Mobile Ad Hoc Networks
Routing
9th Week
20.06.-22.06.2007

CoNe Freiburg

University of Freiburg
Computer Networks and Telematics
Prof. Christian Schindelhauer

Christian Schindelhauer
schindel@informatik.uni-freiburg.de

Reactive protocols – AODV

- **Ad hoc On Demand Distance Vector routing (AODV)**
  - Very popular routing protocol
  - Essentially same basic idea as DSR for discovery procedure
  - Nodes maintain routing tables instead of source routing
  - Sequence numbers added to handle stale caches
  - Nodes remember from where a packet came and populate routing tables with that information

Ad Hoc On-Demand Distance Vector Routing (AODV) [Perkins99Wmcsa]

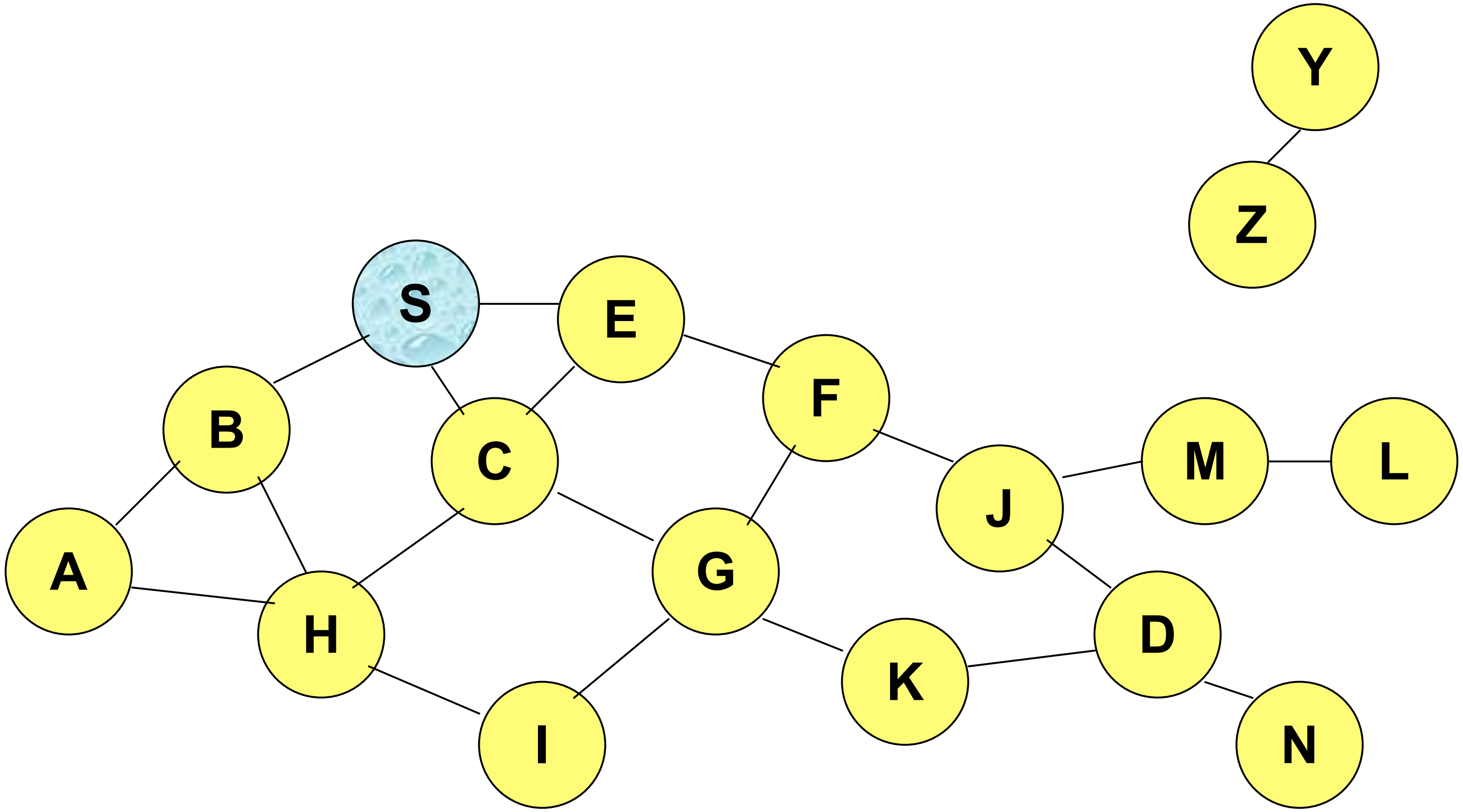
University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

- **DSR includes source routes in packet headers**
- **Resulting large headers can sometimes degrade performance**
  - particularly when data contents of a packet are small
- **AODV attempts to improve on DSR by maintaining routing tables at the nodes, so that data packets do not have to contain routes**
- **AODV retains the desirable feature of DSR that routes are maintained only between nodes which need to communicate**

AODV

- **Route Requests (RREQ) are forwarded in a manner similar to DSR**
- **When a node re-broadcasts a Route Request, it sets up a reverse path pointing towards the source**
  - AODV assumes symmetric (bi-directional) links
- **When the intended destination receives a Route Request, it replies by sending a Route Reply**
- **Route Reply travels along the reverse path set-up when Route Request is forwarded**

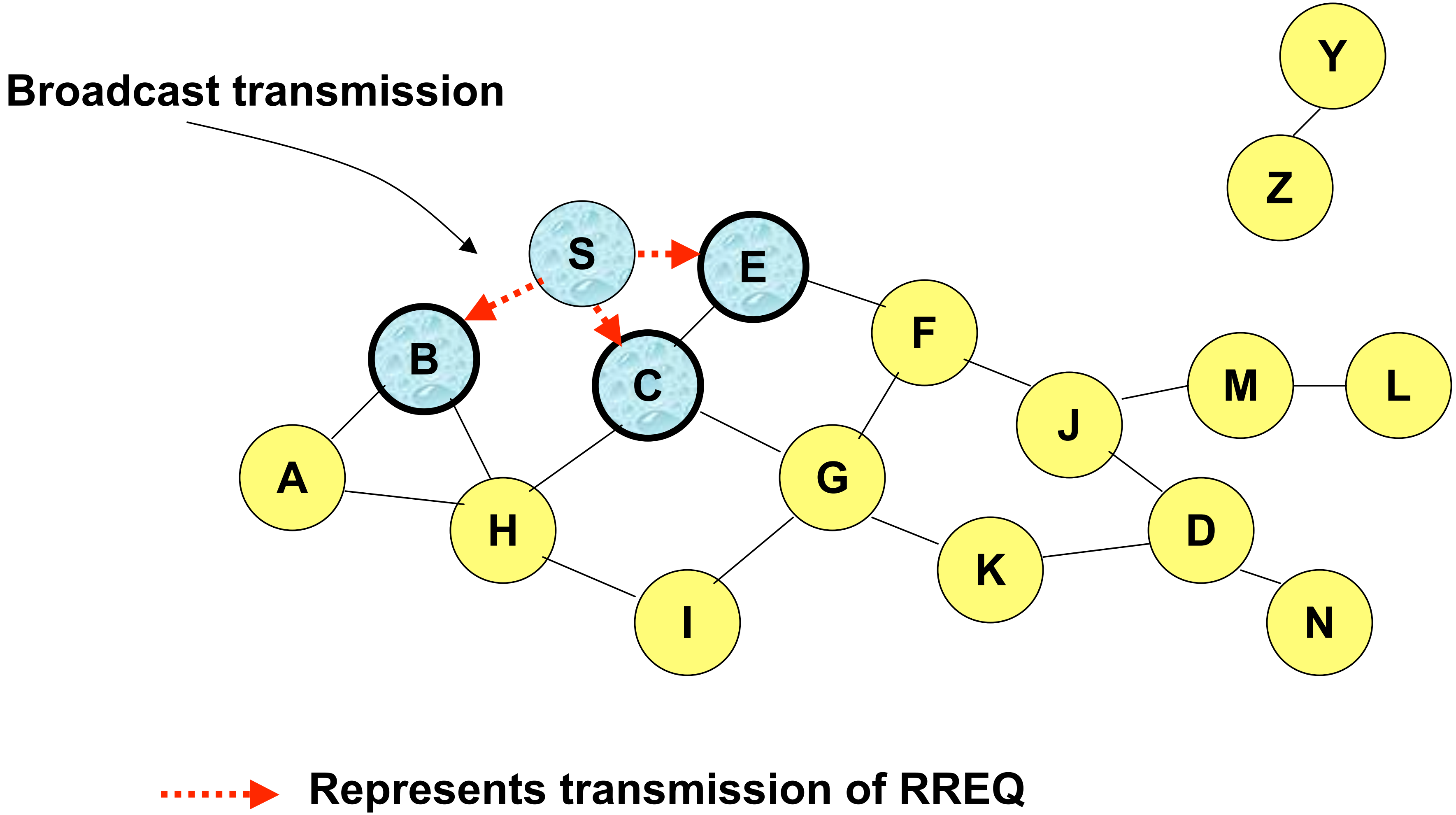
Route Requests in AODV



Represents a node that has received RREQ for D from S

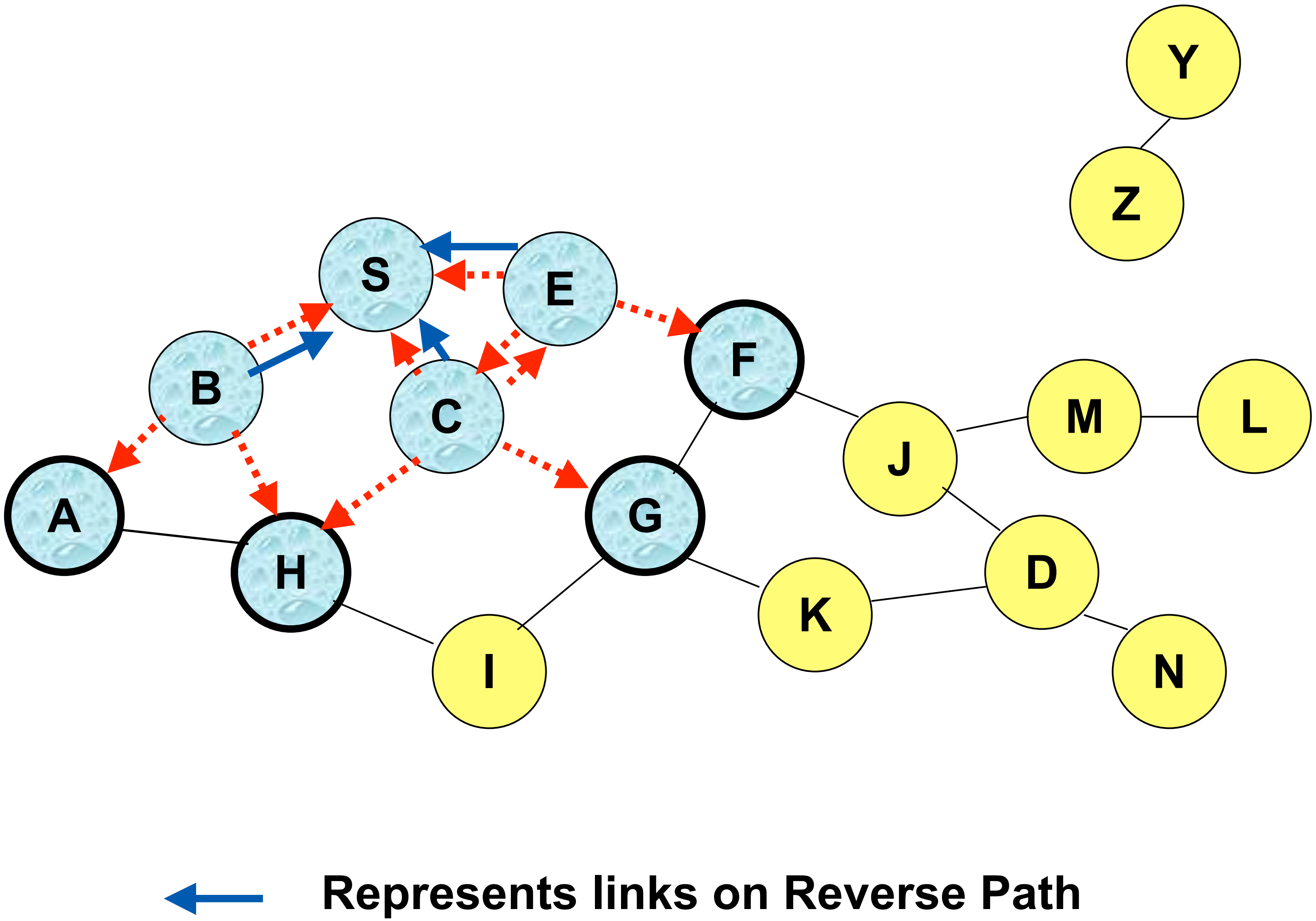
Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Route Requests in AODV



University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

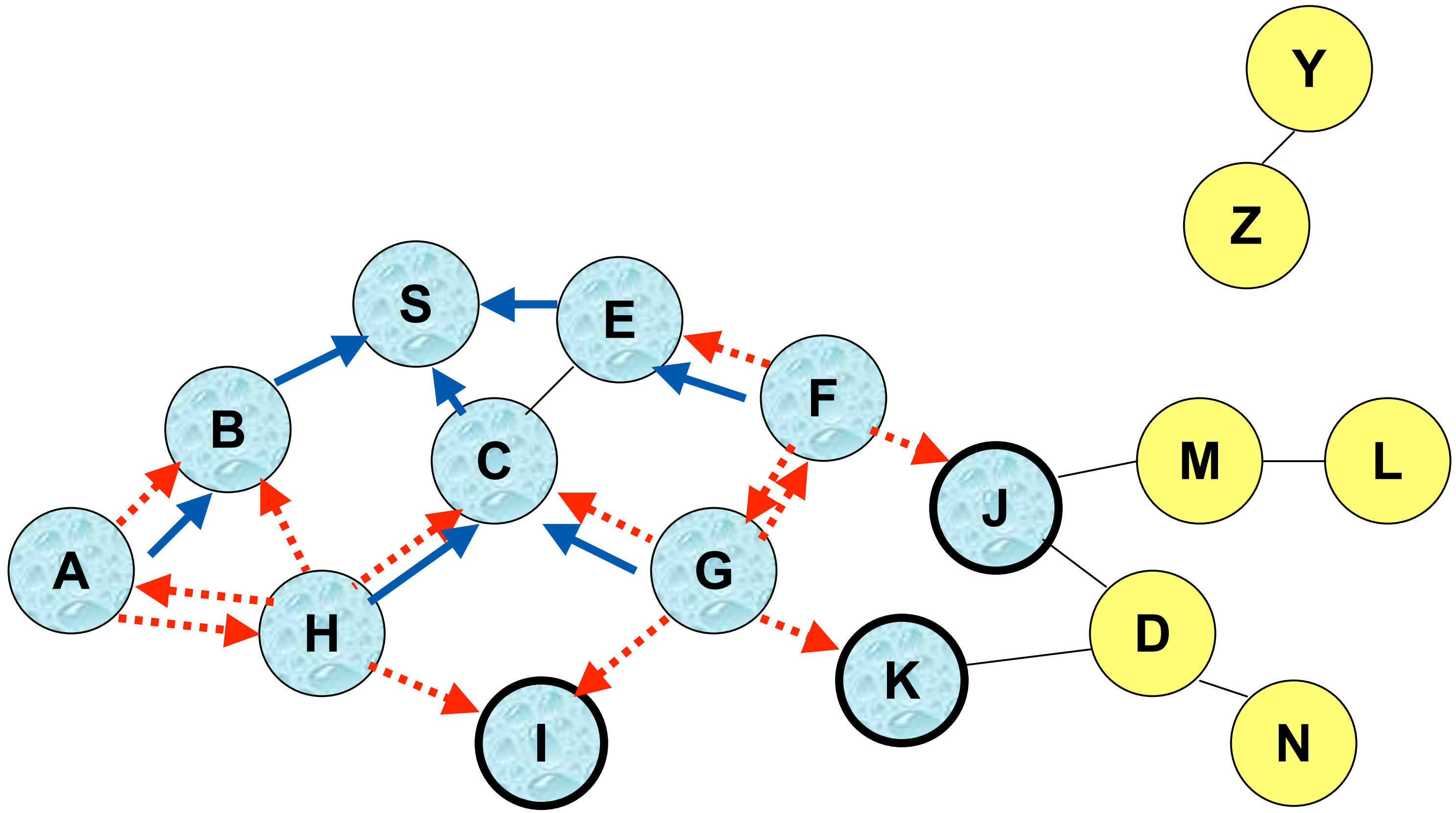
Route Requests in AODV



Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Reverse Path Setup in AODV

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

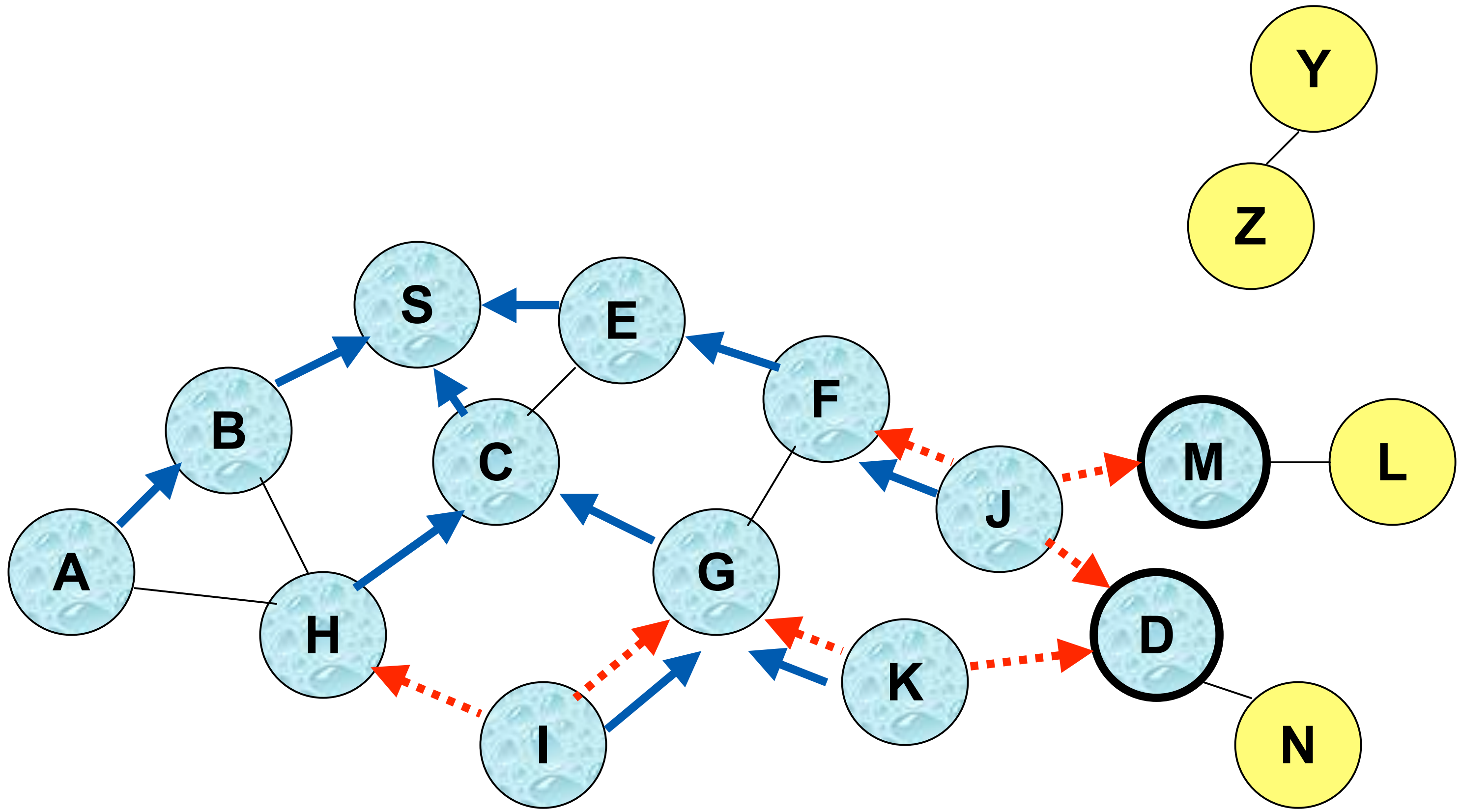


- Node C receives RREQ from G and H, but does not forward it again, because node C has already forwarded RREQ once

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Reverse Path Setup in AODV

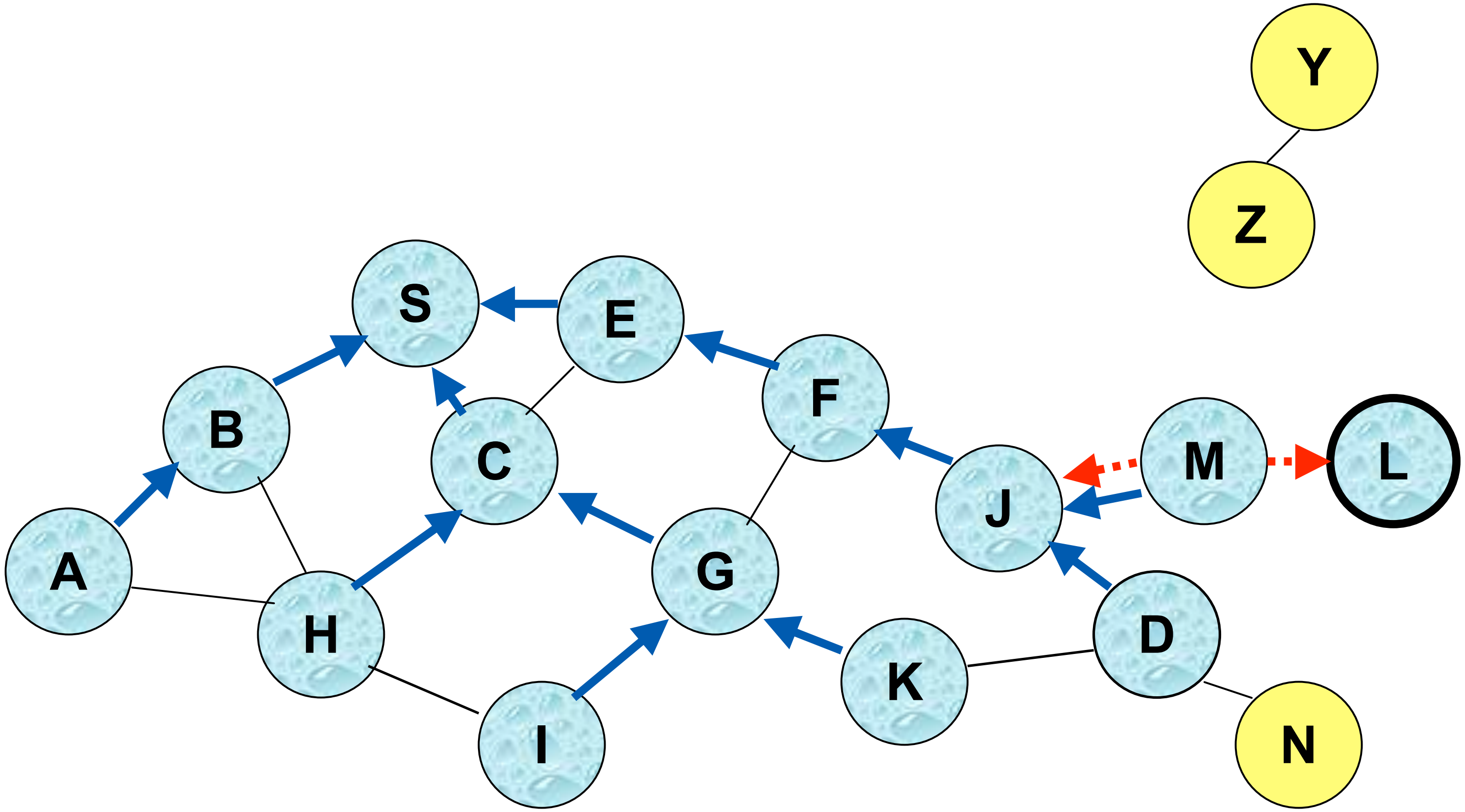
University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer



Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

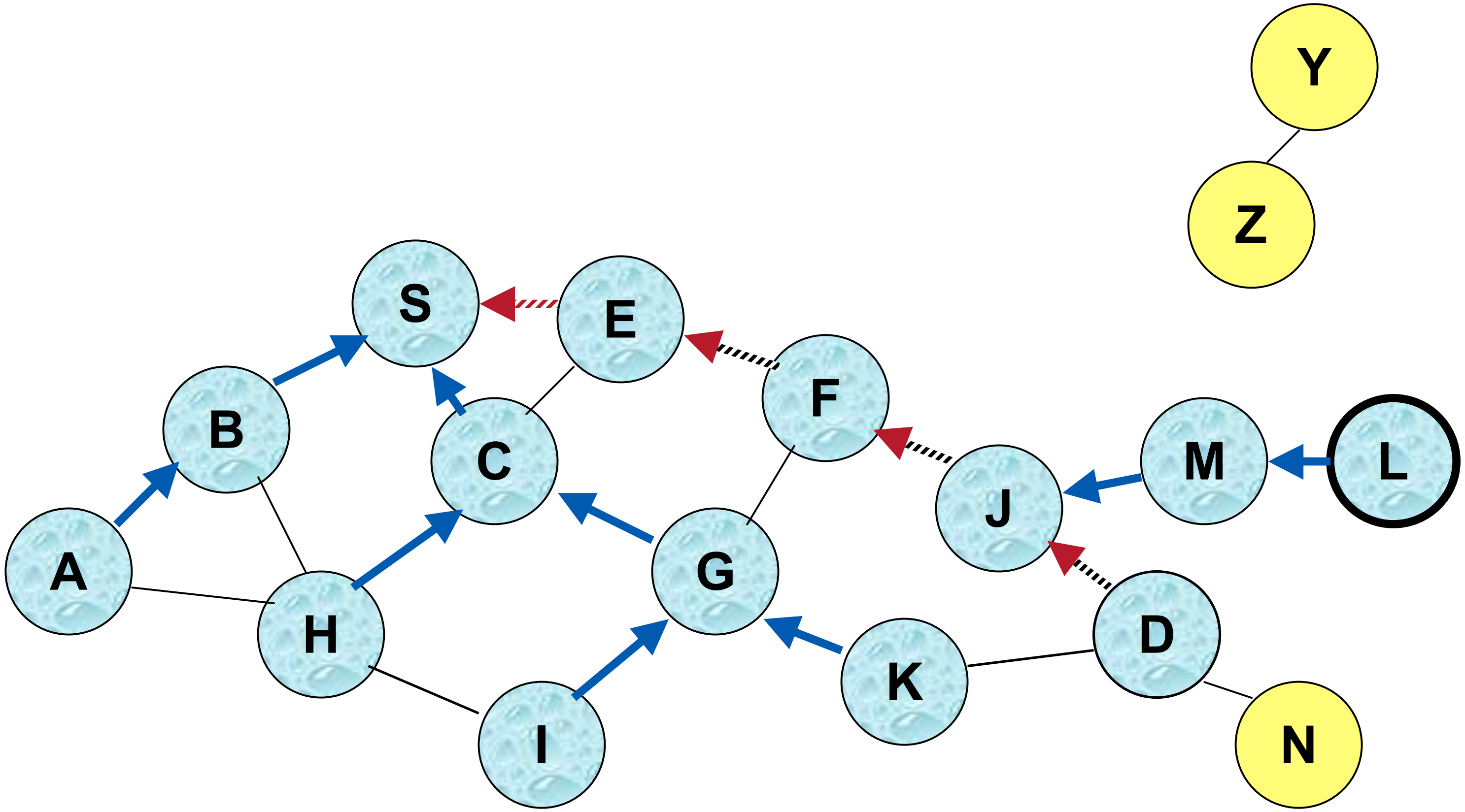
Reverse Path Setup in AODV



- **Node D does not forward RREQ, because node D is the intended target of the RREQ**

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Route Reply in AODV



Represents links on path taken by RREP

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Route Reply in AODV

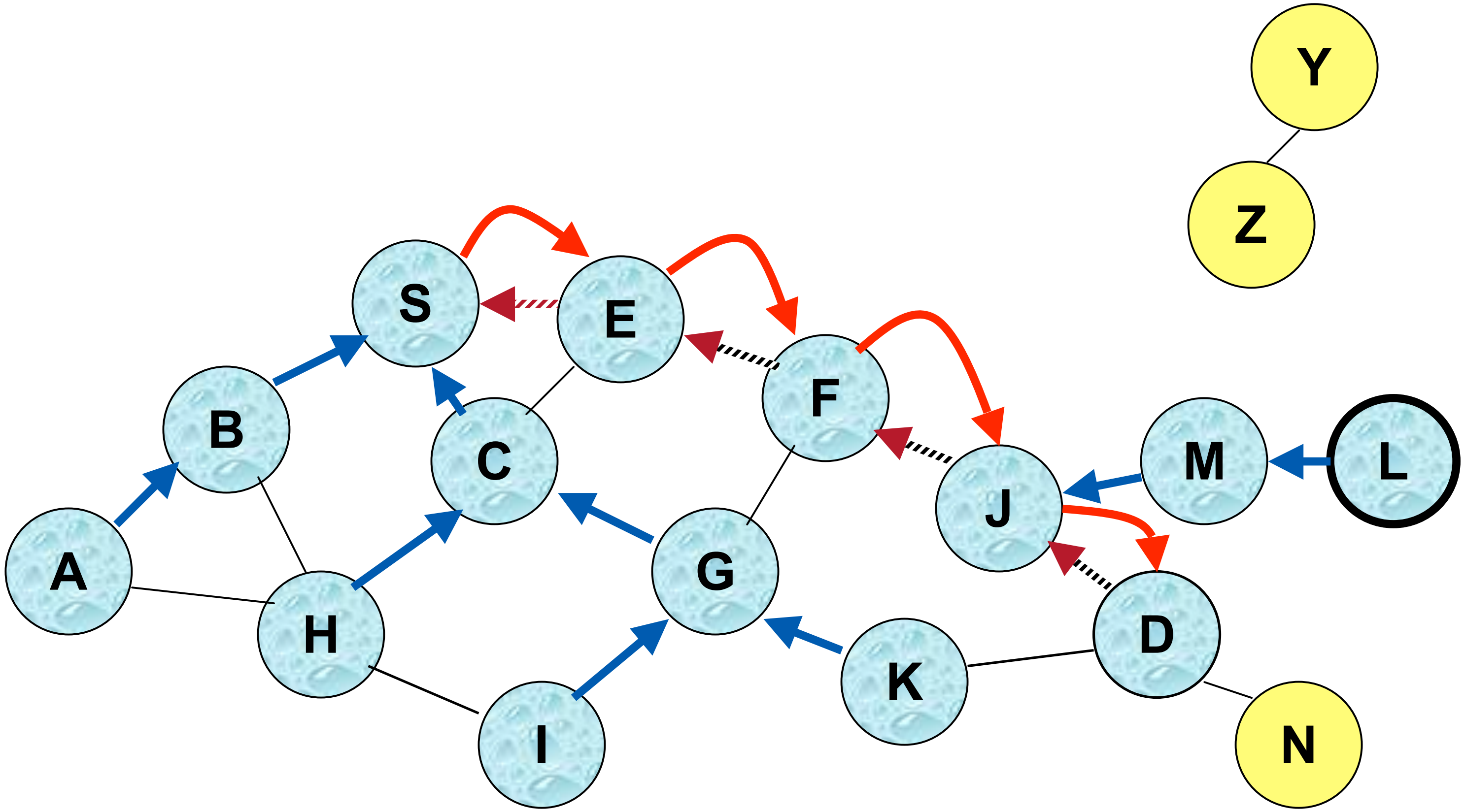
- **An intermediate node (not the destination) may also send a Route Reply (RREP) provided that it knows a more recent path than the one previously known to sender S**

- **To determine whether the path known to an intermediate node is more recent, *destination sequence numbers* are used**

- **The likelihood that an intermediate node will send a Route Reply when using AODV not as high as DSR**
  - A new Route Request by node S for a destination is assigned a higher destination sequence number. An intermediate node which knows a route, but with a smaller sequence number, cannot send Route Reply

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Forward Path Setup in AODV

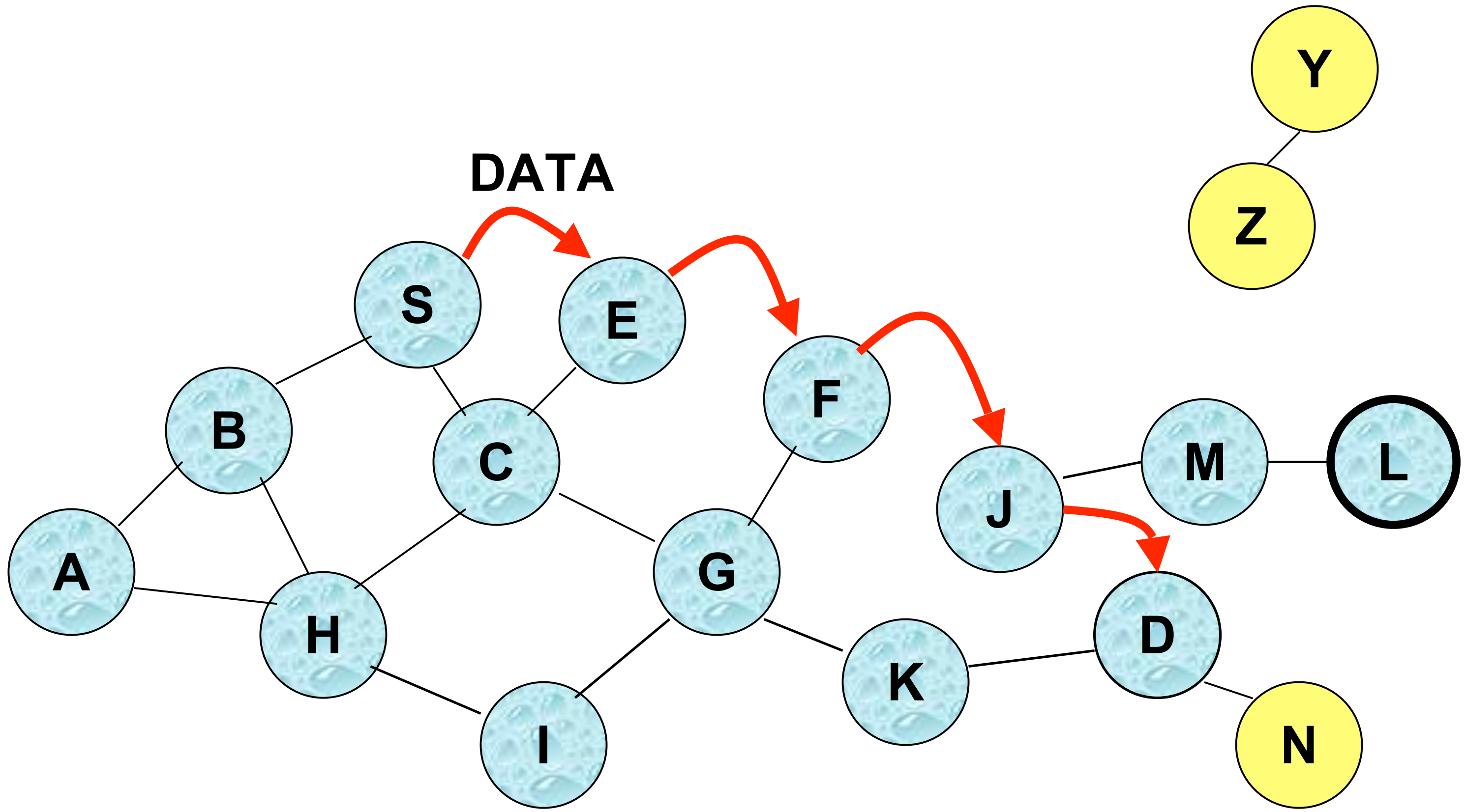


Forward links are setup when RREP travels along the reverse path


Represents a link on the forward path

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Data Delivery in AODV



Routing table entries used to forward data packet.
Route is *not* included in packet header.

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Timeouts

- **A routing table entry maintaining a reverse path is purged after a timeout interval**
  - timeout should be long enough to allow RREP to come back
- **A routing table entry maintaining a forward path is purged if *not used* for a *active_route_timeout* interval**
  - if no data is being sent using a particular routing table entry, that entry will be deleted from the routing table (even if the route may actually still be valid)

Link Failure Reporting

- A neighbor of node X is considered active for a routing table entry if the neighbor sent a packet within *active_route_timeout* interval which was forwarded using that entry

- When the next hop link in a routing table entry breaks, all active neighbors are informed

- Link failures are propagated by means of Route Error messages, which also update destination sequence numbers

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Route Error

- **When node X is unable to forward packet P (from node S to node D) on link (X,Y), it generates a RERR message**
- **Node X increments the destination sequence number for D cached at node X**
- **The incremented sequence number *N* is included in the RERR**
- **When node S receives the RERR, it initiates a new route discovery for D using destination sequence number at least as large as *N***

Link Failure Detection

- *Hello* messages: Neighboring nodes periodically exchange hello message
- Absence of hello message is used as an indication of link failure
- Alternatively, failure to receive several MAC-level acknowledgement may be used as an indication of link failure
- When node D receives the route request with destination sequence number N, node D will set its sequence number to N, unless it is already larger than N

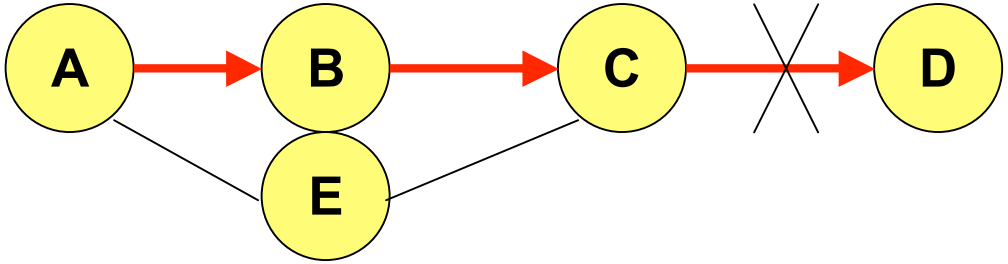
Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Why Sequence Numbers in AODV

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

- **To avoid using old/broken routes**
  - To determine which route is newer

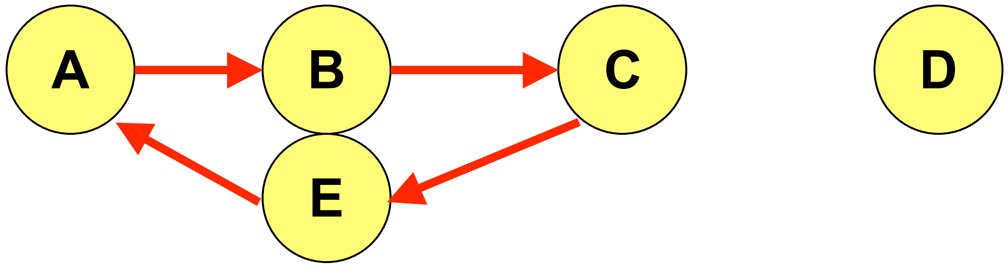
- **To prevent formation of loops**



  - Assume that A does not know about failure of link C-D because RERR sent by C is lost
  - Now C performs a route discovery for D. Node A receives the RREQ (say, via path C-E-A)
  - Node A will reply since A knows a route to D via node B
  - Results in a loop (for instance, C-E-A-B-C)

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Why Sequence Numbers in AODV



– Loop C-E-A-B-C

Optimization: Expanding Ring Search

- **Route Requests are initially sent with small Time-to-Live (TTL) field, to limit their propagation**
  - DSR also includes a similar optimization
- **If no Route Reply is received, then larger TTL tried**

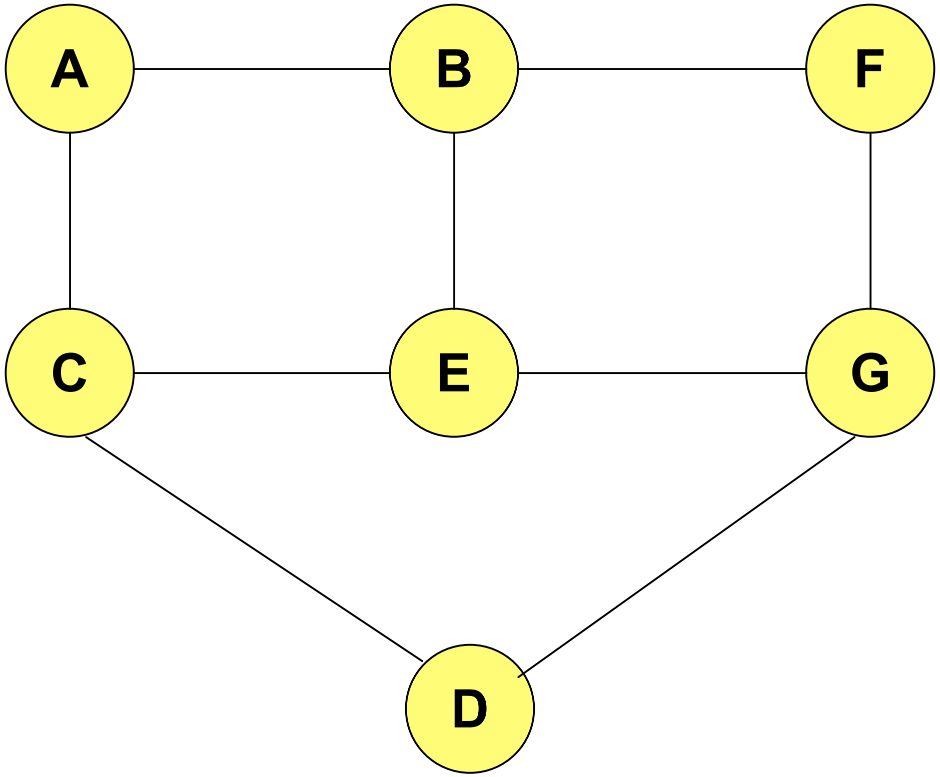
Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Summary: AODV

- **Routes need not be included in packet headers**
- **Nodes maintain routing tables containing entries only for routes that are in active use**
- **At most one next-hop per destination maintained at each node**
  - Multi-path extensions can be designed
  - DSR may maintain several routes for a single destination
- **Unused routes expire even if topology does not change**

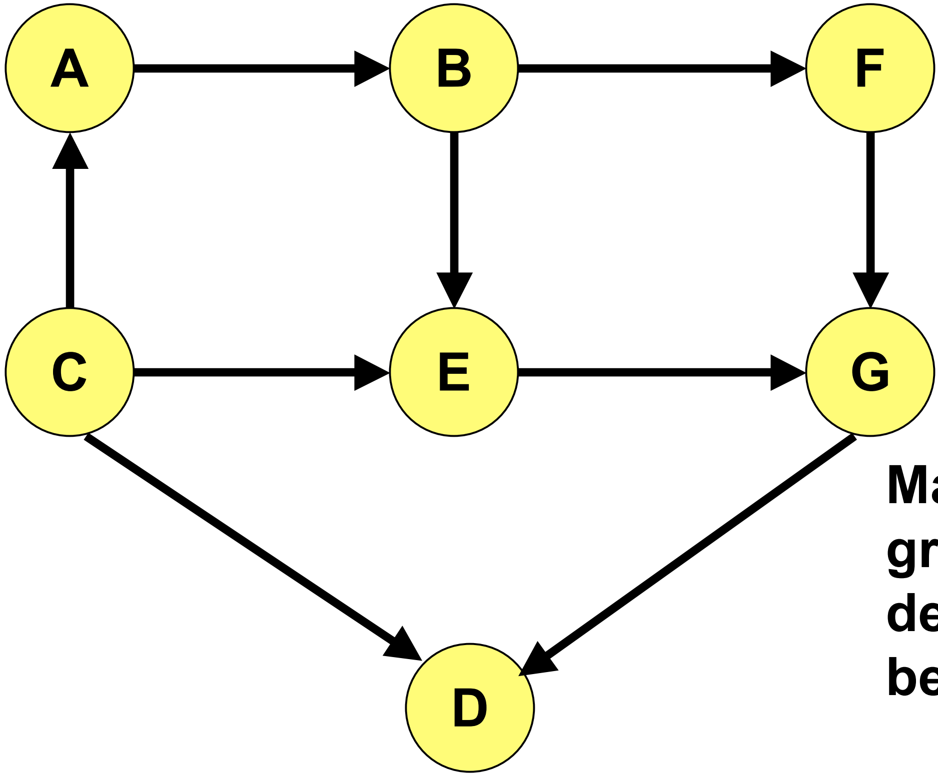
Link Reversal Algorithm

[Gafni81]



Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Link Reversal Algorithm



Links are bi-directional

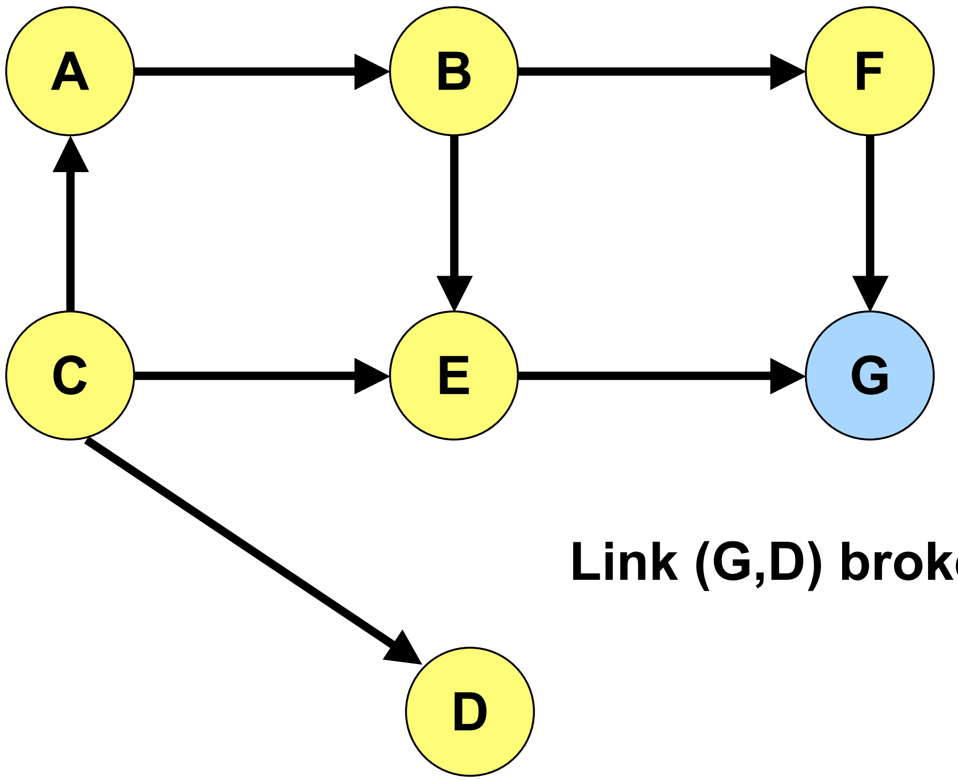
But algorithm imposes logical directions on them

Maintain a directed acyclic graph (DAG) for each destination, with the destination being the *only sink*

This DAG is for *destination node D*

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Link Reversal Algorithm

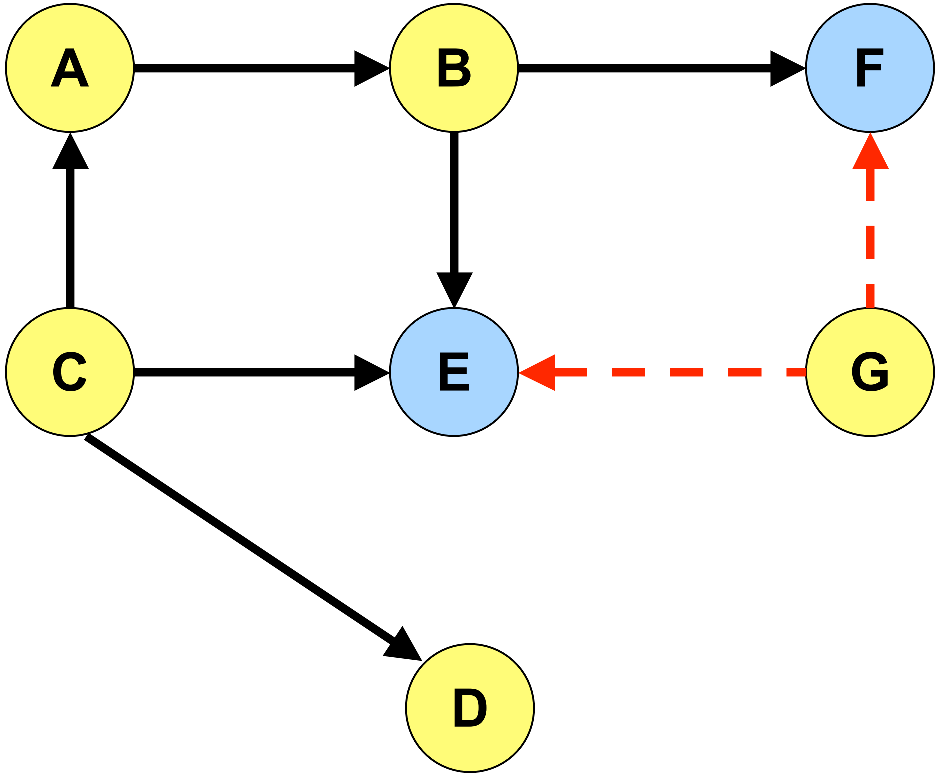


Link (G,D) broke

Any node, other than the destination, that has no outgoing links reverses all its incoming links.
Node G has no outgoing links

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Link Reversal Algorithm

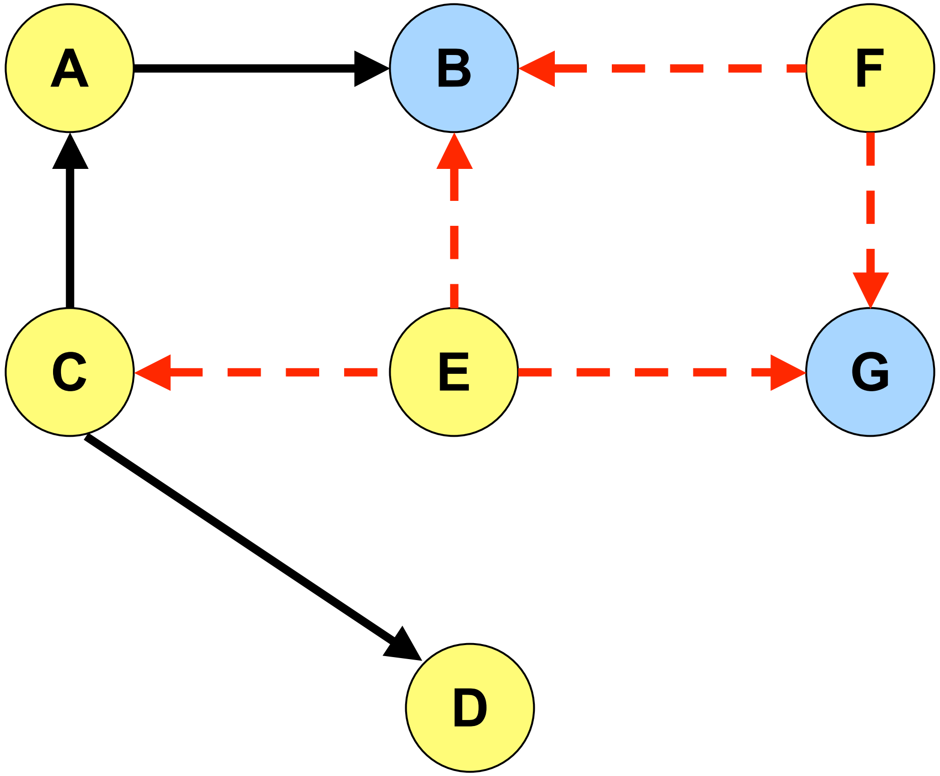


Represents a link that was reversed recently

Now nodes E and F have no outgoing links

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Link Reversal Algorithm

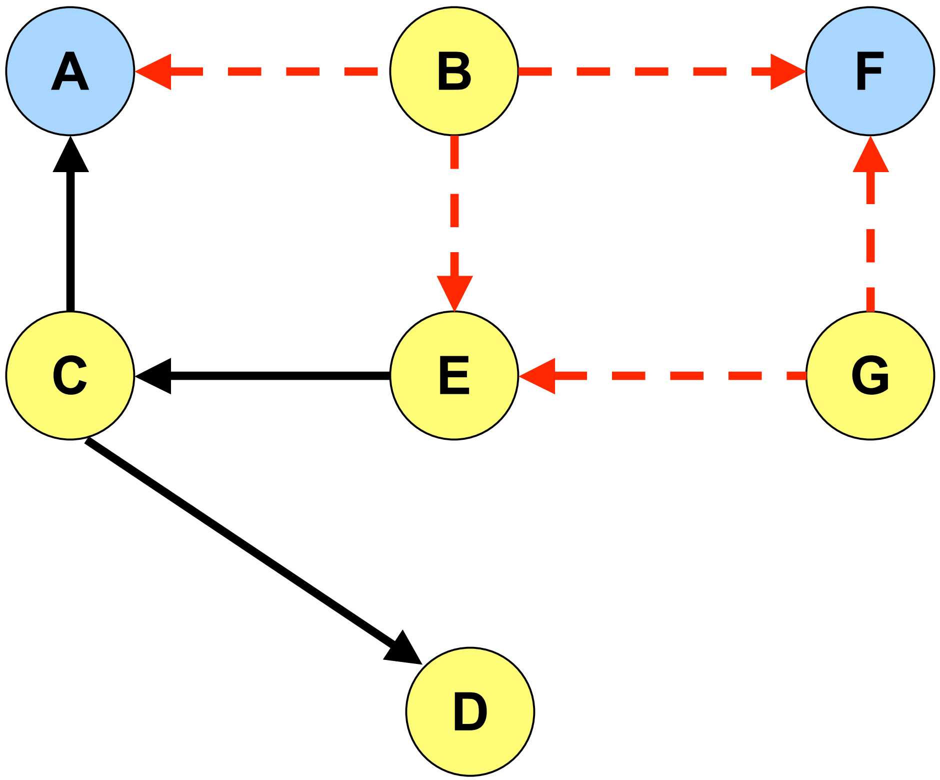


Represents a link that was reversed recently

Now nodes B and G have no outgoing links

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Link Reversal Algorithm

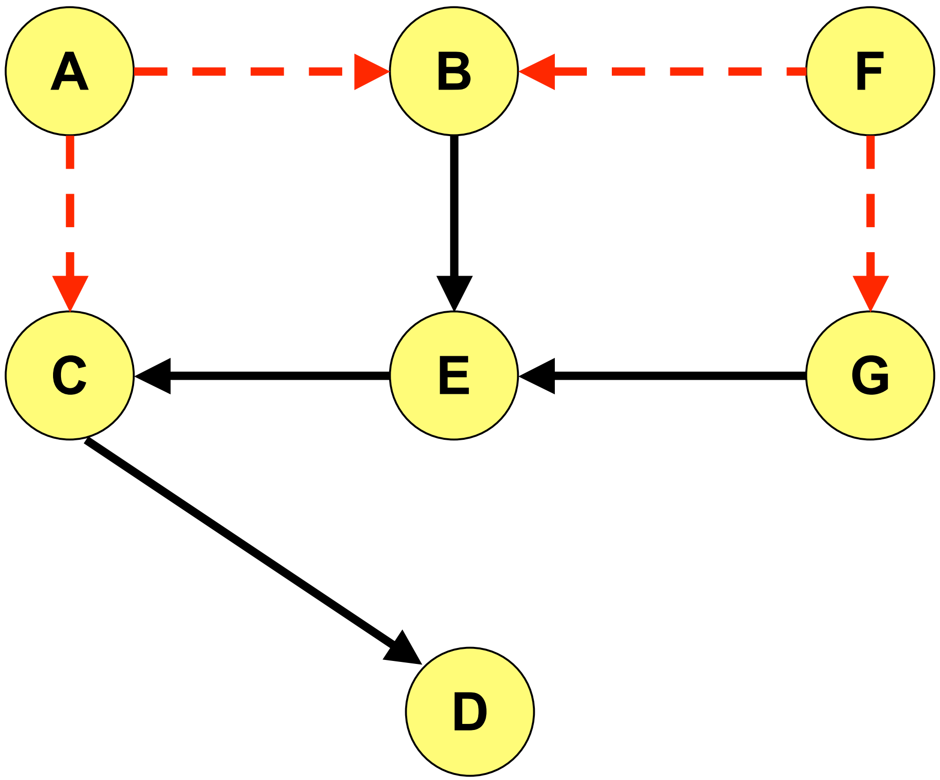


Represents a link that was reversed recently

Now nodes A and F have no outgoing links

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Link Reversal Algorithm

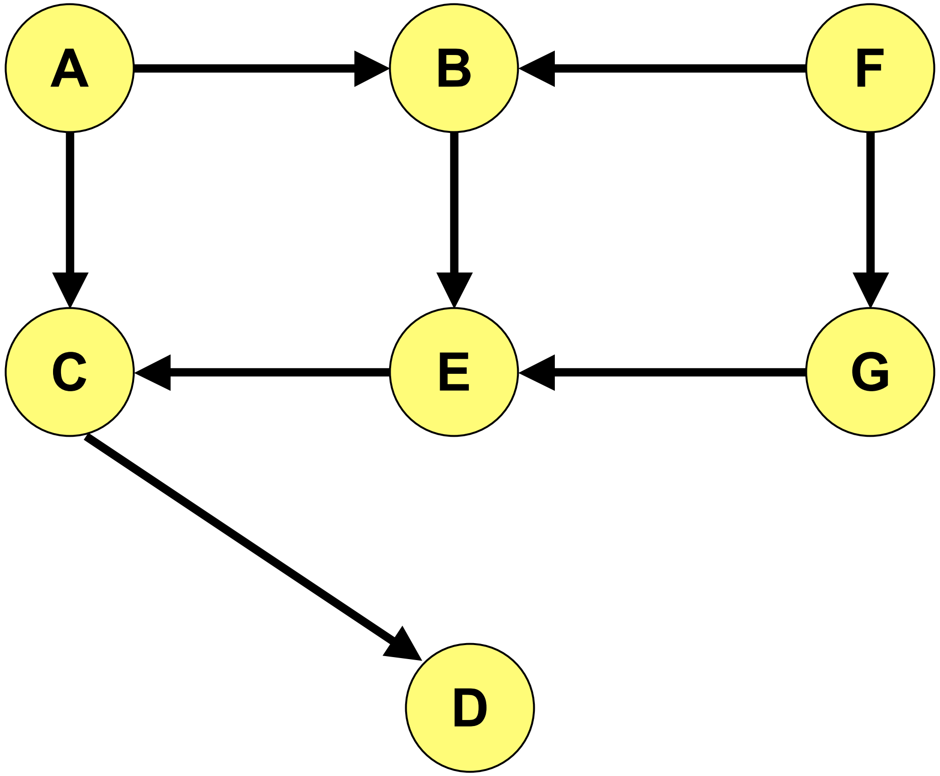


Represents a link that was reversed recently

Now all nodes (other than destination D) have an outgoing link

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Link Reversal Algorithm



DAG has been restored with only the destination as a sink

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Link Reversal Algorithm

- **Attempts to keep link reversals local to where the failure occurred**
  - But this is not guaranteed
- **When the first packet is sent to a destination, the destination oriented DAG is constructed**
- **The initial construction does result in flooding of control packets**

Link Reversal Algorithm

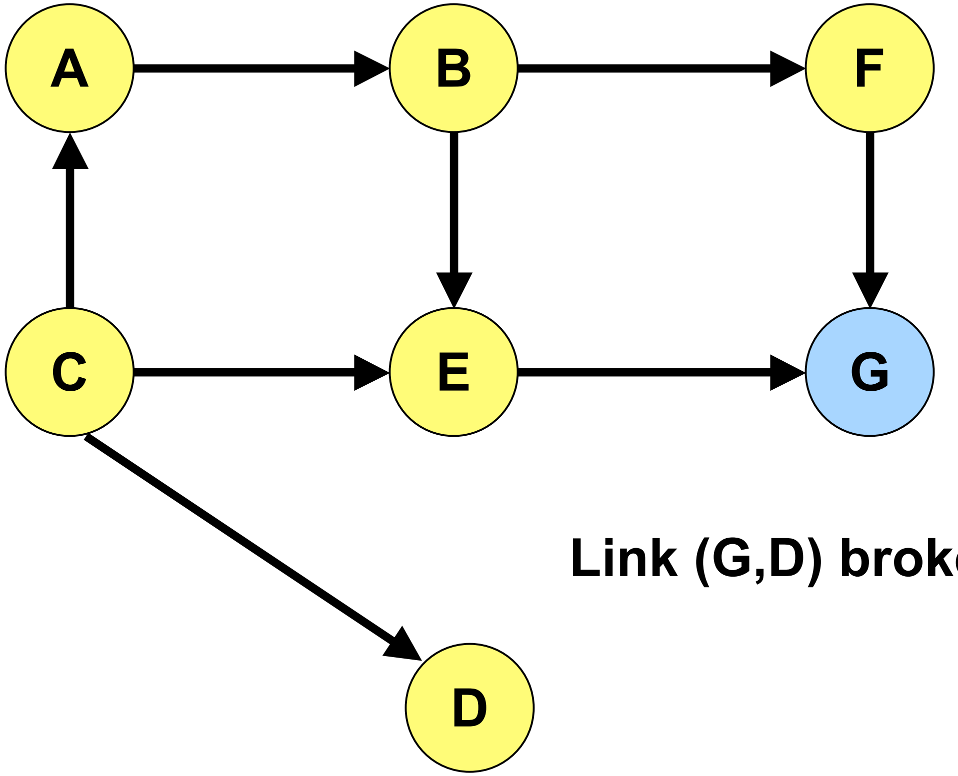
University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

- **The previous algorithm is called a full reversal method since when a node reverses links, it reverses *all* its incoming links**

- **Partial reversal method [Gafni81]: A node reverses incoming links from only those neighbors who have not themselves reversed links "previously"**
  - If all neighbors have reversed links, then the node reverses all its incoming links
  - "Previously" at node X means *since the last link reversal done by node X*

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Partial Reversal Method

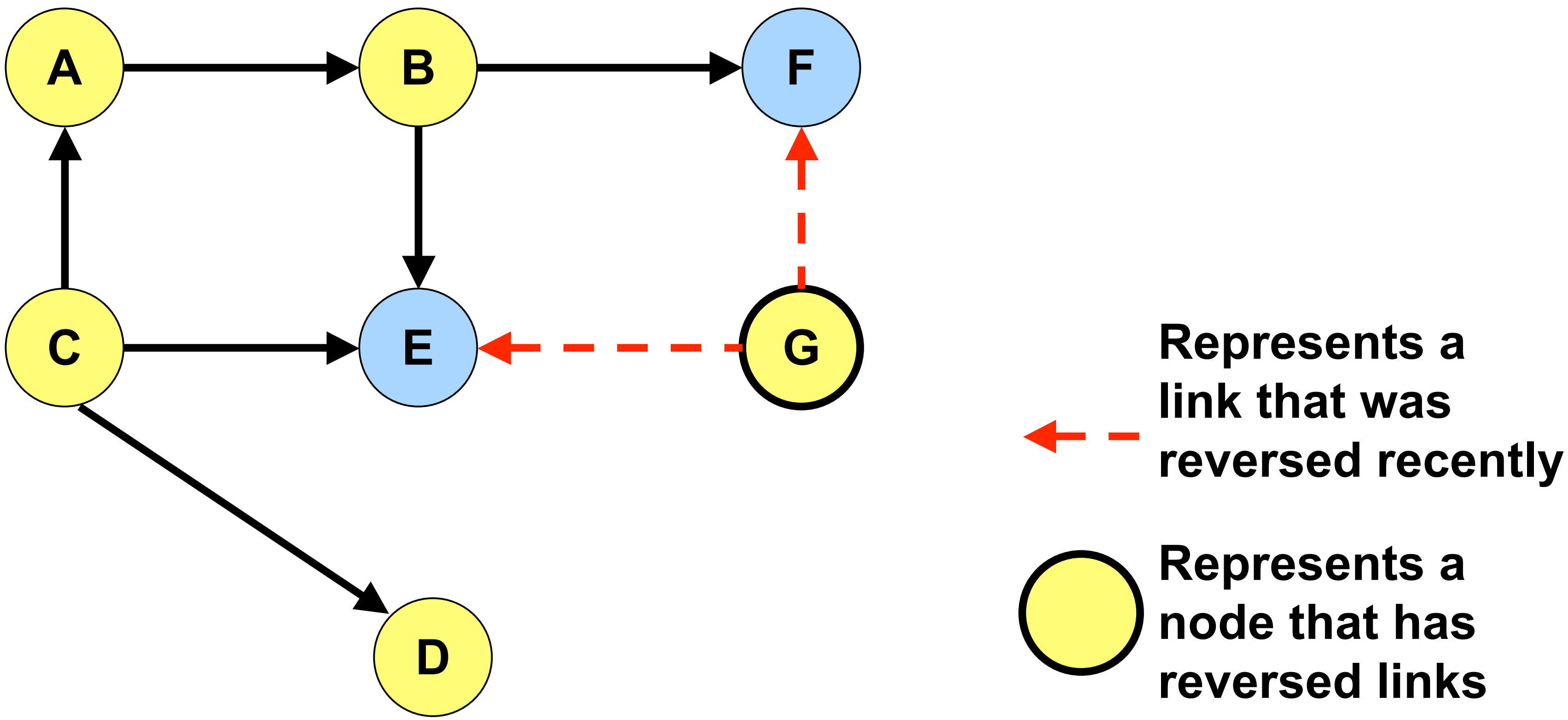


Link (G,D) broke

Node G has no outgoing links

Partial Reversal Method

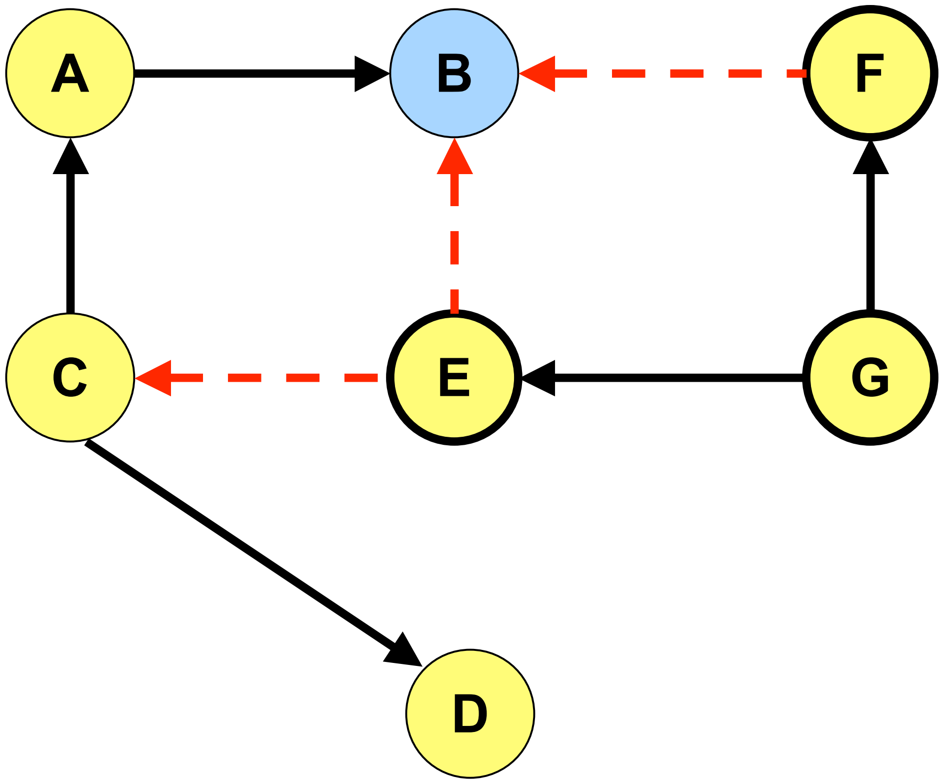
University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer



Now nodes E and F have no outgoing links

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

Partial Reversal Method



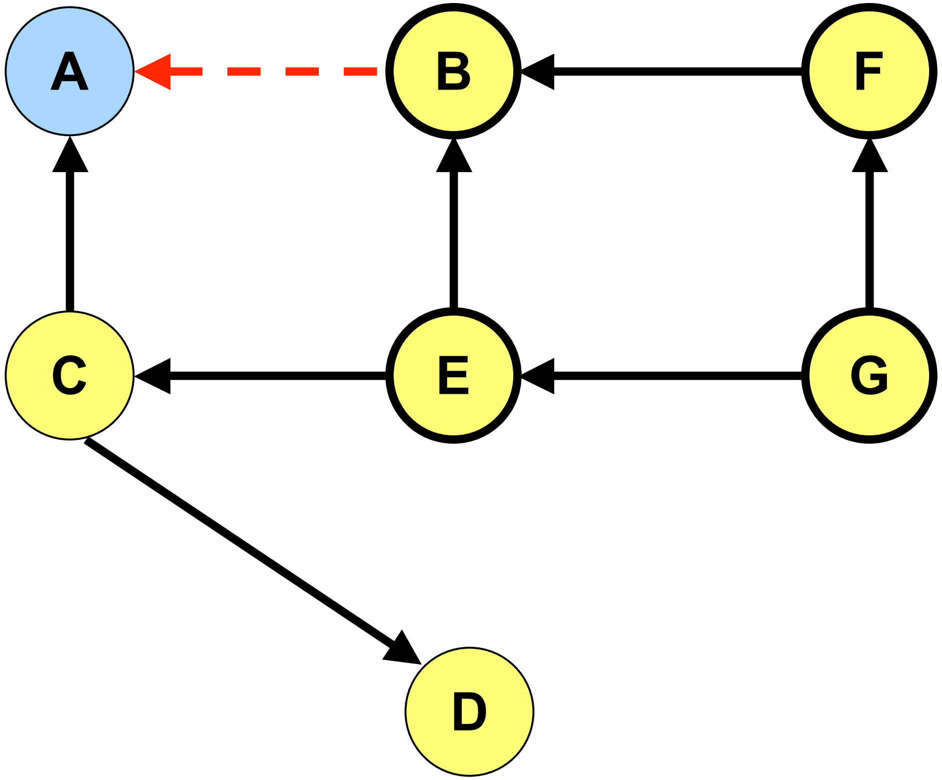
Represents a link that was reversed recently

Nodes E and F *do not* reverse links from node G
Now node B has no outgoing links

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

Partial Reversal Method

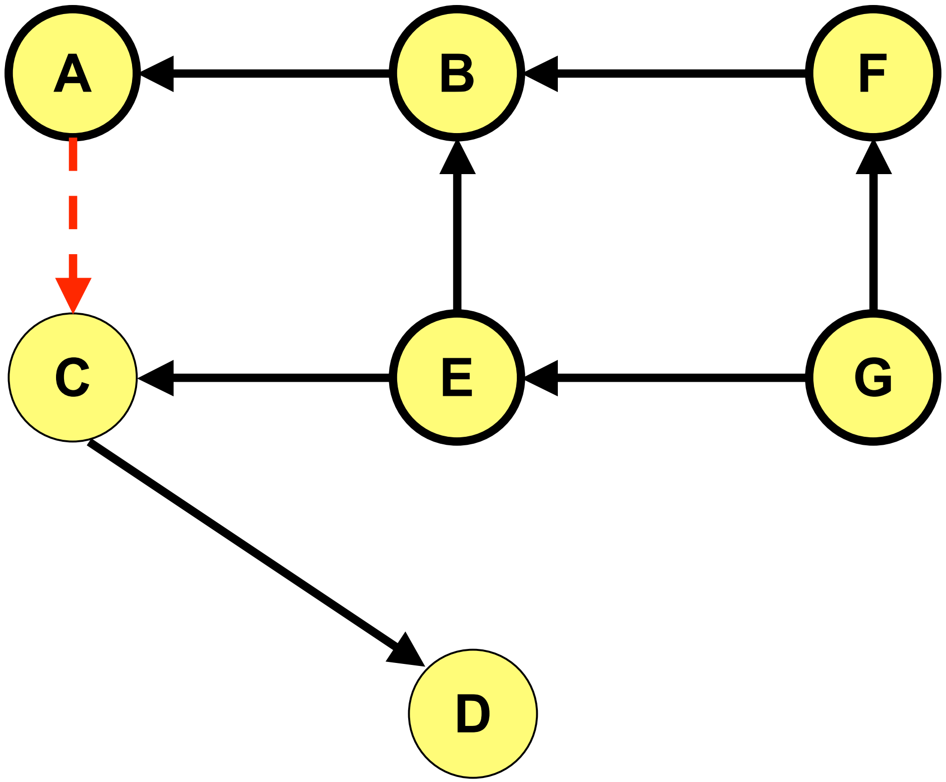


Represents a link that was reversed recently

Now node A has no outgoing links

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

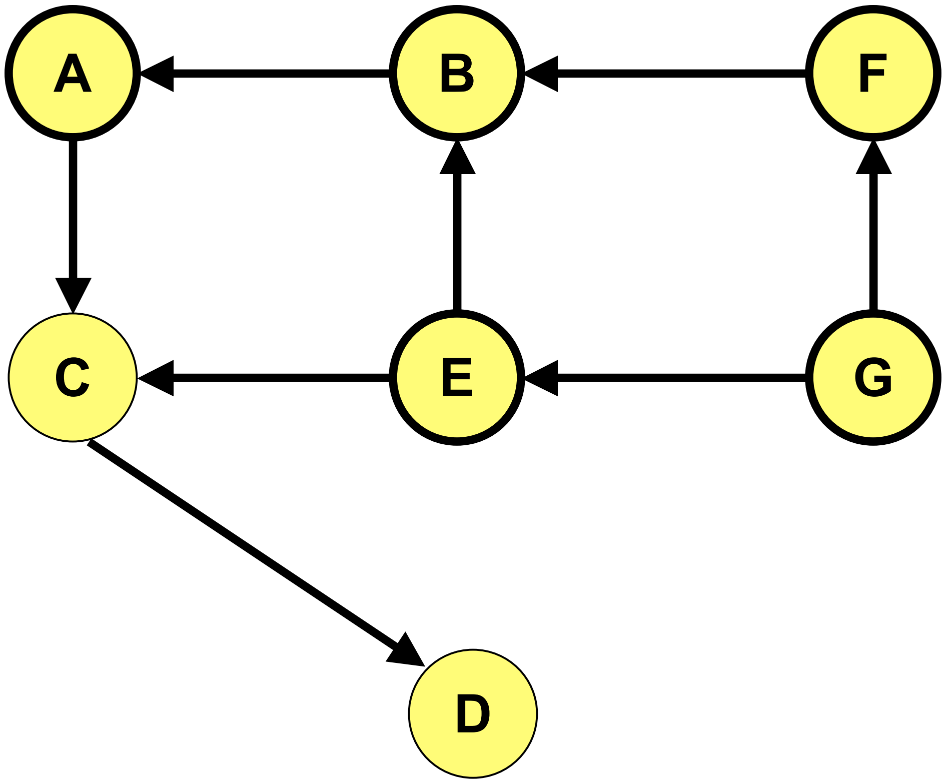
Partial Reversal Method



Represents a link that was reversed recently

Now all nodes (except destination D) have outgoing links

Partial Reversal Method



DAG has been restored with only the destination as a sink

Link Reversal Methods: Advantages

- Link reversal methods attempt to limit updates to routing tables at nodes in the vicinity of a broken link

- Each node may potentially have multiple routes to a destination

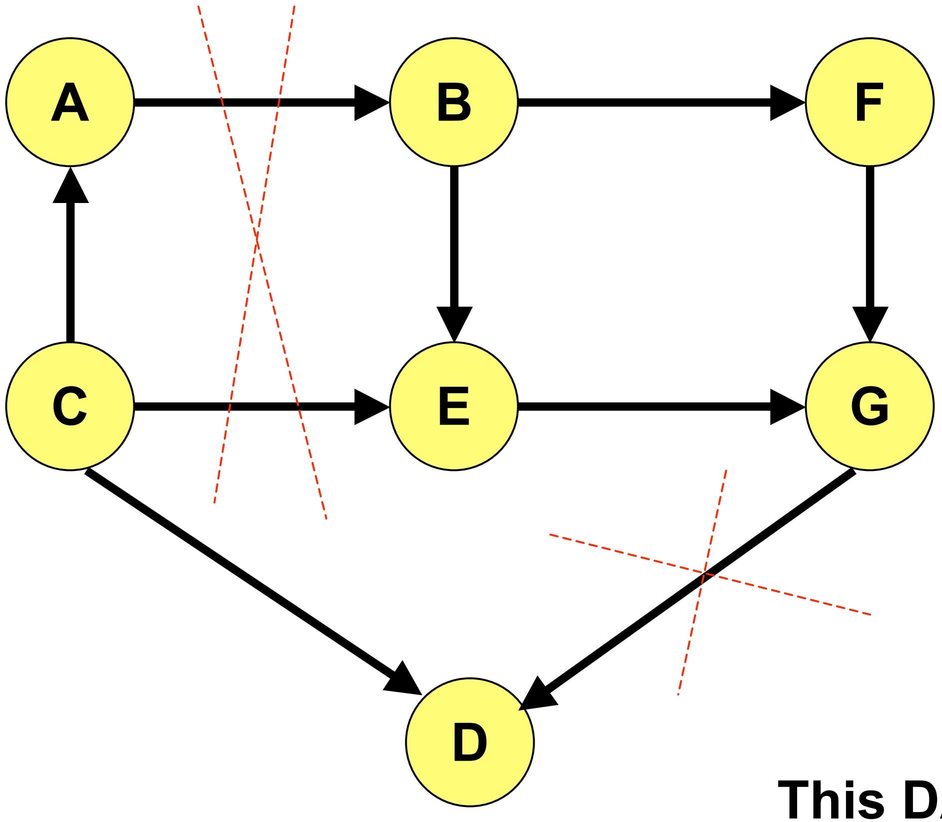
Link Reversal Methods: Disadvantage

- **Need a mechanism to detect link failure**
  - hello messages may be used
  - but hello messages can add to contention

- **If network is partitioned, link reversals continue indefinitely**

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Link Reversal in a Partitioned Network

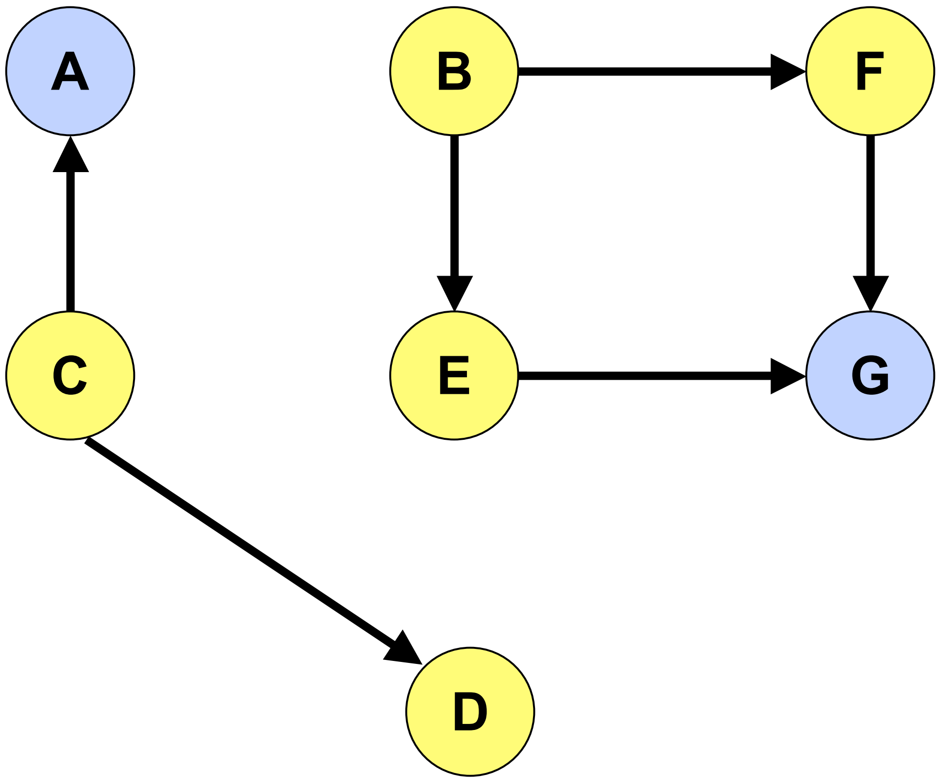


This DAG is for *destination node D*

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Full Reversal in a Partitioned Network

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

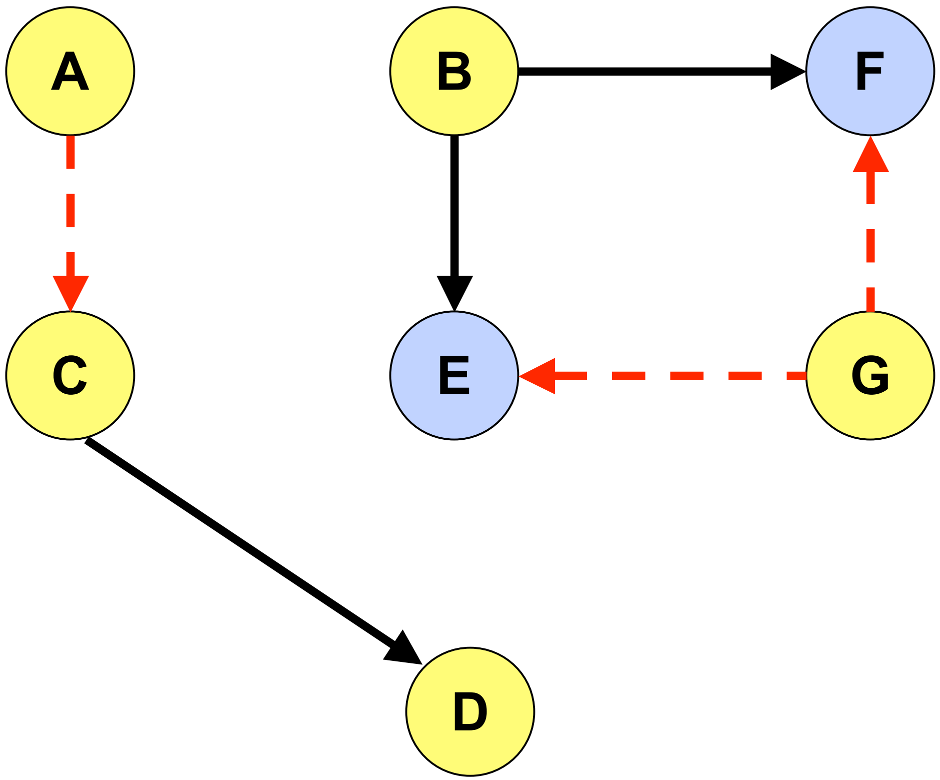


A and G do not have outgoing links

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Full Reversal in a Partitioned Network

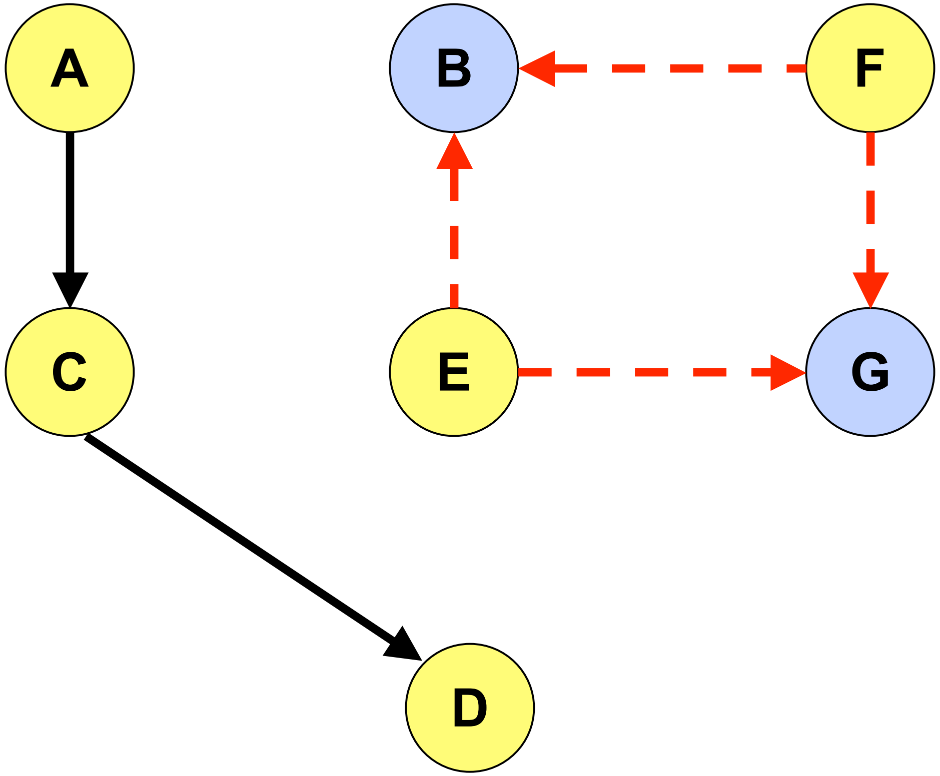
University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer



E and F do not have outgoing links

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Full Reversal in a Partitioned Network

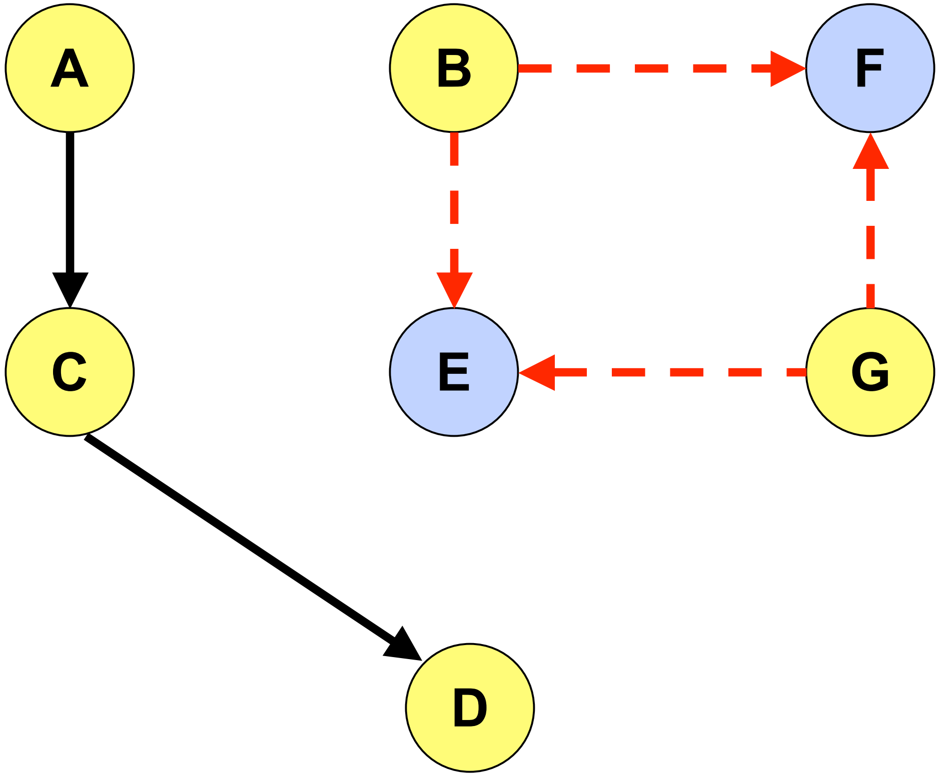


B and G do not have outgoing links

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Full Reversal in a Partitioned Network

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

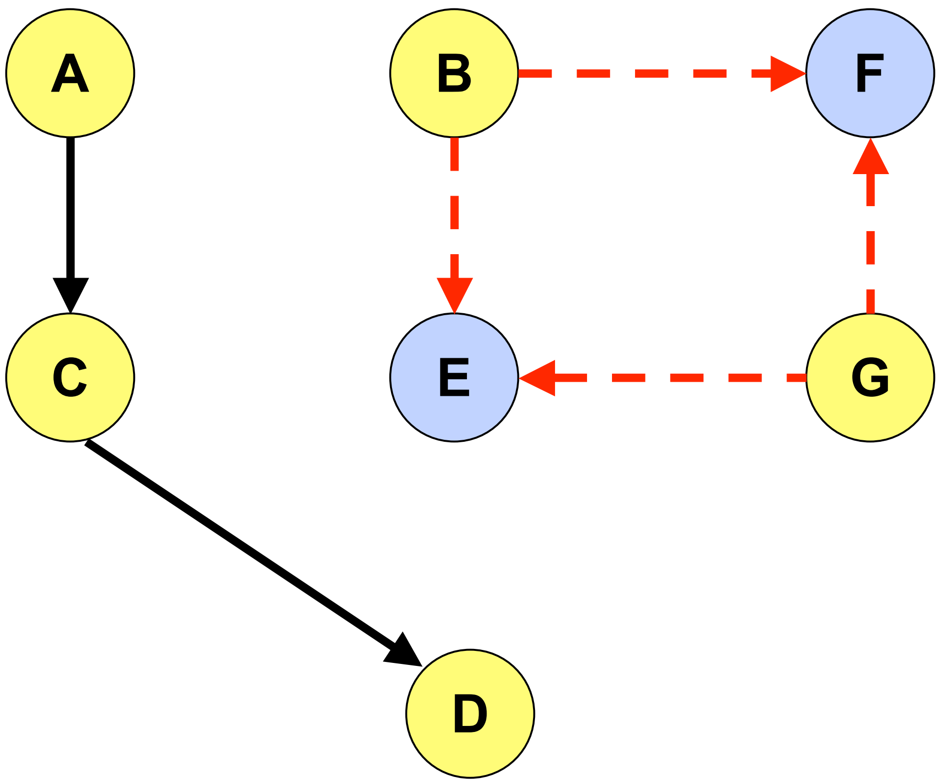


E and F do not have outgoing links

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Full Reversal in a Partitioned Network

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer



In the partition disconnected from destination D, link reversals continue, until the partitions merge

Need a mechanism to minimize this wasteful activity

Similar scenario can occur with partial reversal method too

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Temporally-Ordered Routing Algorithm (TORA) [Park97Infocom]

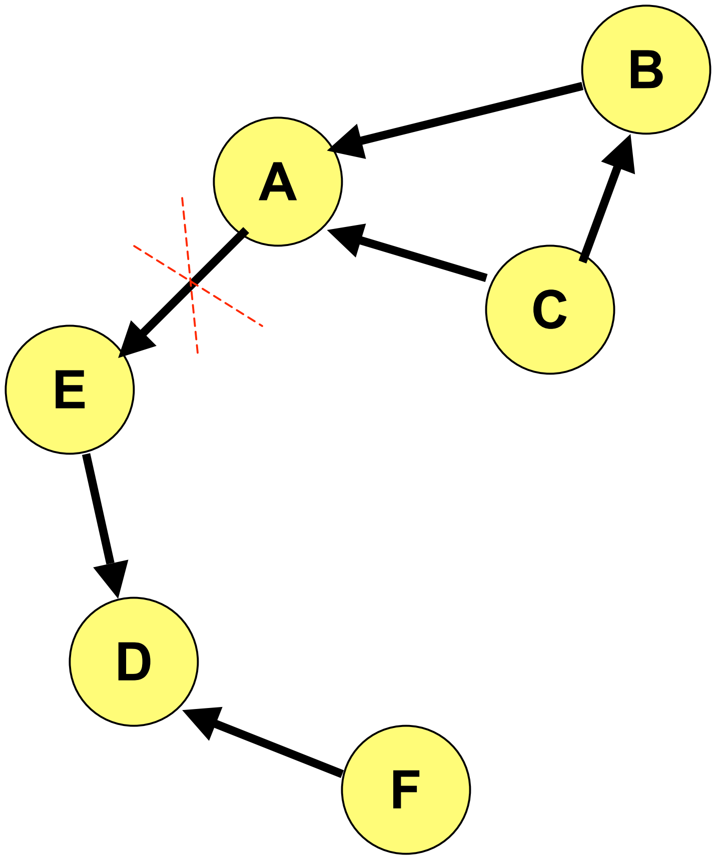
- TORA modifies the partial link reversal method to be able to detect partitions

- When a partition is detected, all nodes in the partition are informed, and link reversals in that partition cease

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

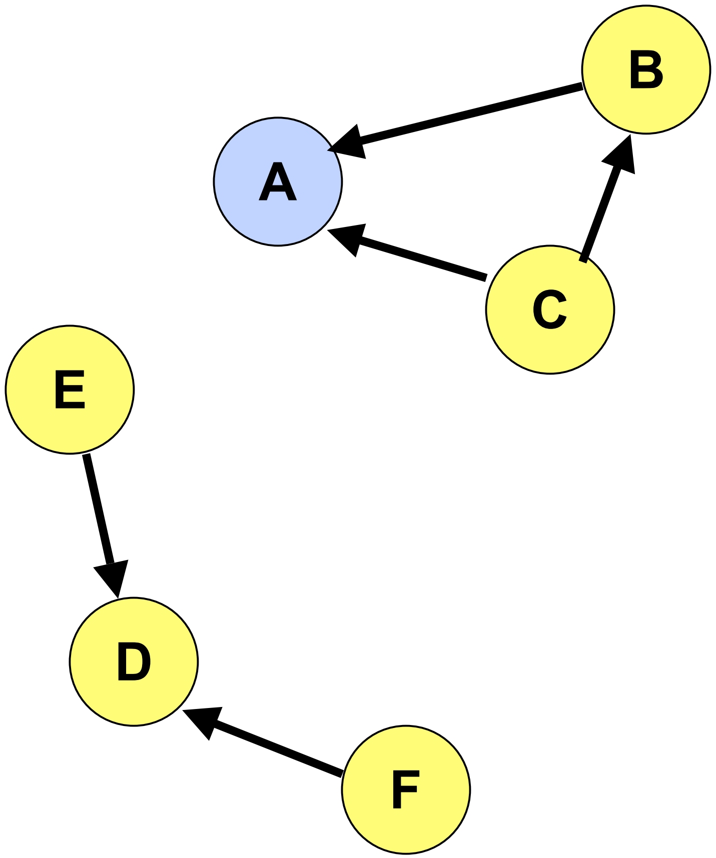
University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

Partition Detection in TORA



DAG for destination D

Partition Detection in TORA



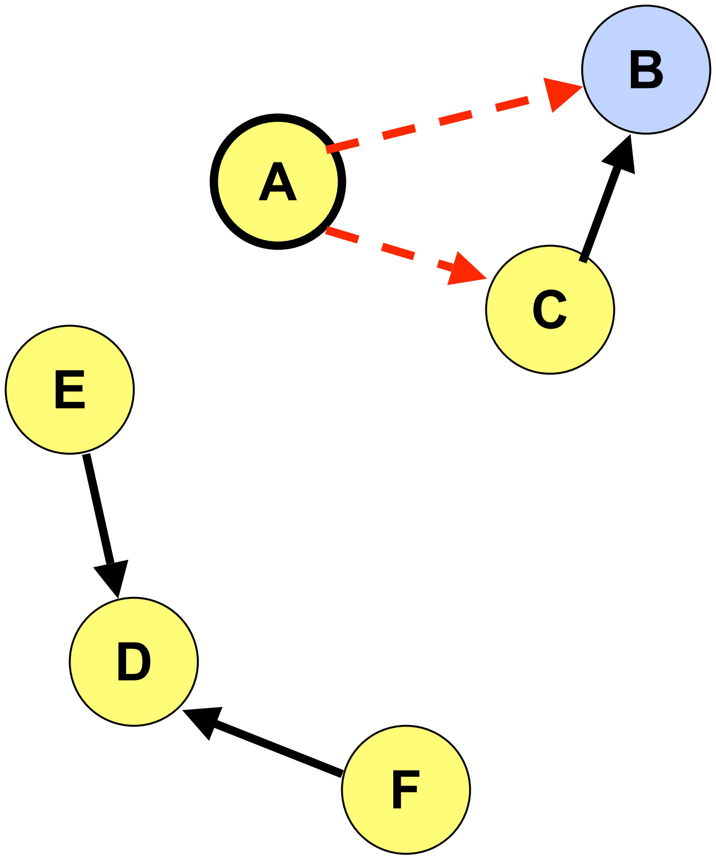
TORA uses a modified partial reversal method

Node A has no outgoing links

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Partition Detection in TORA

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer



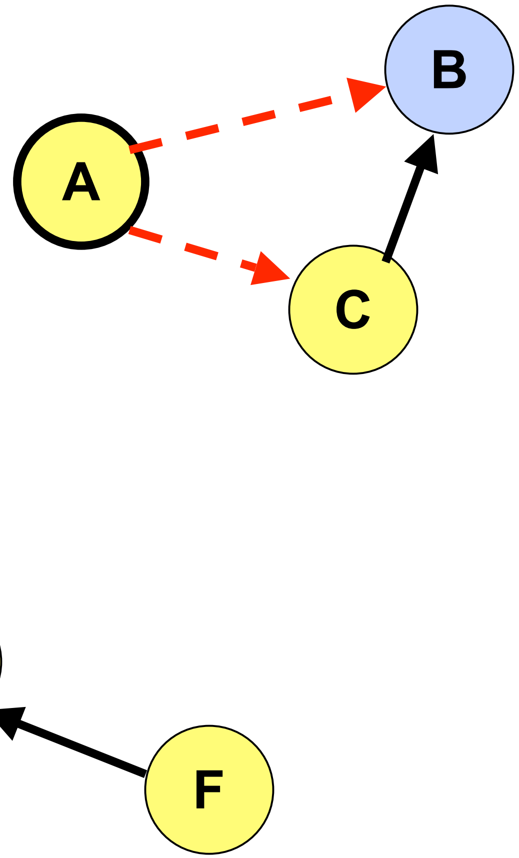
TORA uses a modified partial reversal method

Node B has no outgoing links

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Partition Detection in TORA

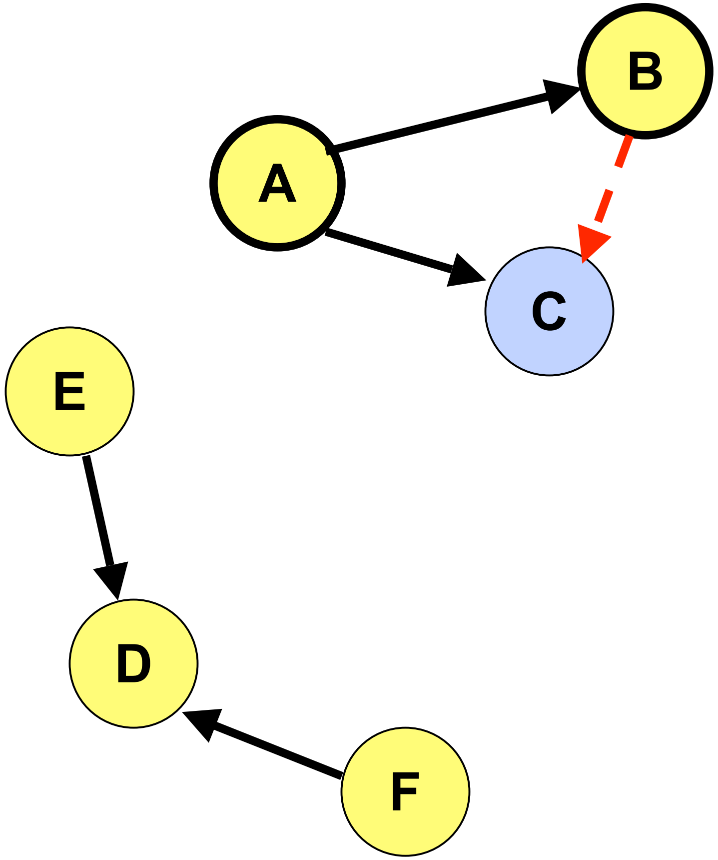
University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer



Node B has no outgoing links

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Partition Detection in TORA

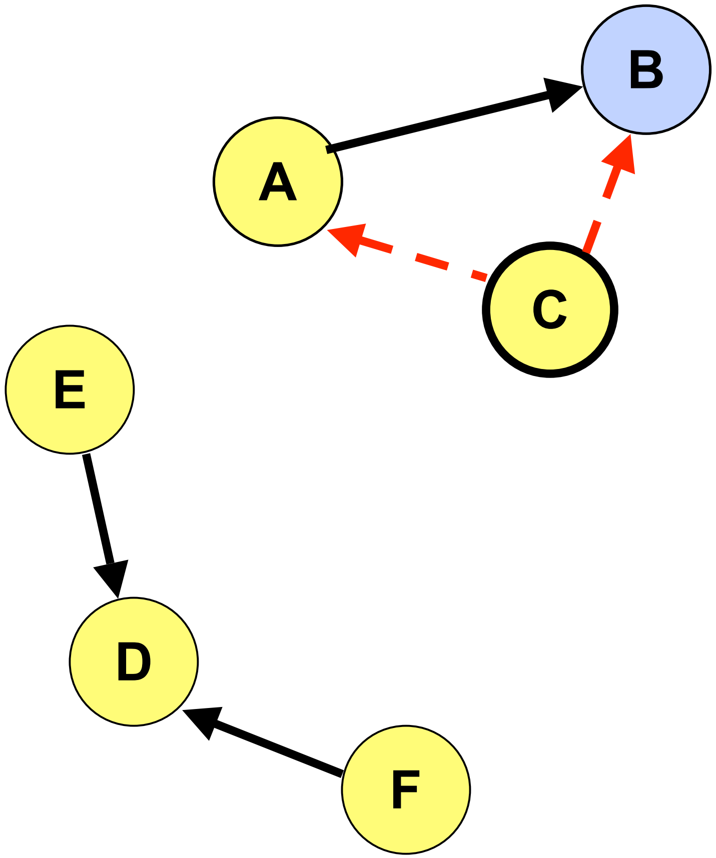


Node C has no outgoing links -- all its neighbor have reversed links previously.

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Partition Detection in TORA

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer



Nodes A and B receive the reflection from node C
Node B now has no outgoing link

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

TORA

- **Improves on the partial link reversal method in [Gafni81] by detecting partitions and stopping non-productive link reversals**
- **Paths may not be shortest**
- **The DAG provides many hosts the ability to send packets to a given destination**
  - Beneficial when many hosts want to communicate with a single destination

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

TORA Design Decision

- **TORA performs link reversals as dictated by [Gafni81]**
- **However, when a link breaks, it looses its direction**

- **When a link is repaired, it may not be assigned a direction, unless some node has performed a route discovery after the link broke**
  - if no one wants to send packets to D anymore, eventually, the DAG for destination D may disappear

- **TORA makes effort to maintain the DAG for D only if someone needs route to D**
  - Reactive behavior

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

TORA Design Decision

- One proposal for modifying TORA optionally allowed a more proactive behavior, such that a DAG would be maintained even if no node is attempting to transmit to the destination
- Moral of the story: The link reversal algorithm in [Gafni81] does not dictate a proactive or reactive response to link failure/repair
- Decision on reactive/proactive behavior should be made based on environment under consideration

So far ...

- **All nodes had identical responsibilities**

- **Some schemes propose giving special responsibilities to a subset of nodes**
  - “Core” based schemes assign additional tasks to nodes belonging to the “core
  - Clustering schemes assign additional tasks to cluster “leaders”

- **Not discussed further in this tutorial**

Reactive protocols – TORA

- **Observation: In hilly terrain, routing to a river's mouth is easy – just go downhill**
- **Idea: Turn network into hilly terrain**
  - Different "landscape" for each destination
  - Assign "heights" to nodes such that when going downhill, destination is reached – in effect: orient edges between neighbors
  - Necessary: resulting directed graph has to be cycle free
- **Reaction to topology changes**
  - When link is removed that was the last "outlet" of a node, reverse direction of all its other links (increase height!)
  - Reapply continuously, until each node except destination has at least a single outlet – will succeed in a connected graph!

Proactive Protocols

- Most of the schemes discussed so far are reactive
- Proactive schemes based on distance-vector and link-state mechanisms have also been proposed

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Link State Routing
[Huitema95]

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

- **Each node periodically floods status of its links**
- **Each node re-broadcasts link state information received from its neighbor**
- **Each node keeps track of link state information received from other nodes**
- **Each node uses above information to determine next hop to each destination**

Optimized Link State Routing (OLSR)

[Jacquet00ietf,Jacquet99Inria]

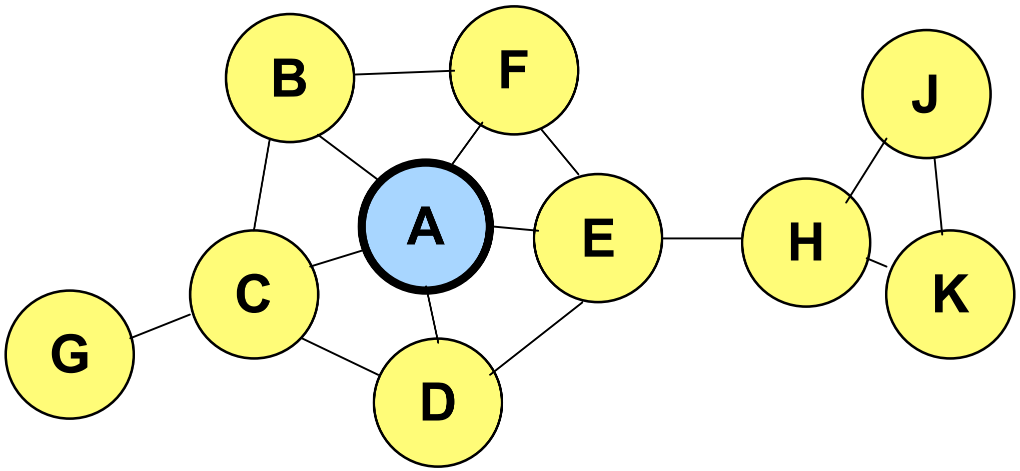
- **The overhead of flooding link state information is reduced by requiring fewer nodes to forward the information**

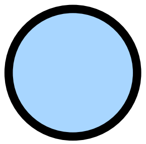
- **A broadcast from node X is only forwarded by its *multipoint relays***

- **Multipoint relays of node X are its neighbors such that each two-hop neighbor of X is a one-hop neighbor of at least one multipoint relay of X**
  - Each node transmits its neighbor list in periodic beacons, so that all nodes can know their 2-hop neighbors, in order to choose the multipoint relays

Optimized Link State Routing (OLSR)

- Nodes C and E are multipoint relays of node A



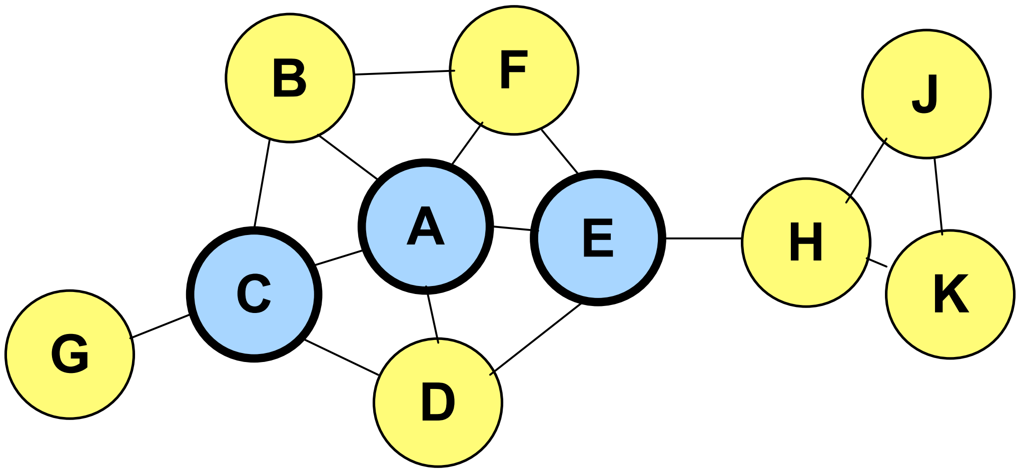


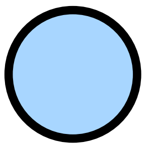
Node that has broadcast state information from A

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Optimized Link State Routing (OLSR)

- Nodes C and E forward information received from A



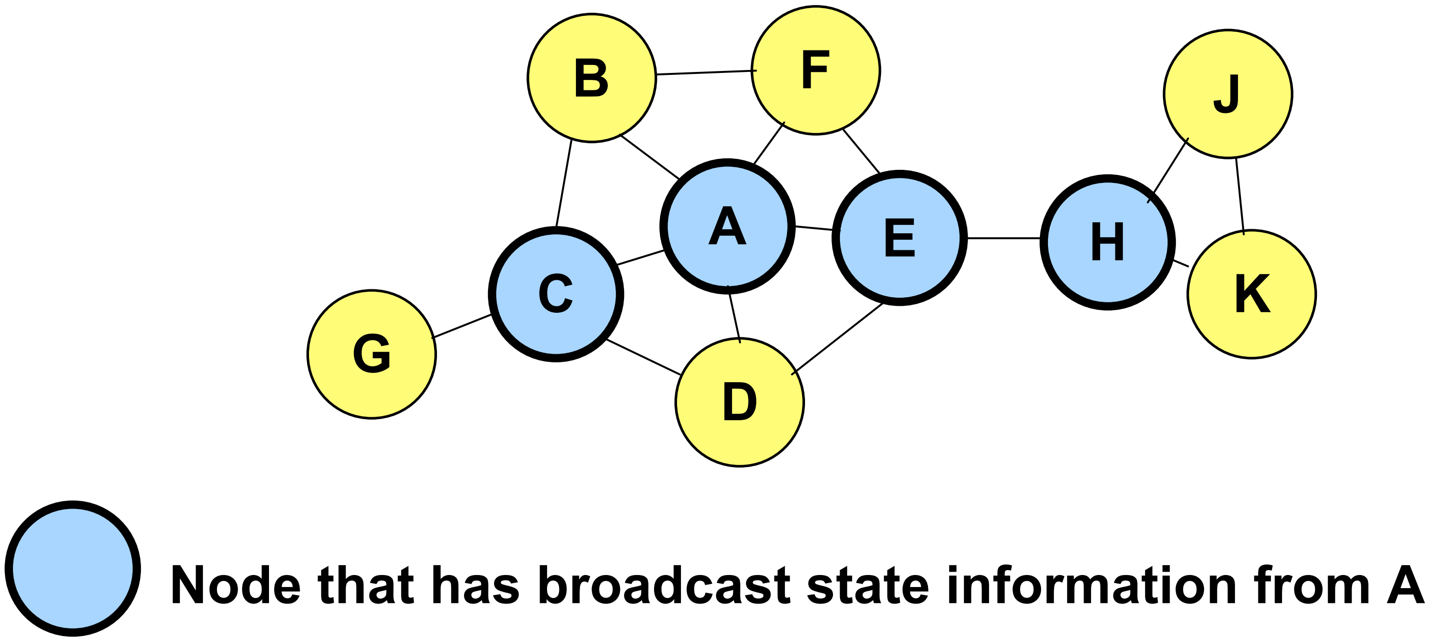


Node that has broadcast state information from A

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Optimized Link State Routing (OLSR)

- **Nodes E and K are multipoint relays for node H**
- **Node K forwards information received from H**
  - E has already forwarded the same information once



Proactive protocols – OLSR

- **Combine link-state protocol & topology control**
- *Optimized Link State Routing* **(***OLSR***)**

- **Topology control component: Each node selects a minimal dominating set for its two-hop neighborhood**
  - Called the ***multipoint relays***
  - Only these nodes are used for packet forwarding
  - Allows for efficient flooding

- **Link-state component: Essentially a standard link-state algorithms on this reduced topology**
  - Observation: Key idea is to reduce flooding overhead (here by modifying topology)

OLSR

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

- **OLSR floods information through the multipoint relays**
- **The flooded information itself is for links connecting nodes to respective multipoint relays**
- **Routes used by OLSR only include multipoint relays as intermediate nodes**

Tutorial by Nitin Vaidya presented on INFOCOM 2006
Tutorial on Mobile Ad Hoc Networks: Routing, MAC and Transport Issues
http://www.crhc.uiuc.edu/wireless/talks/2006.Infocom.ppt

Thank you!

CoNe
Freiburg

University of Freiburg
Computer Networks and Telematics
Prof. Christian Schindelhauer

Mobile Ad Hoc Networks
Christian Schindelhauer
schindel@informatik.uni-freiburg.de

9th Week
20.06.2007