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UNIVERSITÄT FREIBURG

# Algorithms for Radio Networks

## Routing in MANET: Link Reversal, OLSR, ZRP

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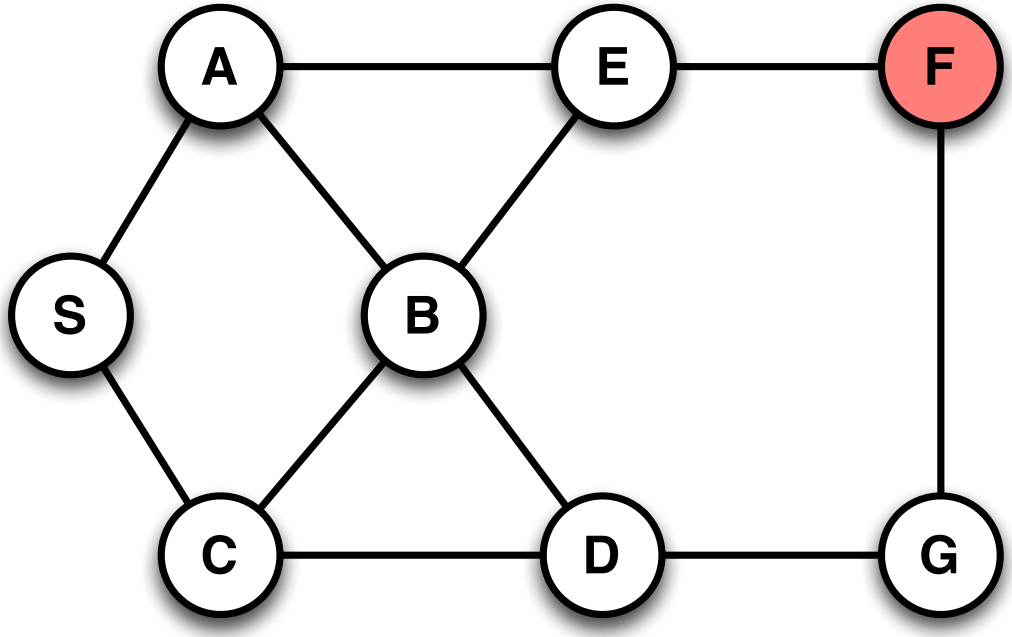
# Link Reversal

- **Gafni, Bertsekas,**
  - *Distributed Algorithms for Generating Loop-Free Routes in Networks with Frequently Changing Topology*, IEEE Transactions on Communications, Vol. 29, No. 1 pp. 11-18, IEEE, January 1981
- **Routing protocol**
  - with special repair mechanism

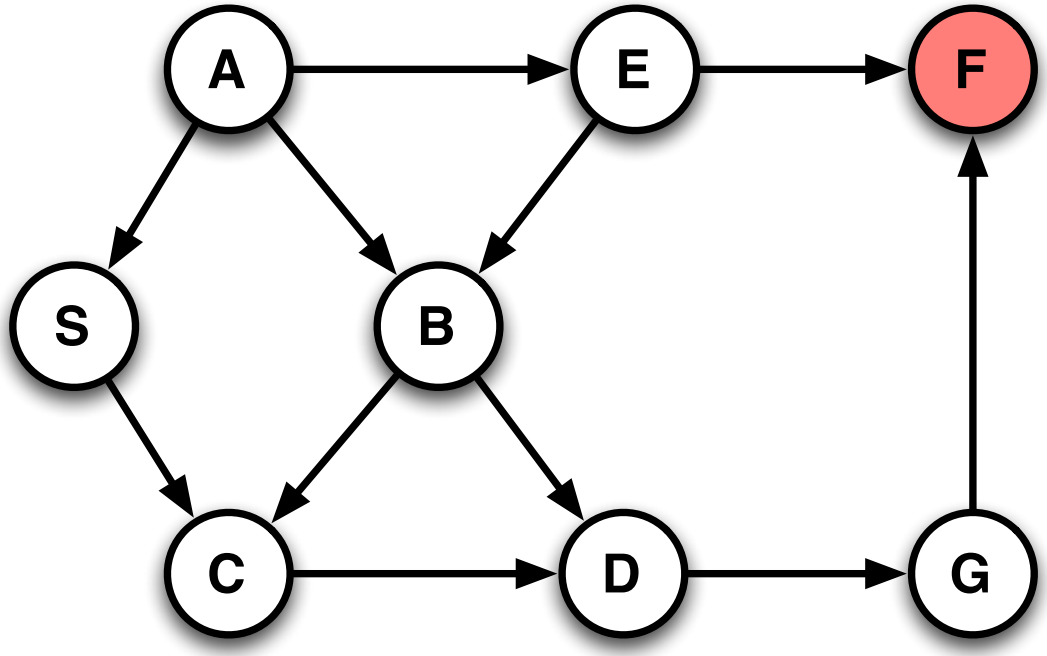
# Link Reversal

- **For each target node a direction for each edge is defined**
  - all edges point towards the target
  - e.g. by flooding and topological sorting
- **Routing**
  - Pick any outgoing edge and send packet



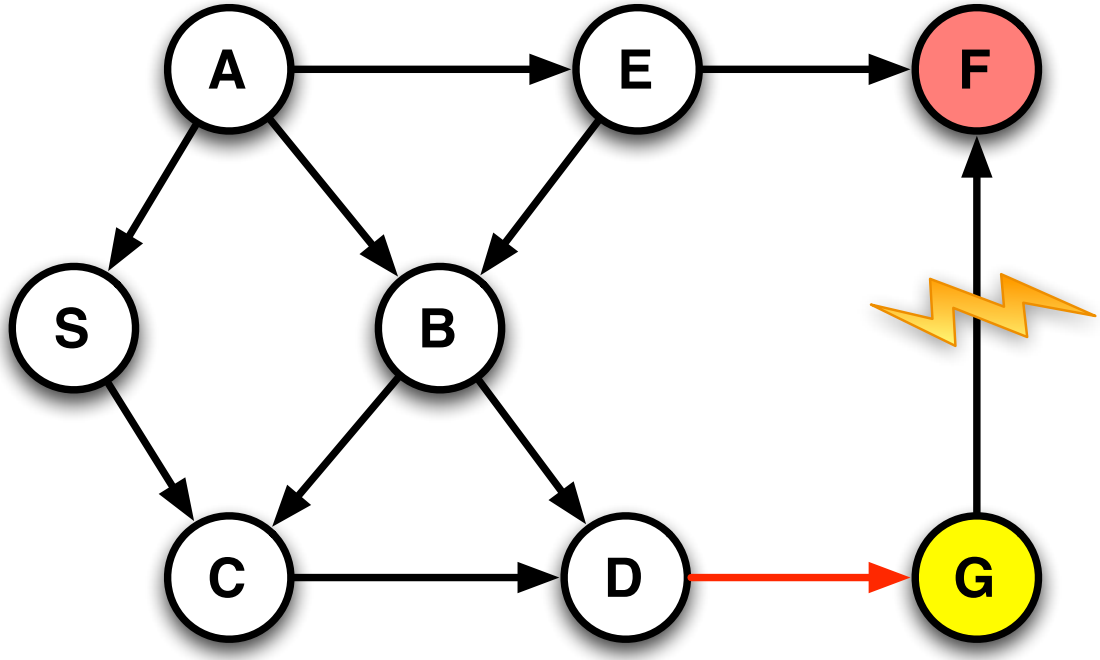
# Link Reversal

- **Directed acyclic graph (DAG) for each target**
  - is preserved also in the case of failing edges
- **Connections are symmetrical**
  - direction are only virtual



# Link Reversal

- **Link F-G is lost**
- **Repair**
  - All nodes without outgoing edges change the orientation of all incoming edges



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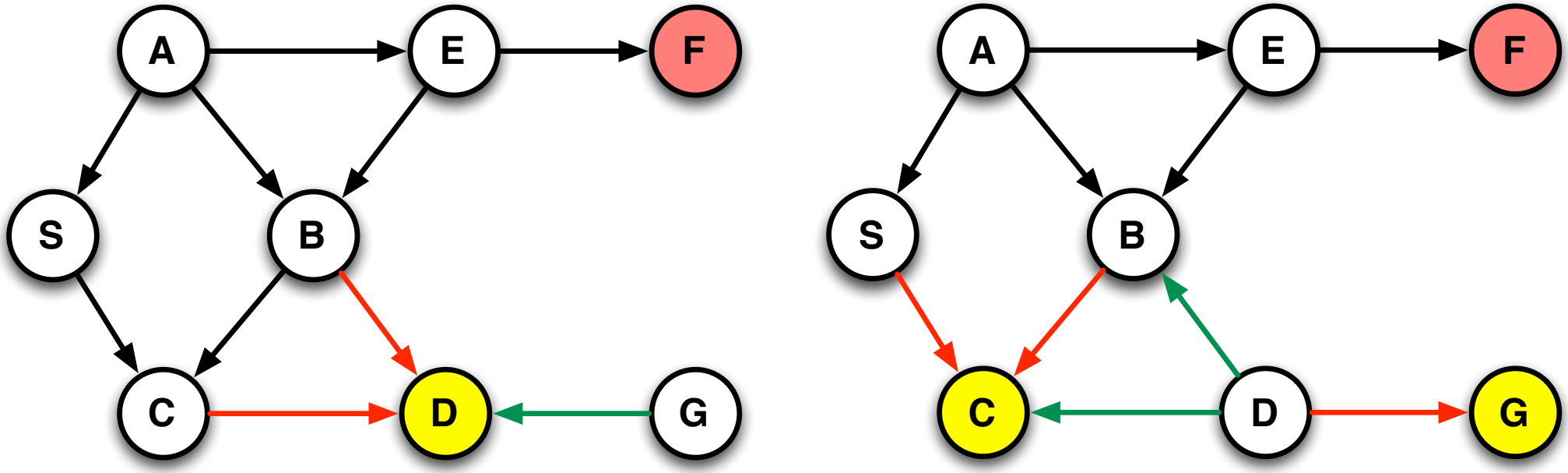

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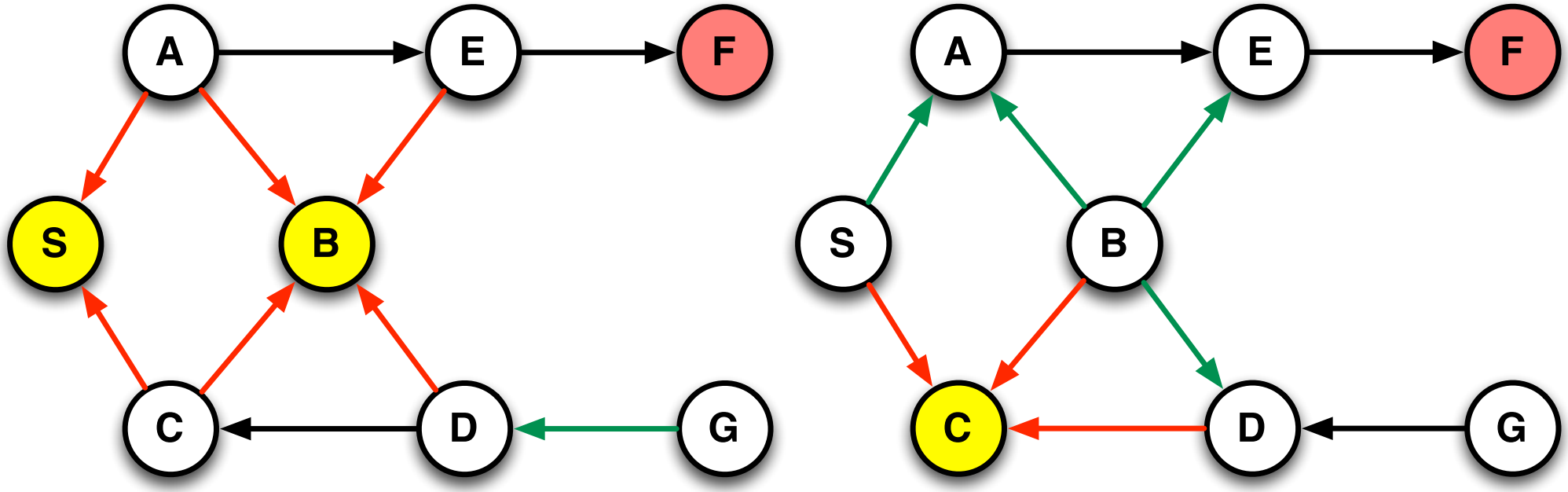

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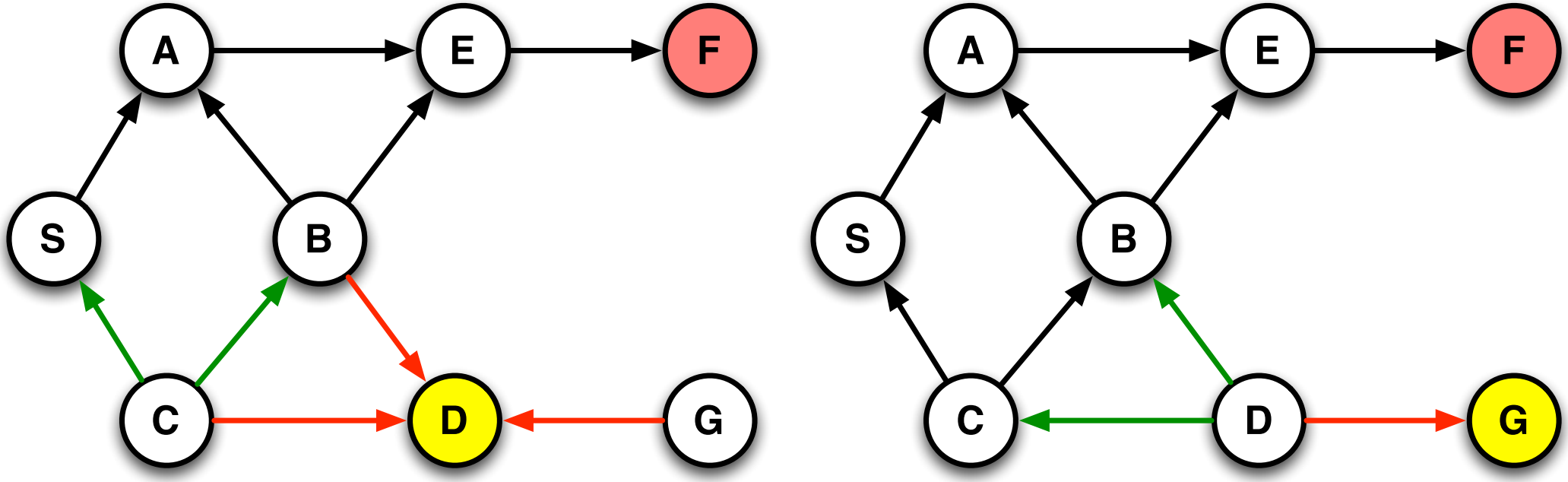

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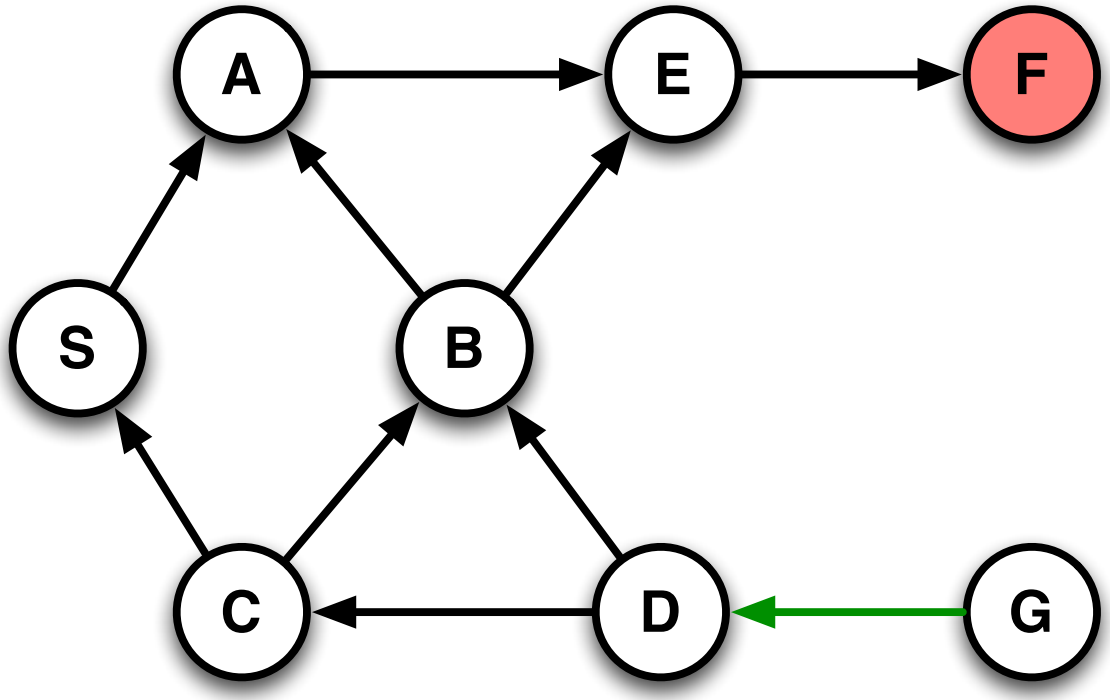


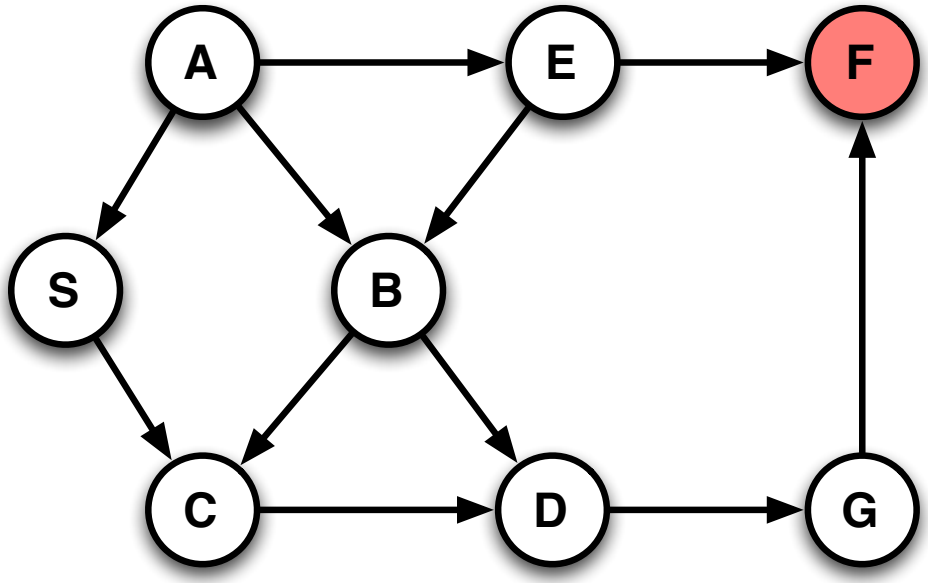
# Link Reversal

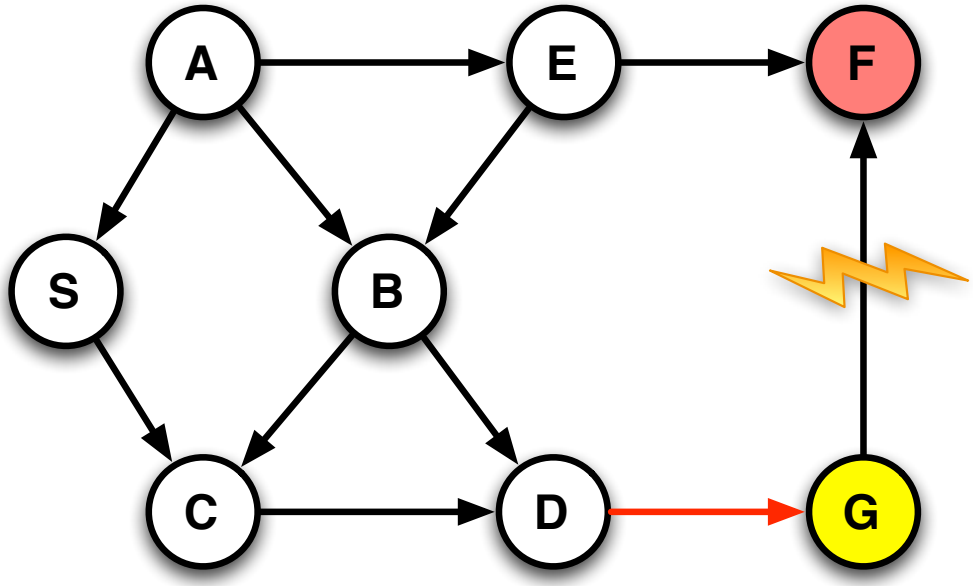
- **Motivation**
  - Link reversal should cause only local changes
  - Not necessarily the case
- **Repair is initiated,**
  - when the first packet is sent
- **Method known as a full reversal**

# Partial Reversal

- **Partial reversal**
  - Only the edges are reversed which have not been reversed before
  - If all edges have been already reversed, then reverse all edges again

# Partial Reversal



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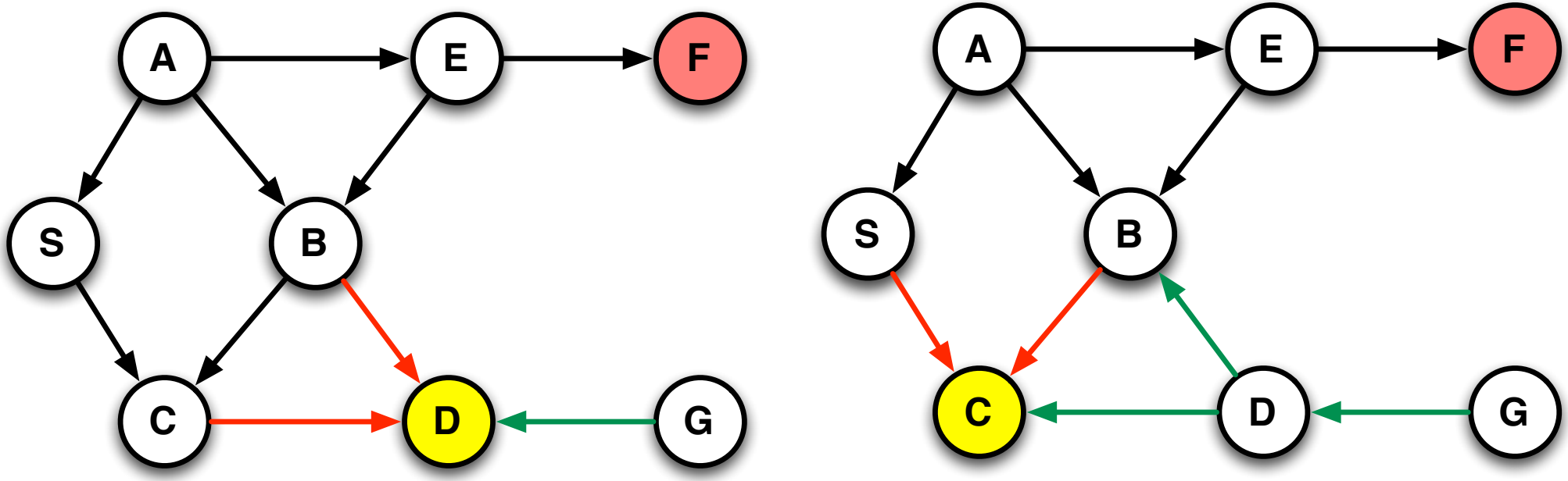

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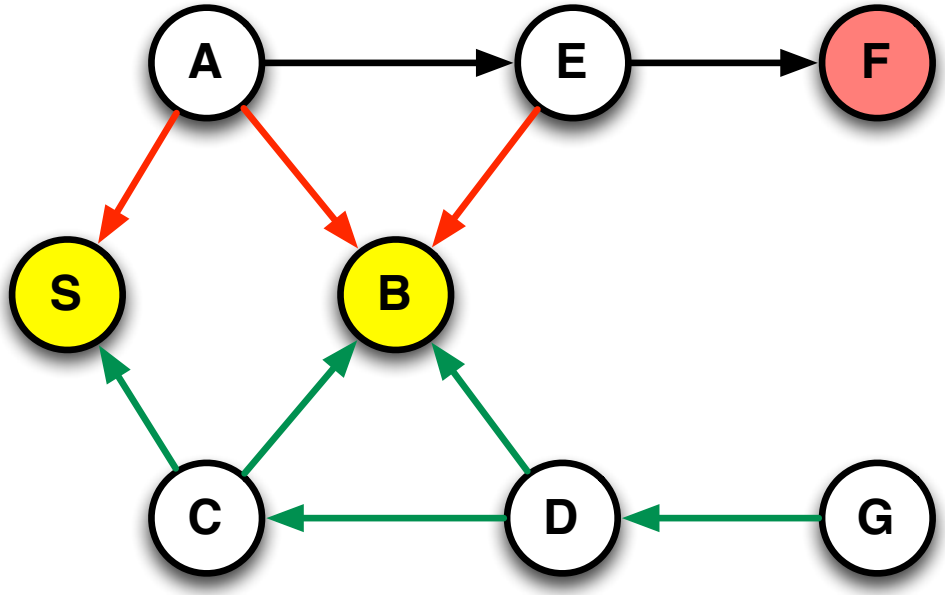
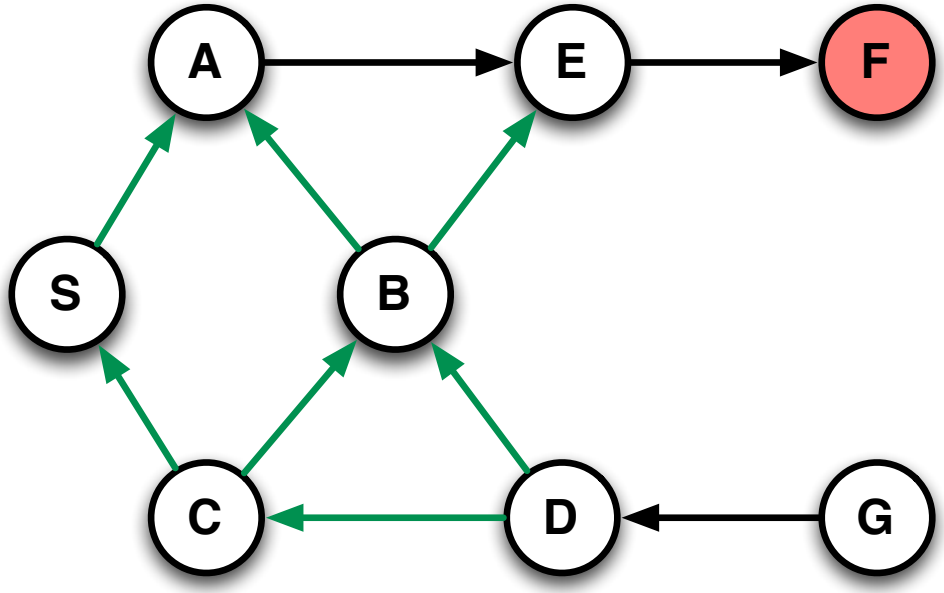
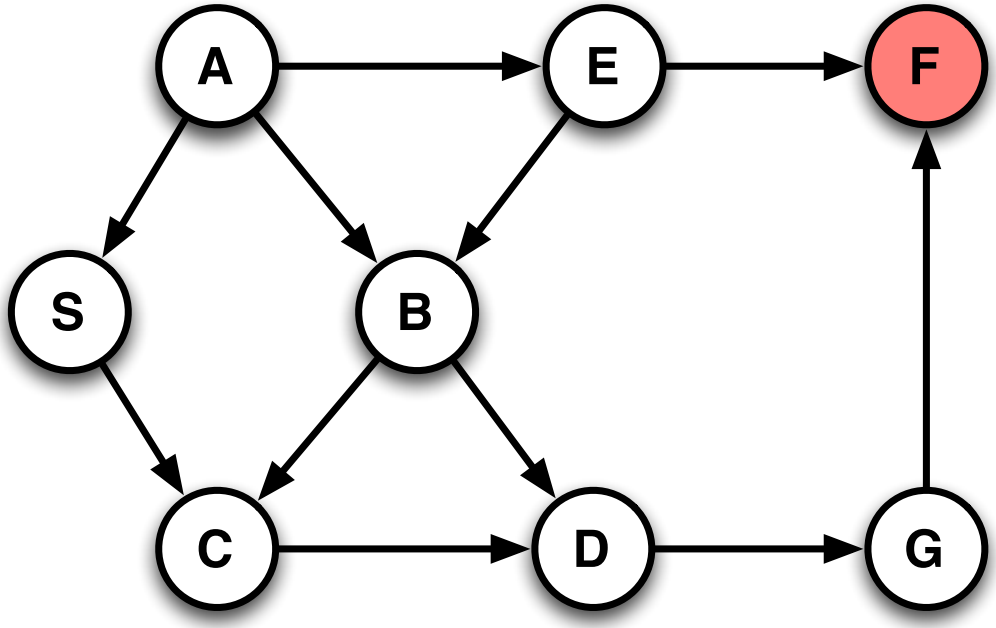


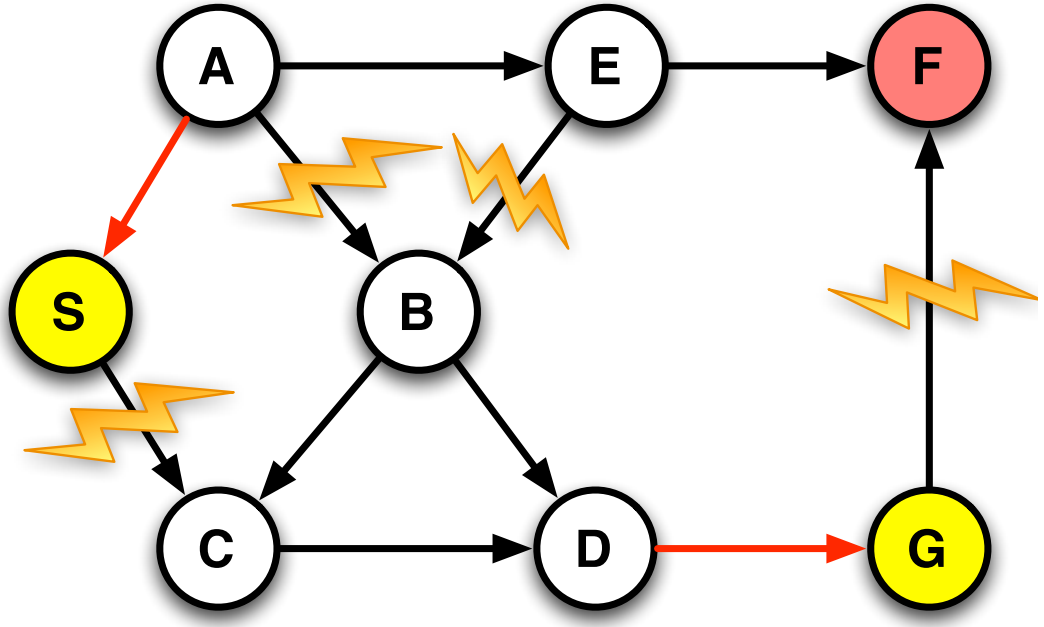



# Link Reversal

- **Advantages**
  - Link reversal intends local repair
  - Several substitute routes (potentially) available
- **Disadvantages**
  - Connection errors must be detected
    - Hello messages cause additional traffic
  - If network is partitioned, the repair mechanism does not terminate

# Link Reversal if Network is Partitioned



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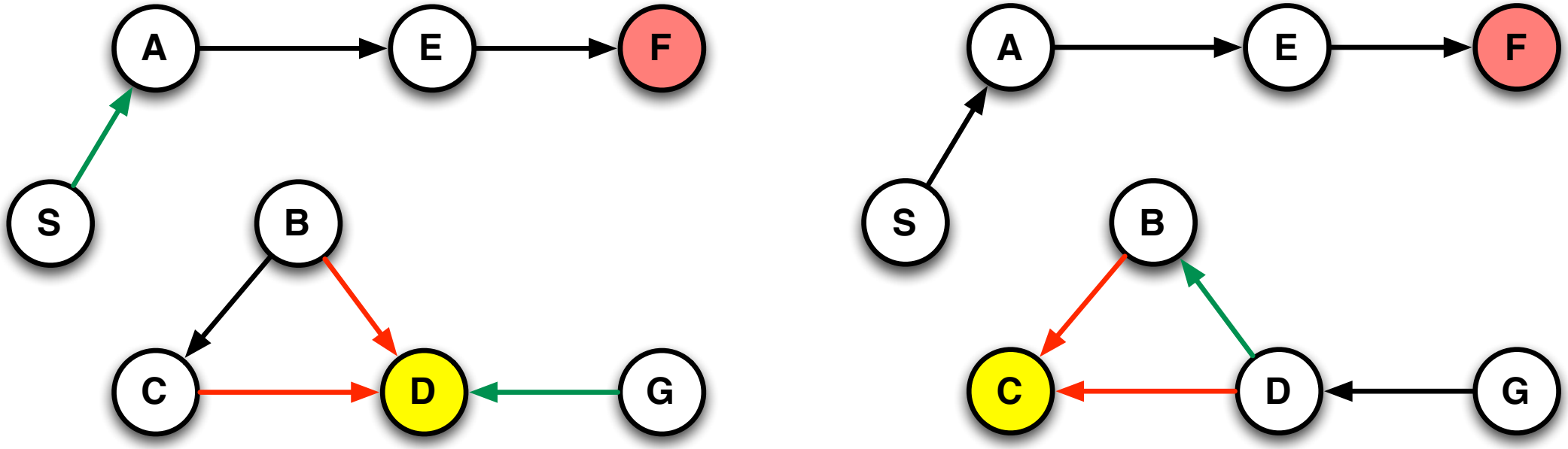

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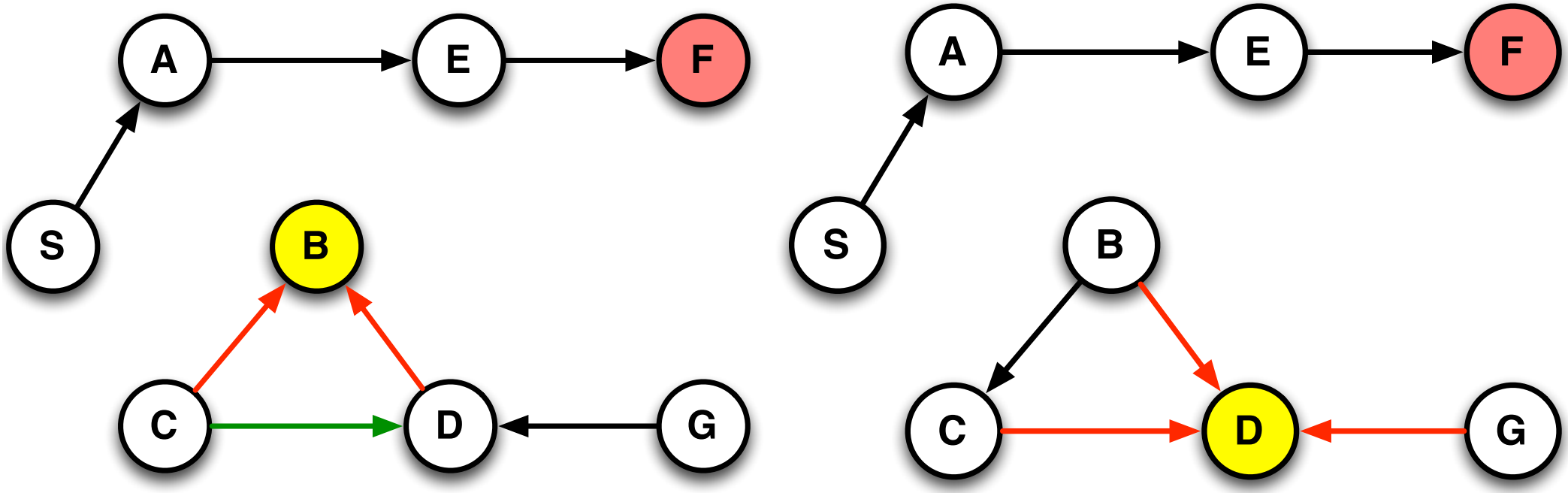

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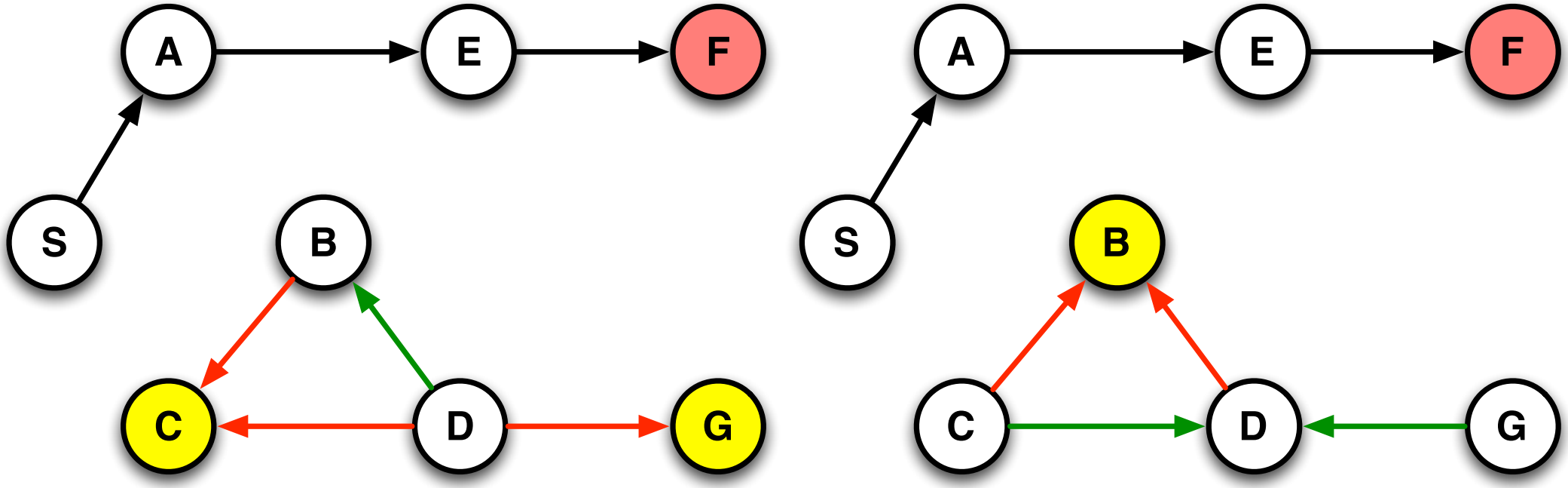


# TORA

- **Separate network does not terminate with link reversals**
- **Mechanism for recognizing partitioning**
  - TORA (Temporally-Ordered Routing Algorithm (TORA)
    - Park, Corson, Highly Adaptive Distributed Routing Algorithm for Mobile Wireless Networks, Infocom 1997
  - Analysis of link reversal provides this information

# Link Reversal

- **Reactive protocol**
  - Repair only when data packet is not delivered
- **Proactive protocol**
  - Hello packets check all connections
- **Link reversal can be both proactive and reactive**

# Routing in MANETs

- **Routing**
  - Determination of message paths
  - Transport of data
- **Protocol types**
  - proactive
    - Routing tables with updates
  - reactive
    - repair of message paths only when necessary
  - hybrid
    - combination of proactive and reactive

# Routing Protocols

- **Proactive**
  - Routes are **demand independent**
  - Standard Link-State und Distance-Vector Protocols
    - Destination Sequenced Distance Vector (**DSDV**)
    - Optimized Link State Routing (**OLSR**)
- **Reactive**
  - Route are determined when needed
    - Dynamic Source Routing (**DSR**)
    - Ad hoc On-demand Distance Vector (**AODV**)
    - Dynamic MANET On-demand Routing Protocol
    - Temporally Ordered Routing Algorithm (**TORA**)
- **Hybrid**
  - combination of reactive und proactive
    - Zone Routing Protocol (**ZRP**)
    - Greedy Perimeter Stateless Routing (**GPSR**)

# Optimized Link State Routing

- **Literature**
  - RFC3626: Clausen, Jacquet, *Optimized Link State Routing Protocol, 2003*
  - First published 1999
- **Most proaktive protocols are are based on**
  - Link-state routing
  - Distance-Vector routing

# Link State Routing

- **Connections are periodically published throughout the network**
- **Nodes propagate information to their neighbors**
  - i.e. flooding
- **All network information is stored**
  - with time stamp
- **Each node computes shortest paths**
  - possibly also other route optimizations

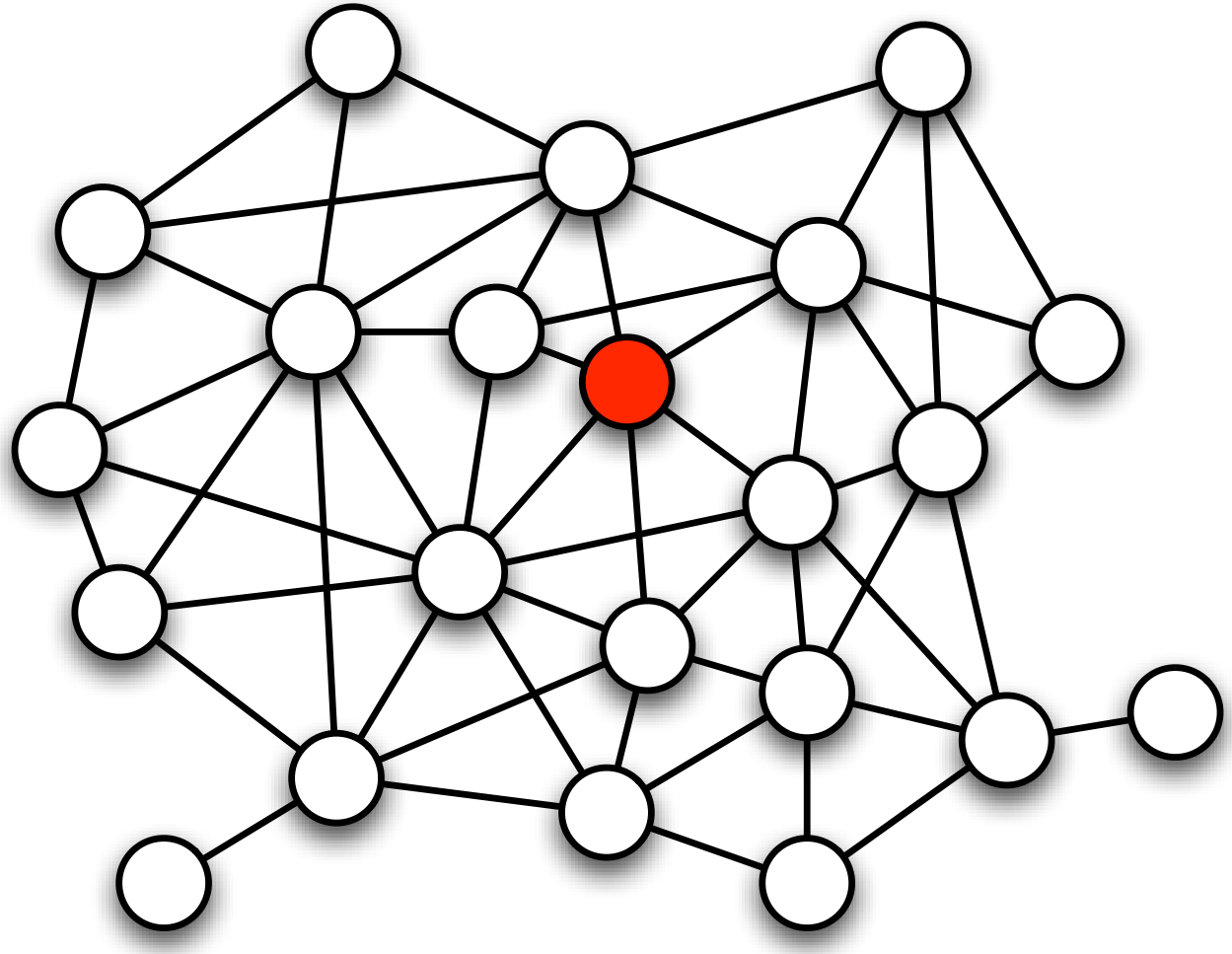
# Optimized Link State Routing (OLSR)

- **Each nodes broadcasts its neighborhood list**
  - Each node can determinate its 2-hop neighborhood
- **Reducing the number of messages**
  - fewer nodes participate in flooding
- **Multipoint relay node (MPRs)**
  - are chosen such that each node has at least one multipoint relay node as in its 2-hop neighborhood
  - Only multipoint relay nodes propagate link information
- **Node sends their neighborhood lists**
  - such that multipoint relay nodes in the 2-hop neighborhood can be chosen

# Optimized Link State Routing (OLSR)

- **Combines Link-State protocol and topology control**
- **Topology control**
  - Each node chooses a minimal dominating set of the 2 hope neighborhood
    - ***multipoint relays (MPR)***
    - Only these nodes propagate link information
    - More efficient flooding
- **Link State component**
  - Standard link state algorithm on a reduced network

# Optimized Link State Routing (OLSR)



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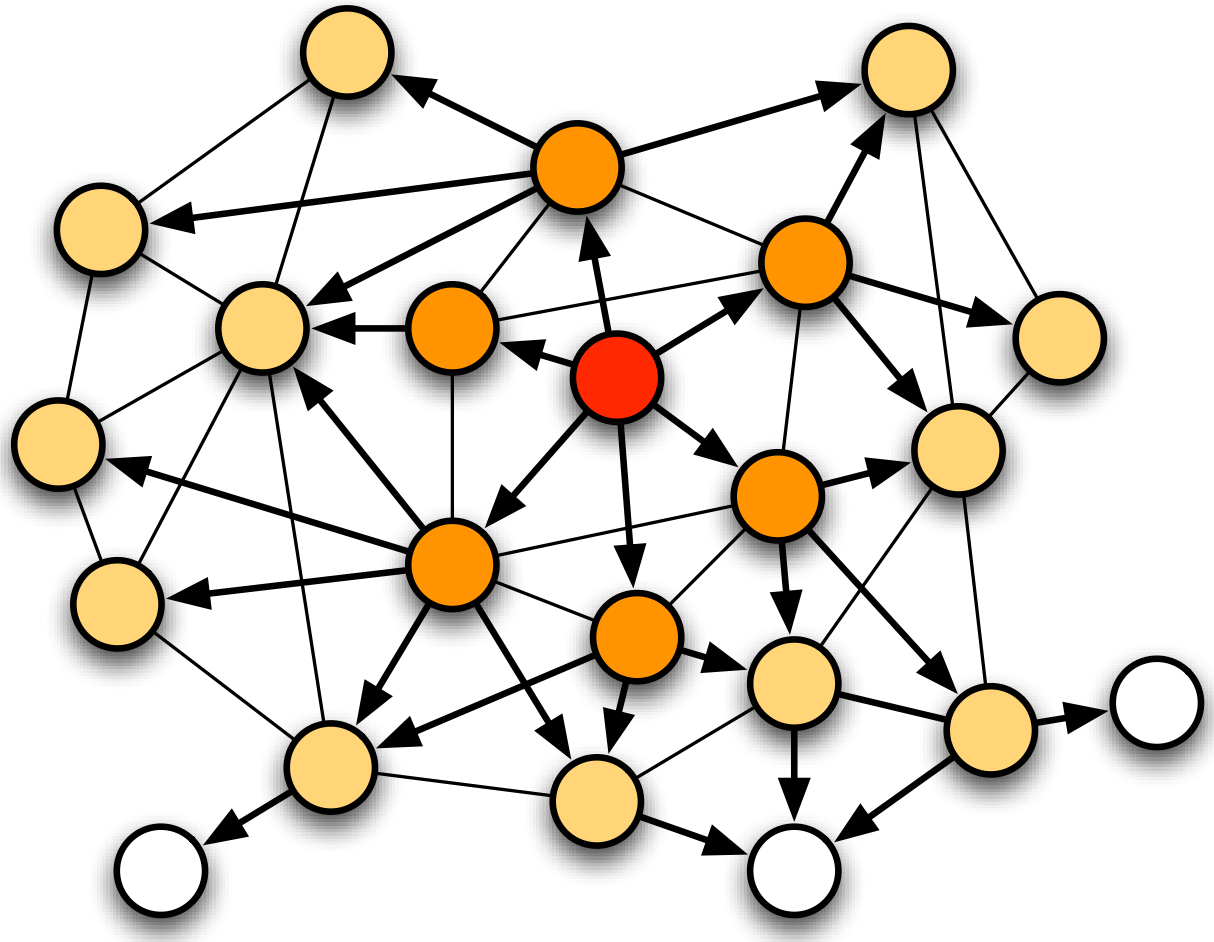

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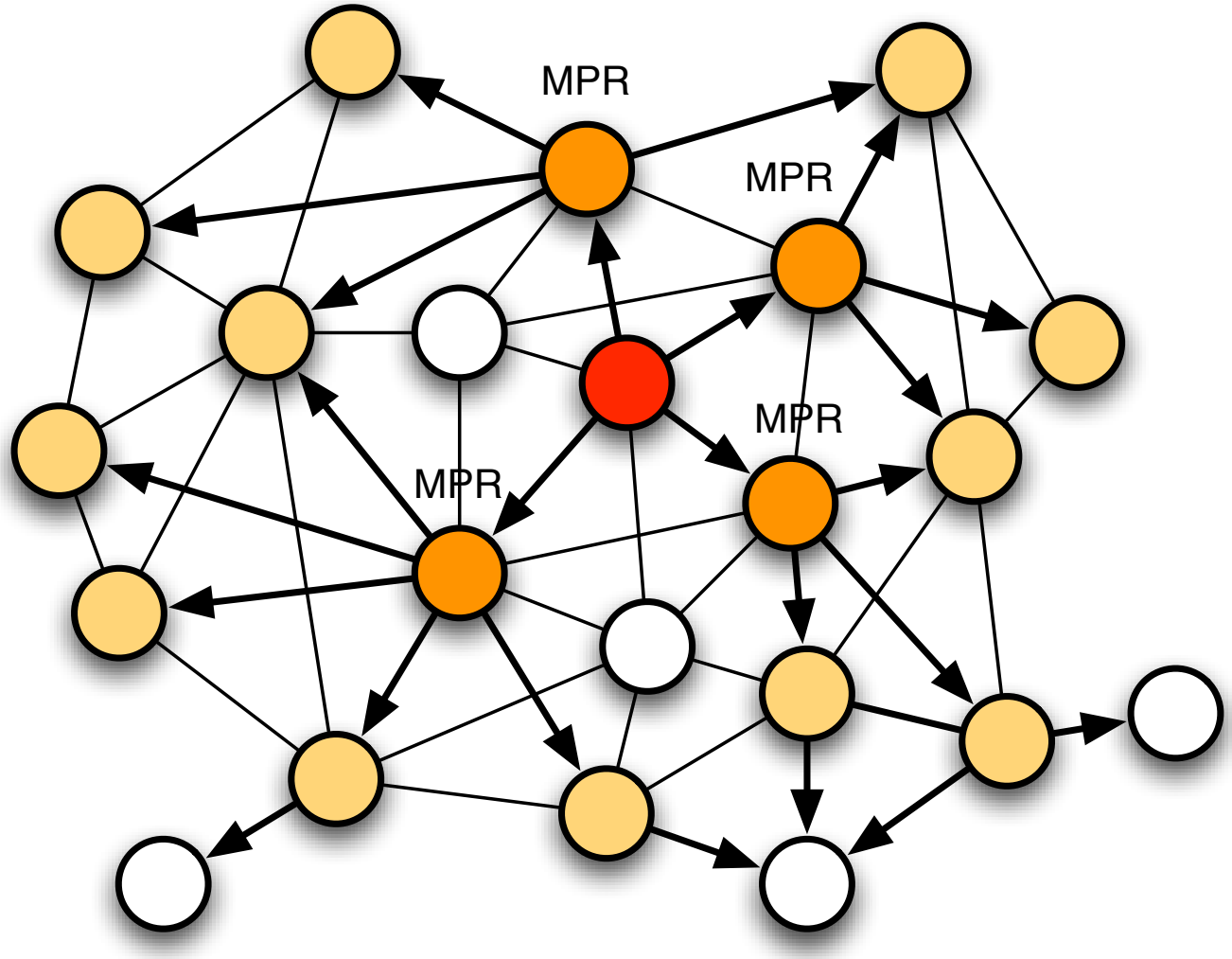


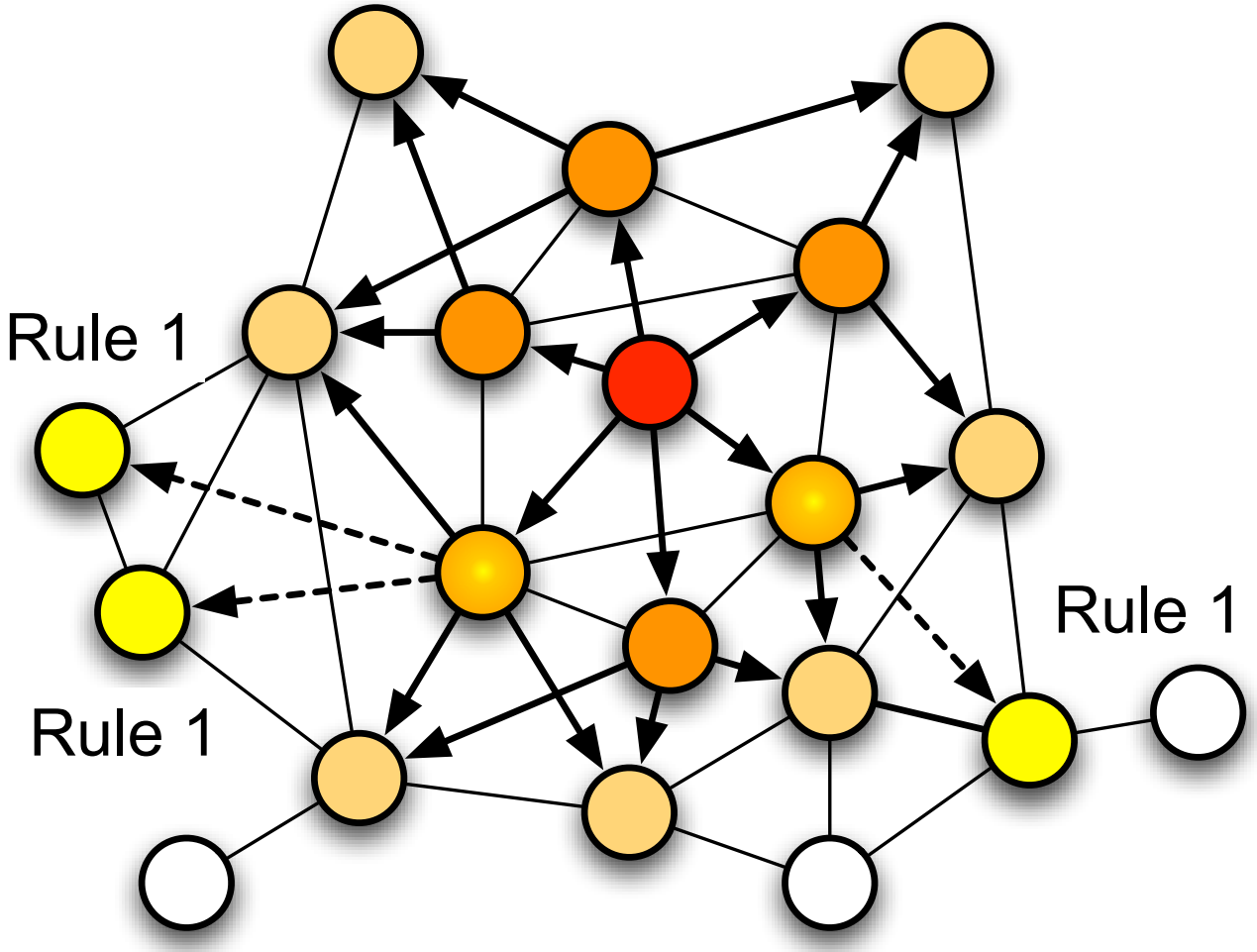
# Selection of MPRs

- **Multipoint Relaying for Flooding Broadcast Messages in Mobile Wireless Networks, Amir Qayyum, Laurent Viennot, Anis Laouiti, HICCS 2002**
- **Problem is NP-complete**
- **Heuristics**
  - recommended for OLSR
- **Notations**
  - N(x): 1 hop neighborhood of x
  - $N^2$(x): 2 hop neighborhood of x
  - Alle connections are symmetrical

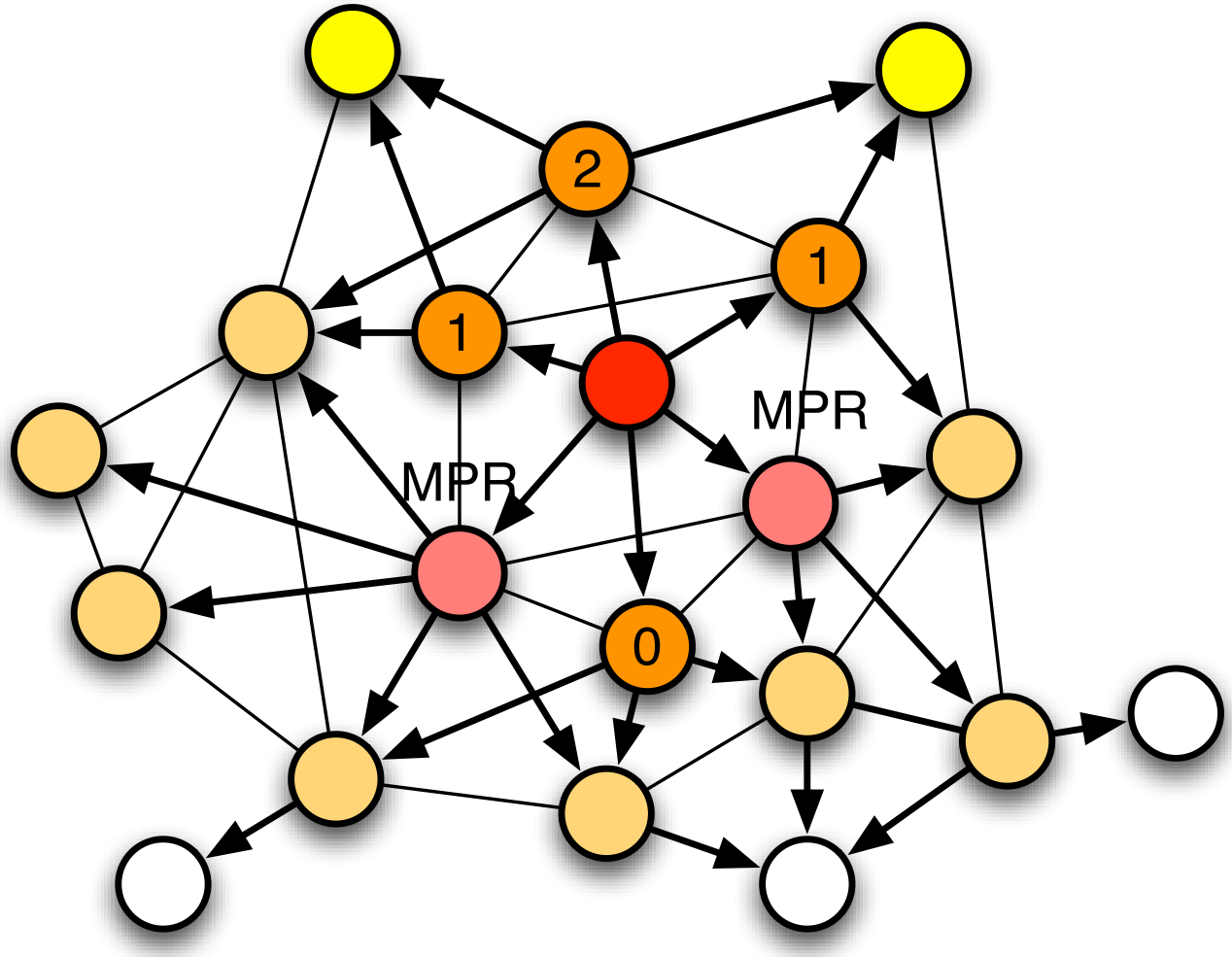
# Selection of MPRs

- **At the beginning there is no MPR**
  - Each node chooses its MPRs
- **Rule 1: A node of x is selected as MPR, if**
  - it in N(x) and
  - it is the only neighborhood node in the node $N^2(x)$
- **Rule 2: If nodes in $N^2$ (x) are not covered:**
  - Compute for each node in N(x) the number of uncovered nodes in $N^2(x)$
  - Select as MPR the node that maximizes the value

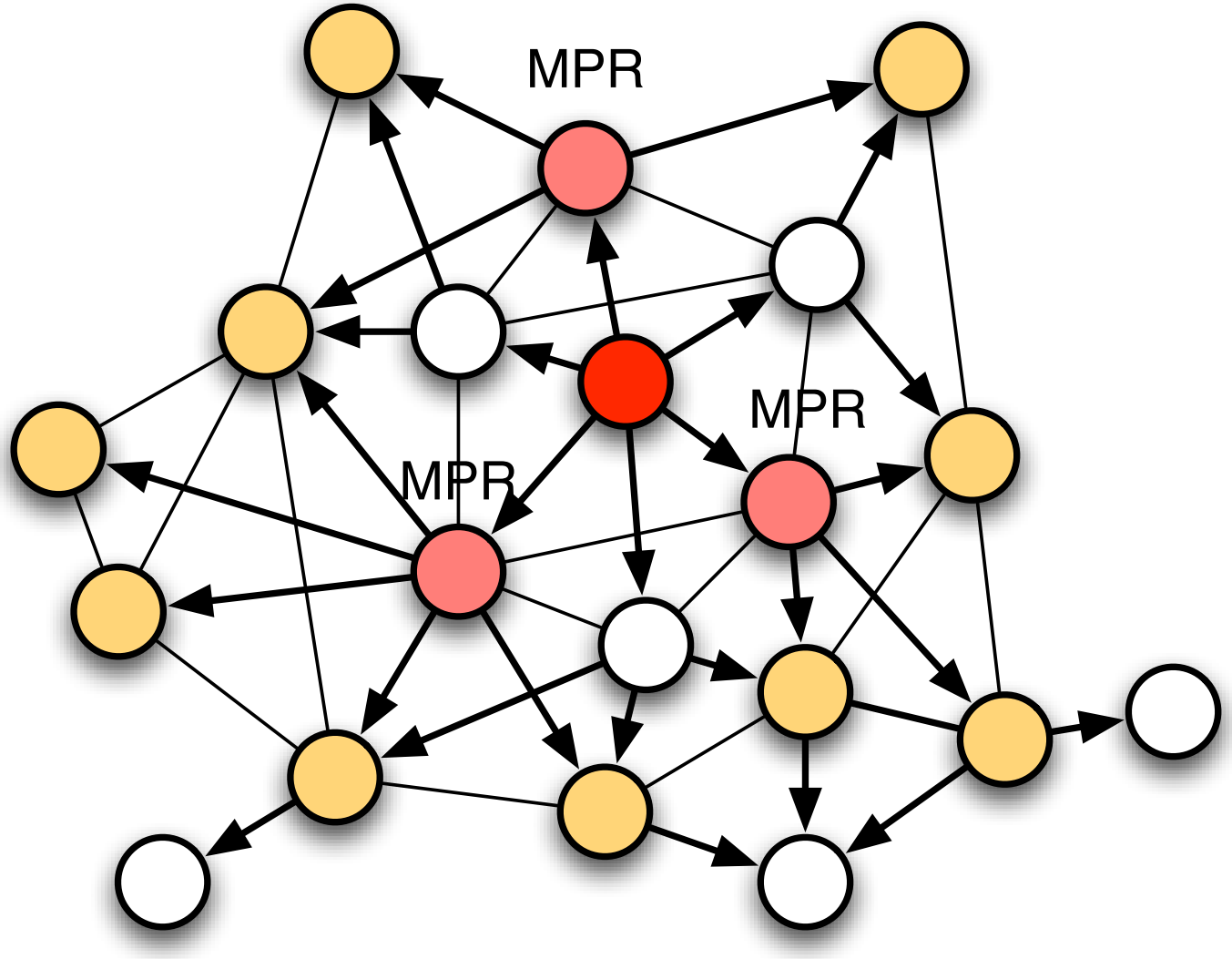
# Rule 1



# Rule 2



# MPRs



# OLSR

- **OLSR is flooding link information using MPRs**
  - Multipoint-Relays
- **Receivers choose their own MPRs for propagating**
  - Each node chooses its own MPRs
- **Routes use only MPRs as intermediate nodes**

# Zone Routing Protocol (ZRP)

- **Haas 1997**
  - *A new routing protocol for the reconfigurable wireless networks*, Proc. of IEEE 6th International Conference on Universal Personal Communications, 562–566
- **Zone Routing Protocol combine**
  - Proactive protocol
    - for local routing
  - reactive protocol
    - for global routing

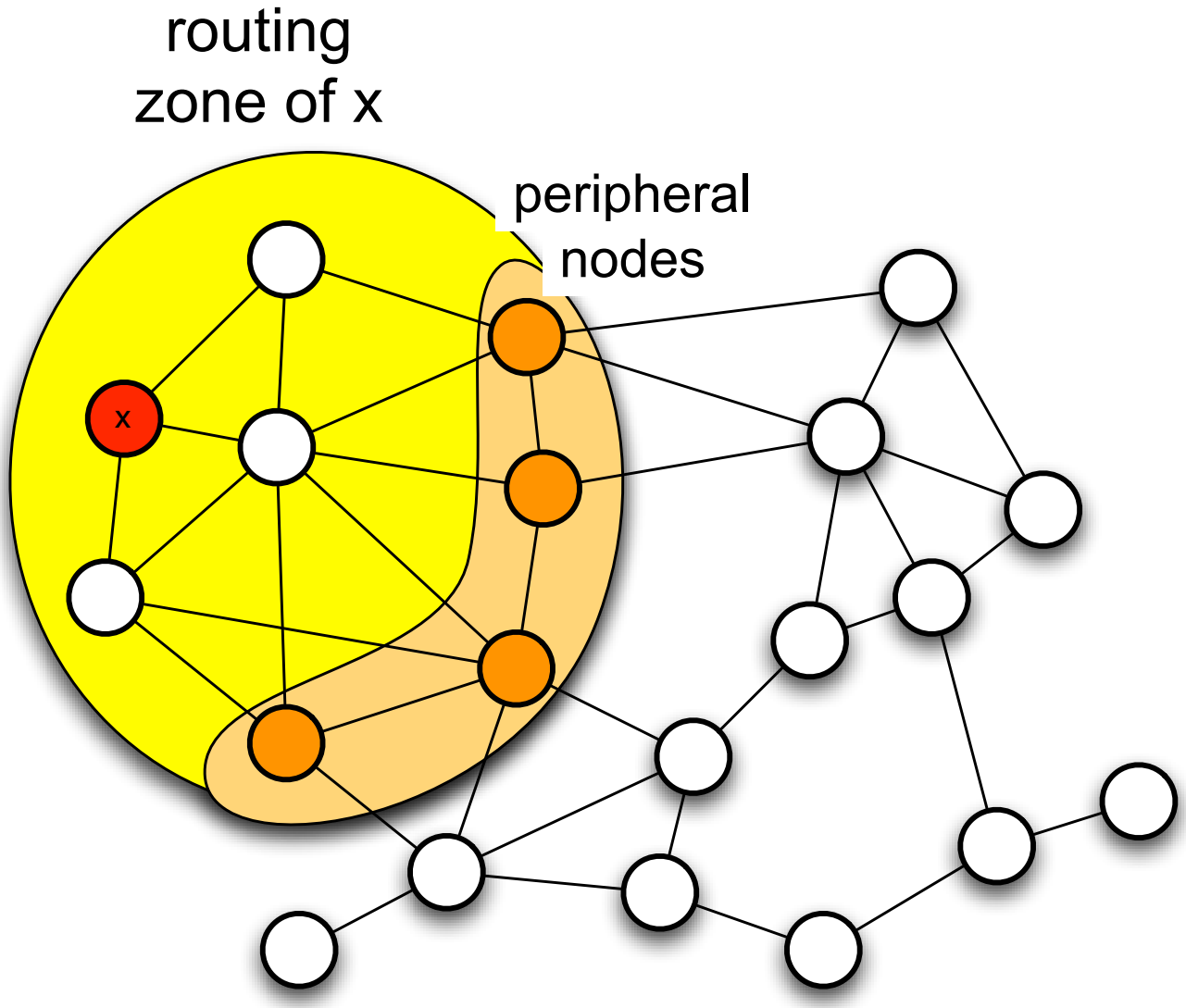
# ZRP

- **Routing zone of a node x**
  - Nodes in a given maximum hop-distance d
- **Peripheral nodes**
  - all nodes have exactly the hop-distance d have
  - within the routing zone x

# ZRP

- **Intra zone routing**
  - proactive update the connection information in the routing zone of node
    - e.g. with link state or distance vector protocols
- **Inter zone routing**
  - Reactive route discovery is used for distant / unknown nodes
  - Procedure similar to DSR
  - Only peripheral nodes reach further information

# ZRP: Example with radius d=2



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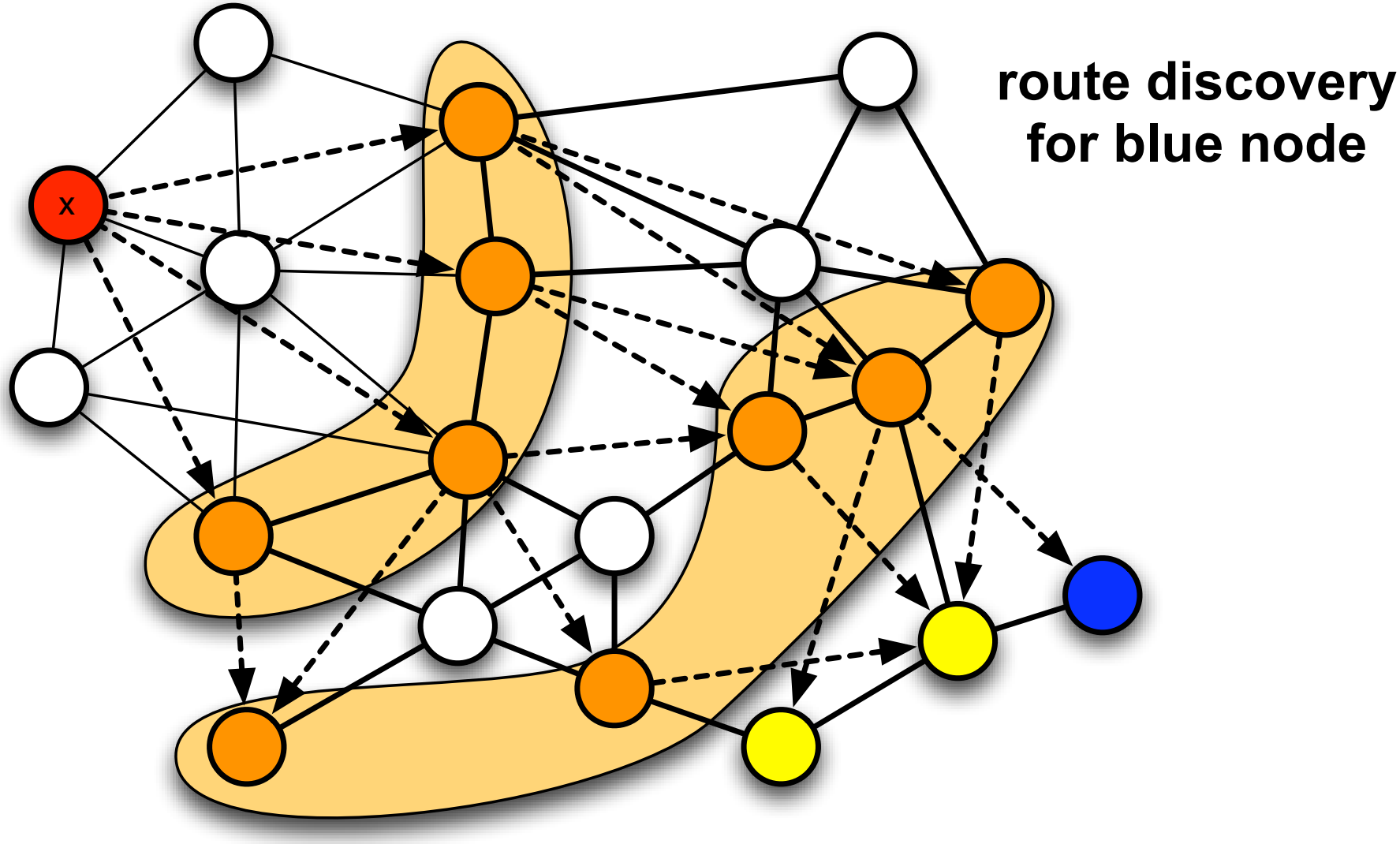

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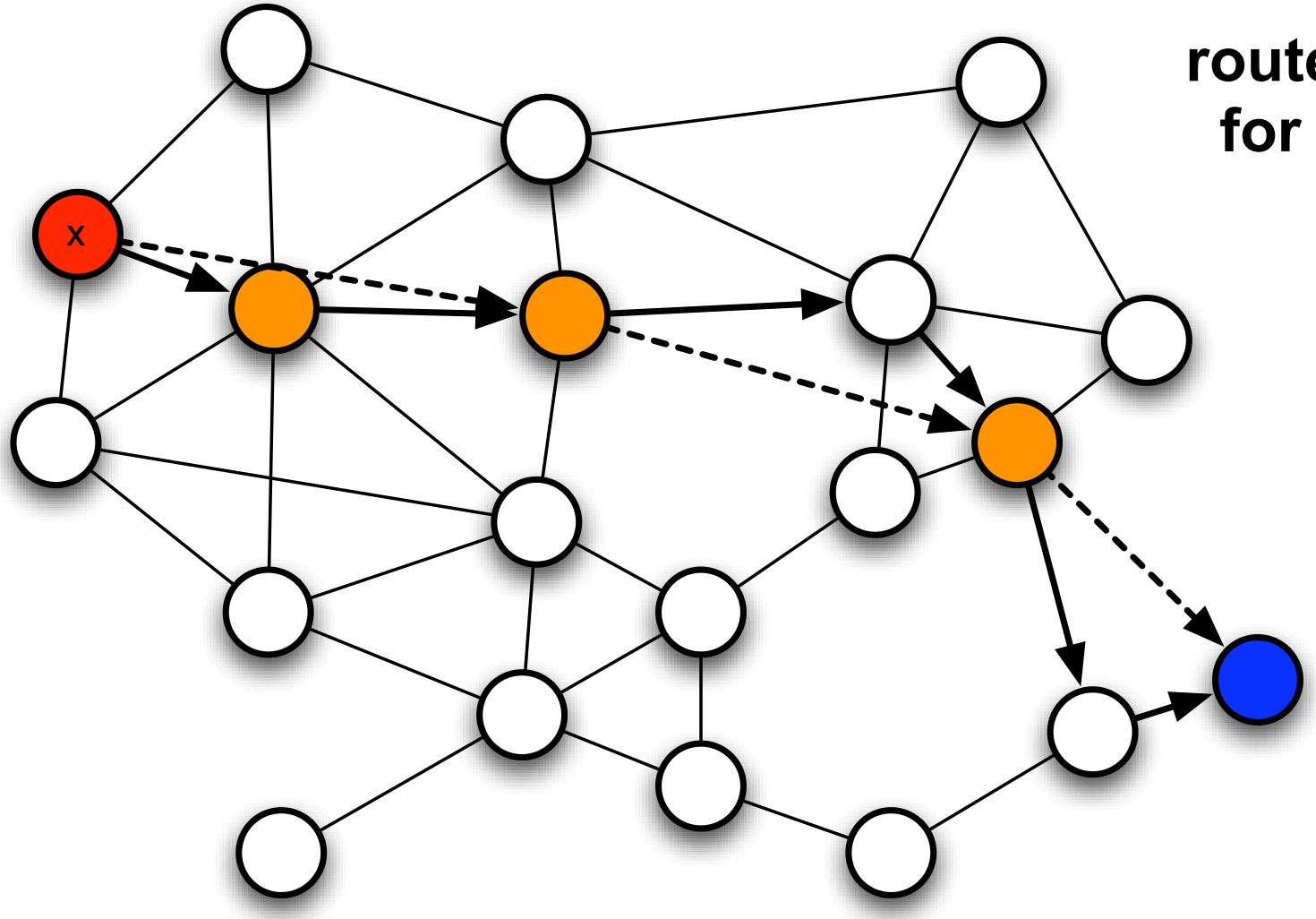
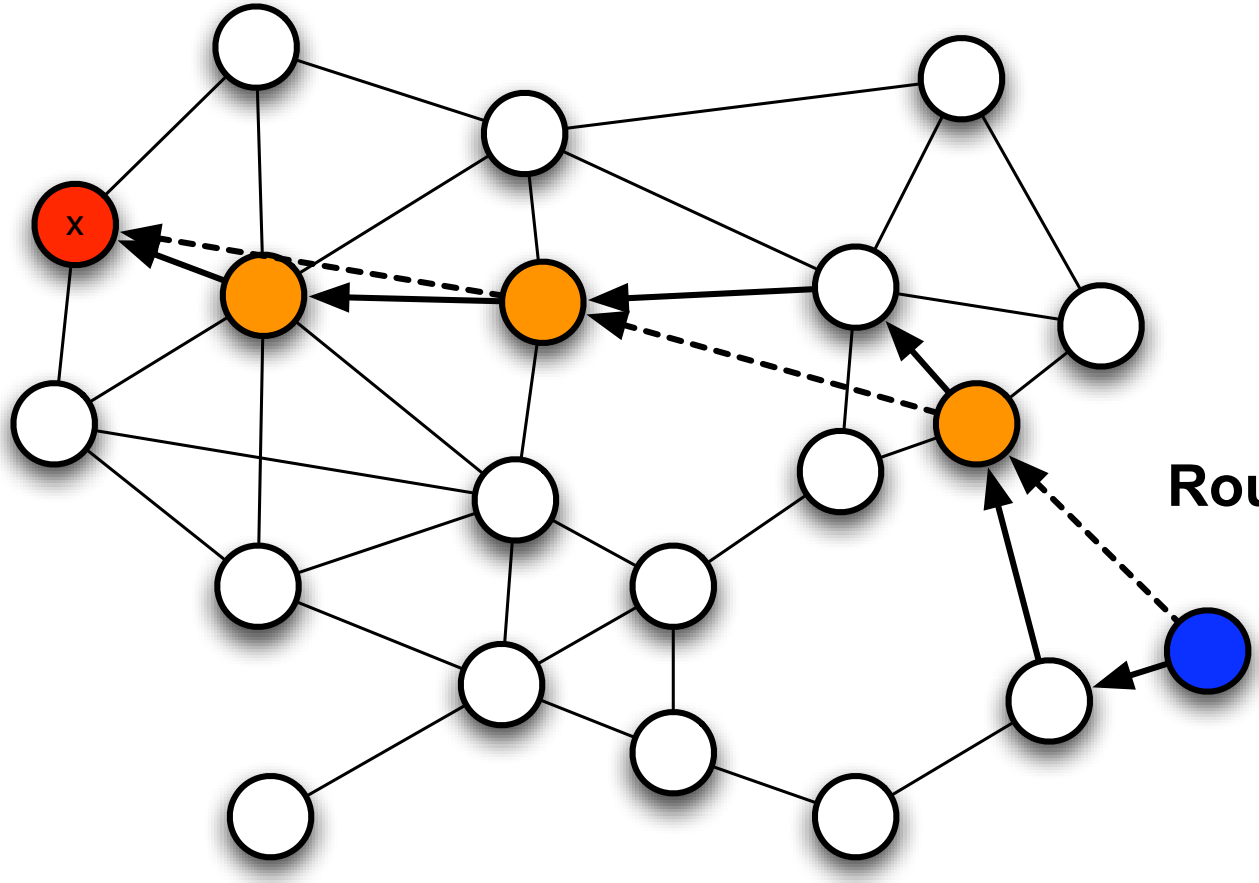



**route discovery for blue node**

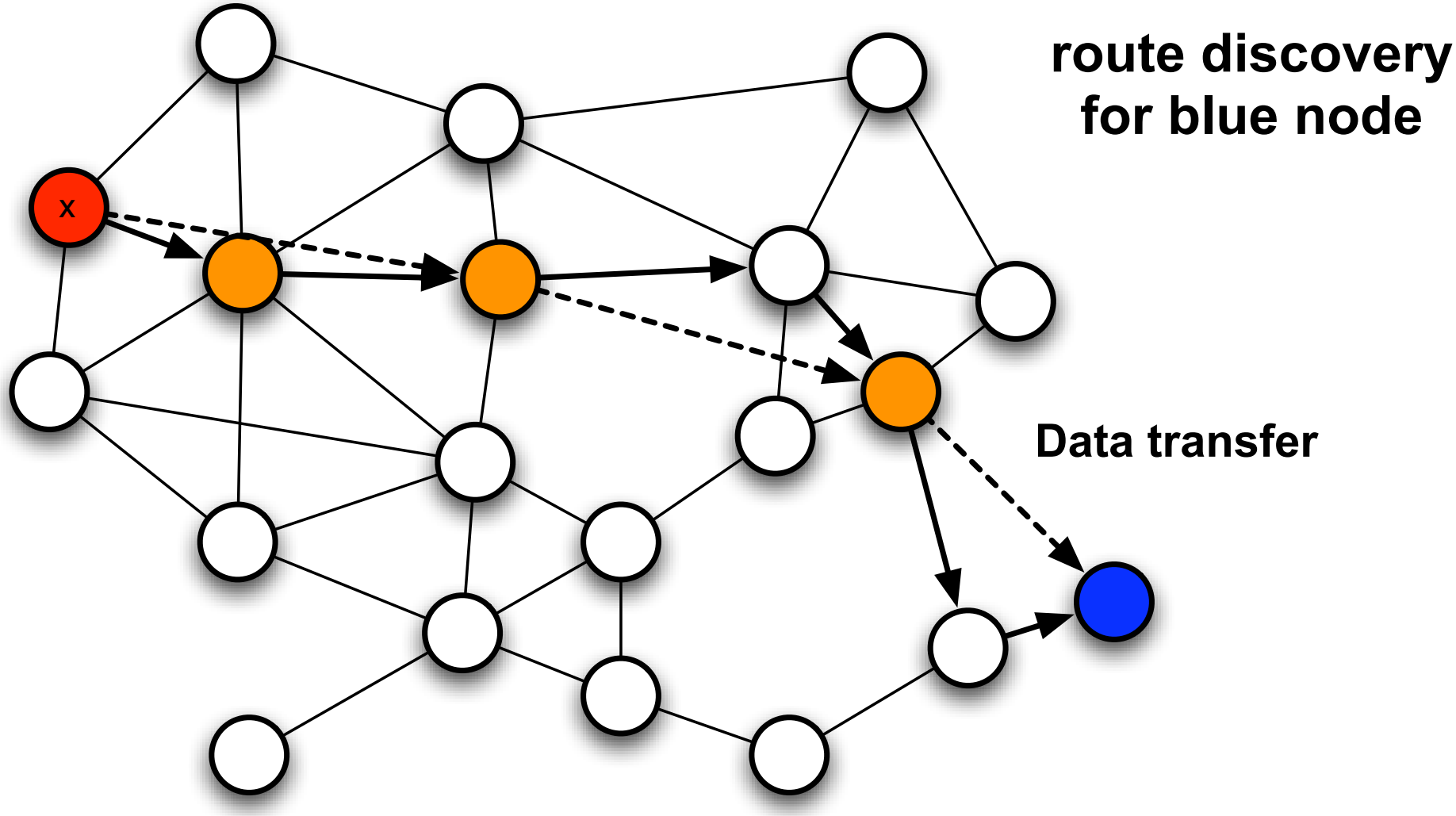
# ZRP: Example with radius d=2




route discovery
for blue node

Route Reply

# ZRP: Example with radius d=2



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