Ad Hoc Networks Routing

Presents:

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Outline

- Presentation
- OLSR – Technical Description
- Research Target

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PART I

PRESENTATION

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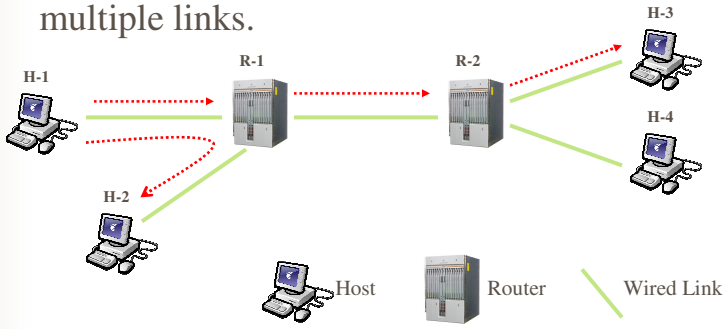
Computer Networks

- System for exchanging information (e.g. messages) among two or more hosts.
- The information is passed over a single or multiple links.



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Ad Hoc Networks

- Wireless hosts (mainly standard 802.11)
- Communication without a fixed infrastructure
- Nodes behave as hosts and as routers
- The hosts are mainly assumed to be mobile
- Self-configuring network
- Medium range

..... Wireless link

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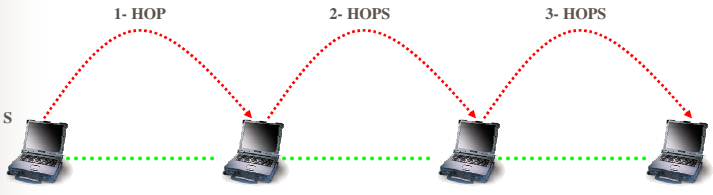
Ad Hoc Networks (2)

- Nodes inside the transmission radius of any node *"S"* are considered neighbors (**1 hop away distance**)
- The communication with no-neighbors is achieved in multi-hop fashion



..... Wireless link

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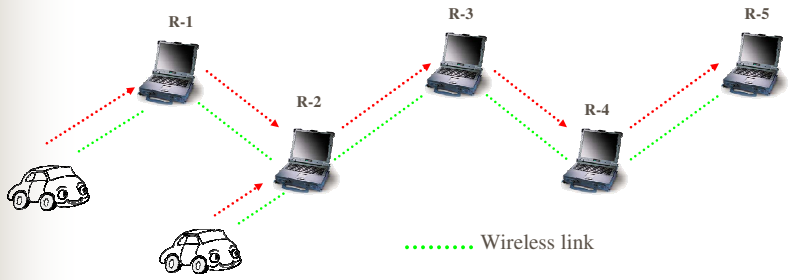
Ad Hoc Applications

- Soldiers on the battlefield
- Laptop networks in conference room
- Emergency disaster relief networks



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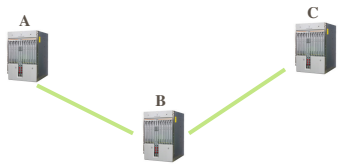
Routing

- Mechanism for finding paths from source host to destination host.
- **Routing Protocol**: Facilitates the exchange of information to support routing between networks.
- Routing information is stored in "***routing tables***" by the routers.



Dest	Next
B	B
C	B

Routing Table at router A

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Routing (2)

- Protocols use different metrics to find network paths.
  - Hop count, bandwidth, delay, path cost, load, link quality (wireless).
- Routing Technologies
  - Flooding (the simplest)
  - Distance-vector routing (*e.g RIP*)
  - Links-state routing (*e.g OSPF*)

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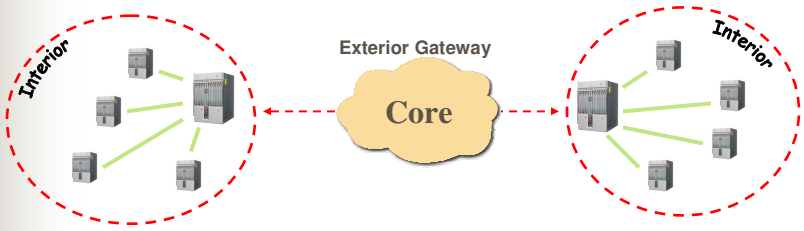
Routing (3)

- Interior Gateway Protocols
  - Exchange the routing information inside a single autonomous system (e.g. RIP, OSPF, IGRP, EIGRP, IS-IS)
- Exterior Gateway Protocols
  - Exchange the routing information between separate autonomous systems (e.g. EGP, BGP)

Previous Hop



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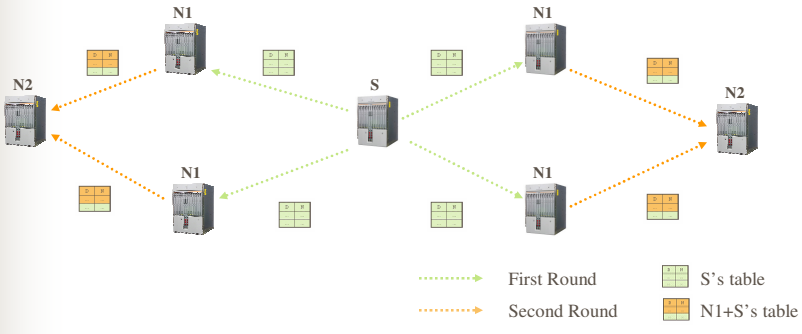
Distance Vector Protocols

- The routers exchange their routing tables. They say: "*For me the network looks like…*"



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Distance Vector Protocols (2)

- Advantages
  - Simple and efficient for small networks
  - The required management is minimum
  - Routing tables are sent only to neighboring nodes
- Disadvantages
  - Not *scalable!!!*
  - Poor convergence properties
  - The exchanged routing tables might be very large

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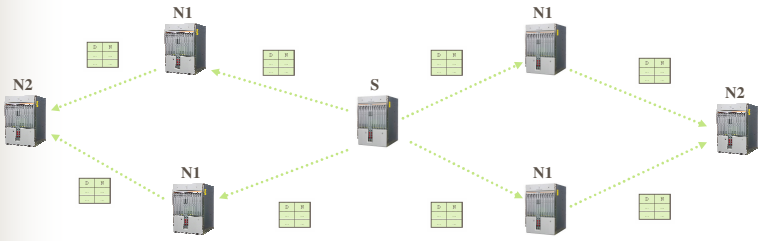
Link State Protocols

- The routers flood, the availability of links to their neighbors. They say: "*My neighbors are…*"



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Link State Protocols (2)

- Advantages
  - React quickly and in a bounded amount of time to topology changes (**Faster convergence**)
  - Exchanged information is small
  - More scalable than Distance-Vector
- Disadvantages
  - Requires larger storage and CPU power to maintain the network map (**more expensive to support**)
  - Exchanged information is flooded into the network

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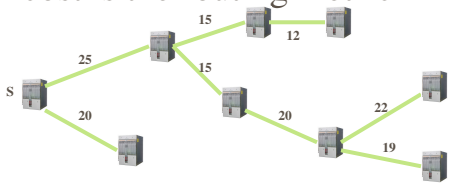
OSPF Protocol

- OSPF (Open Shortest Path First)
- Link State, Interior Gateway Protocol
- Dijkstra's algorithm is used to calculate the shortest path to any destination from a source "*S*"
- Link state database is constructed at each router
- Link cost is the routing metric



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OLSR Protocol

- OLSR (Optimized Link State Routing Protocol)
- Optimizes the link state flooding mechanism
- **M**ultipoint **R**elay (MPR) nodes achieve the optimization
- A set of MPR nodes is chosen by each node in the network
- The node's view of the topology becomes partial
- Proactive Protocol (*Routes immediately available*)

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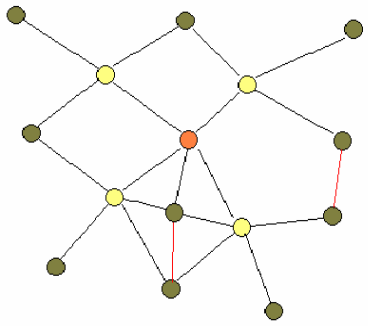
OLSR Protocol (2)

- MPR nodes are chosen in such a way that every 2-Hop neighbor can be reached by the MPRs



Sender

MPR (Forwarder)

End node

Not in the MPR topology

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PART II

OLSR – Technical Description

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Terminology

- OLSR Host
  - OLSR Interfaces (**Each one with unique IP**)
    - None (**It may be injected to the OLSR routing domain**)
    - Single
    - Multiple
      - Main address and Secondary addresses
  - Main Address
    - Node identifier
    - IP address of any interface

 Main  Secondary

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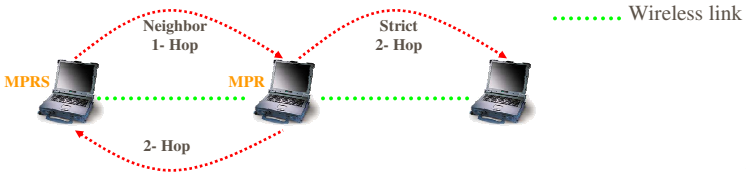
Terminology (2)

- Nodes
  - Neighbor
  - 2-Hop neighbor
  - Strict 2-Hop neighbor
  - Multipoint relay (MPR)
  - Multipoint relay selector (MPRS)



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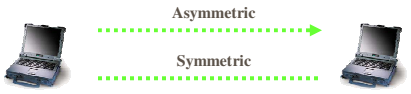
Terminology (3)

- Link Type
  - Asymmetric
  - Symmetric



- Link Status
  - Down
  - Up
    - Good quality
    - Medium quality
    - Poor quality

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Terminology (4)

- Data Packets
  - Transmit user's information from a source to a destination
  - The information is referred as the *"payload"* of the packet
- Control Packets
  - Transmit protocol supporting data
  - Mostly transmitted before Data Packets
  - From next slide onwards referred as *"Packets"* only

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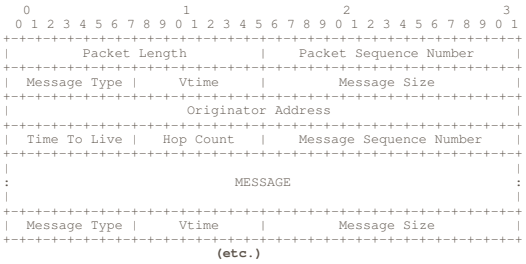
OLSR Packets

- Packets are transmitted using UDP port 698
- Each packet encapsulates more than one message
- OLSR implements different types of messages



OLSR Packet Format

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OLSR Message Types

- Sent in the data-portion of the OLSR Packet
- Types of messages:
  - MID (Multiple Interface Declaration)
  - HELLO
  - TC (Topology Control)
  - HNA (Host and Network Association)
- New types can be added

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Packets forwarding

- Transmitted packets are temporally stored
- Forwarding is performed on all interfaces by the MPR nodes
- Unknown messages are forwarded once by the so called *Default Forwarding Algorithm*
- If required some messages can bypass the MPRs
- Nodes add jitters to avoid messages collisions
  - Jitter = random delay before retransmitting

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Information Repositories

- Duplicate Set
- Interface Association Set (interface - main address)
- Link set (symmetric, asymmetric or lost)
- Neighbors (symmetric, not_symmetric and willingness)
  - Neighbor set
  - 2-hop Neighbor set
- MPR
  - MPR set
  - MPR Selector set
- Topology set (Destination and previous hop)

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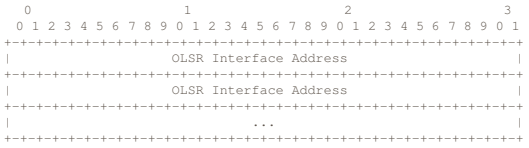
Multiple Interfaces

- OLSR interfaces are linked to **main address**
- Each node announces its multiple interfaces
- Multiple Interfaces Declaration (MID) messages
- MID messages are flooded by MPRs (TTL=255)
- Only Link Sensing uses this information



MID message Format

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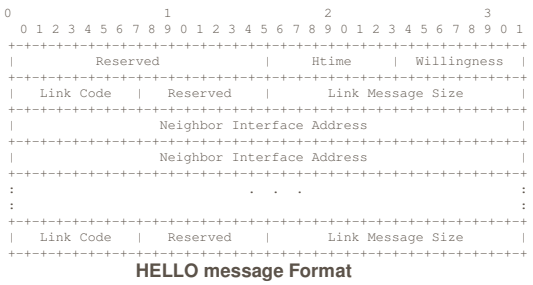
Hello messages

- Generated per each node on each interface
- Advertises the entire 1-hop neighbourhood
- Willingness to carry and forward traffic (MPR)



HELLO message Format

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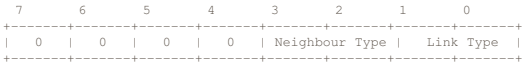
Hello messages (2)

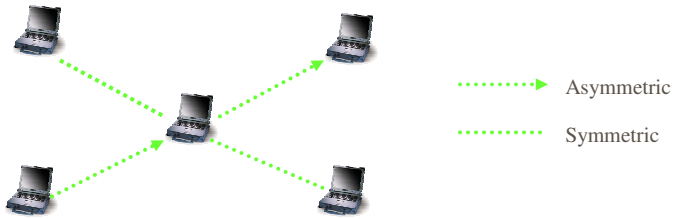
- Based on local *link set*, *neighbour set*, *MPR set*
- Support link sensing, neighbour detection and MPR signalling
- Link Types:
  - Unspecified, Asymmetric, Symmetric, Lost
- Neighbour Types:
  - Symmetric, MPR, Not Neighbour



Link Code field Format in HELLO message

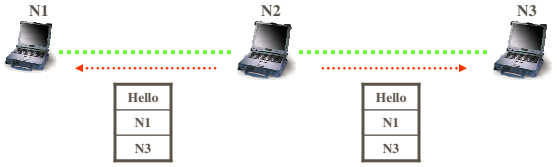
Link Sensing

- Populates the Link Set
- Based on the exchange of *Hello* messages
- Detects links with neighbors
- Each link can be symmetric or asymmetric



Neighbor detection

- Populates the Neighbor Set
- Based on status and changes of the Link set
- Populates the 2-hops neighbor set
- Populates the MPR set
- Populates the MPR selector set



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MPR computation

- MPRs optimize the classical flooding mechanism
- Each node selects its own MPRs from its 1-hop symmetric neighbours
- Through the MPRs all symmetric strict 2-hop neighbours must be reached
- Recalculated when symmetric neighbourhoods change (1-hop or strict 2-hop)

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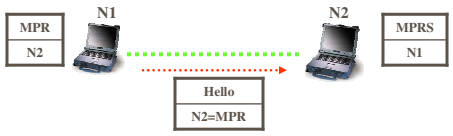
MPR computation (2)

- MPRs are signalled as *MPR* neighbour type, inside *Hello* messages
- MPR Selector (MPRS) set is populated when any node is signalled as a MPR neighbour
- MPRs are computed per interface.
- MPR candidate nodes must have willingness different from **Will_Never**



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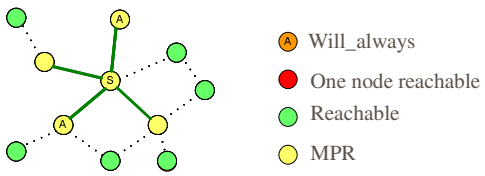
MPR computation (3)

1. MPR set = Ø
2. MPR += 1-hop neighbors with willingness=**Will_always**
3. MPR += 1-hop neighbors that are the only ones reaching a 2-hops neighbor
4. Remove the 2-hop neighbors reached by the MPRs
5. Add 1-hop nodes (to the MPR set) providing maximum reachability of 2-hop neighbors UNTIL reaching all 2-hop neighbors.



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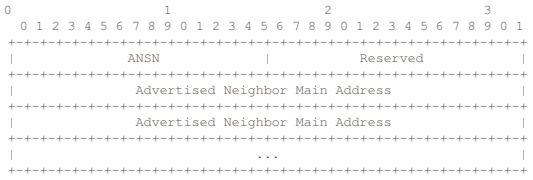
Topology discovery

- Information dissemination to construct routes
- Broadcast by MPRs only
- Links between an MPR and its selector set (Advertised Neighbor set) are the minimum information that must be broadcast



TC message Format

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Topology discovery (2)

- The disseminated topology view is partial
- The ANSN (Advertised Neighbor Sequence Number) keeps track of the most recent information.
- The topology information supports the routing table calculation mechanism

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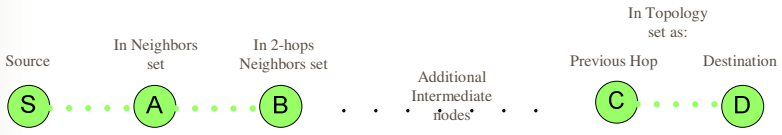
Routing Table

- Each node maintains its own routing table
- Based on the Link and Topology sets.
- Recalculated (without transmitting any message) when a change is detected in either:
  - Link set
  - Neighbor set
  - 2-hop neighbor set
  - Topology set
  - Multiple interface association set.

Routing Table (2)

- Calculated using a shortest path algorithm
- Assuming existence of:



ID	Destination address	Next Hop address	Hop Distance	Interface address
1	Dest_1	NH_A	d0	Iface_a
2	Dest_2	NH_B	d1	Iface_b

Example of Routing Table

Node configuration

- MANET nodes must be part of the same subnet
- Additional networks connected to the MANET must be part of distinct subnets
- MANET nodes connected to external networks must provide paths to them
- OLSR **maintains the Routing Table** but it ***DOES NOT*** perform packet forwarding

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Non OLSR-interfaces

- Interfaces connected to separate network
- External route information has to be injected into OLSR domain (MANET)
- It is injected by Gateway nodes broadcasting HNA (Host and Network Association) messages

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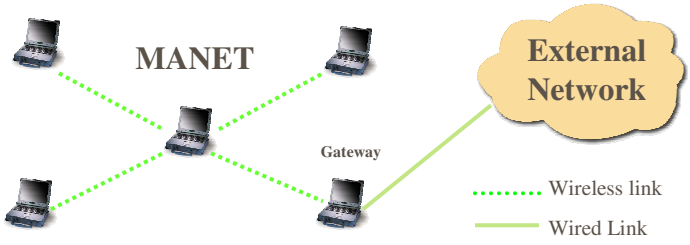
Non OLSR-interfaces (2)

- Gateways broadcast external network address and network mask
- Information is stored in the Association Set
- HNA messages are similar to TC messages



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Part III

RESEARCH TARGETS

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Targets

- Relax MPR selection mechanism to satisfy multiple path-constraints
- Provide multiple paths to same destination for load balancing
- Extend the OLSR messages to distribute node and link specific information

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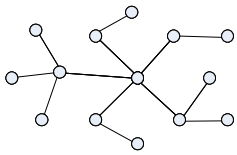
Relax MPR Mechanism

- Relax the partial view of the network topology to provide enough constraint-compliant links
- Increase Routing Reliability
- Gradually and dynamically adjust the amount of topology information exchanged while maintaining flooding optimality



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Multiple-Paths to destination

- Multiple paths for any destination will be provided (when possible)
- Paths will be introduced in the routing table and will be ranked according to their optimality
- OS kernel has to be modified to allow multiple paths for same destination

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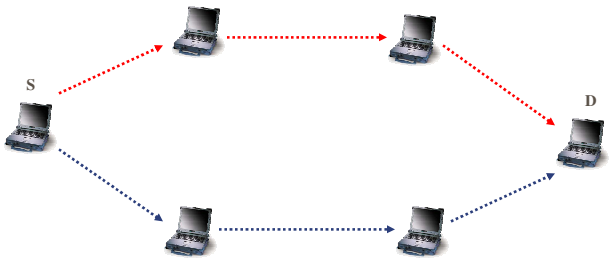
Multiple-Paths to destination (2)

- OS forwarding mechanism will make use of multiple paths when required



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Extend OLSR messages

- The new messages will be designed by following the OLSR-RFC specifications in order to make them compatible with any OLSR implementation
- The information carried by the new messages will be provided by the Data Collection group

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Extend OLSR messages (2)

- The node-specific information might include:
  - *Remaining battery*
  - *Available buffer space*

- The link-specific information might include:
  - B*andwidth available*
  - *Error rate*
  - *Signal strength*

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Ad Hoc Networks Routing

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