The Necessity of Timekeeping in Adversarial Queueing

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13.5.05

Routing

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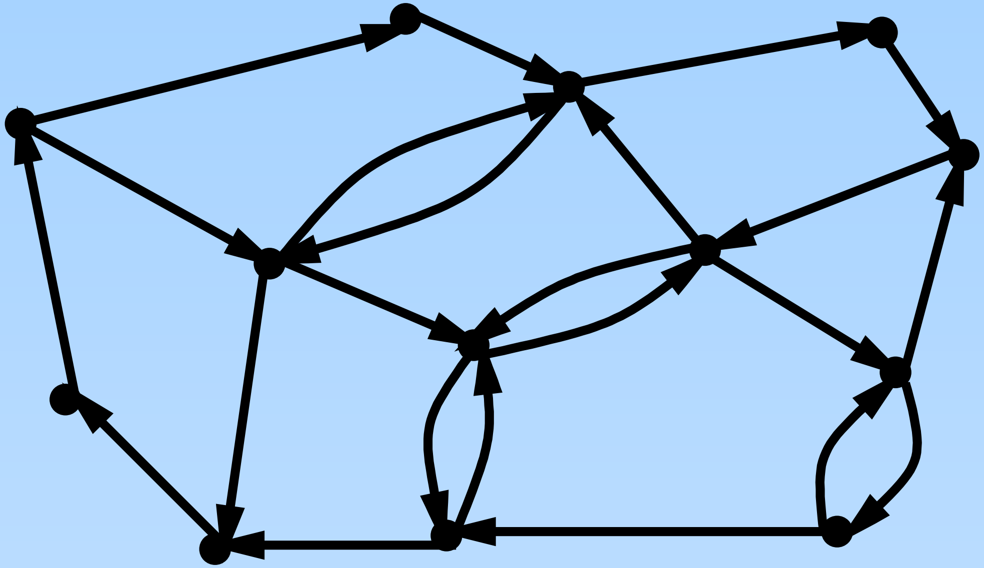
Graph G



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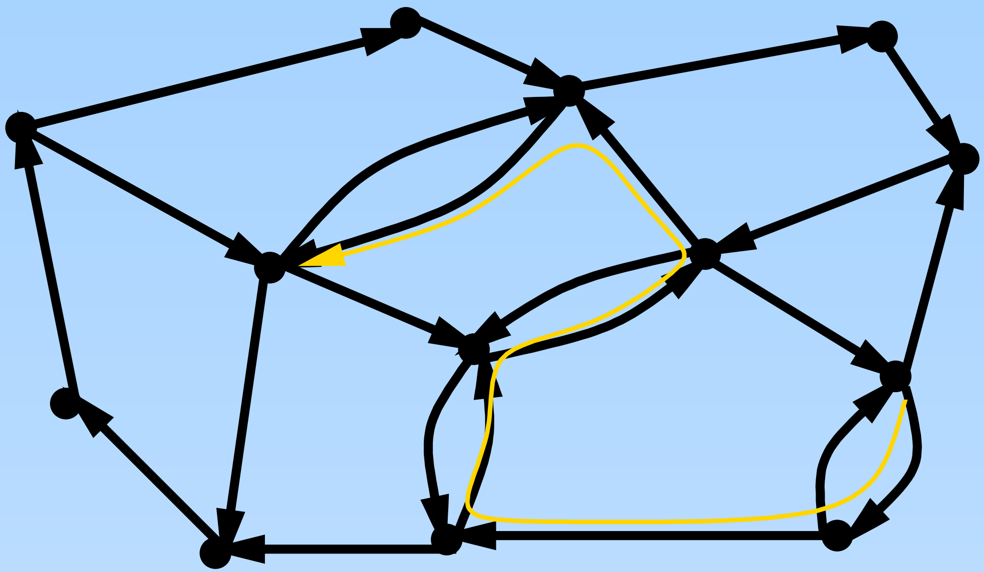

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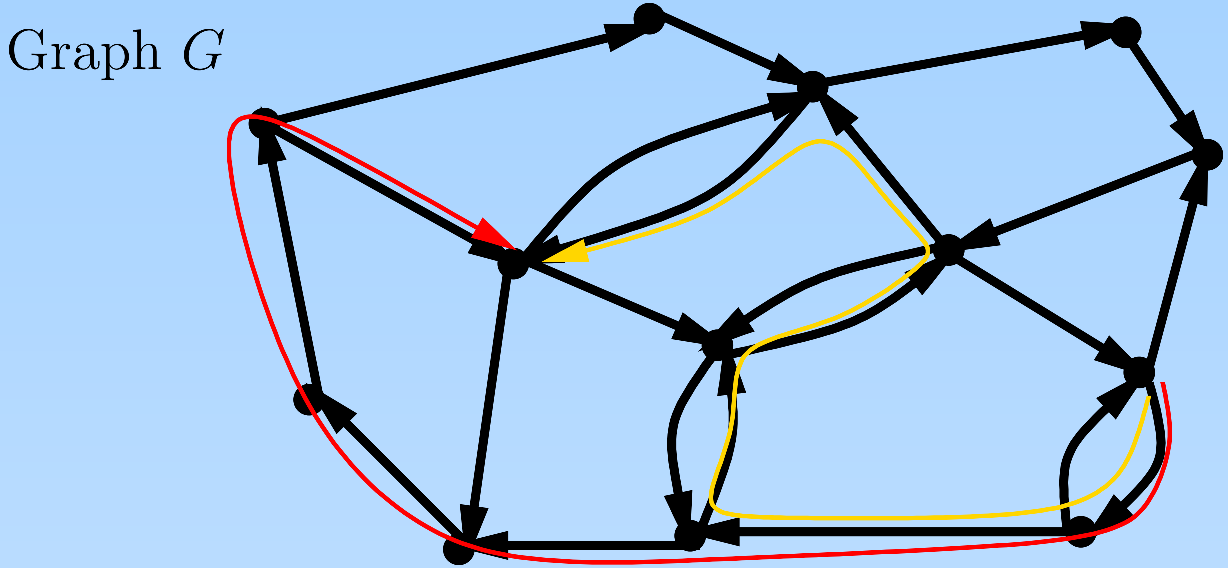

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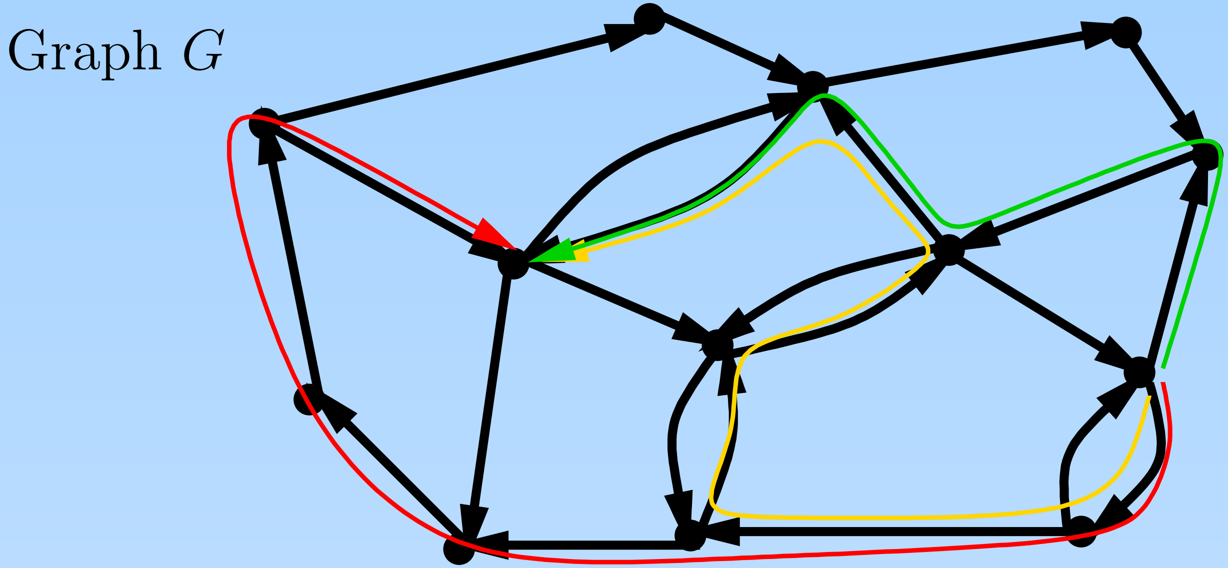

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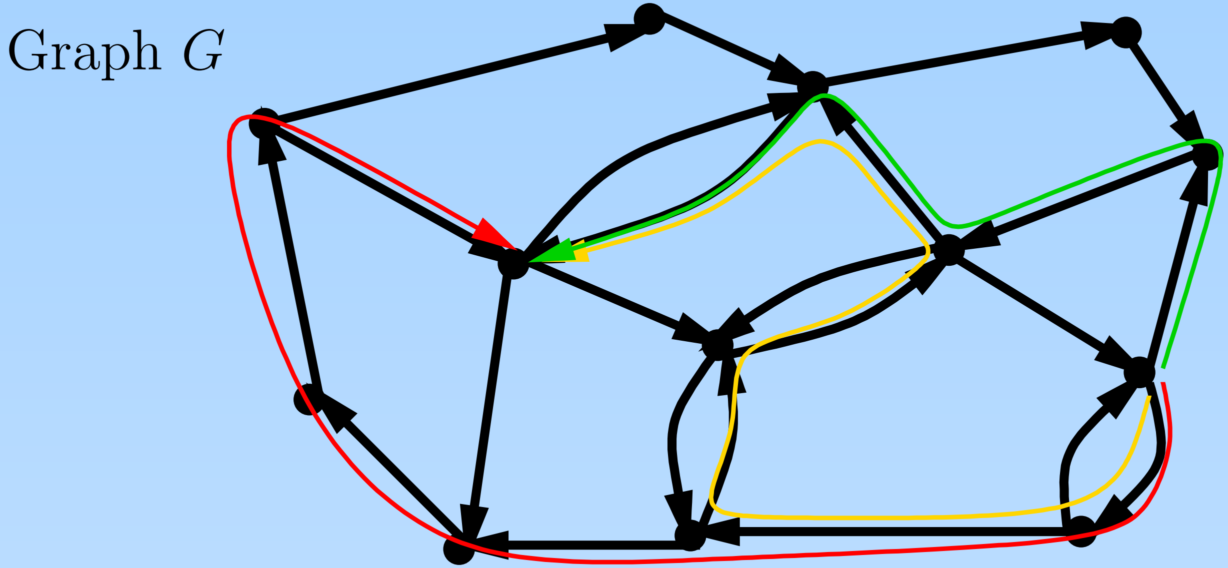

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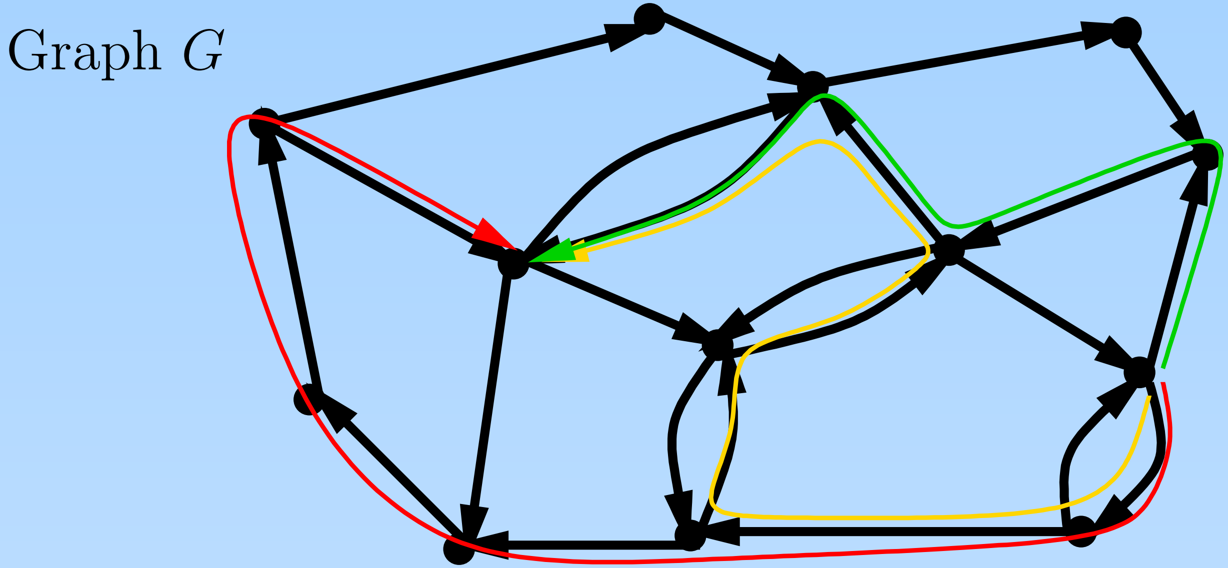

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We assume unit capacity and unit speed edges.

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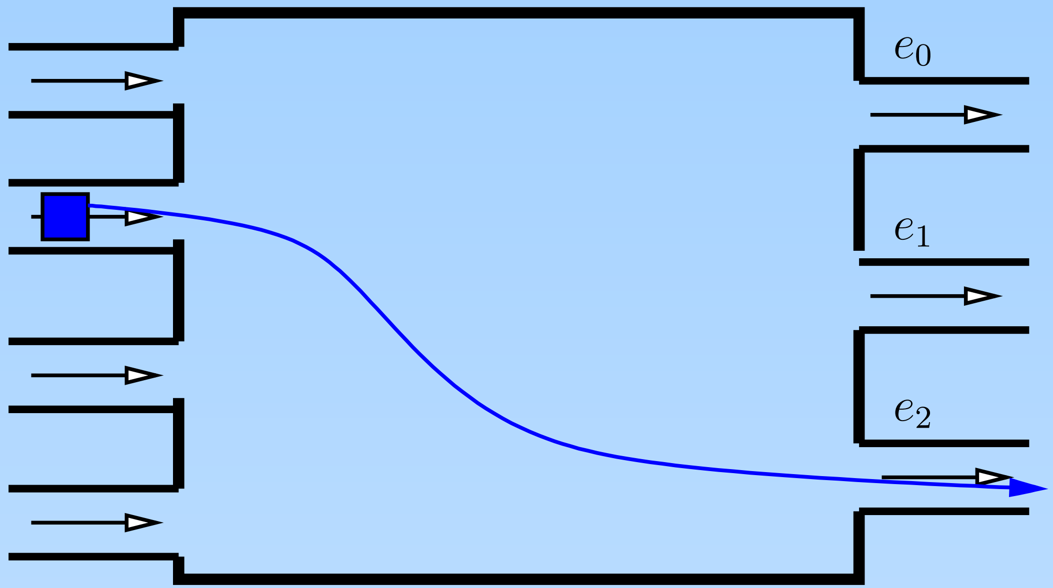

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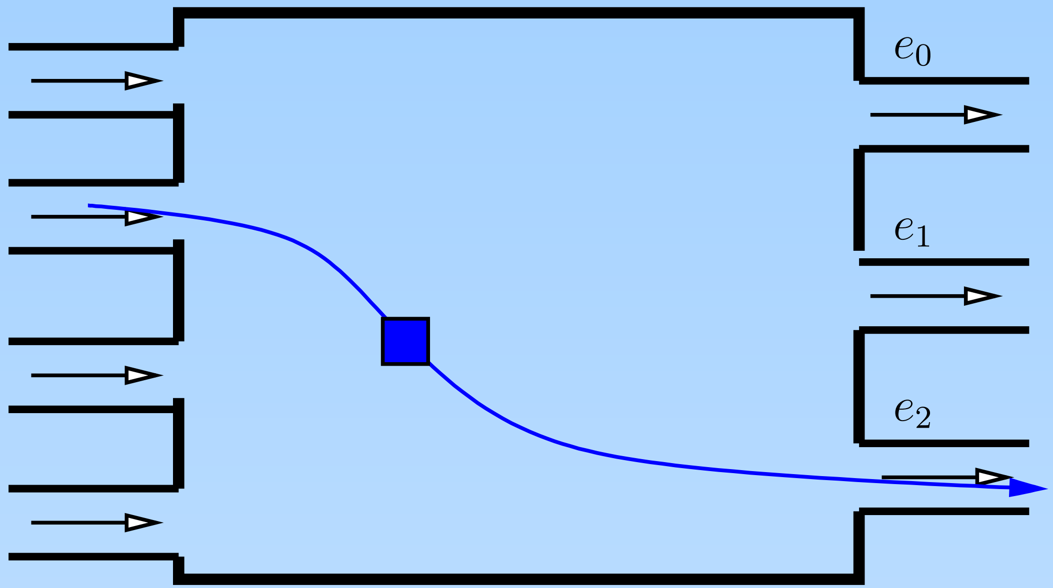

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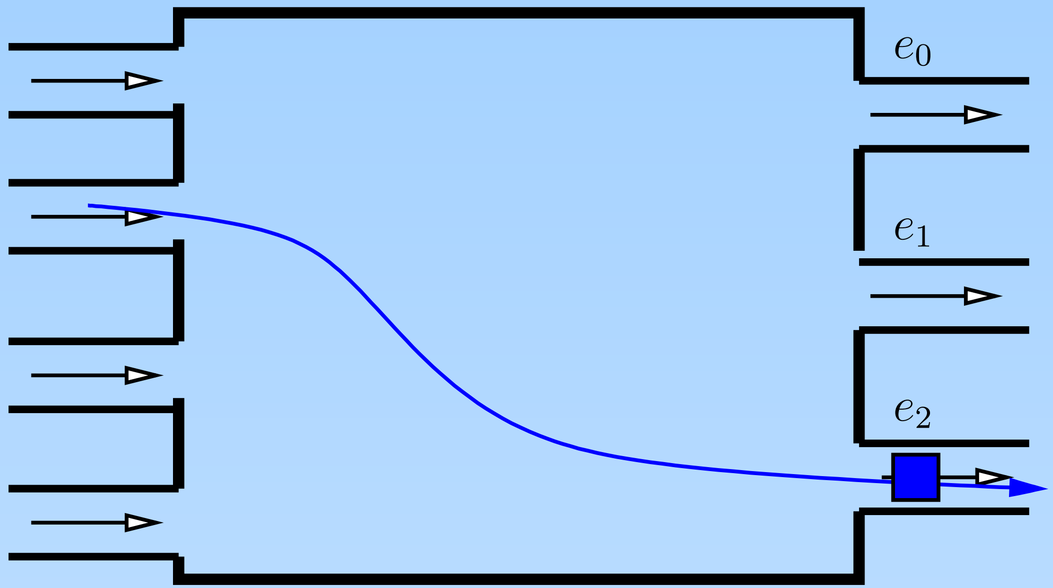

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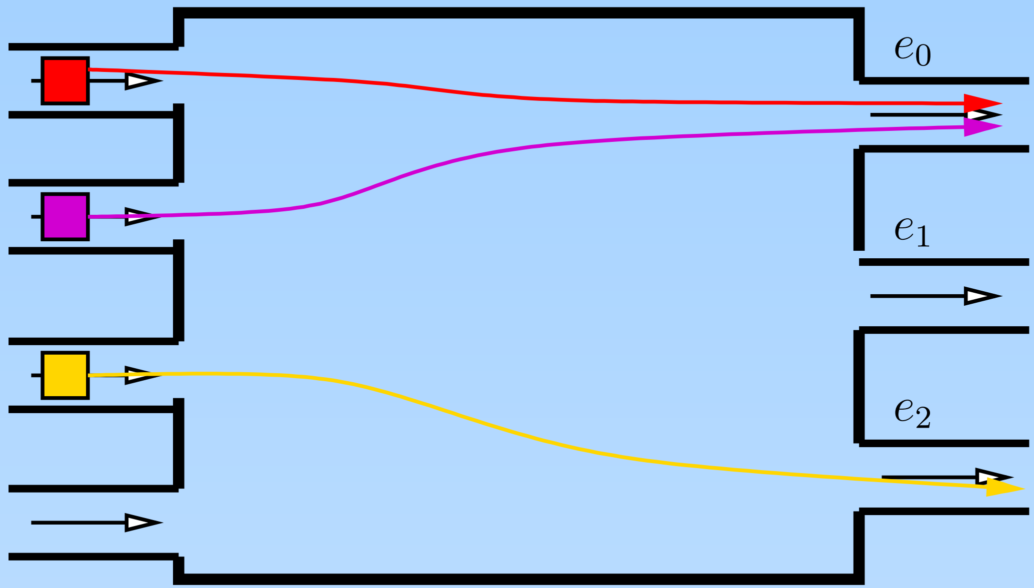

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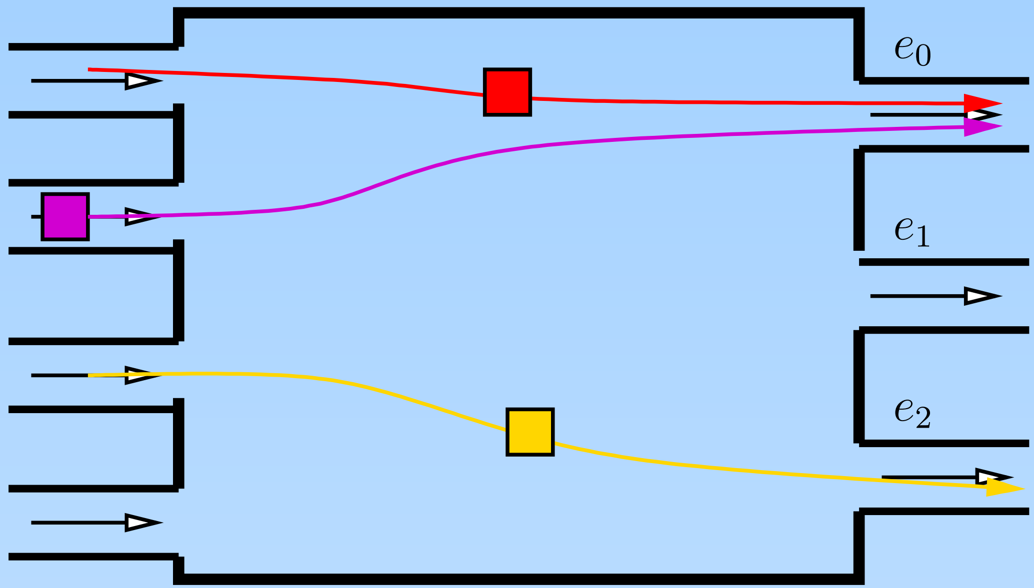

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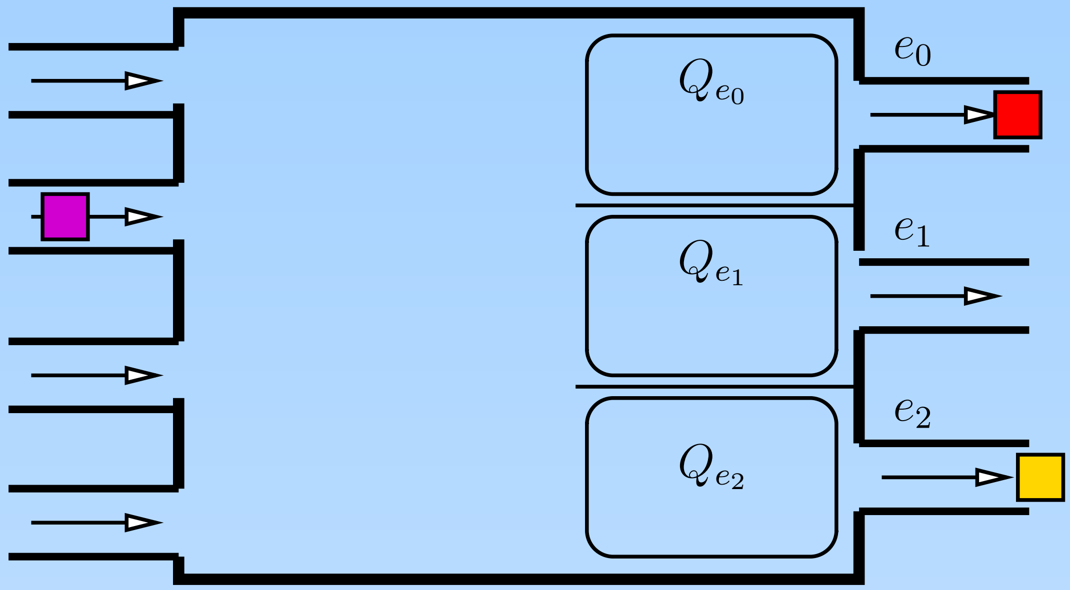

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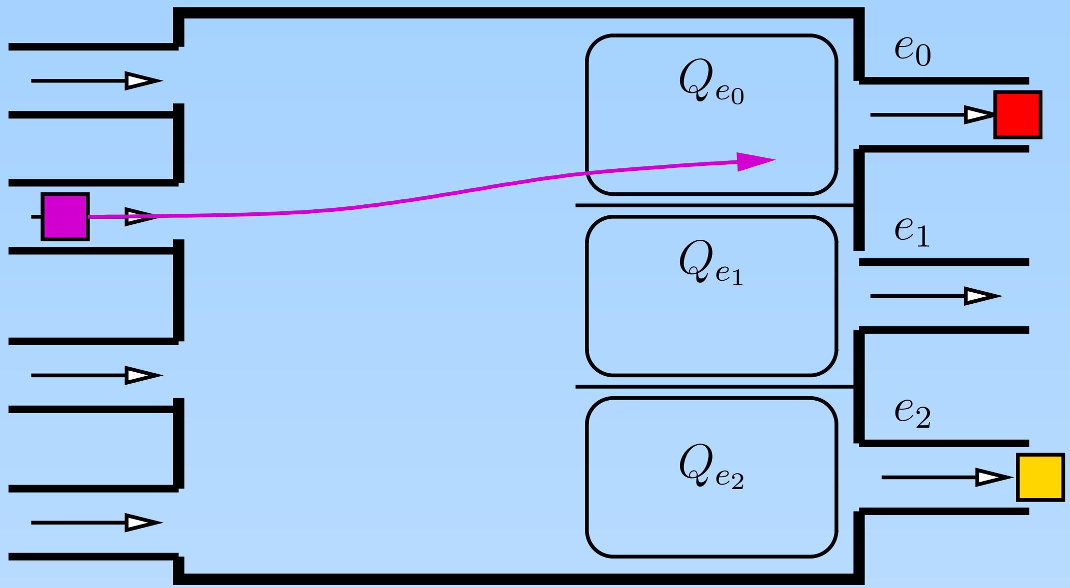

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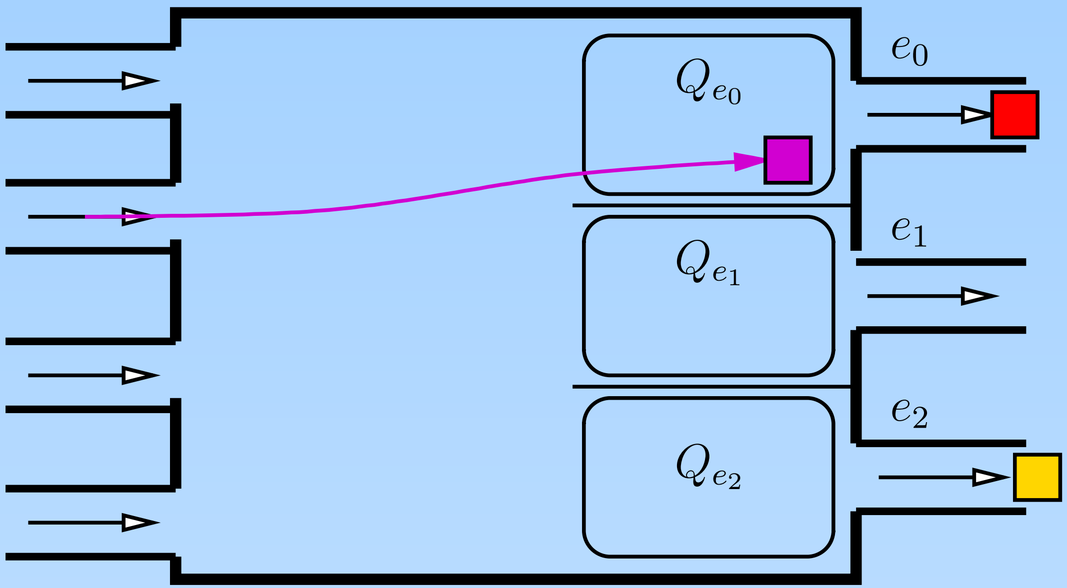

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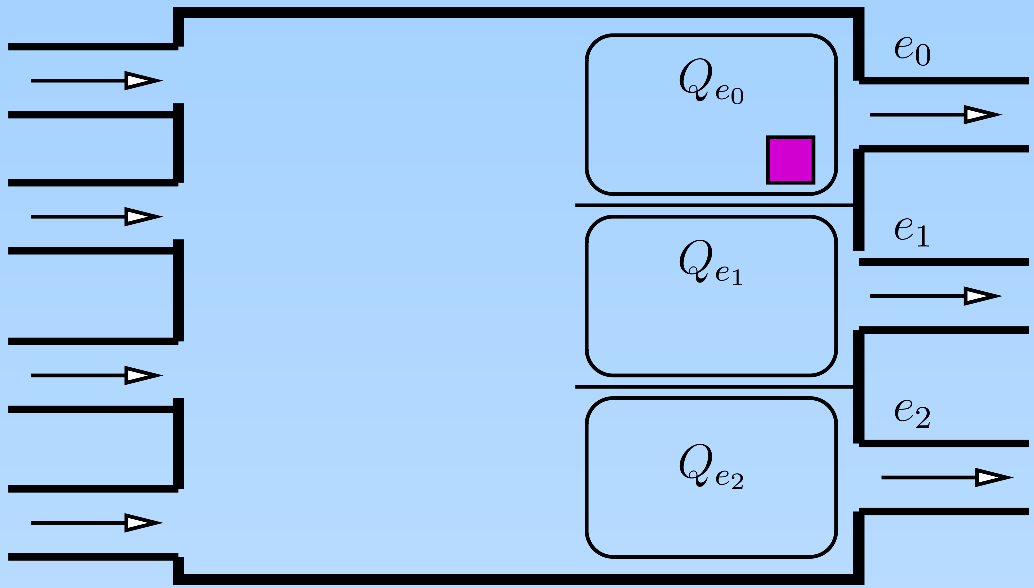

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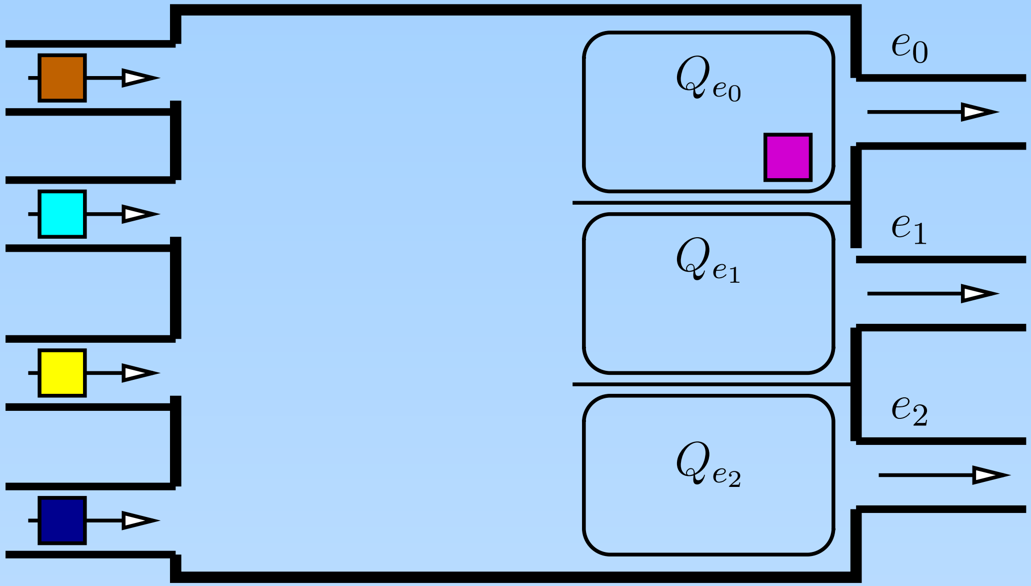

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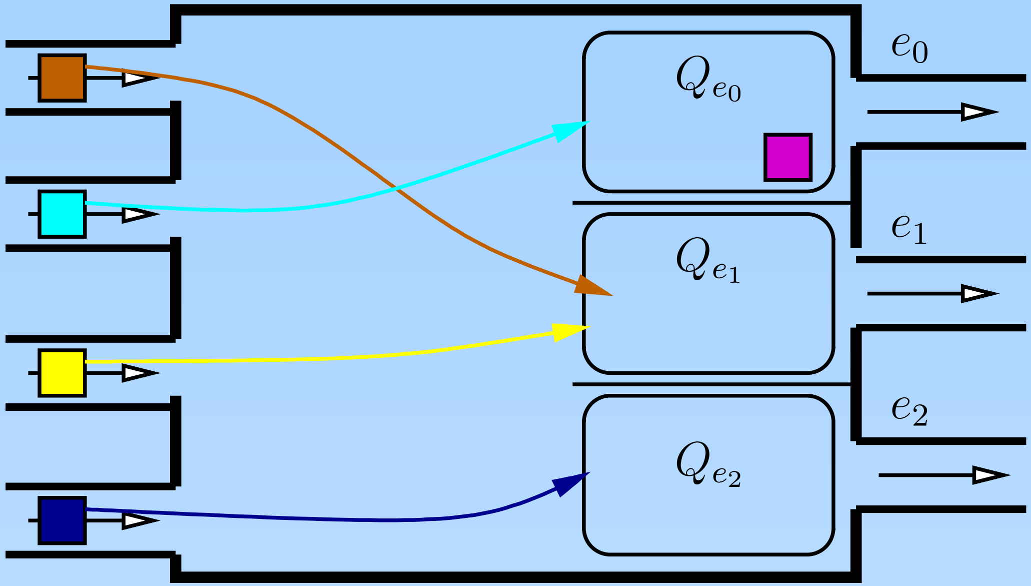

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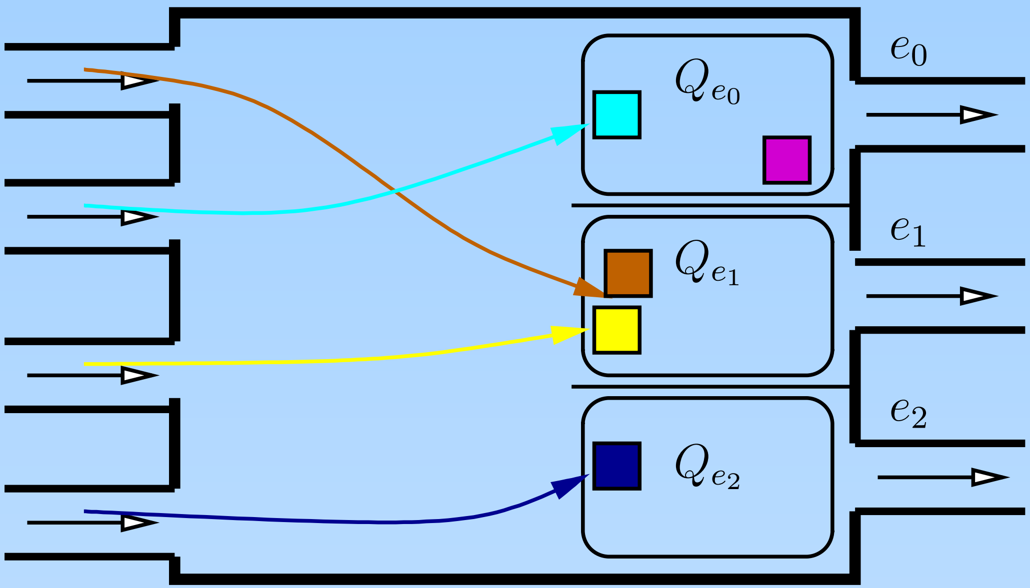

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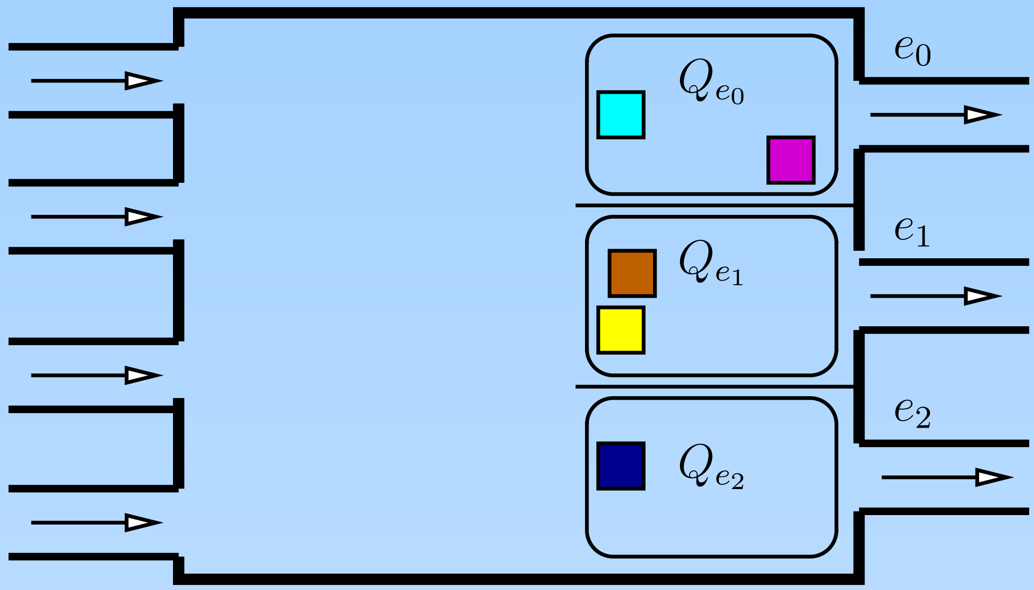

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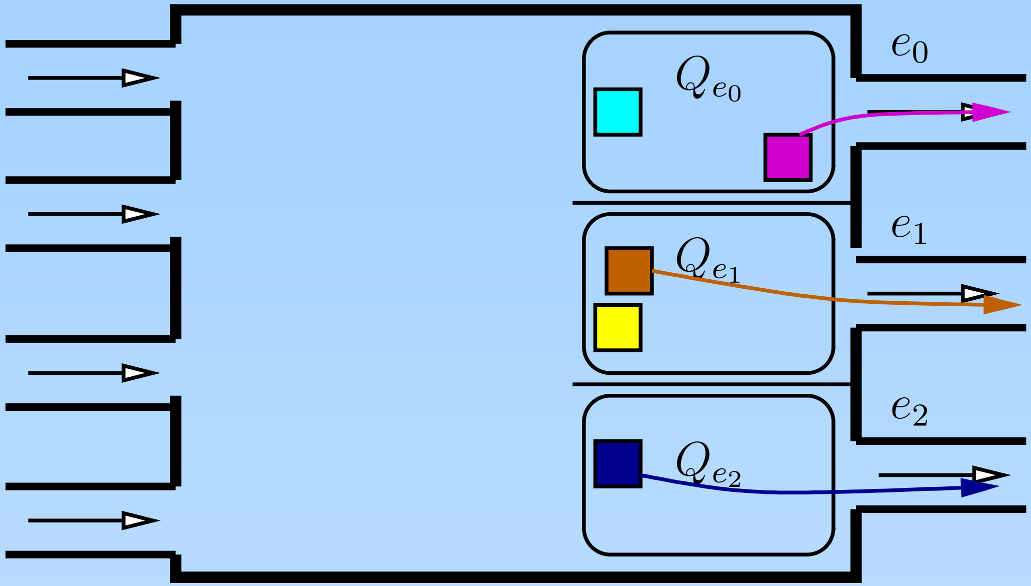

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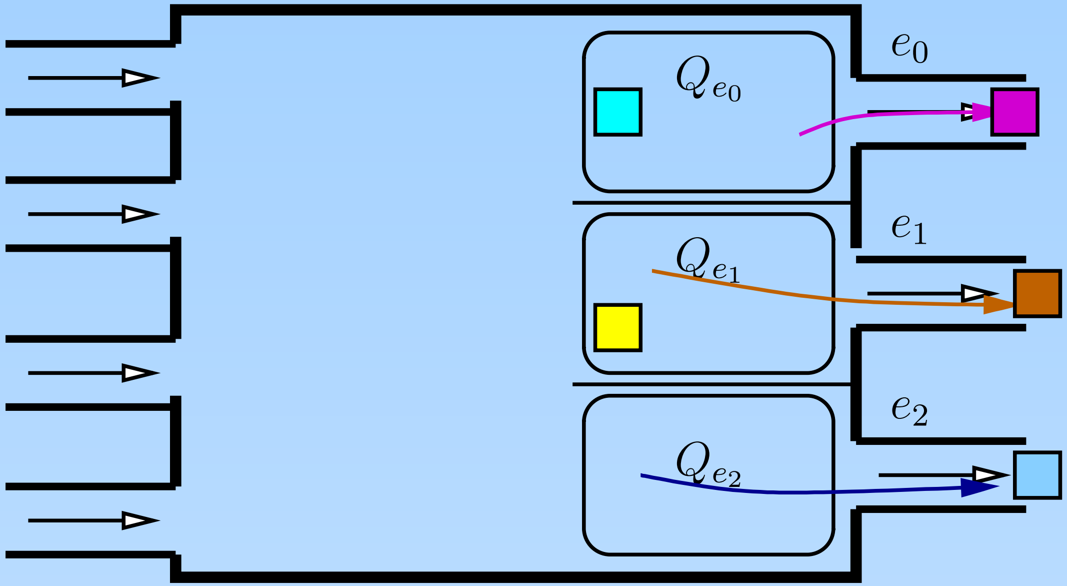

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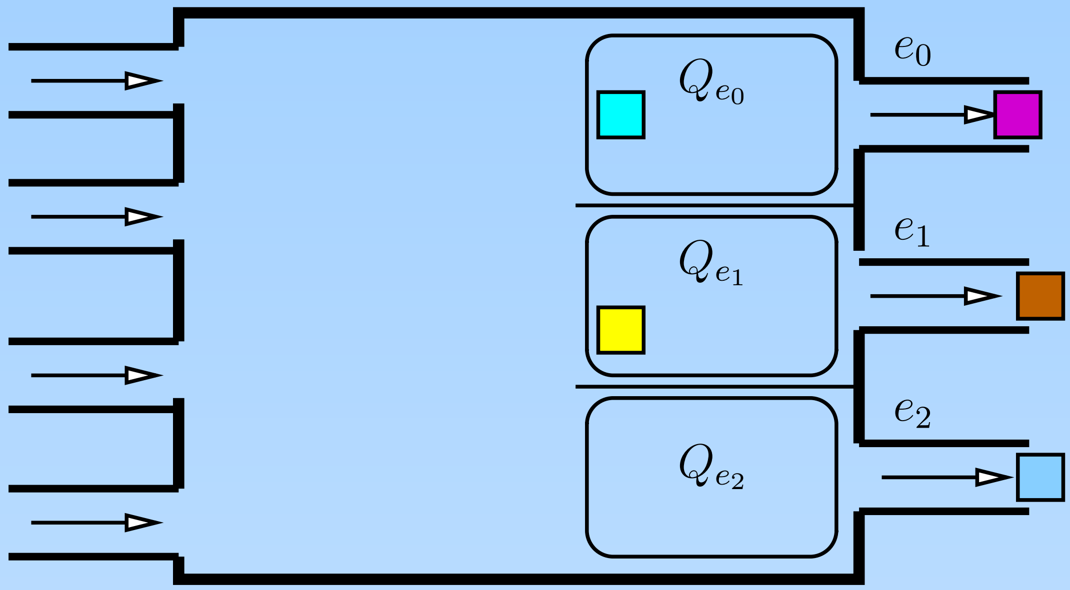

Queueing strategies decide which packet may proceed.

Queueing Policies

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A queueing strategy is *universally stable* if it is stable on every graph against every (r, b)-adversary with $r < 1$.

Previous Work

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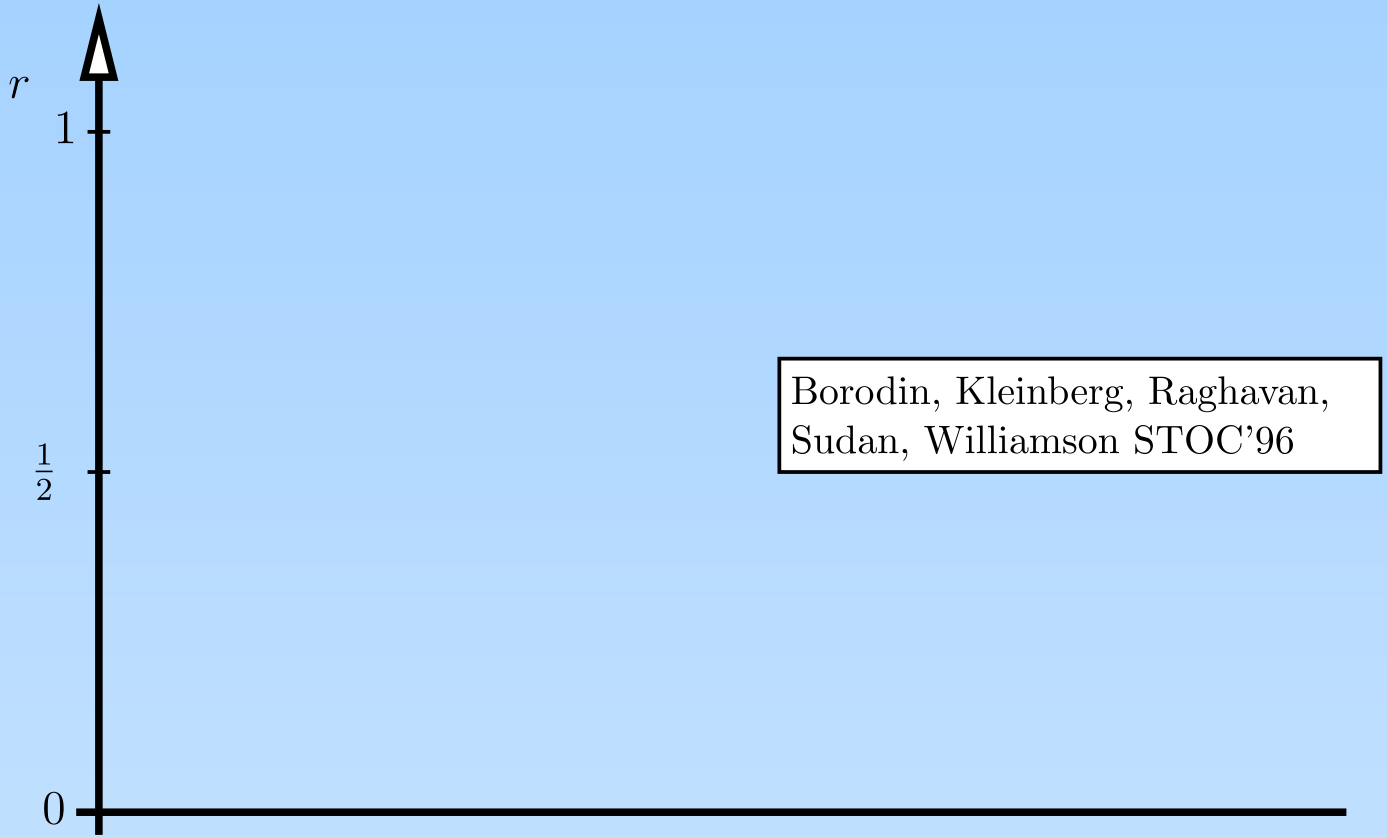

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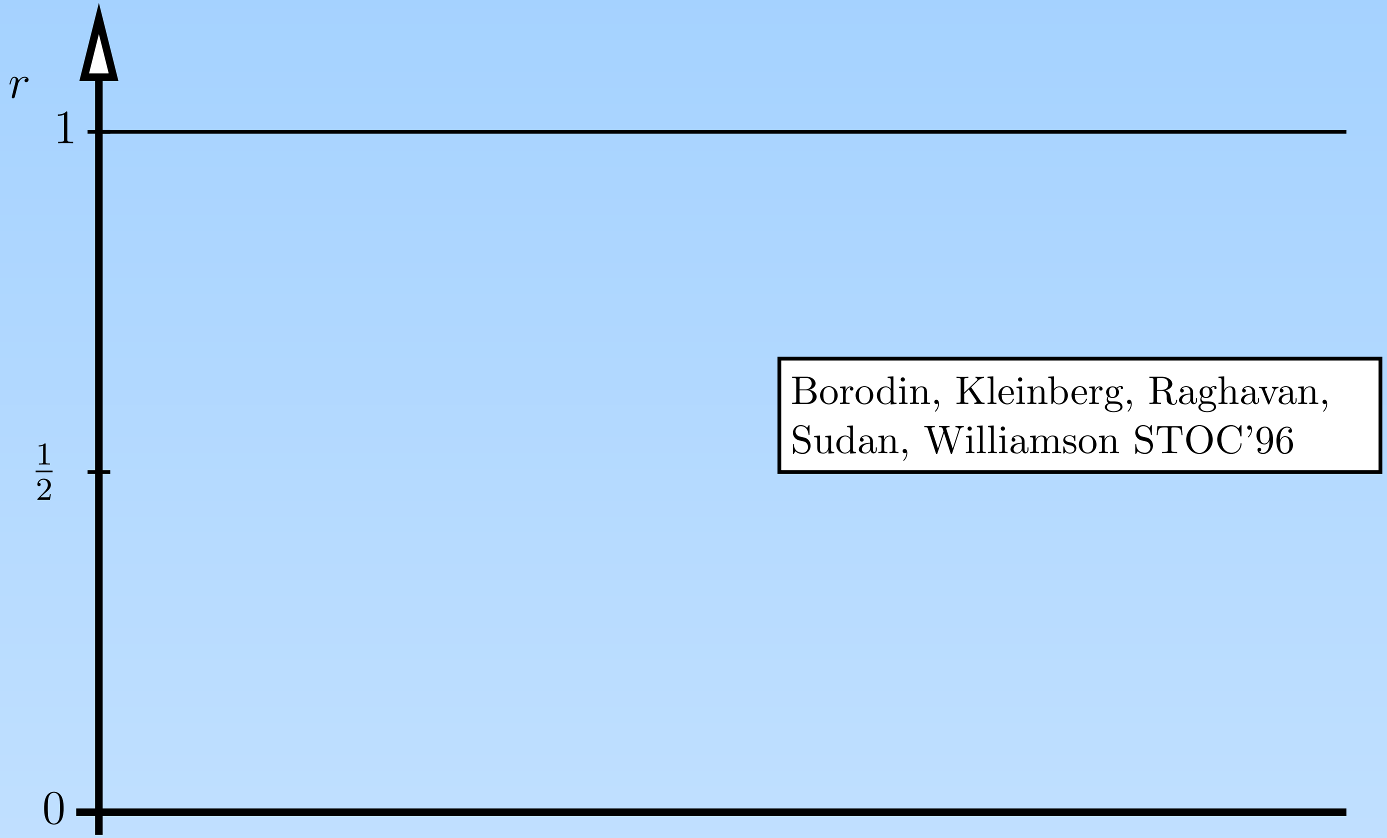

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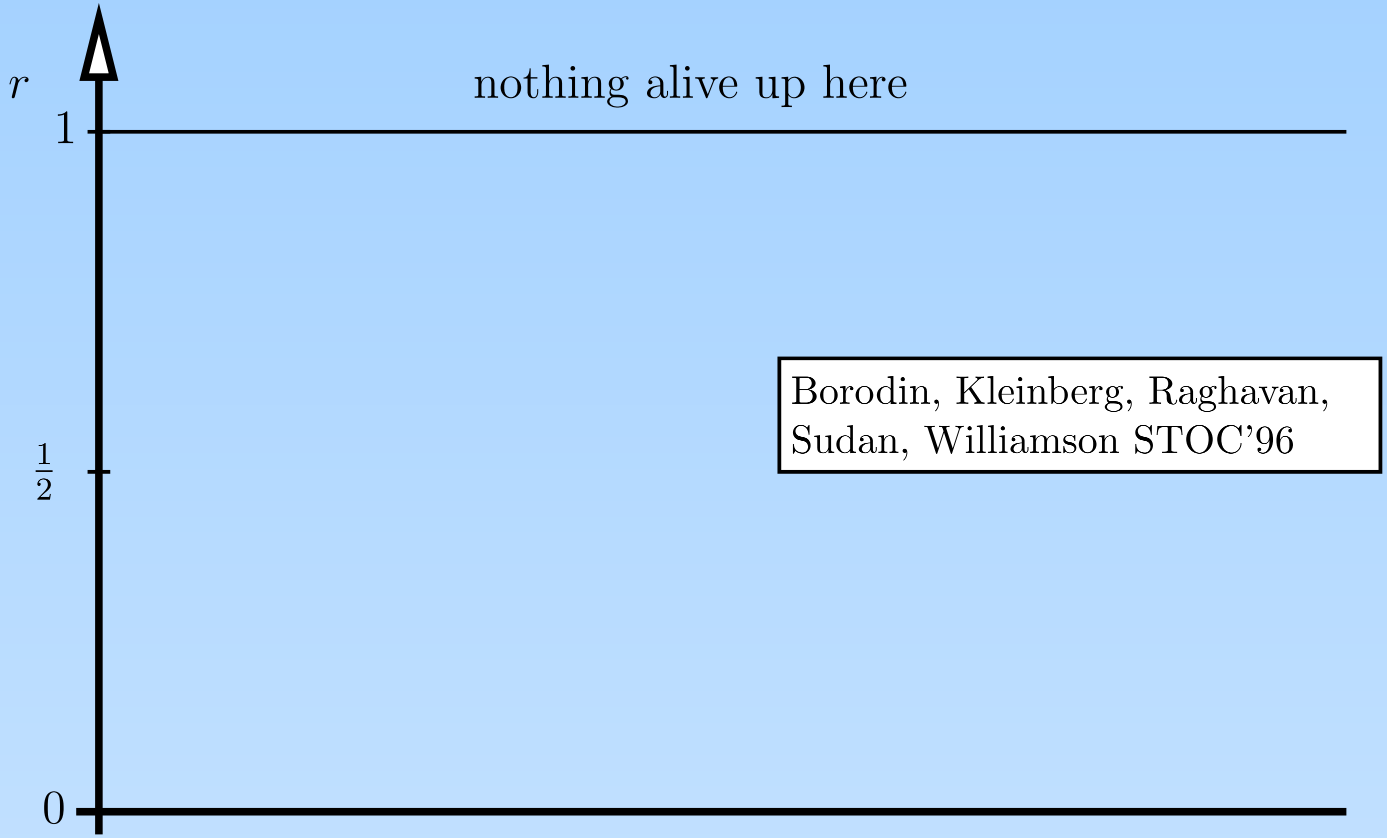

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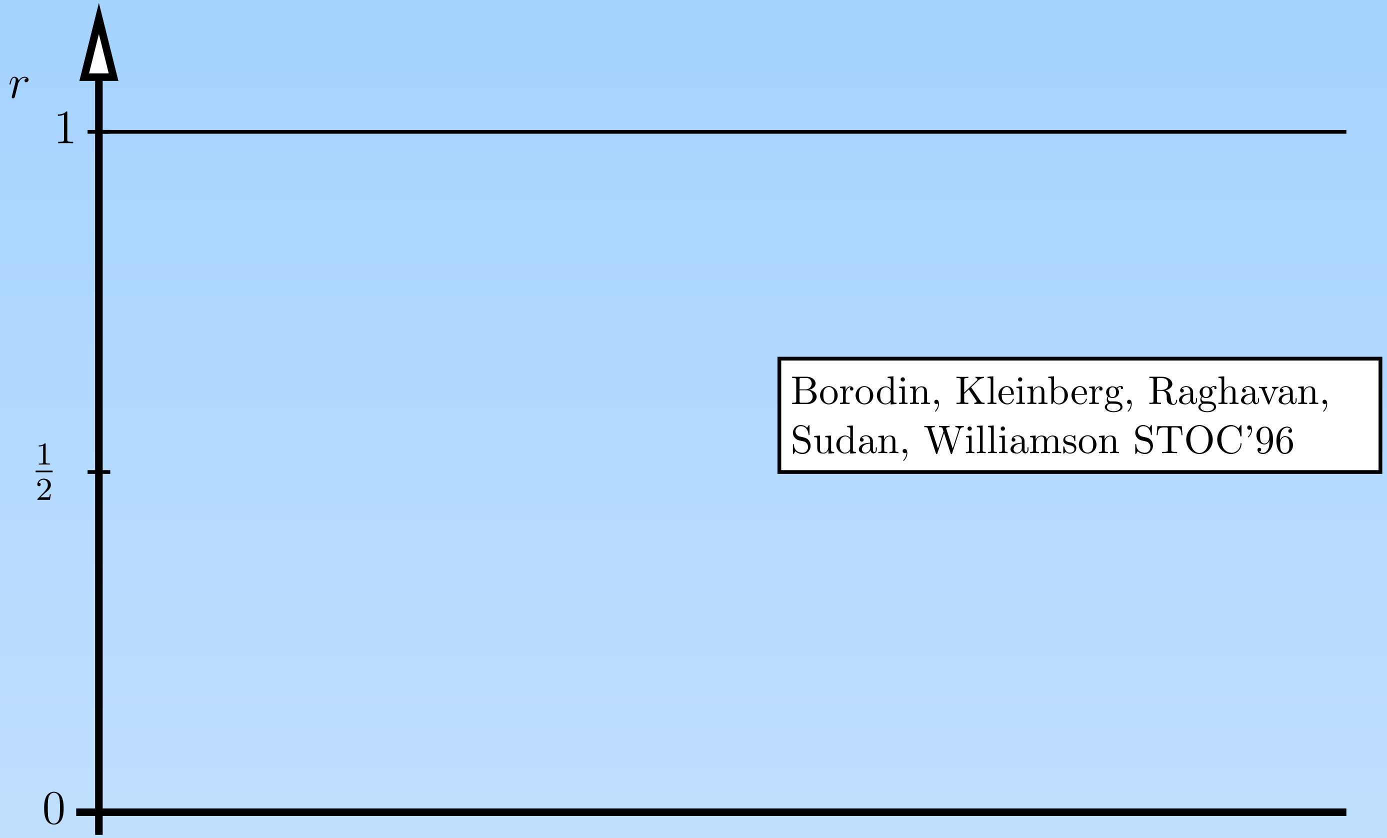

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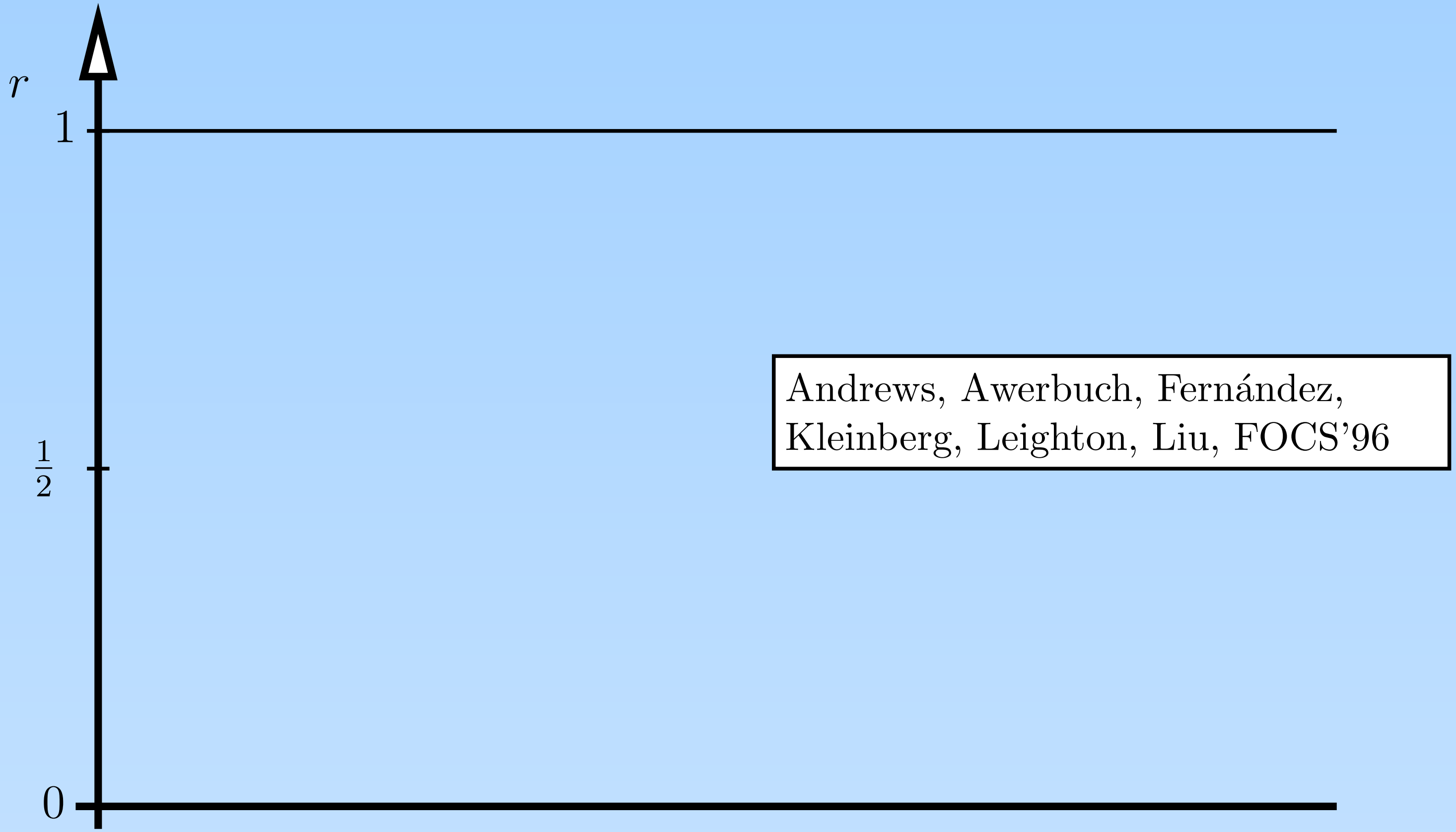

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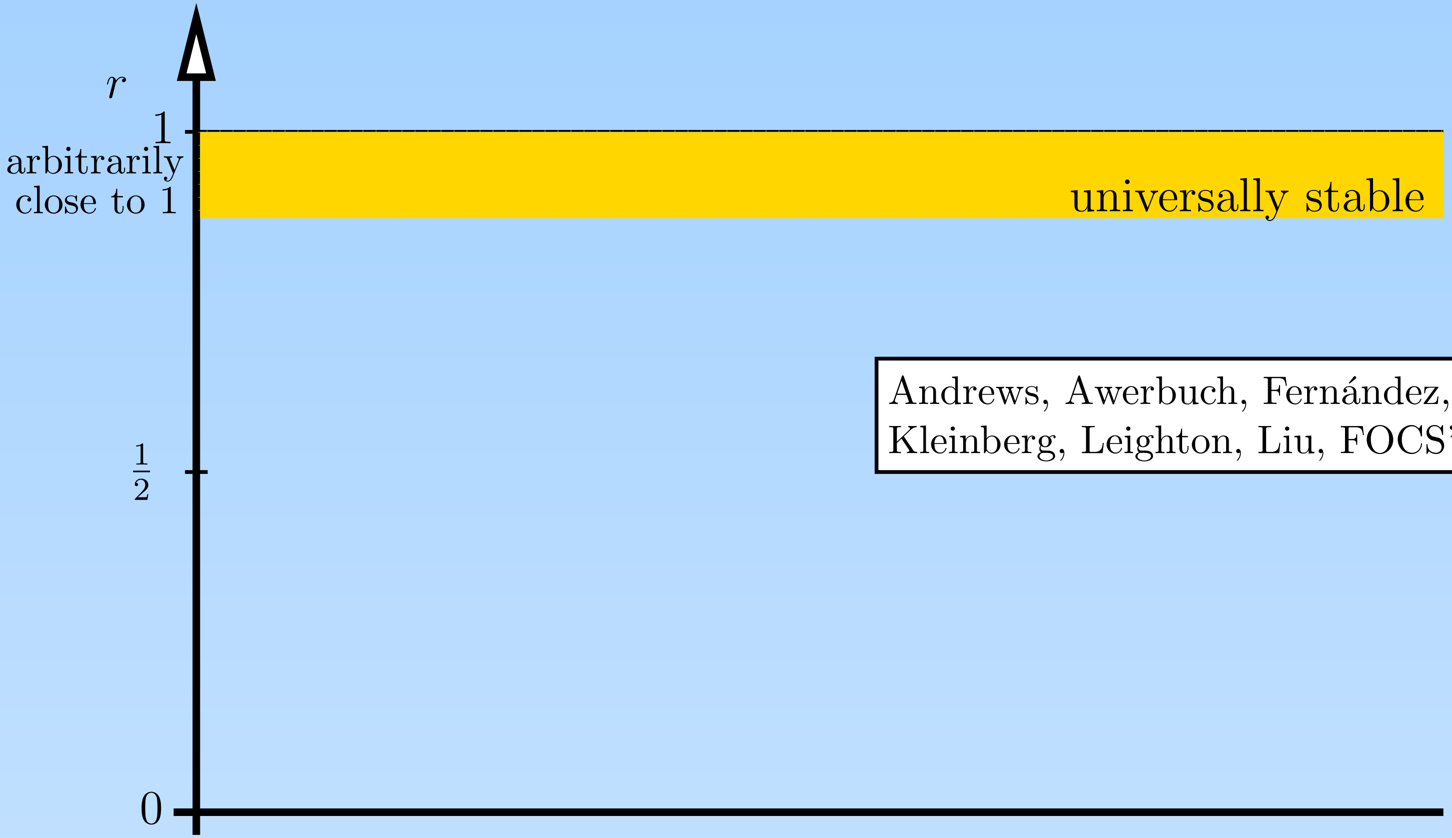

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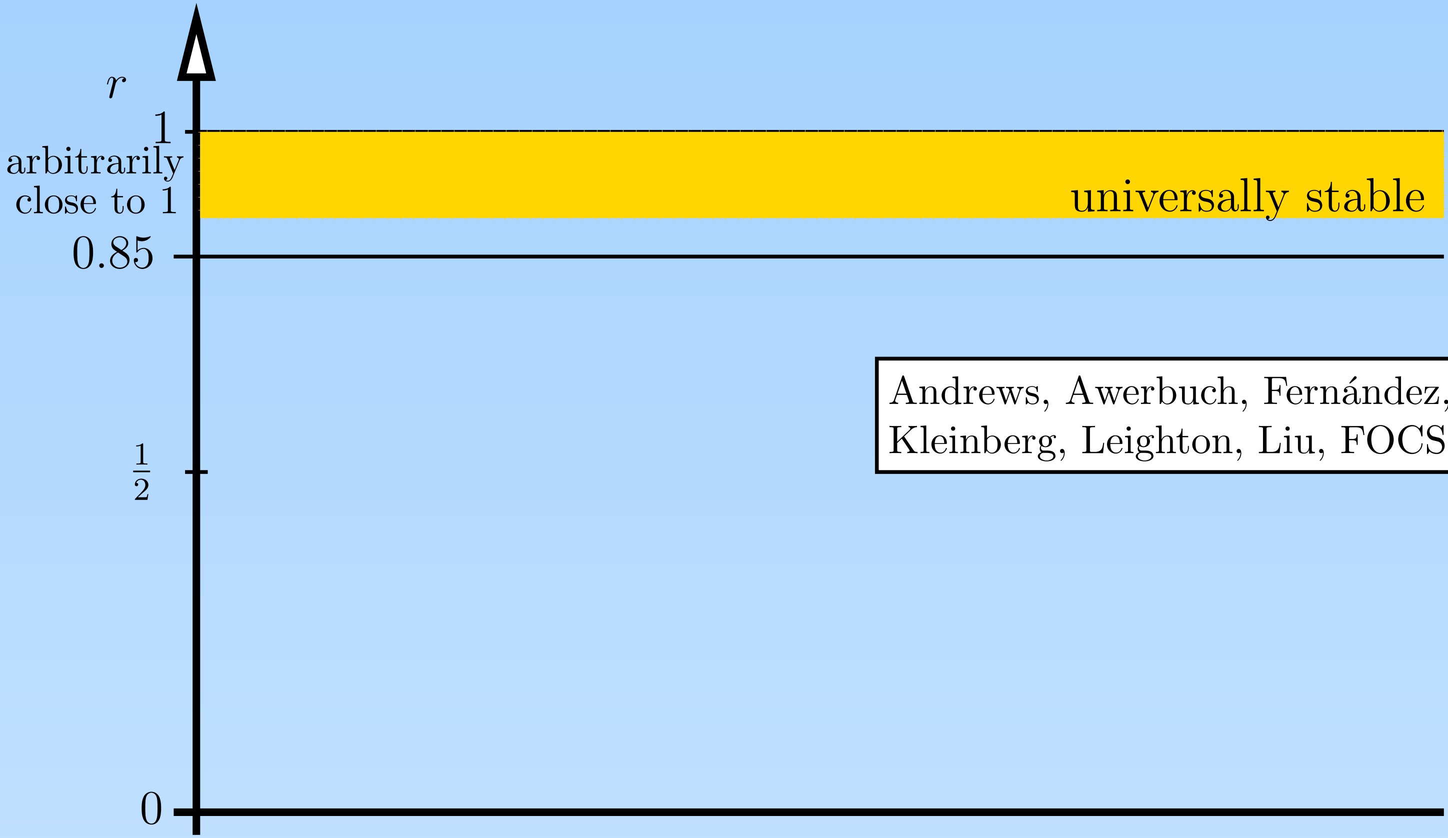

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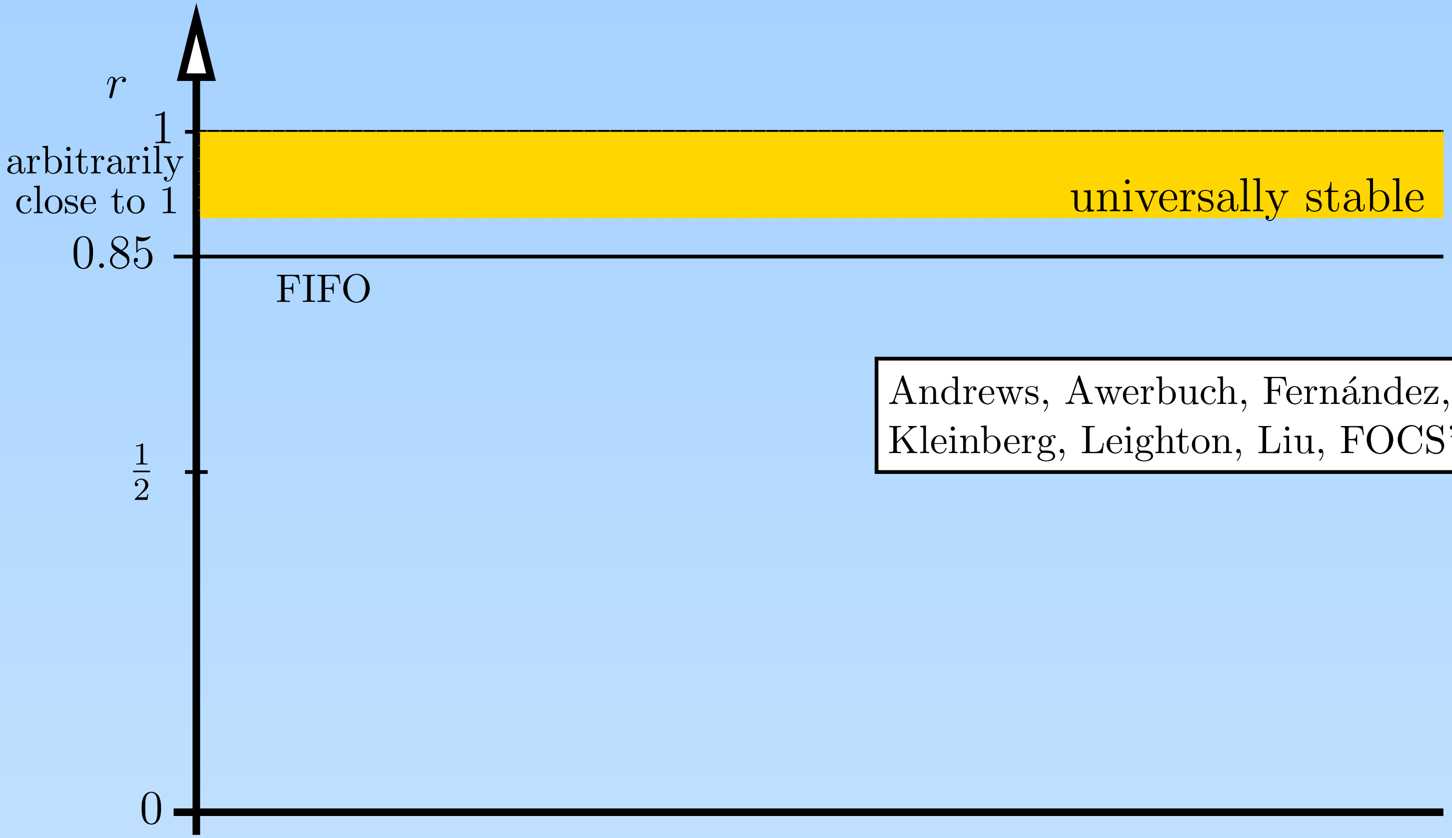

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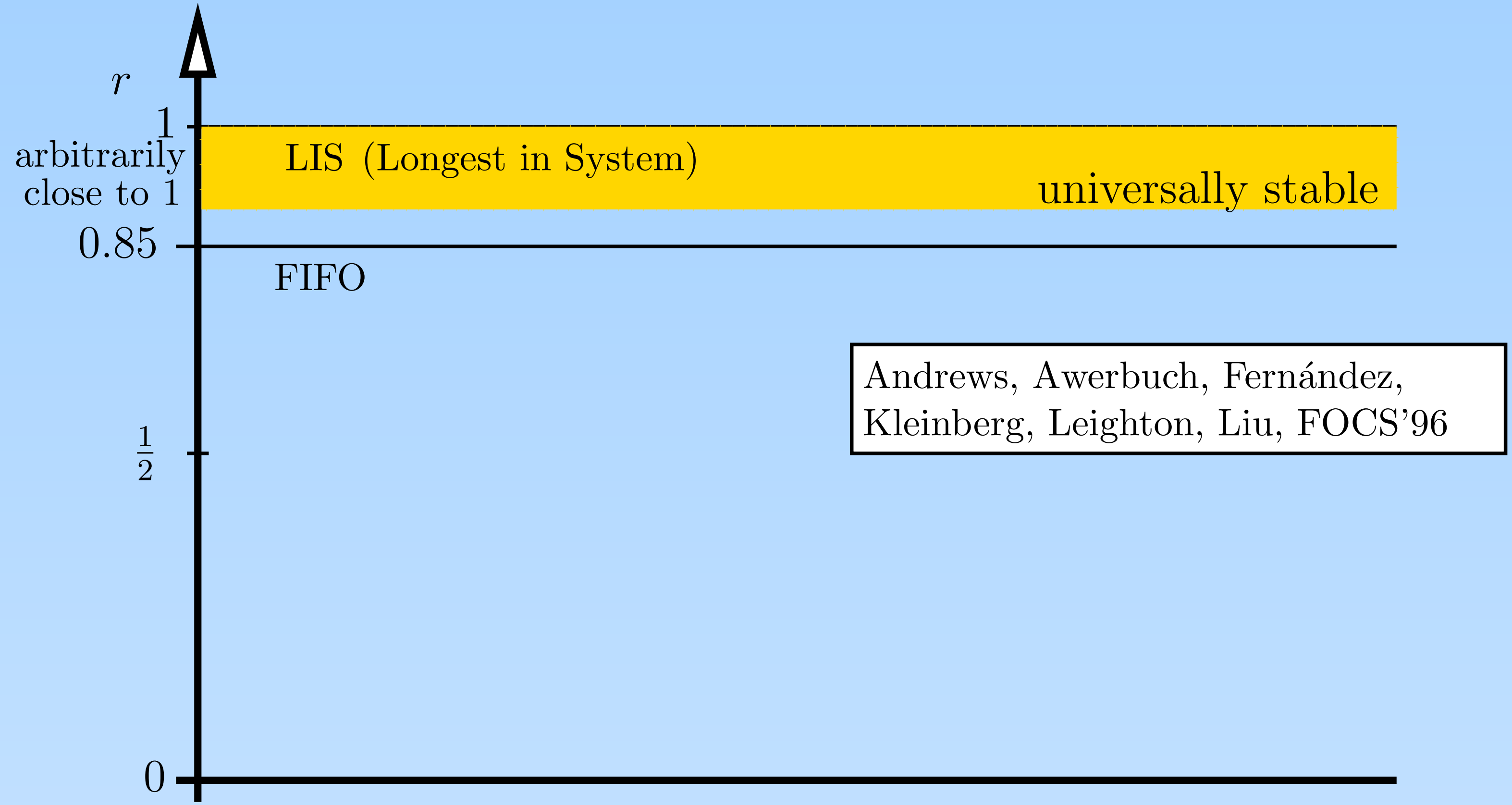

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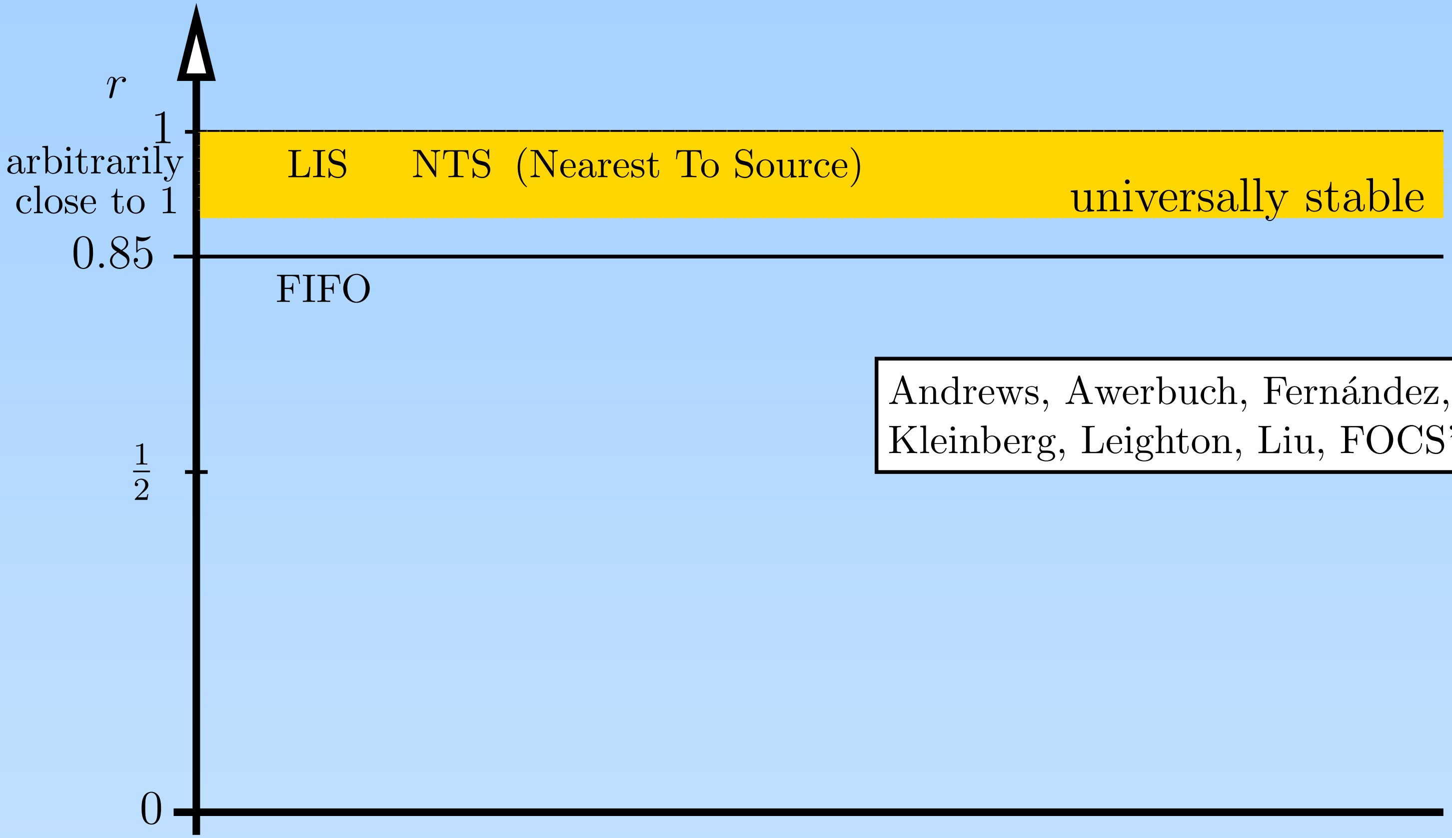

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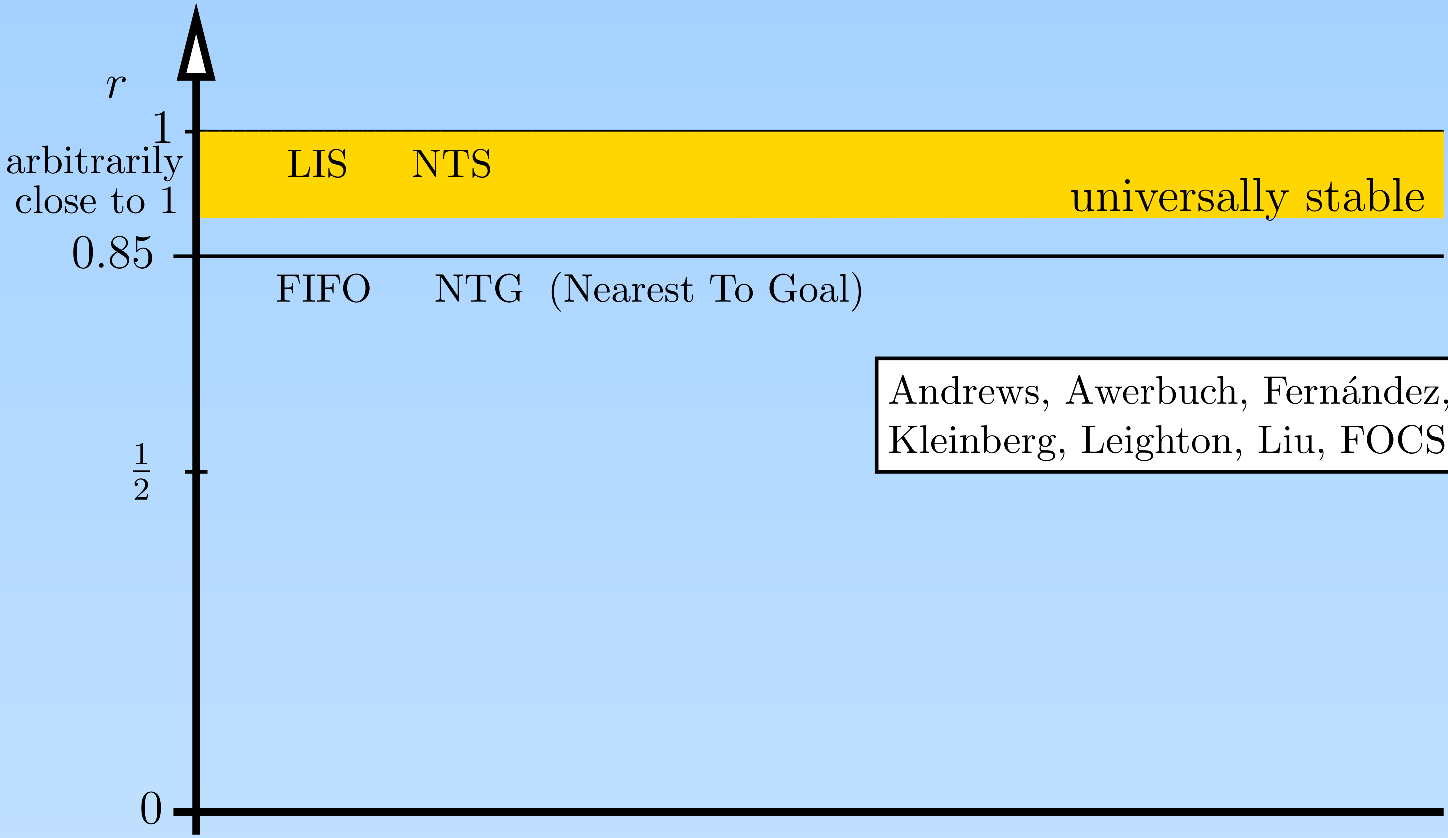

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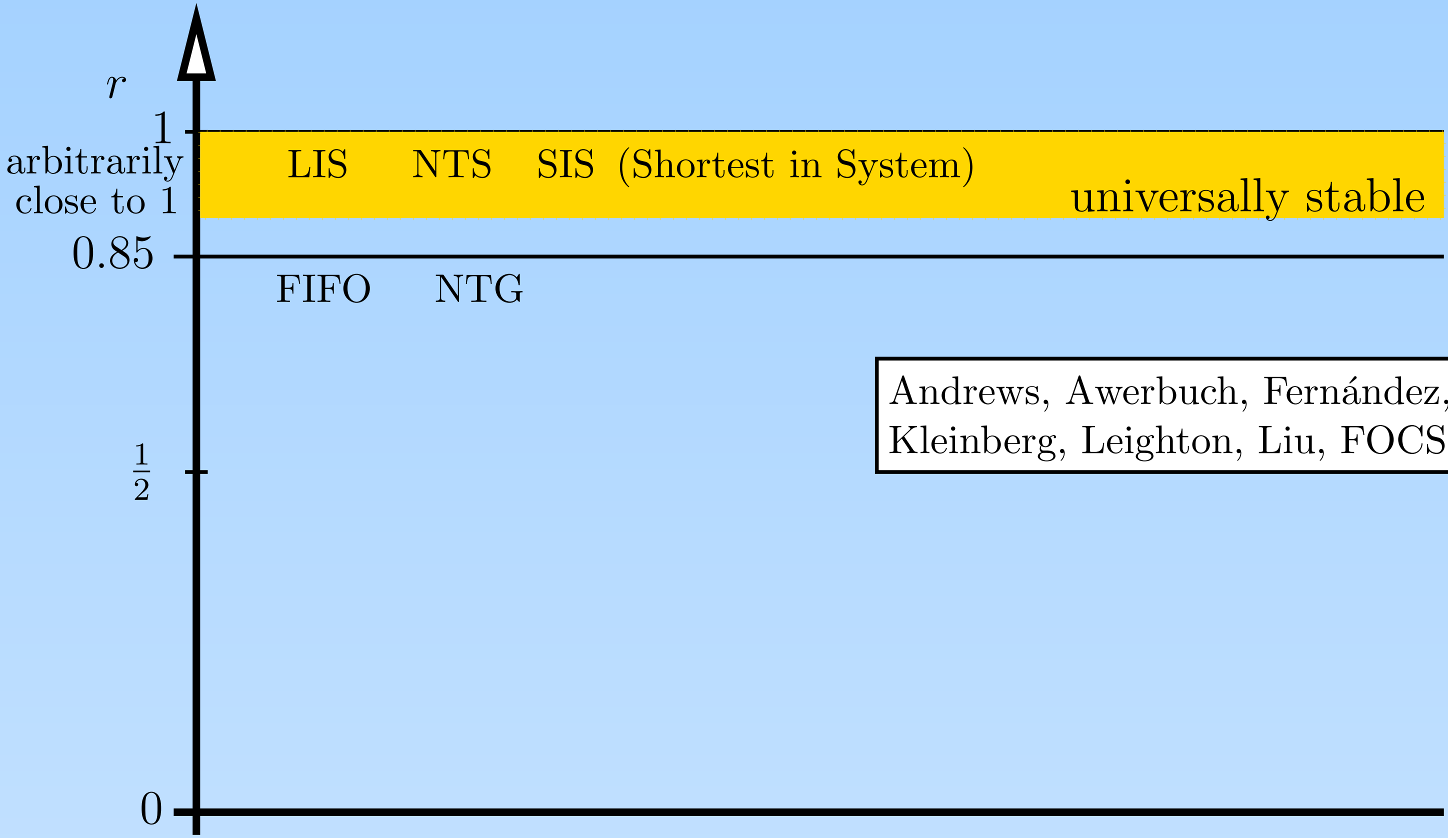

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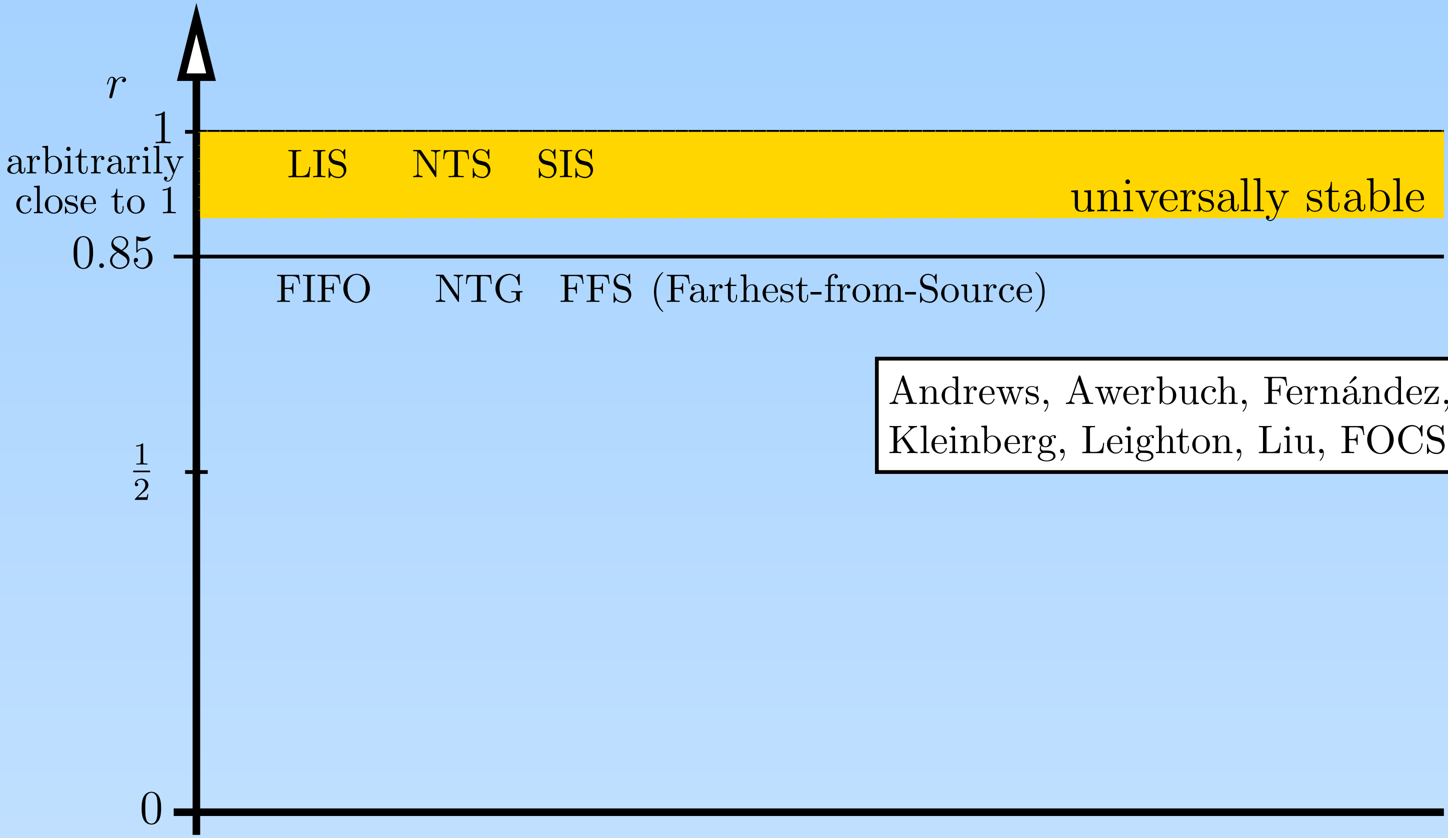

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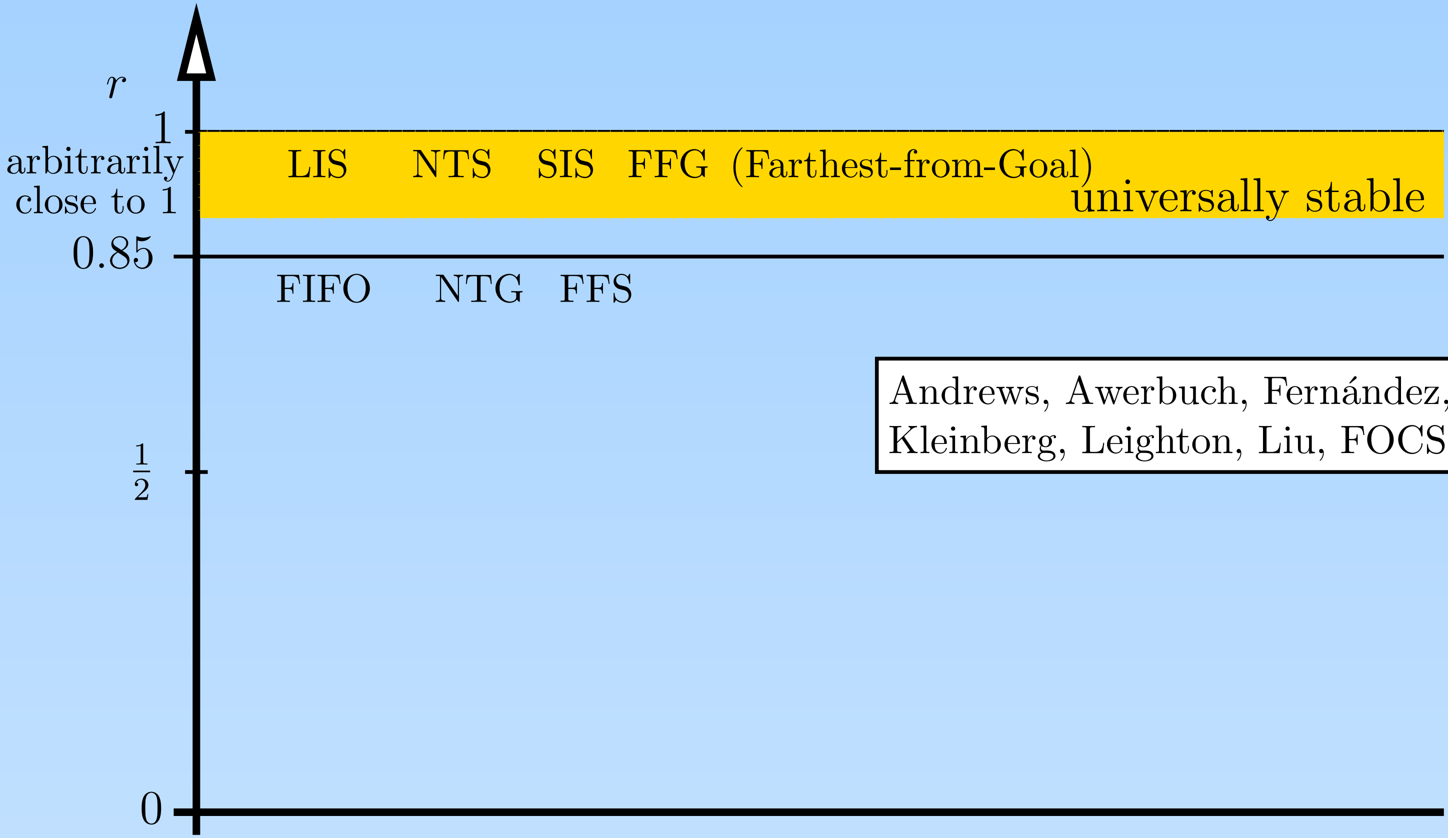

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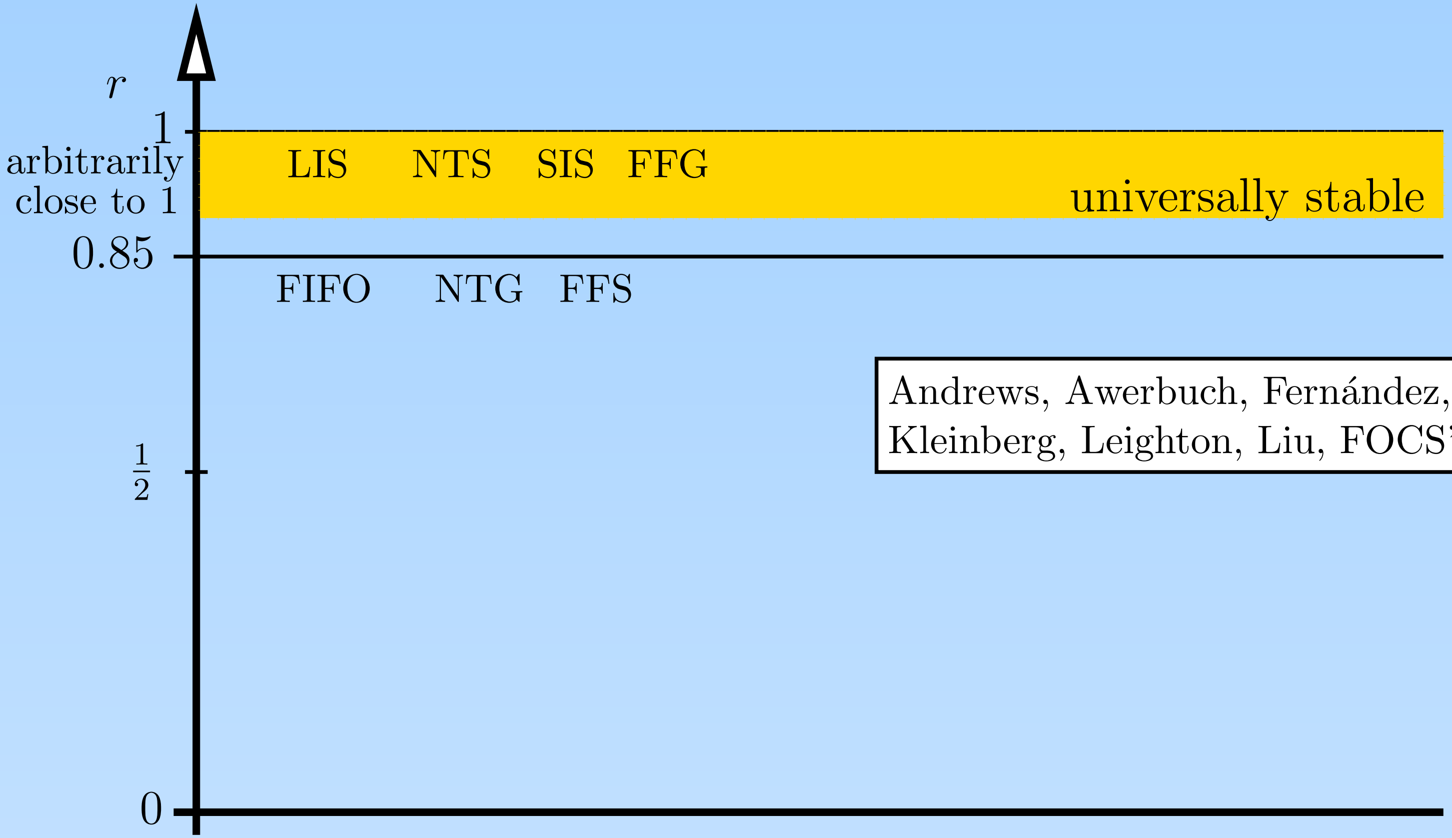

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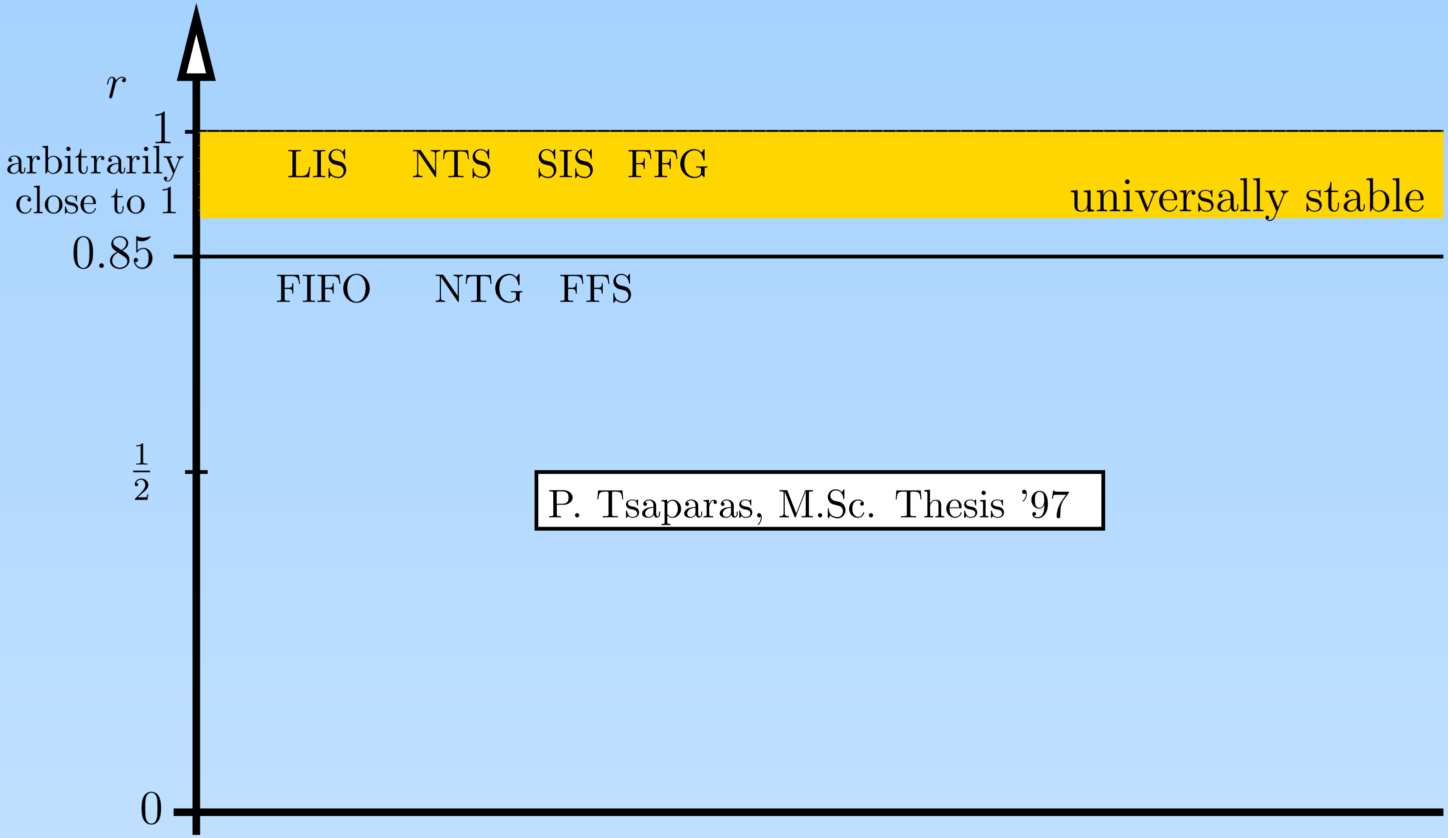

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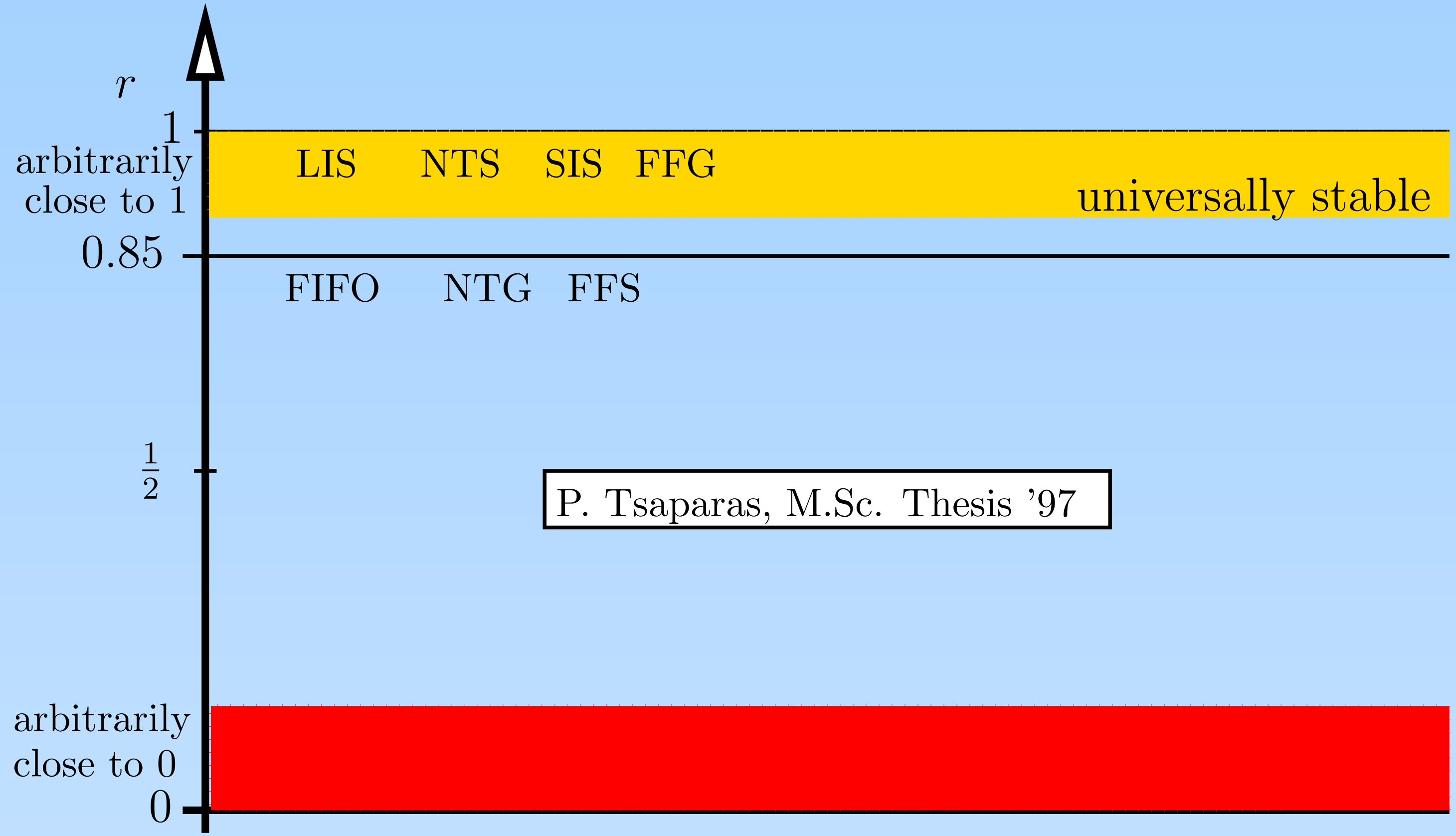

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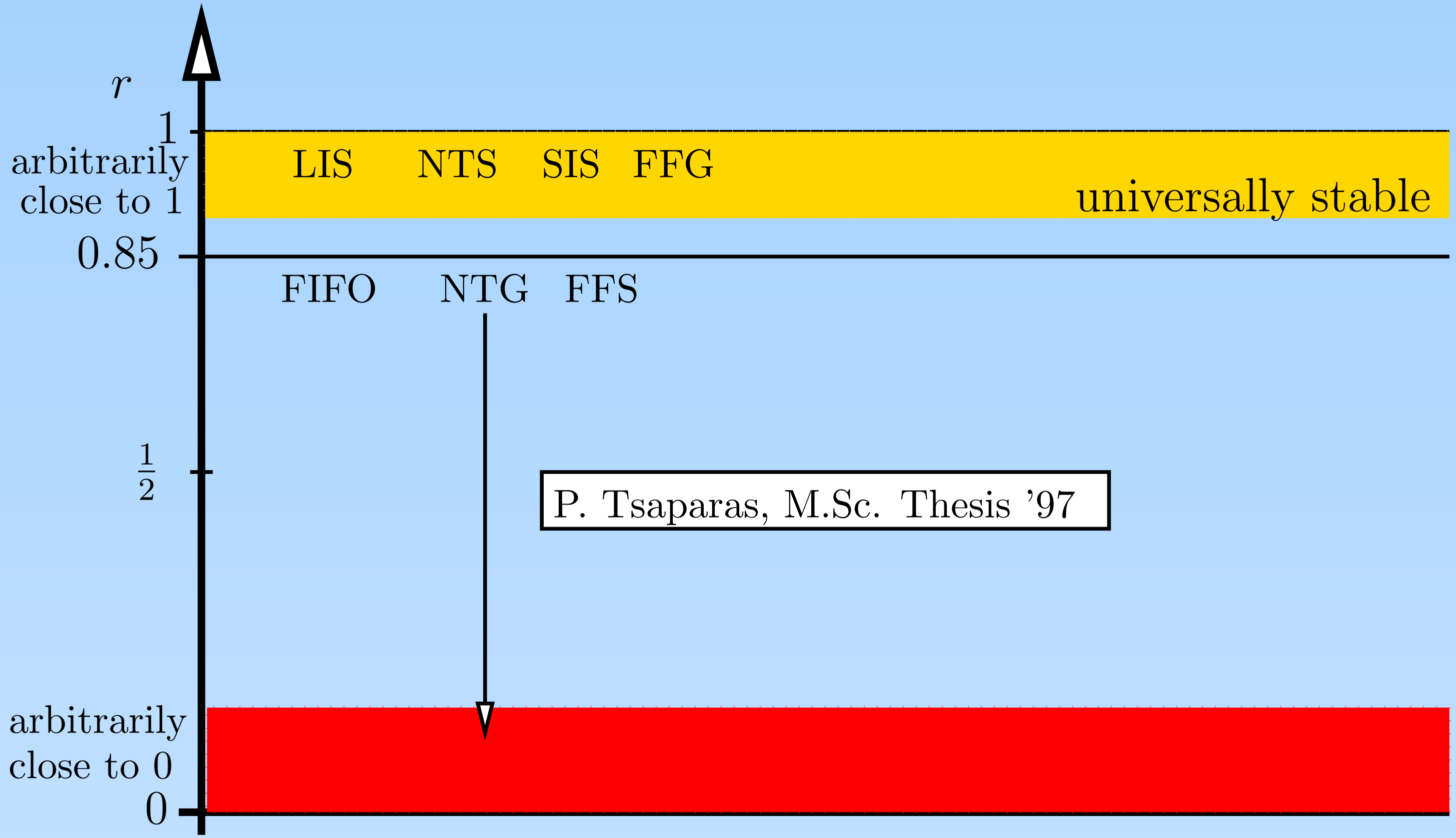

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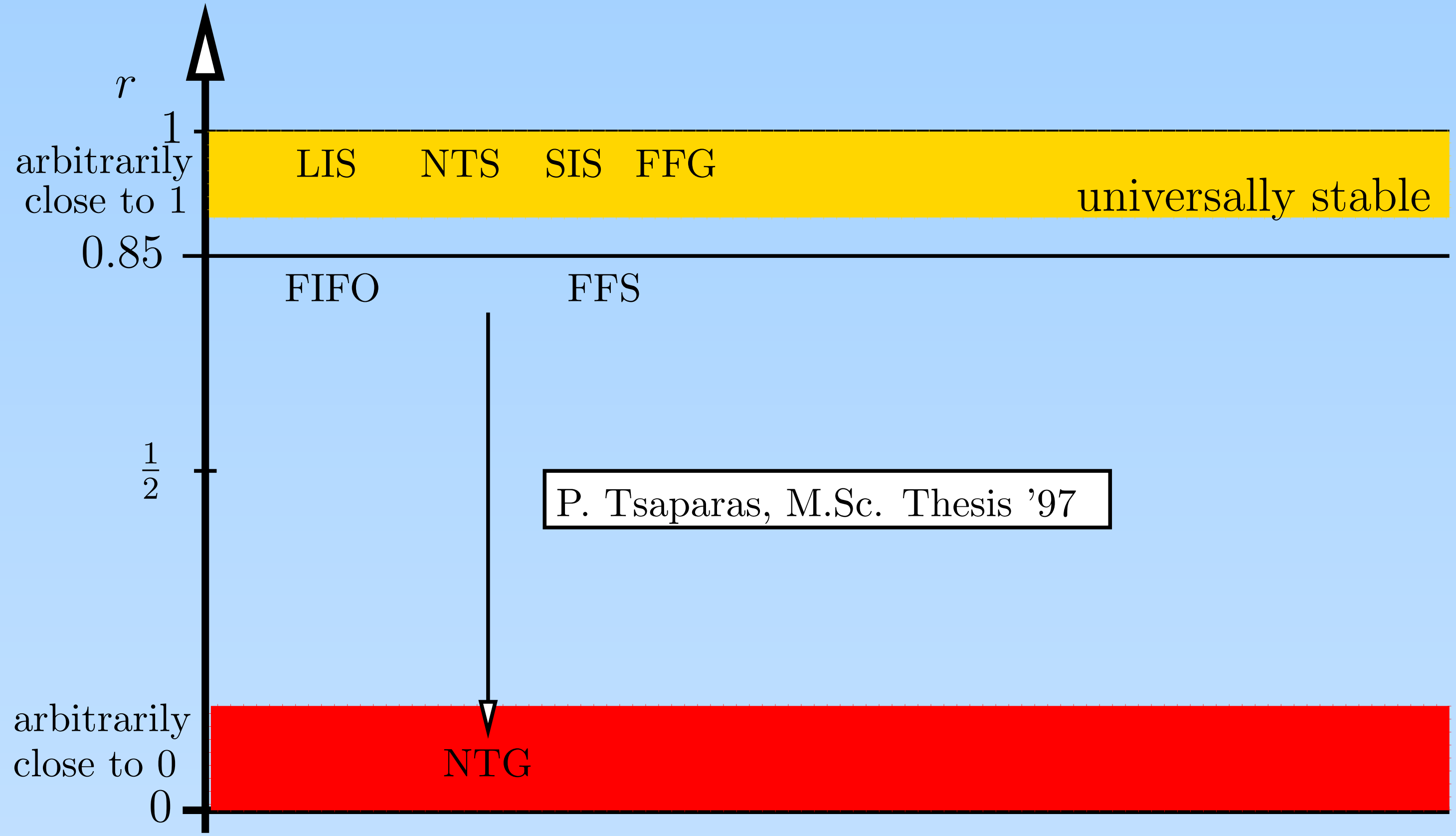

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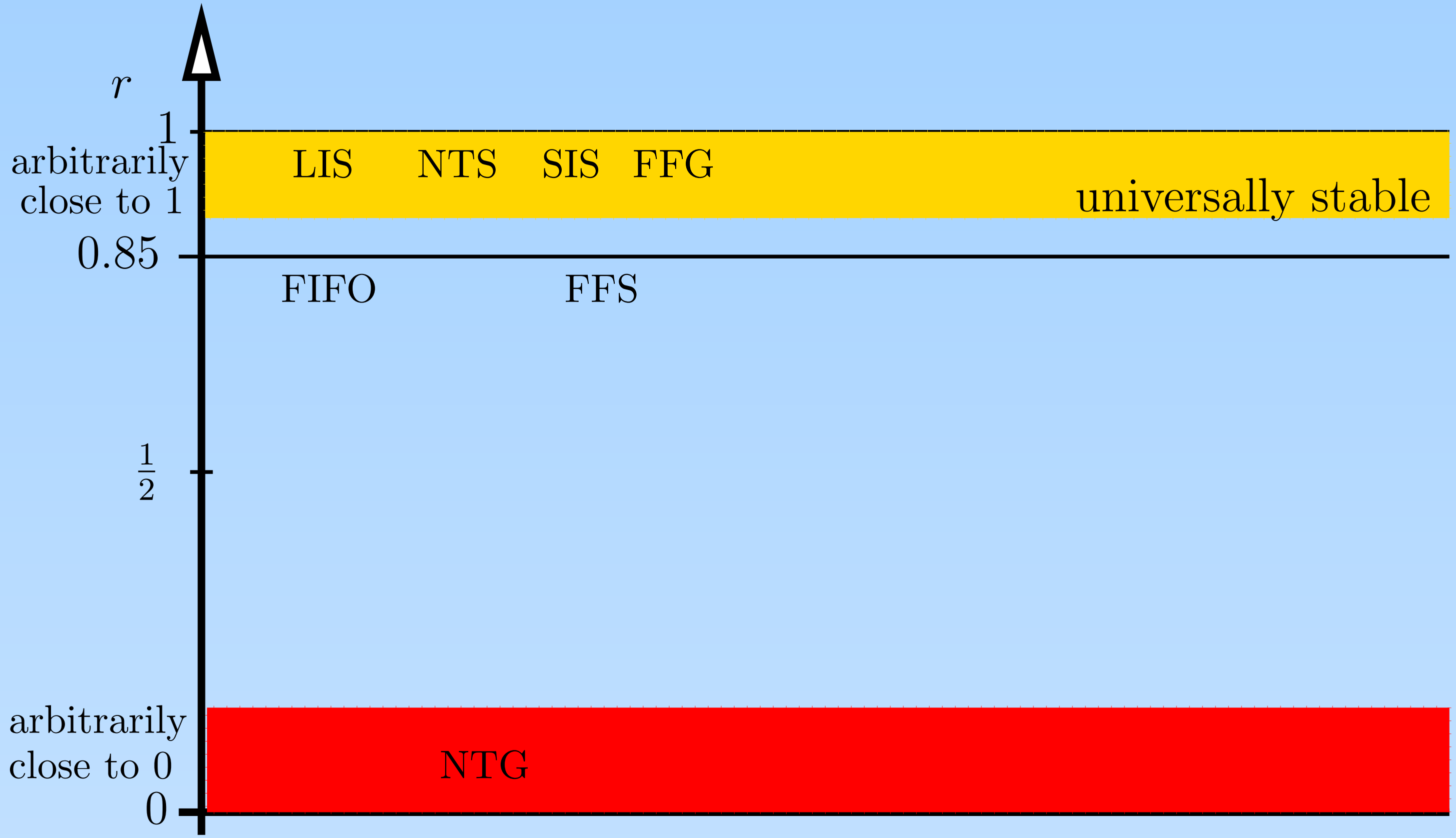

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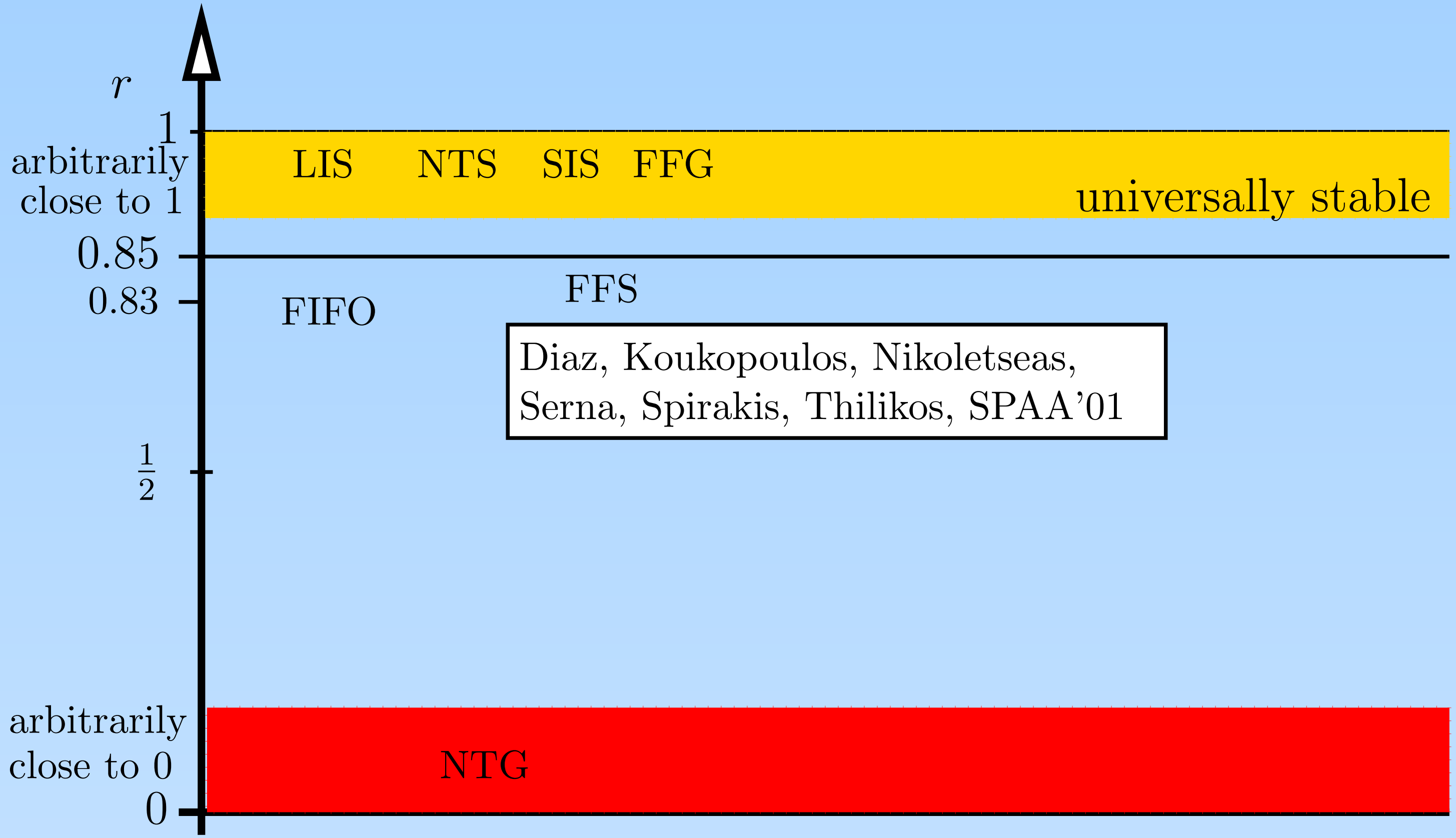

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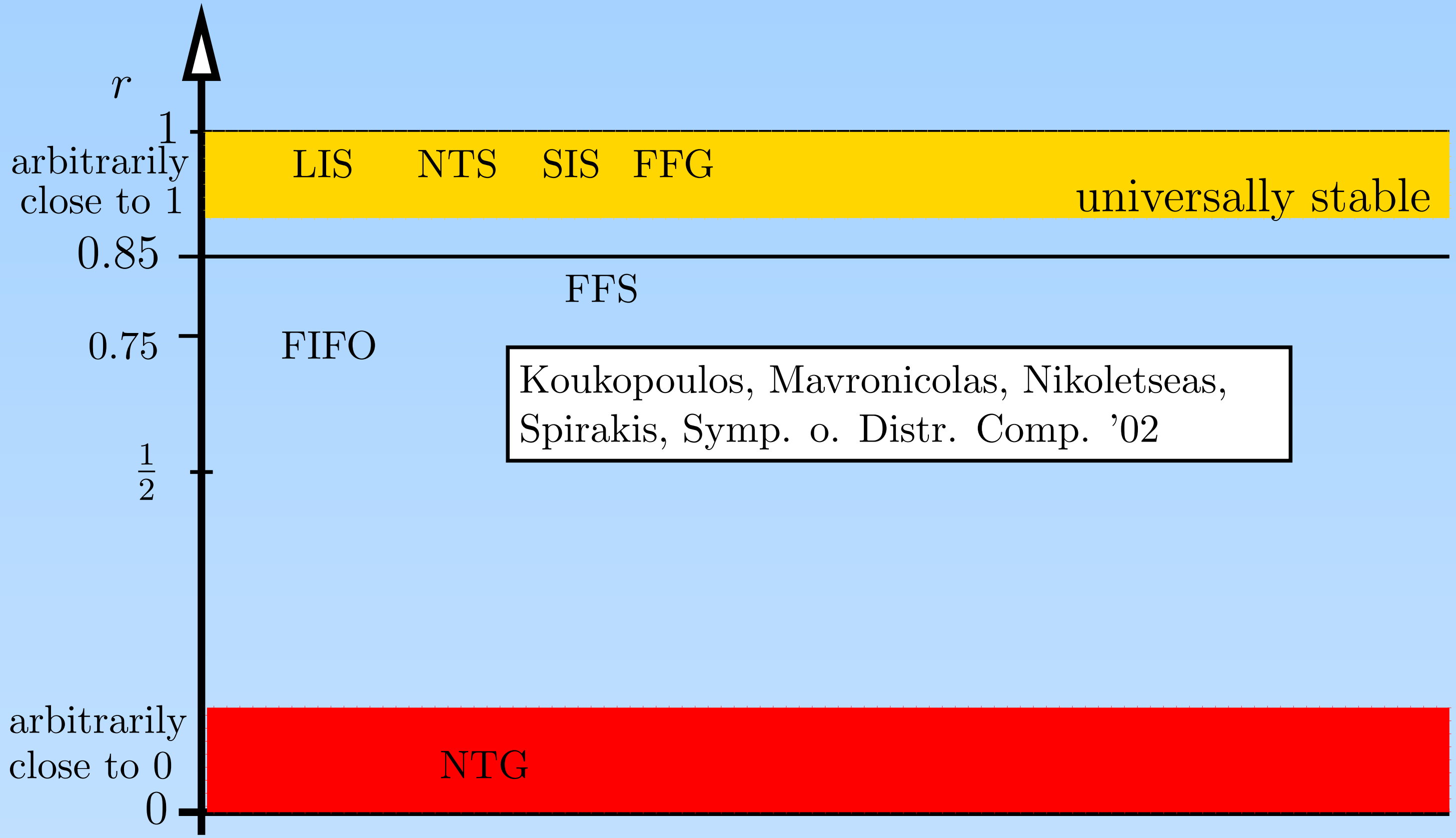

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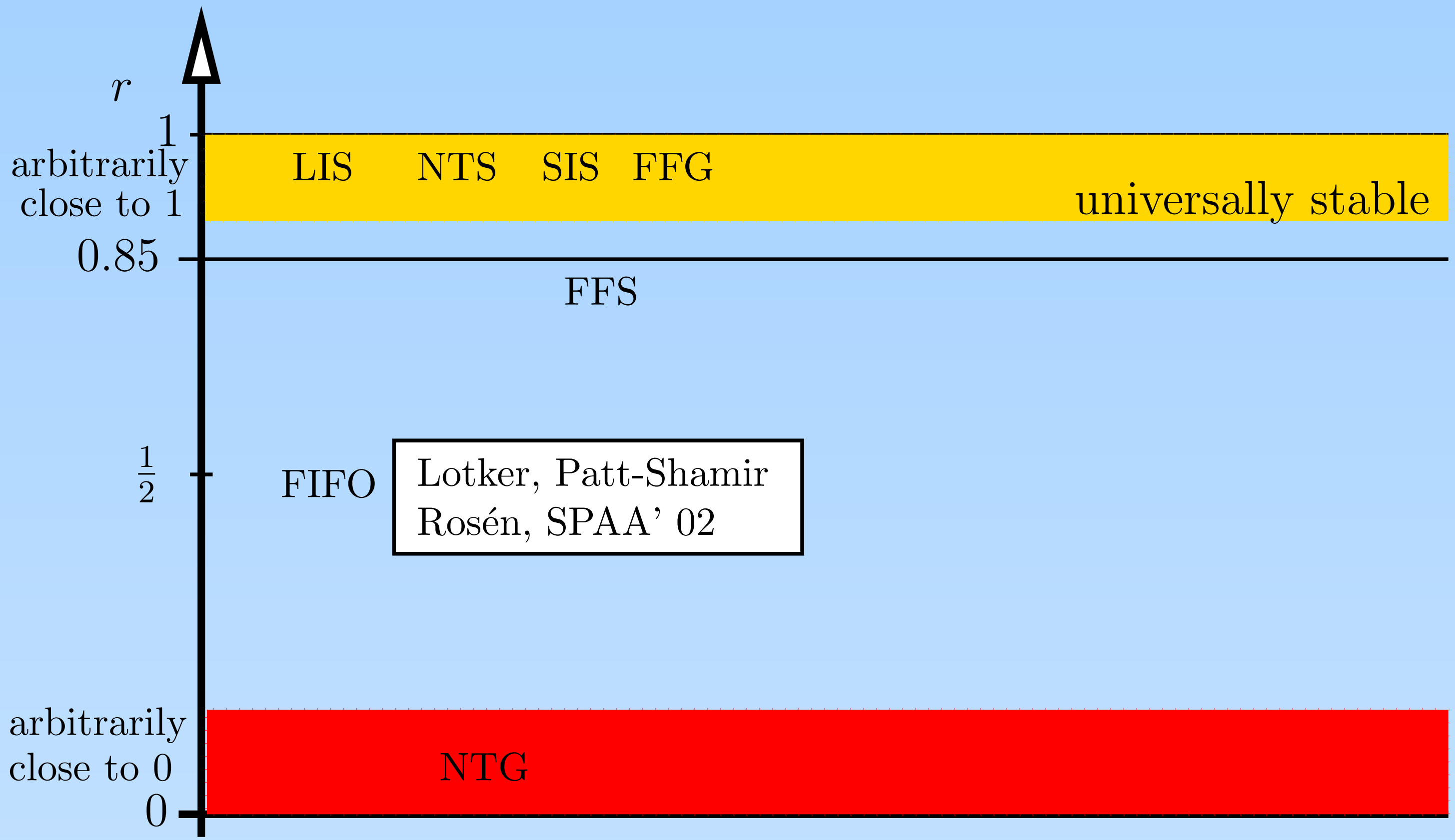

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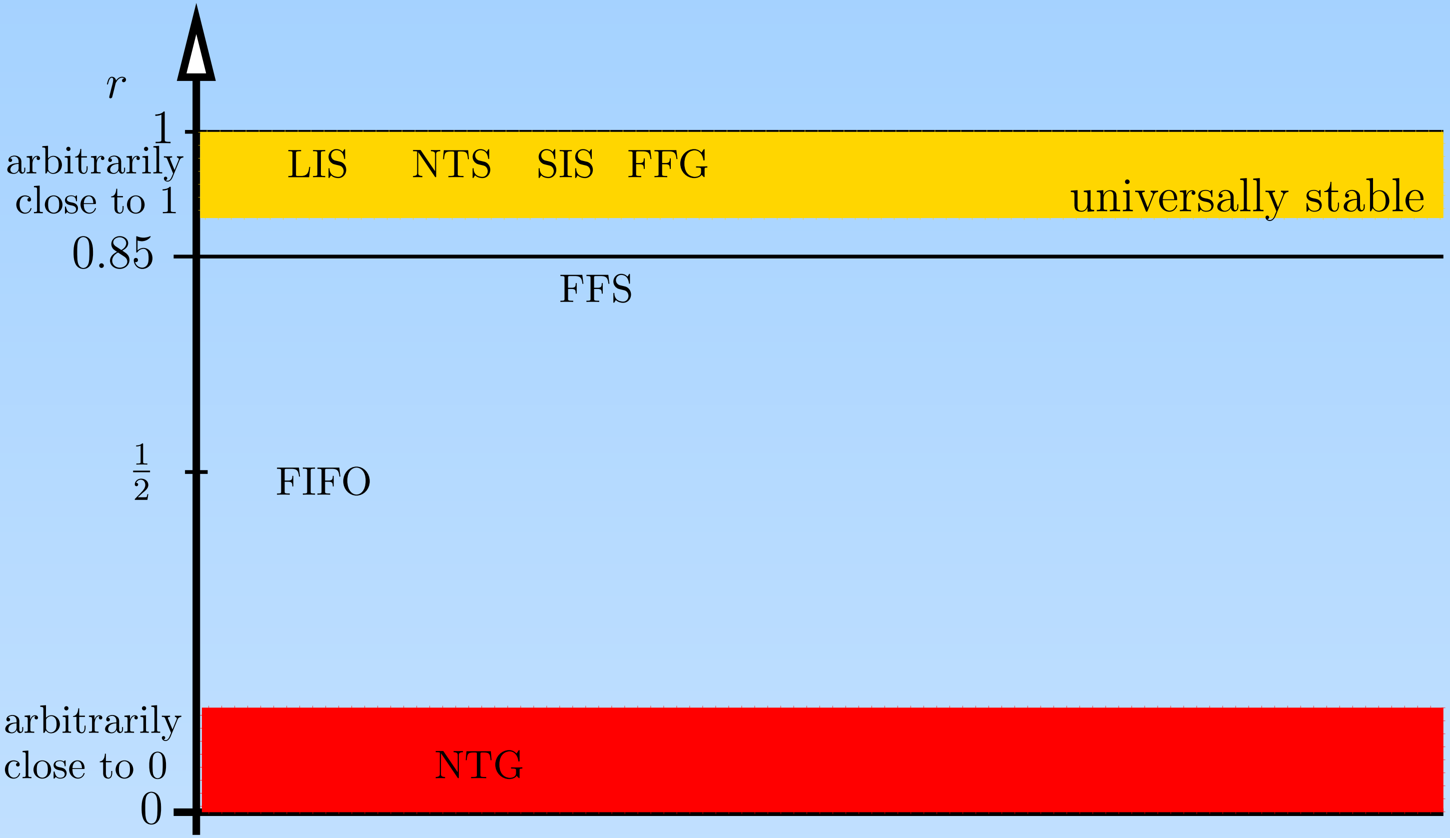

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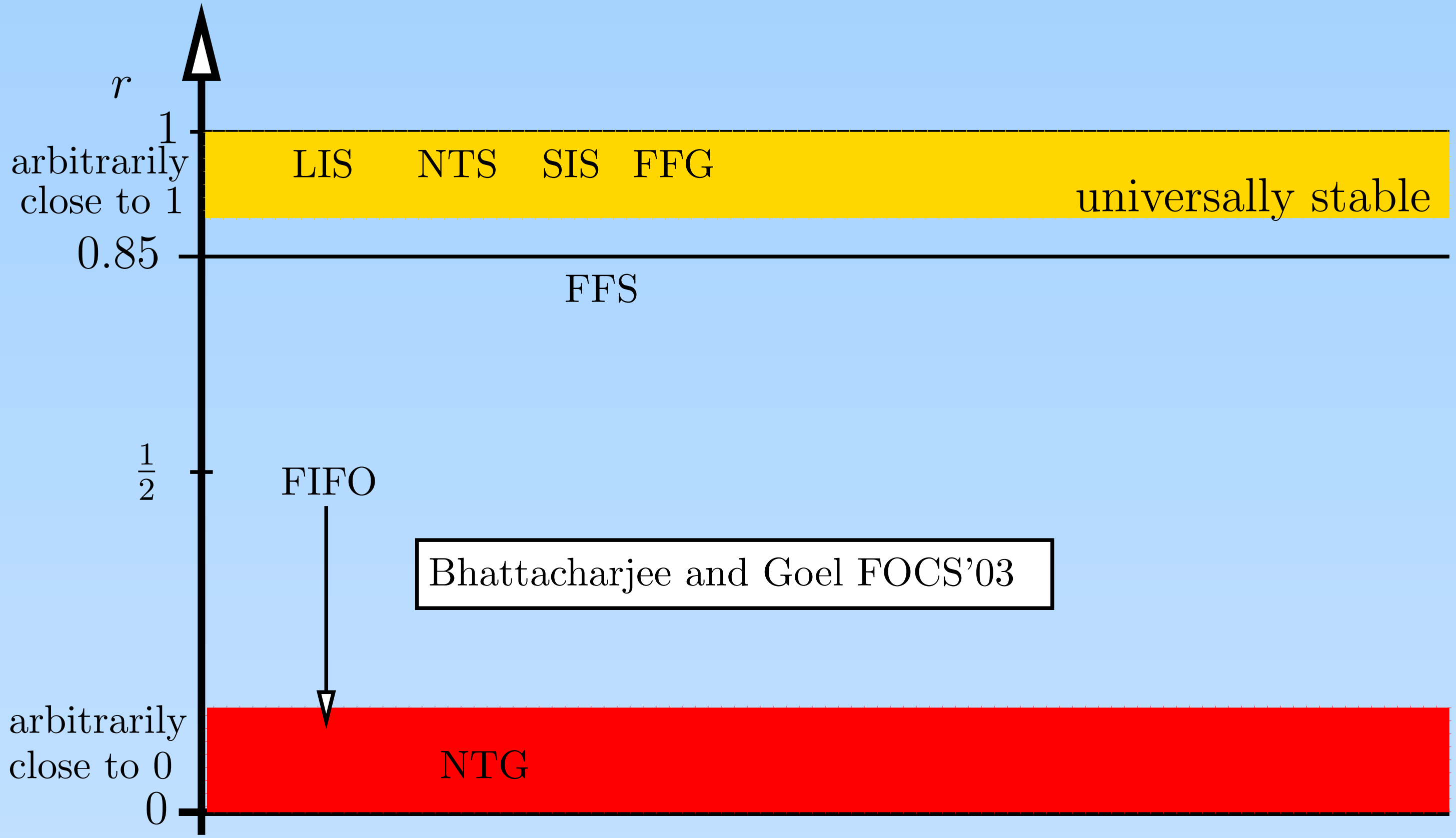

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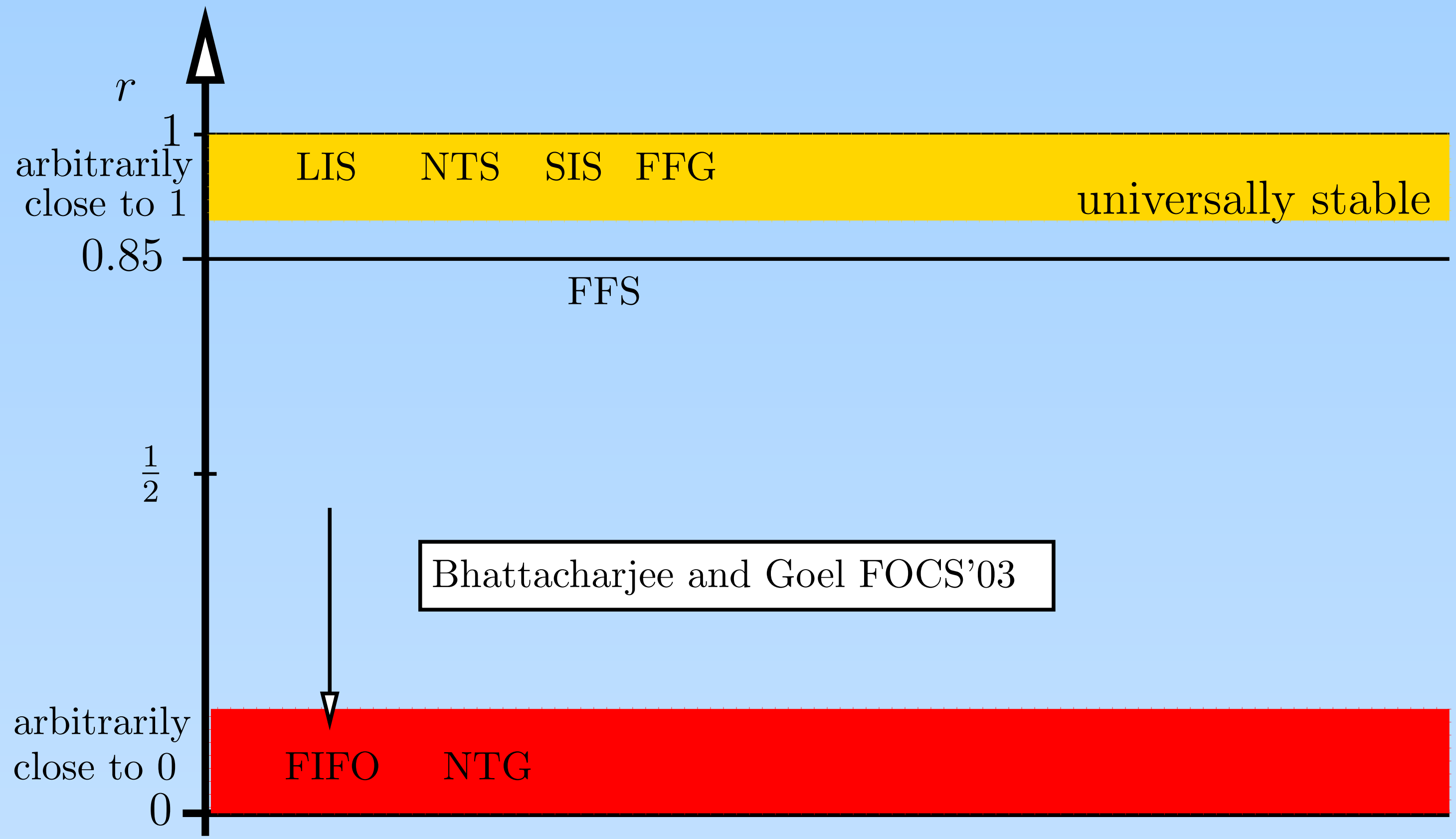

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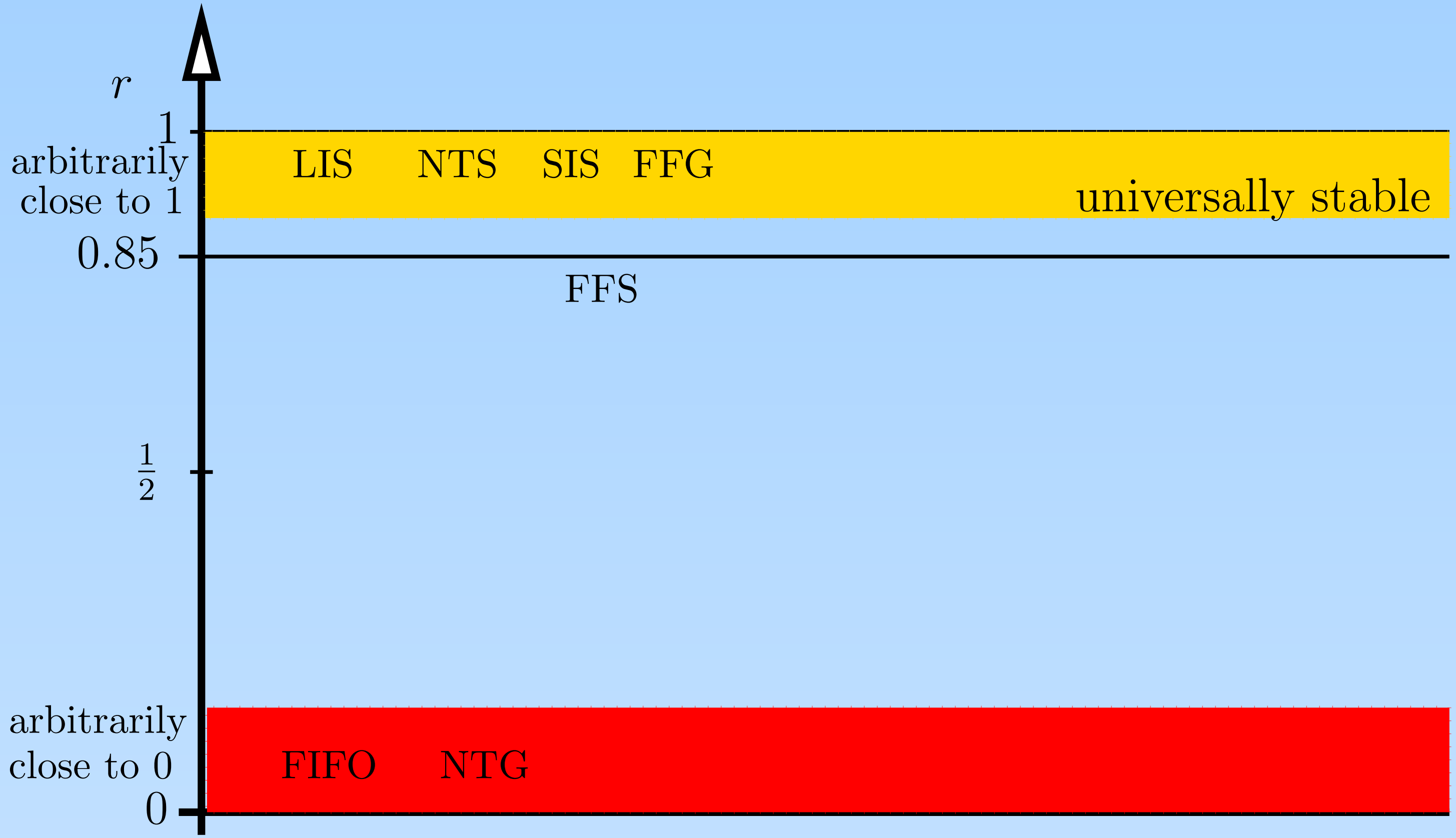

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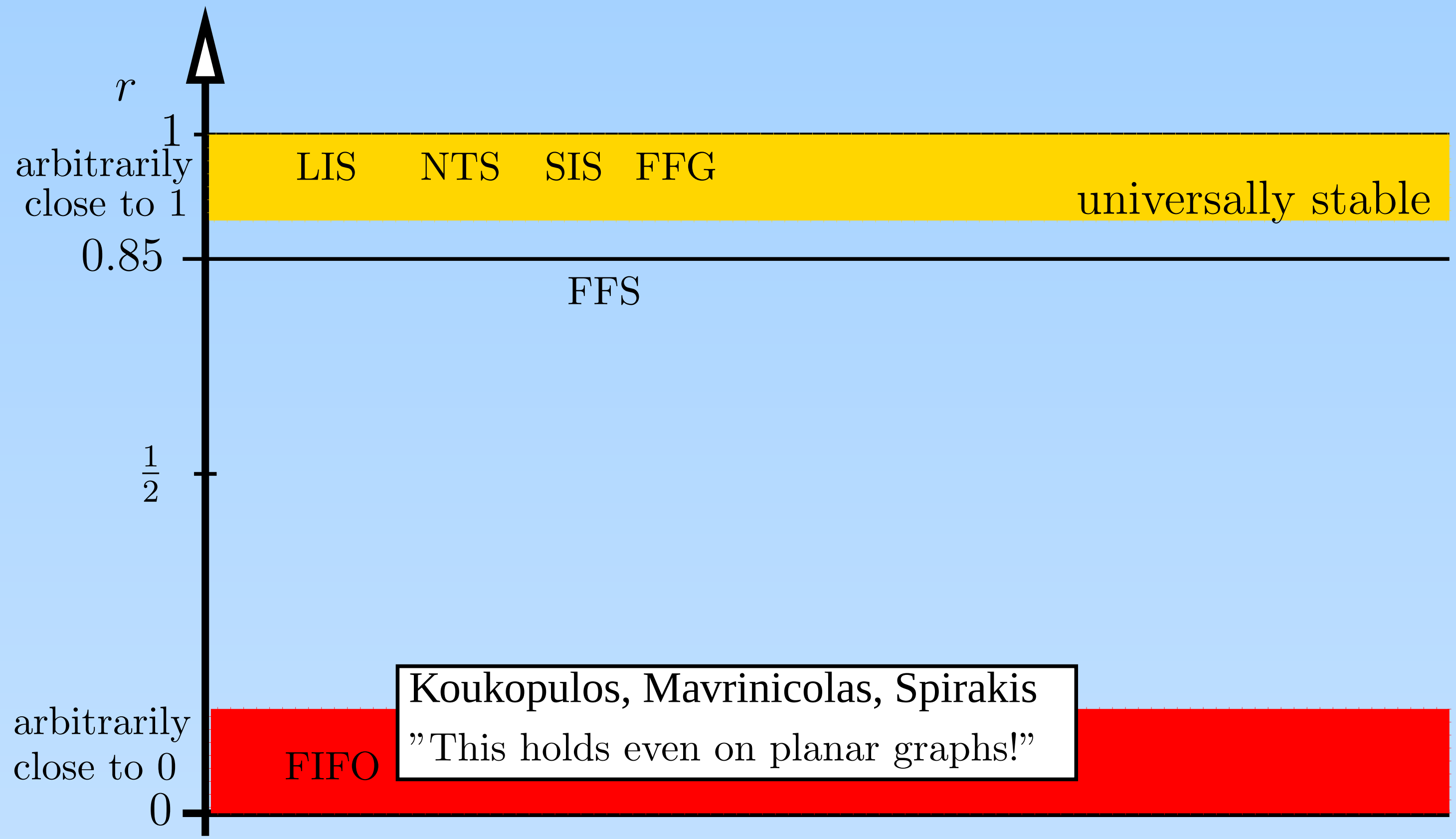

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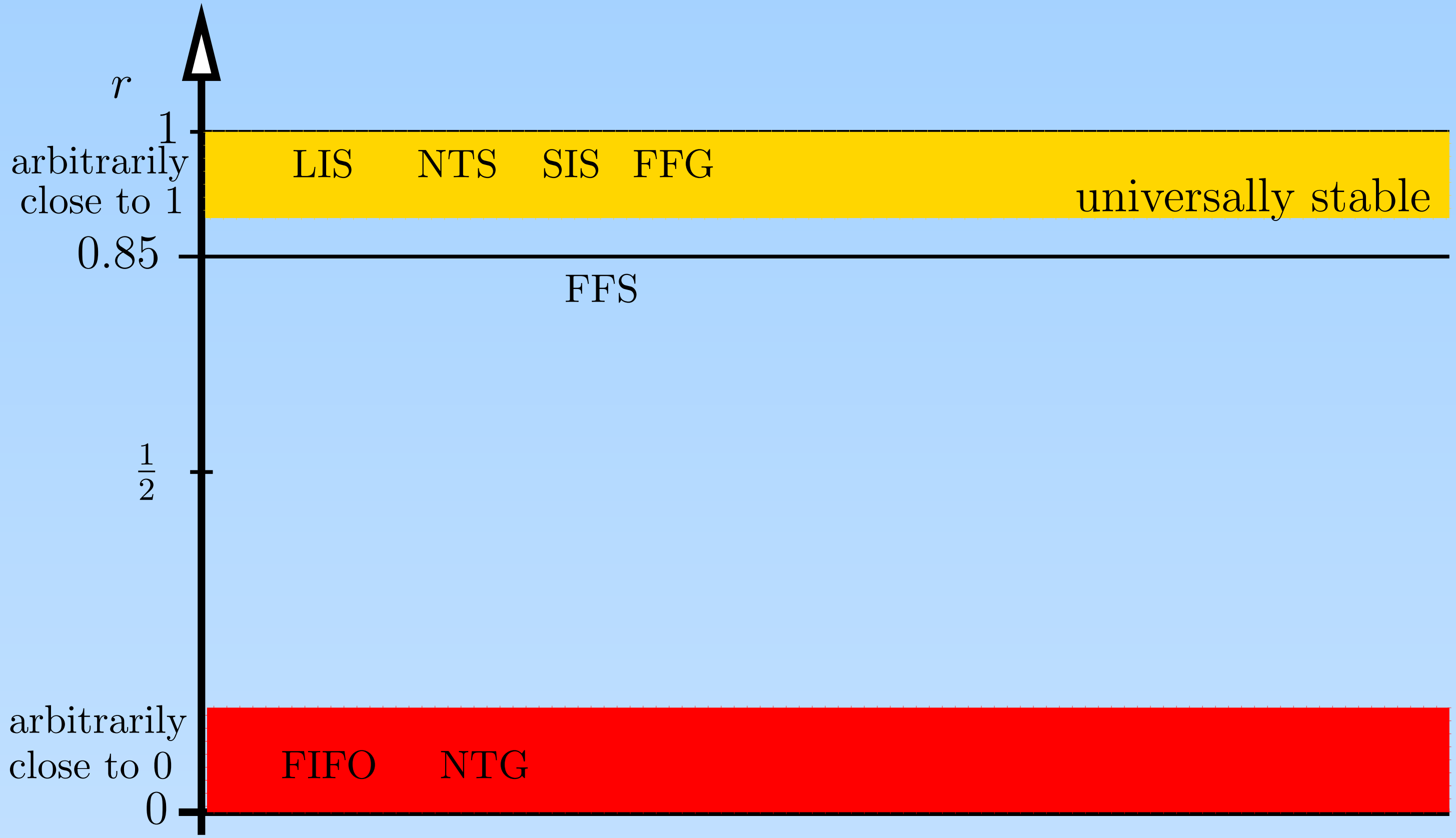

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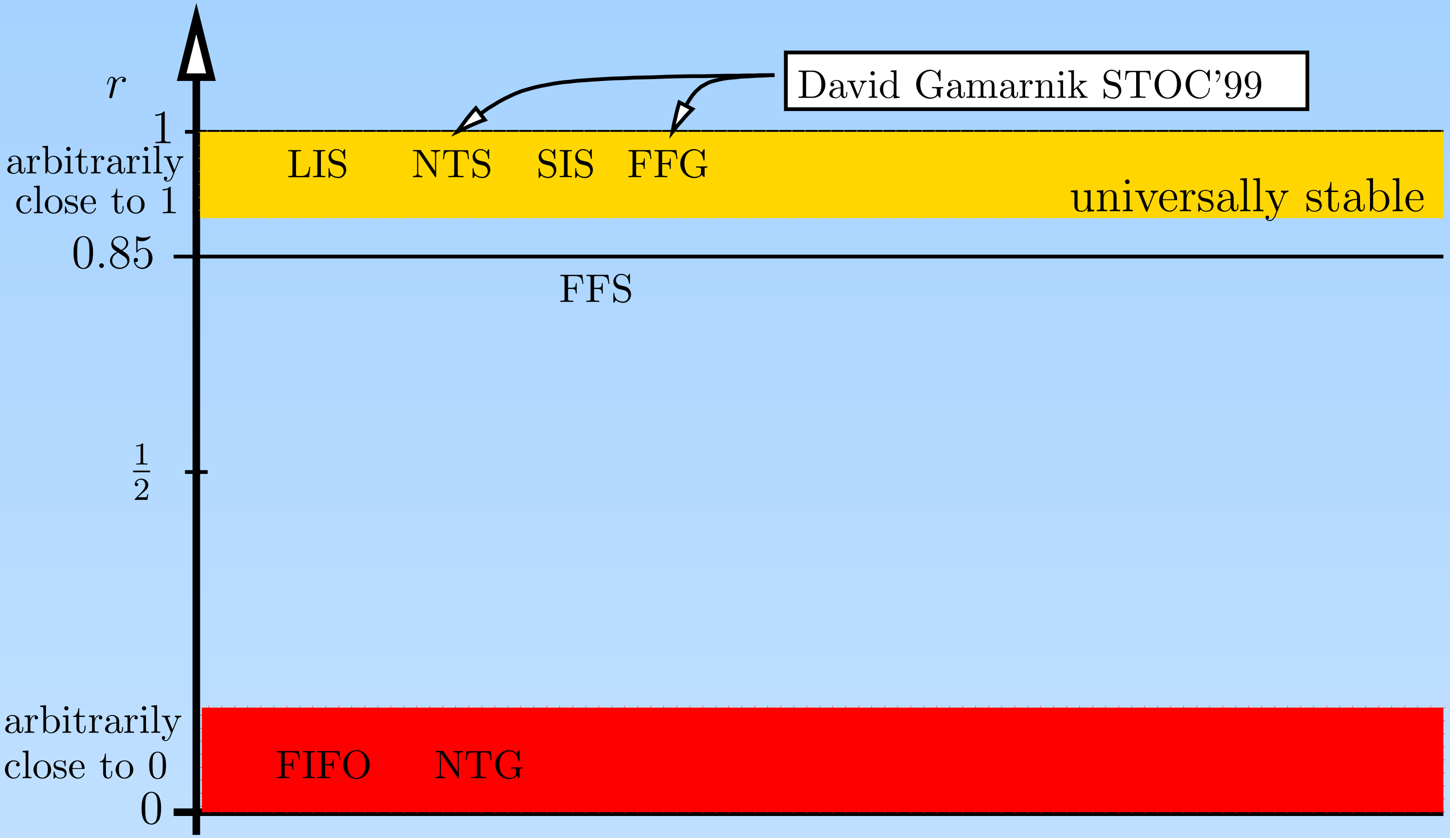

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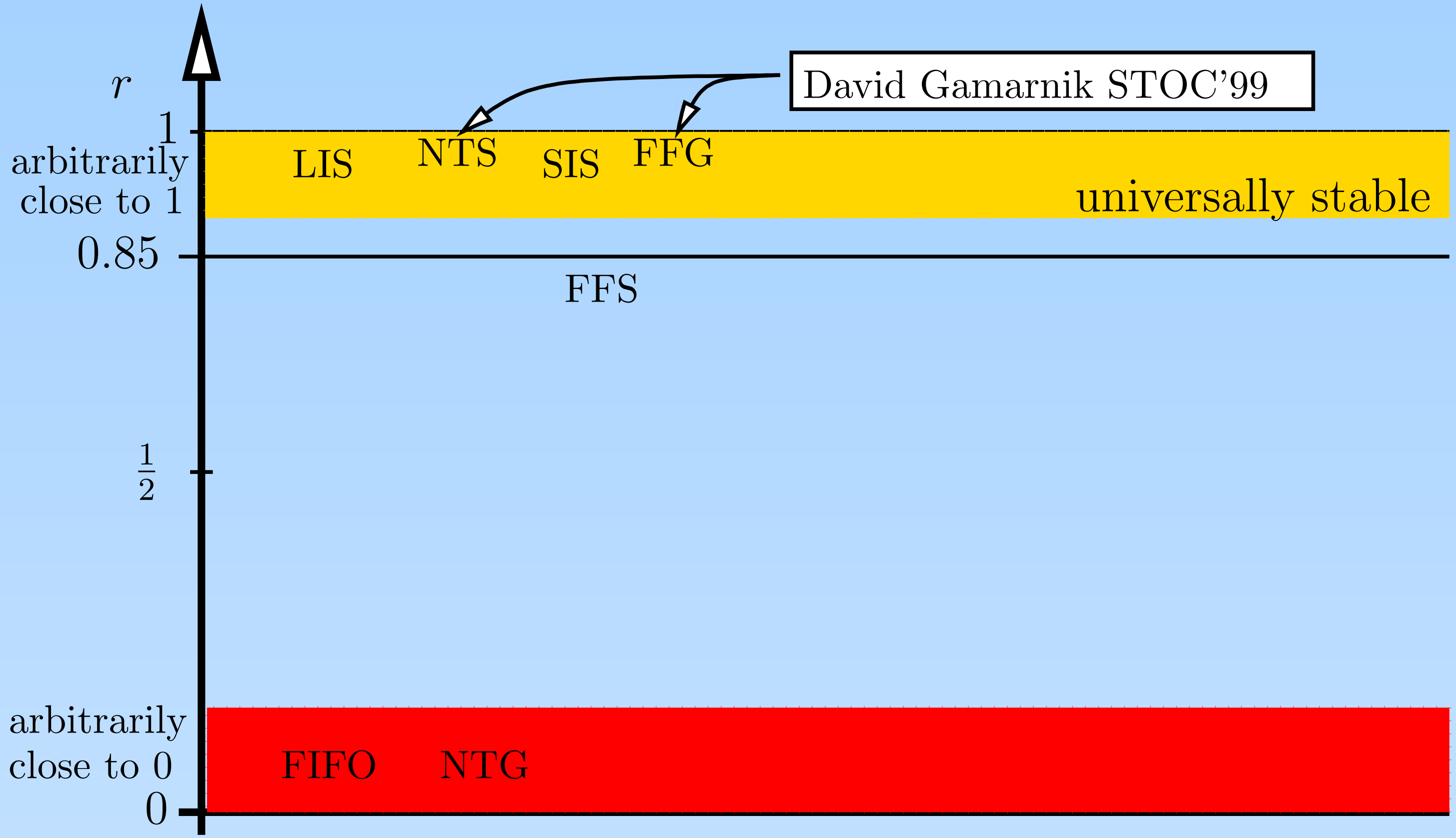

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- **Question:**

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- **Question:** How difficult do strategies with polynomial delay need to be?

WTS-Strategies

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At every contested edge a packet of maximum priority is advanced.

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- FIFO uses a packets current waiting time.

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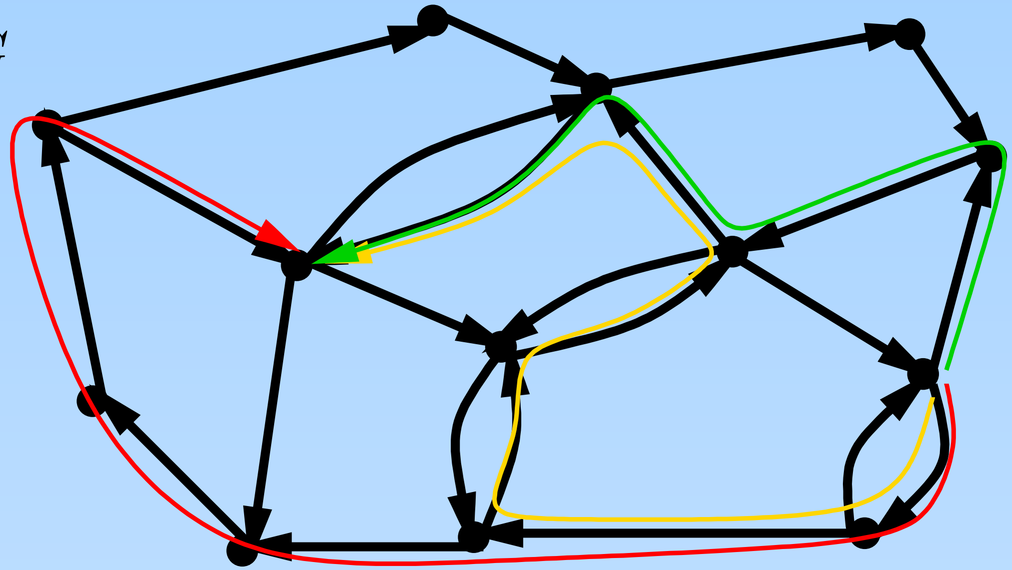
Graph G



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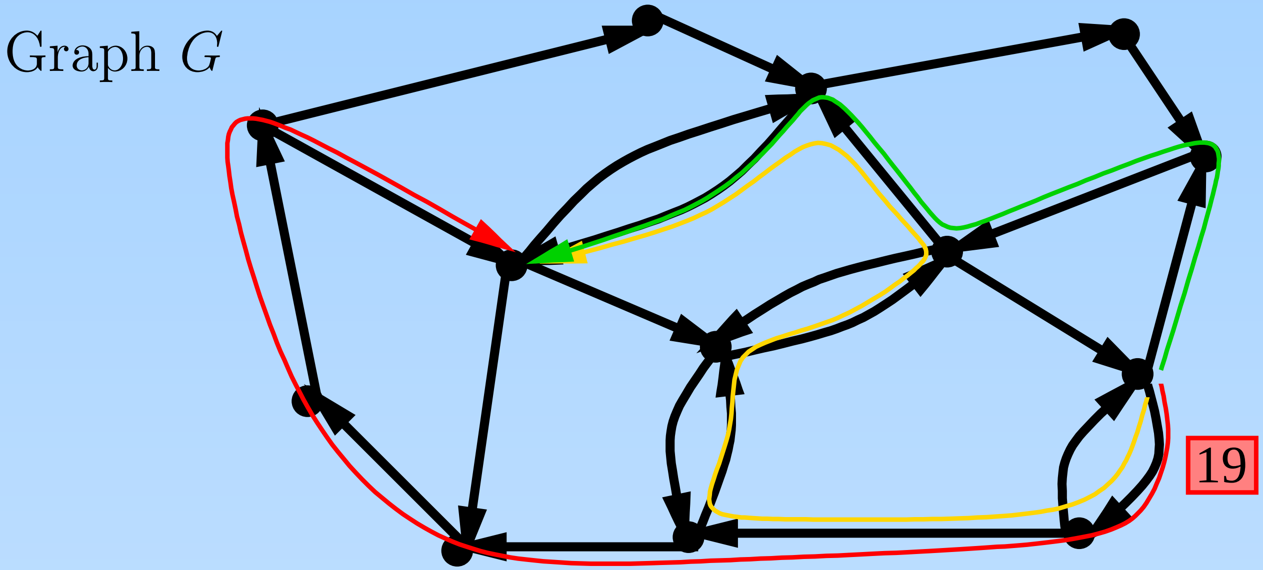

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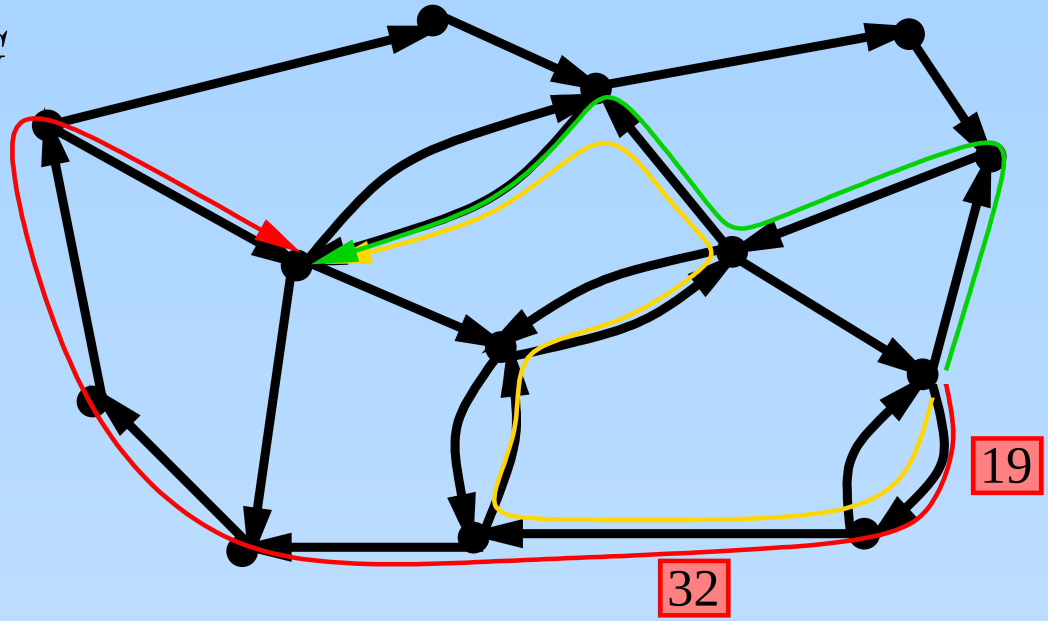

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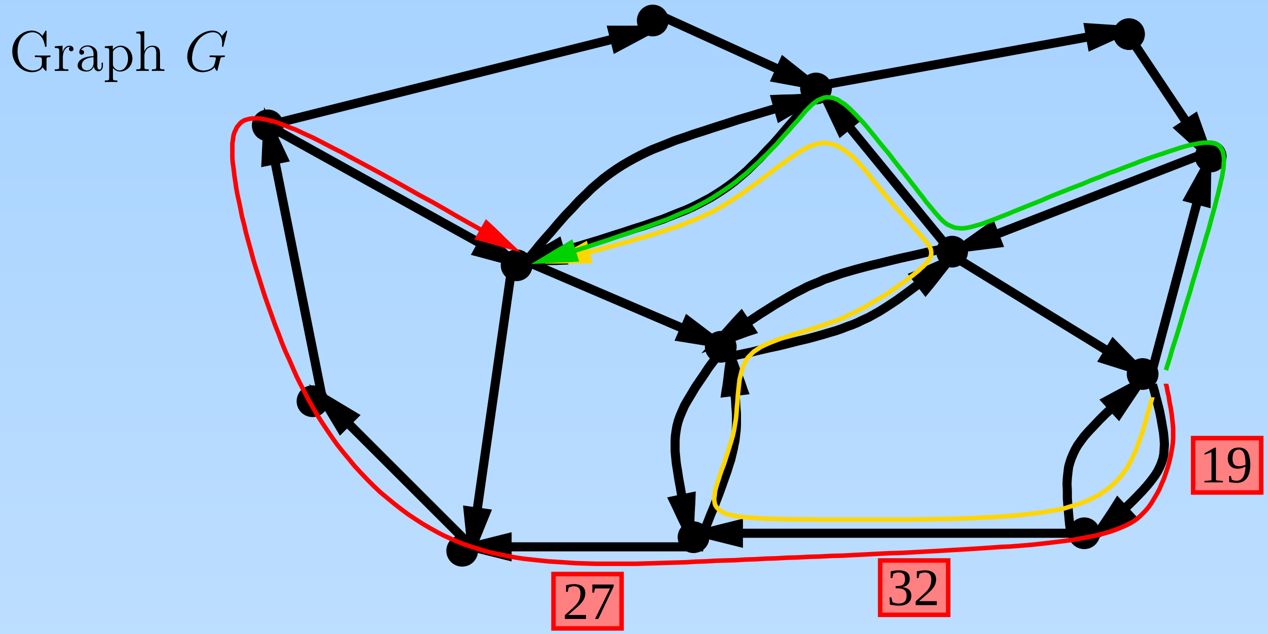

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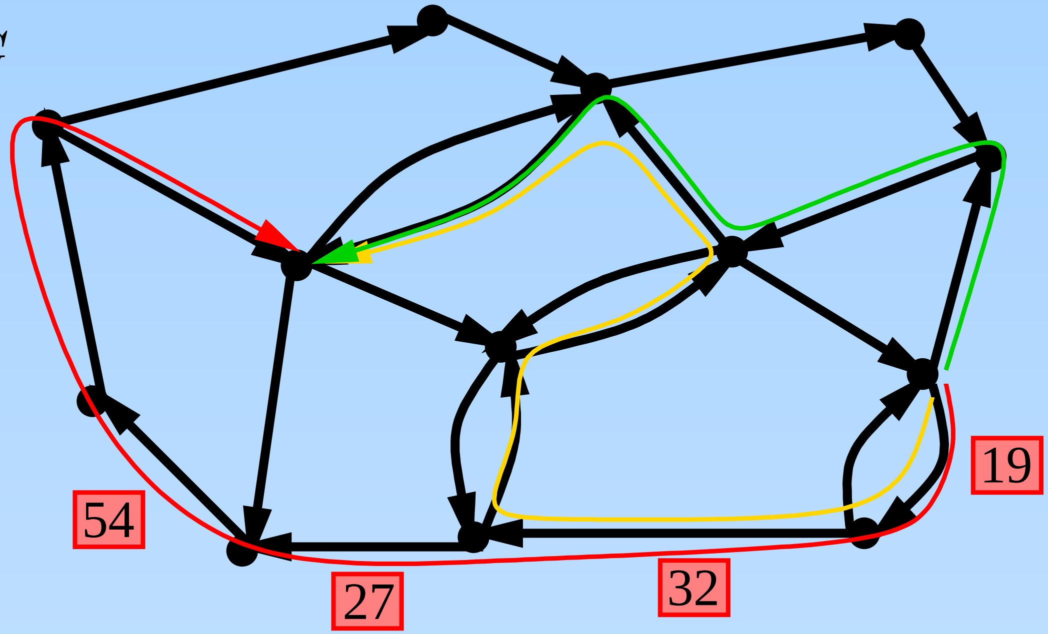

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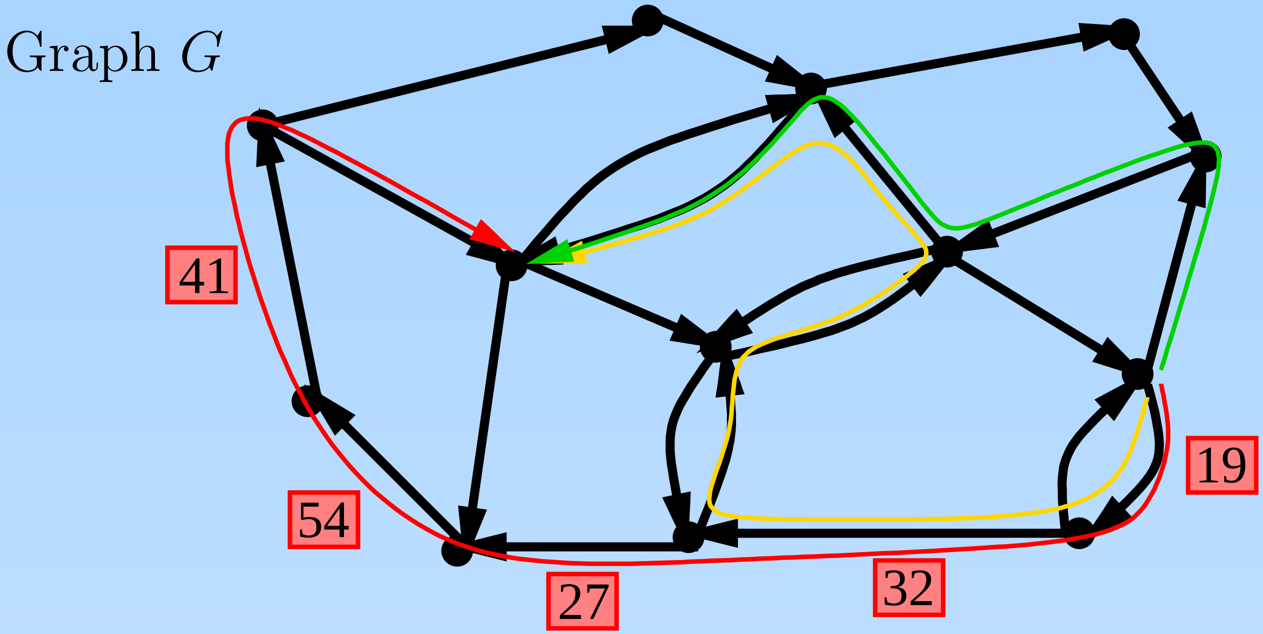

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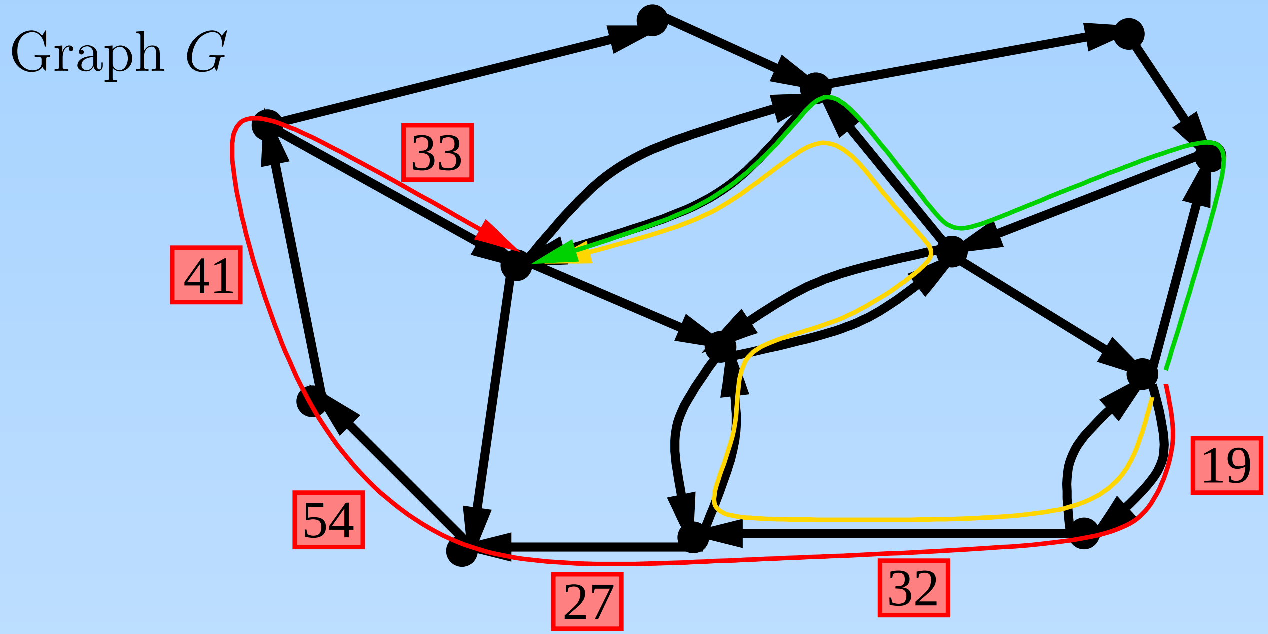

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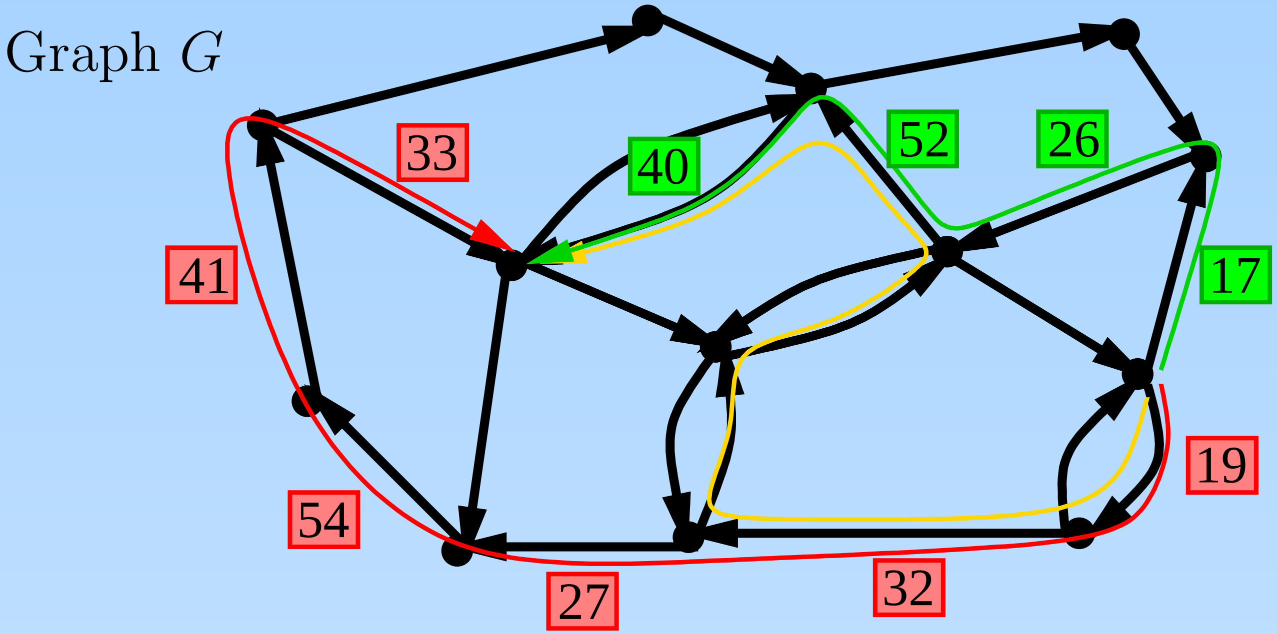

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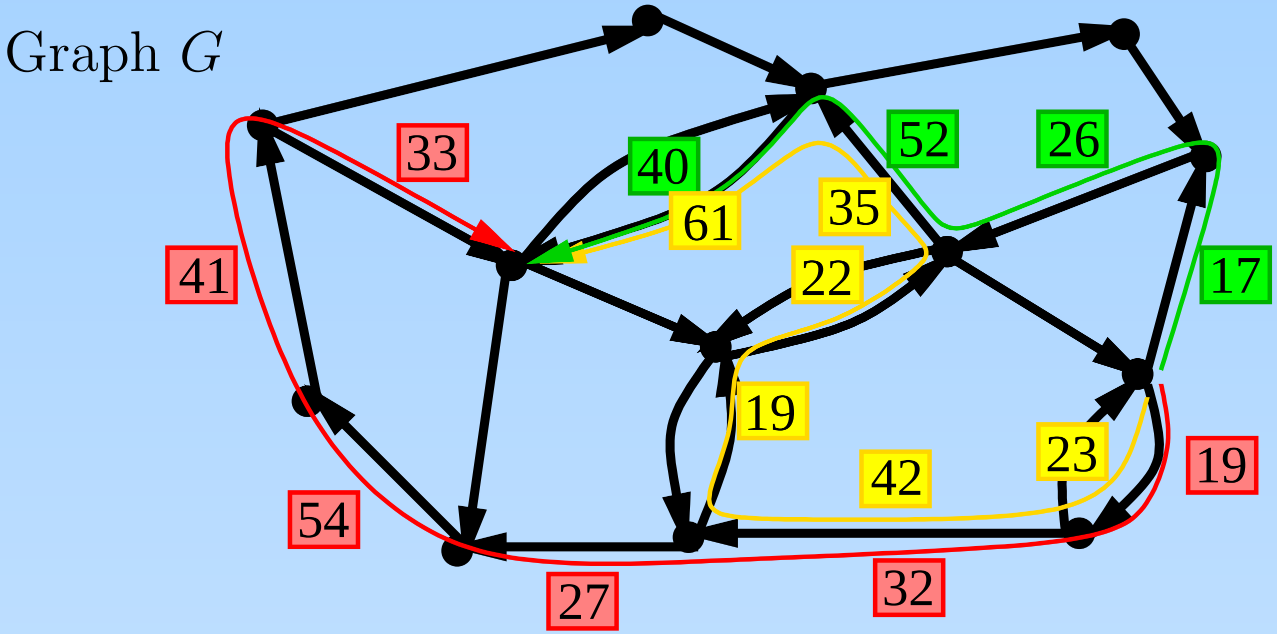

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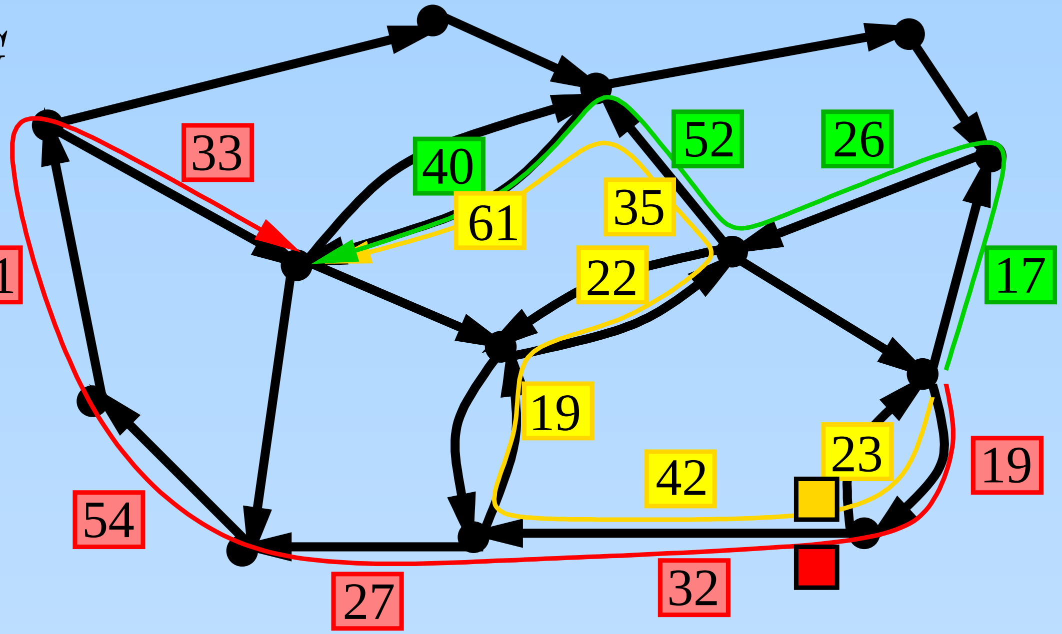

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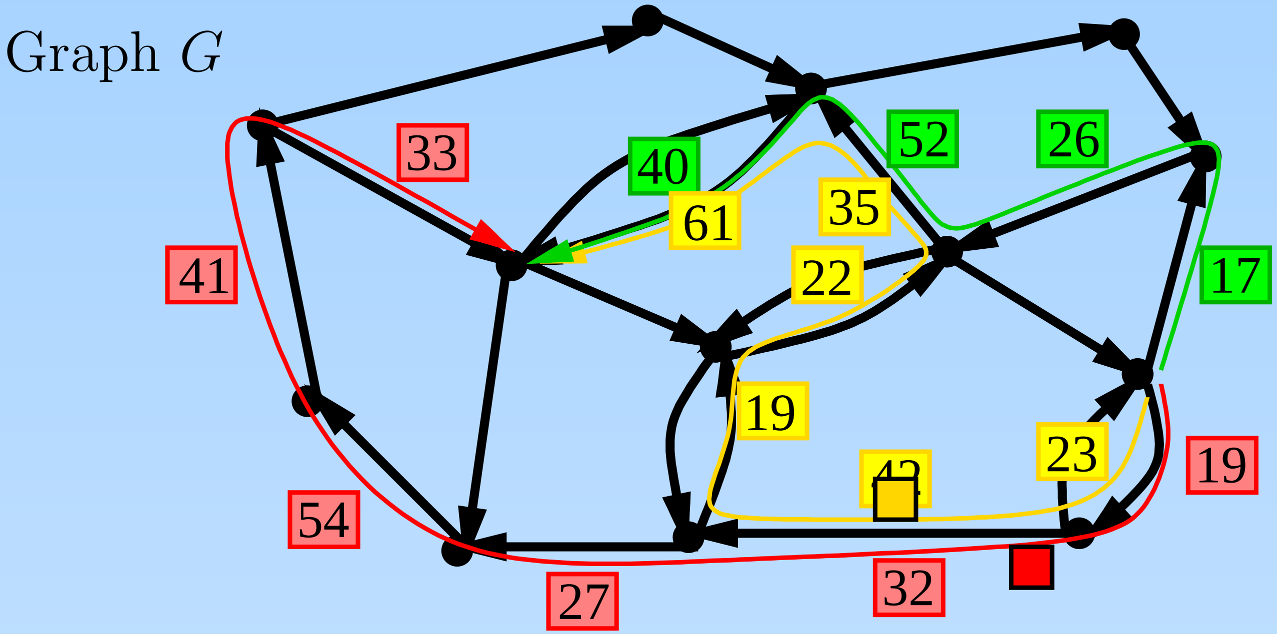

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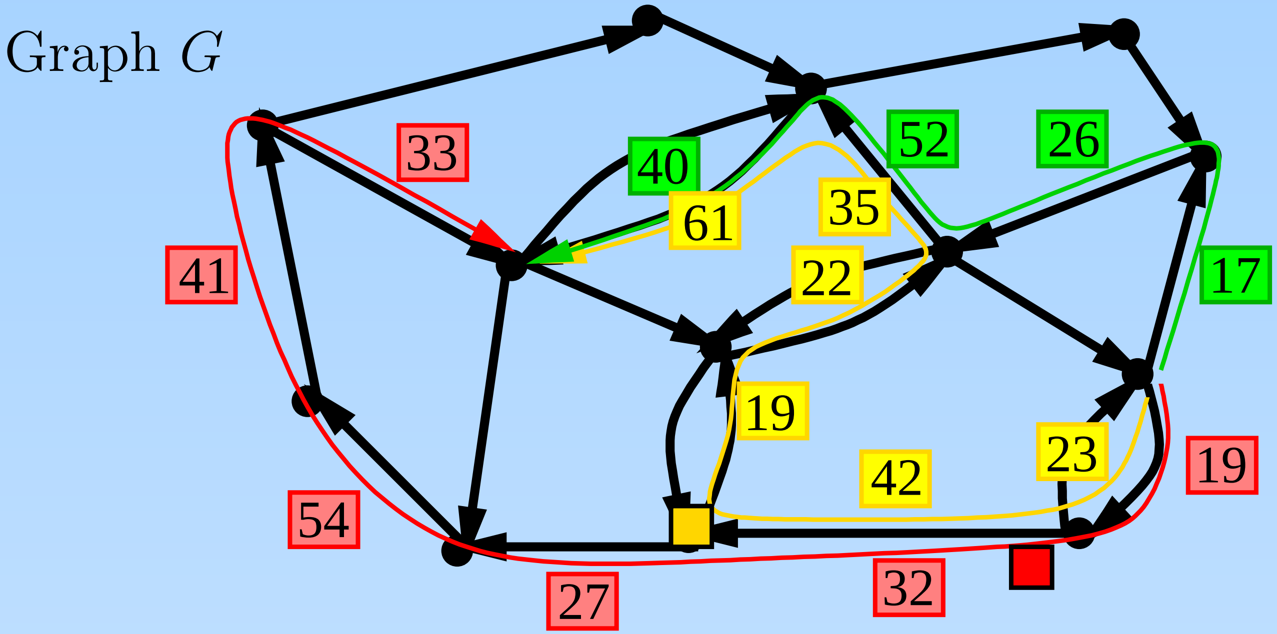

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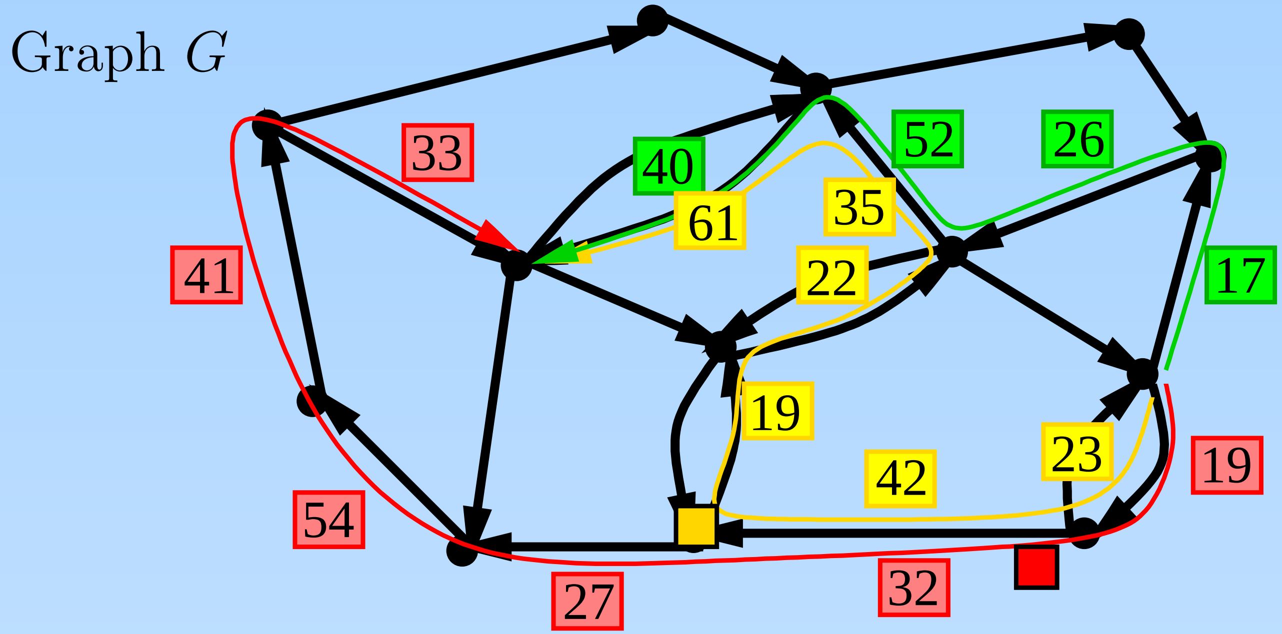

We seek a negative result about all WTS-strategies.

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Problem: Provide a family of graphs, so that for every possible assignment of priorities, a jam of exponentially many packets can be created.

How to create a traffic jam

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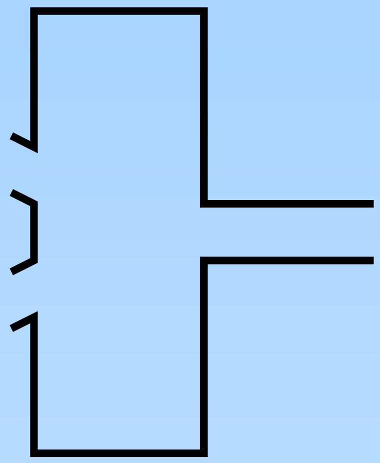

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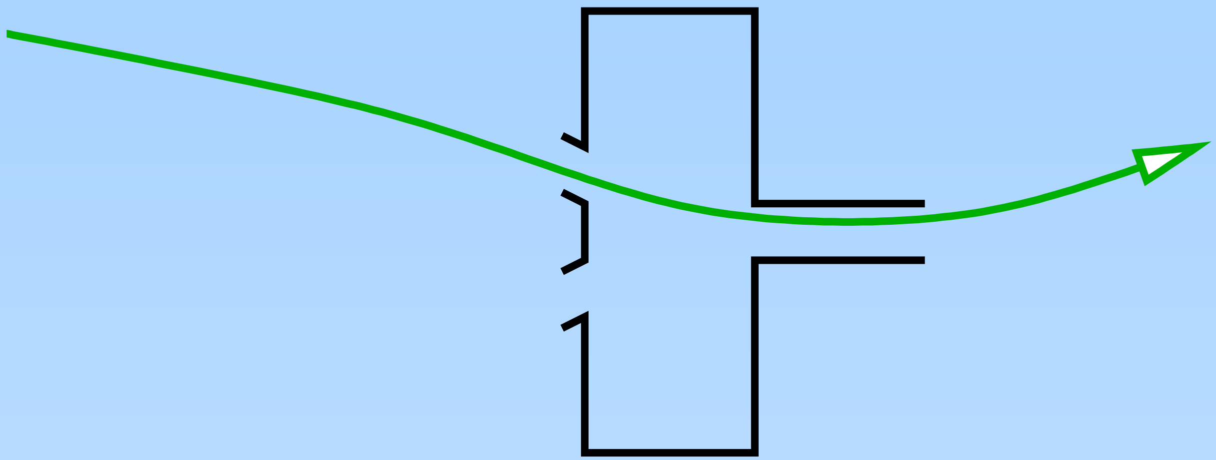

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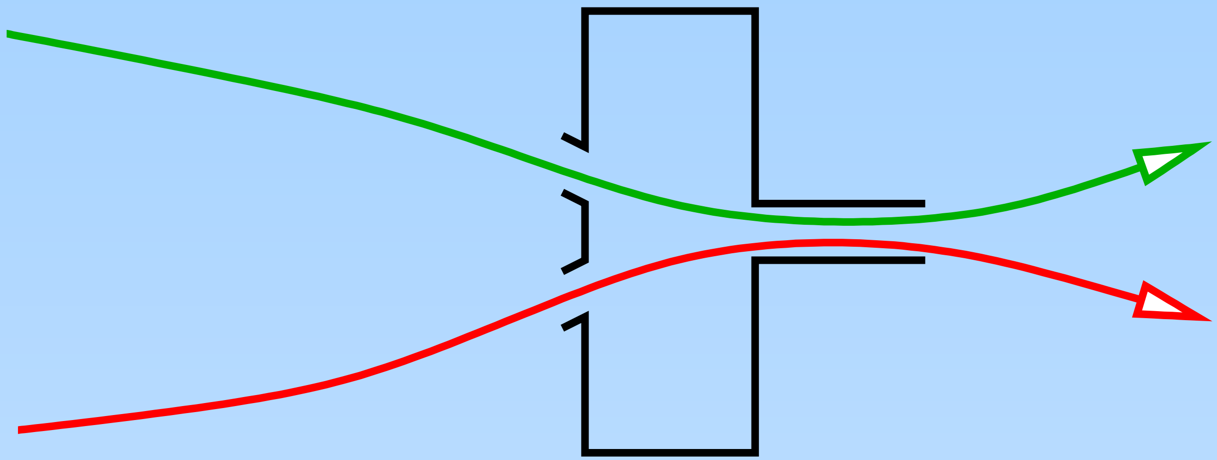

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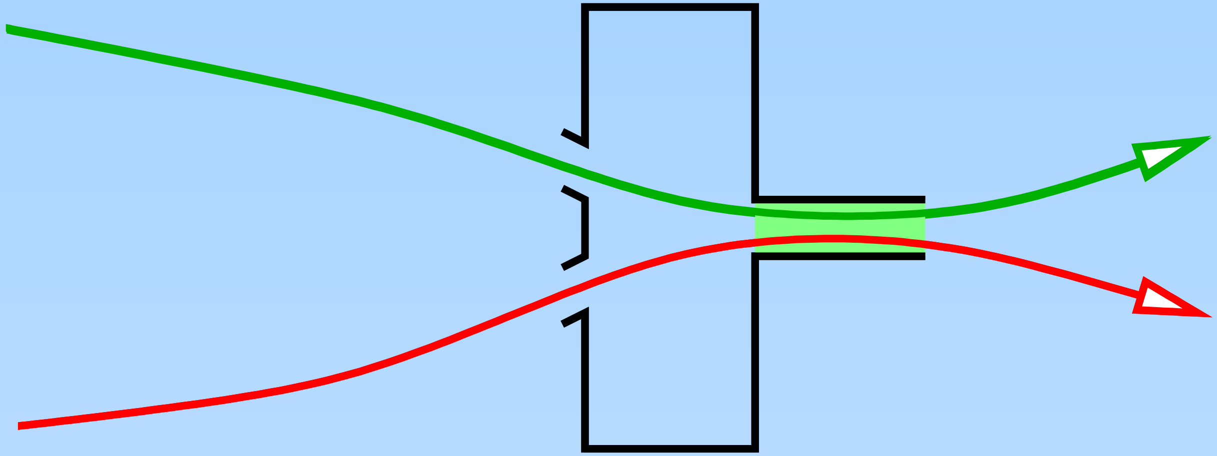

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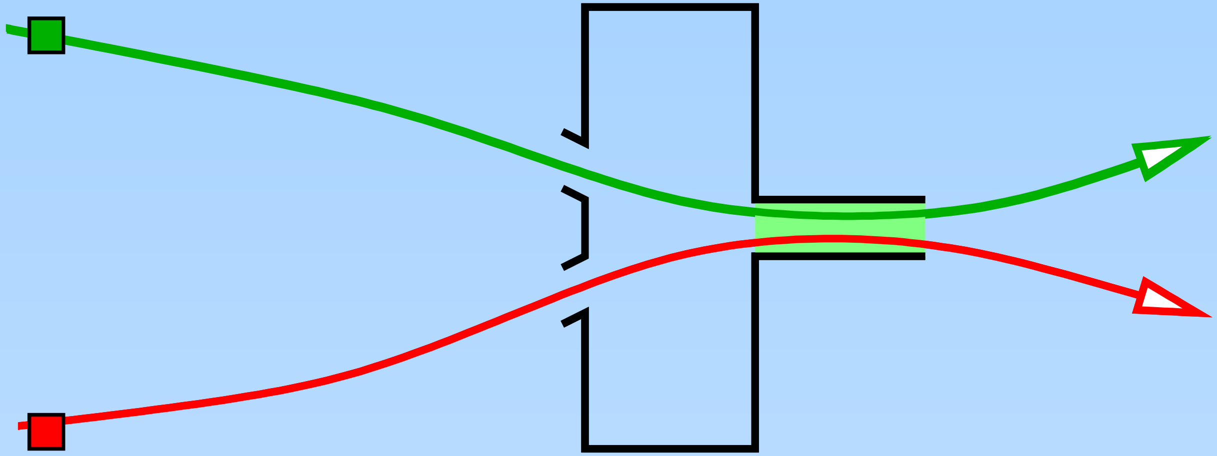

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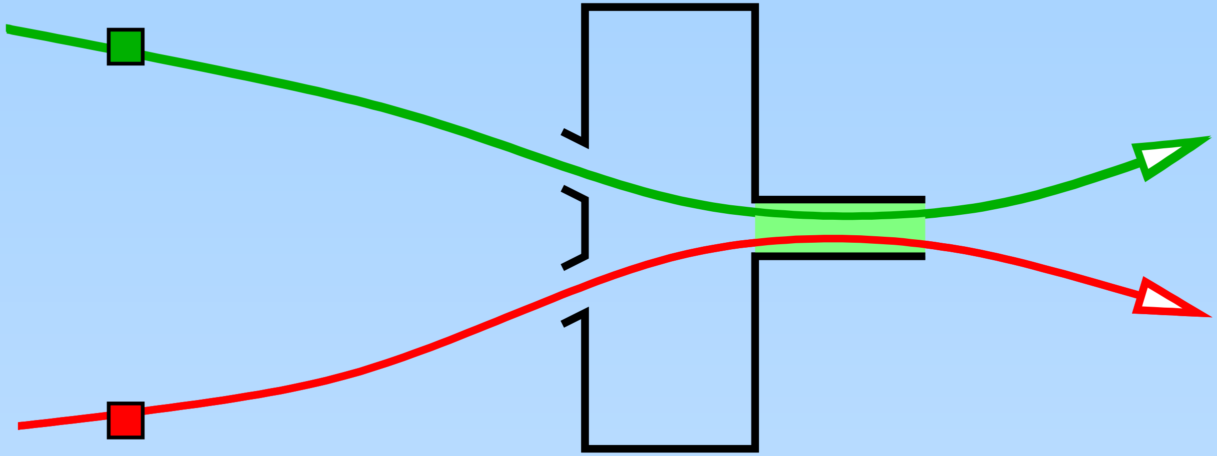

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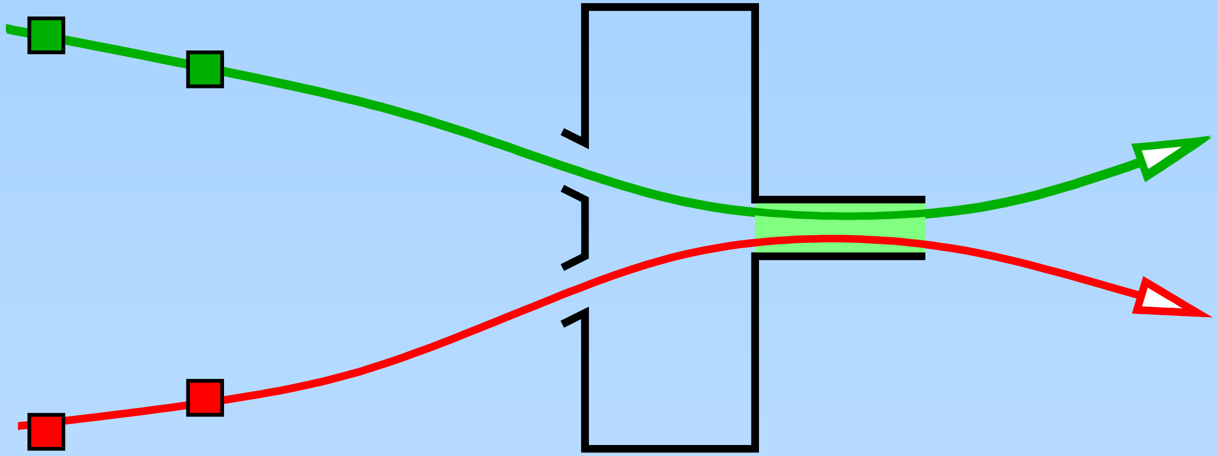

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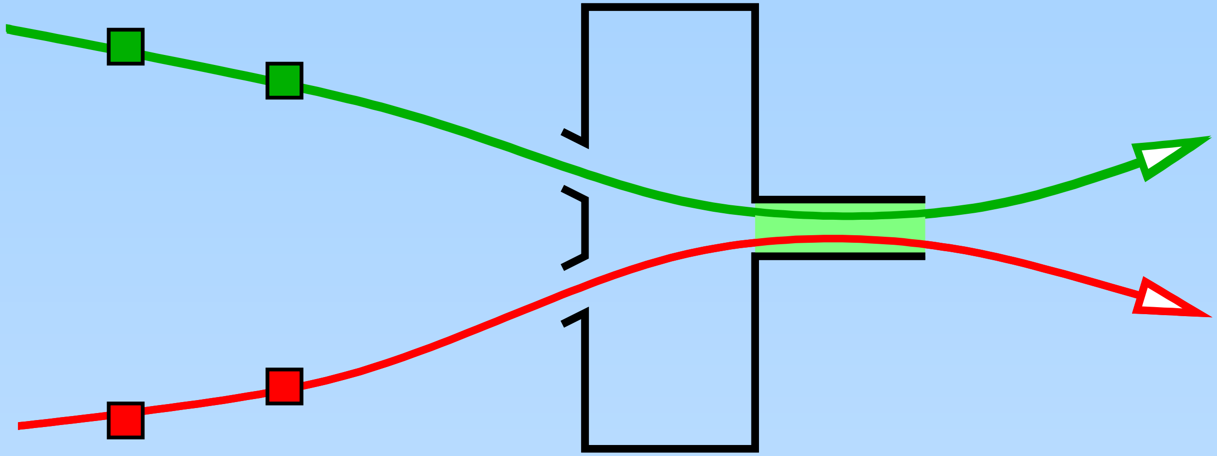

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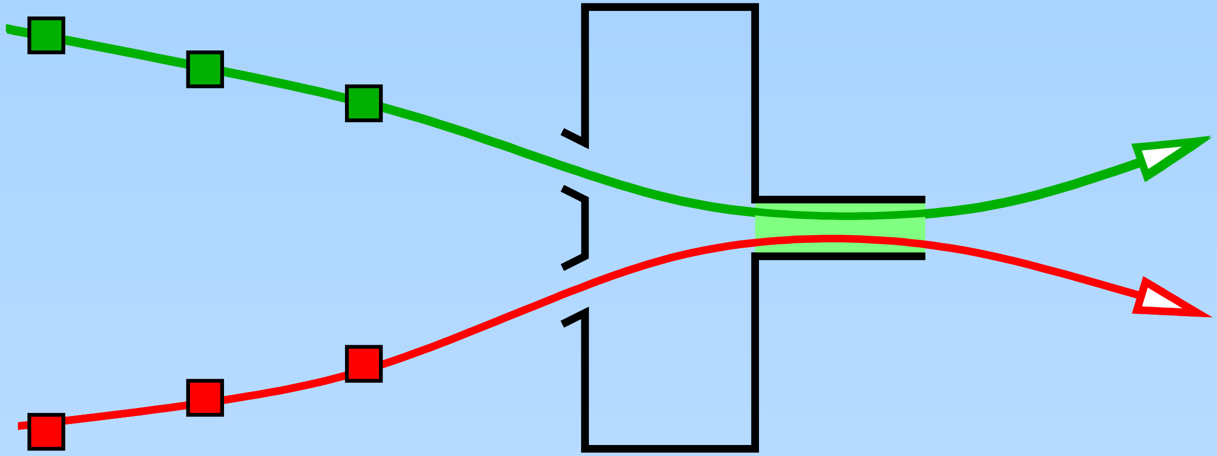

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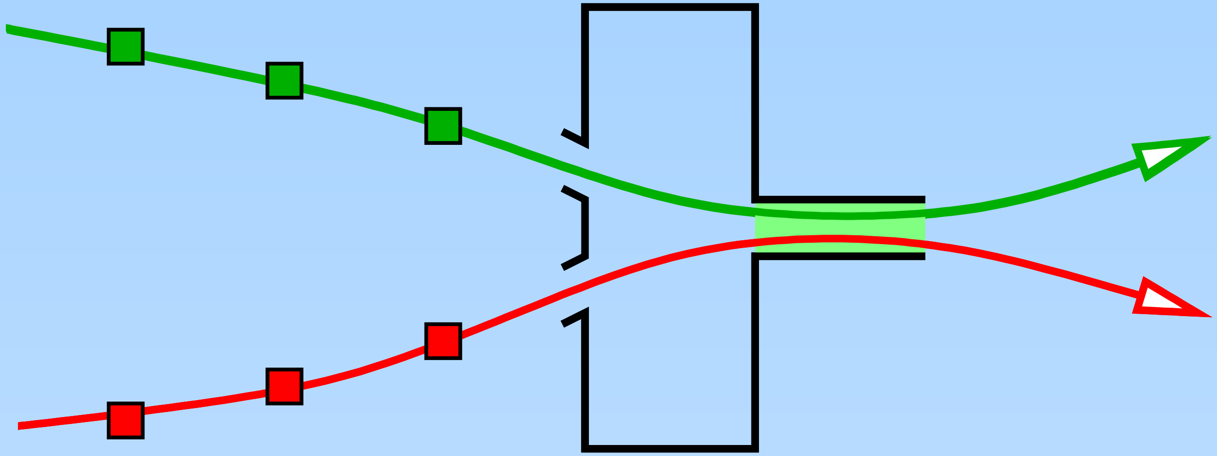

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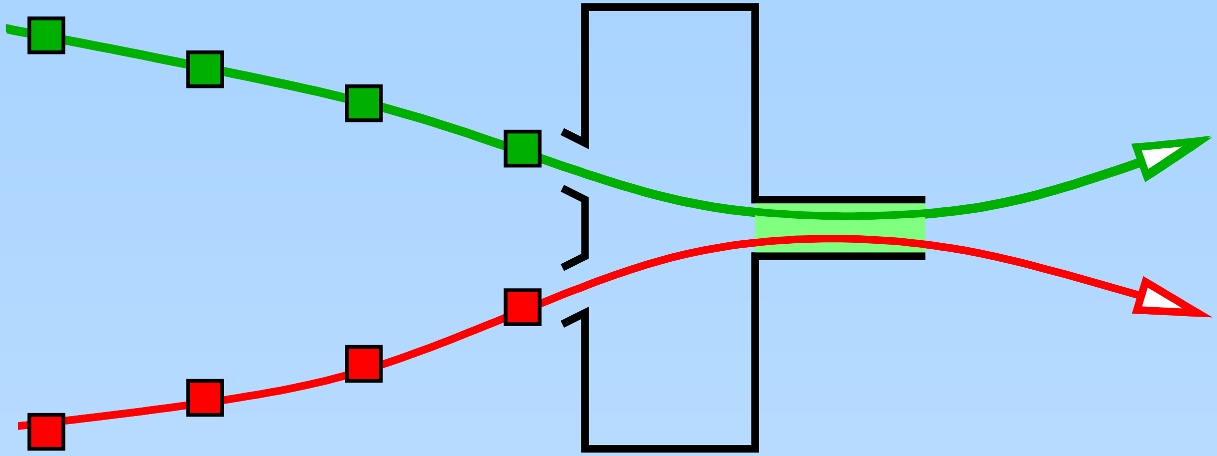

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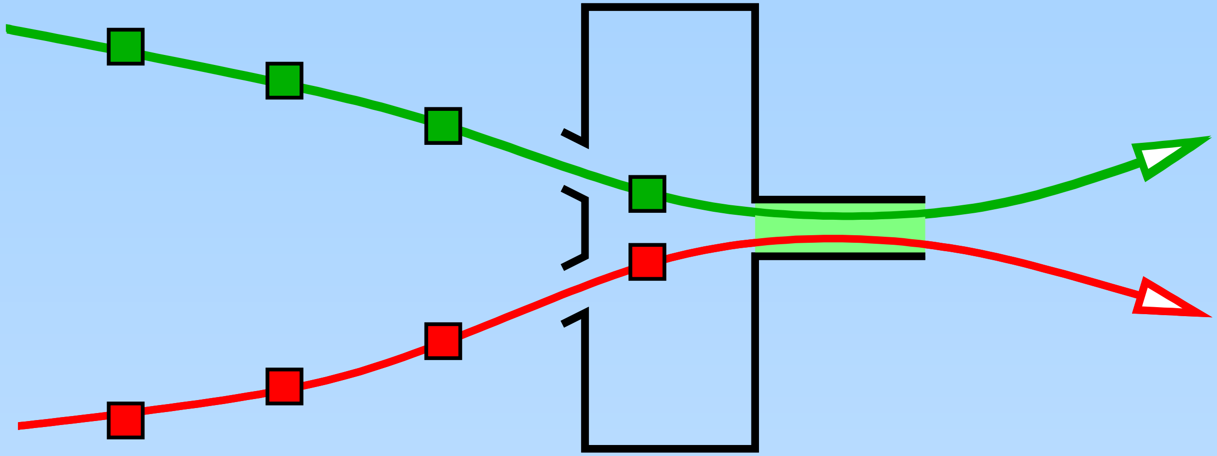

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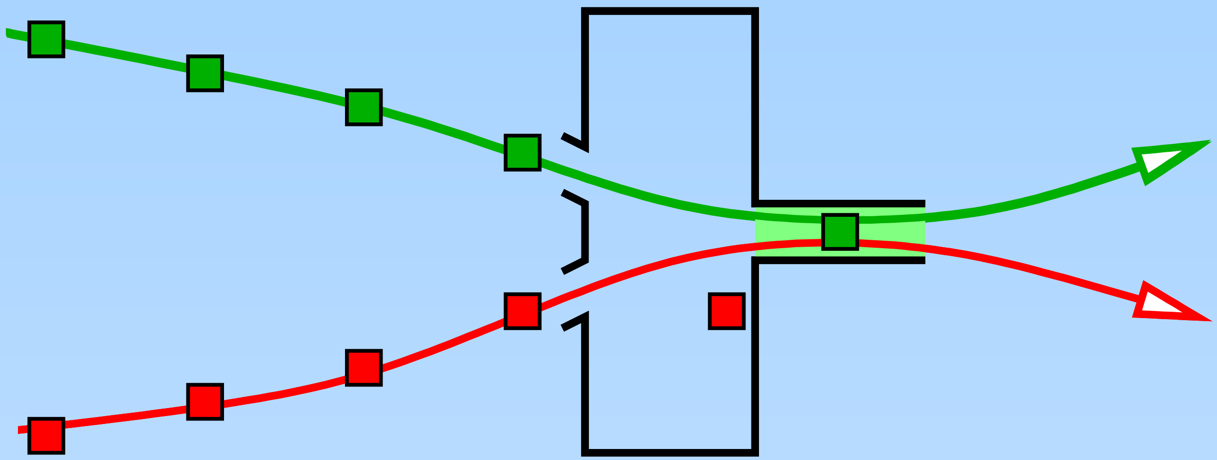

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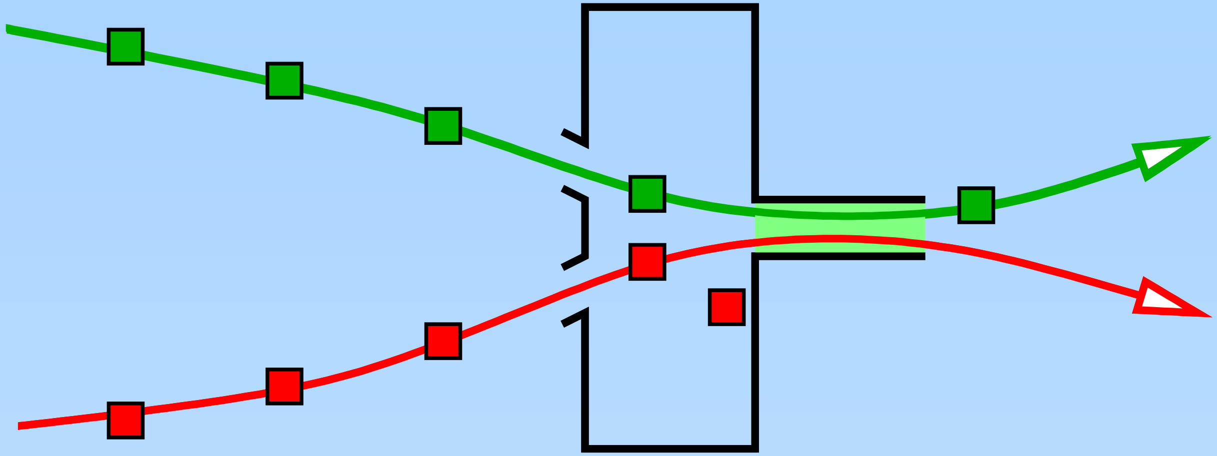

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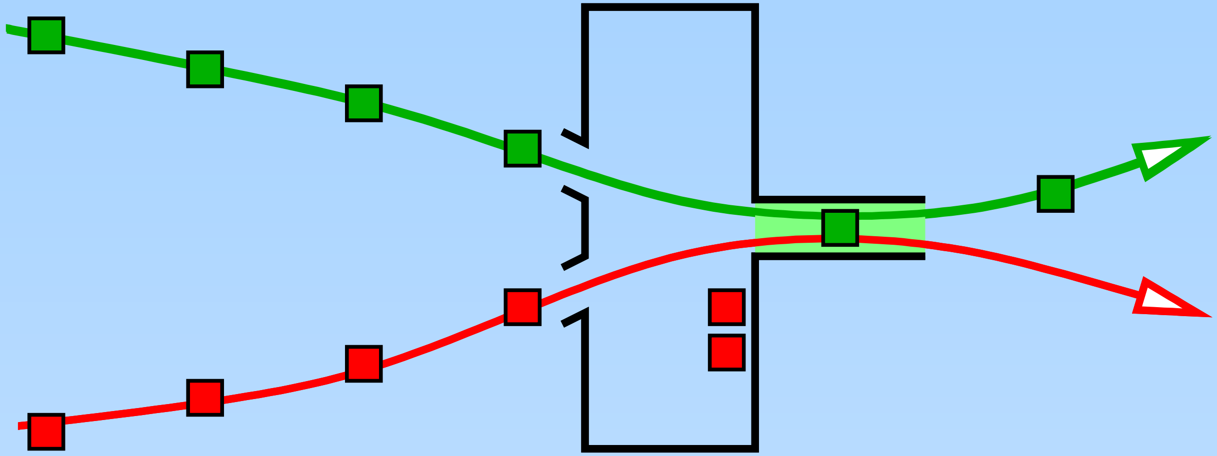

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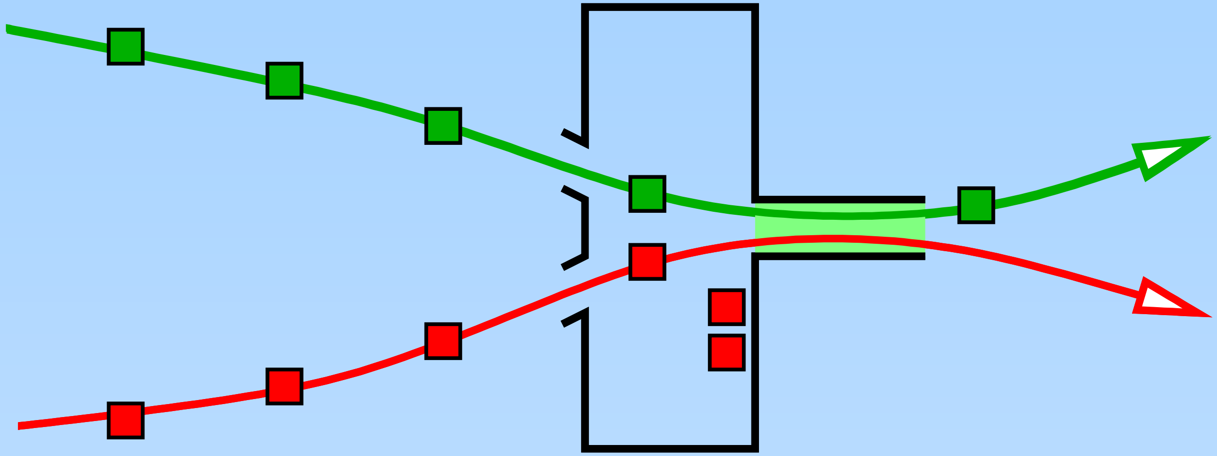

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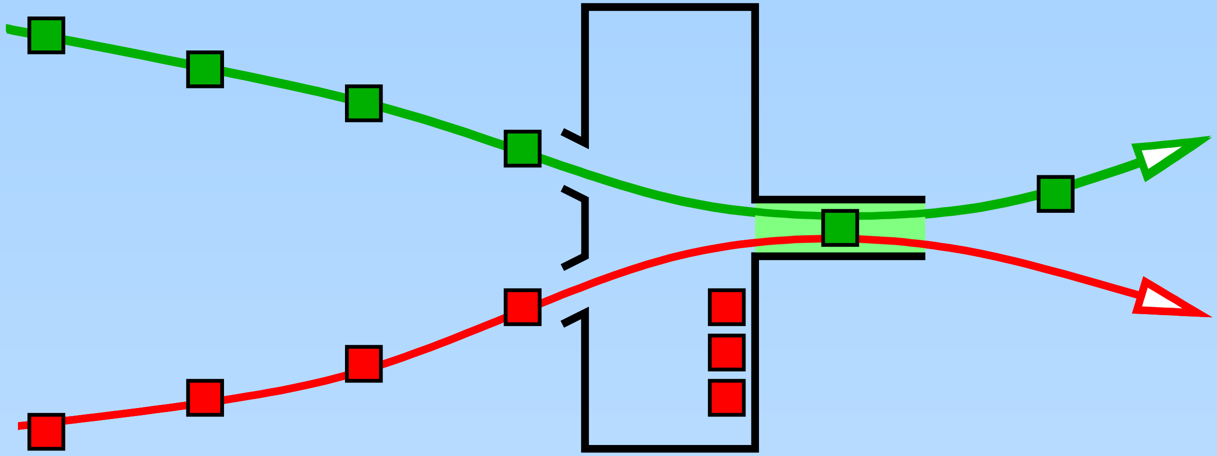

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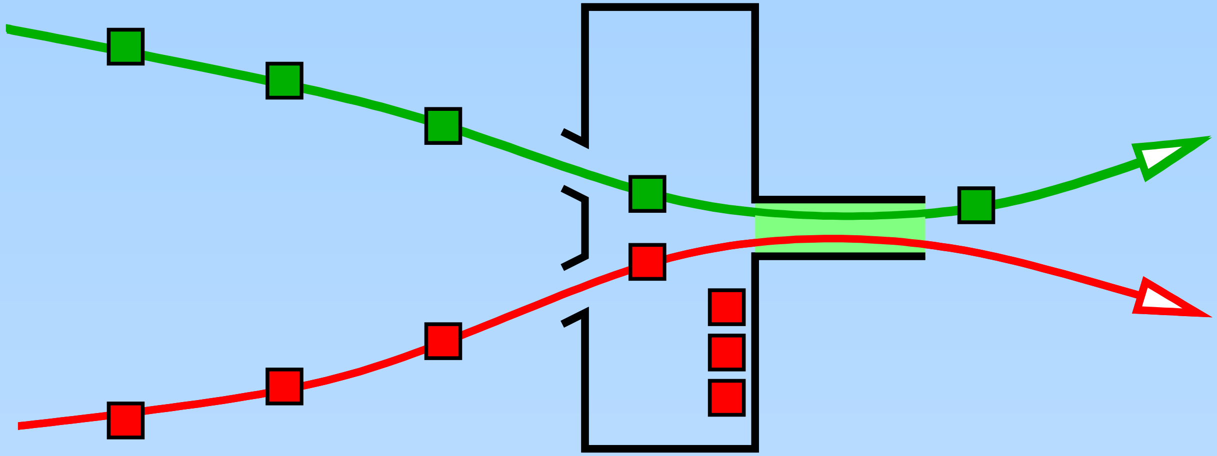

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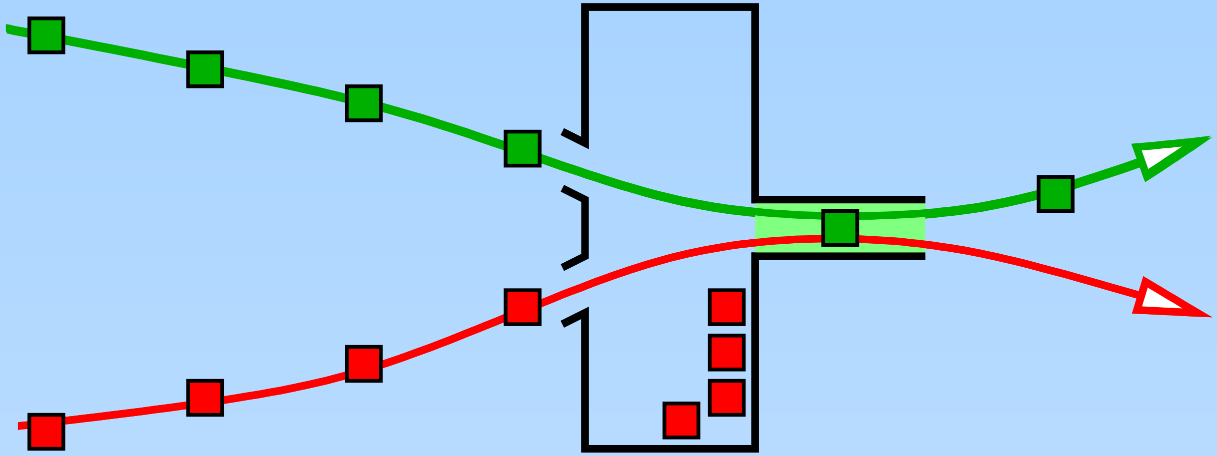

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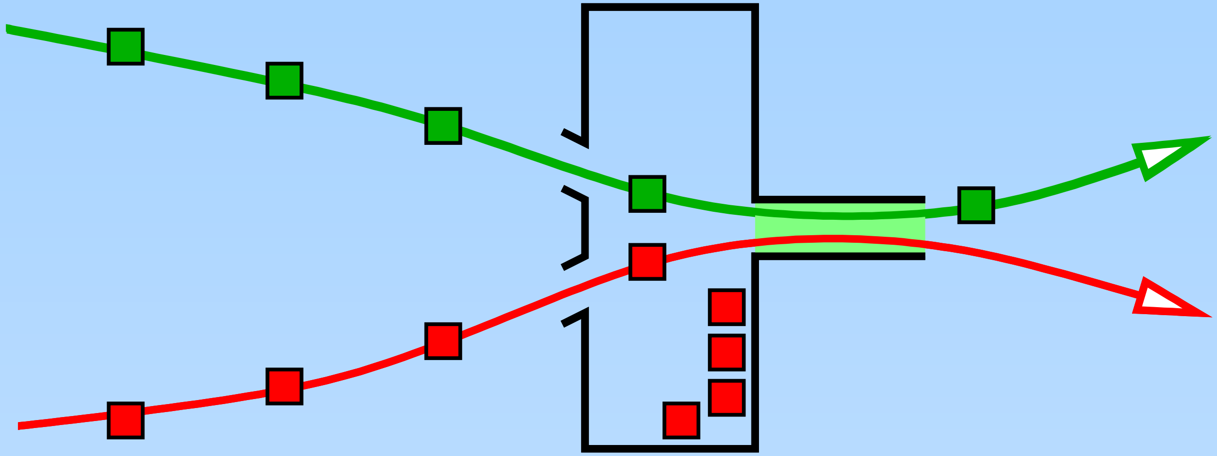

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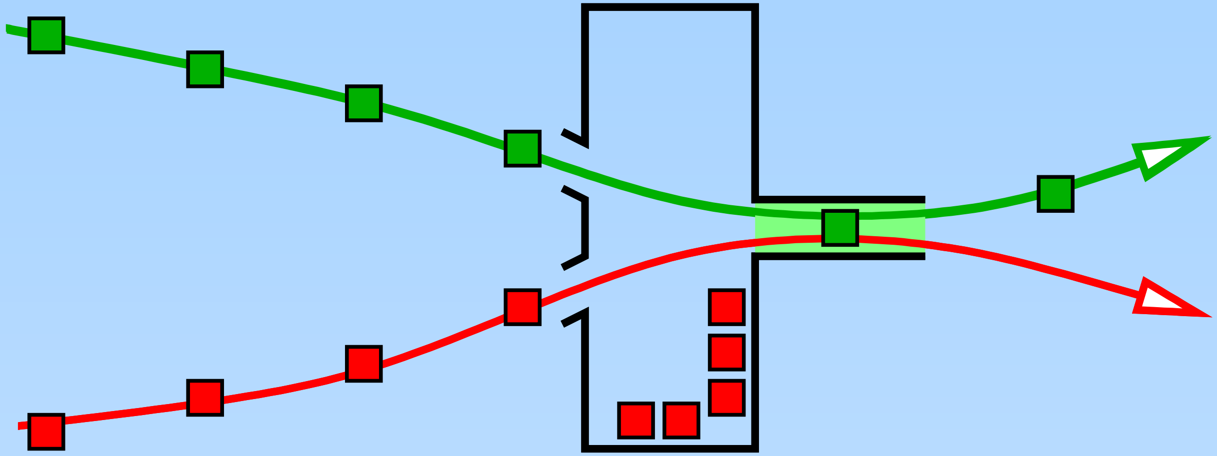

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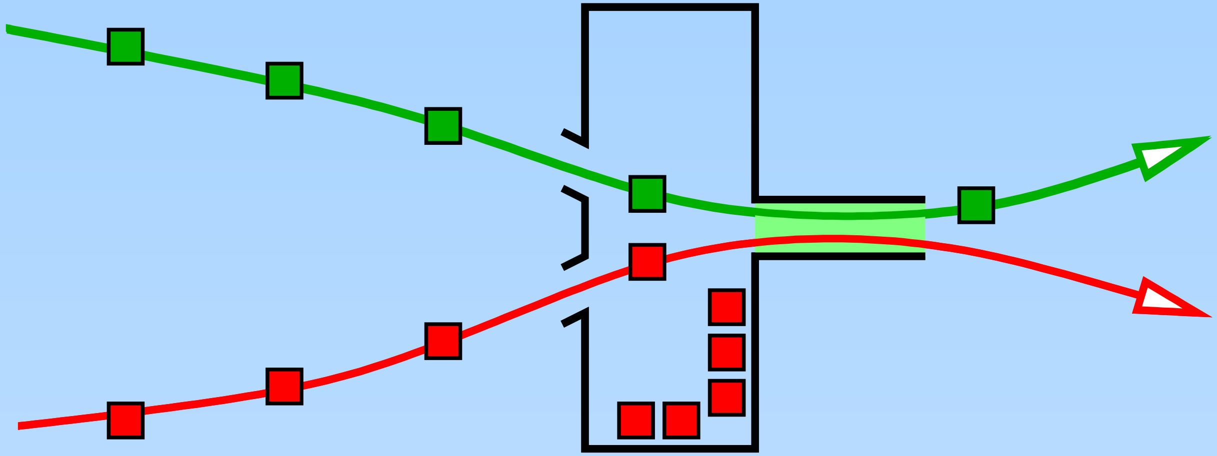

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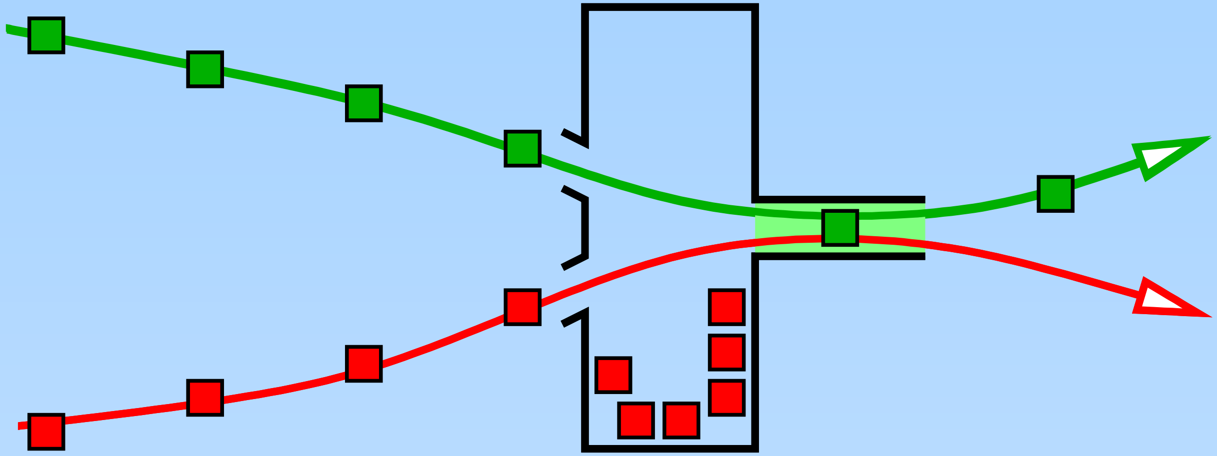

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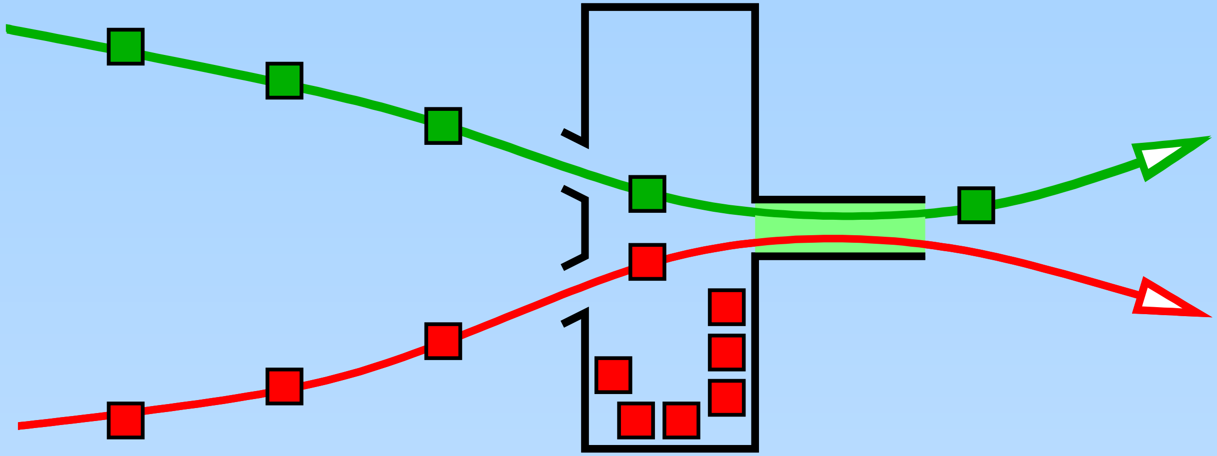

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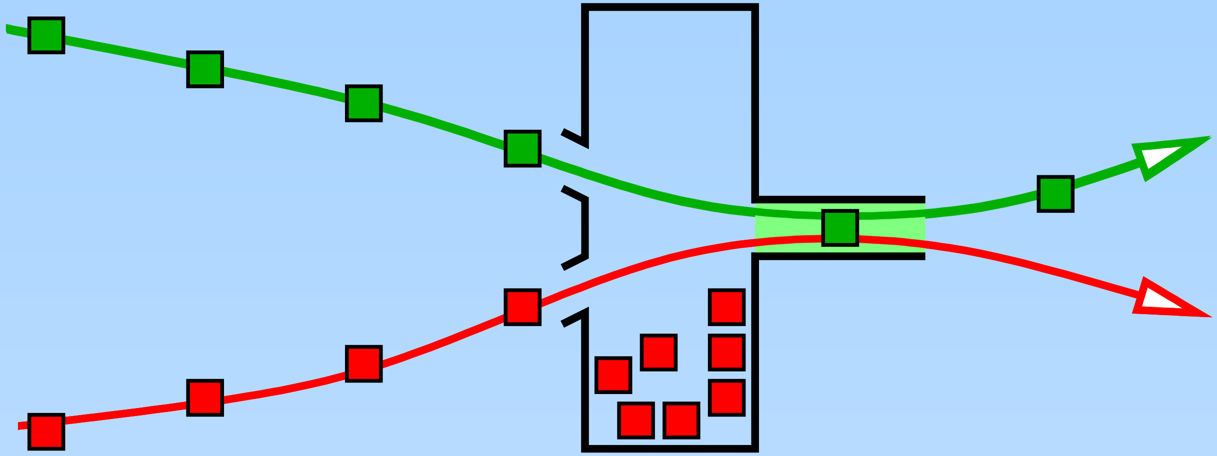

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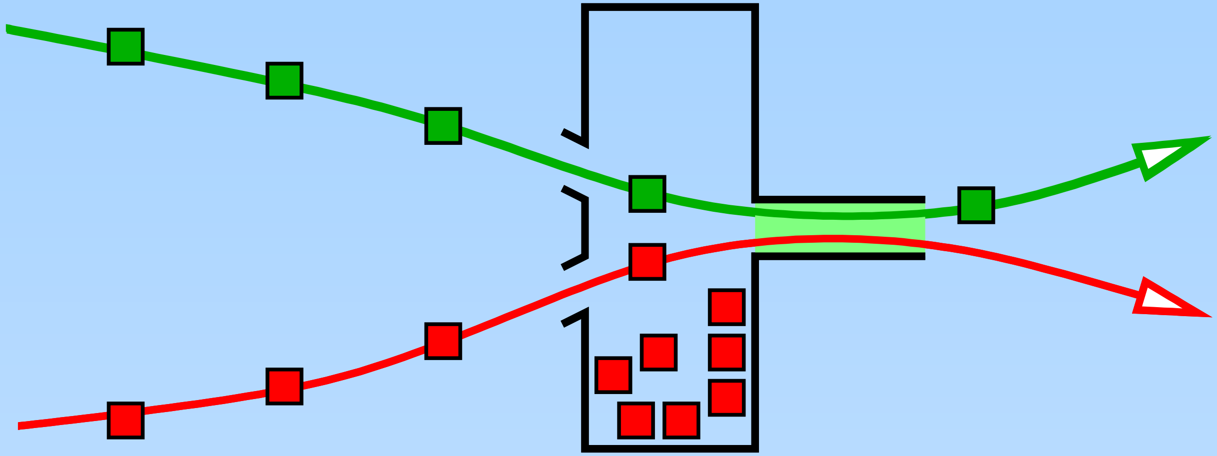

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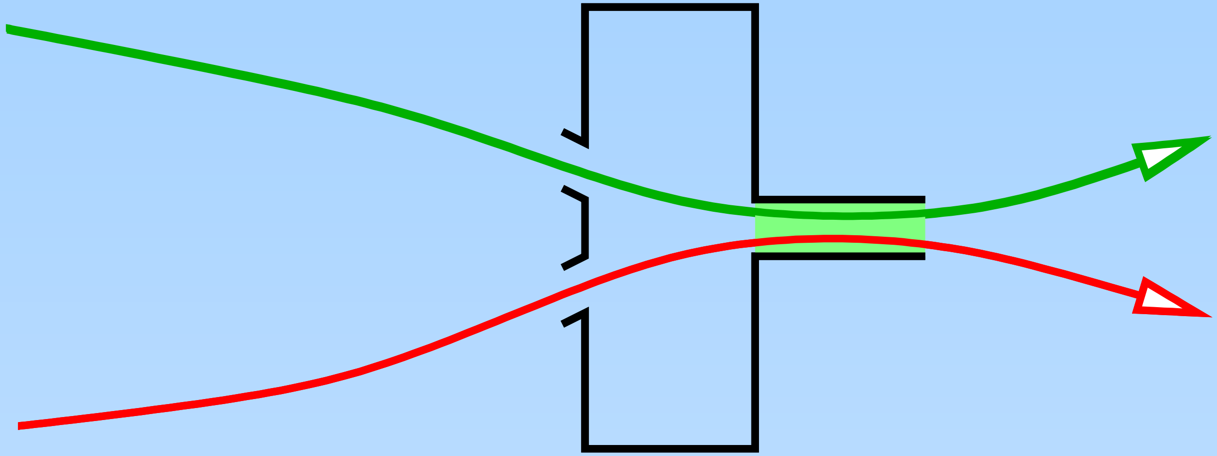

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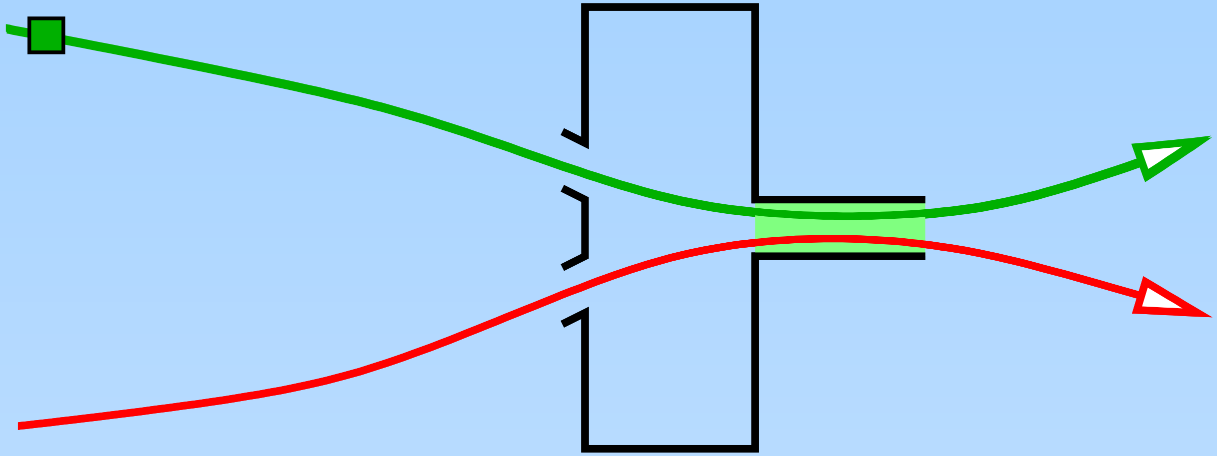

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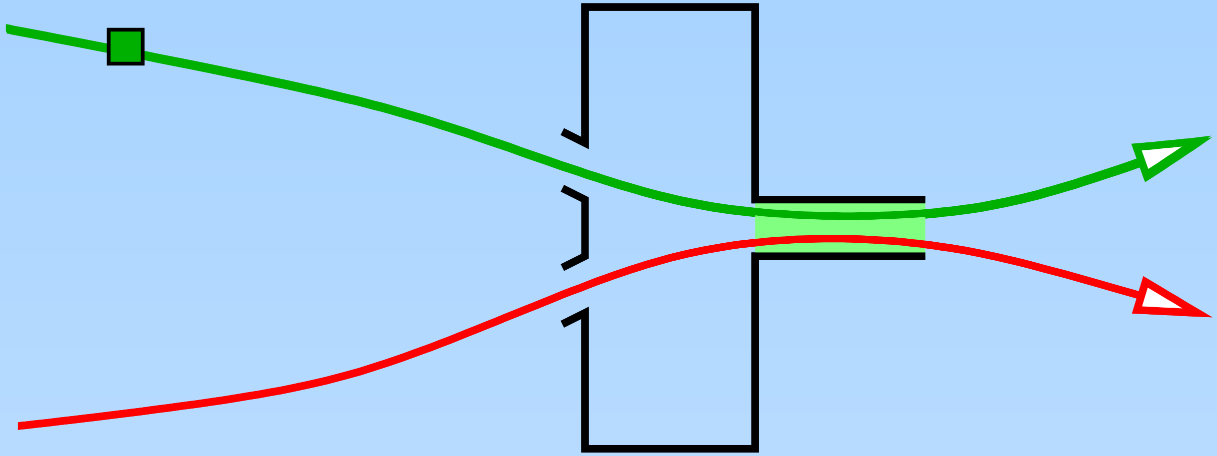

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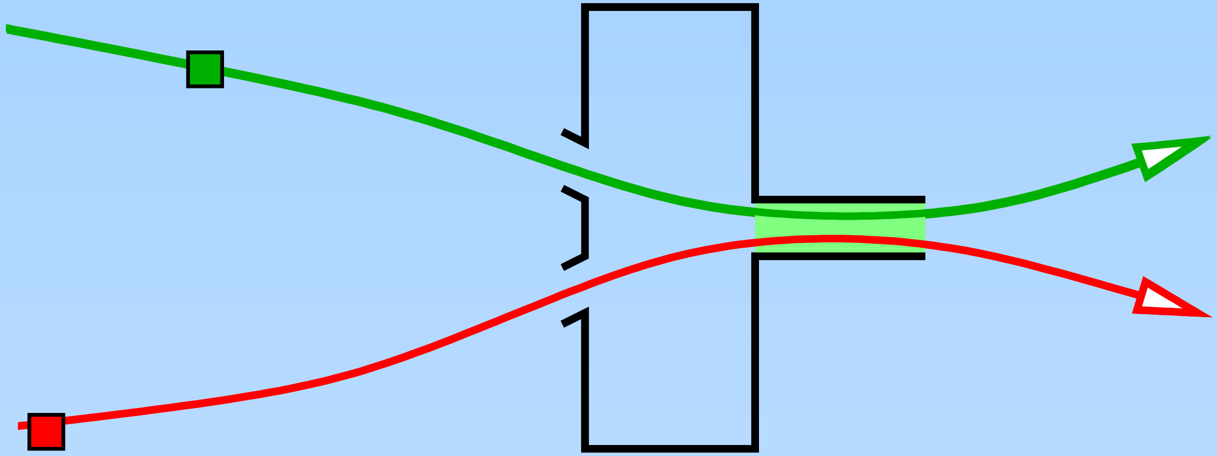

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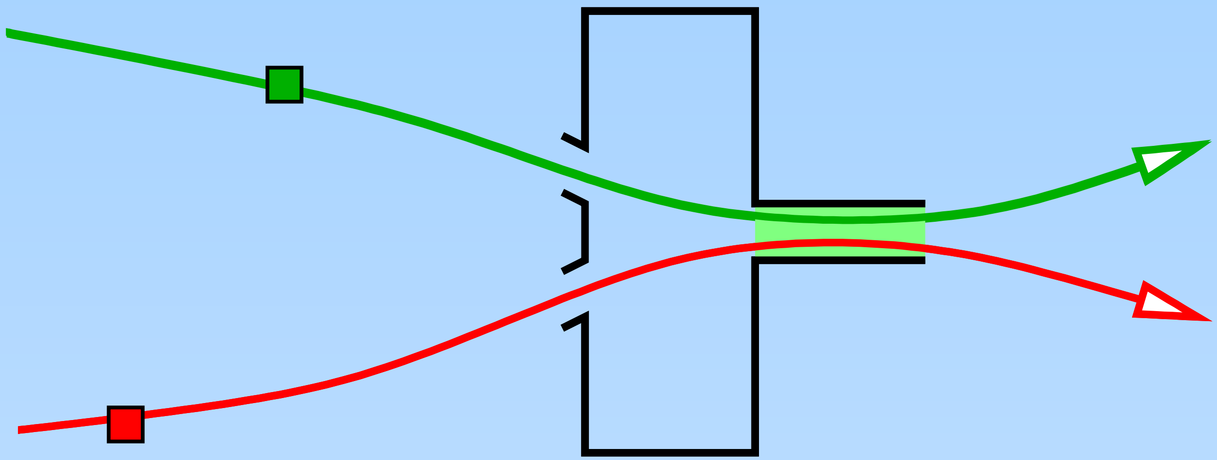

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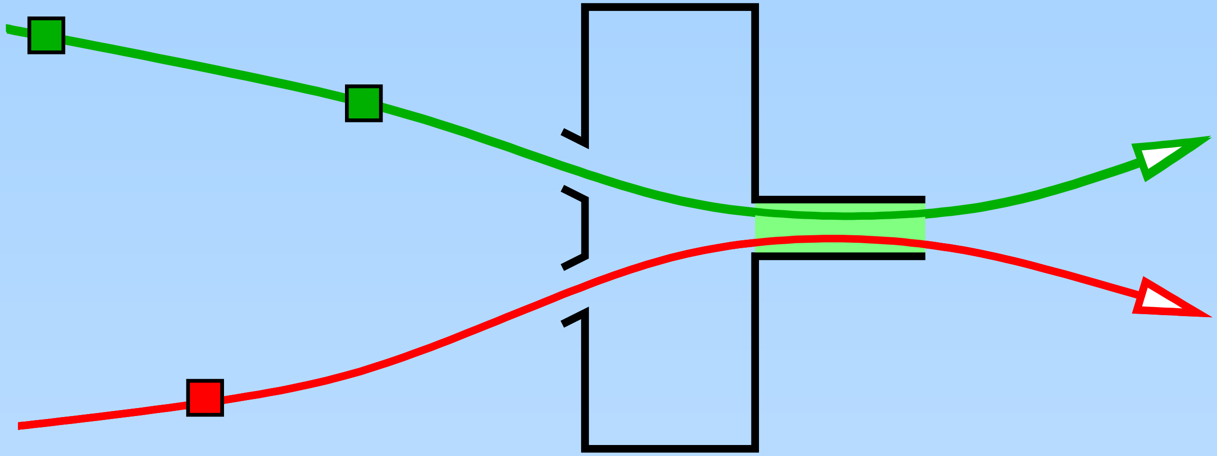

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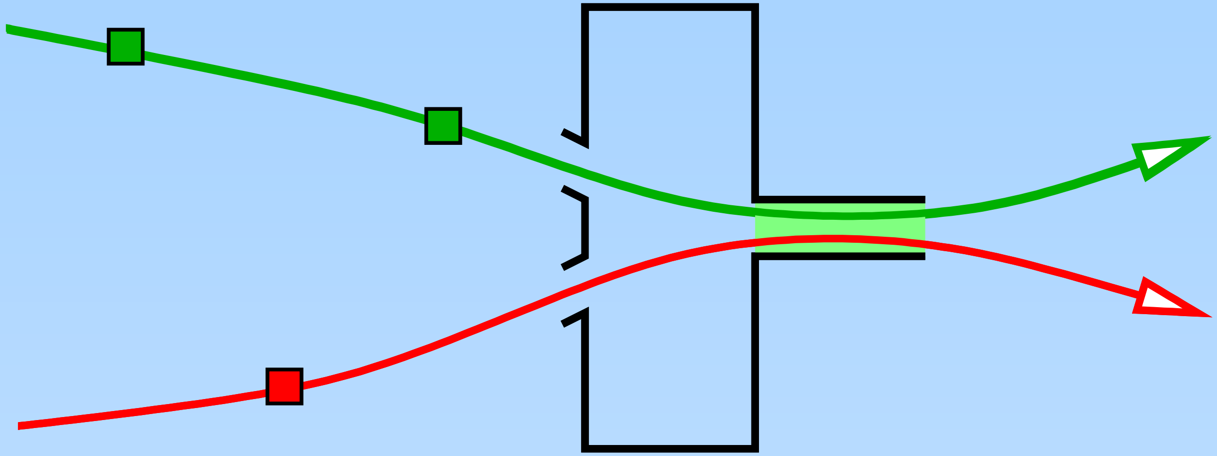

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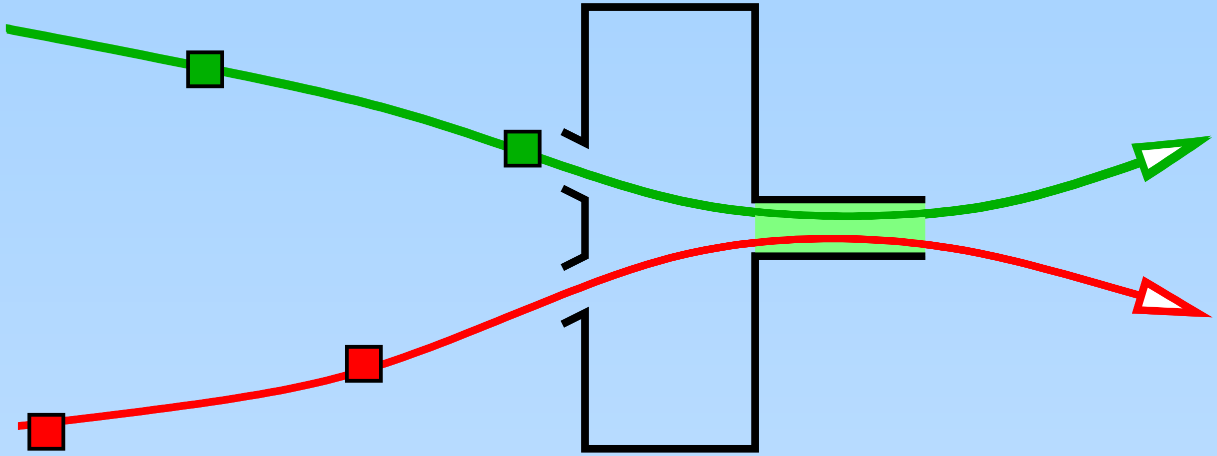

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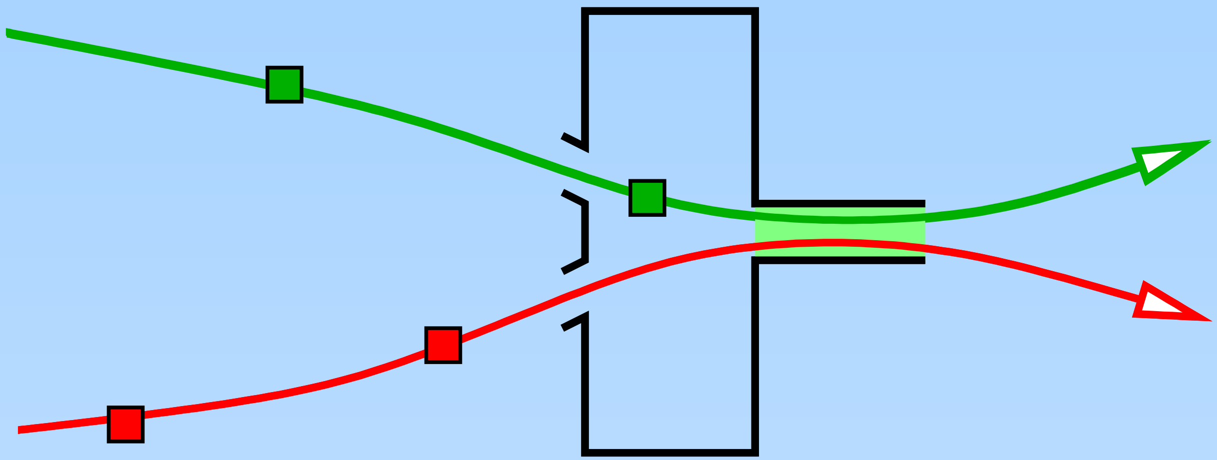

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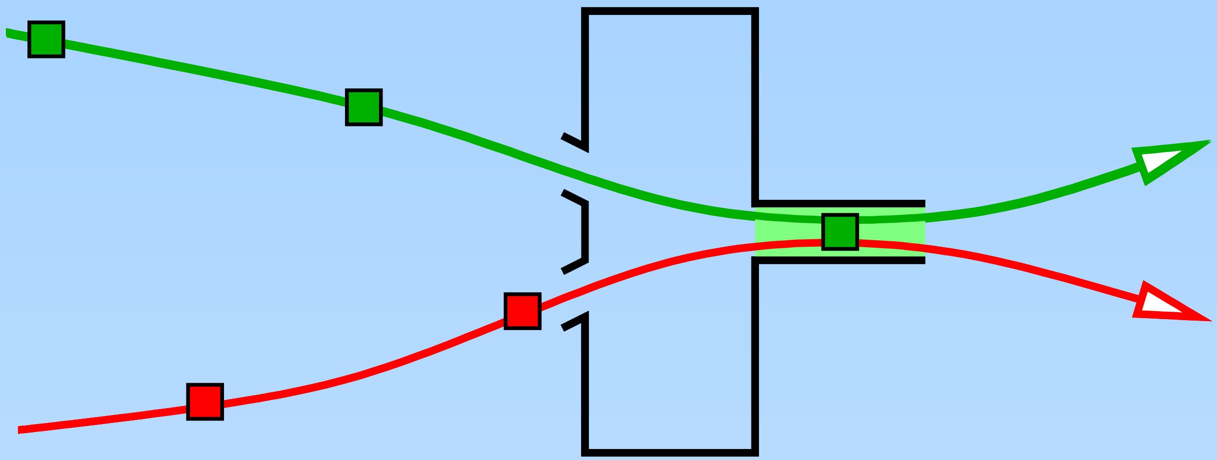

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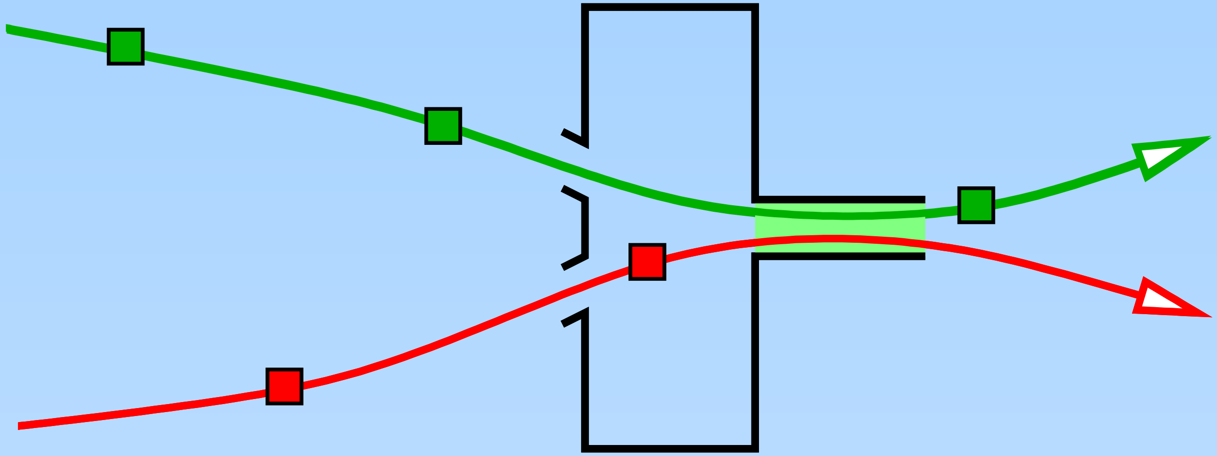

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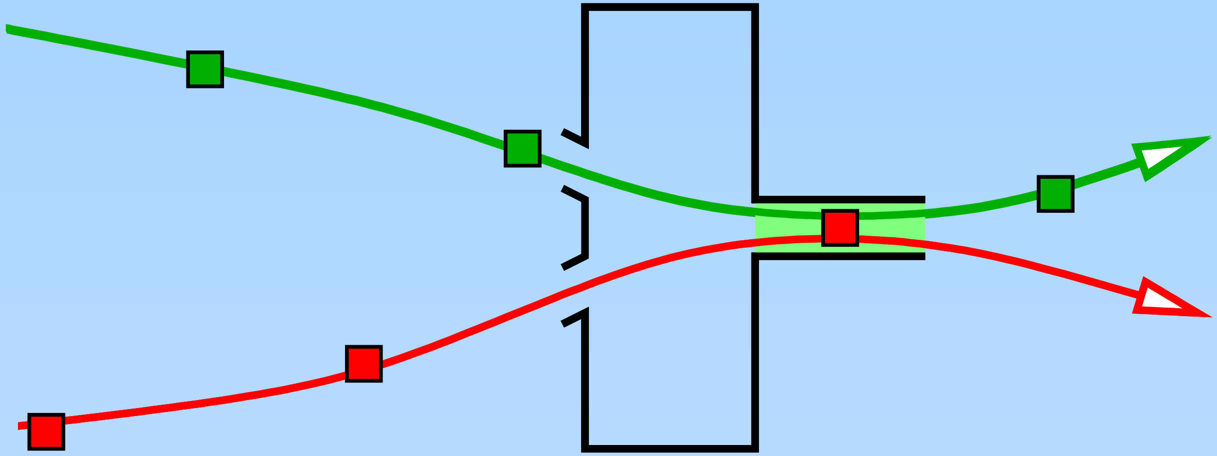

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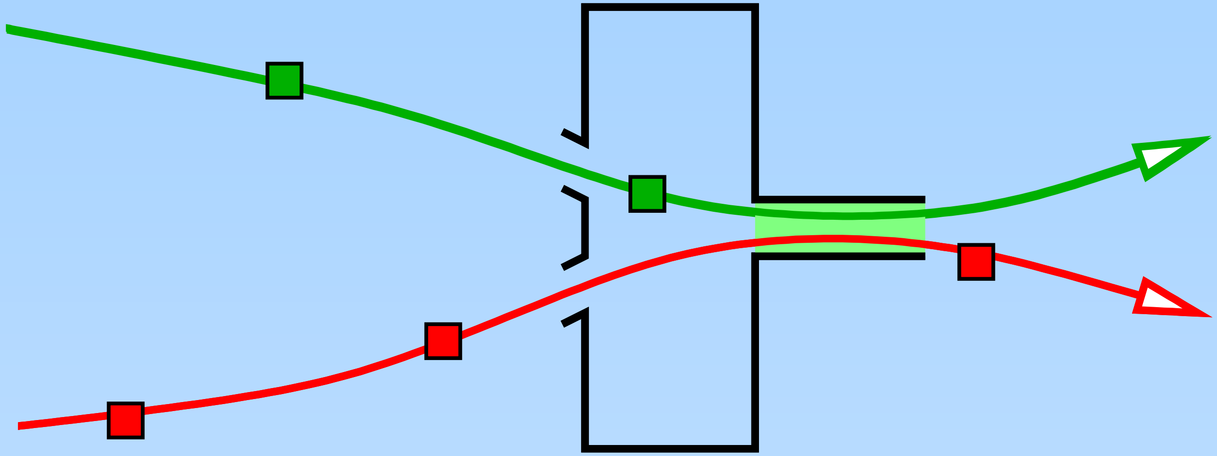

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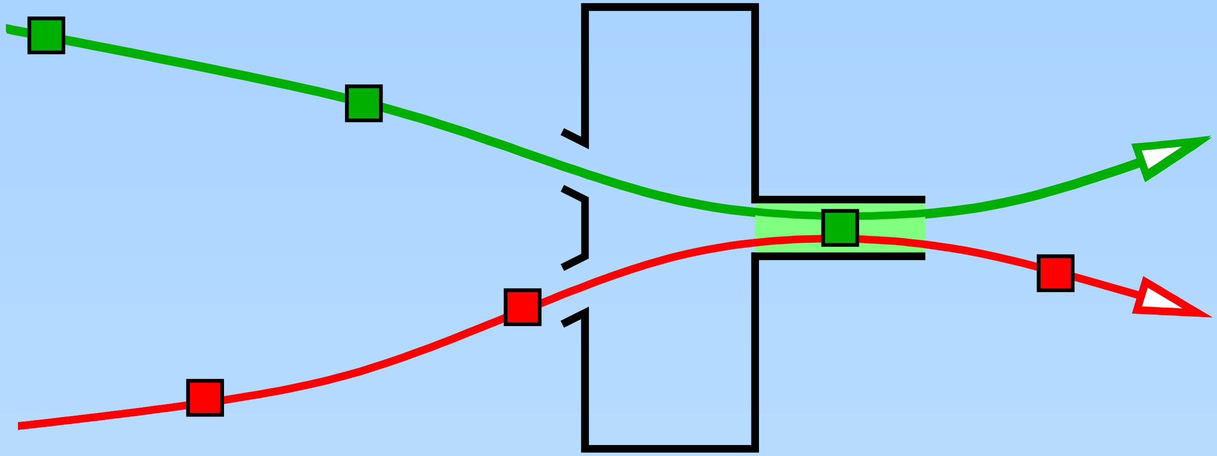

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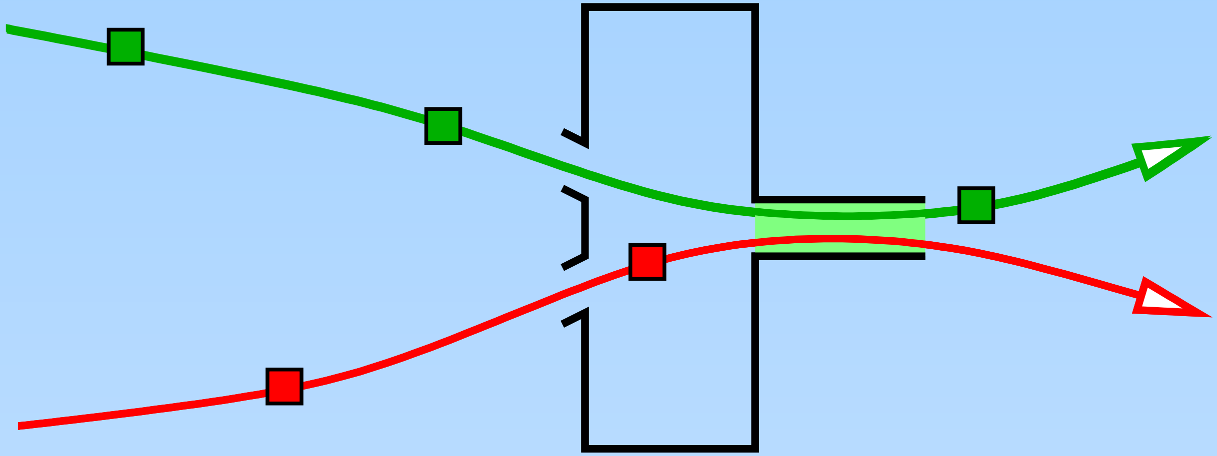

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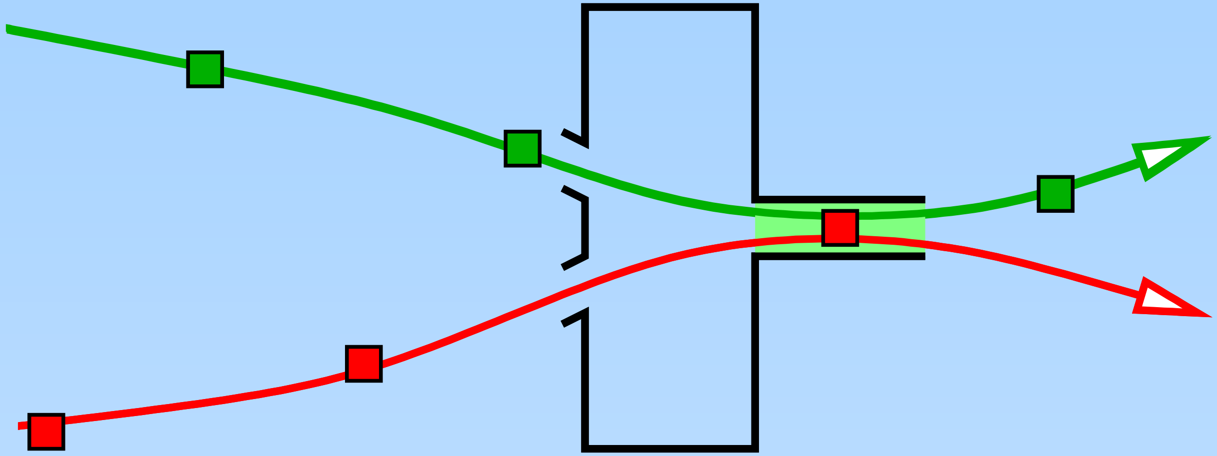

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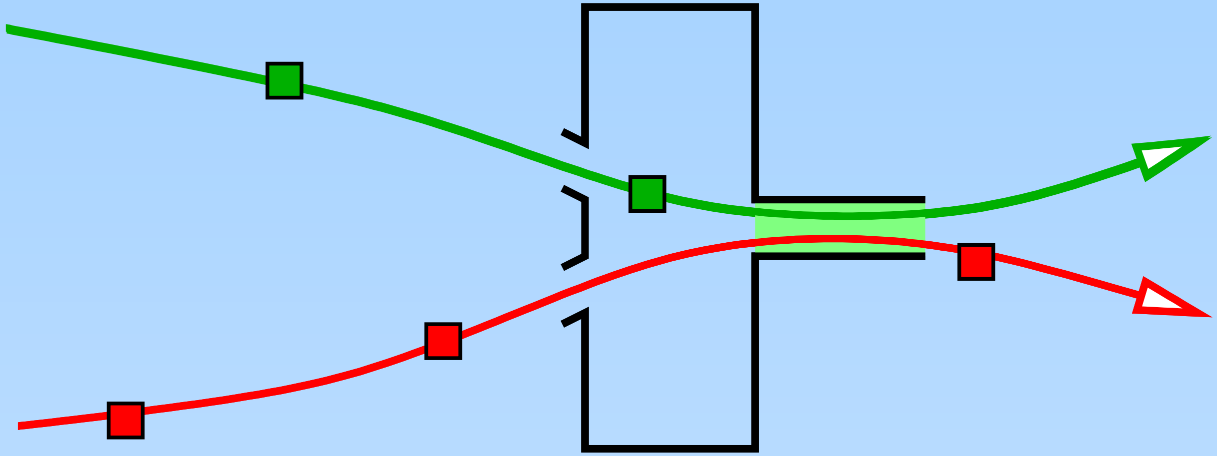

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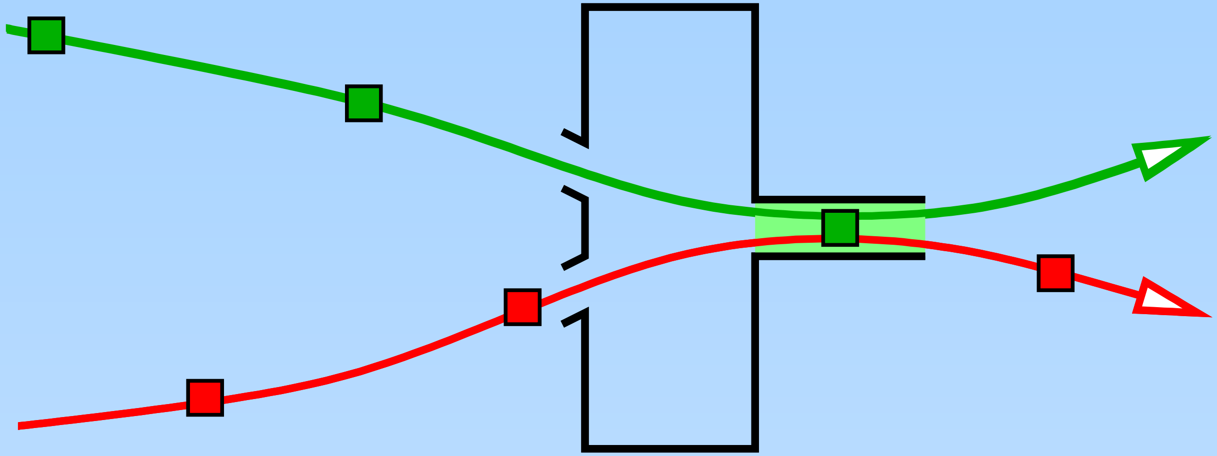

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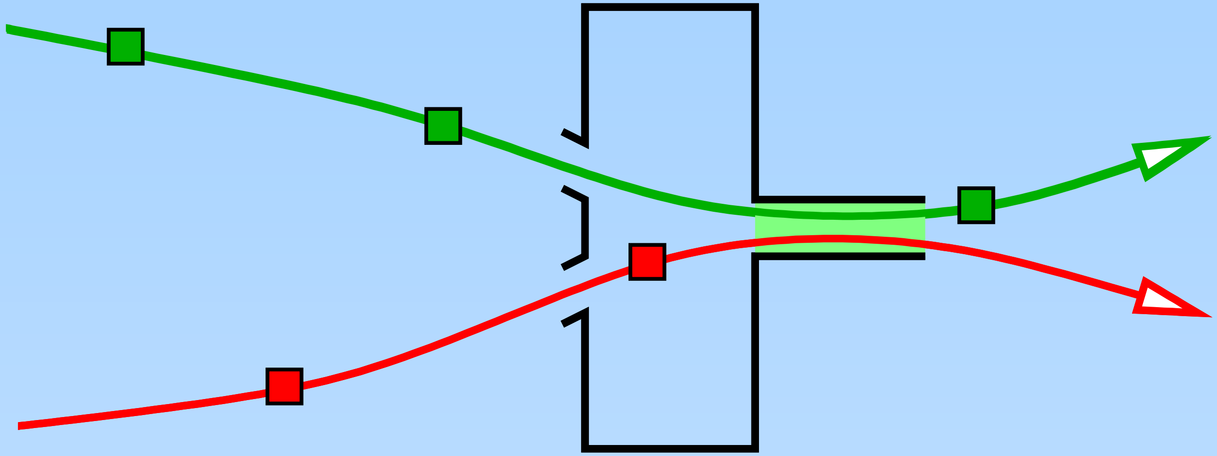
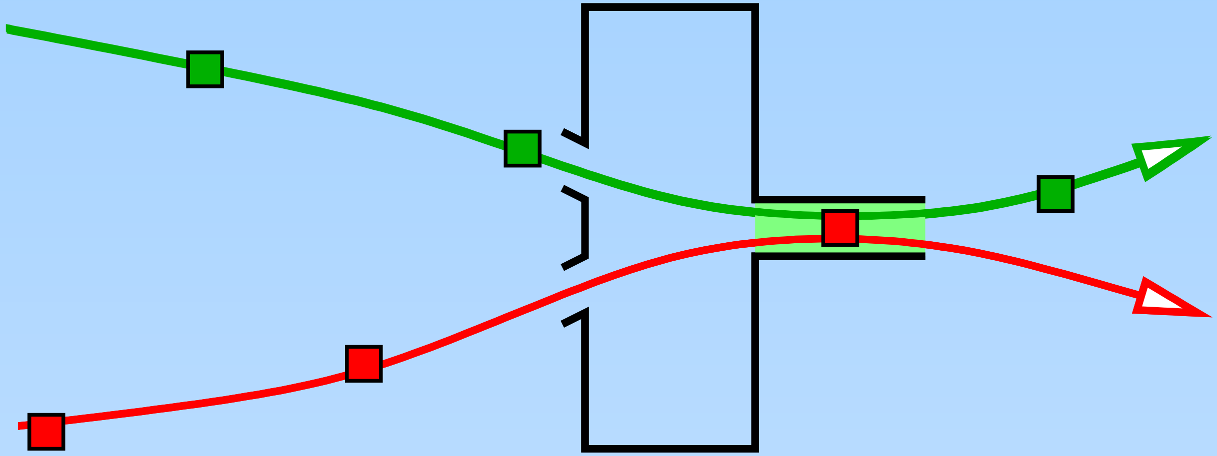


Joint edge is overloaded.

How to create a traffic jam



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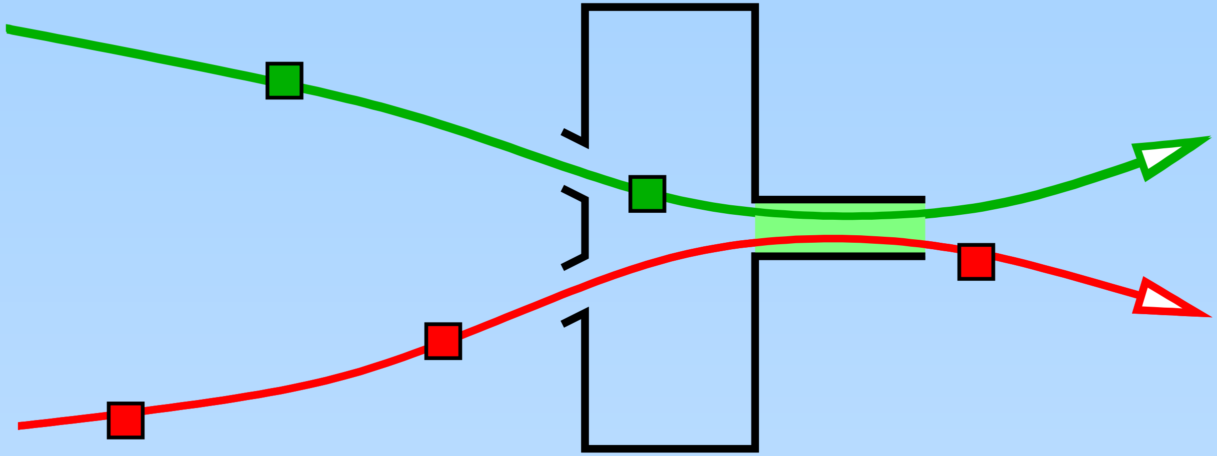
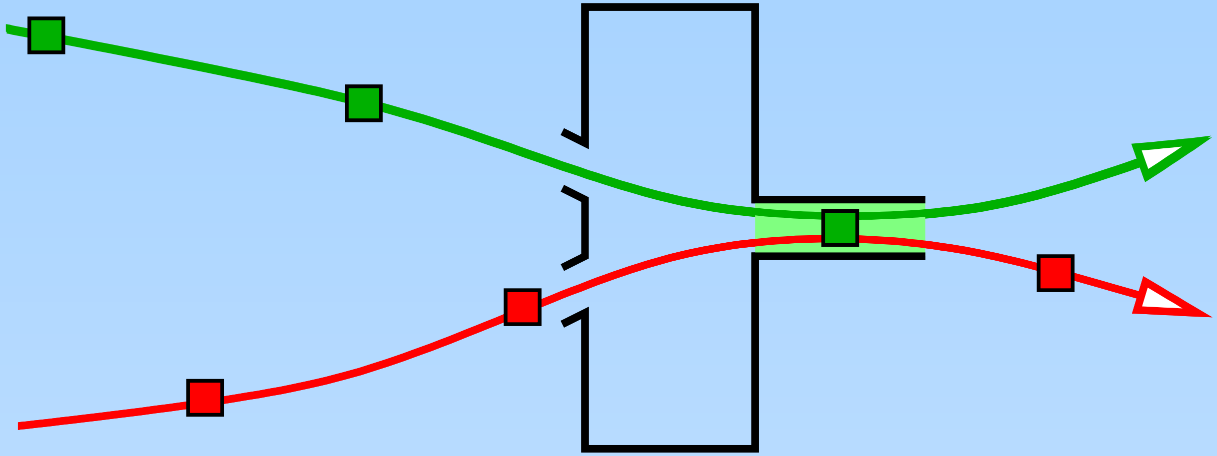


Joint edge is overloaded.

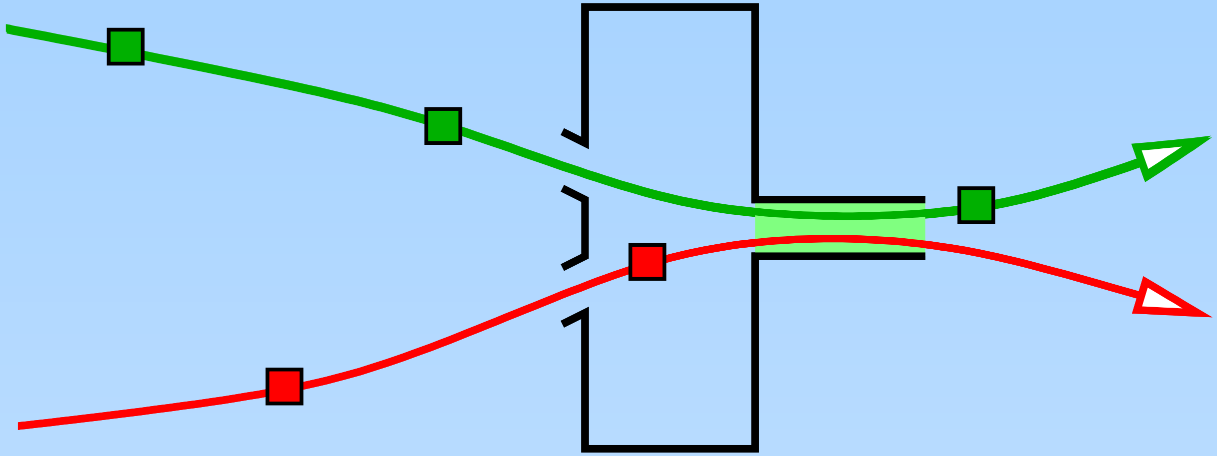
How to create a traffic jam



Joint edge is overloaded.

For legal insertions no jam is created.

How to create a traffic jam



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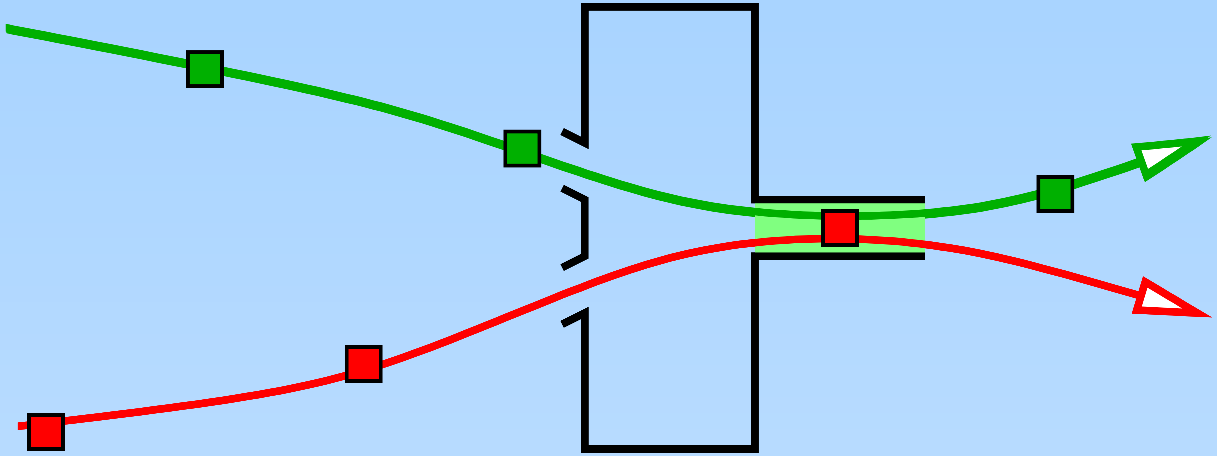

Joint edge is overloaded.

For legal insertions no jam is created.

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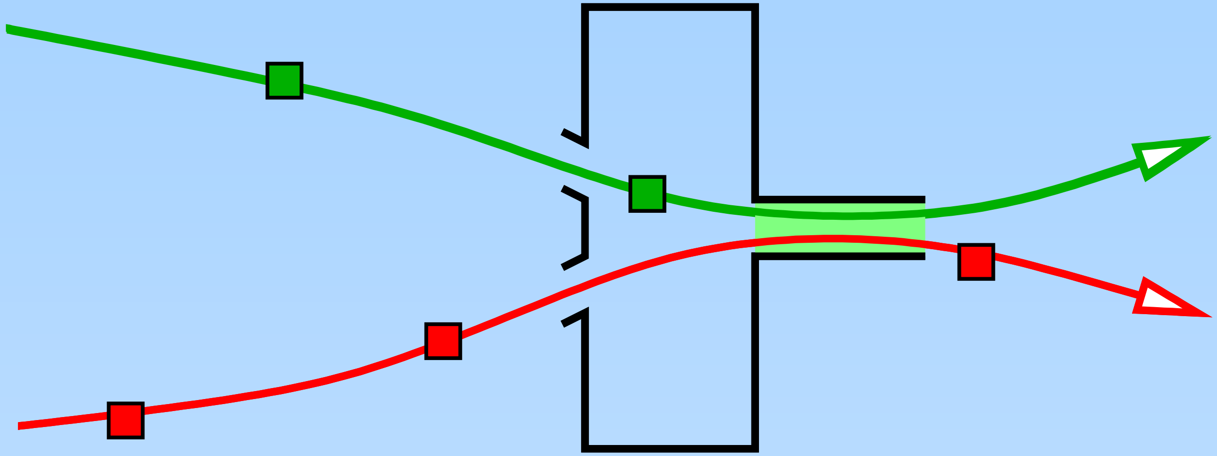

Joint edge is overloaded.

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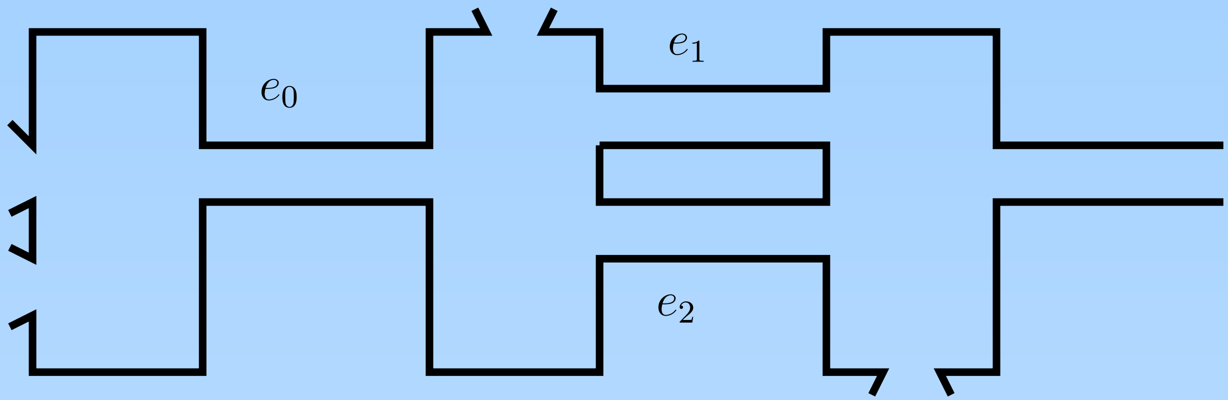
Piling up packets



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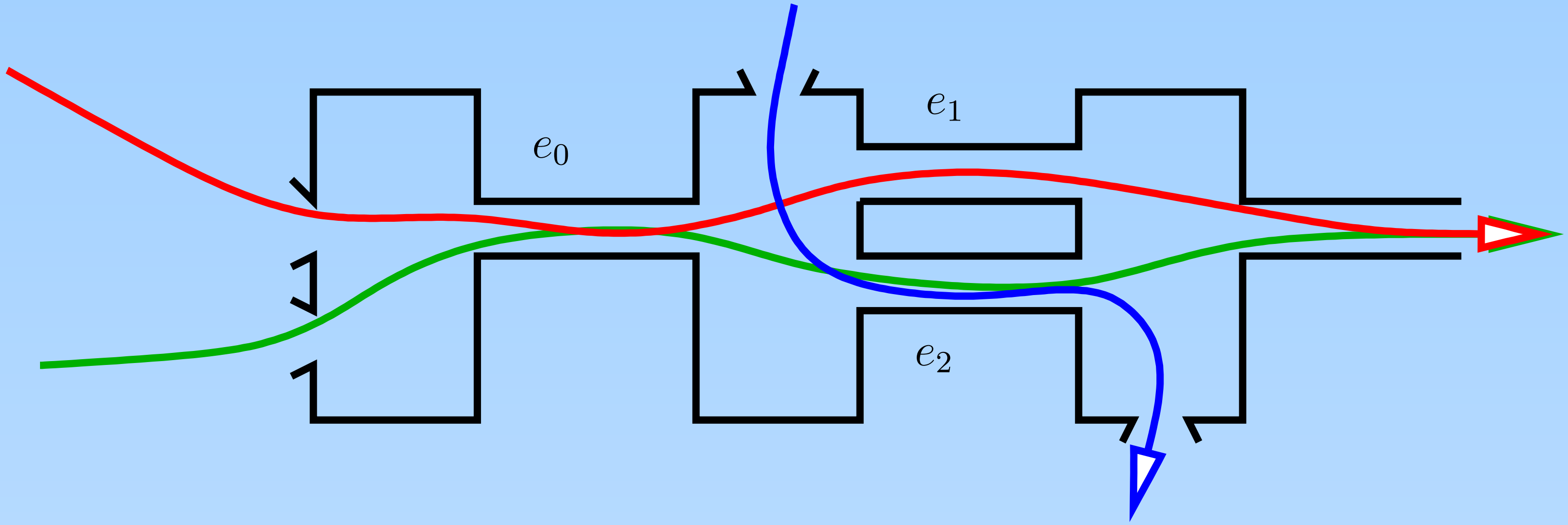

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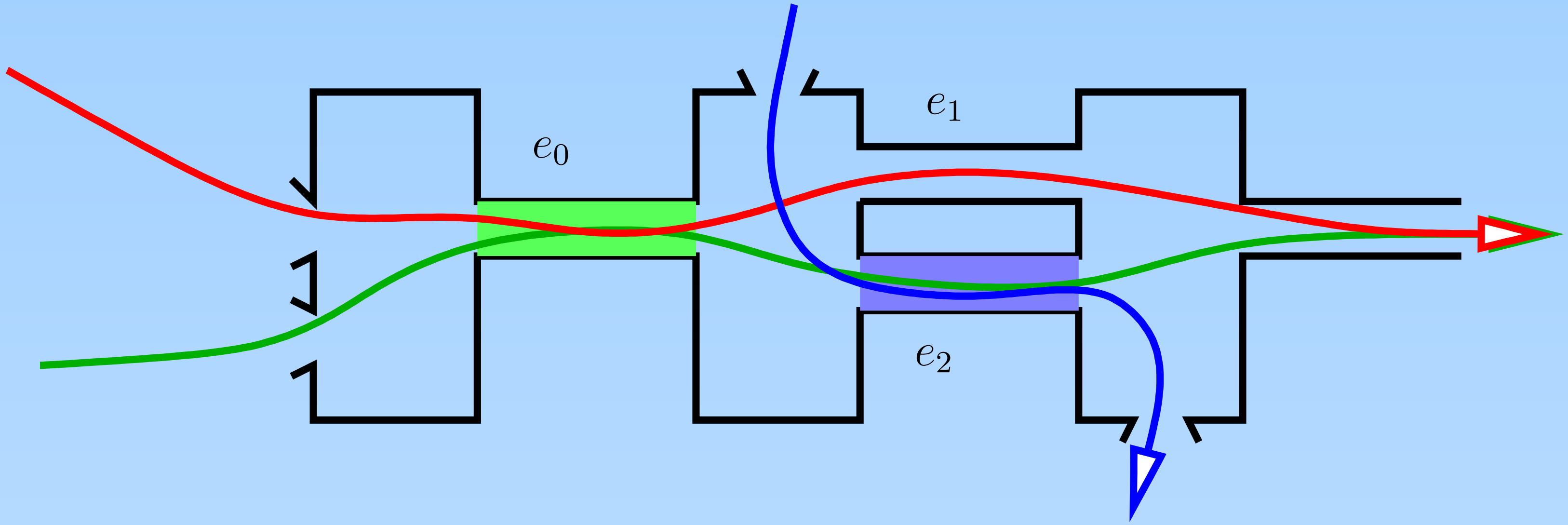

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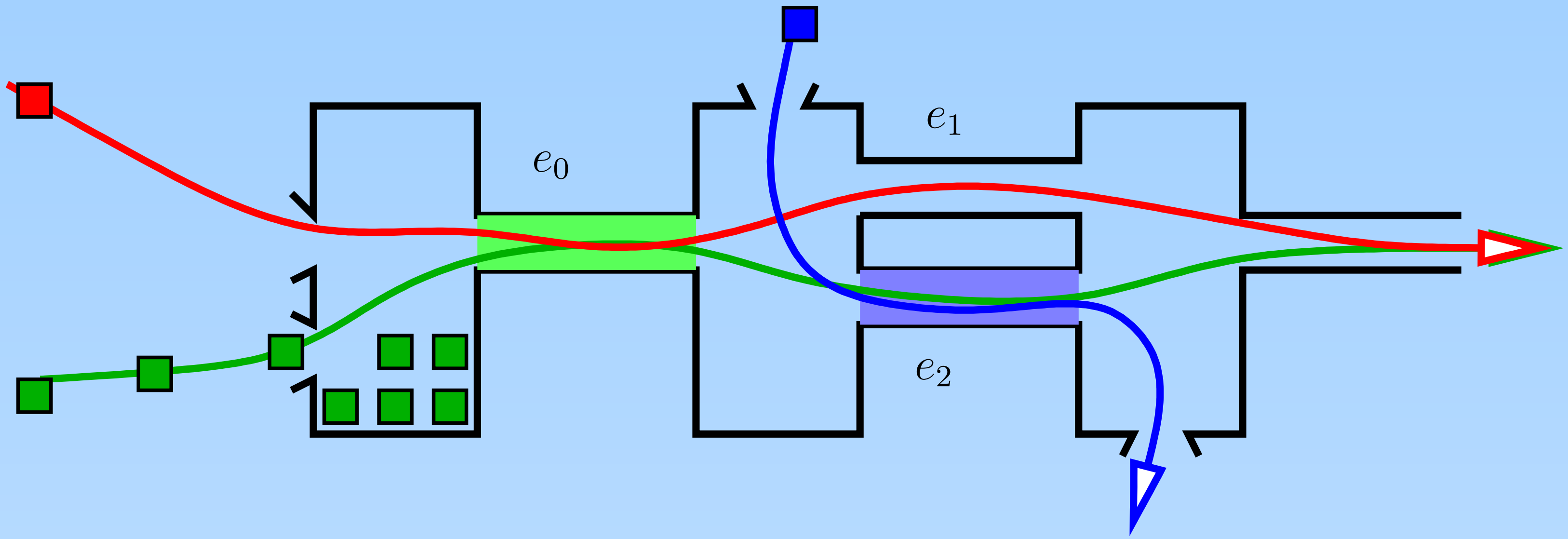
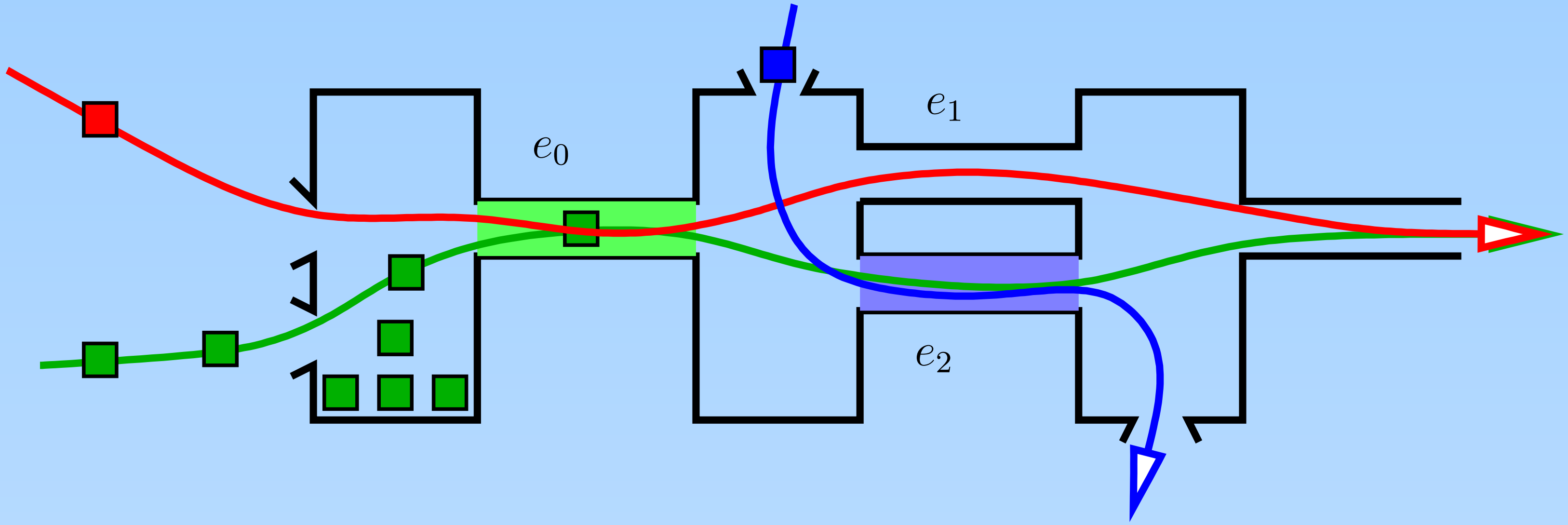


# Packets	
# green	s
# red	rs
# blue	rs

Piling up packets



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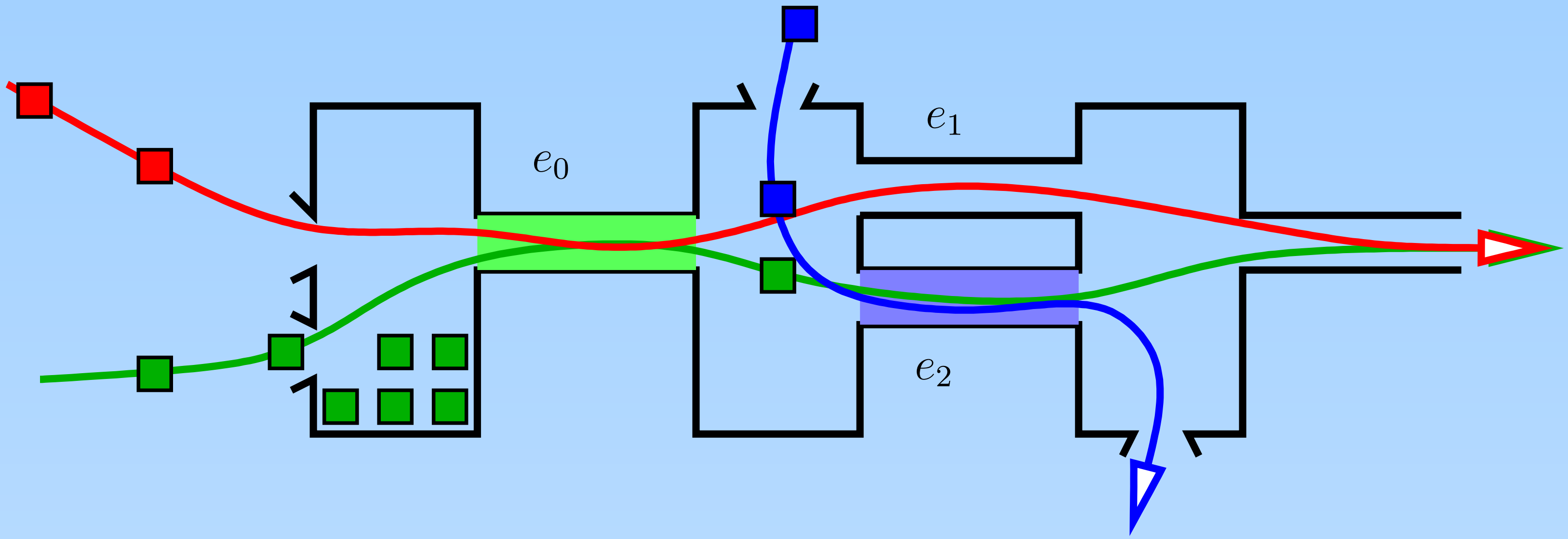

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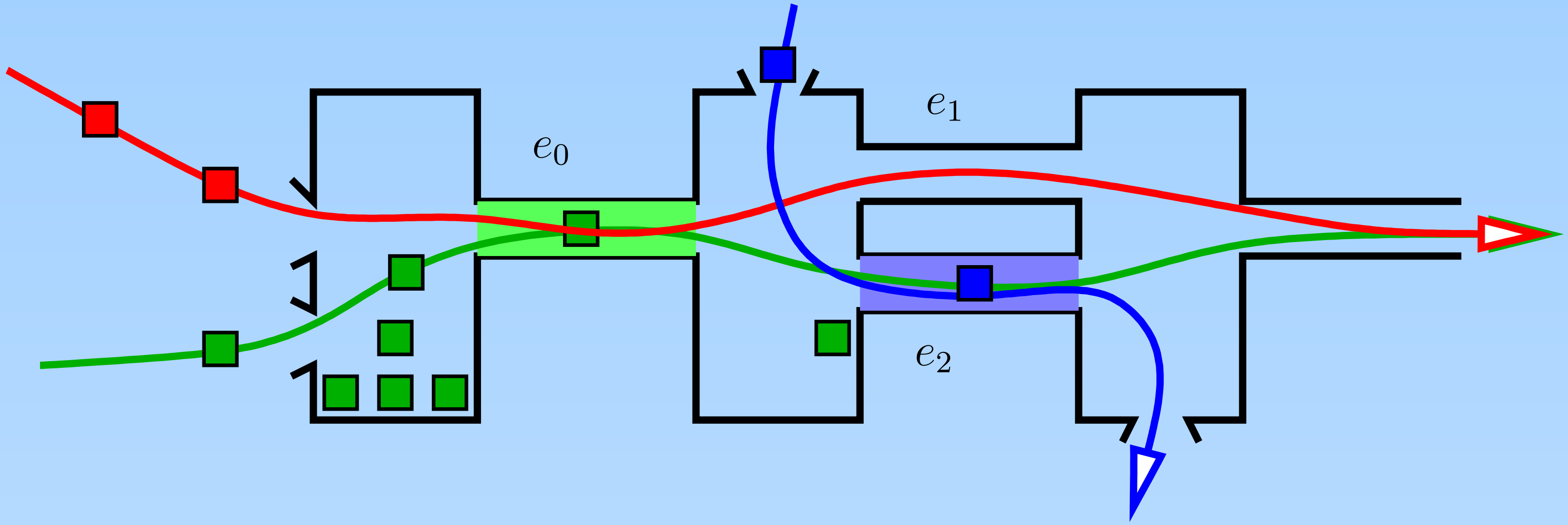

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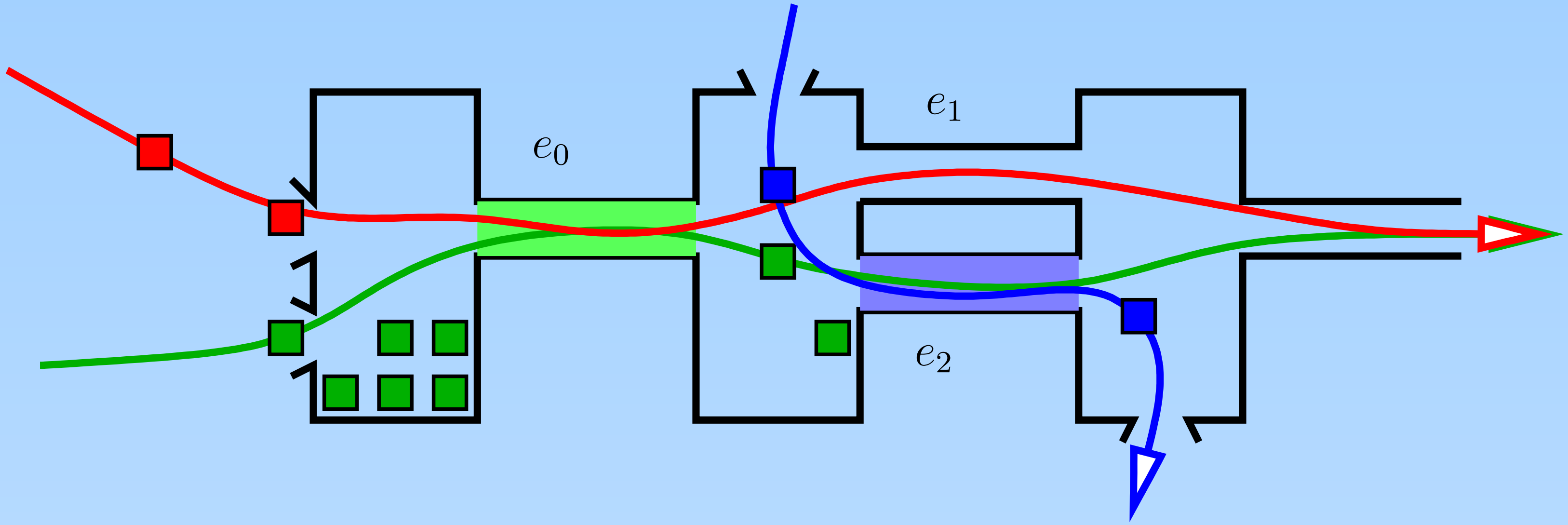

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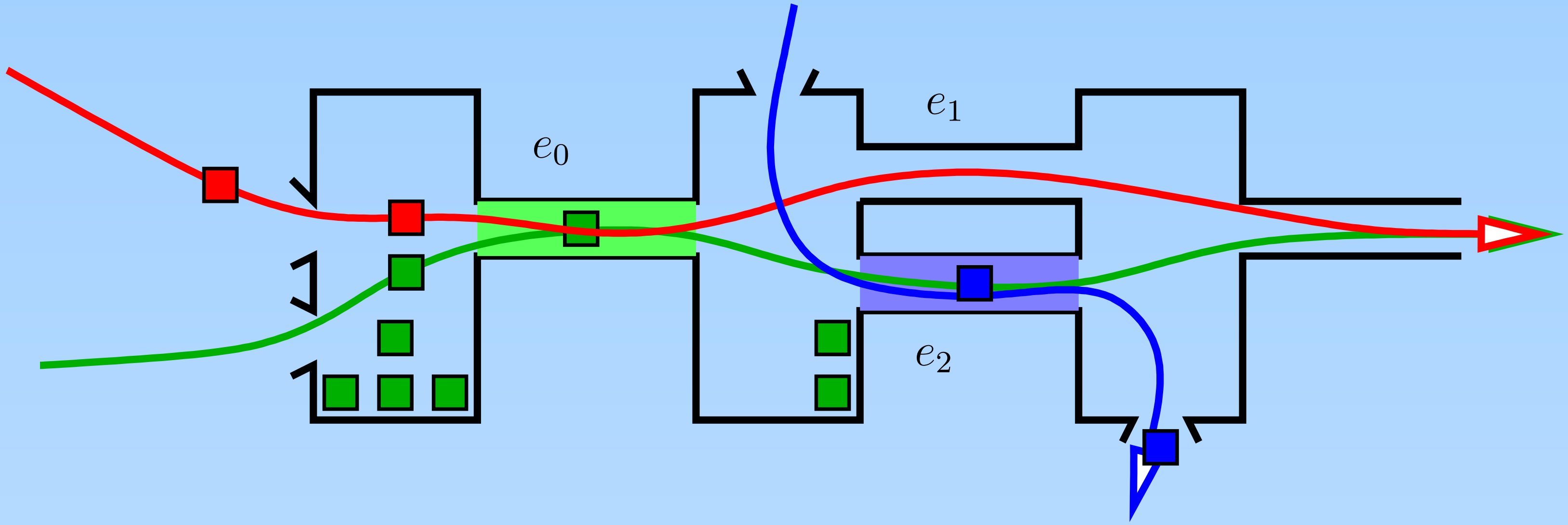
Piling up packets



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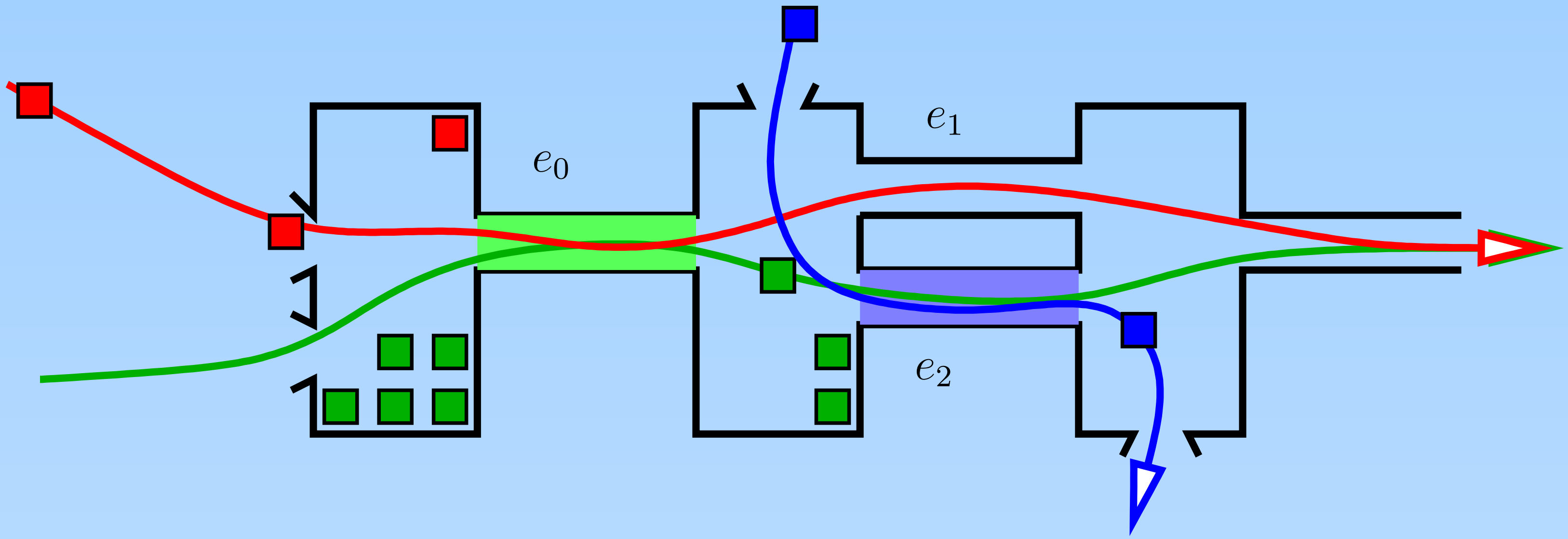

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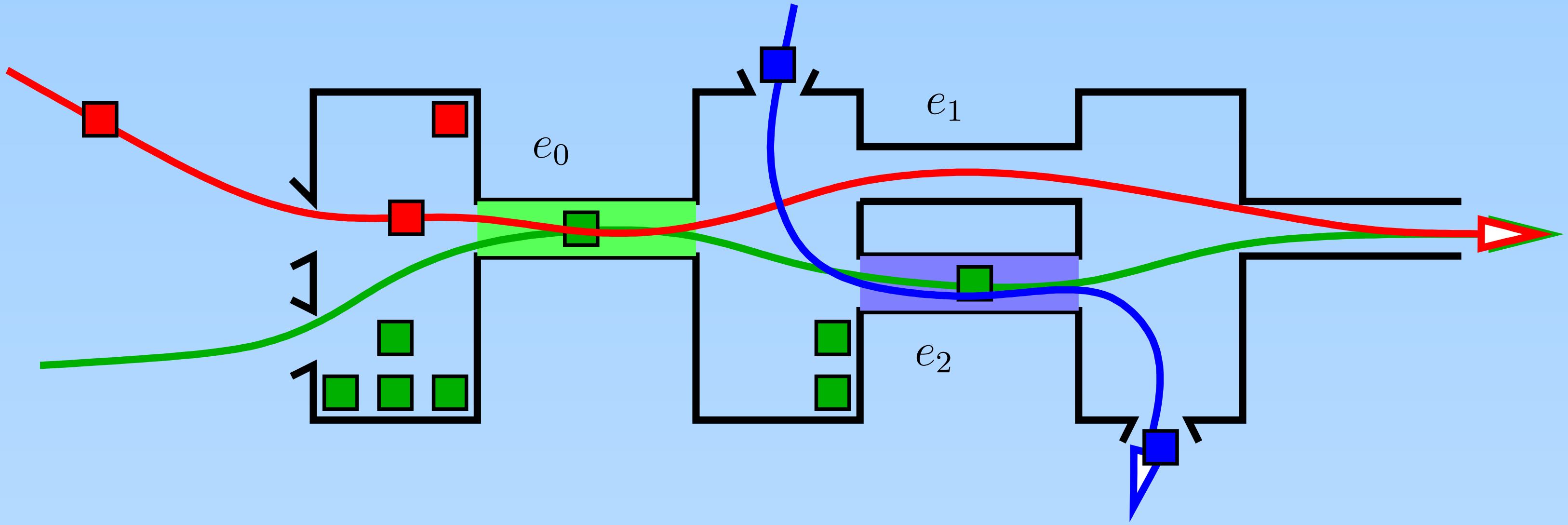

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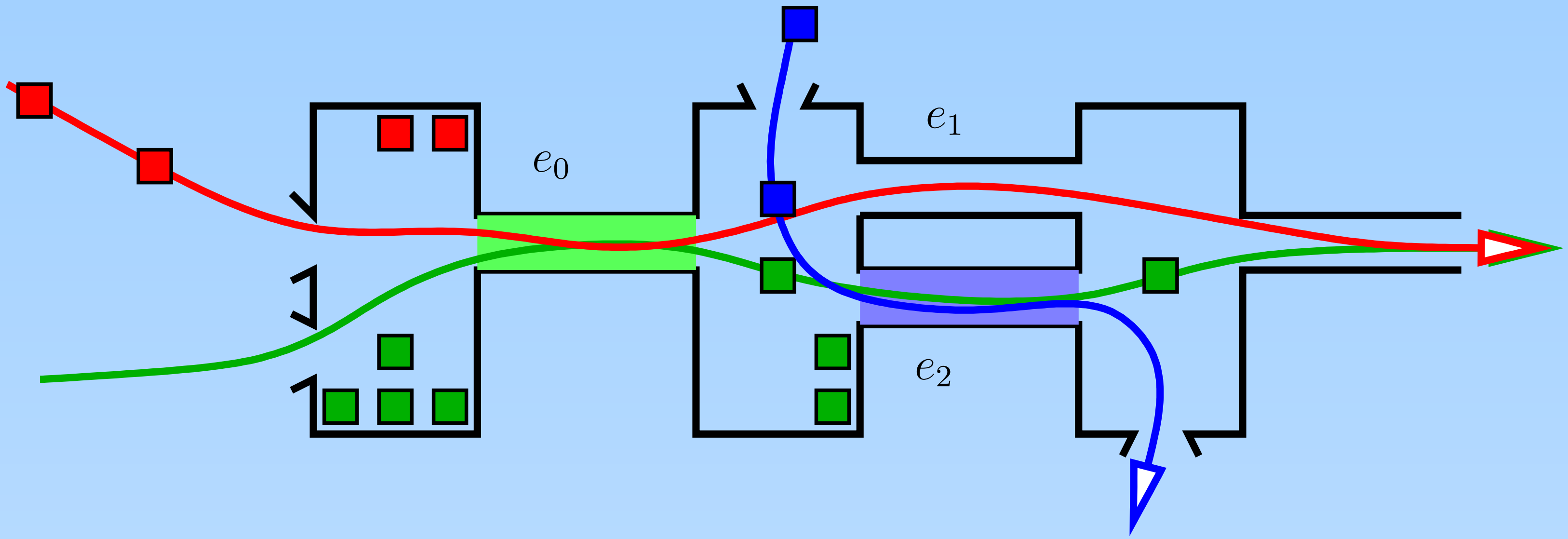

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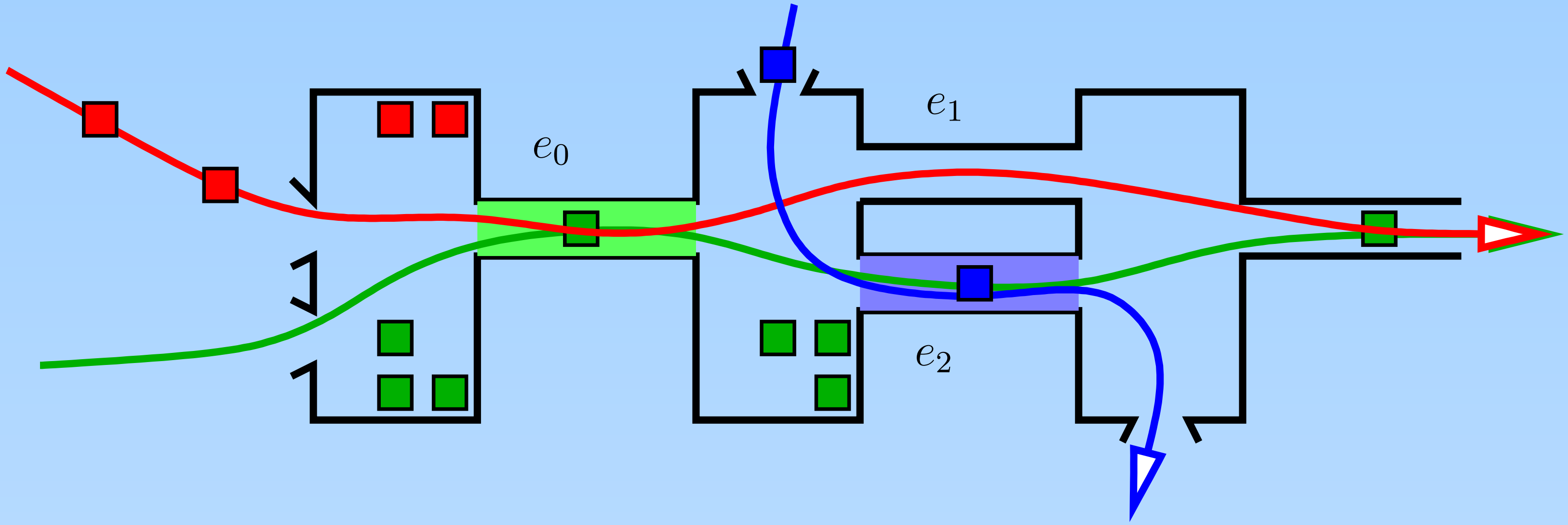

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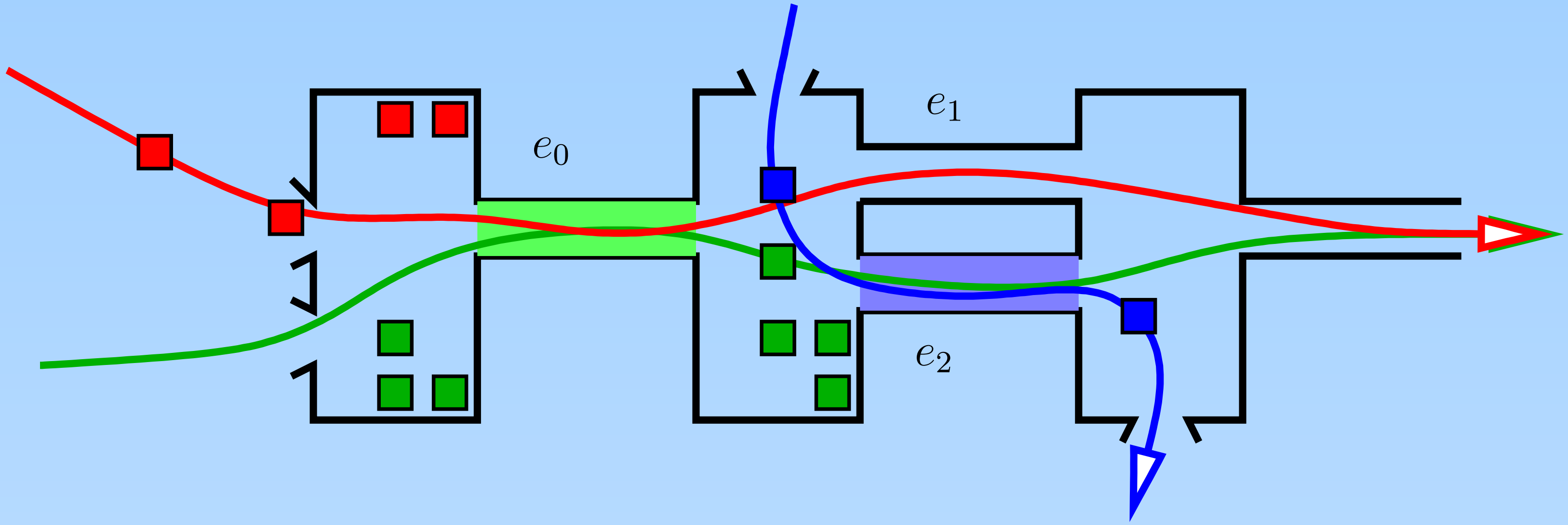
Piling up packets



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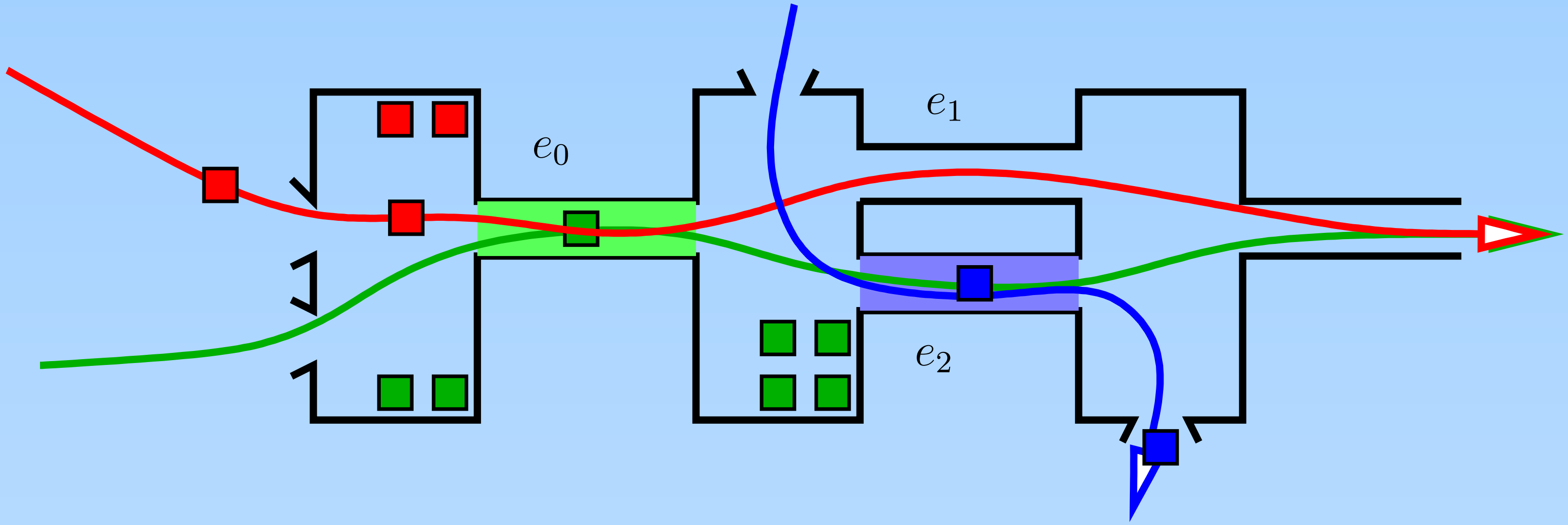

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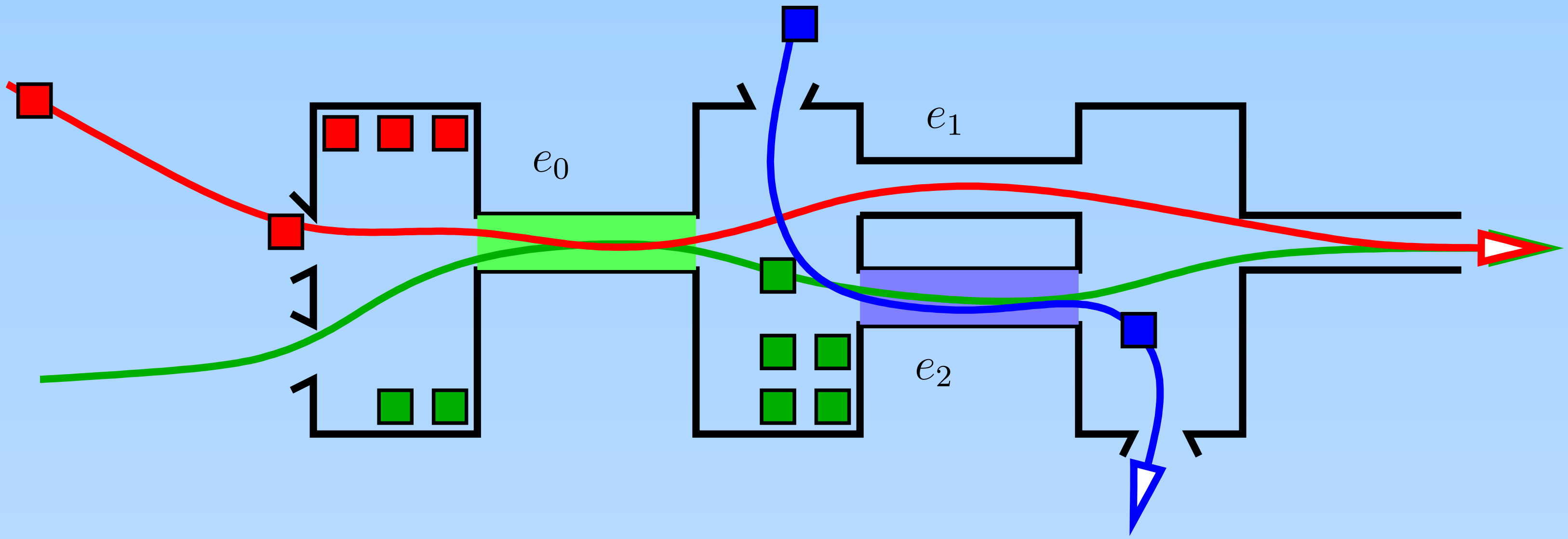
Piling up packets



# Packets	
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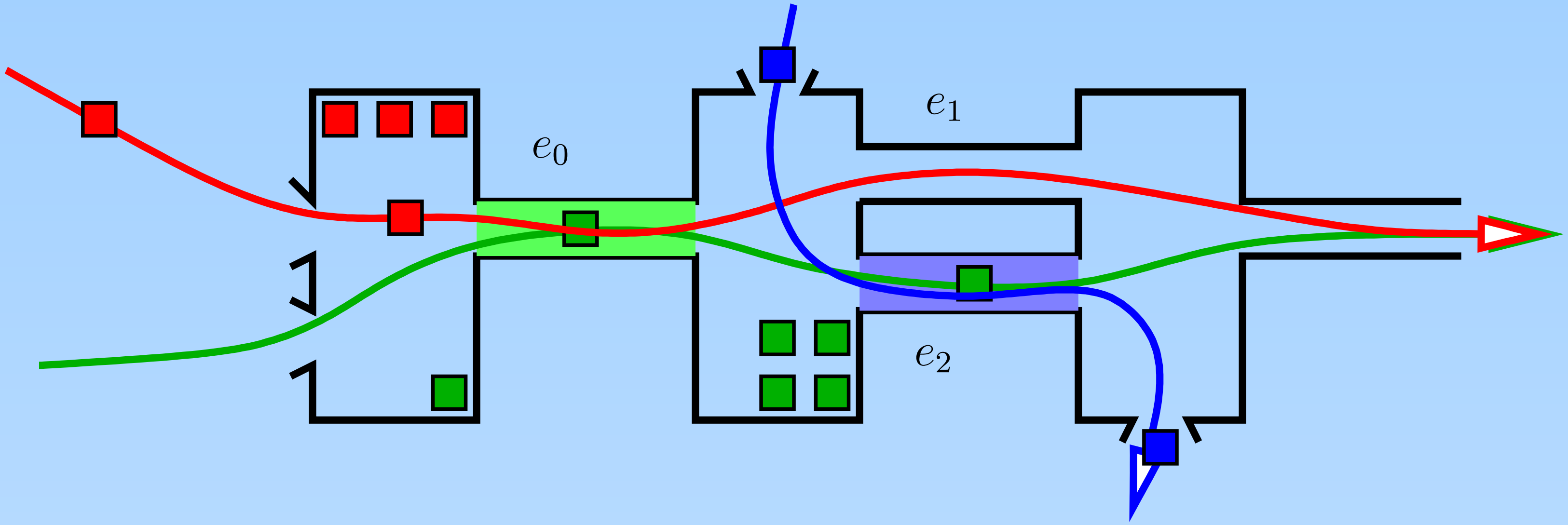
# red	rs
# blue	rs

No red packet traverses the system.

Piling up packets



# Packets	
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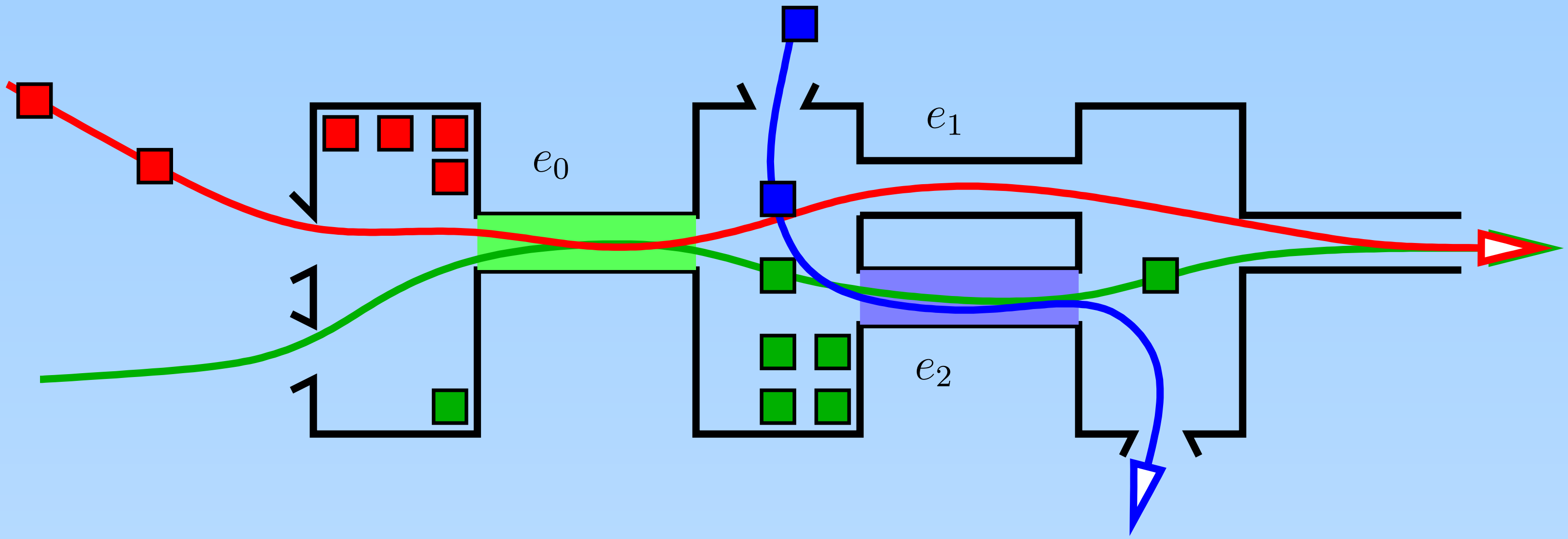
# red	rs
# blue	rs

No red packet traverses the system.
Only $(1 - r) \cdot s$ green packets slip through.

Piling up packets



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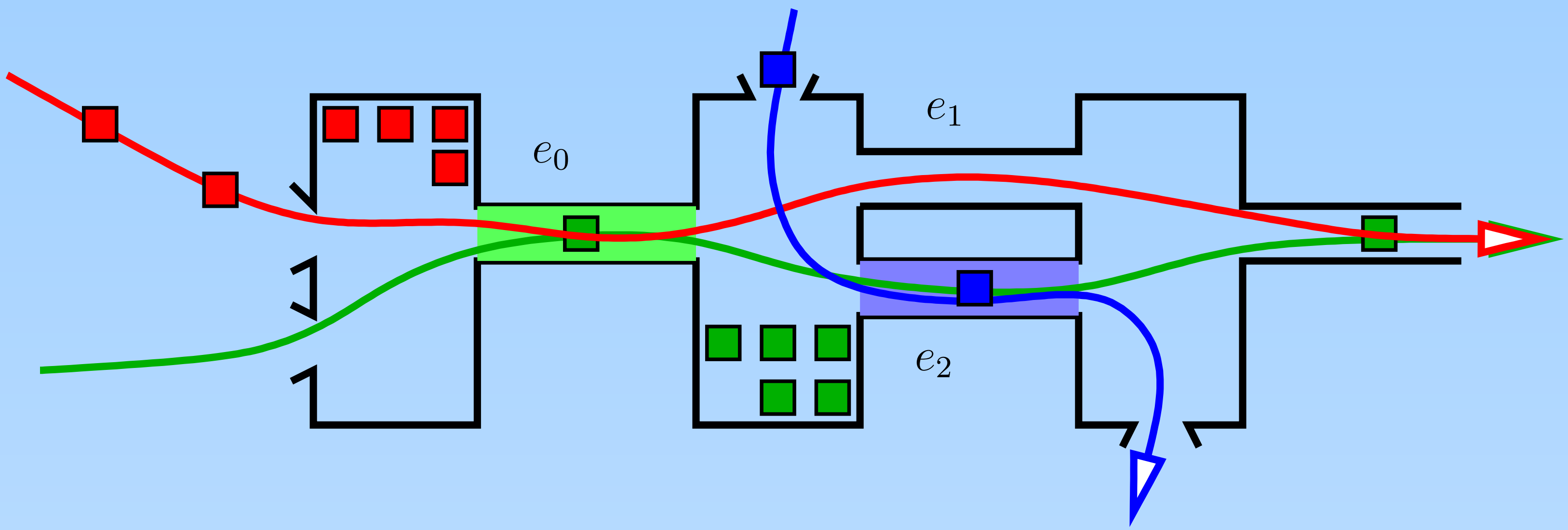

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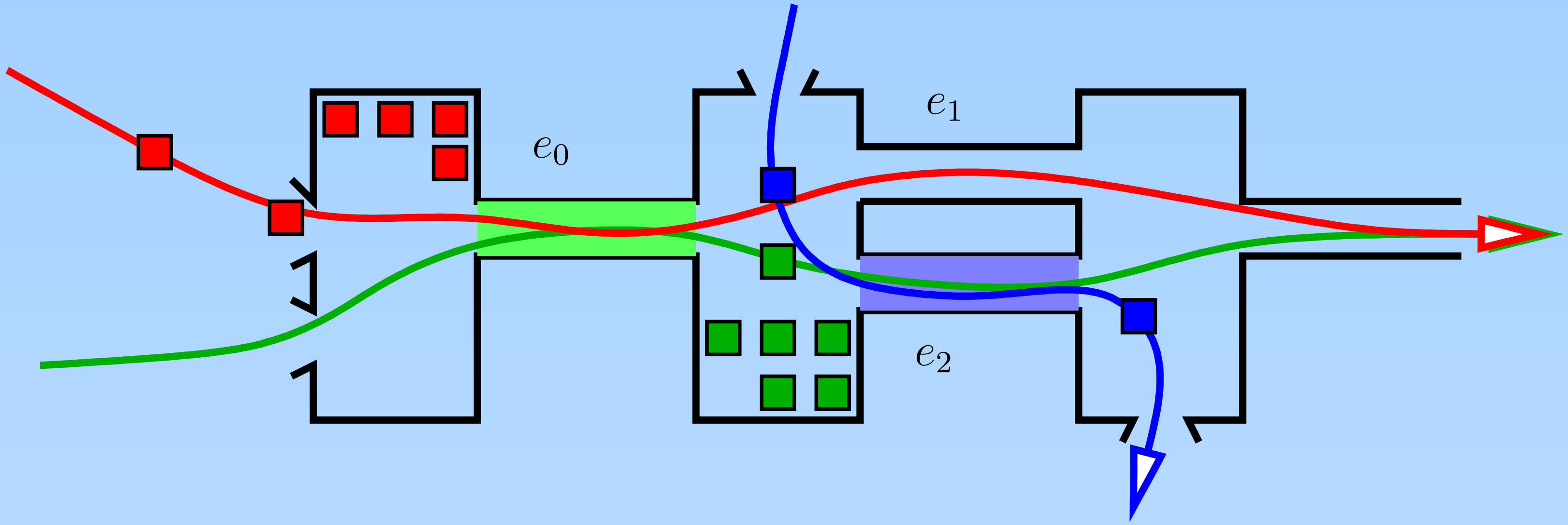

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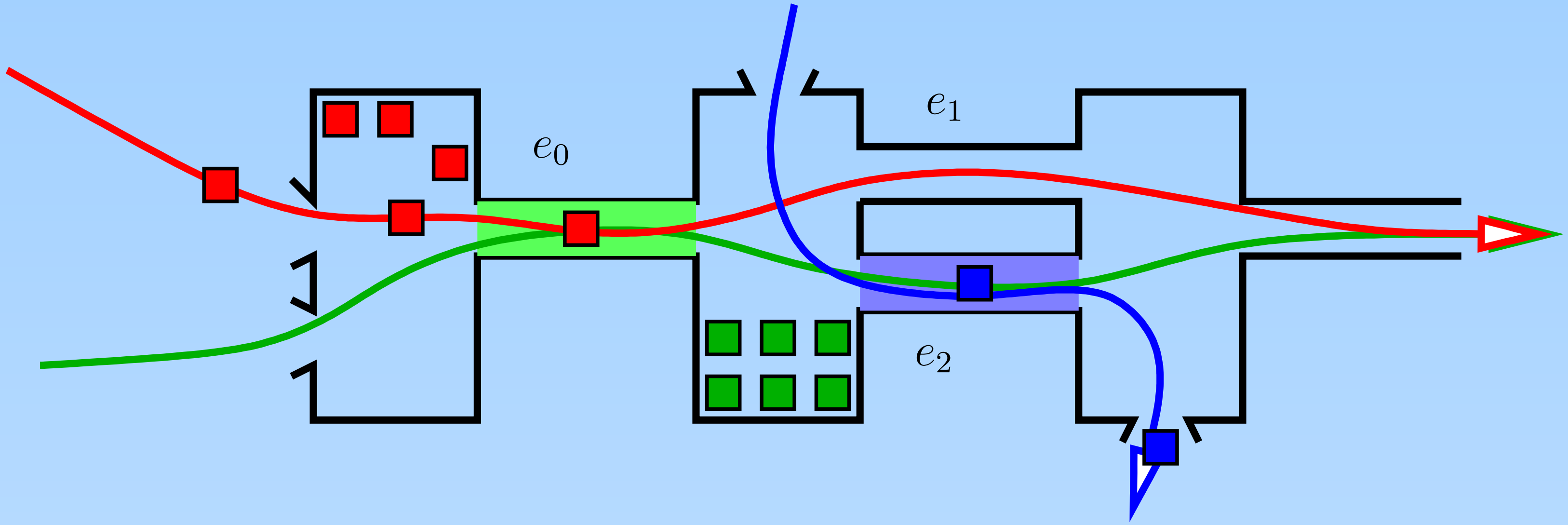

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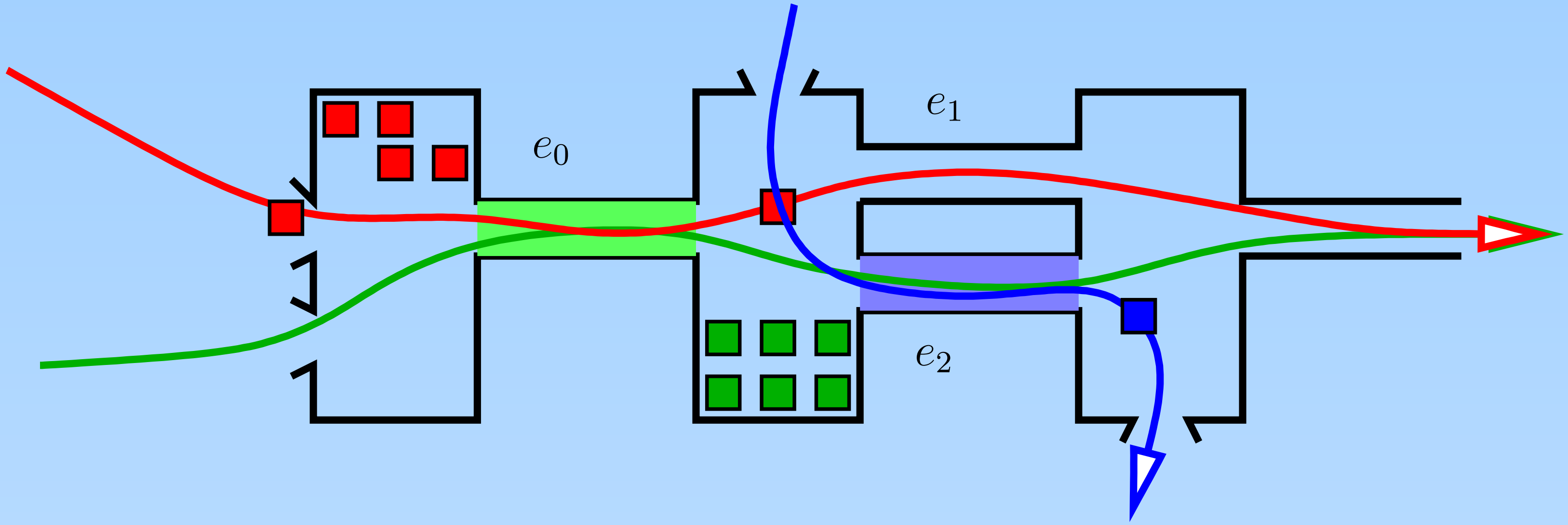

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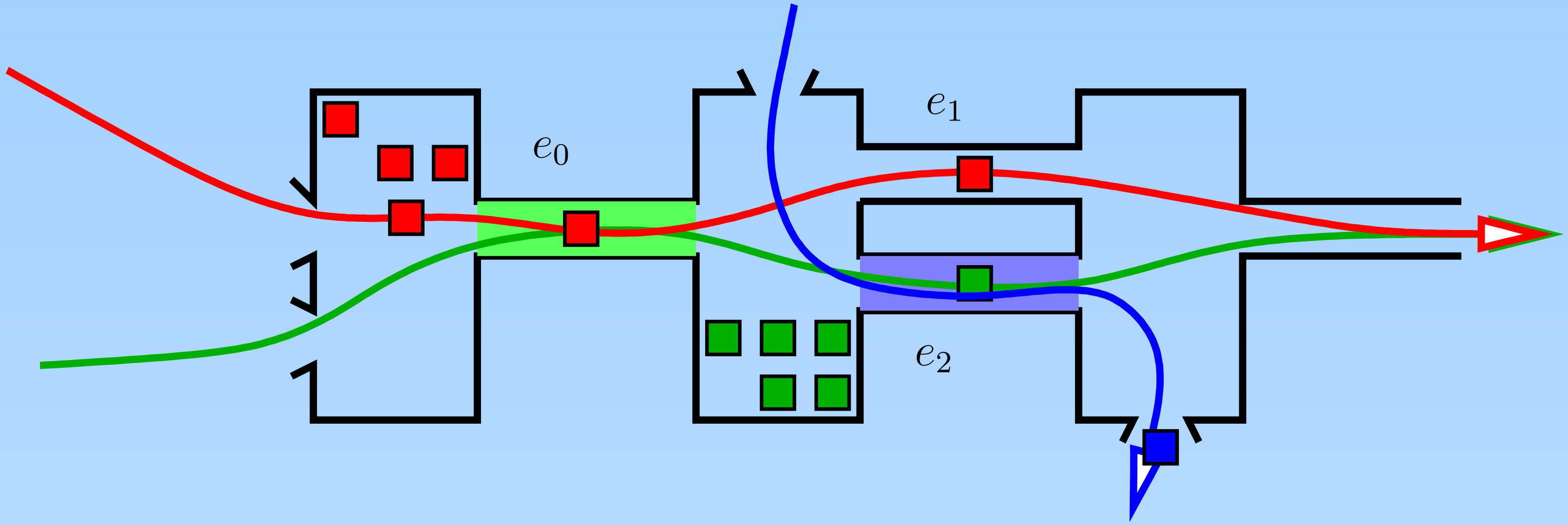

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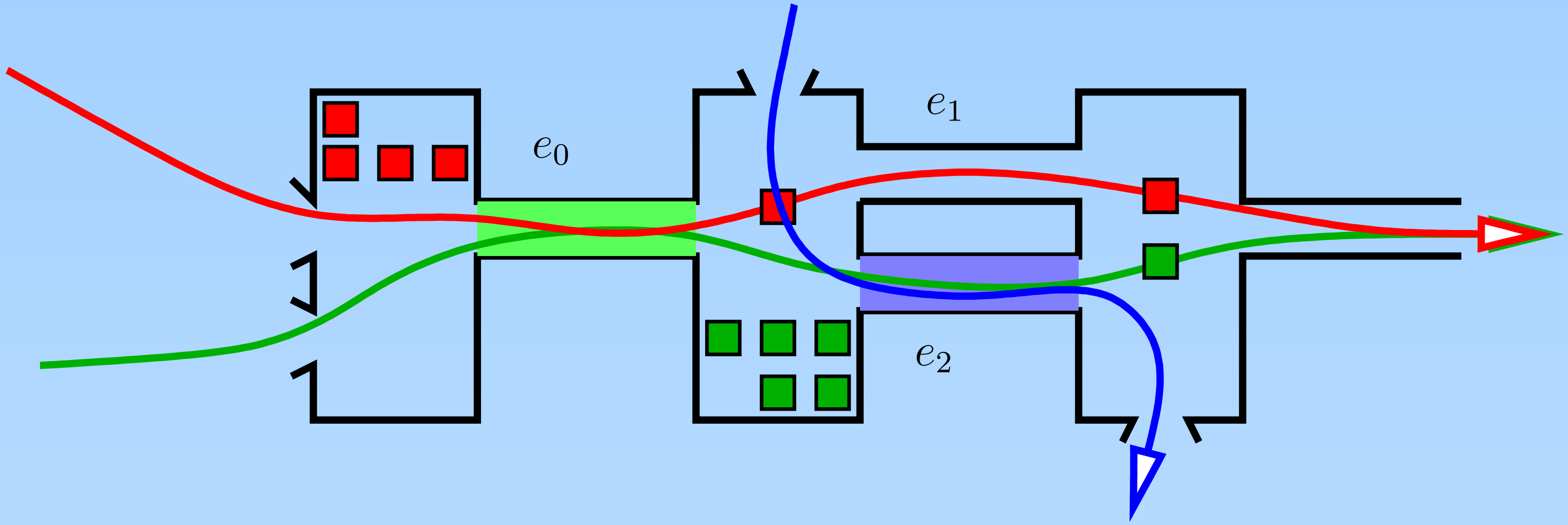
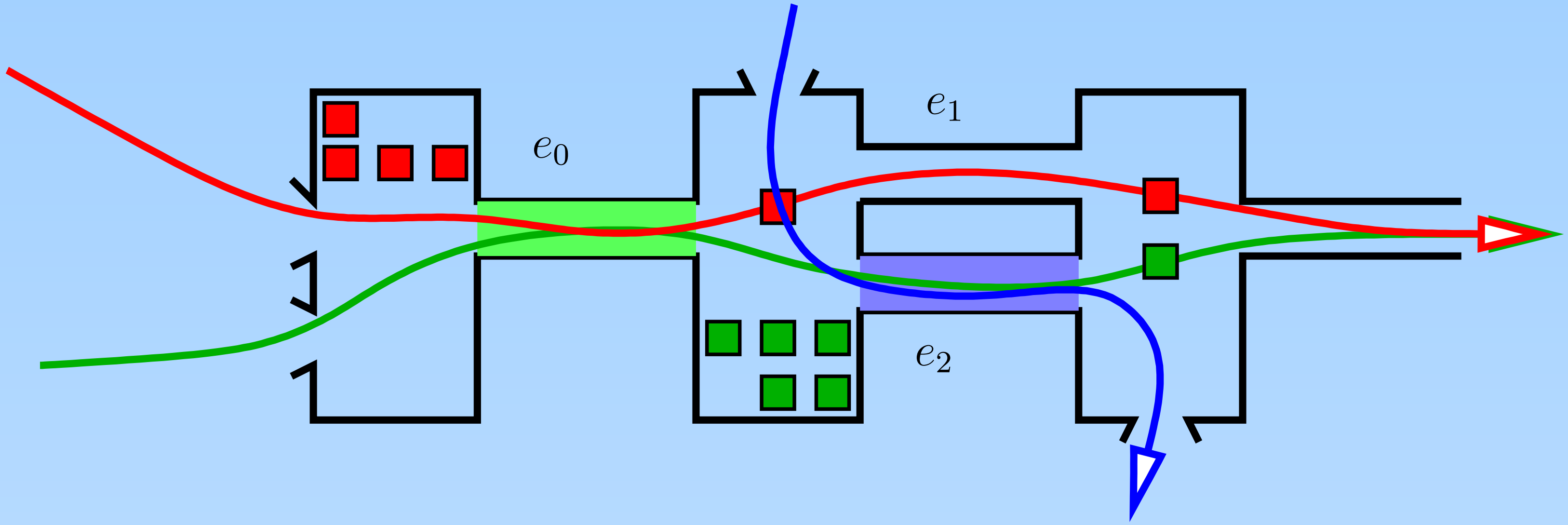


# Packets	
# green	s
# red	rs
# blue	rs

No red packet traverses the system.
Only $(1-r)\cdot s$ green packets slip through.
Remaining packets: $2r \cdot s$.

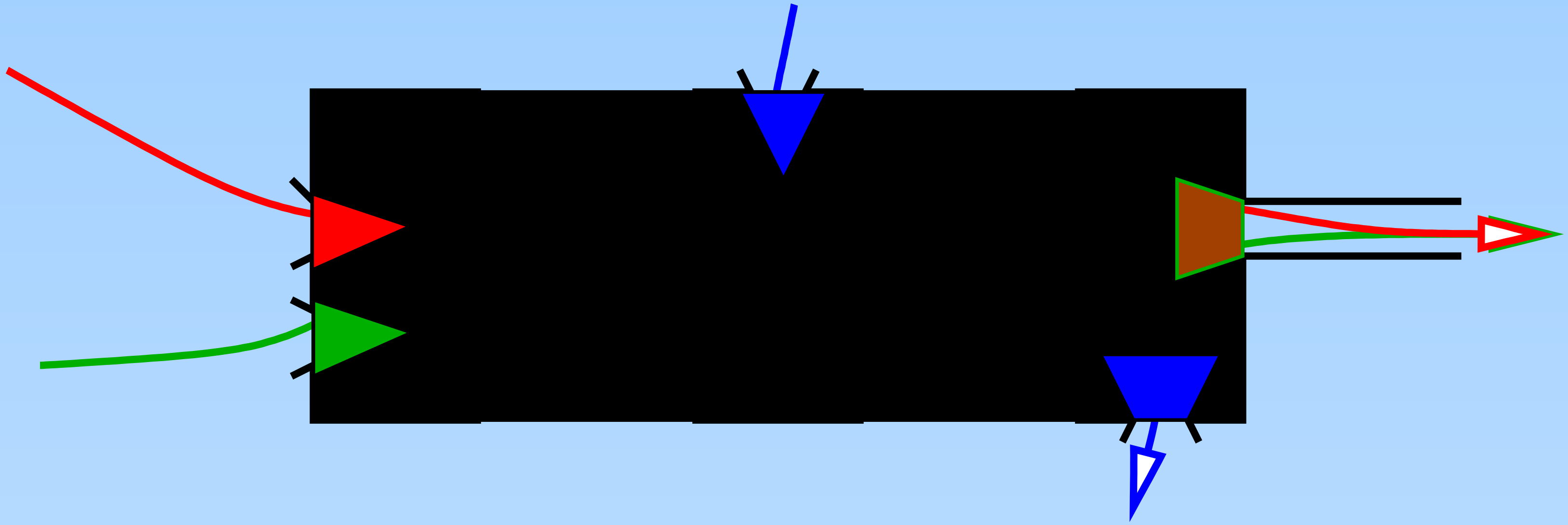
Piling up packets



# Packets	
# green	s
# red	rs
# blue	rs

No red packet traverses the system.
Only $(1-r)\cdot s$ green packets slip through.
Remaining packets: $2r\cdot s$.
For $r > \frac{1}{2}$ the set of packets grows by a multiplicative factor.

Piling up packets



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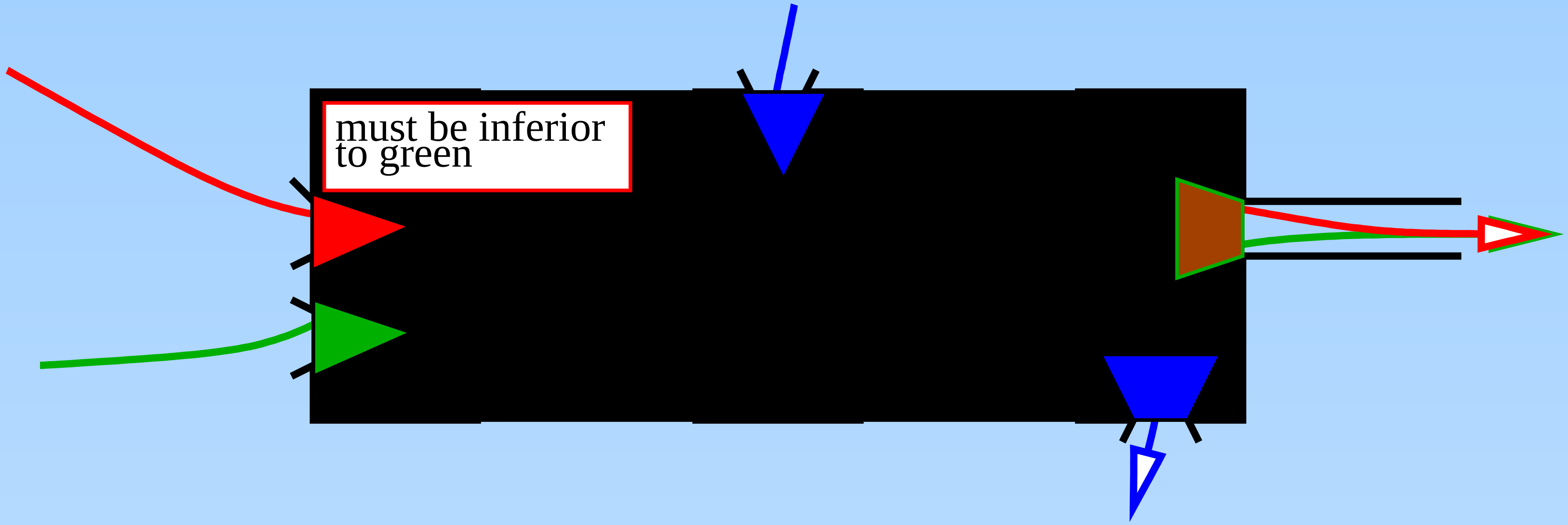

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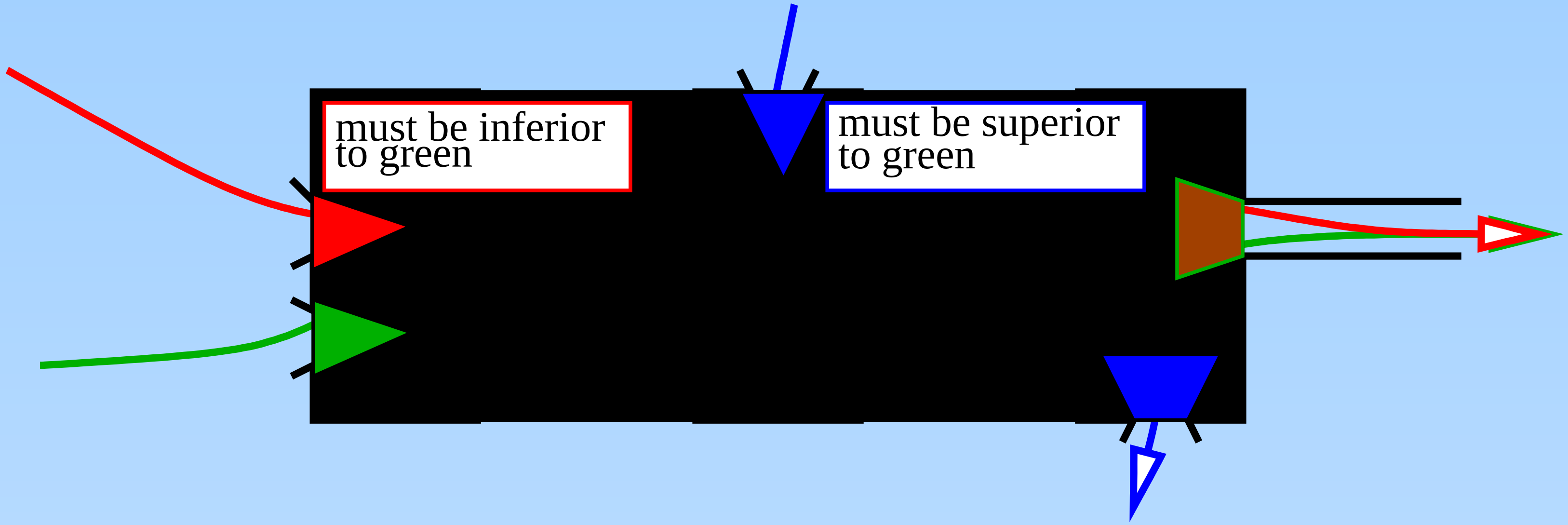

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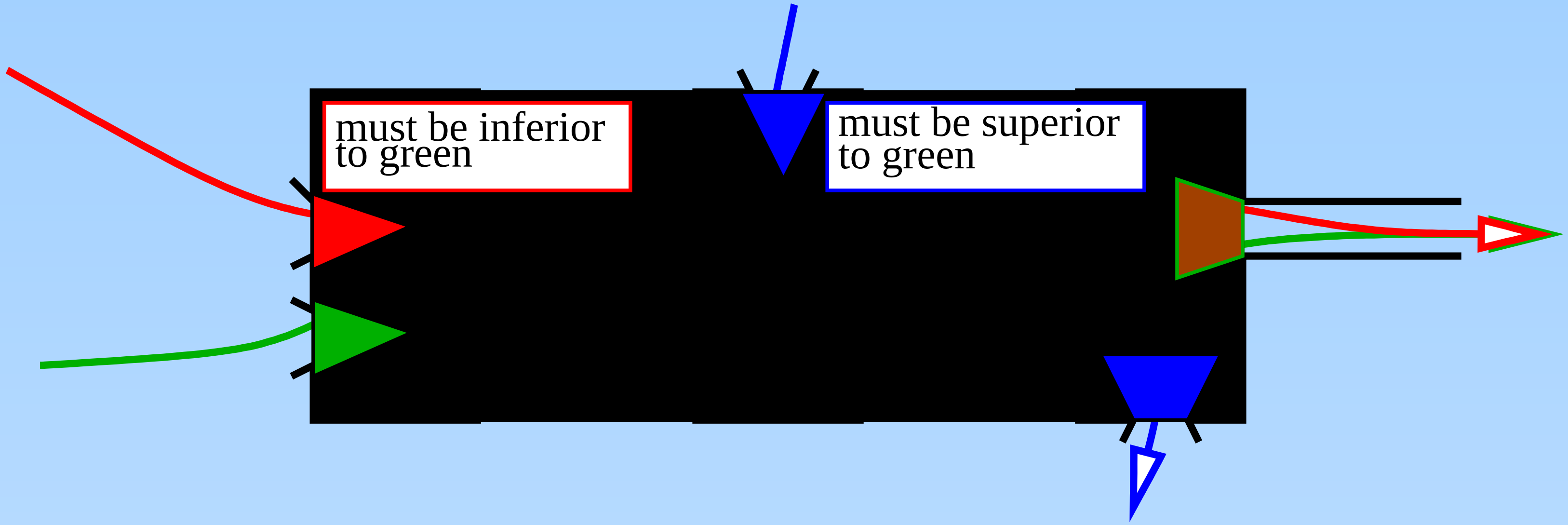

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Concatenating Gadgets

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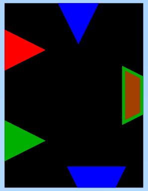

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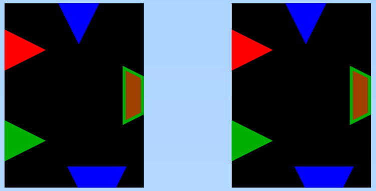
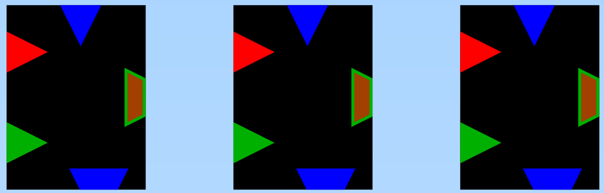


Concatenating Gadgets



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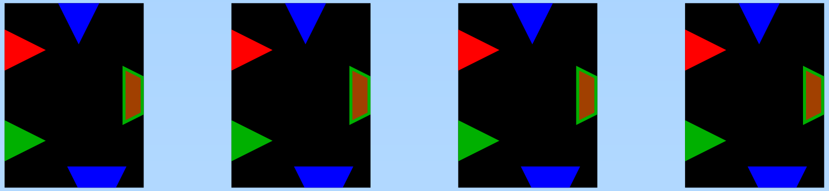
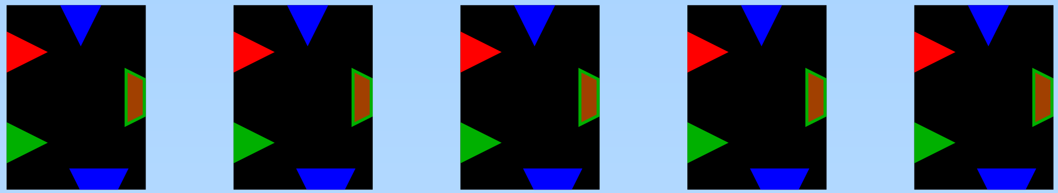
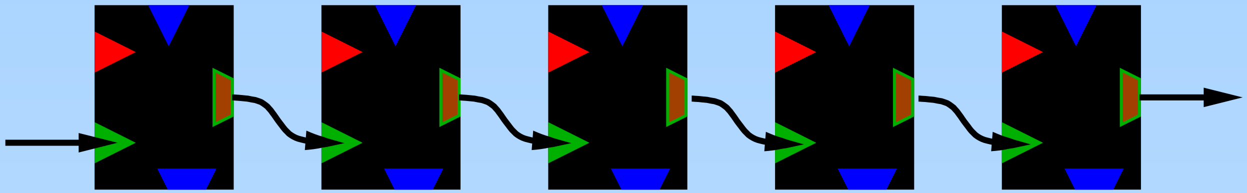


Concatenating Gadgets



Concatenating Gadgets



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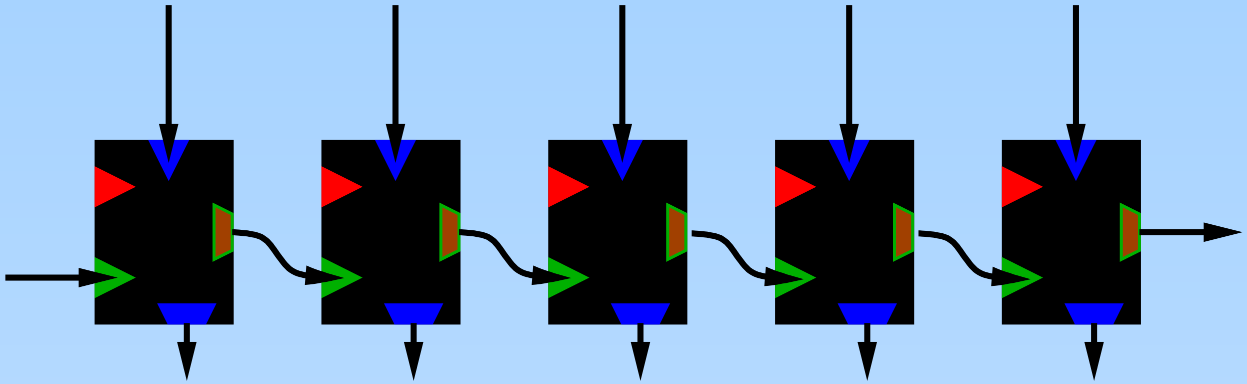
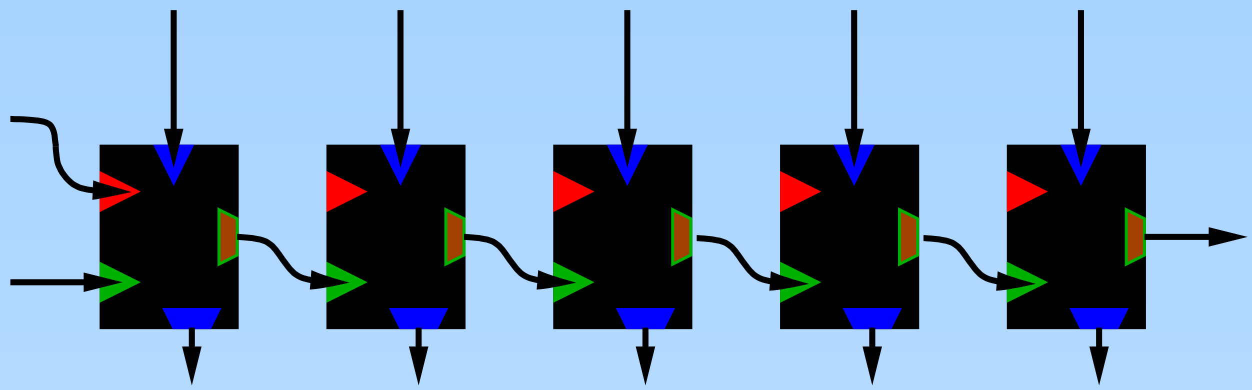


Concatenating Gadgets



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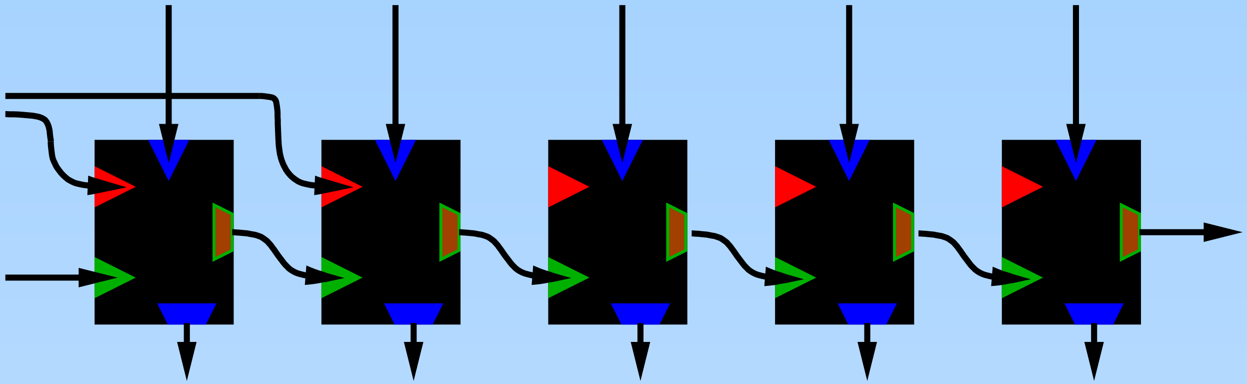

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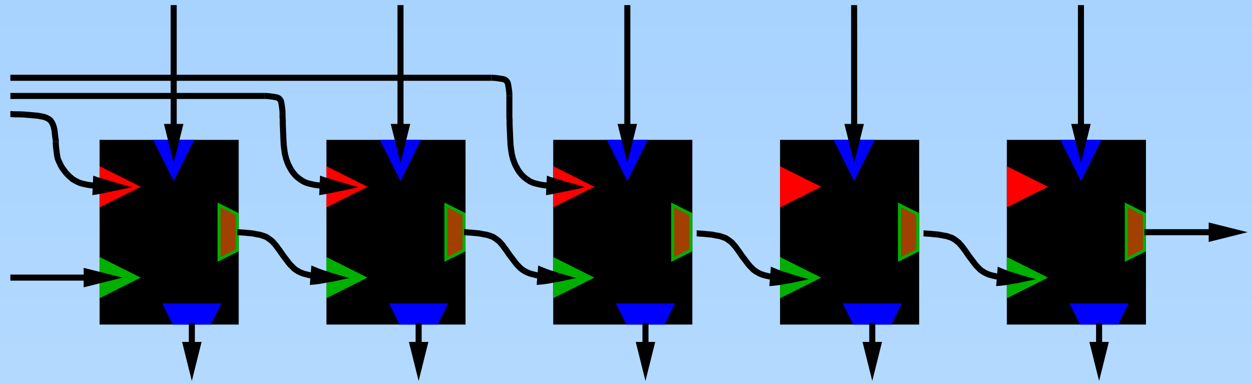

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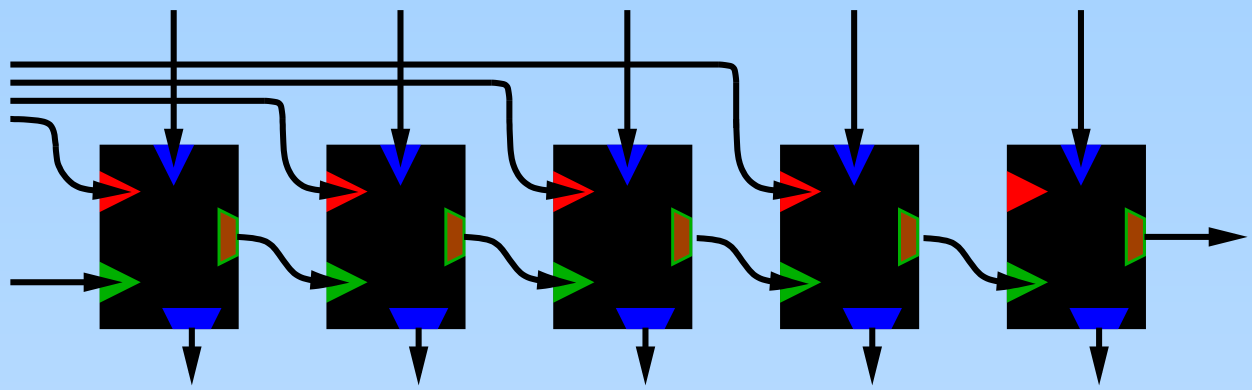

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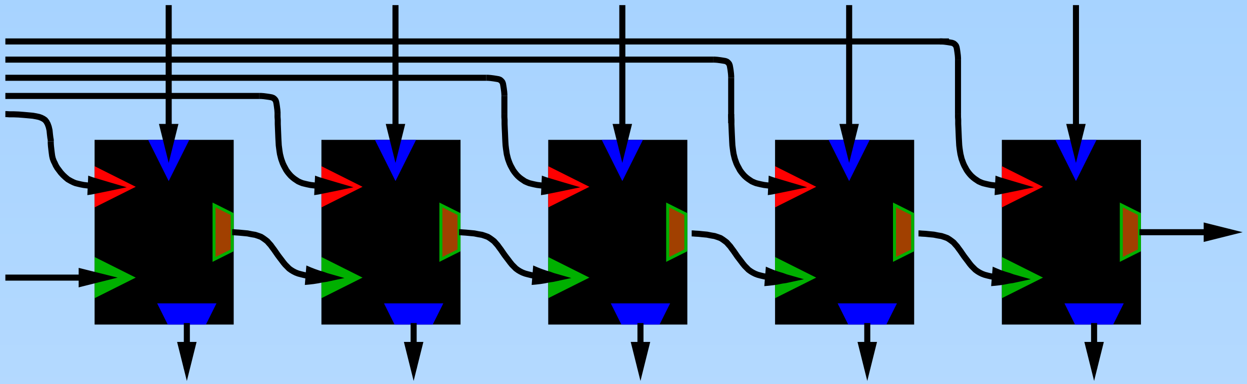

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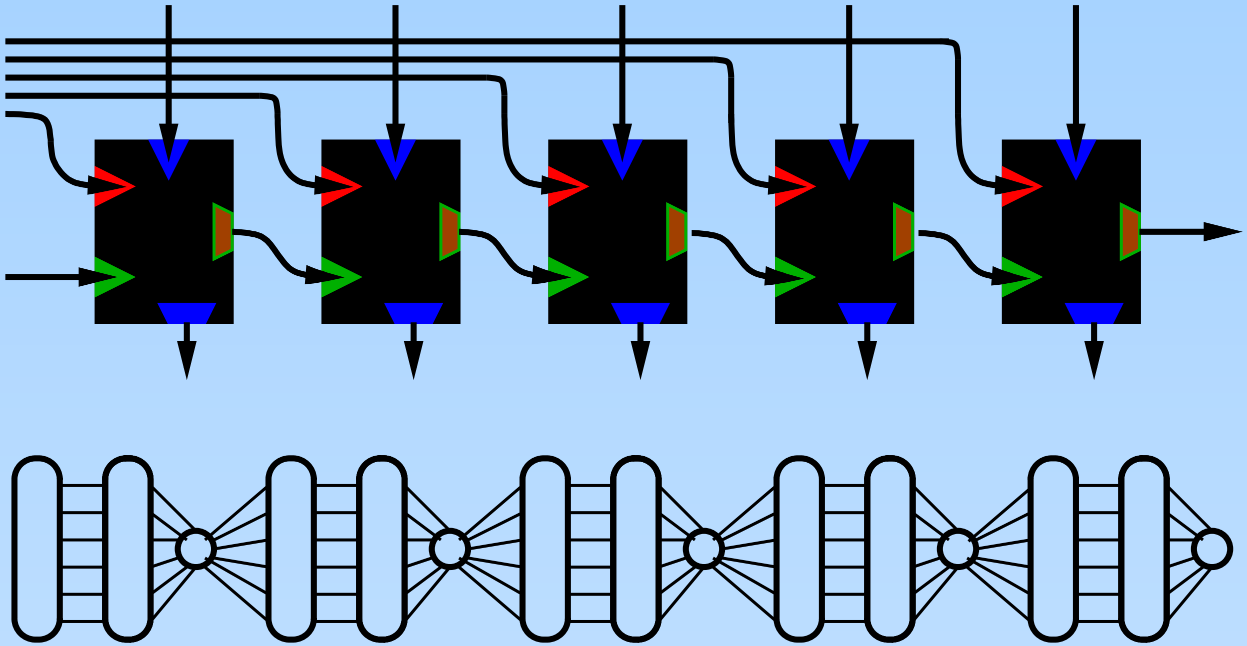

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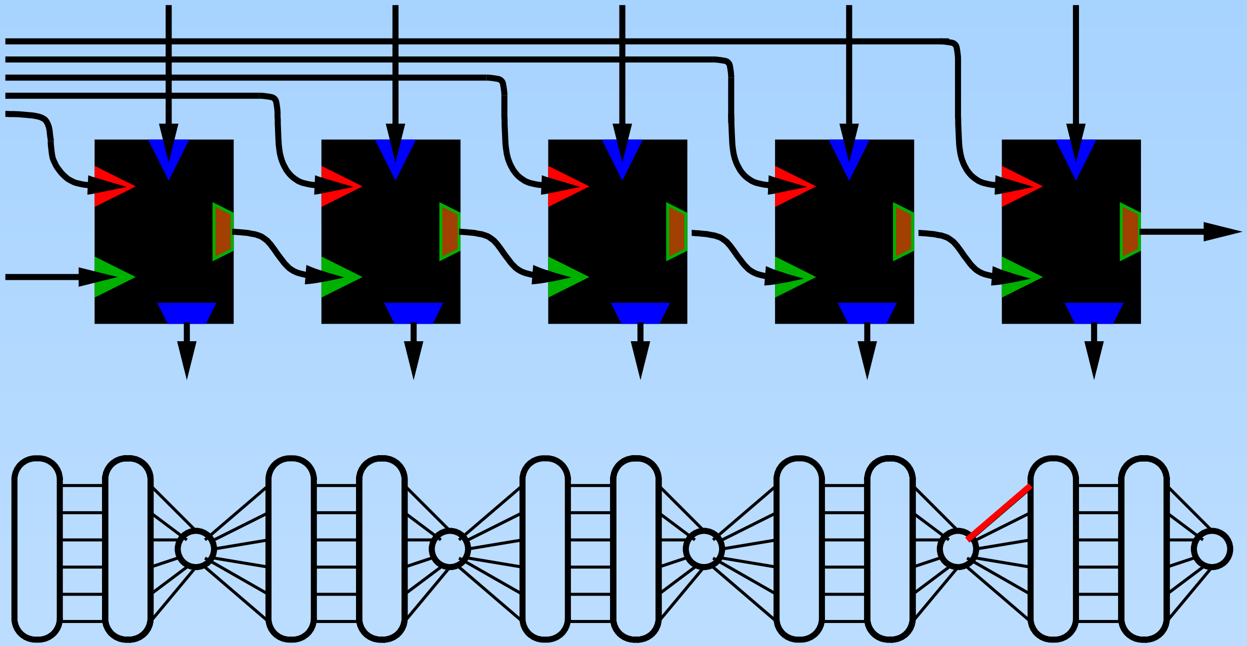

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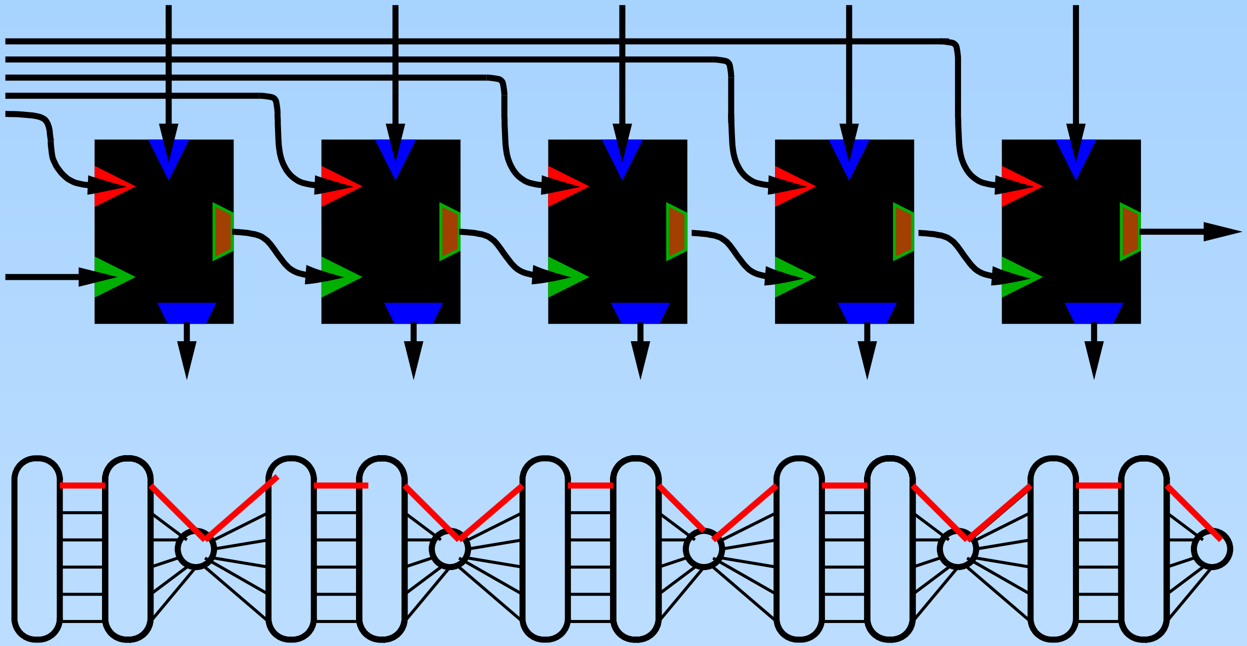

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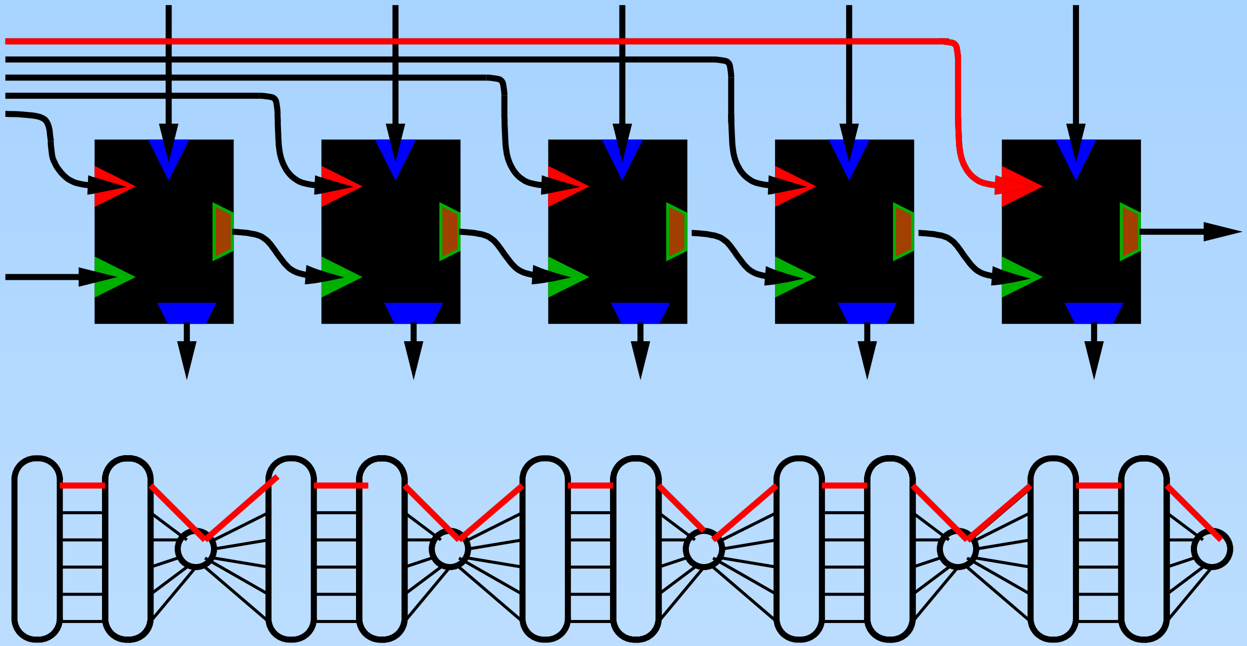

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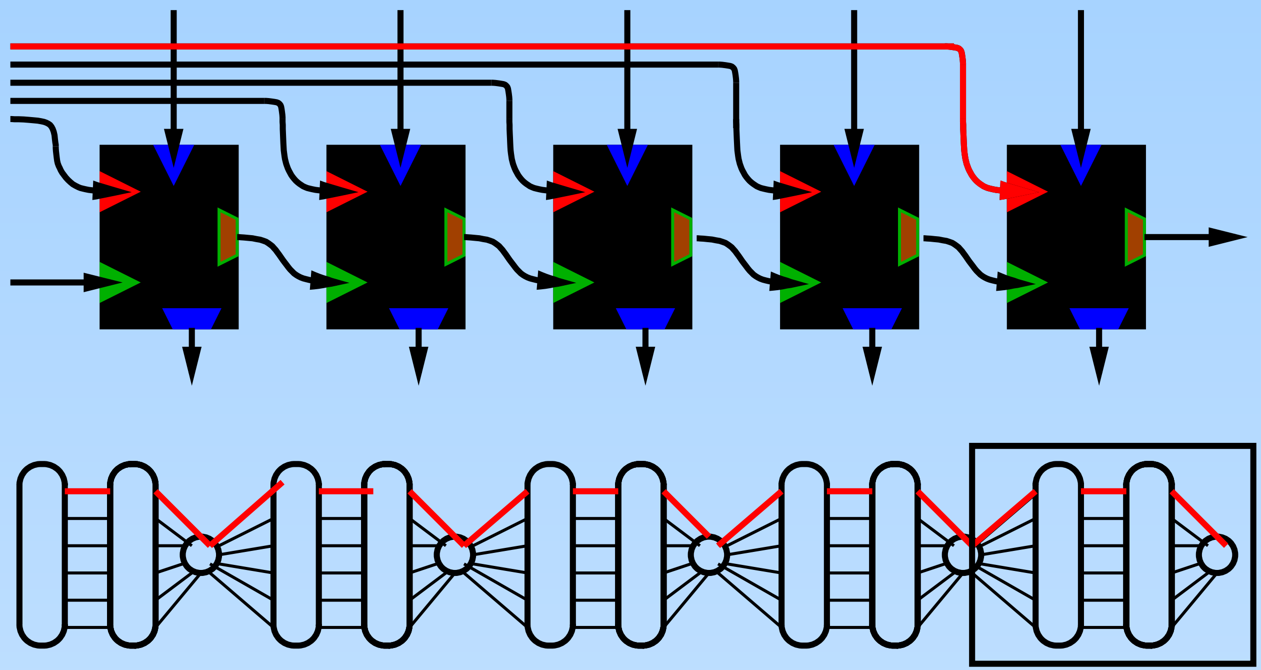

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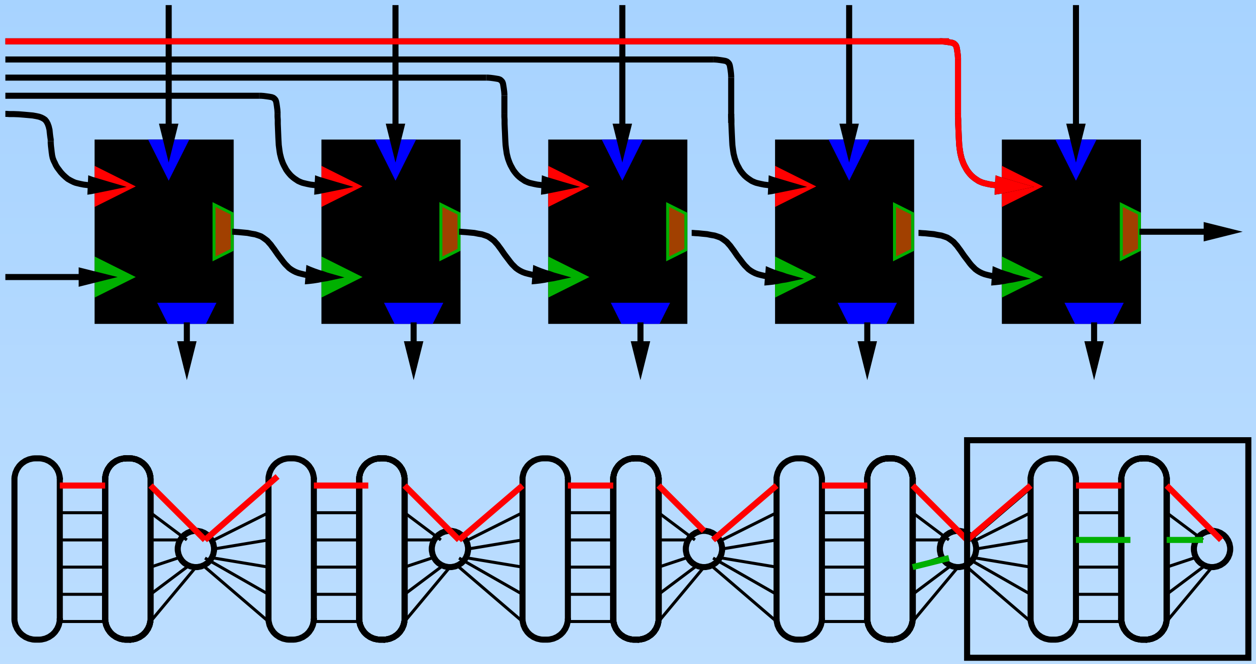

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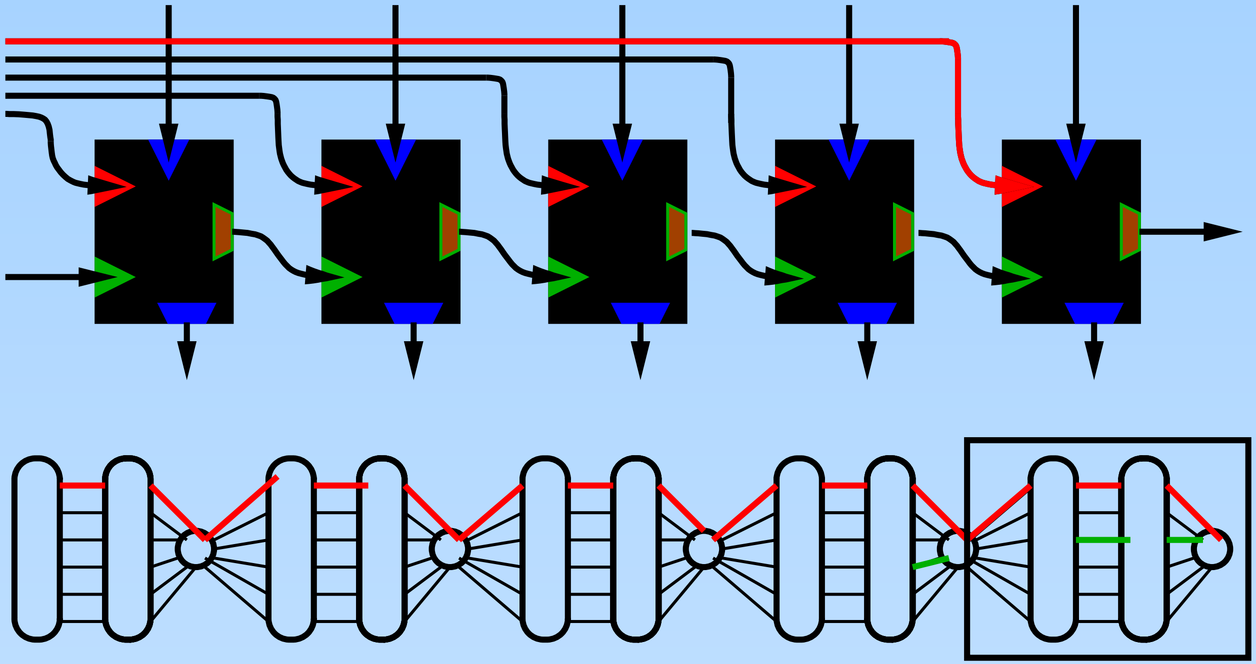

How can we get (blue) paths capable of blocking?

Idea: Improve Gadget

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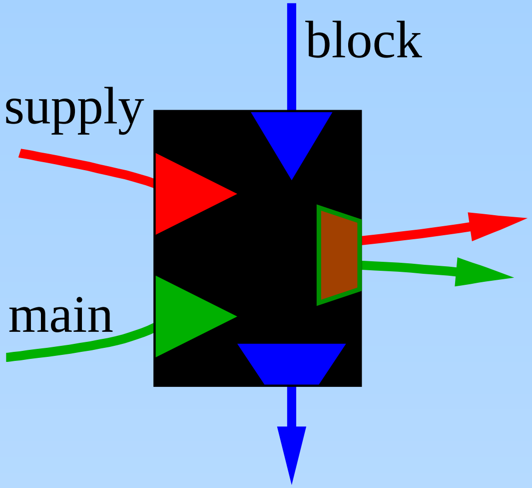
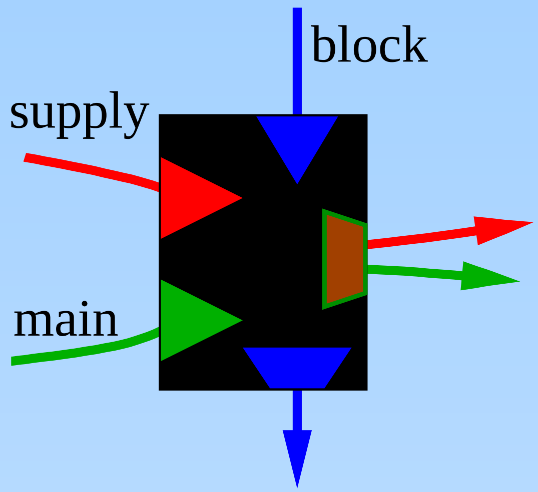
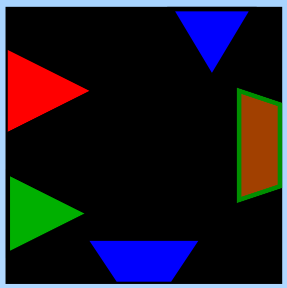


If green packets cannot be blocked by blue packets...

Idea: Improve Gadget

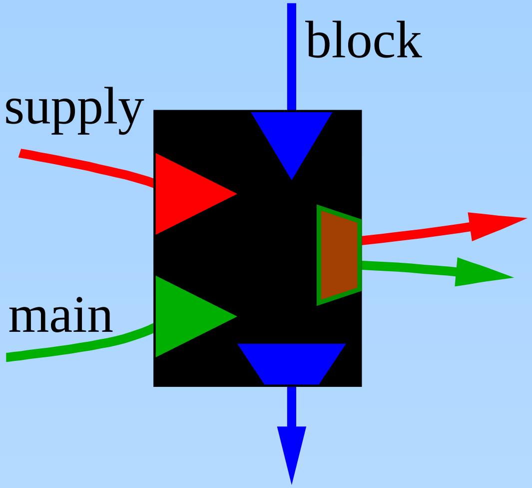


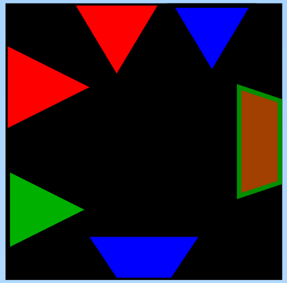


If green packets cannot be blocked by blue packets...

... then blue packets can be blocked by green packets.

Idea: Improve Gadget





If green packets cannot be blocked by blue packets...

... then blue packets can be blocked by green packets.

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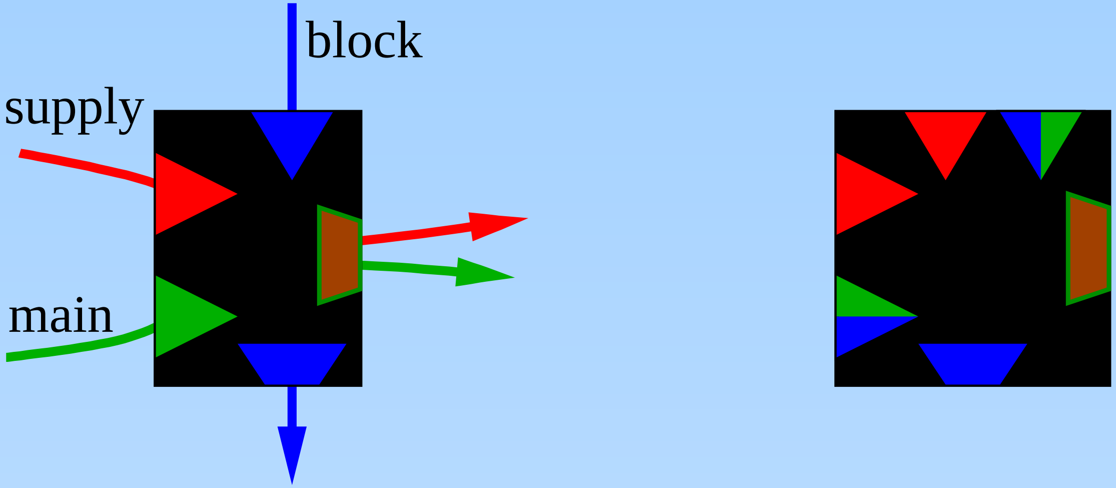

If green packets cannot be blocked by blue packets...

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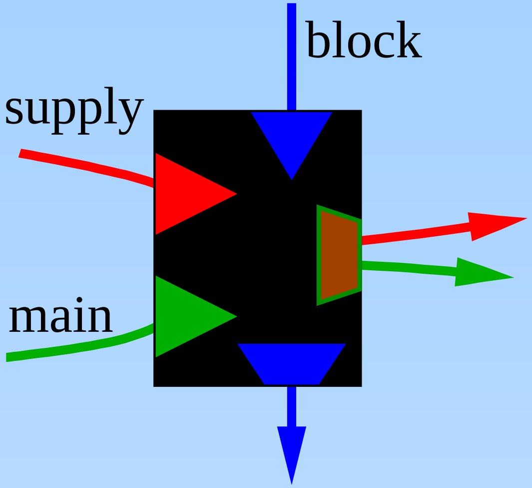
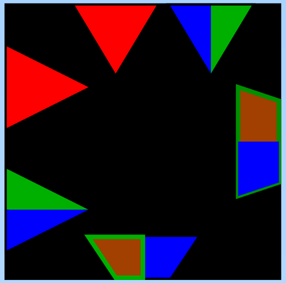
Idea: Improve Gadget





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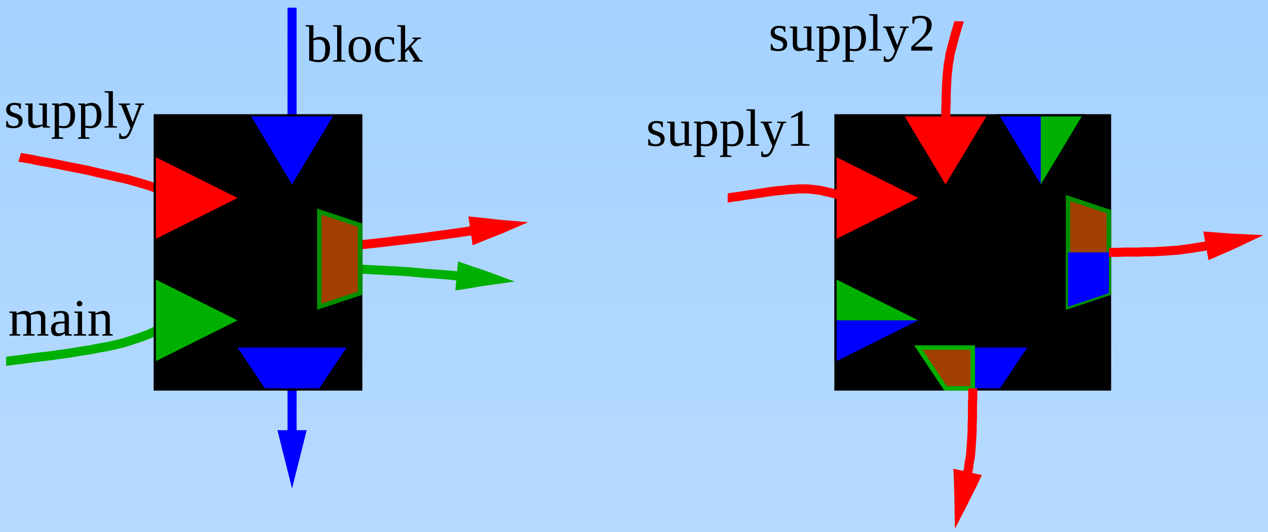

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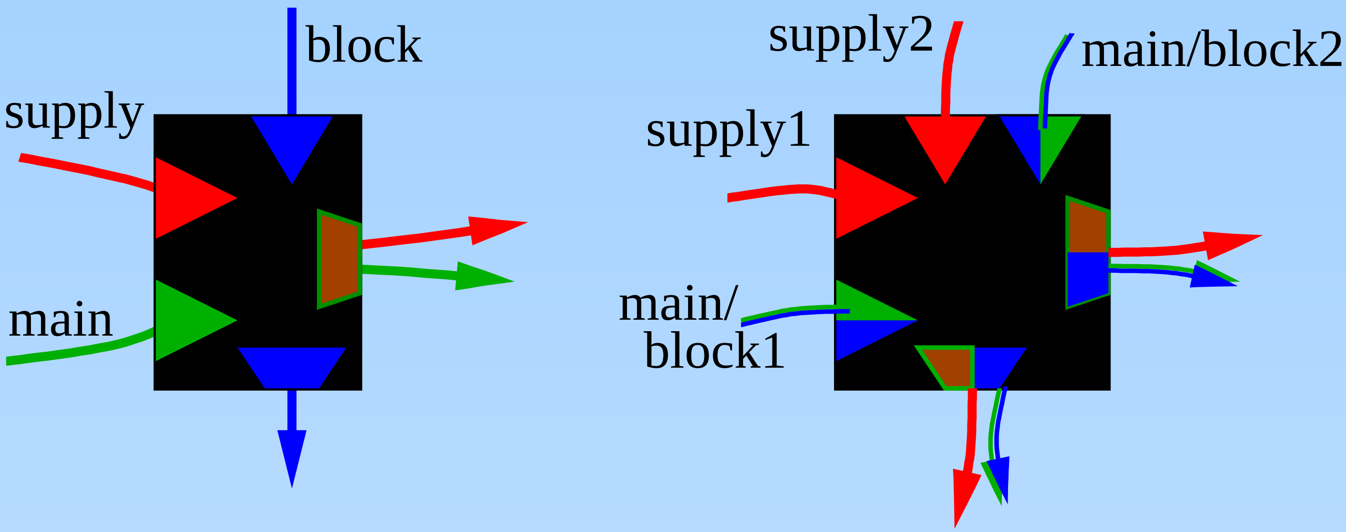

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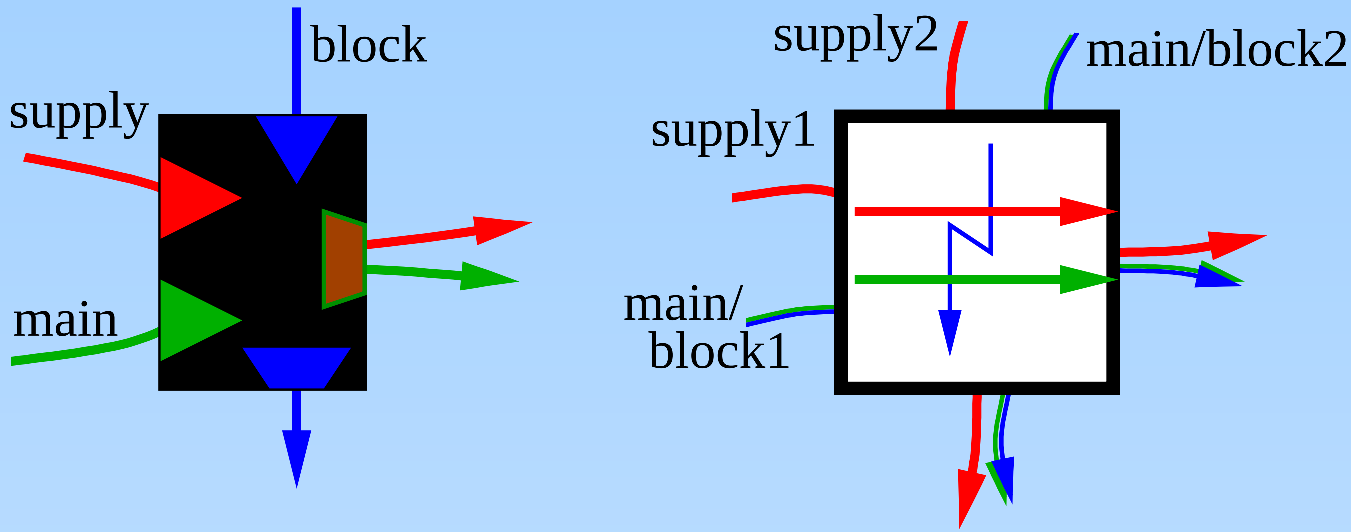

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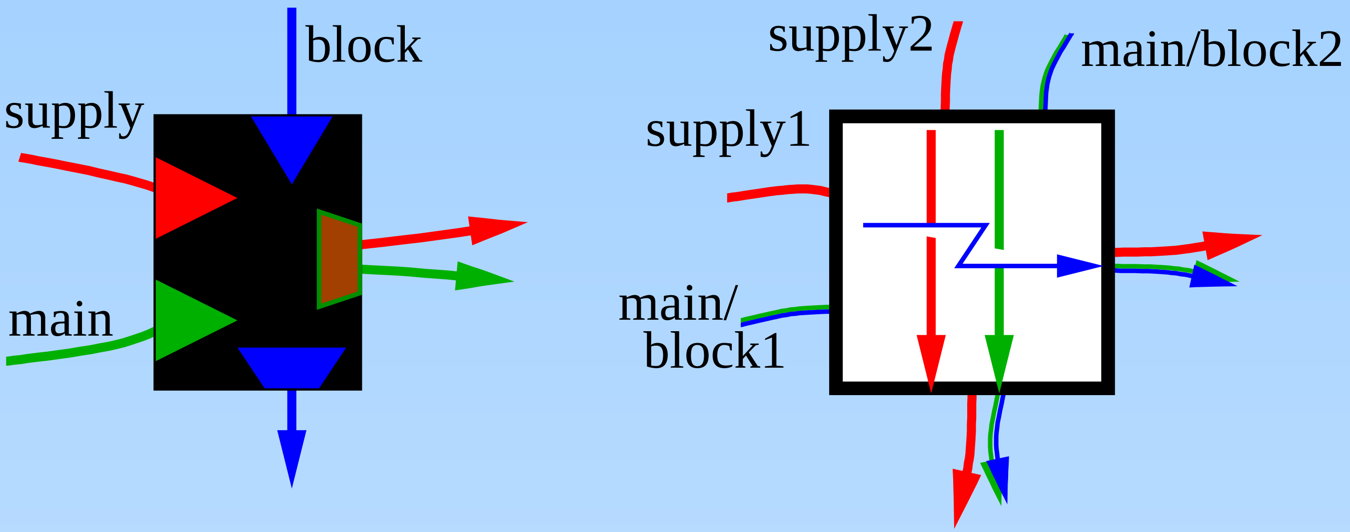

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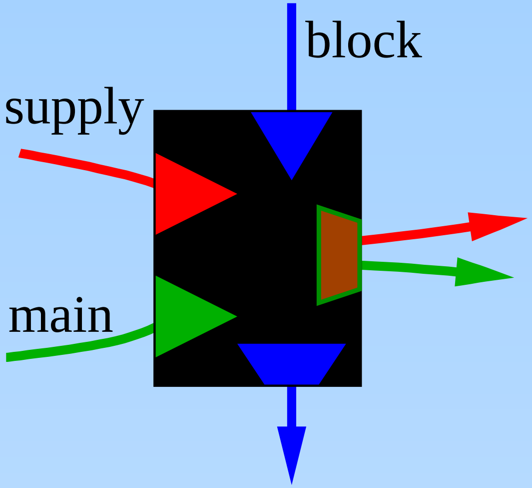

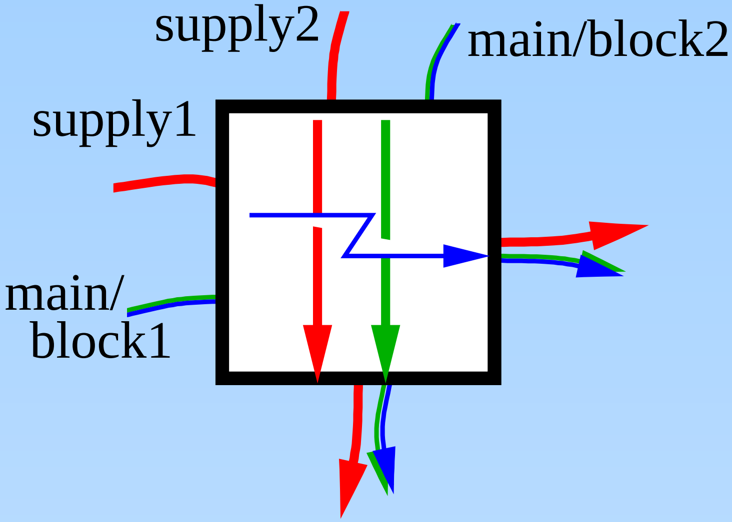

If green packets cannot be blocked by blue packets...

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Gadget works in at least one orientation.

Arranging a Gadget Matrix

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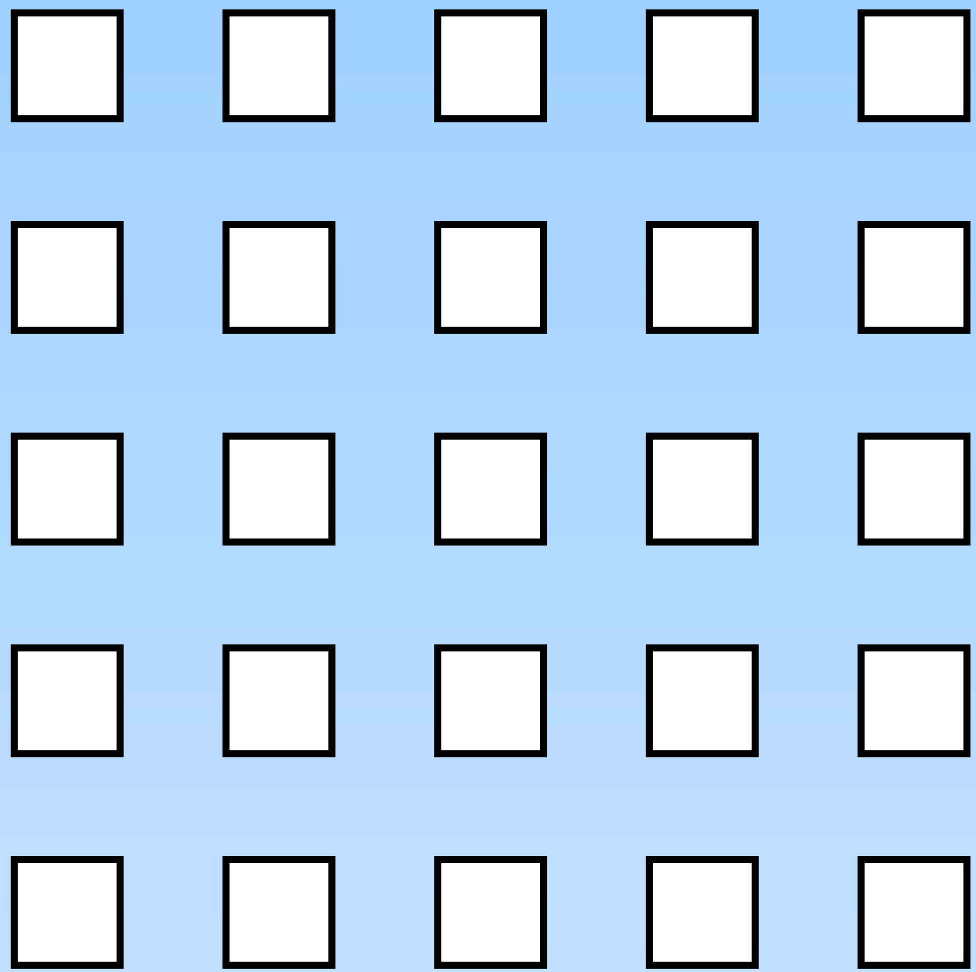

A $k \times k$ matrix of gadgets.

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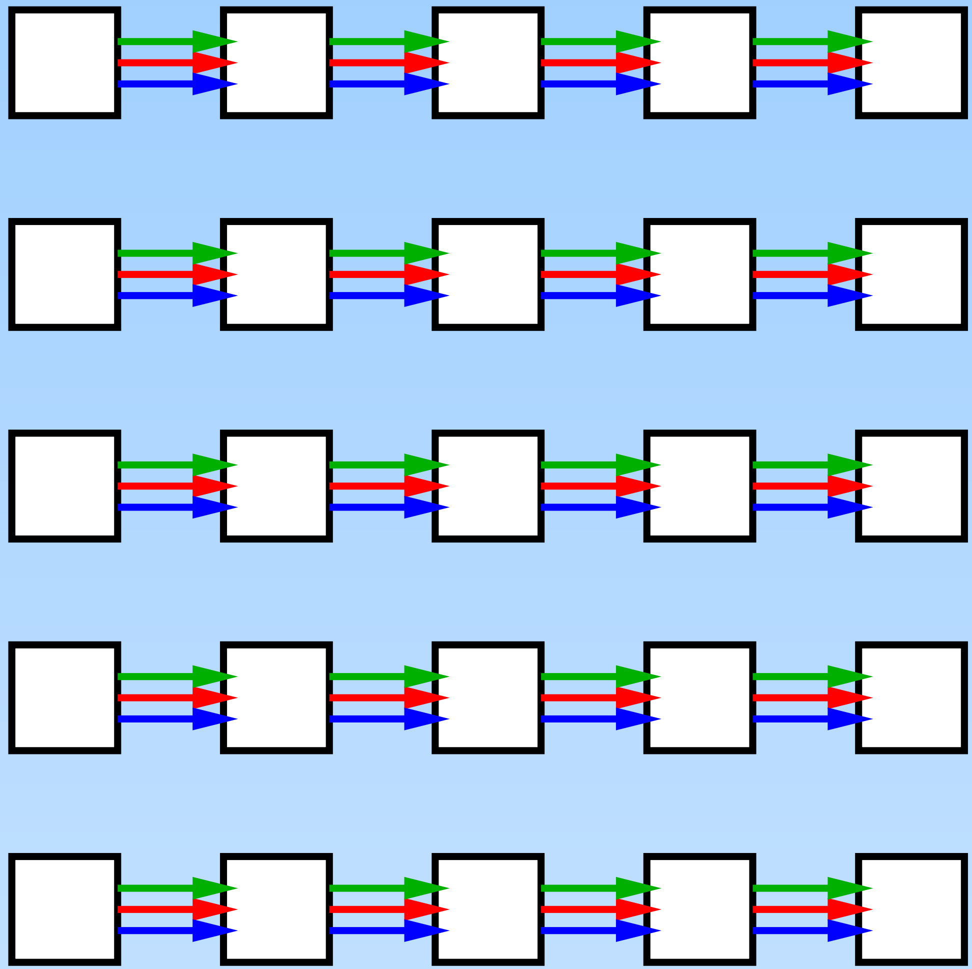

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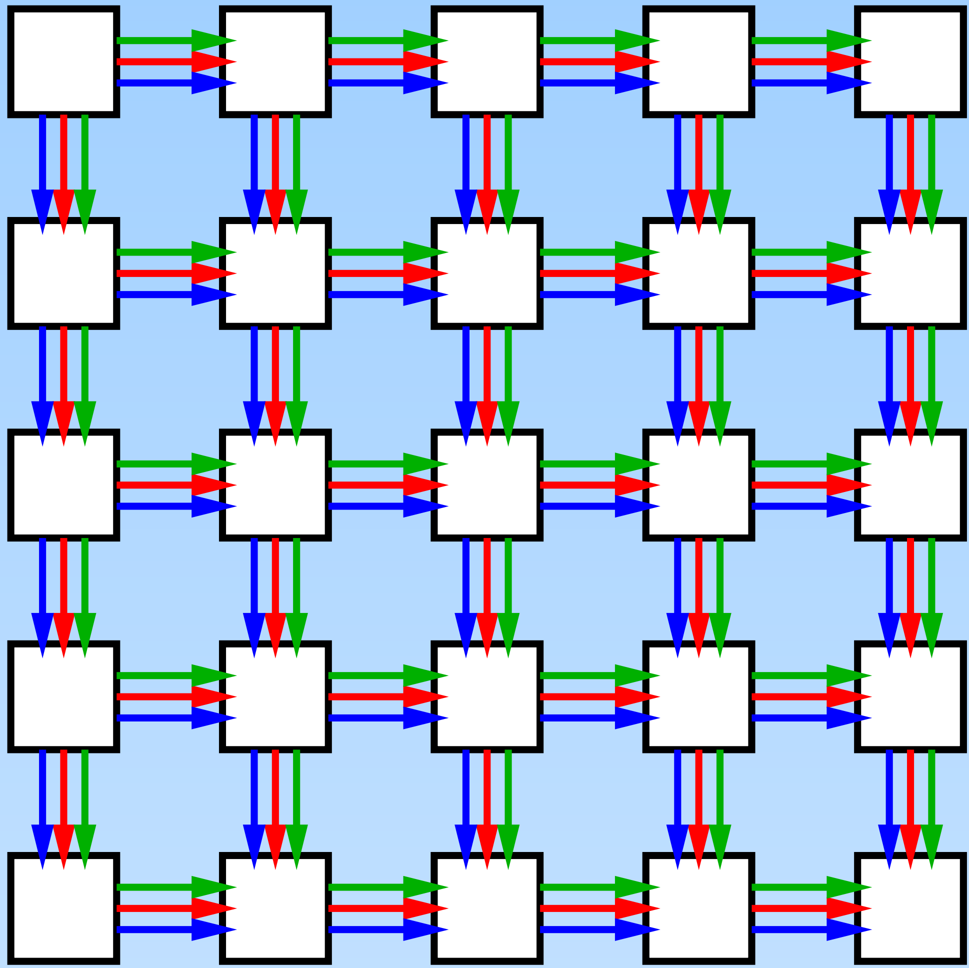

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Diameter: $\Theta(k)$.

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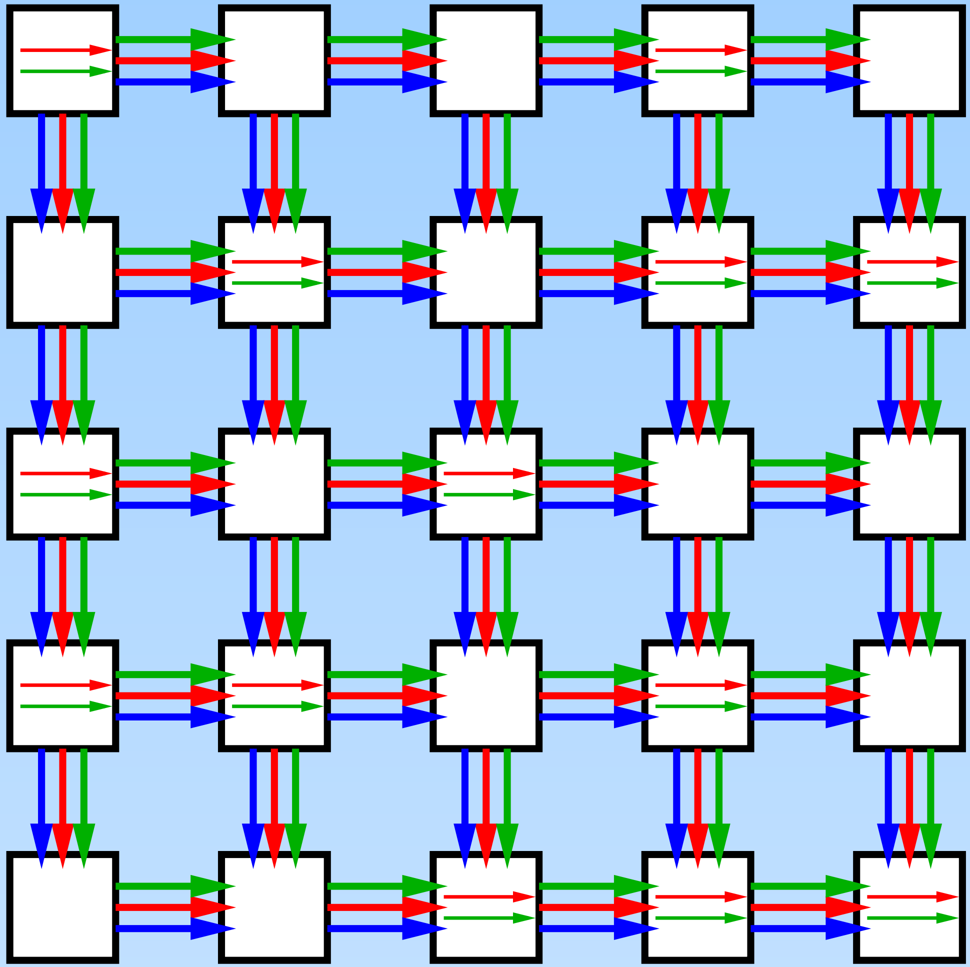

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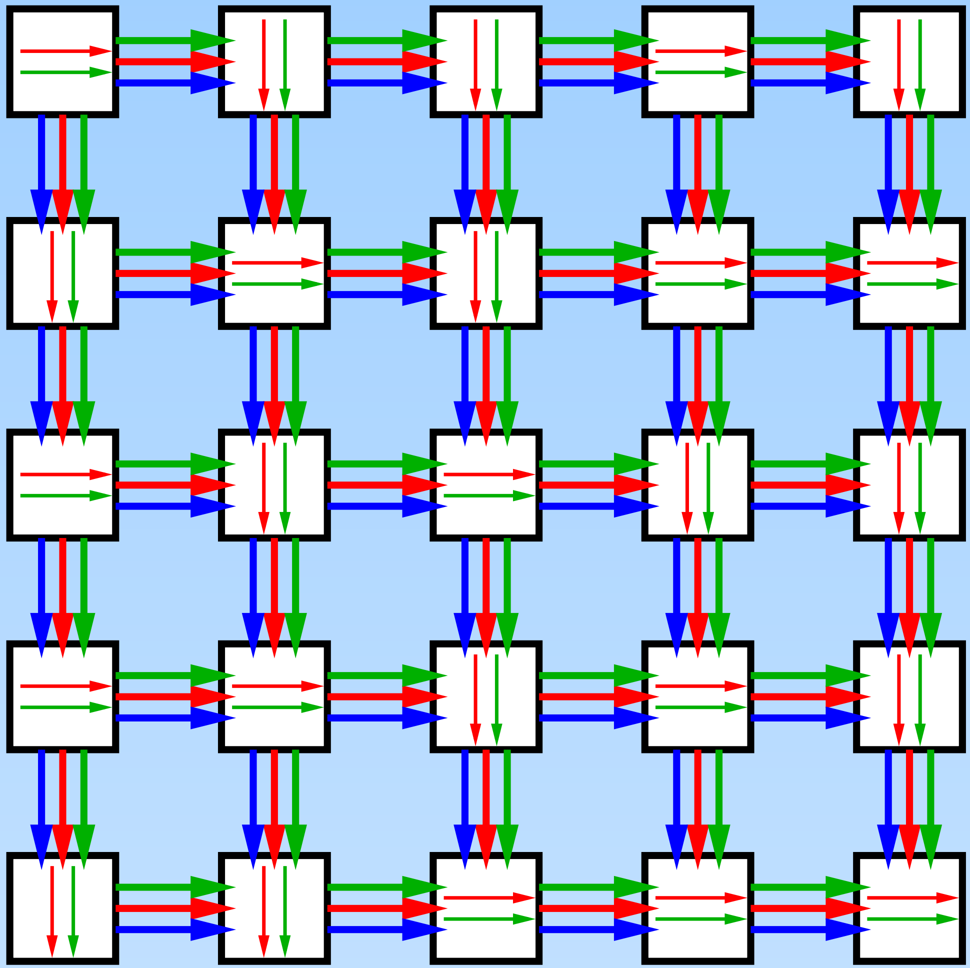
Diameter: $\Theta(k)$.

Each gadgets works in one orientation.

Arranging a Gadget Matrix



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There exists one row/column with at least $k/2$ usable gadgets.

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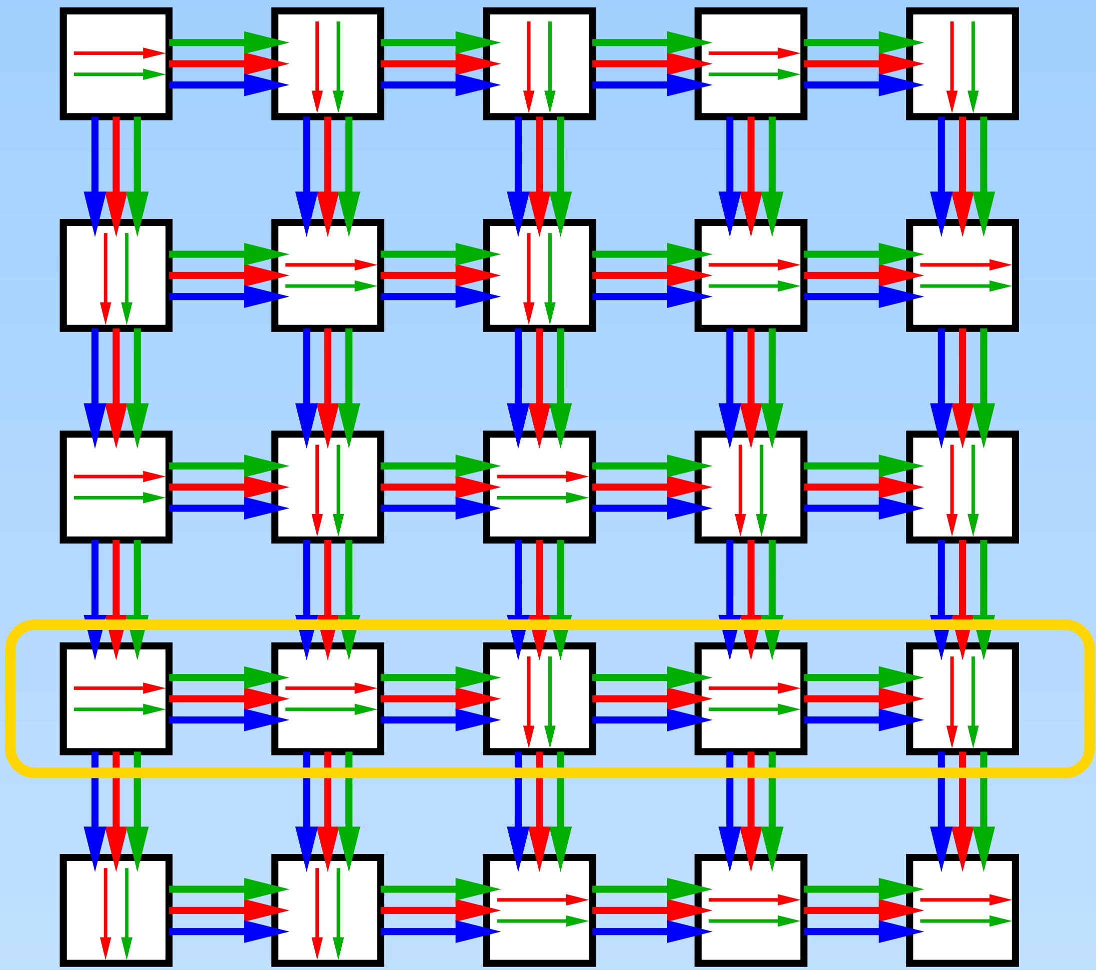

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$2^{\Theta(k)}$ packets can be piled up.

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THANK YOU