# The Network Layer

Antonio Carzaniga

Faculty of Informatics
Università della Svizzera italiana

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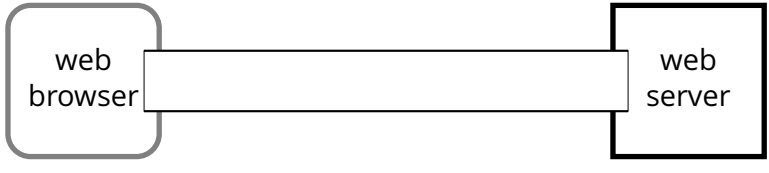
# Outline

- 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


web
browser
web
server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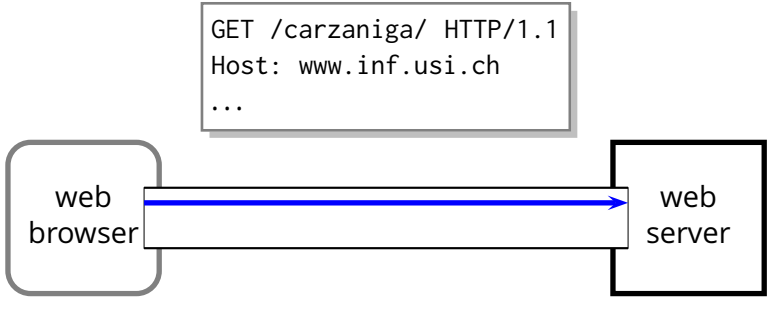
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web
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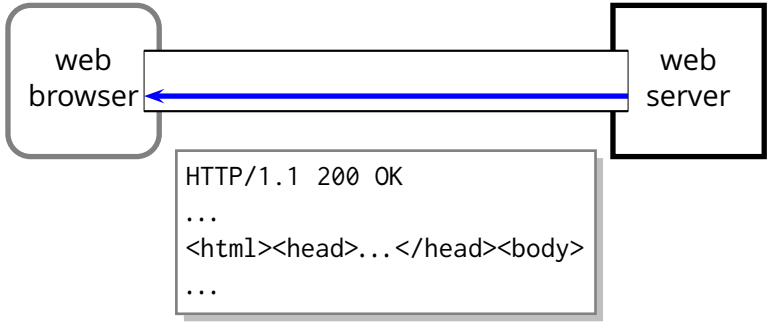
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HTTP/1.1 200 OK
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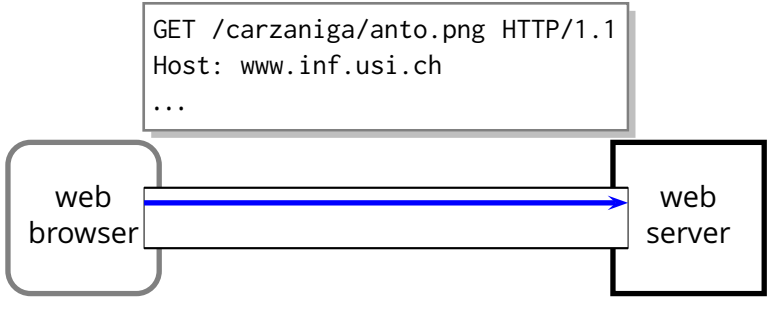
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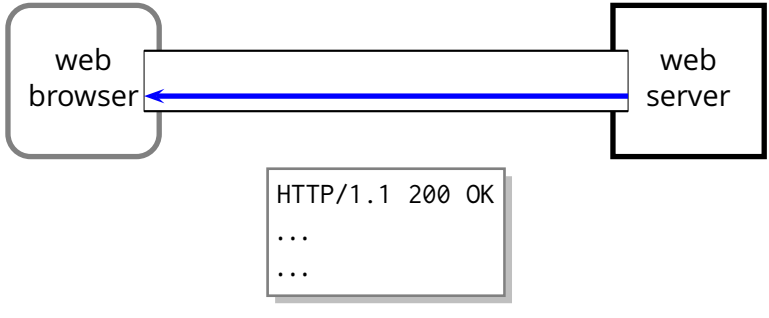
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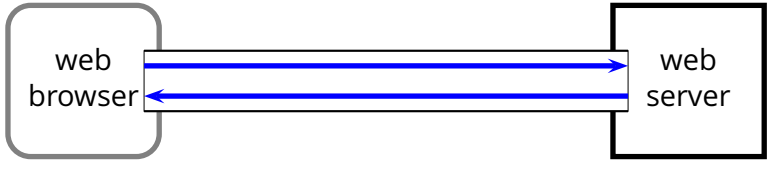
# Transport Level



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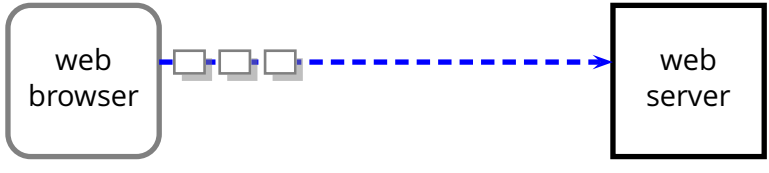

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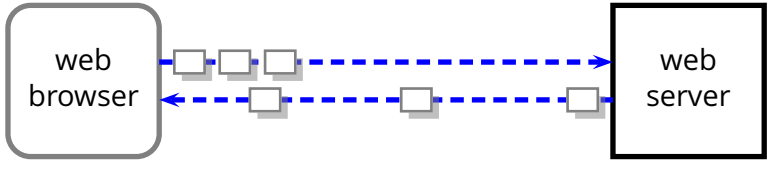


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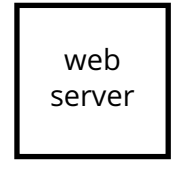
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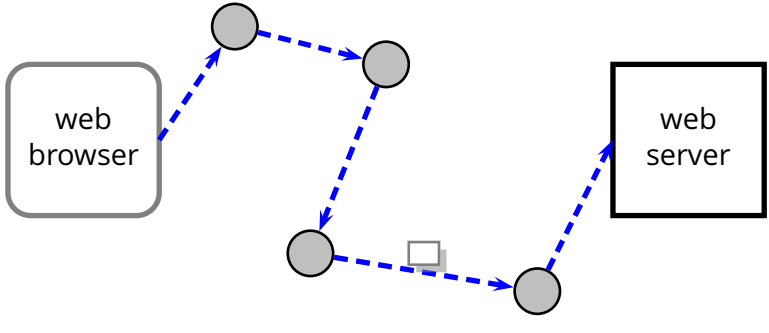
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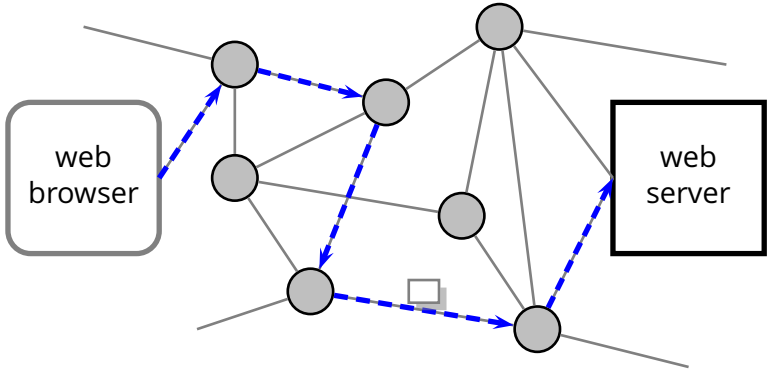
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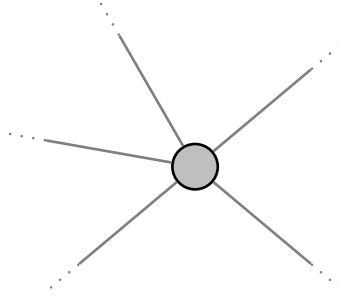

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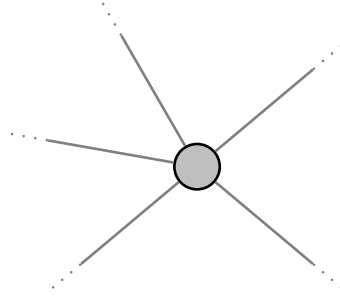

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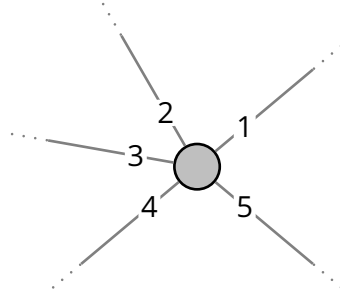


- Fundamental component of the network layer
- A *node in a graph*
- A finite set of input/output (physical) connections
  - a.k.a., ***interfaces*** or ***ports***

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  - congestion indication: none

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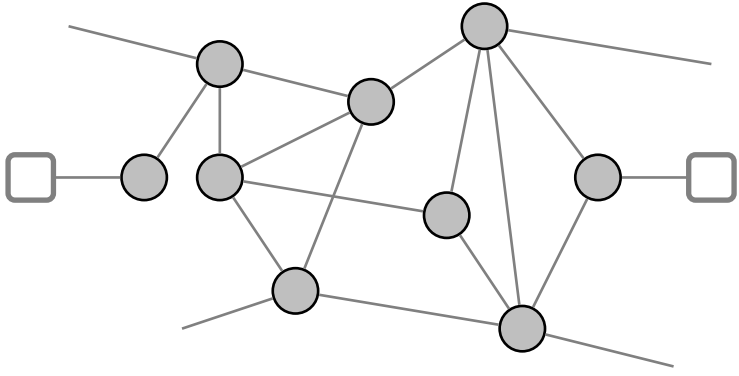

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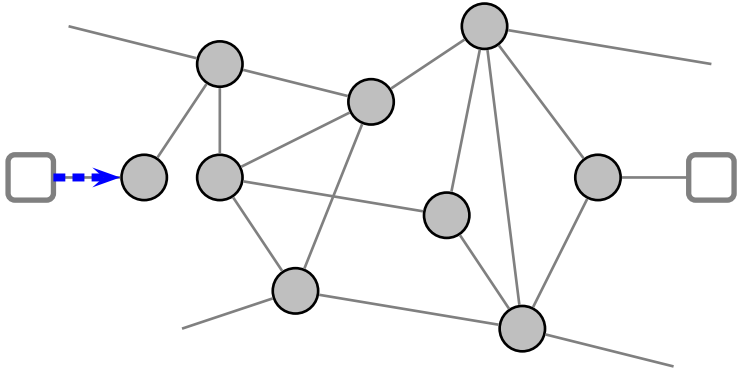

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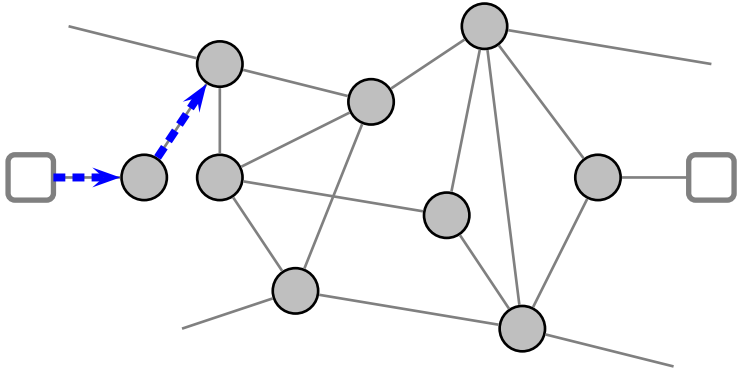

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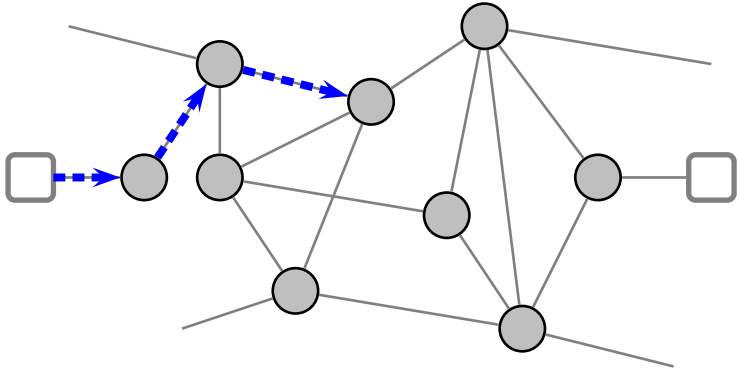

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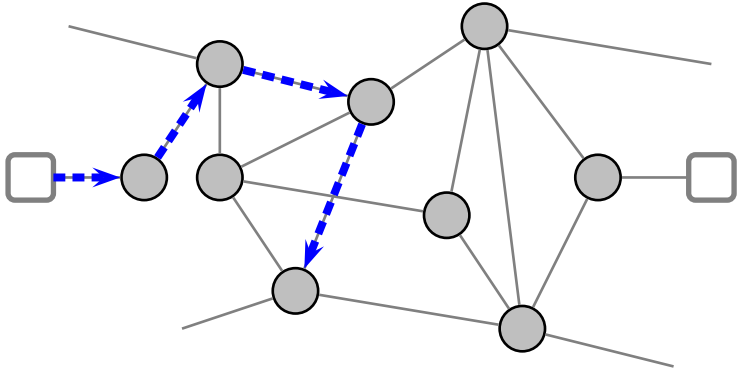

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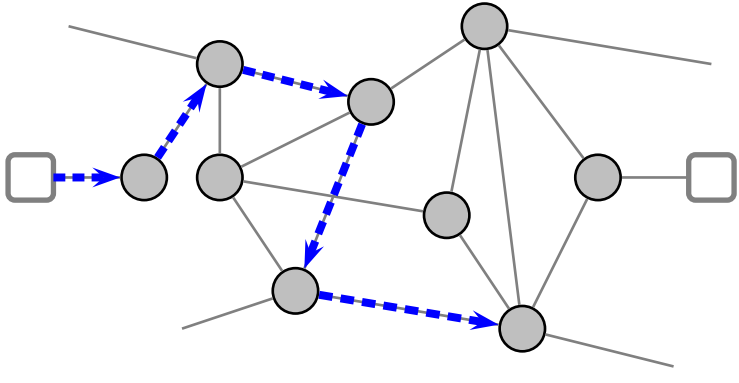

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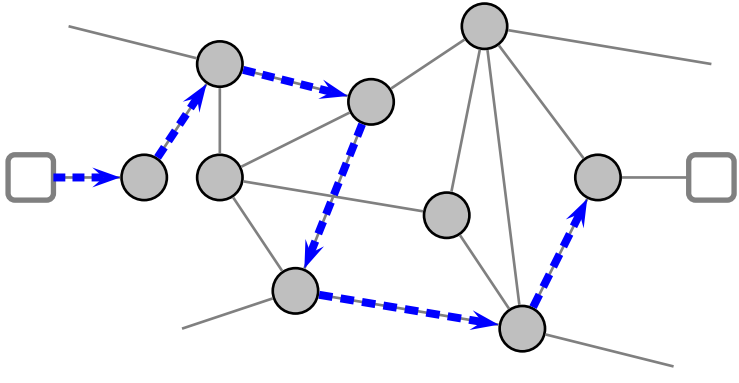

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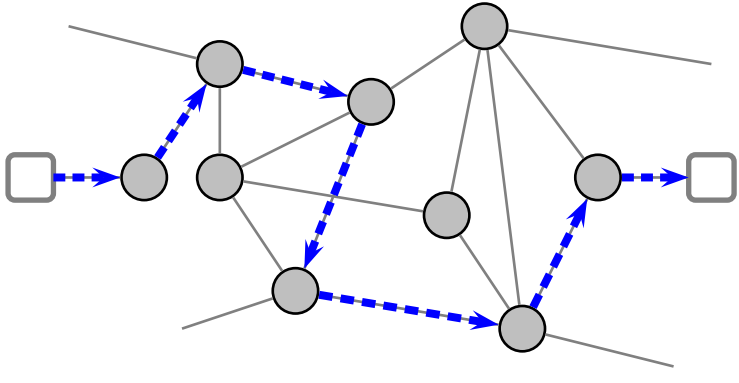

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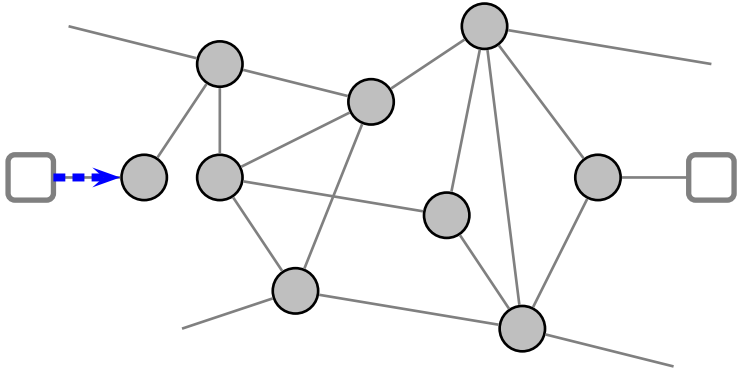

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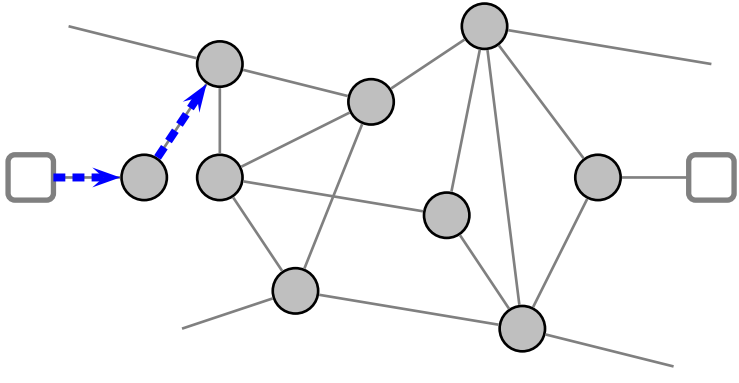

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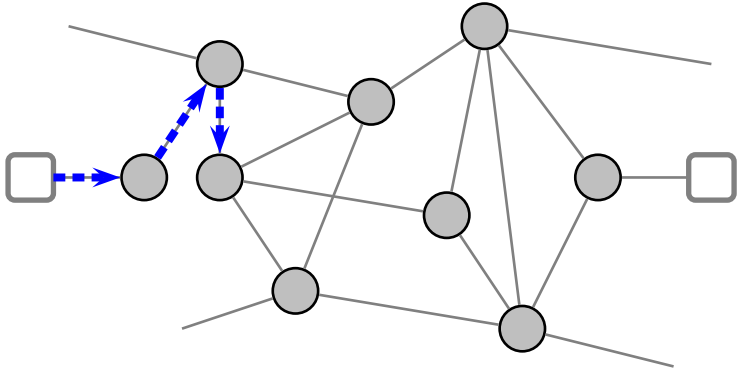

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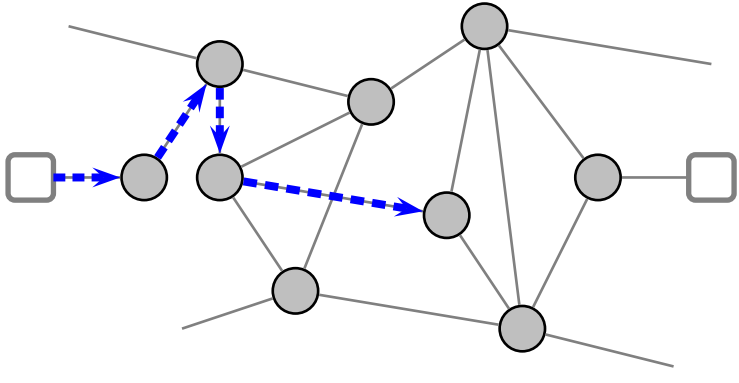

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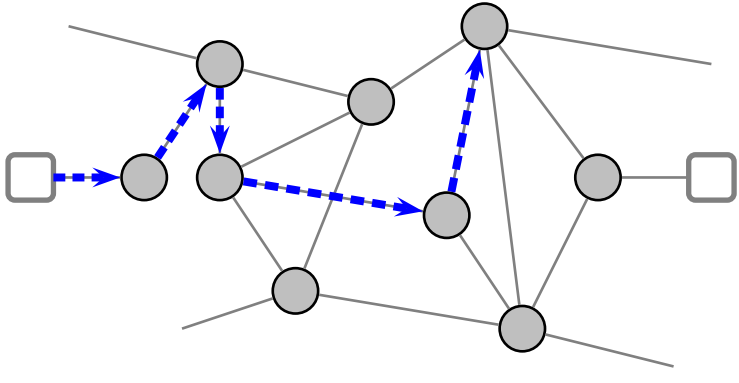

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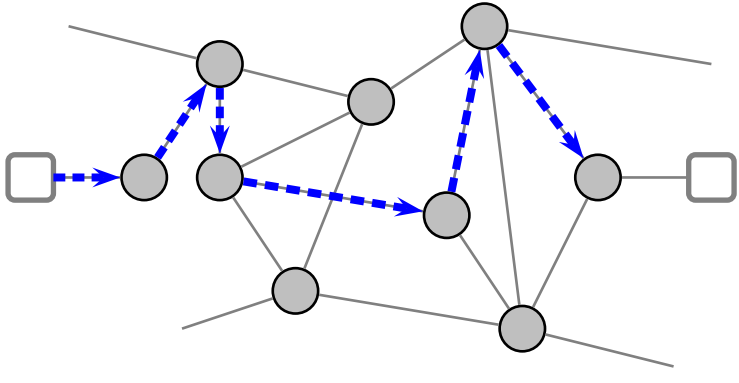

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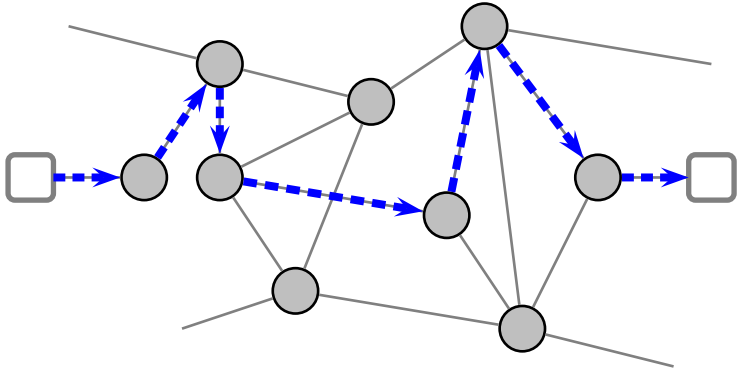

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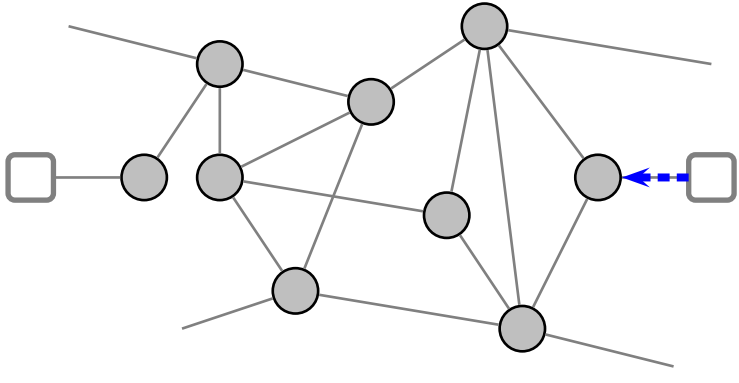

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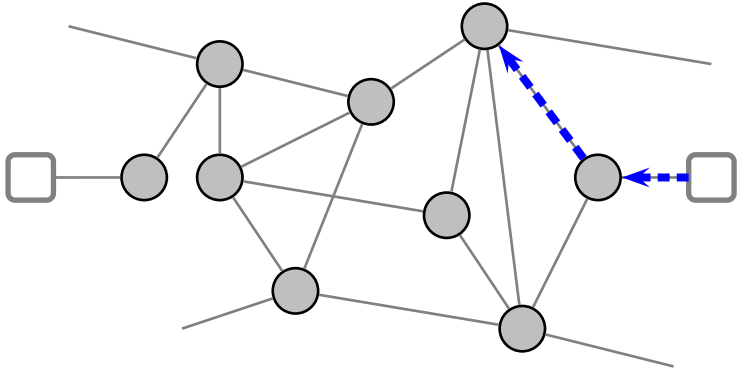

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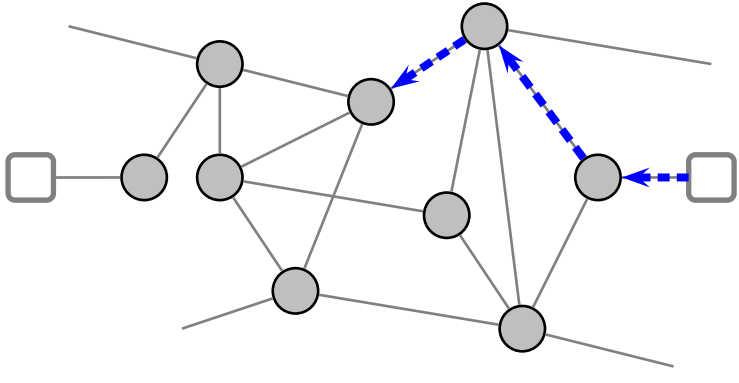

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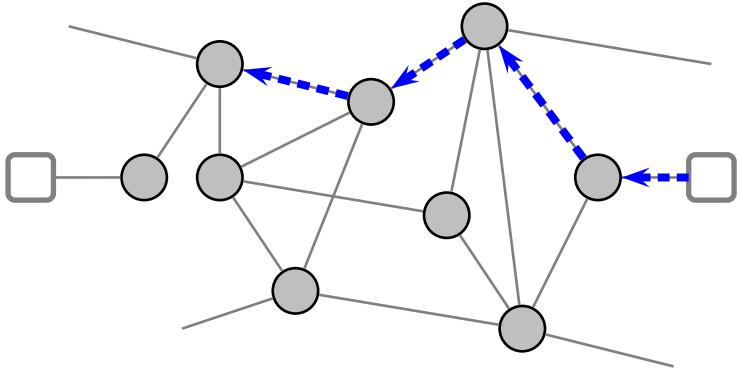

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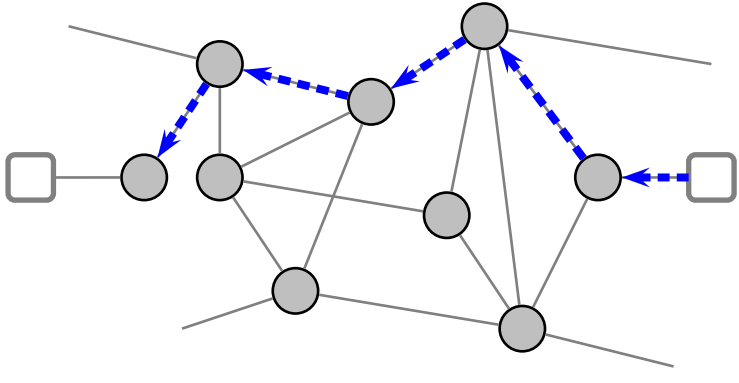

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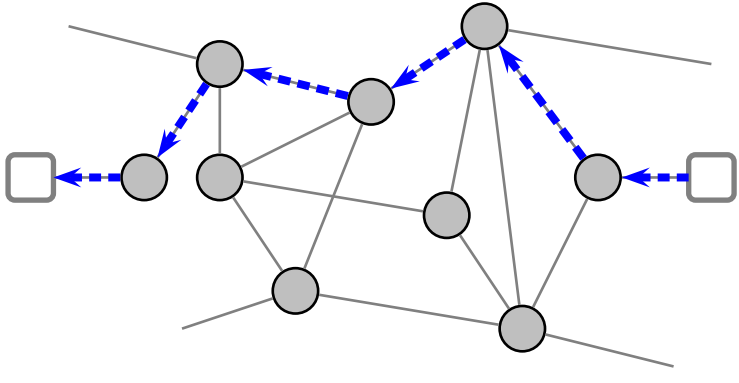

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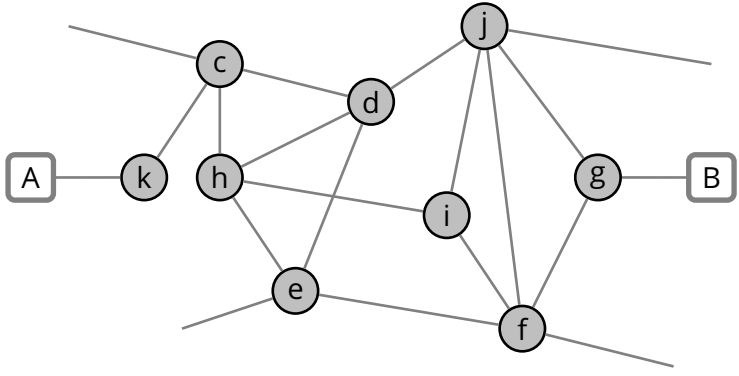


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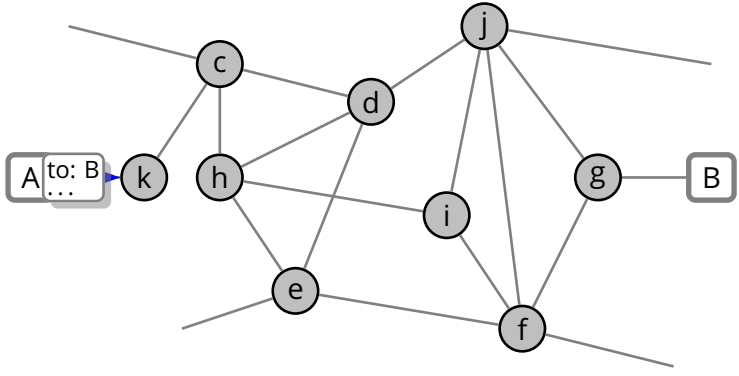


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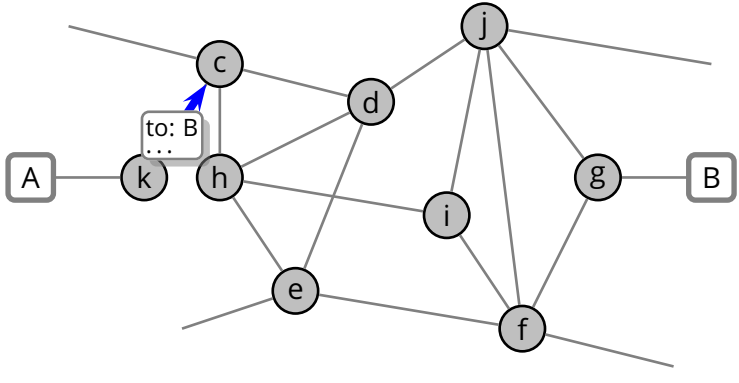


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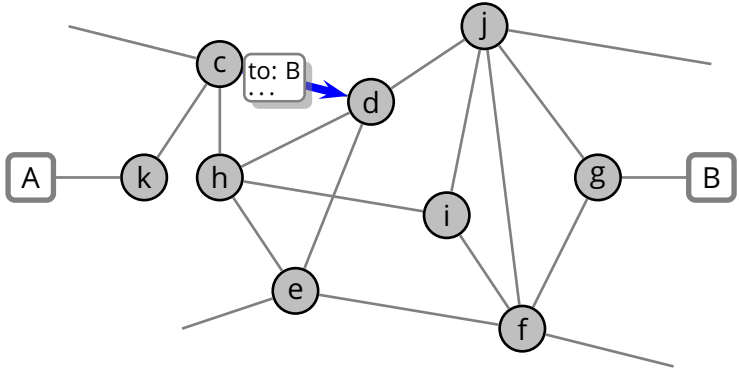

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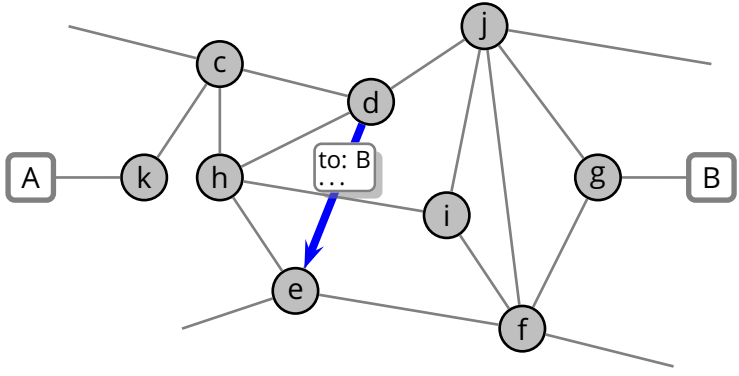

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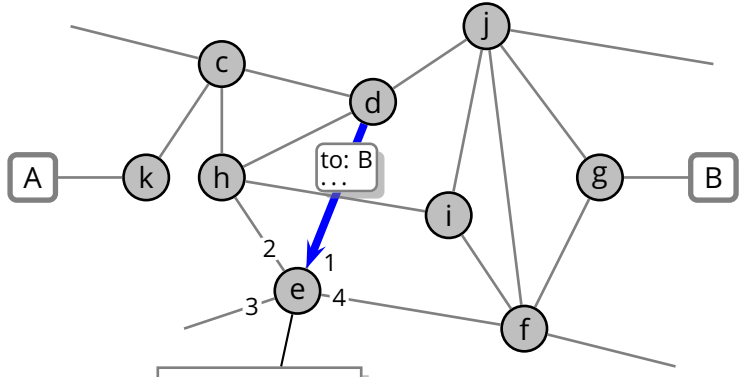

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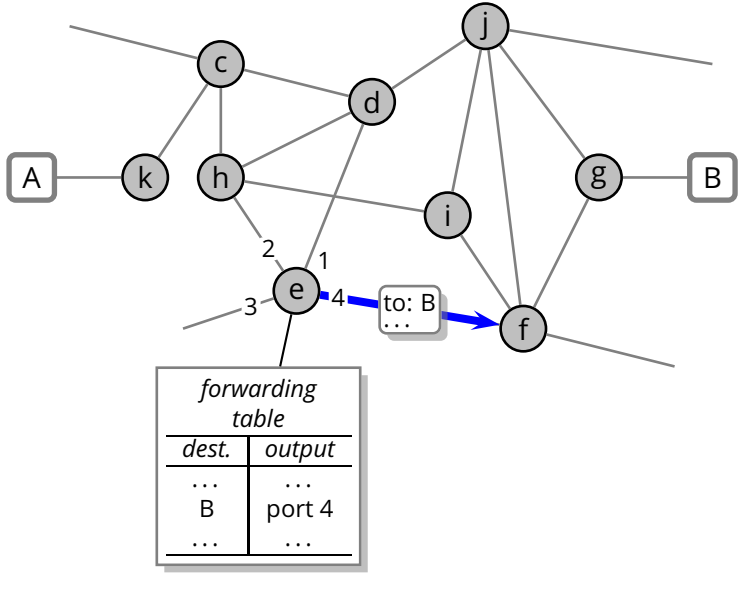

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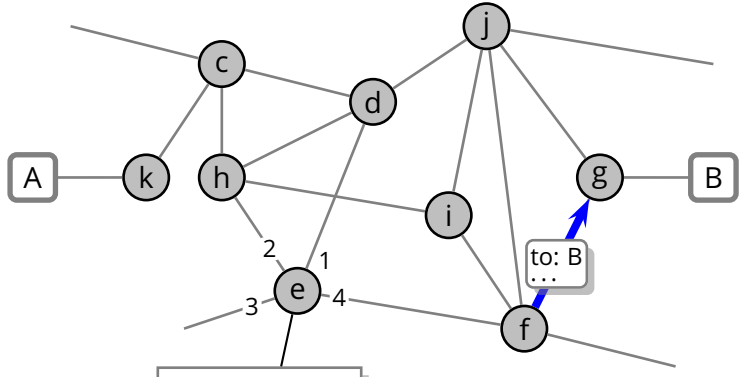

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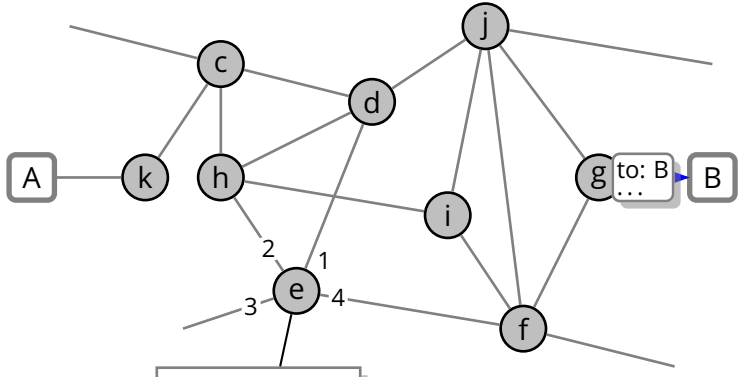

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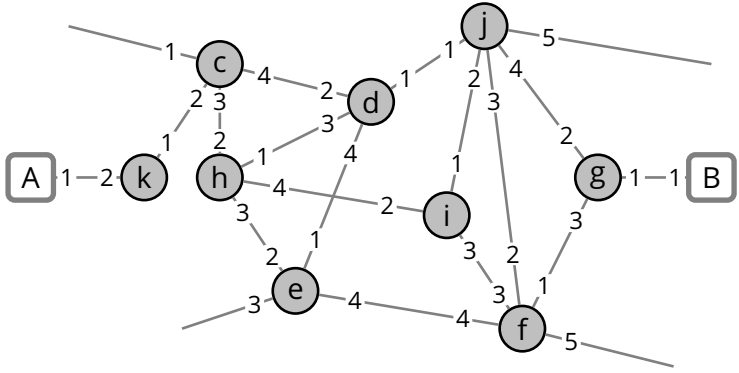
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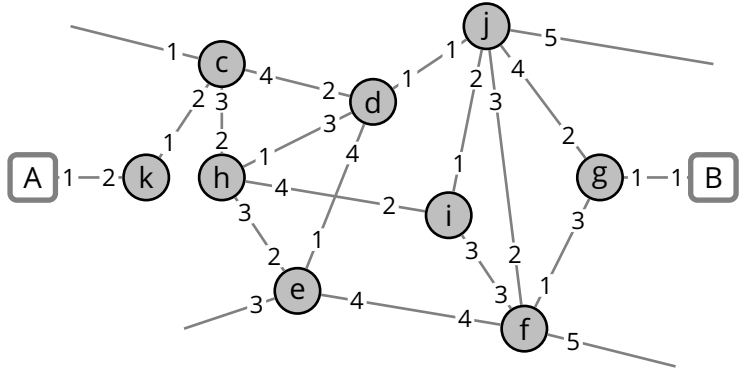


| *router k* | |
|---|---|
| A | 2 |
| B | 1 |

...

# Router Functions

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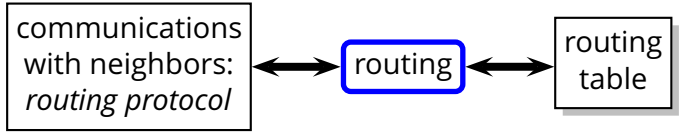

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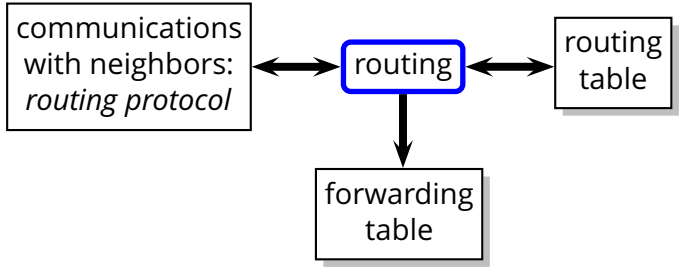

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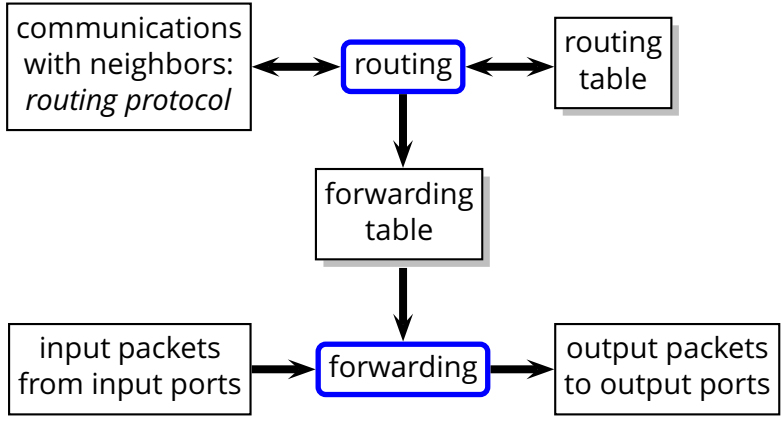

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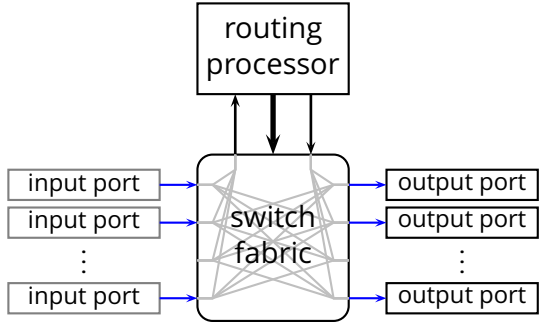

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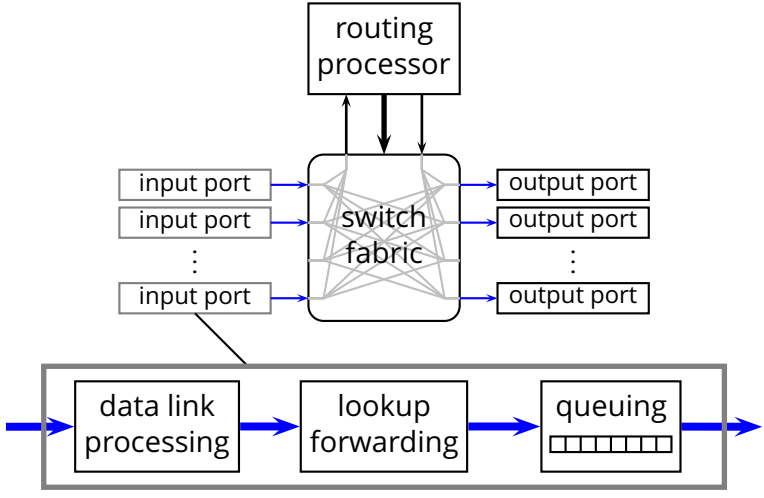

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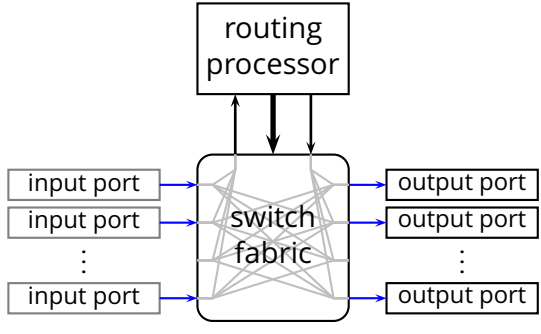

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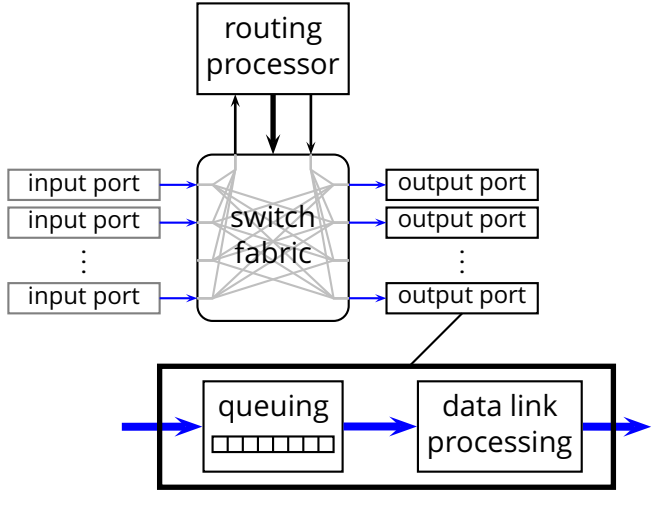

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  - *drop tail:* drop arriving packets when queues are full
  - *active queue management:* a set of policies and algorithms to decide when and how to drop or mark packets in the attempt to prevent congestion

# Internet Network Layer

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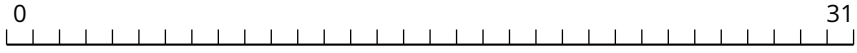
# IPv4 Datagram Format



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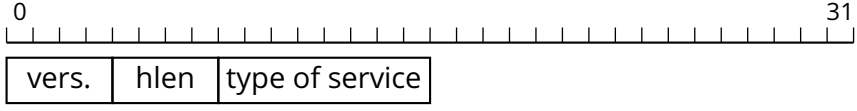

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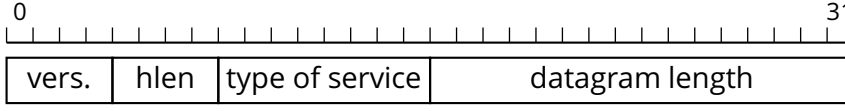

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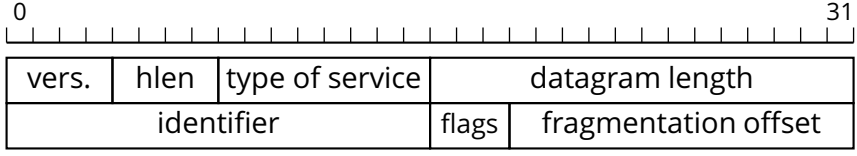

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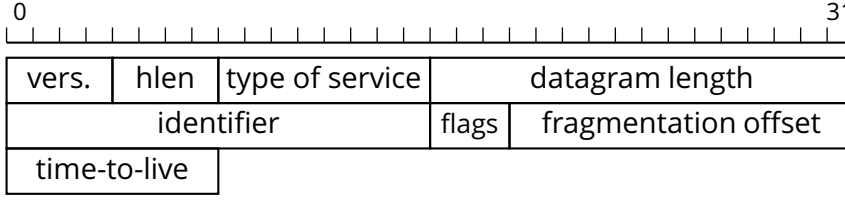

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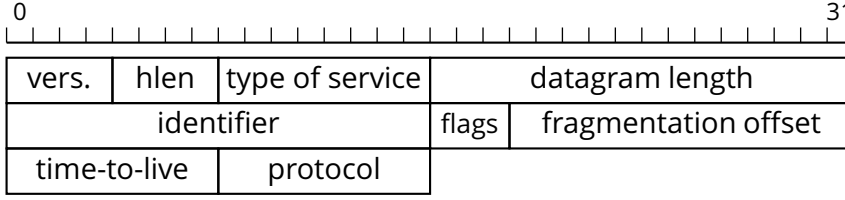

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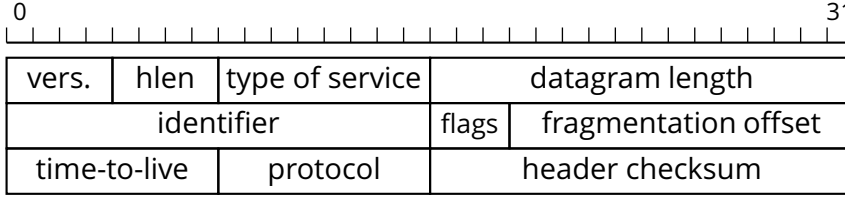

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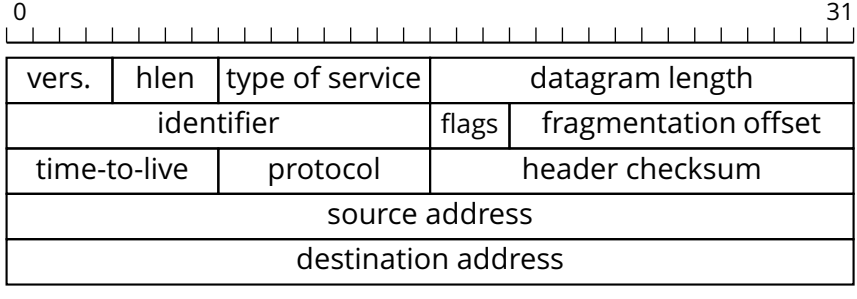

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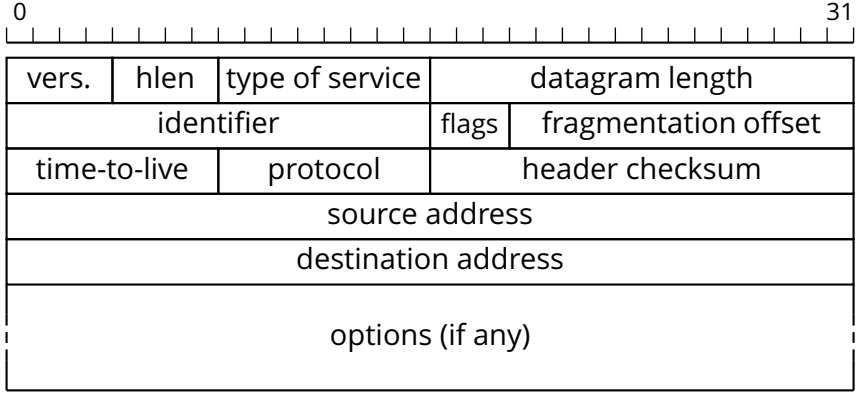

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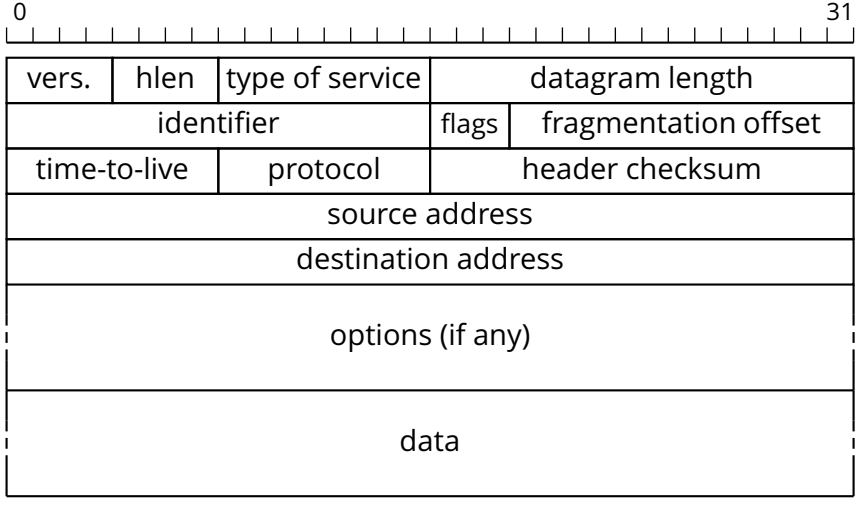
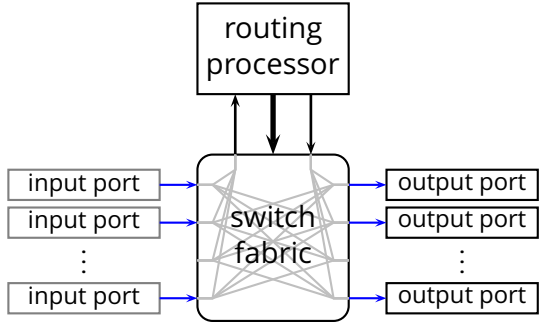


# Fragmentation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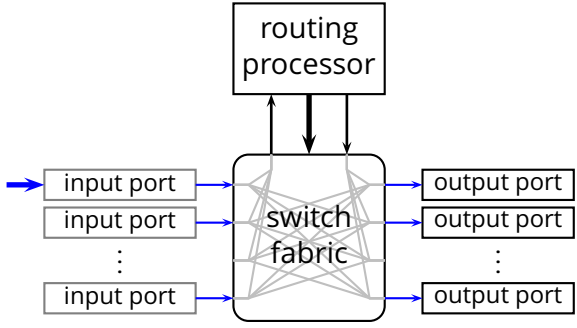

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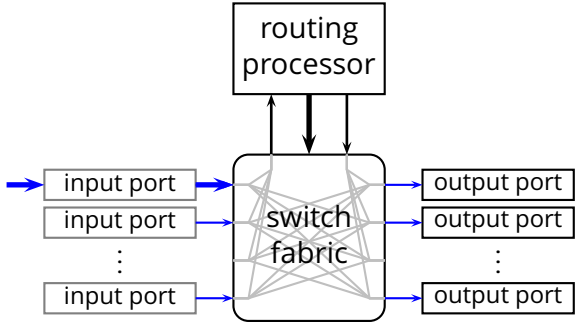

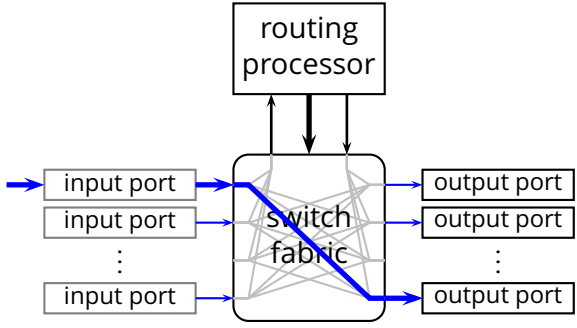
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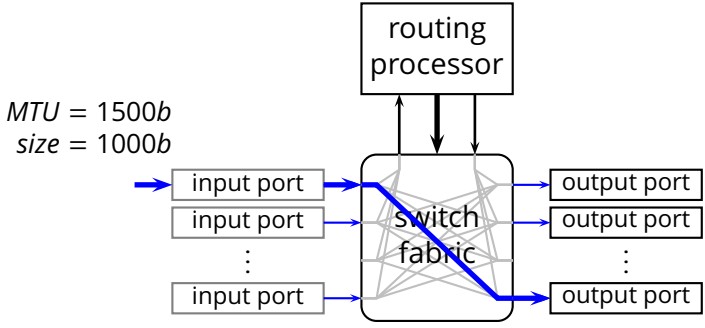

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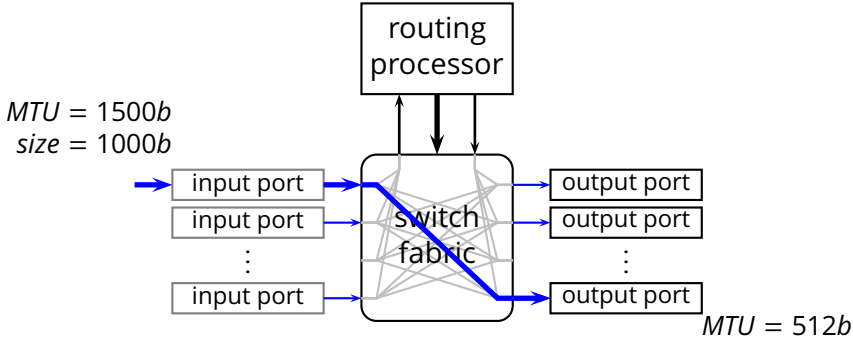

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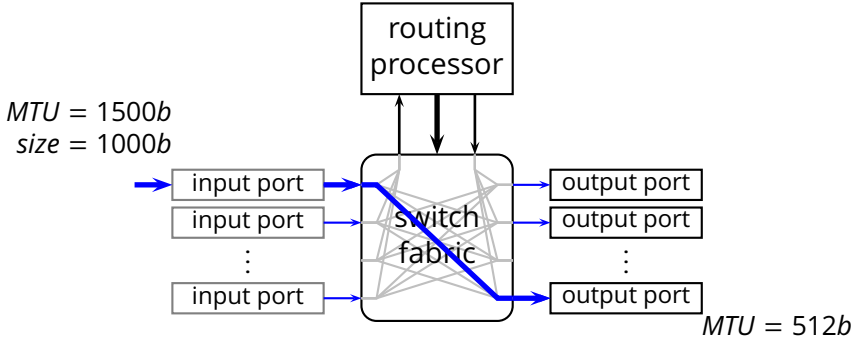


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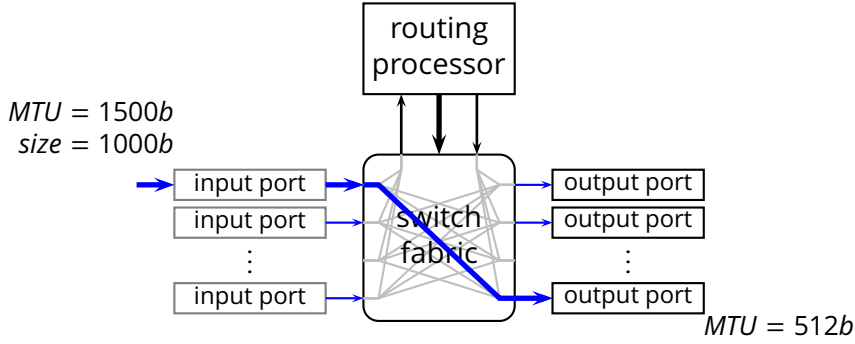


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- The datagram is ***fragmented***

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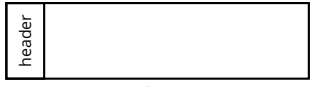


*input datagram*

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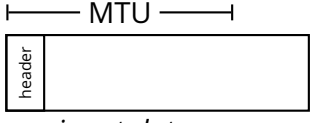

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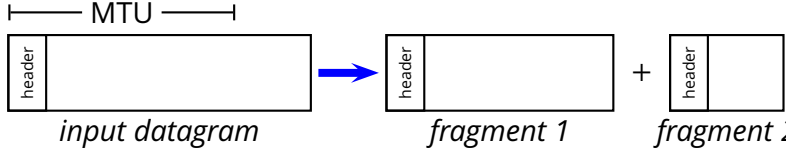

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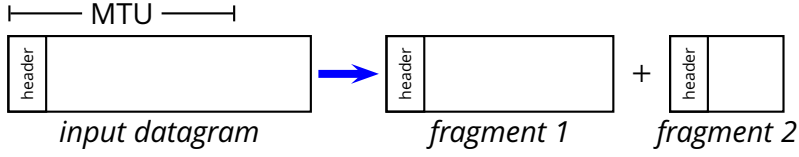


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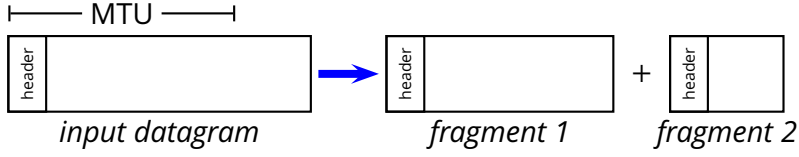


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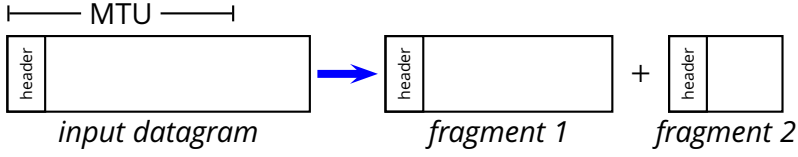


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  - intermediate routers must be able to fragment a datagram to whatever level necessary

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

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|---|---|---|---|---|
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| *identifier* | *fragment offset* | *more fragments* | *header length* | *total length* |
|---|---|---|---|---|
| 789 | 61 | 1 | 20 | 508 |

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|---|---|---|---|---|
| 789 | 0 | 1 | 20 | 508 |

| *identifier* | *fragment offset* | *more fragments* | *header length* | *total length* |
|---|---|---|---|---|
| 789 | 61 | 1 | 20 | 508 |

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