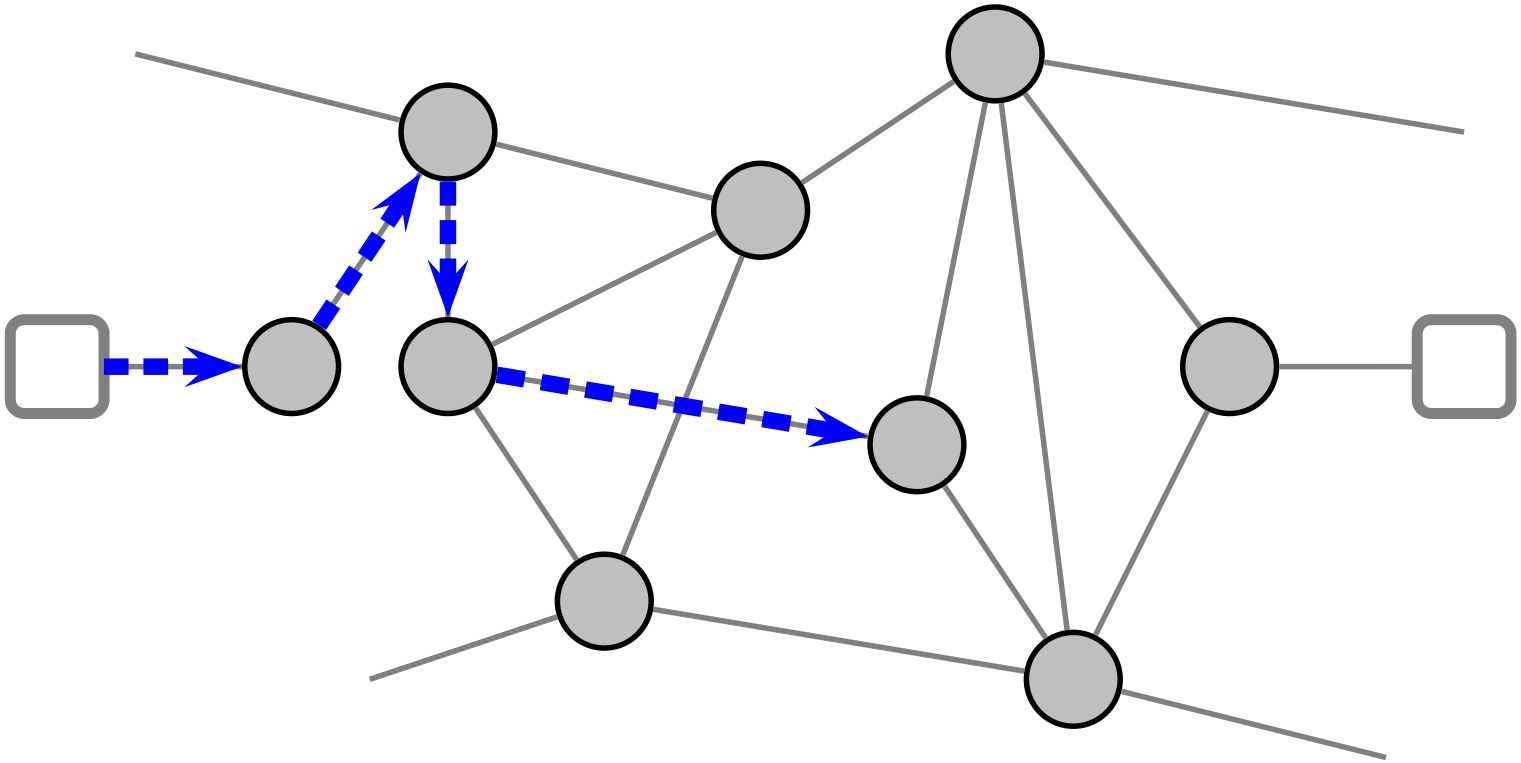

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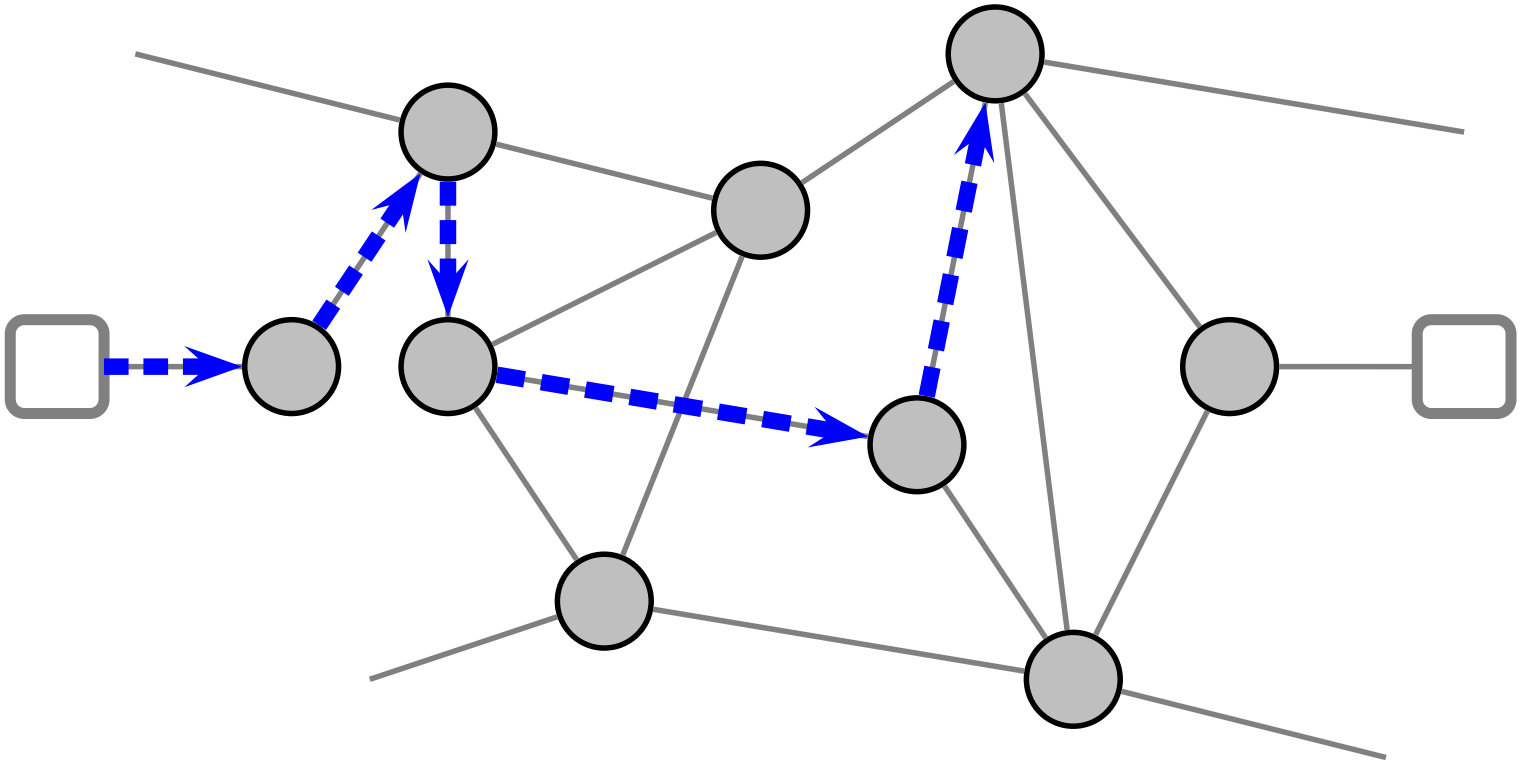

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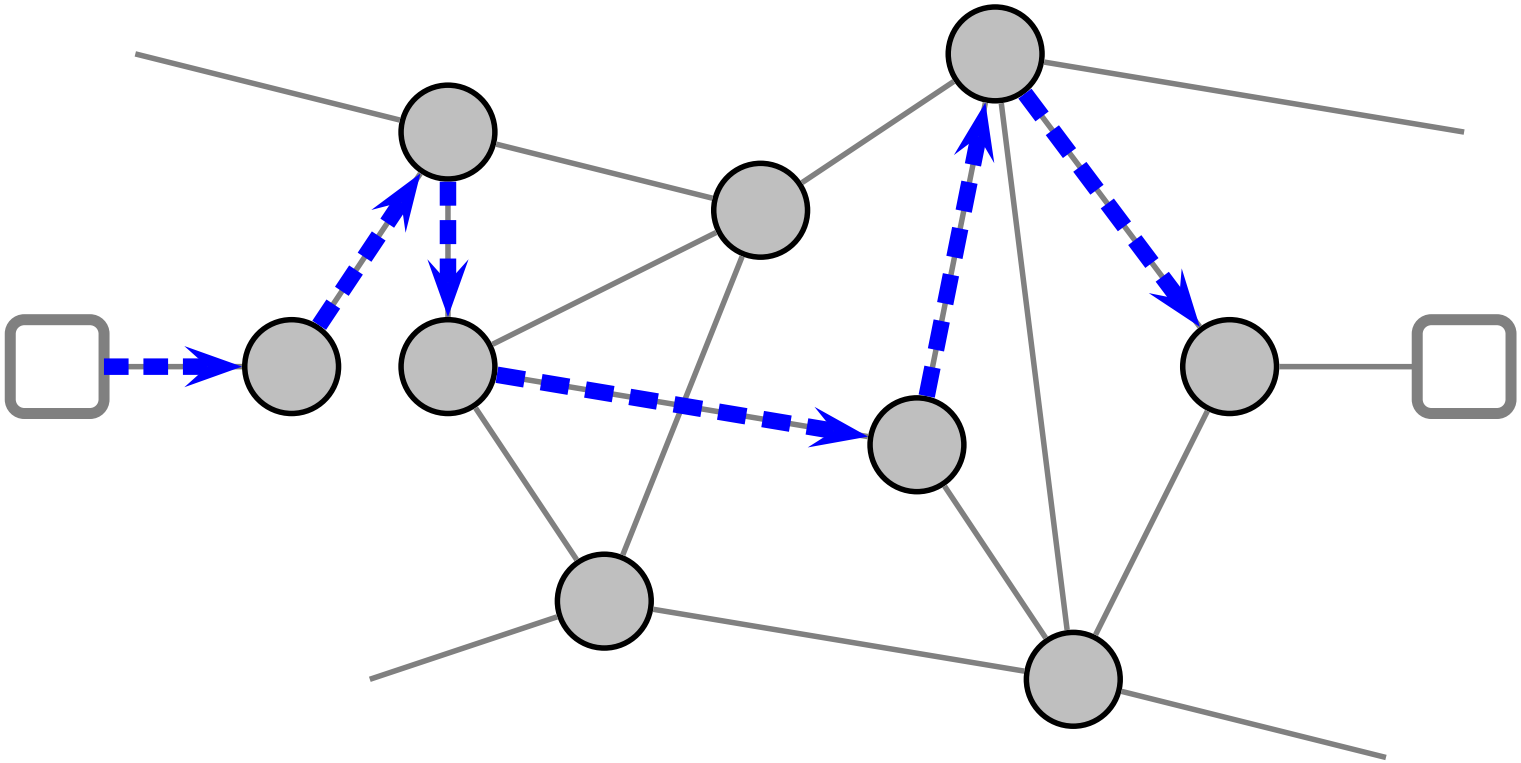

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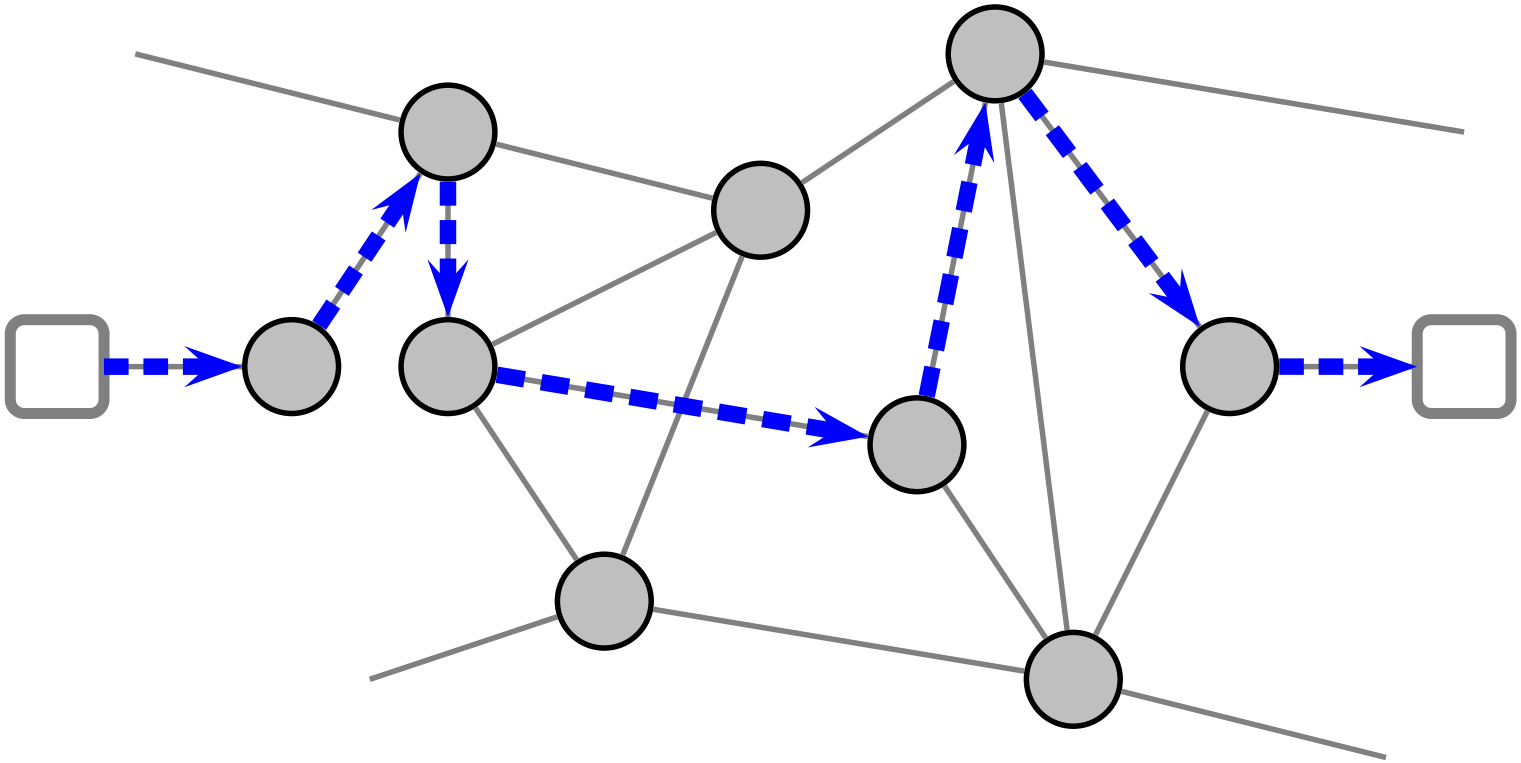

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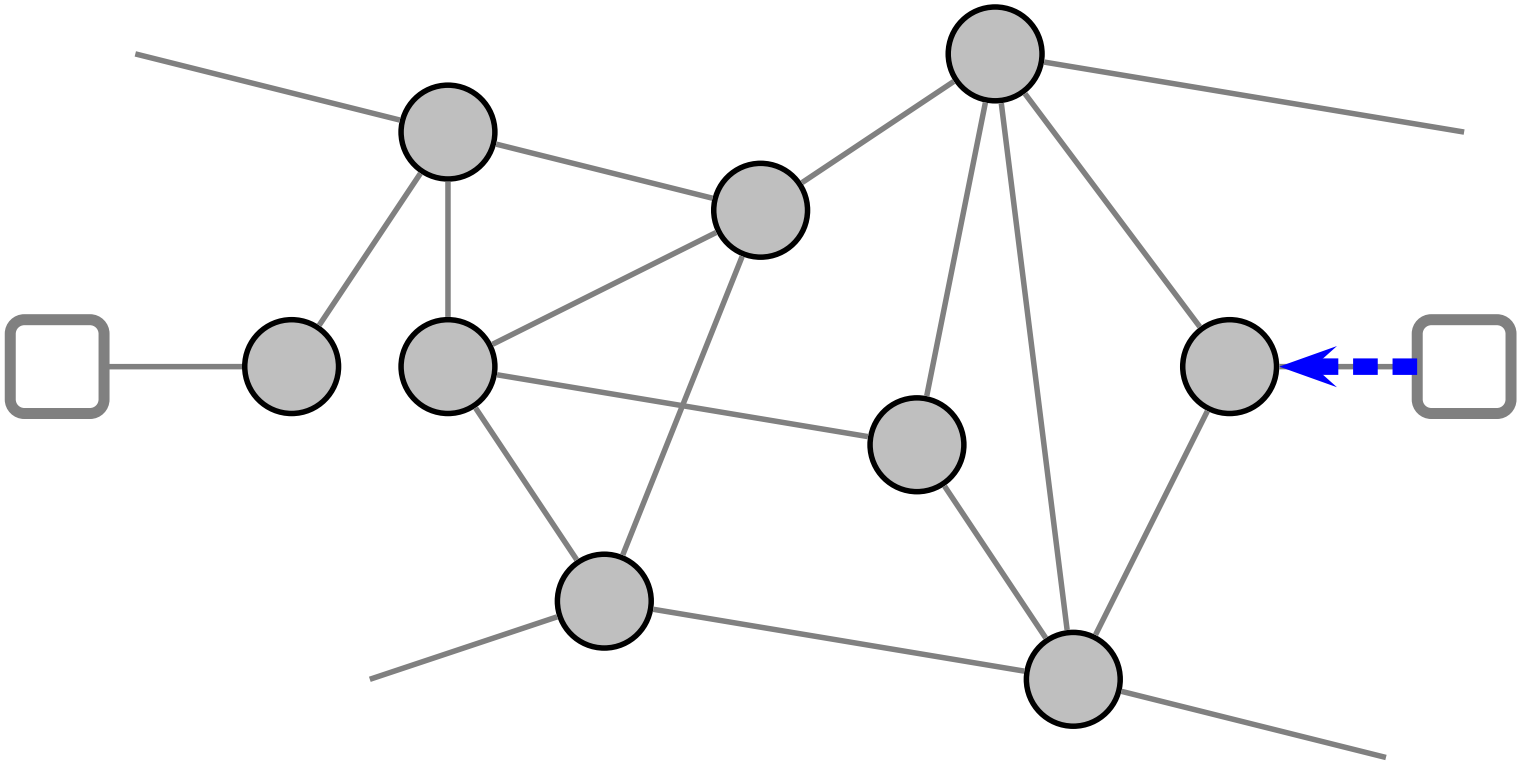

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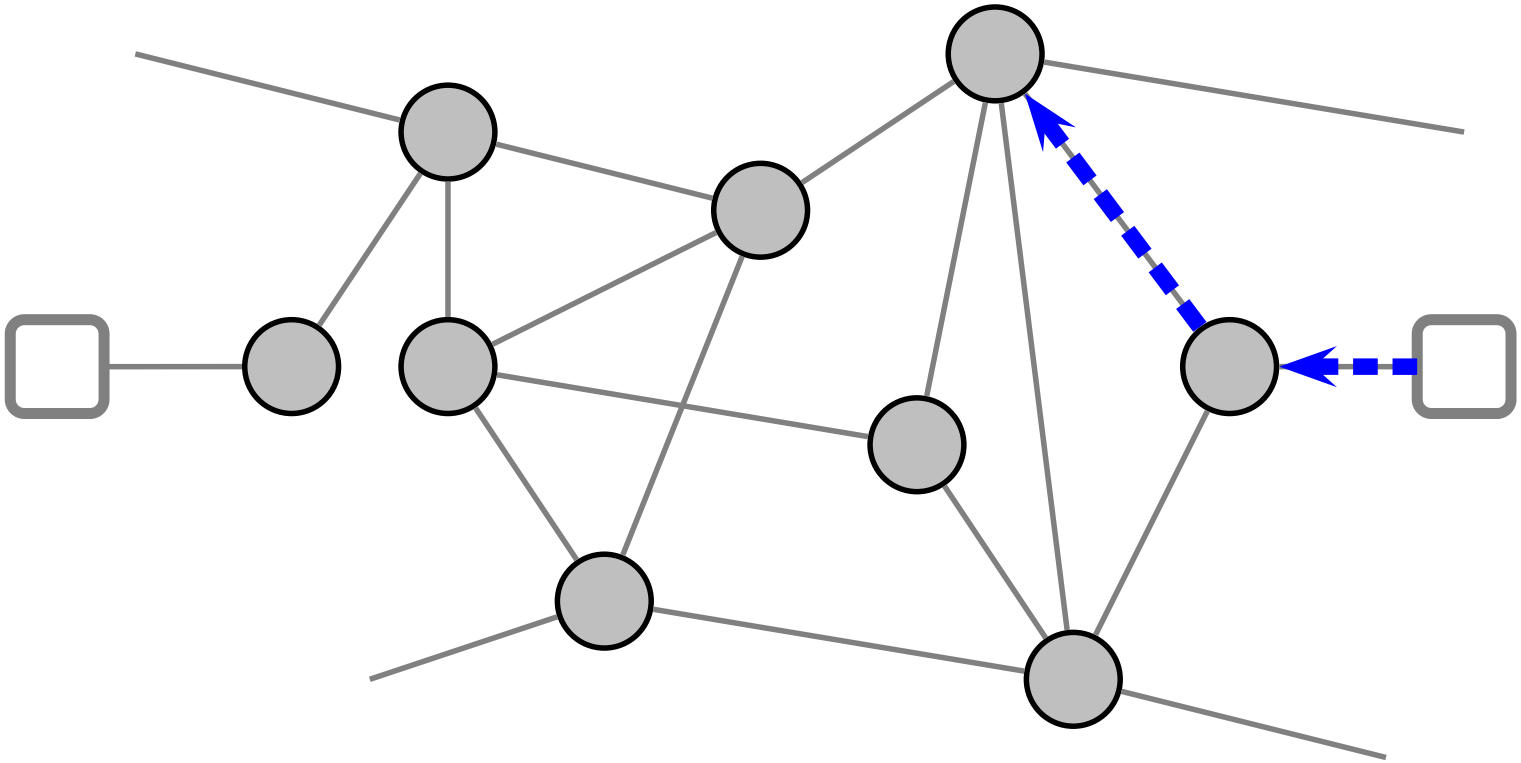

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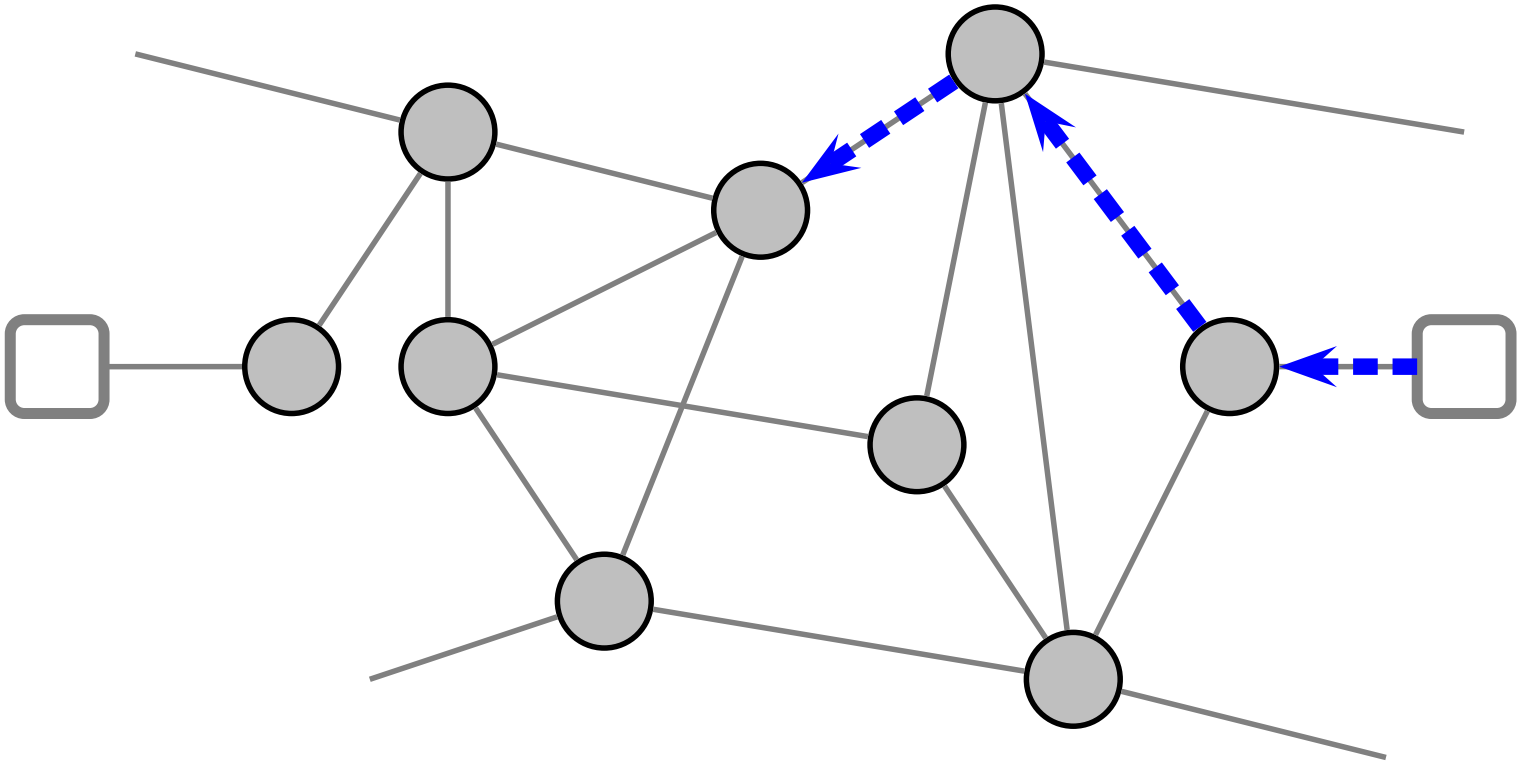

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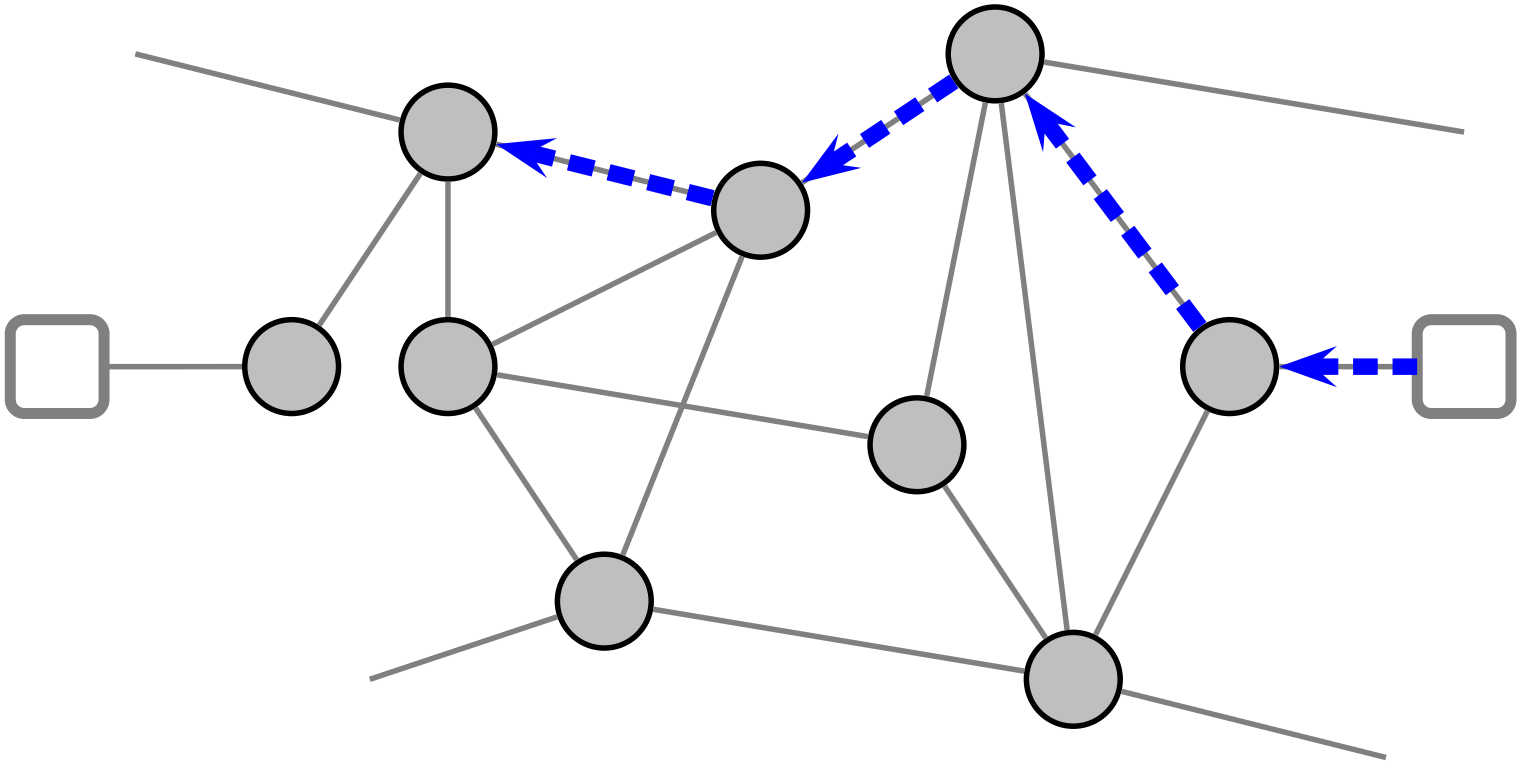

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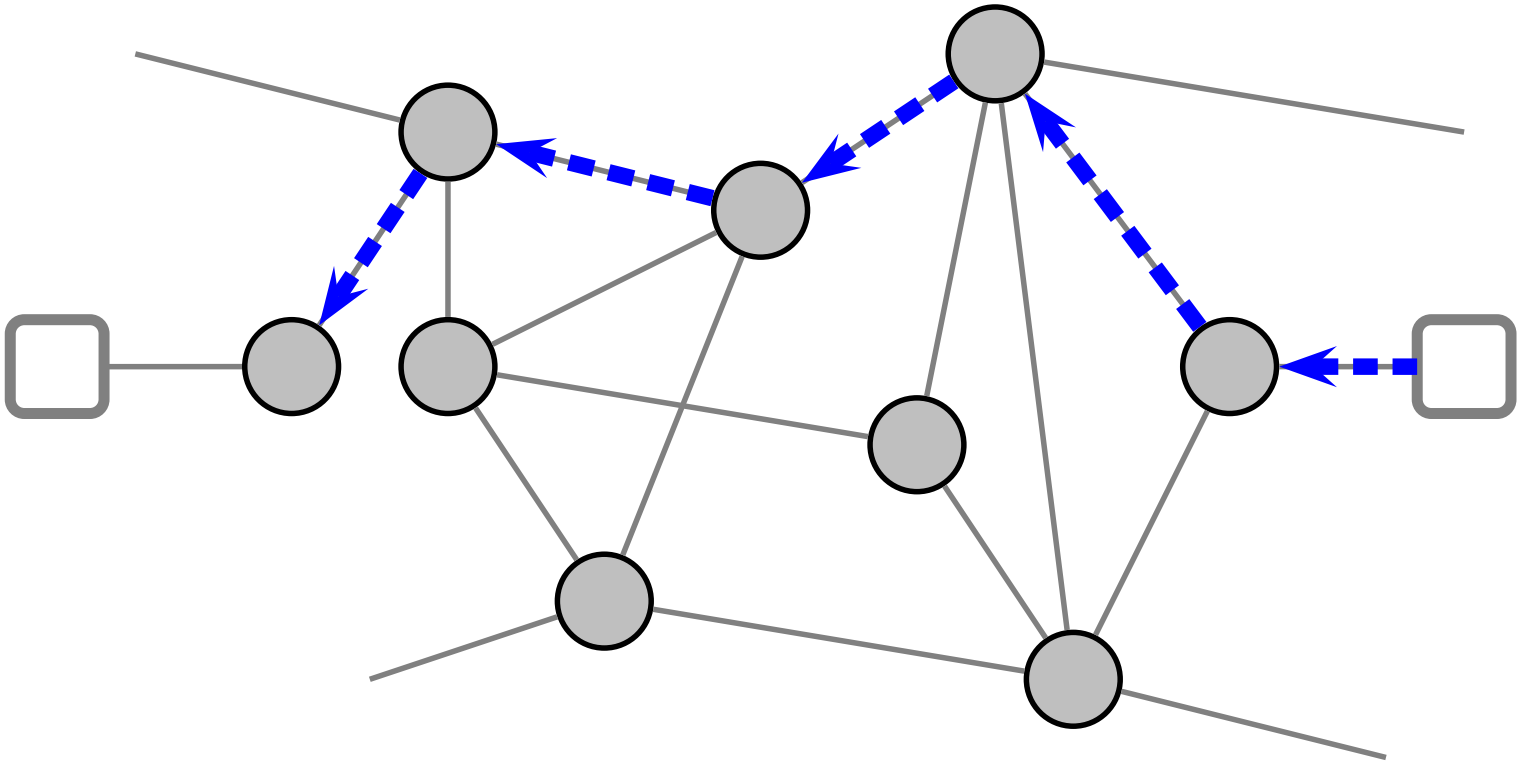

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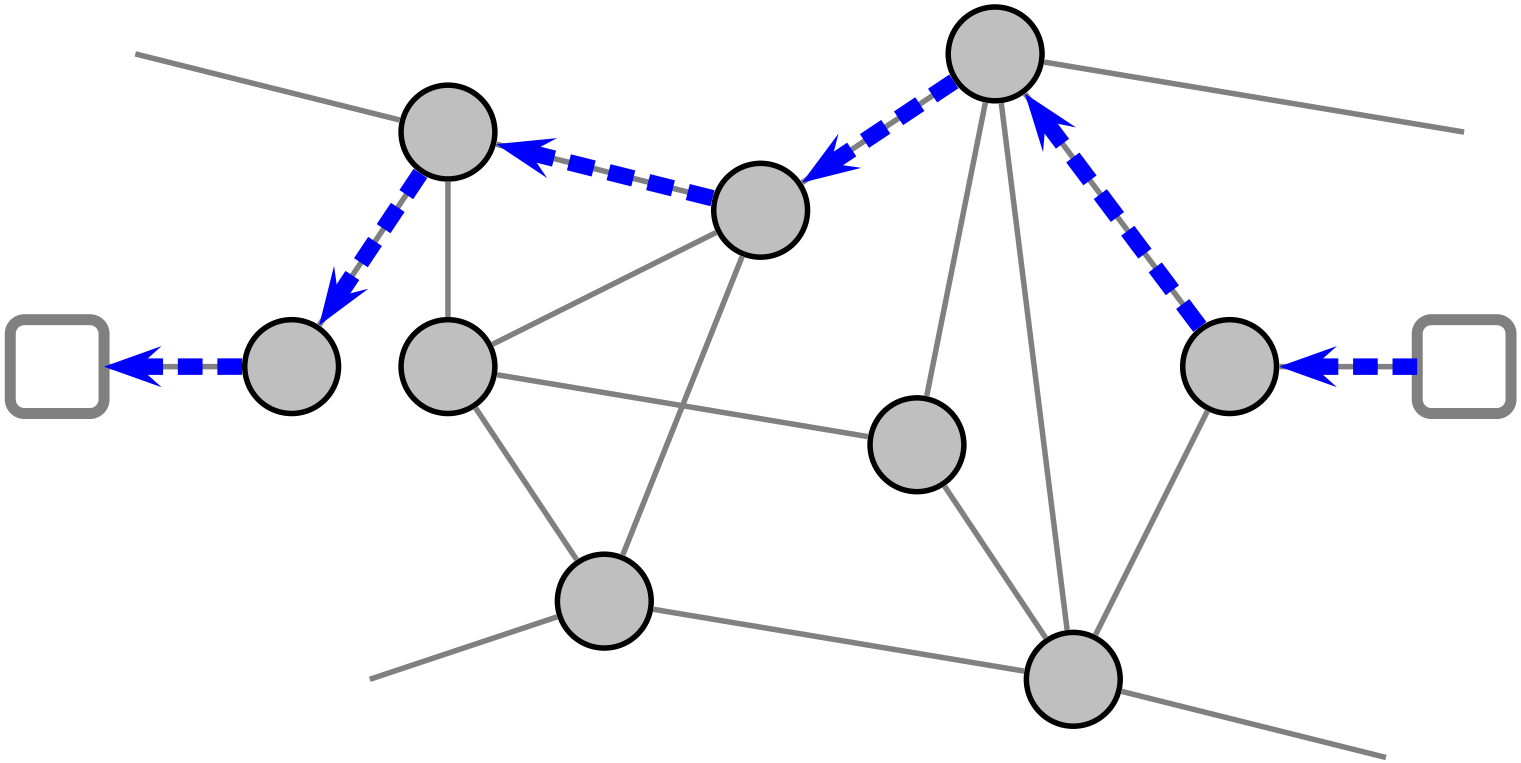

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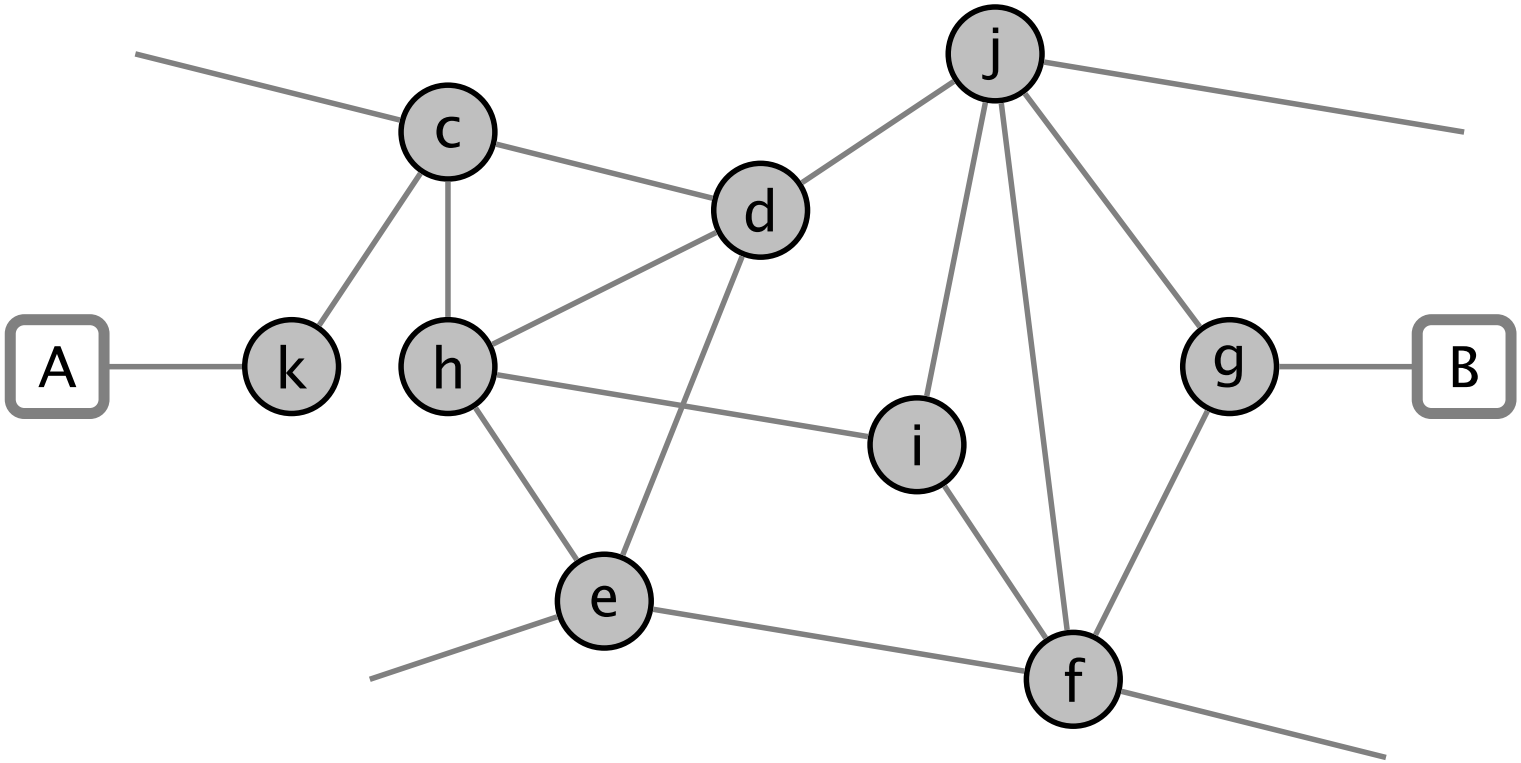

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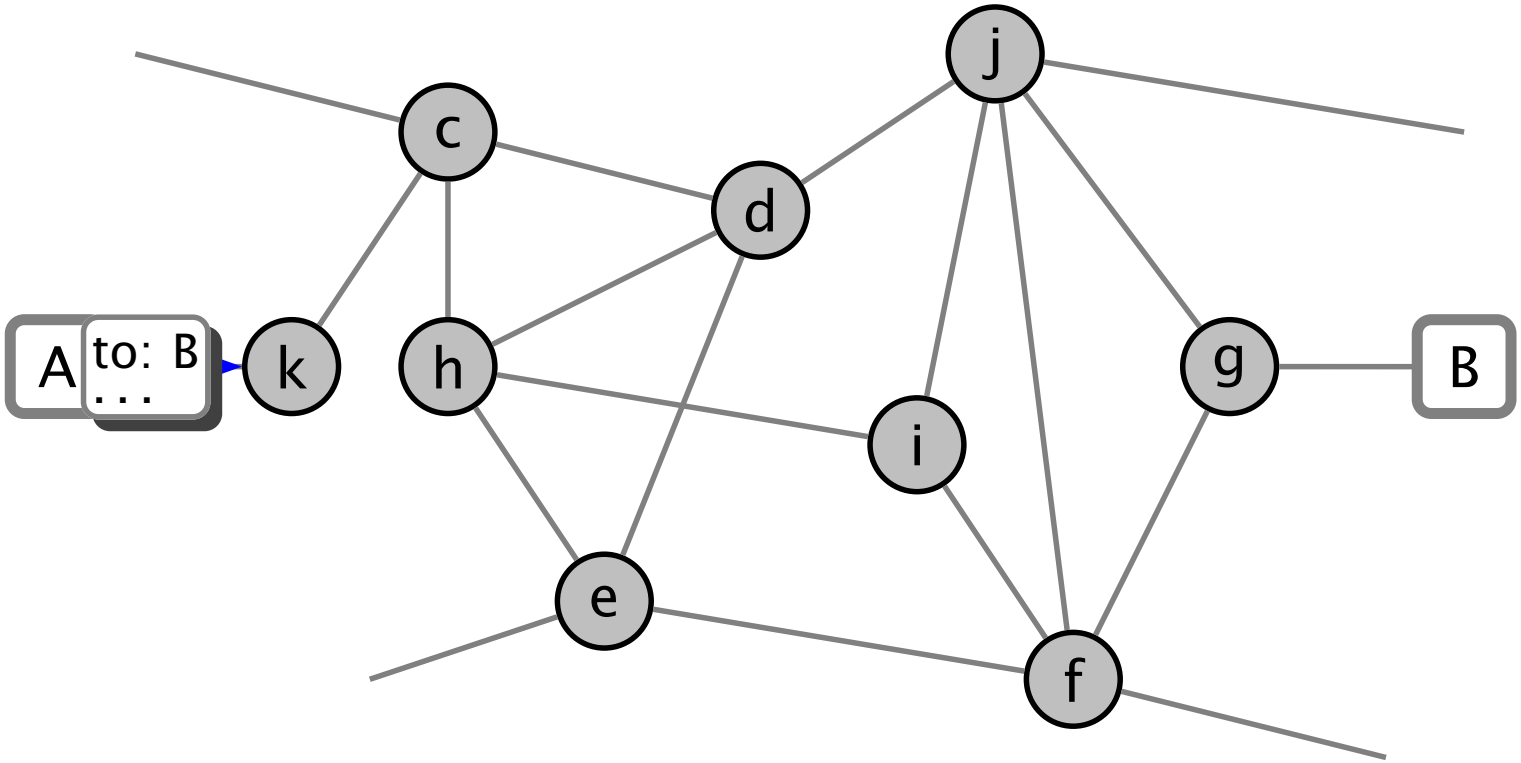

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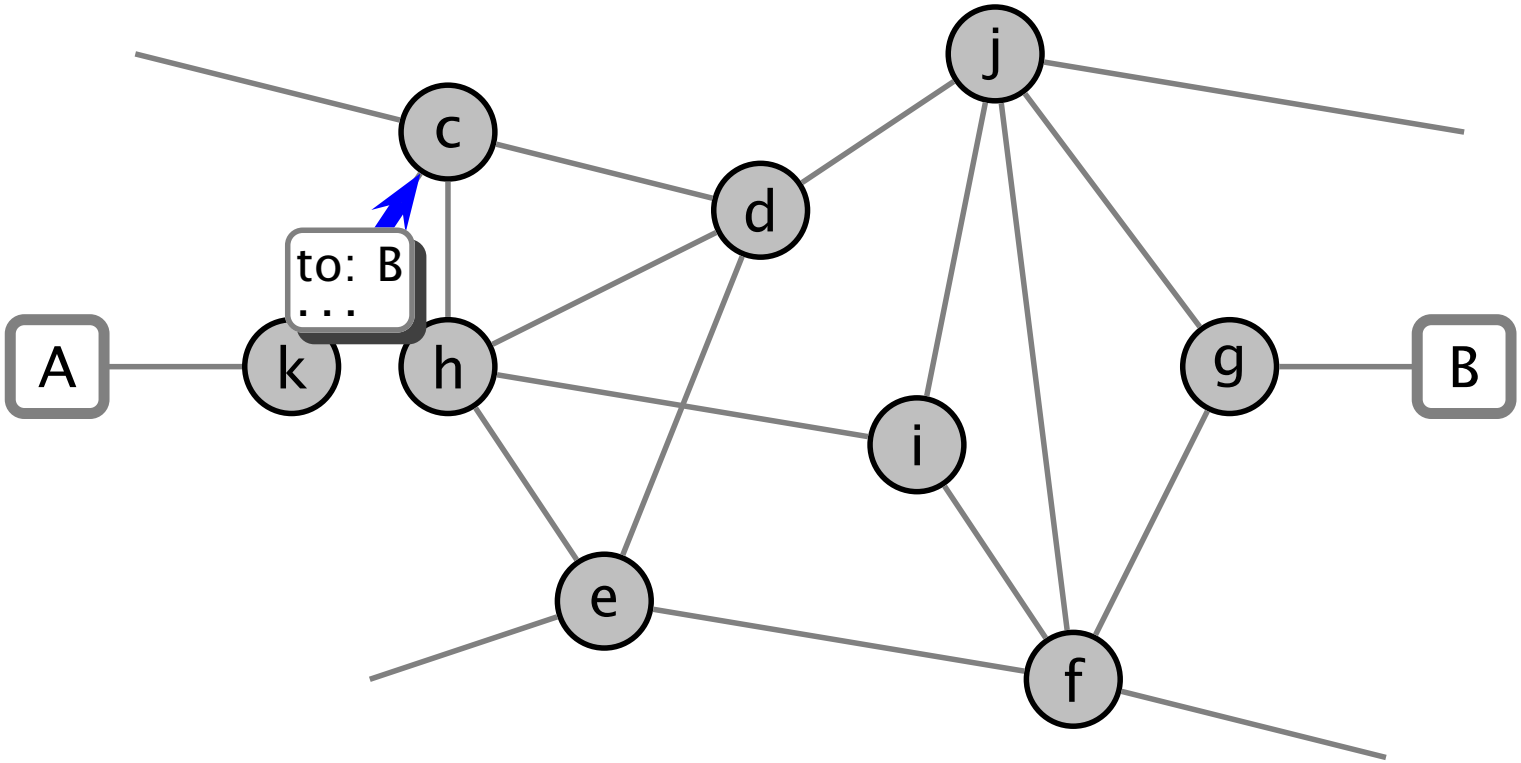

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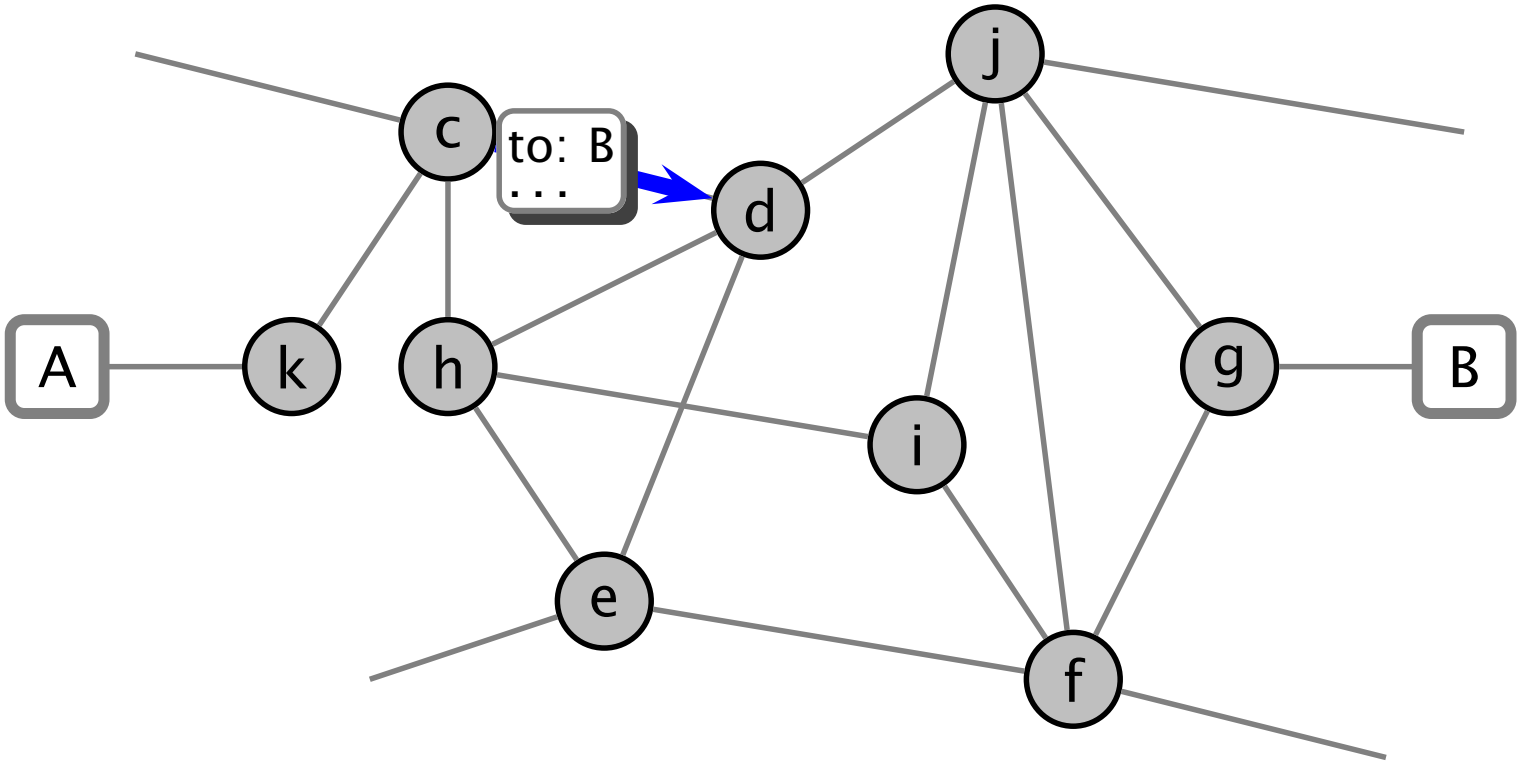

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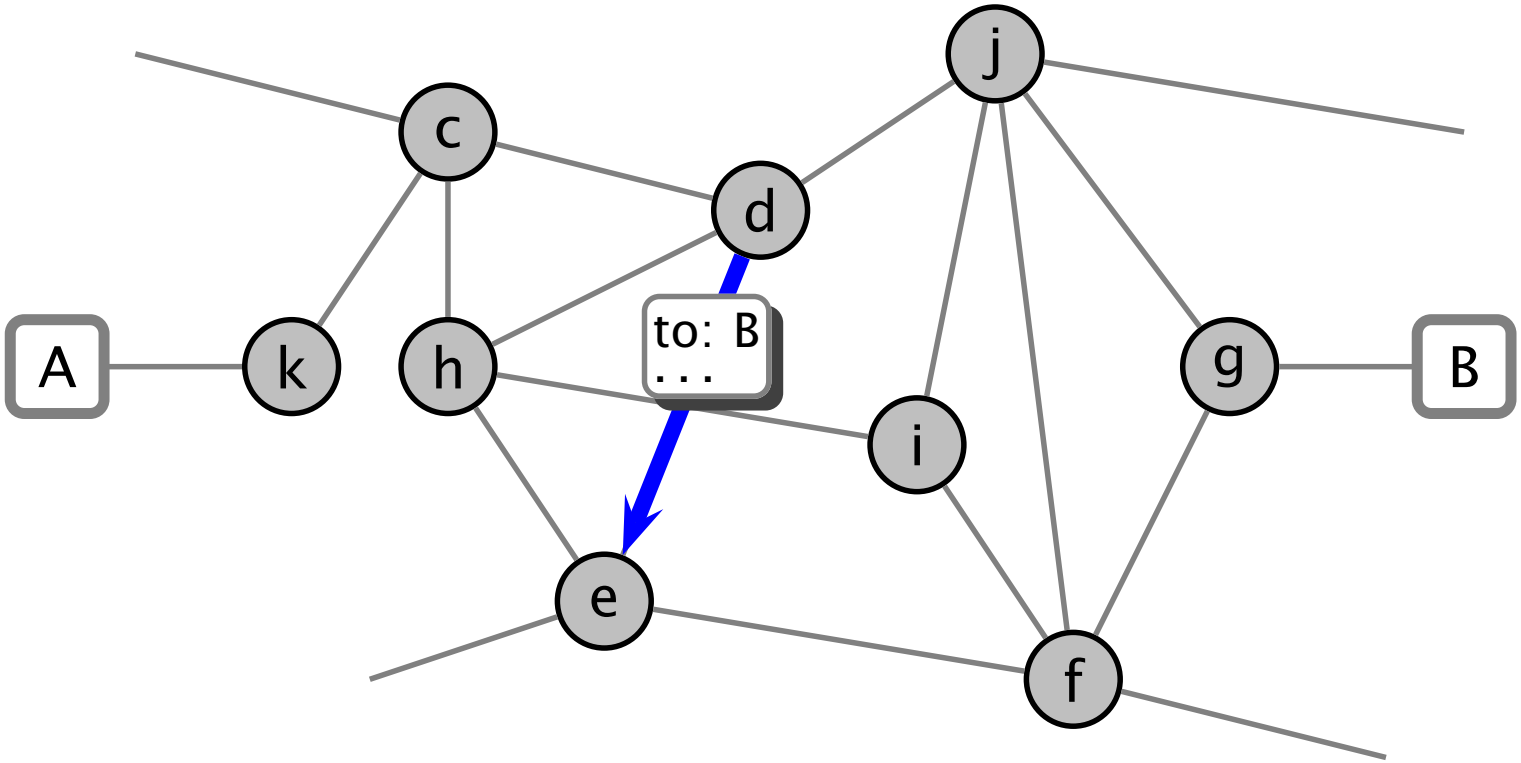

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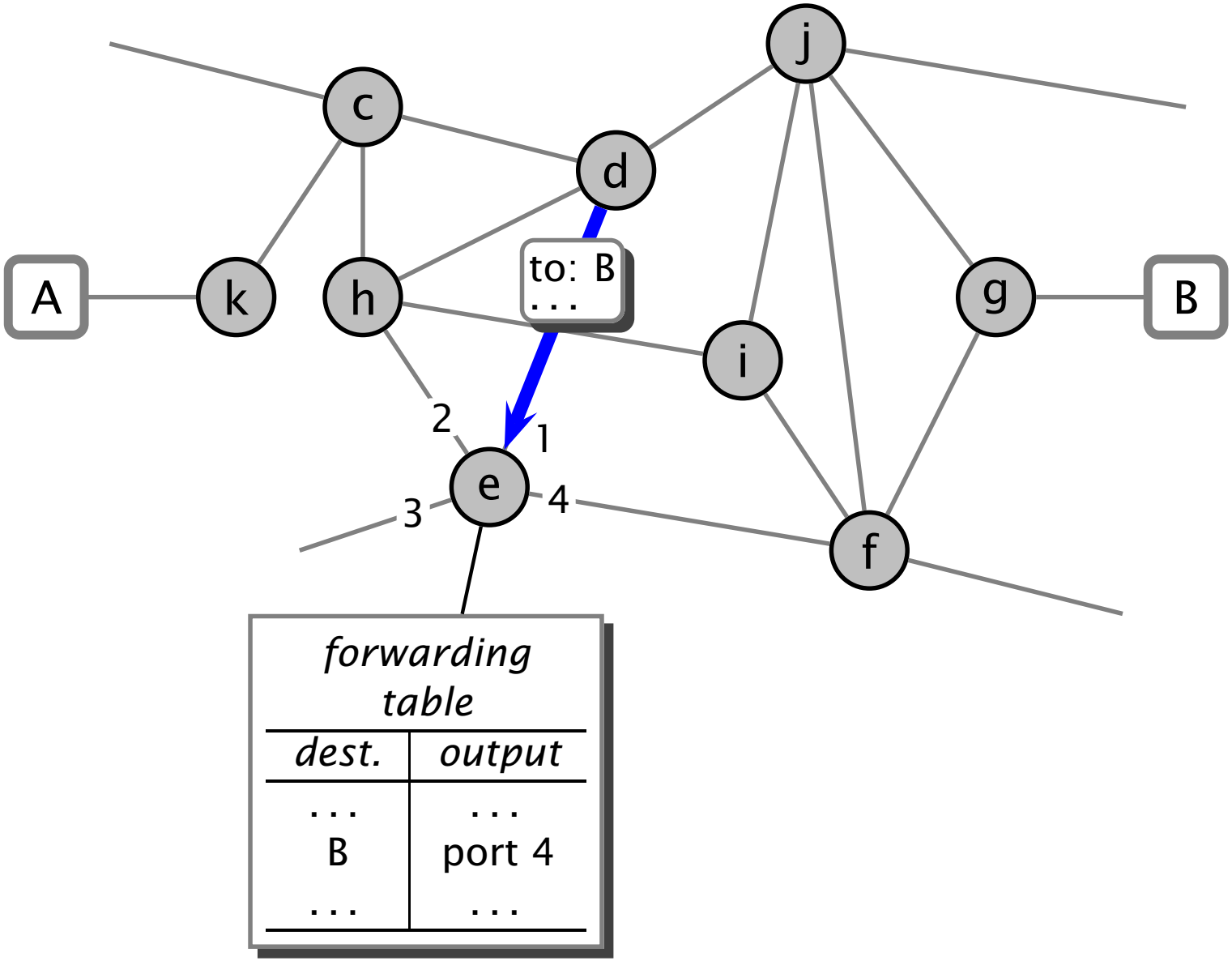

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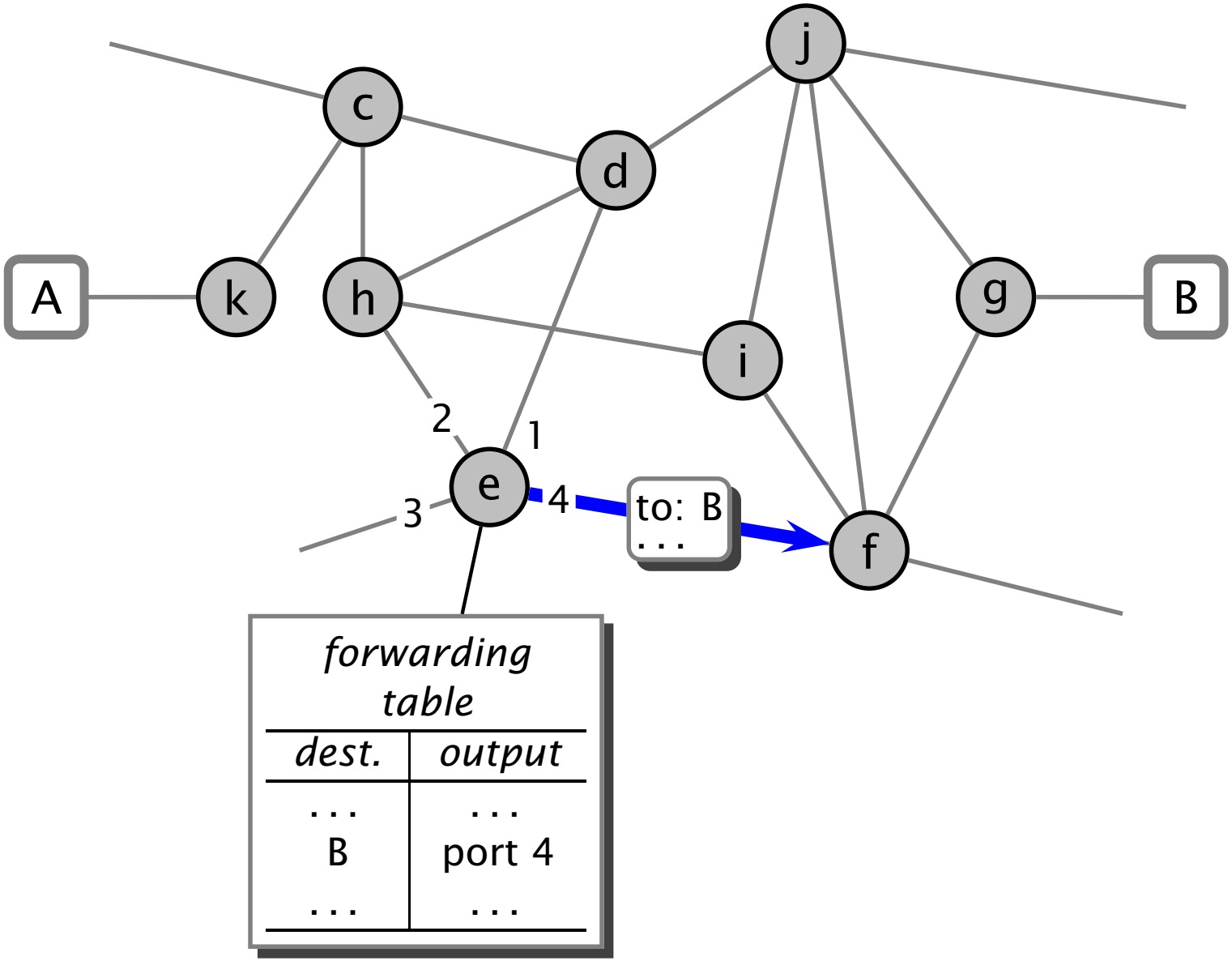

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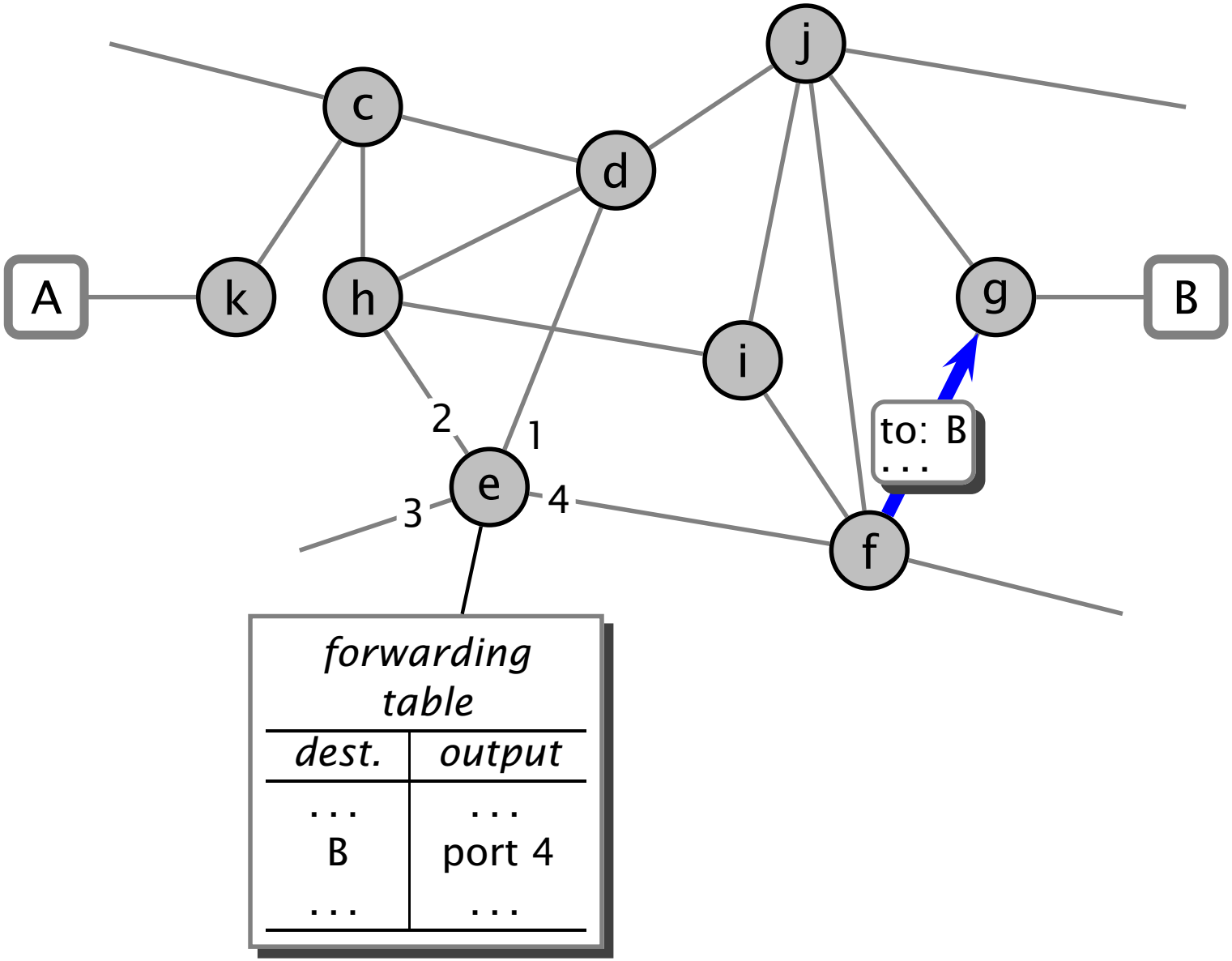

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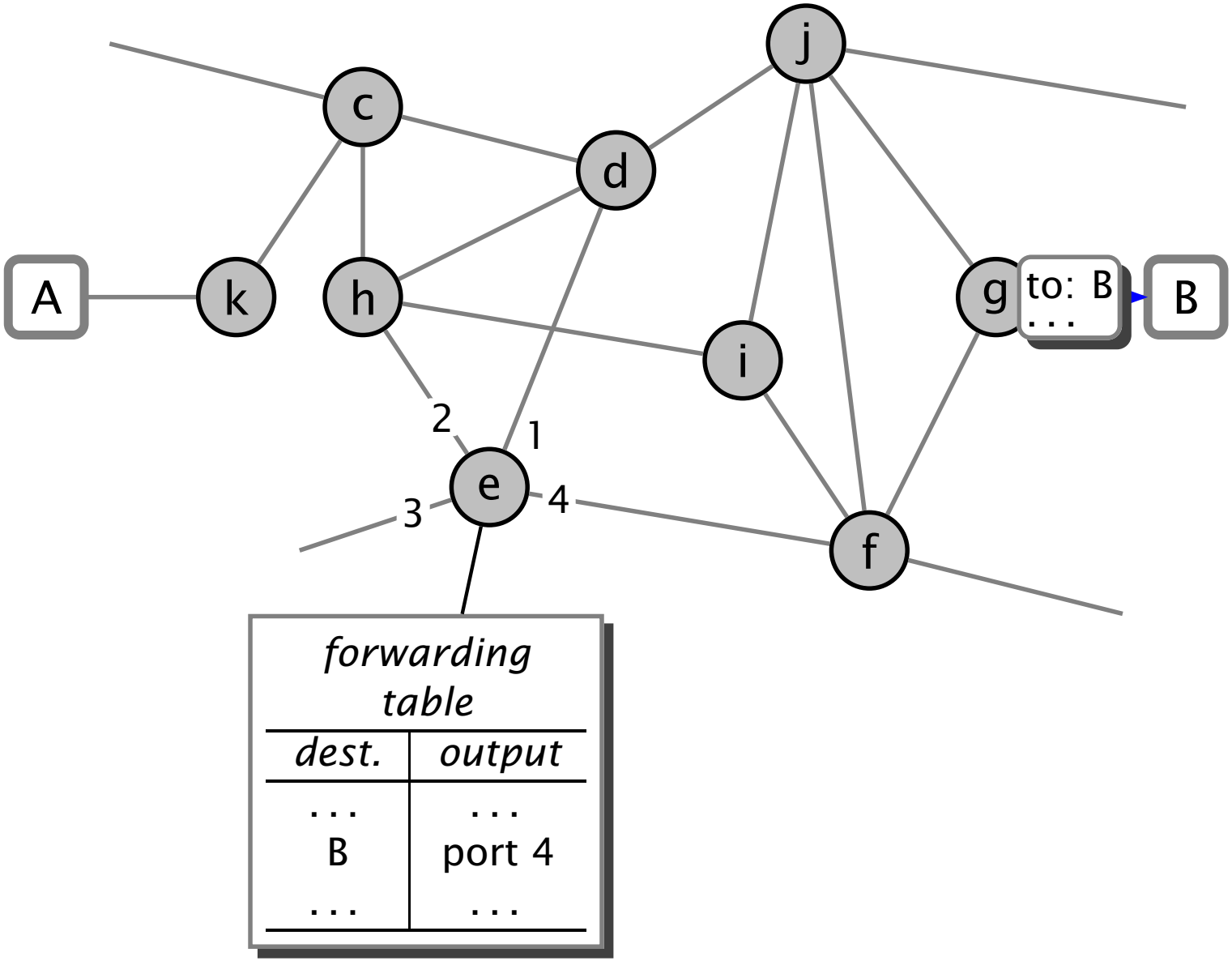

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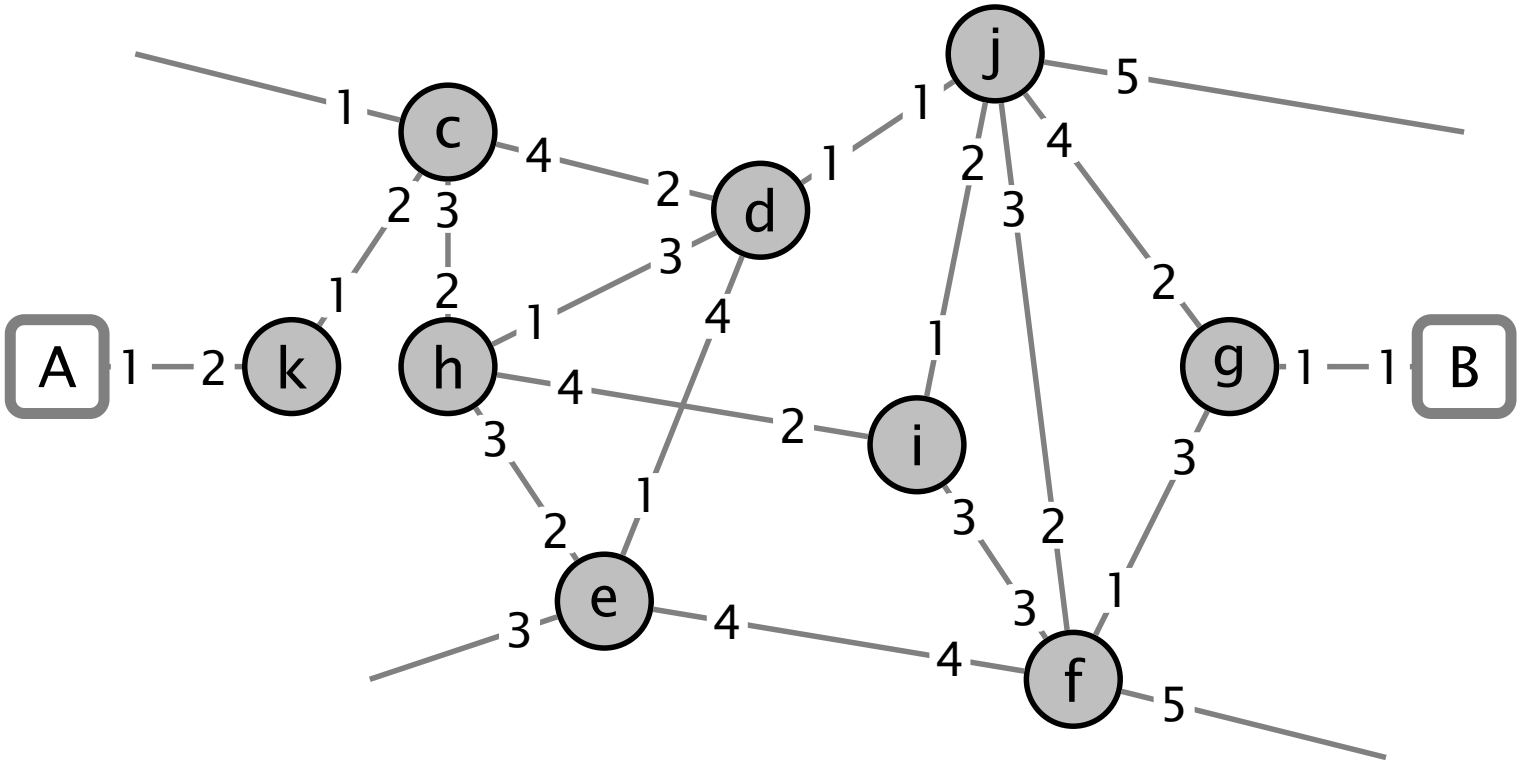

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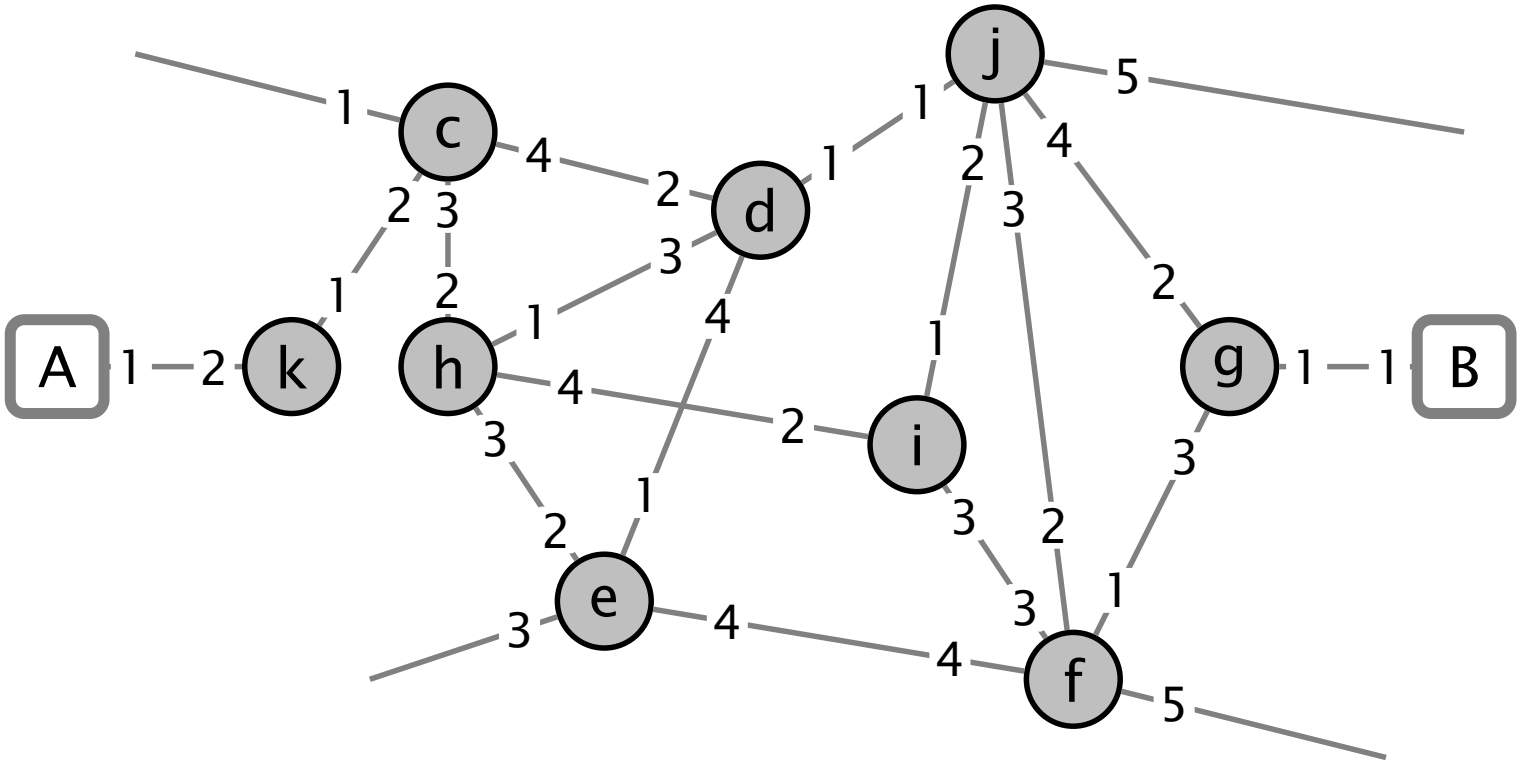

router k	
A	2
B	1

. . .

Router Functions

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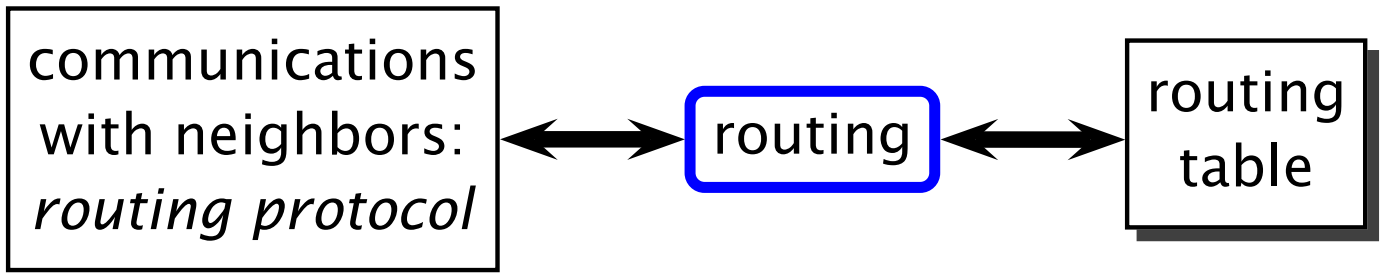

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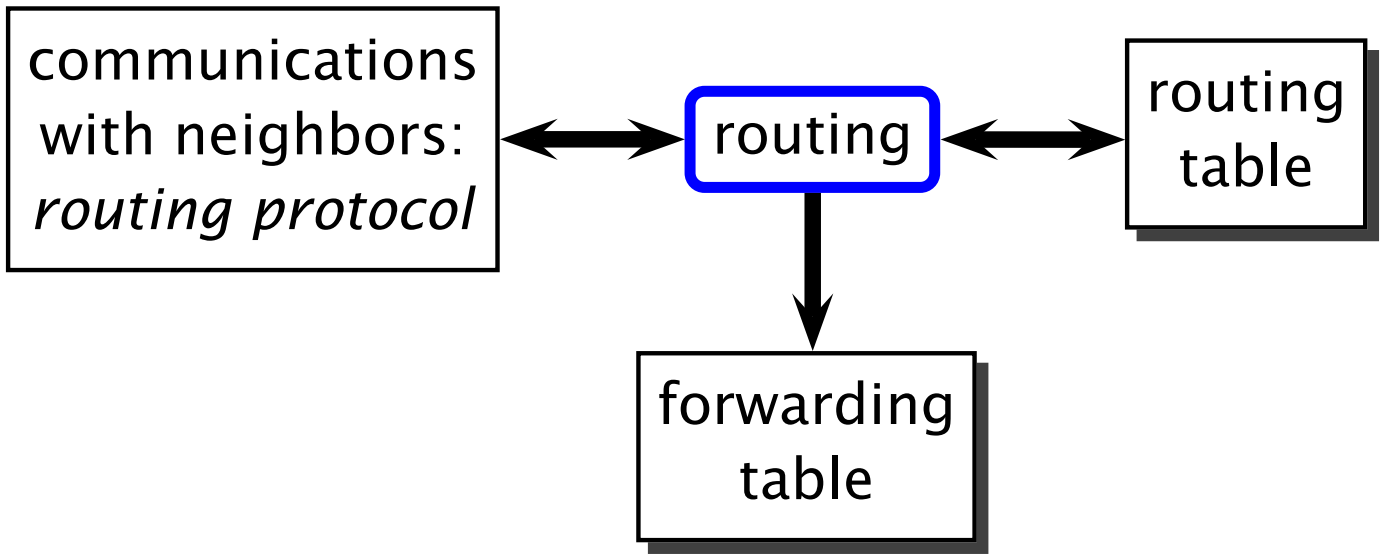

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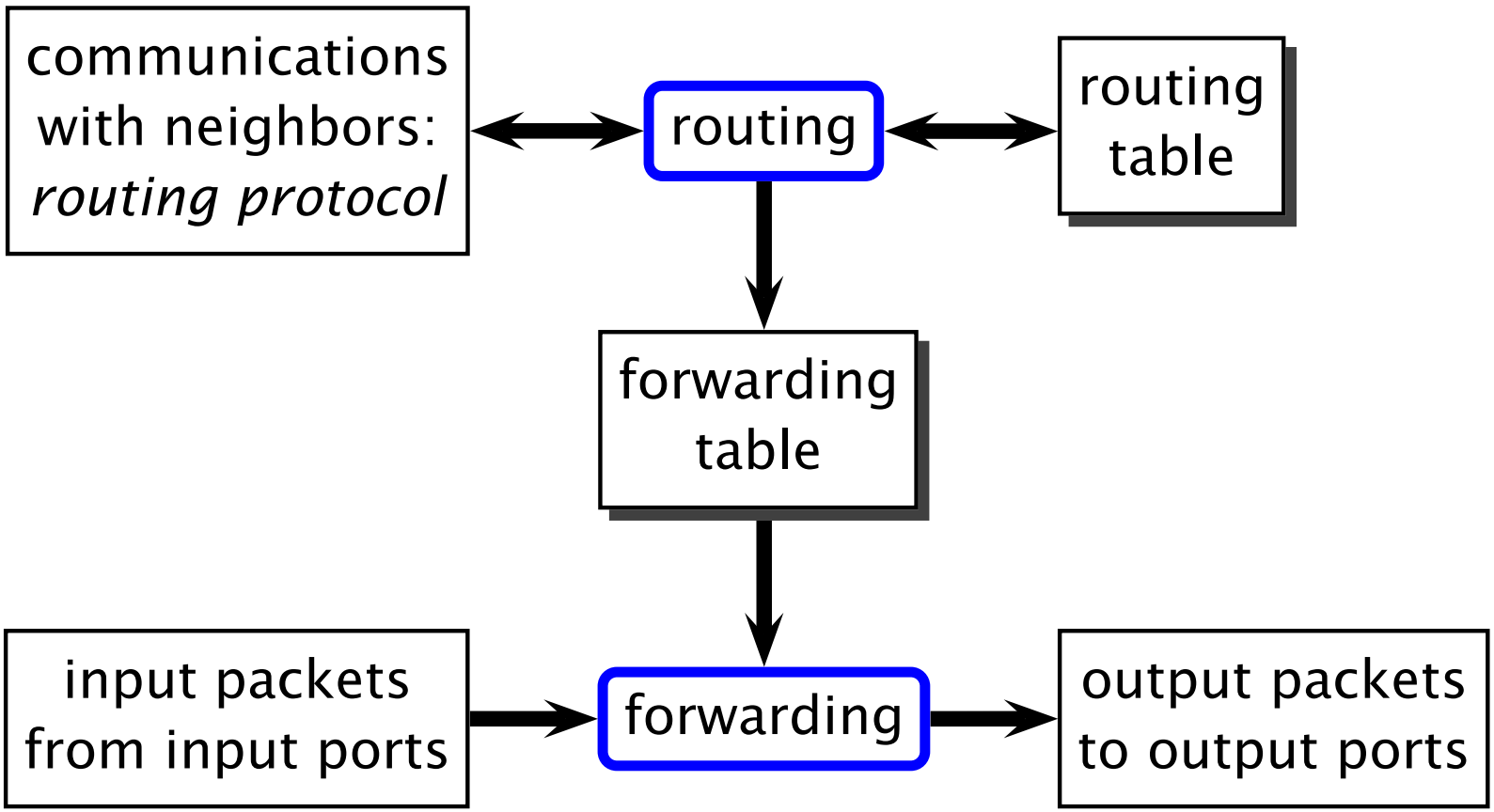

Anatomy of a Router

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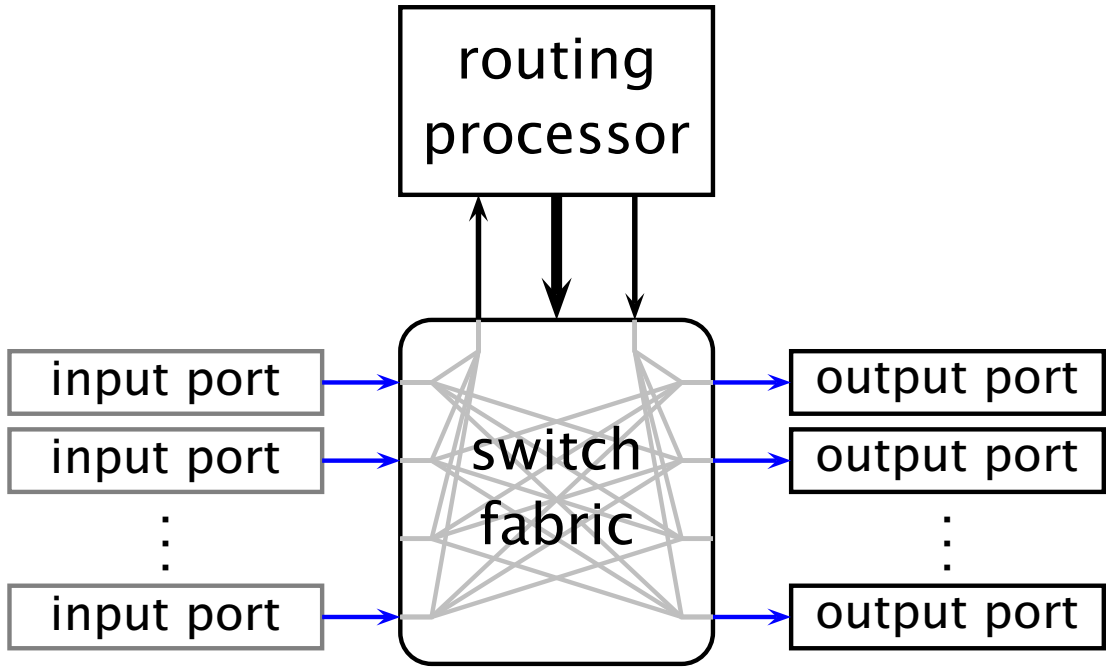

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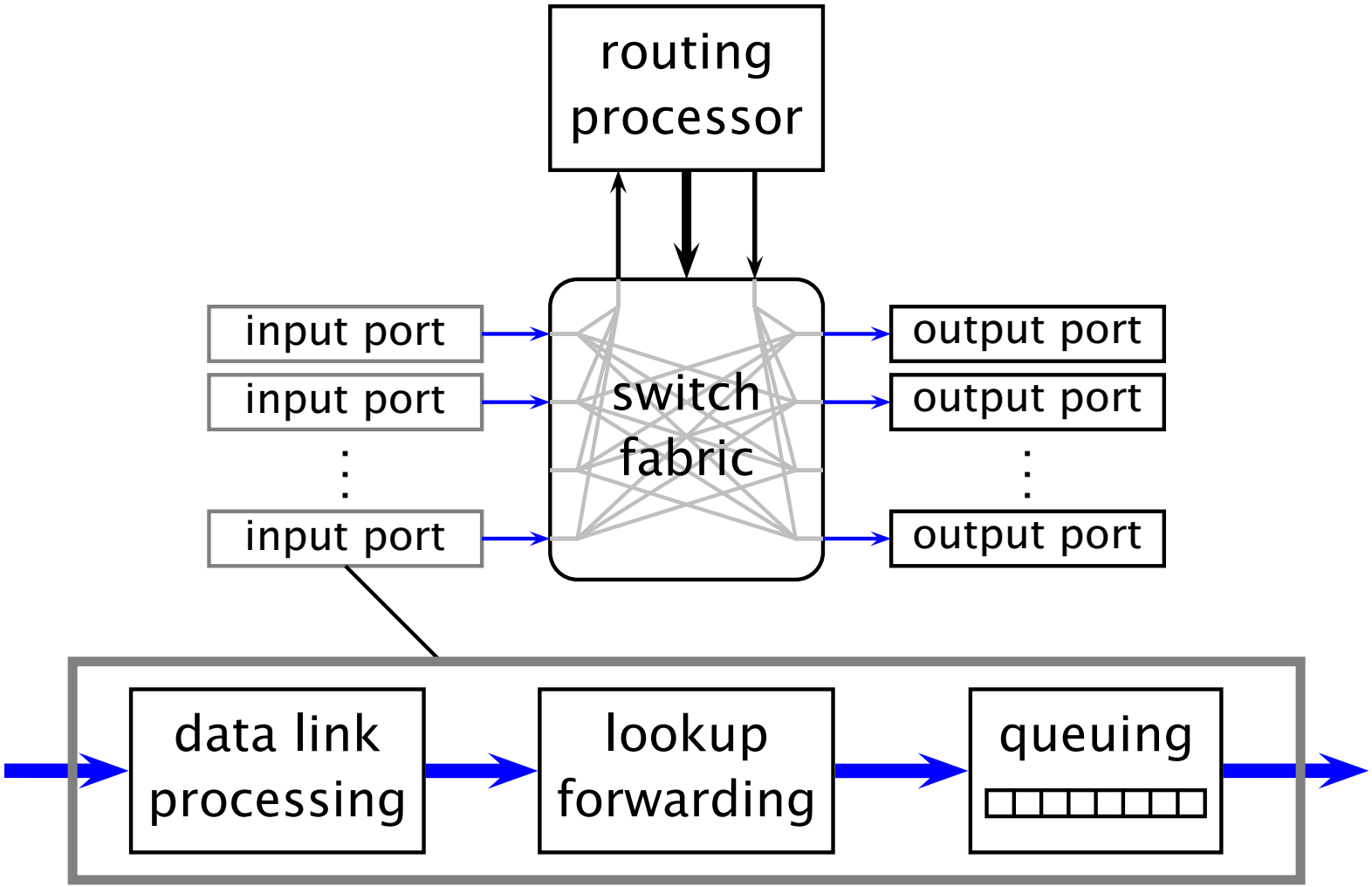

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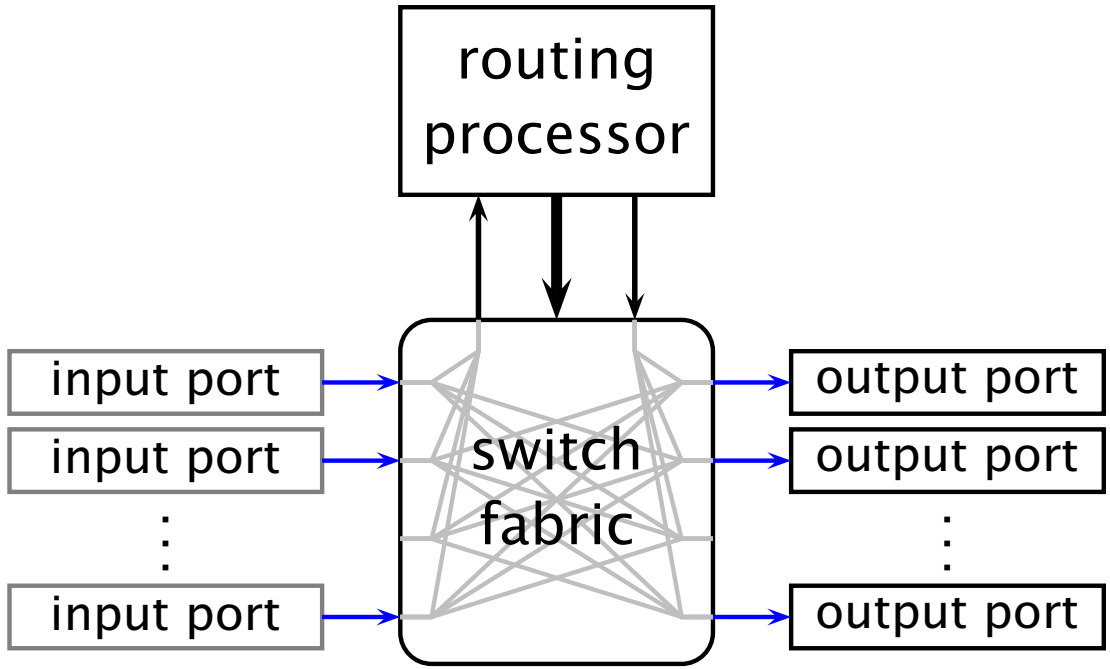

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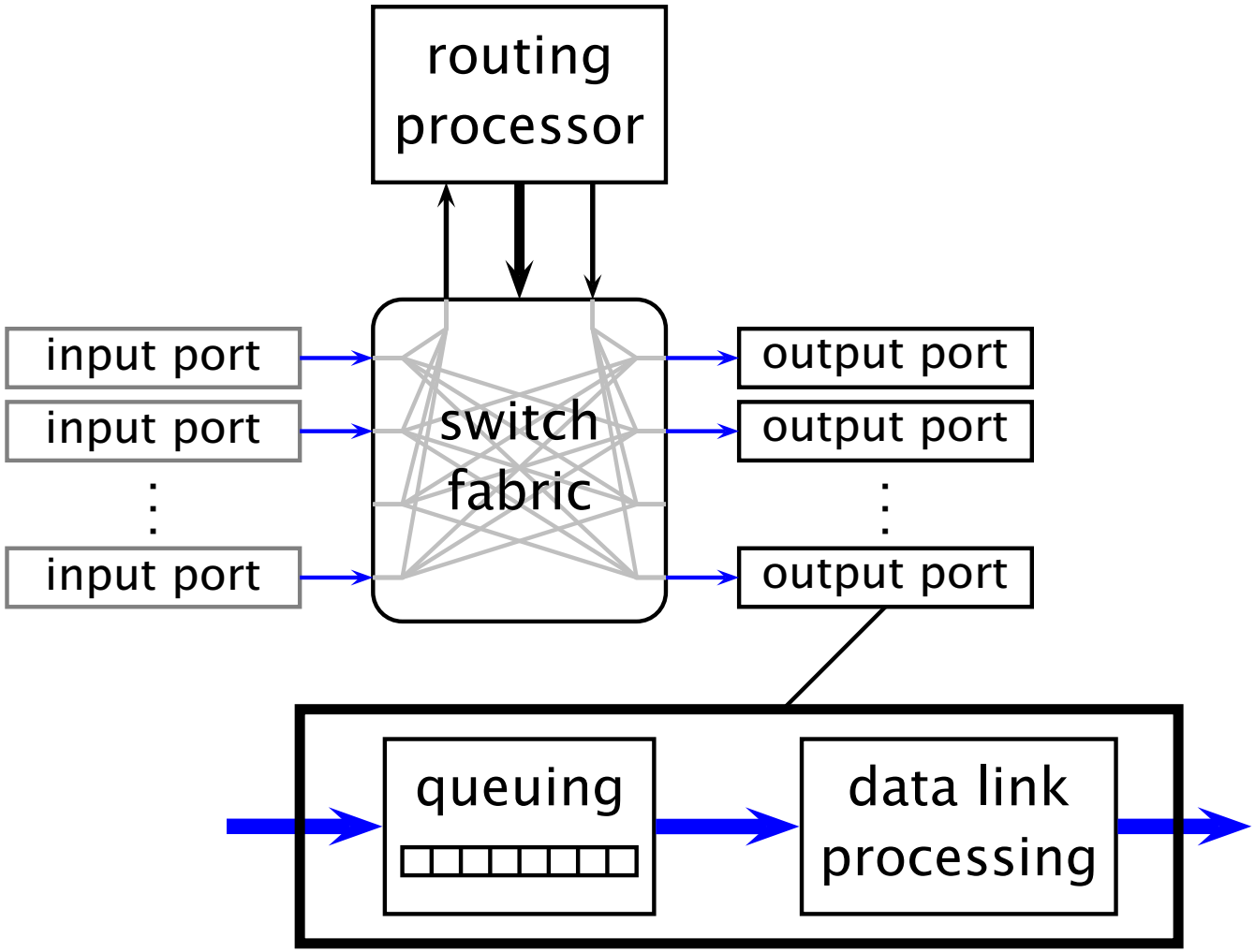

Queuing

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  - queuing may occur here because of the limited throughput of the output link. I.e., $R_{out} < \min(R_S, nR_{in})$

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  - *drop tail:* drop arriving packets when queues are full
  - *active queue management:* a set of policies and algorithms to decide when and how to drop or mark packets in the attempt to prevent congestion

Internet Network Layer

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IPv4 Datagram Format

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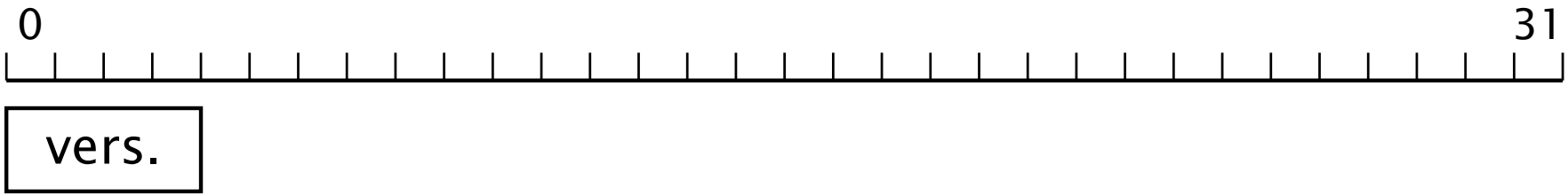

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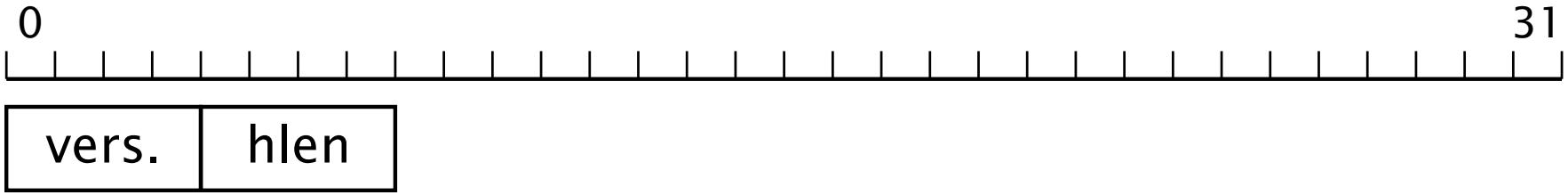

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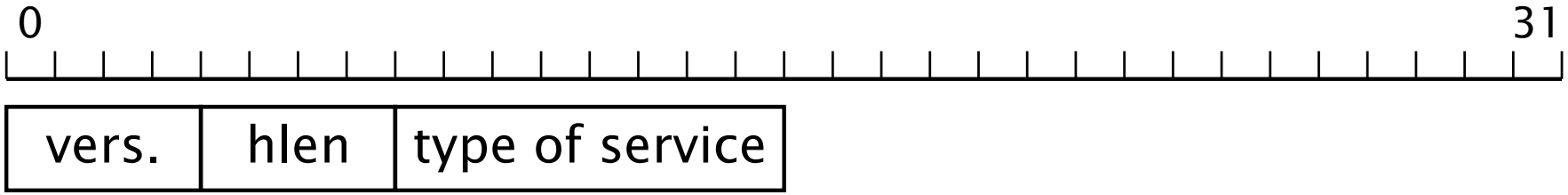

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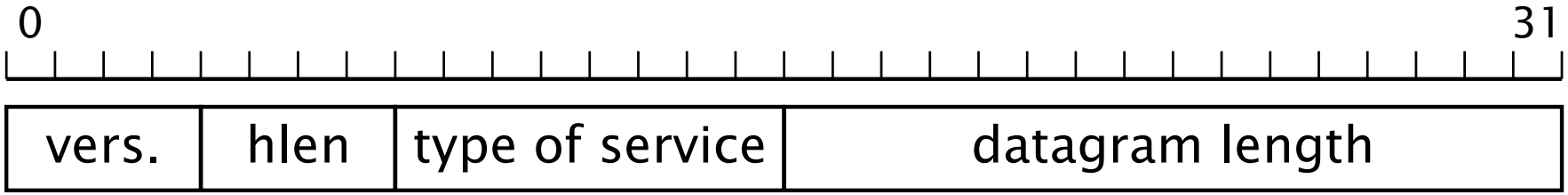

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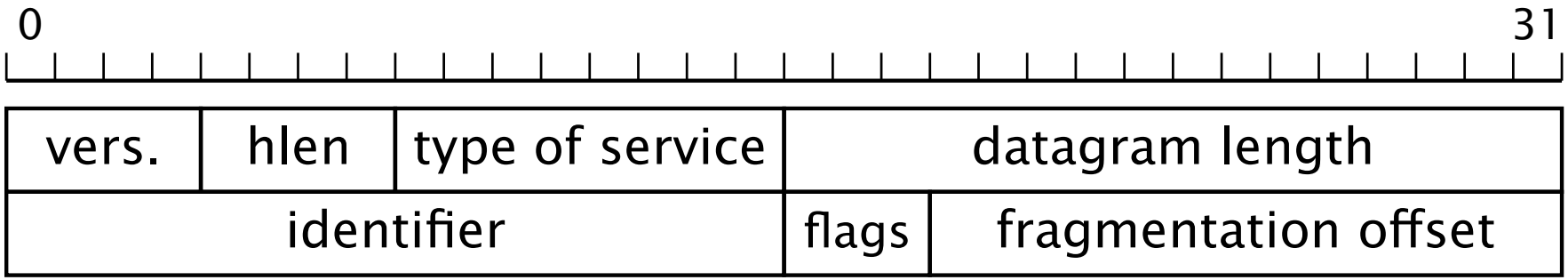

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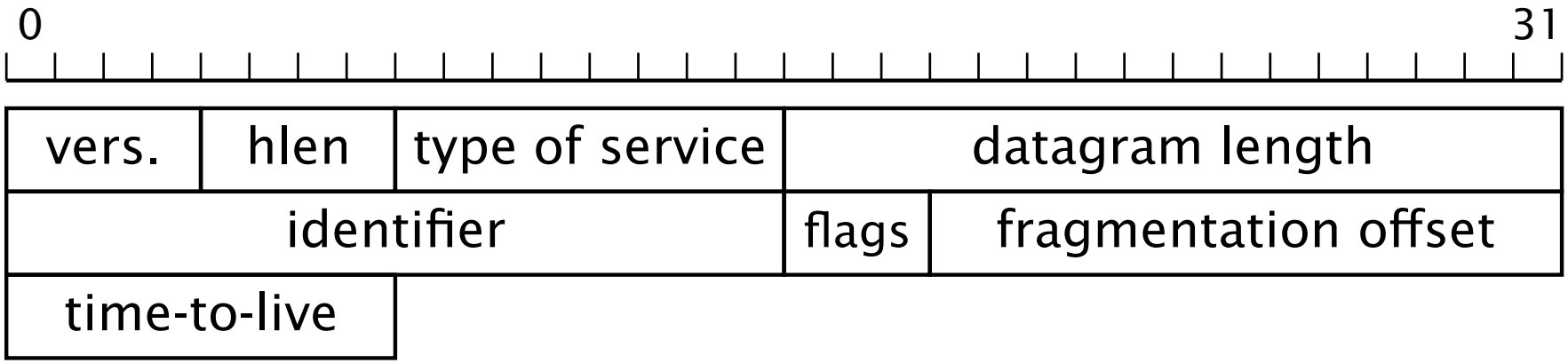

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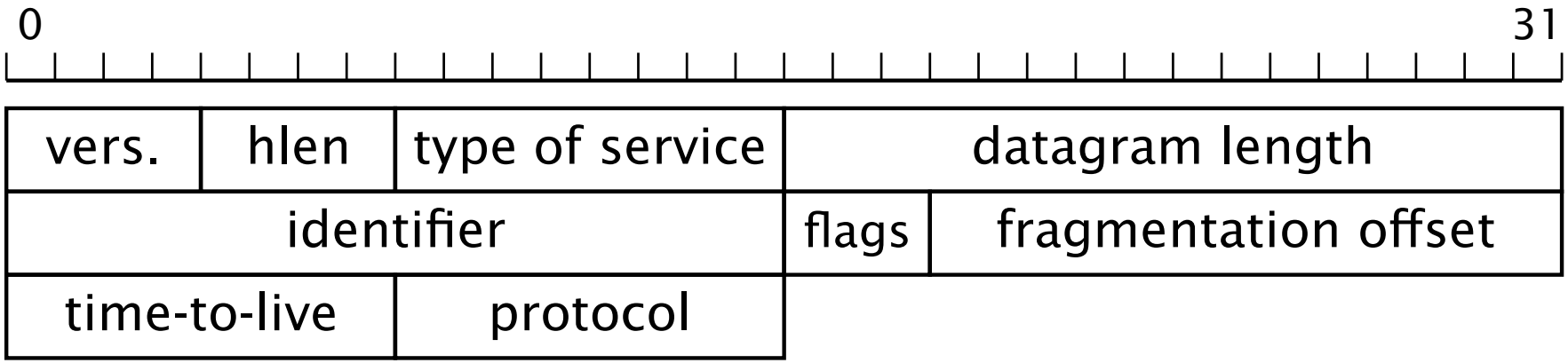

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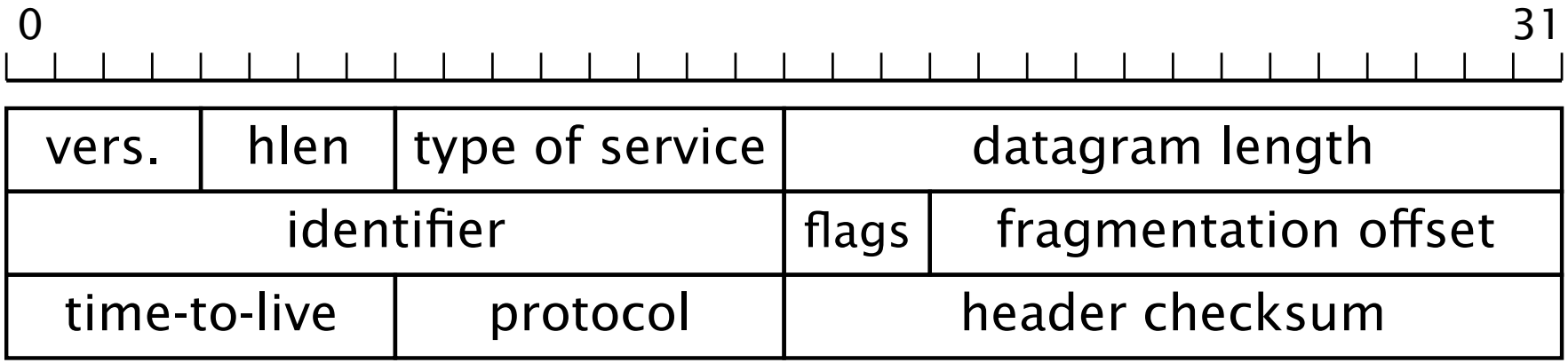

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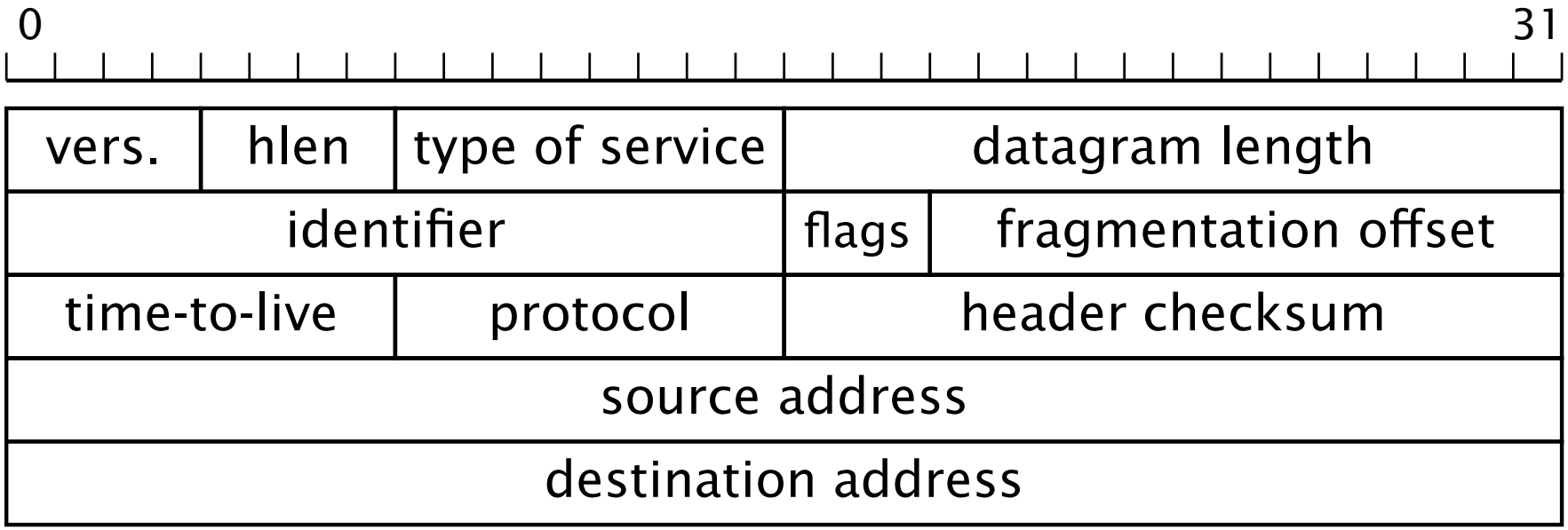

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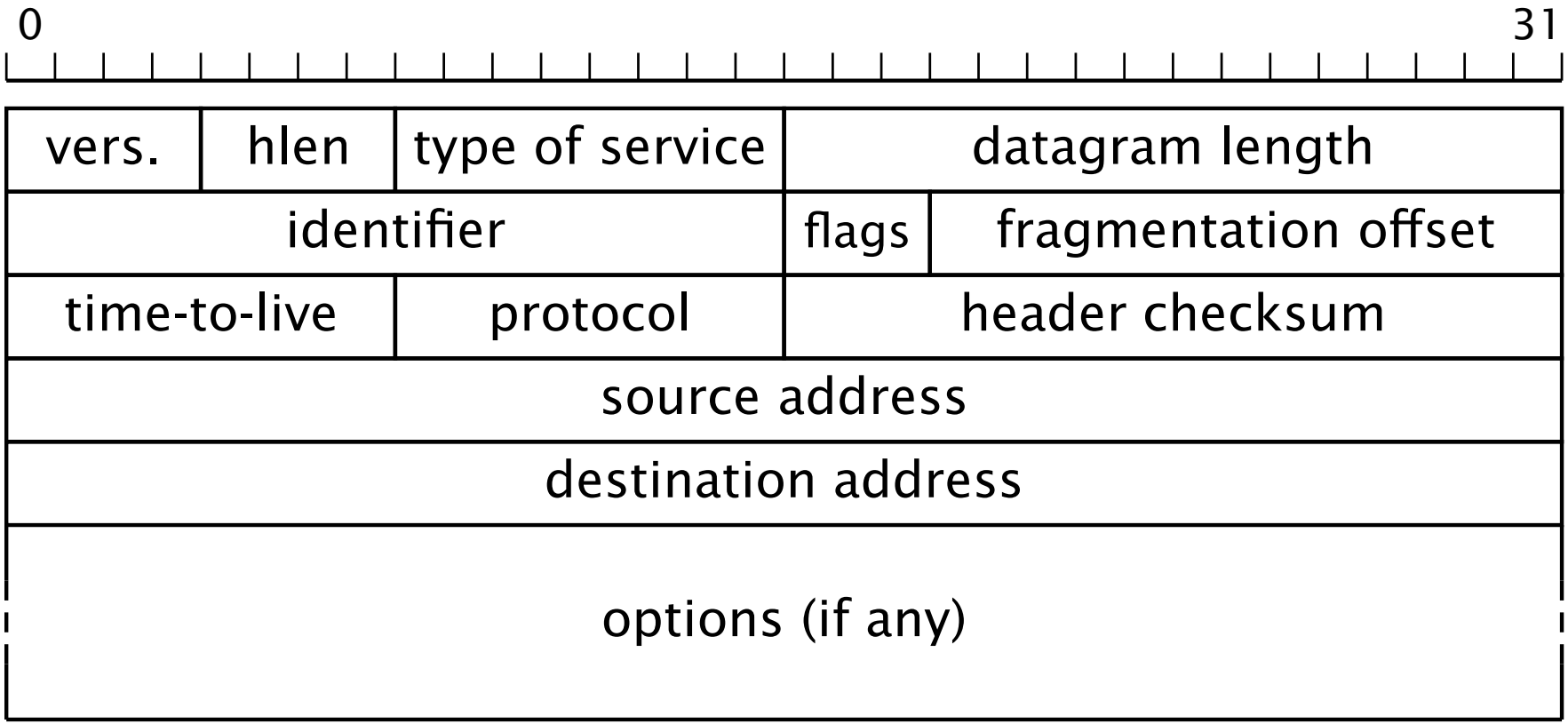

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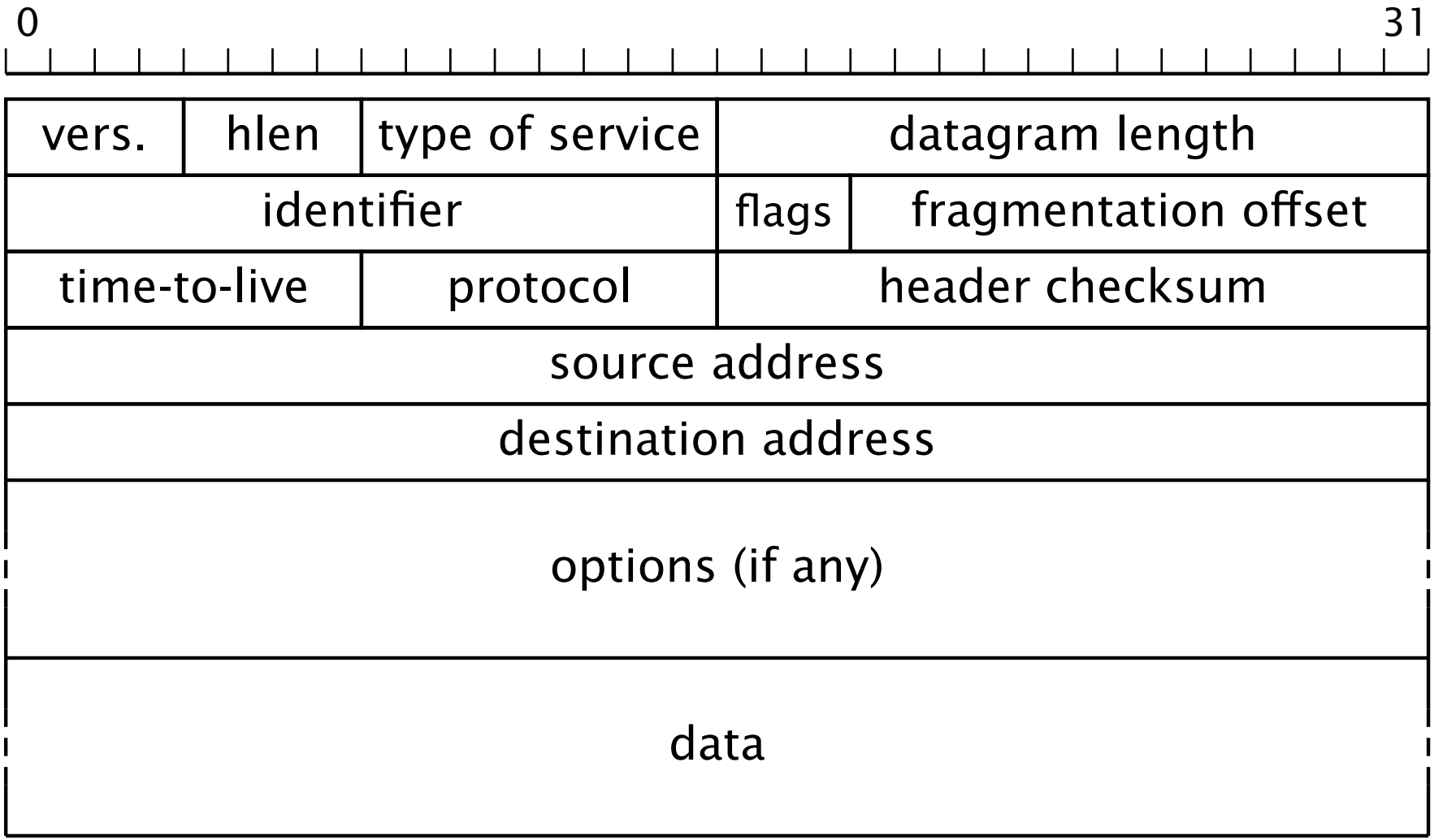

Fragmentation

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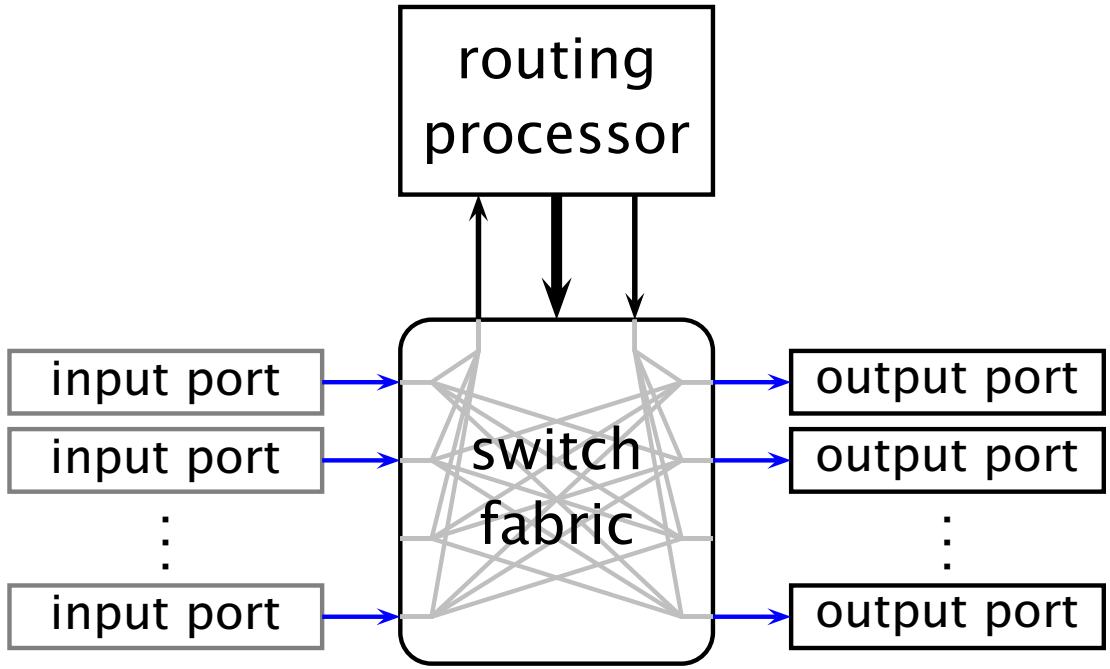

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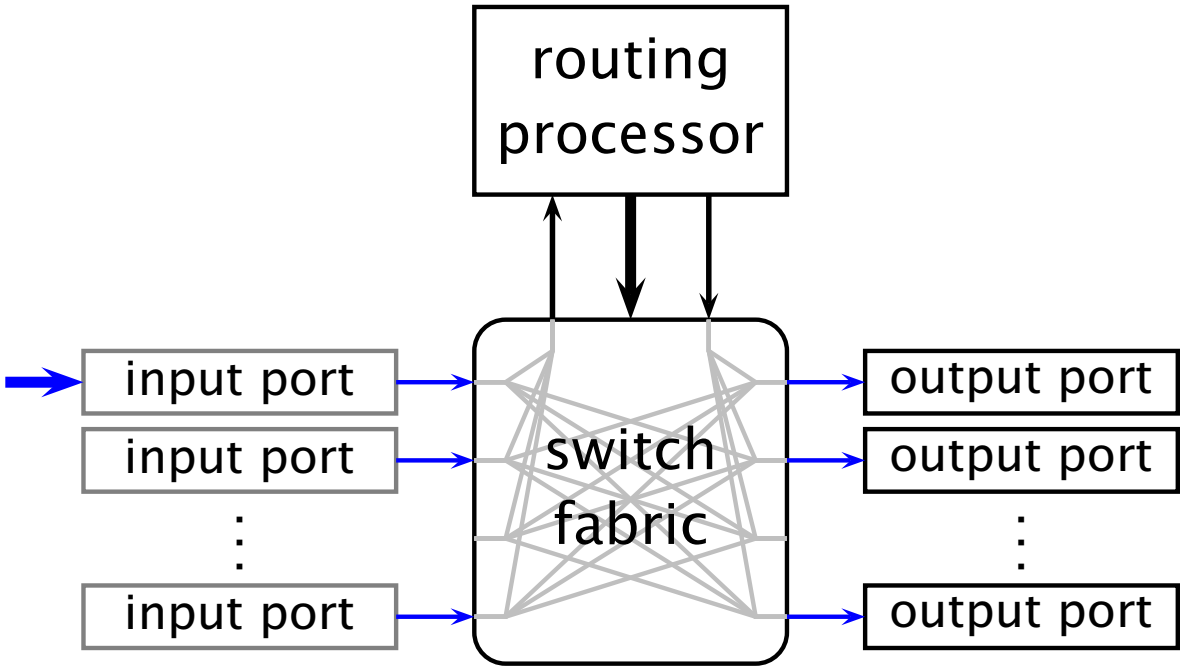

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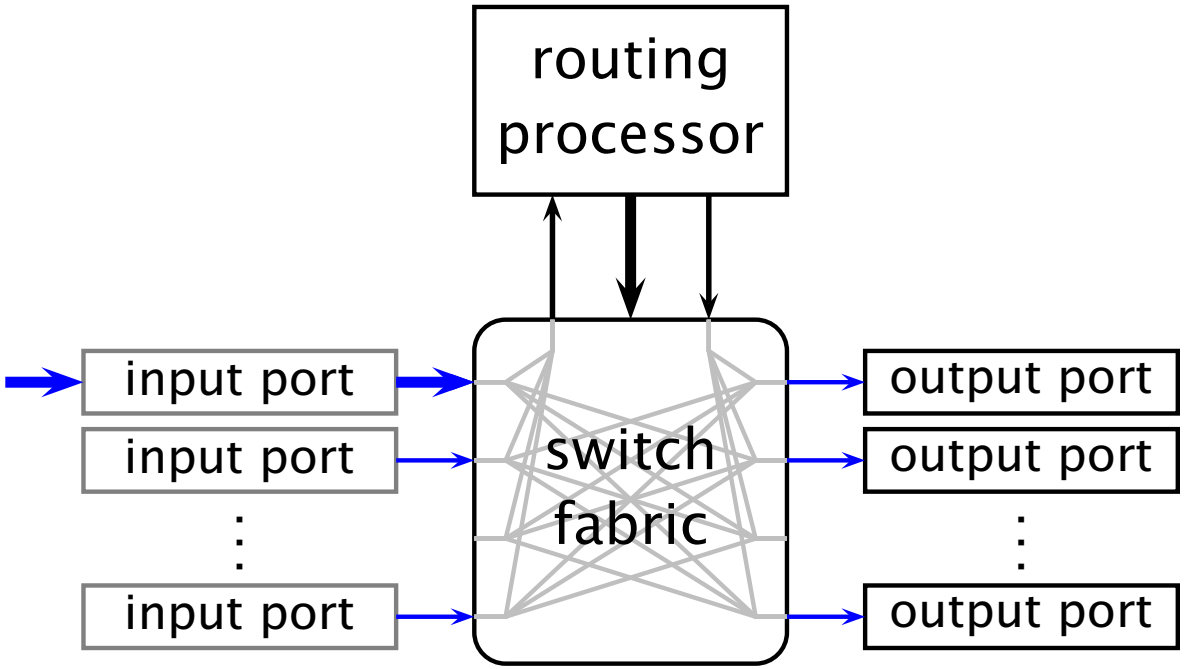

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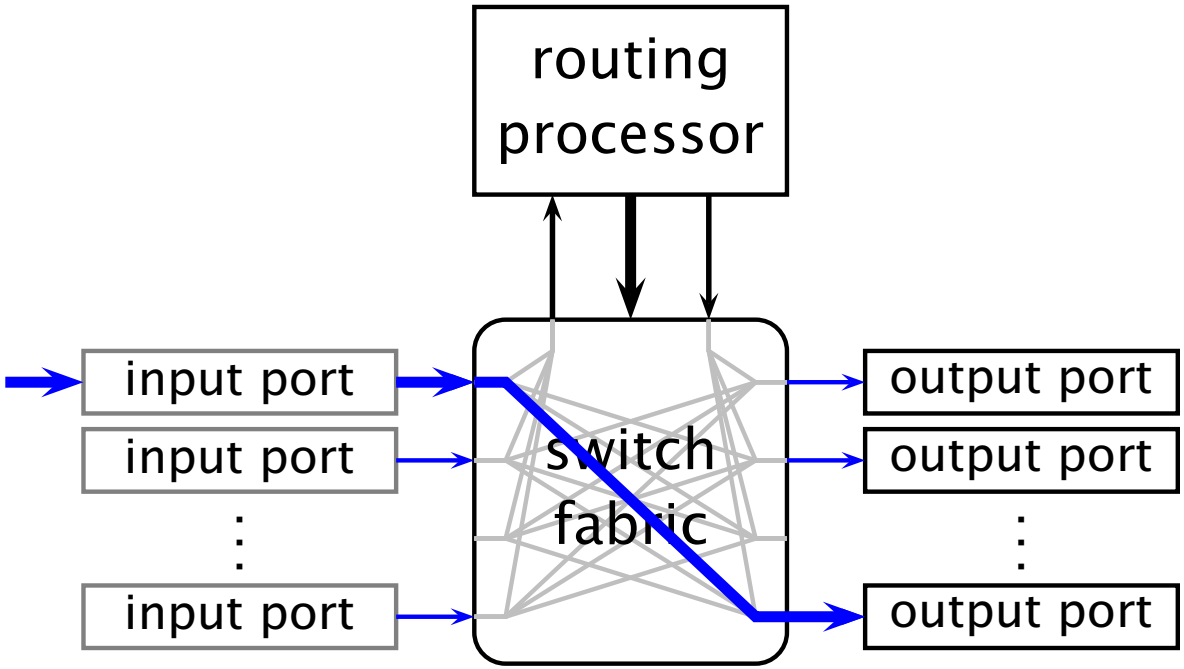
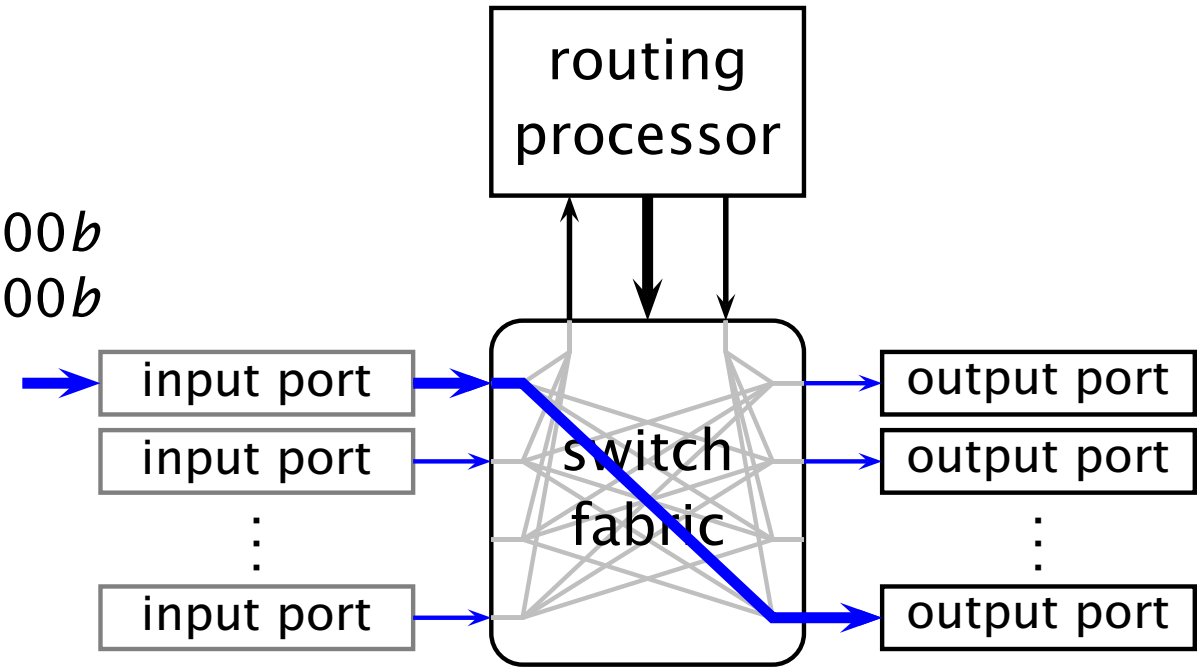


Fragmentation

$MTU = 1500b$
$size = 1000b$



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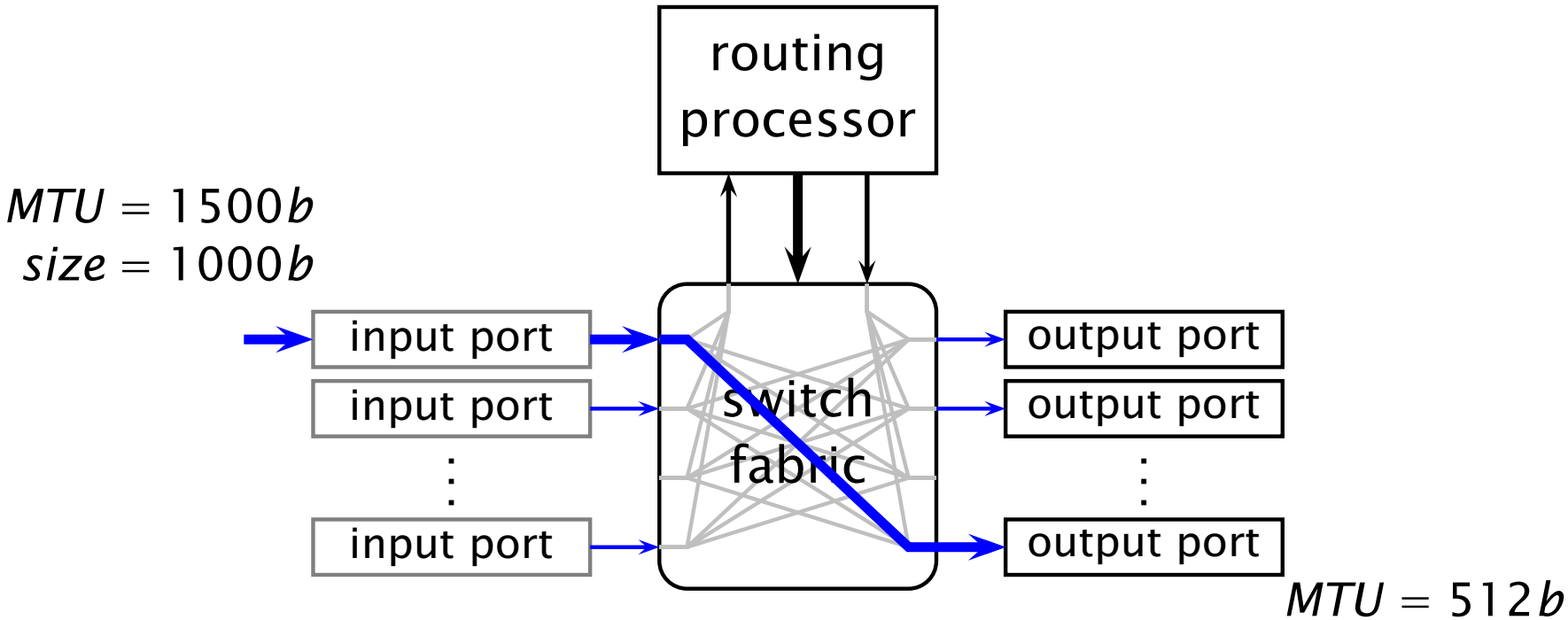

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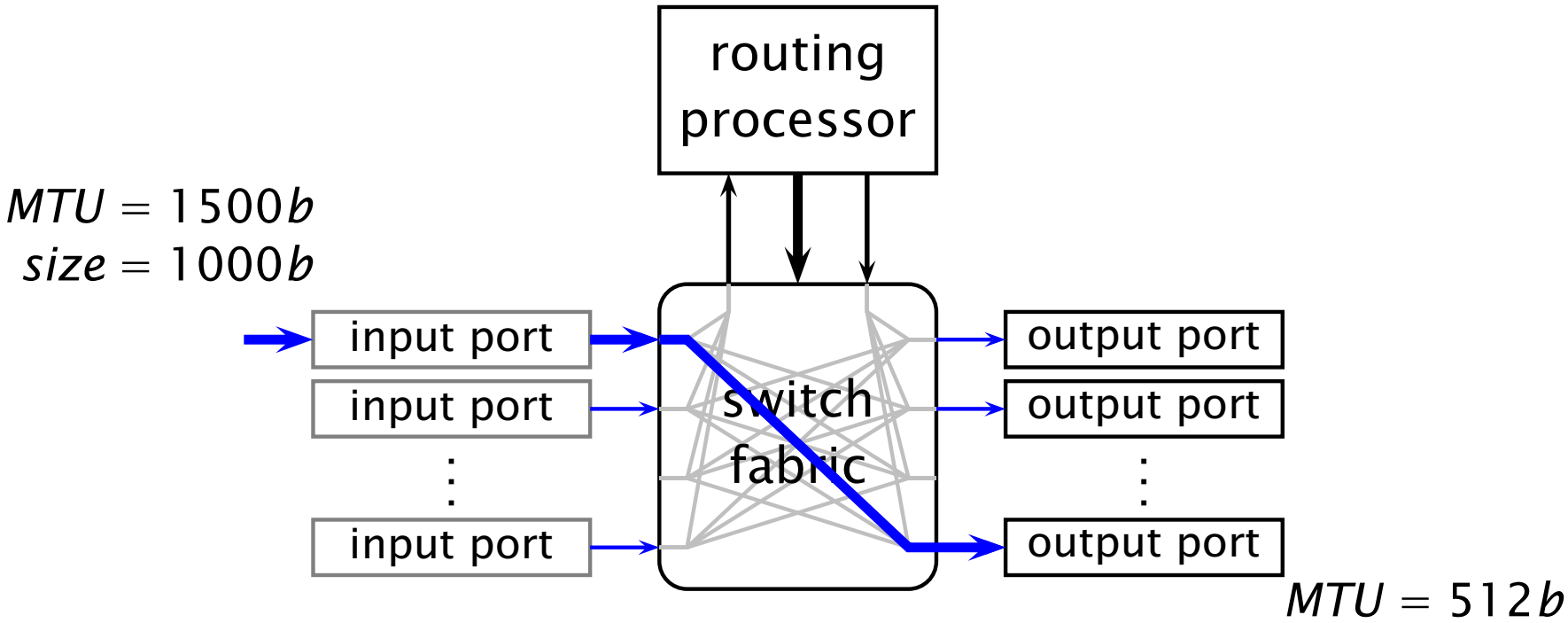

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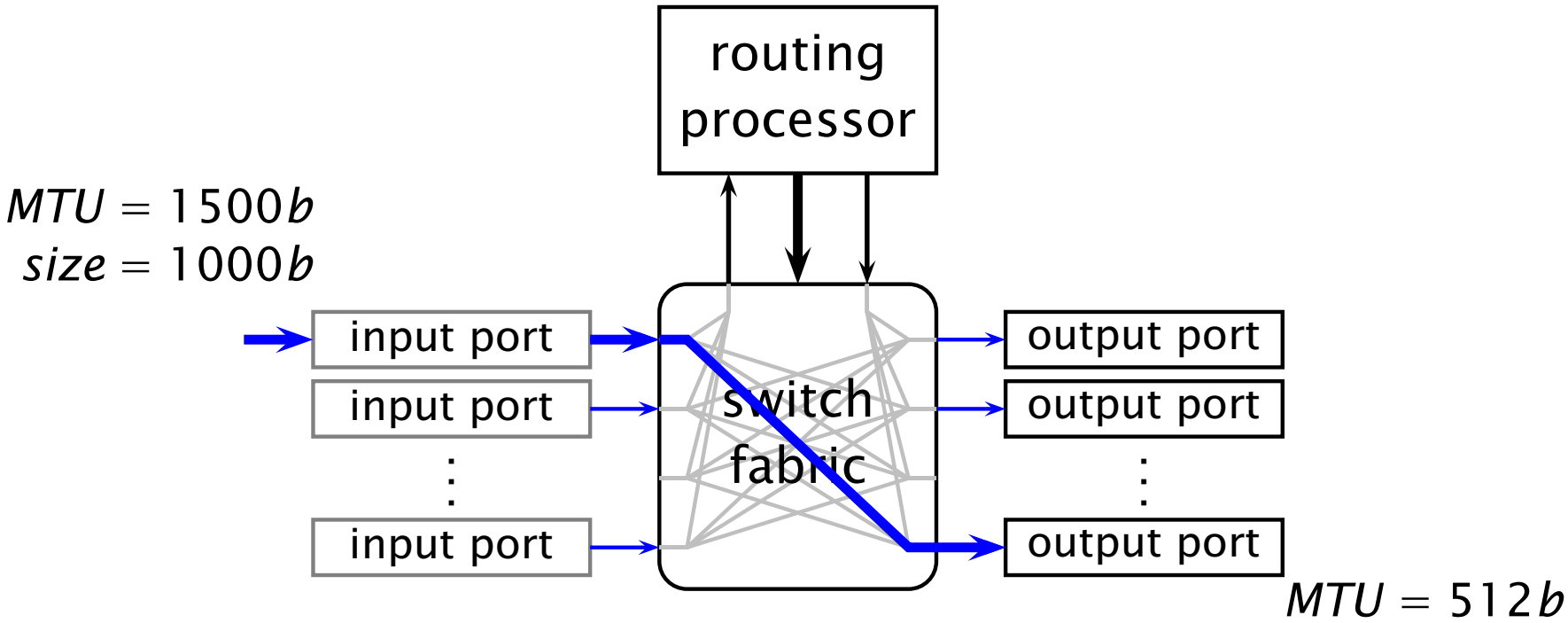

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Fragmentation

input datagram

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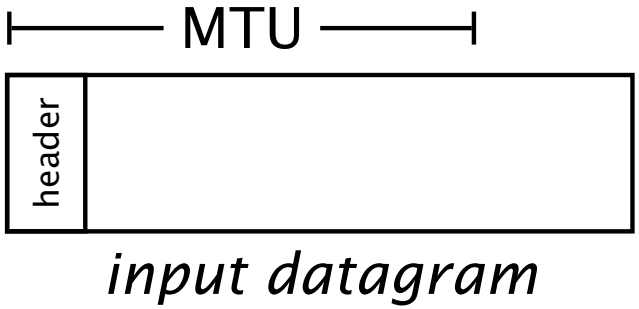

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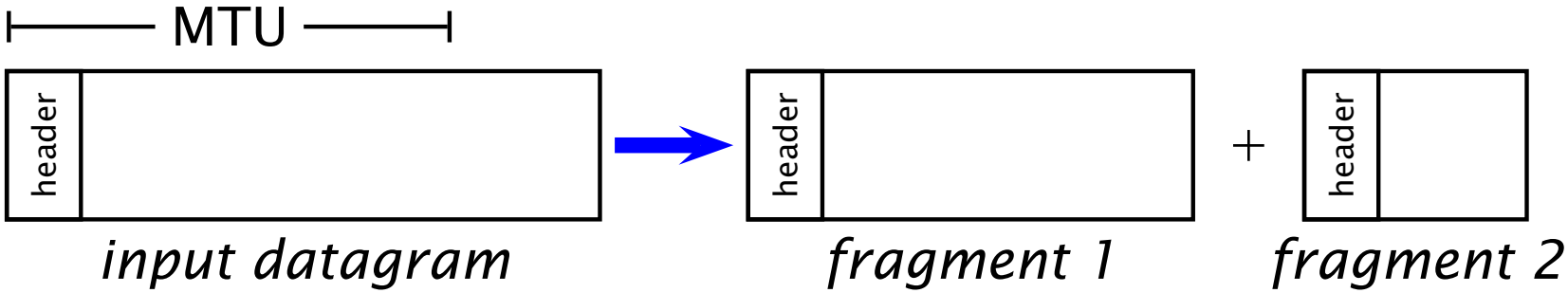

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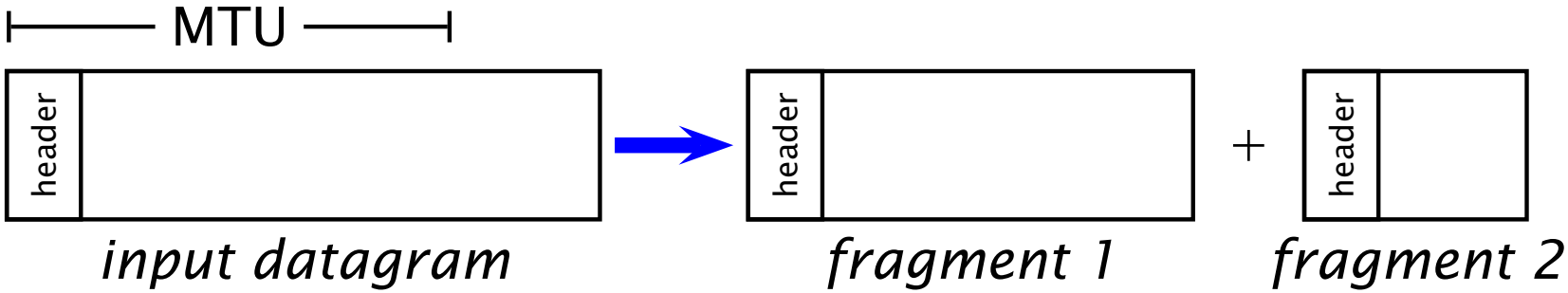

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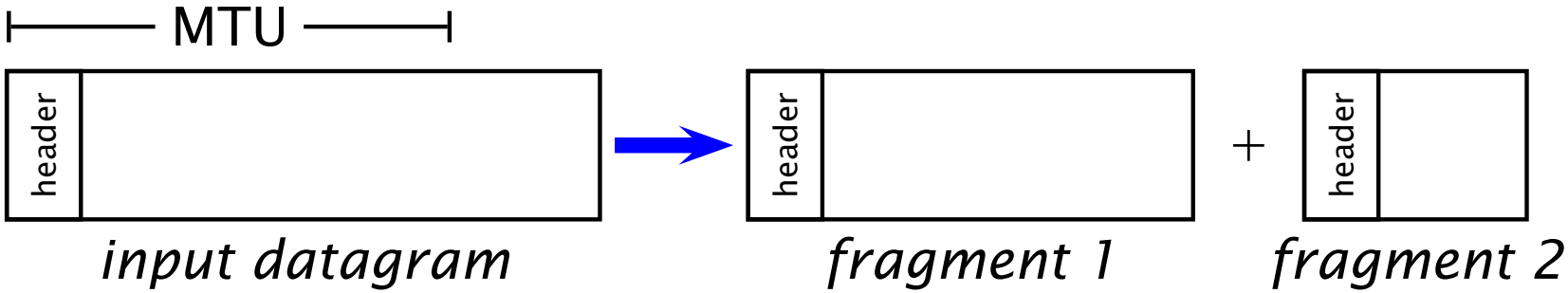

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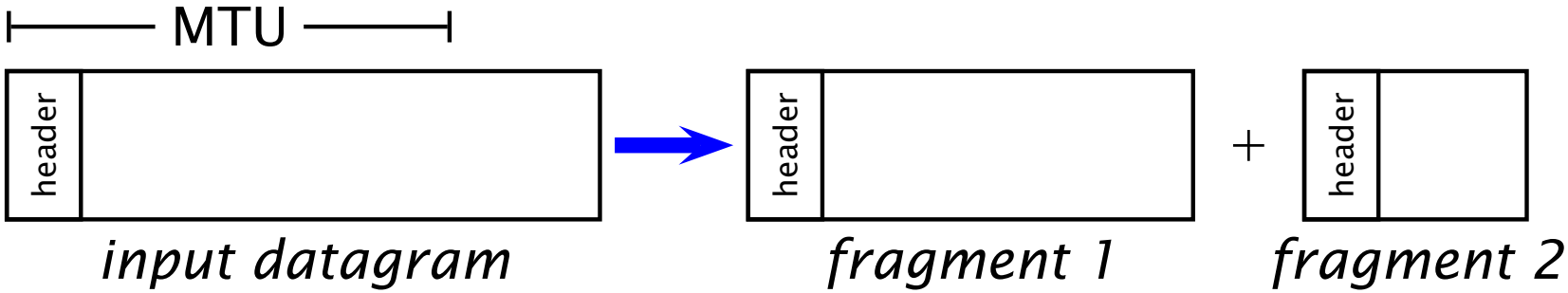

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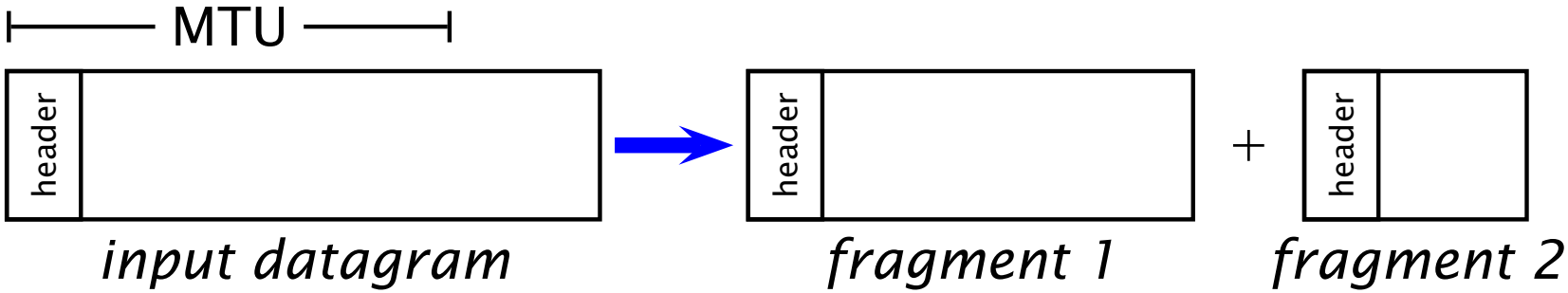

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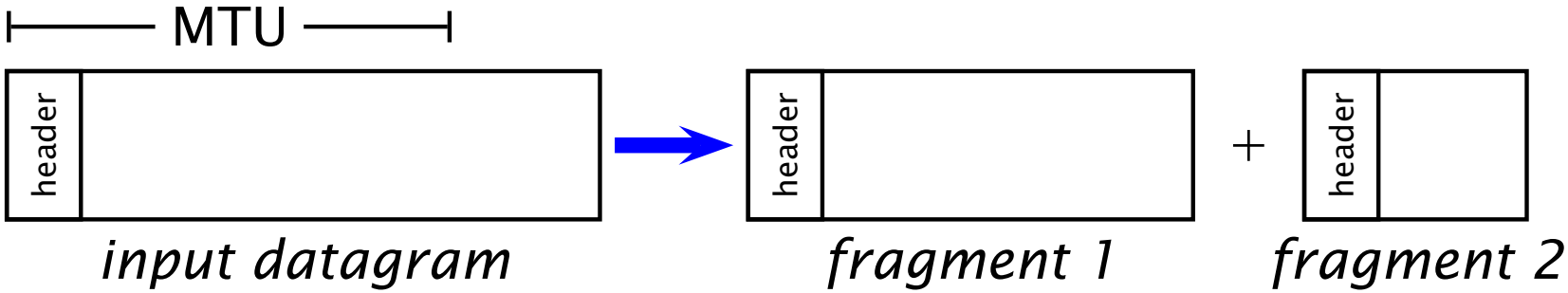

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identifier	*fragment offset*	*more fragments*	*header length*	*total length*
789	0	0	20	1020

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identifier	*fragment offset*	*more fragments*	*header length*	*total length*
789	122	0	20	44