Lecture 11-12
Wireless routing

Reference
"INTRODUCTION TO WIRELESS AND MOBILE SYSTEMS", *DHARMA ARAWAL*"

Contents

- *Multi-hop communication • routing •*
- *Routing process*
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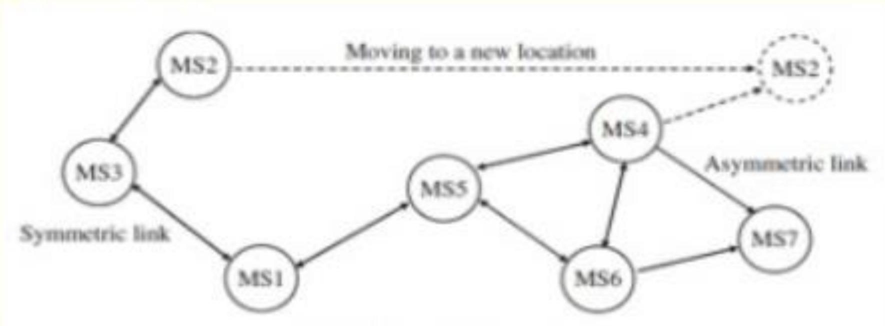
- *Proactive versus reactive*
- *DSDV protocol • DSR protocol • GSR protocol*

Mobile Adhoc Network (MANET)

- MANETs are basically peer-to-peer, multihop wireless networks in which information packets are transmitted in a store-and-forward manner from a source to an arbitrary destination, via intermediate nodes move.



a MANET can be defined as an autonomous system of nodes or MSs (also serving as routers) connected by wireless links, the union of which forms a communication network modeled in the form of an arbitrary communication graph , the connectivity may change based on relative locations of other nodes. The resulting change in the network topology known at the local level must be passed on to the other nodes so that old topology information can be updated

This is in contrast to the well-known single-hop cellular network model that supports the needs of wireless communications by having BSs as access points. In these cellular networks, communication between two mobile nodes relies on the wired backbone and the fixed base stations.

In a MANET, no such infrastructure exists and the network topology may change dynamically in an unpredictable manner since nodes are free to move and each node has limited transmitting power, restricting access to the node only in the neighboring range

Characteristic of MANET

- Dynamic topologies
- Bandwidth-constrained and variable capacity links
- Energy-constrained operation
- Limited physical security

Dynamic topologies: Nodes are free to move arbitrarily; thus, the network topology may change randomly and unpredictably and primarily consists of bidirectional links. In some cases, where the transmission power of two nodes is different, a unidirectional link may exist.

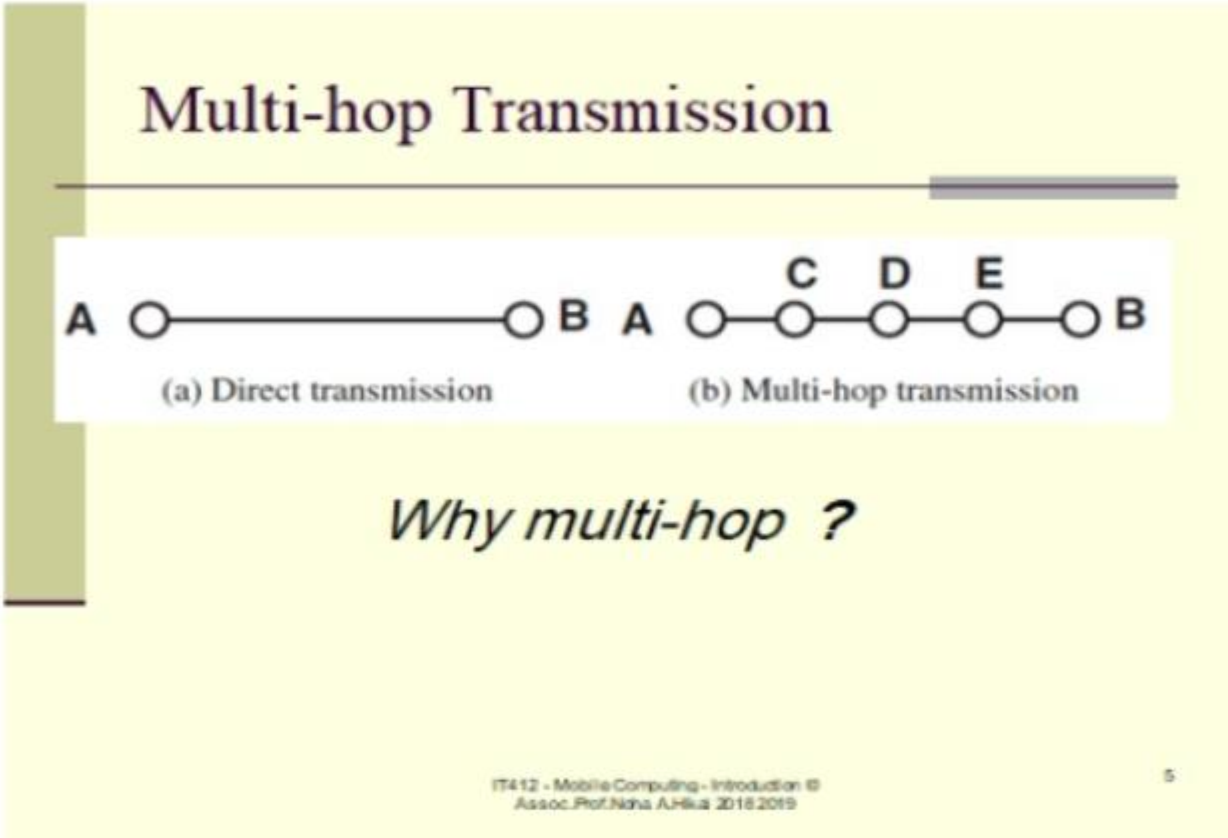
Bandwidth-constrained and variable capacity links: Wireless links have significantly lower capacity than infrastructured networks. In addition, The effects of multiple access, fading, noise, interference conditions, and so on— Moreover, low to moderate link capacities is that congestion is typically the norm rather than the exception

Energy-constrained operation: Some or all of the MSs in a MANET may rely on batteries or other exhaustible means for their energy. For these nodes, the most important system design optimization criteria may be energy conservation.

Limited physical security: MANETs are generally more prone to physical security threats than wireline networks. The increased possibility of eavesdropping, spoofing, and denial of service (DoS) attacks should be carefully considered.

MANET APPLICATIONS:

Defense applications, Crisis-management applications, Telemedicine, Tele-geoprocessing applications, Vehicular area network (VANET), Virtual navigation, Education via the Internet:



Why multi-hop transmission?

In case all nodes are close by within each other's radio range, there are no routing issues to be addressed. In real-life scenarios, these networks will be made of vastly different types of devices, some more portable than the others. In such heterogeneous dynamic topologies, it is reasonable to assume that a node will not have enough transmitting power to reach all nodes in the network. In real situations, the power needed to obtain connectivity of all nodes in the network may be, at least, infeasible, and issues such as battery life come into play as well. Therefore, we are interested in scenarios in which only a few nodes are within each other's radio range. Moreover, another issue is considered, that of symmetric (bidirectional) and asymmetric (unidirectional) links

Routing Challenges in MANET

1. Symmetric-vs-Asymmetric links
2. Heterogonous-vs nodes
3. Varying the mobility patterns of different nodes (stationary-high mobility)
4. Efficient routing
5. Consumed power
6. Time delay

Routing in a MANET depends on many factors, including modeling of the topology, selection of routers, initiation of a route request, and specific underlying characteristics that could serve as heuristics in finding the path efficiently

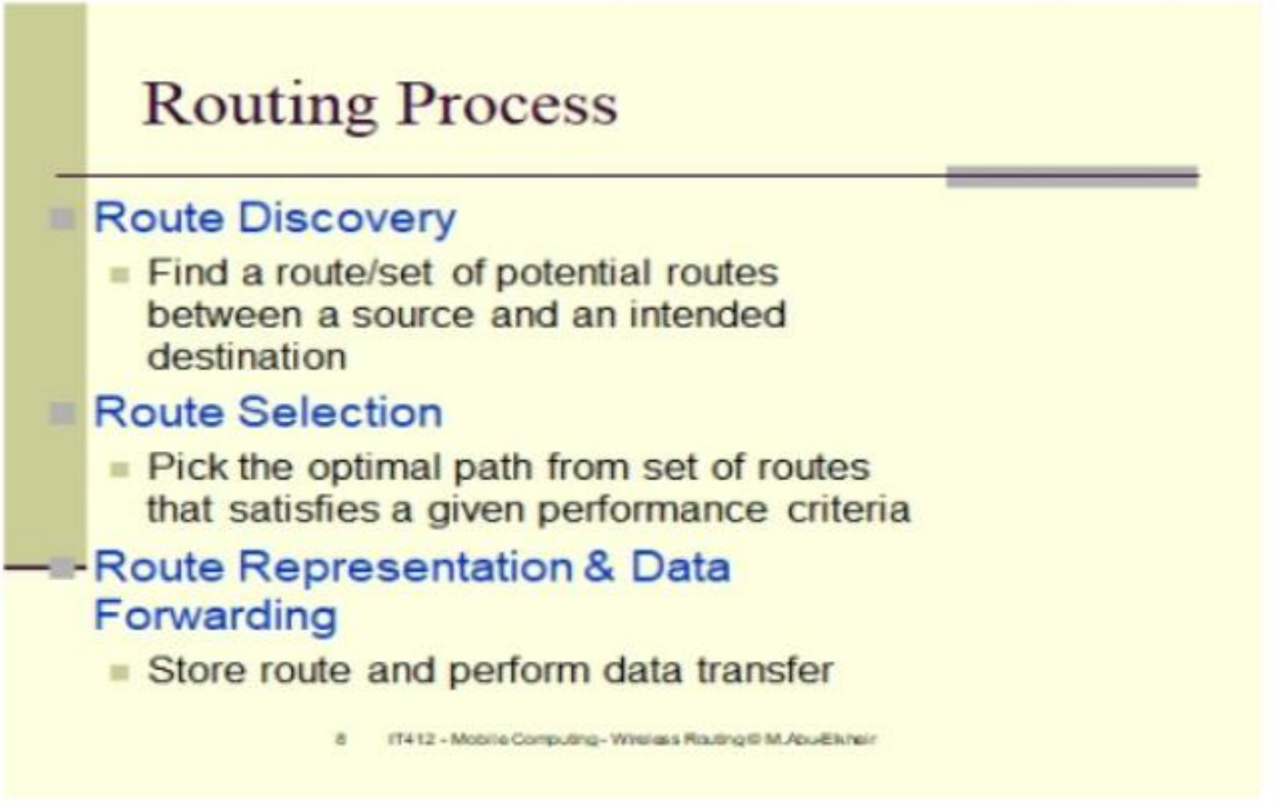
Routing

- Find the "optimal" path between two nodes through intermediate (relay) nodes
- intermediate nodes provide multiple potential paths

Optimality

means

meeting performance requirements



<u>MANET routing typically has the following goals:</u>

1. Route computation must be distributed, because centralized routing in a dynamic network is impossible, even for fairly small networks.

2. Route computation should not involve maintenance of a global state, or even significant amounts of volatile nonlocal state. In particular, link state routing is not feasible due to the enormous state propagation overhead when the network topology changes.

3. As few nodes as possible must be involved in route computation and state propagation, as this involves monitoring and updating at least some states in the network. On the other hand, every host must have quick access to the routes on demand.

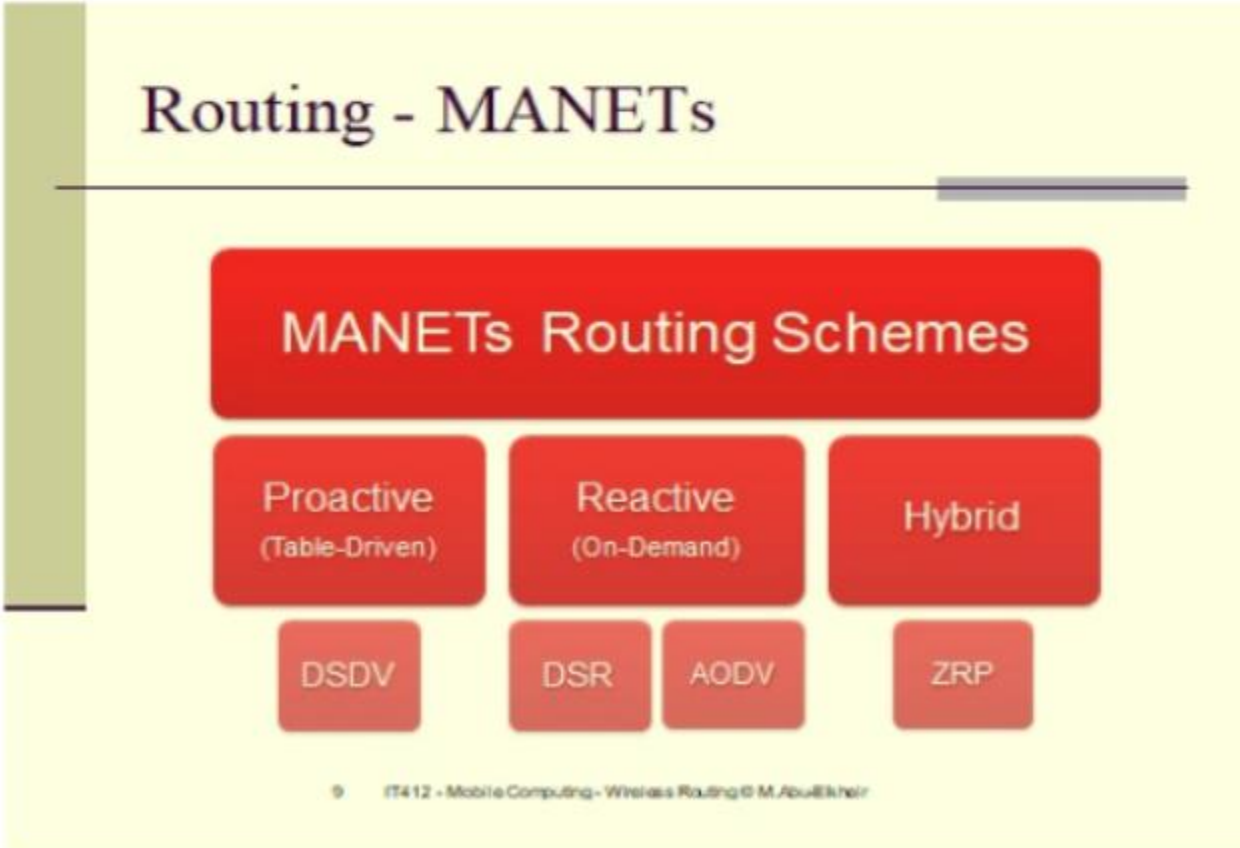
4. Each node must care only about the routes to its destination and must not be involved in frequent topology updates for those portions of the network that have no traffic.

5. Stale routes must be either avoided or detected and eliminated quickly.

6. Broadcasts must be avoided as much as possible, because broadcasts can be time consuming for MANETs .The simpler function of multicasting is observed to be even more complex than uncontrolled broadcasting.

7. If the topology stabilizes, then routes must converge to the optimal routes.

8. It is desirable to have a backup route when the primary route has become stale and is to be recomputed.



<u>In proactive protocols</u>

+ There is negligible delay in determining the route.

- Use a large portion of the network capacity to keep the routing information current

<u>In reactive protocols</u>

- Route information may not be available at the time a datagram is received, the delay to determine a route can be significant.

- The global flood-search procedure of the reactive protocols incurs significant control traffic.

The routing protocols may also be categorized as follows:

1-Table-driven protocols

Each node is required to maintain one or more tables to store routing information on every other node in the network. They are essentially proactive in nature so that the routing information is always consistent and up-to-date. The protocols respond to changes in network topology by propagating the updates throughout the network so that every node has a consistent view of the network. (DSDV, CGSR, WRP)

2- Source-initiated on-demand protocols

The source-initiated approach generates routes only when a source demands it. In other words, when a source requires a route to a destination, the source initiates a route-discovery process in the network. This process finishes when a route to the destination has been discovered or all possible routes have been examined without any success. The route thus discovered is maintained by a route maintenance procedure, until it is no longer desired or the destination becomes inaccessible.(AODV, DSR, TORA,ABR, SSR)

Hybrid protocols

Pure reactive routing protocols may not be adequate for any real-time communication. However, pure proactive schemes are likewise not appropriate for the MANET environment, as they continuously move quickly and the changes may be more frequent

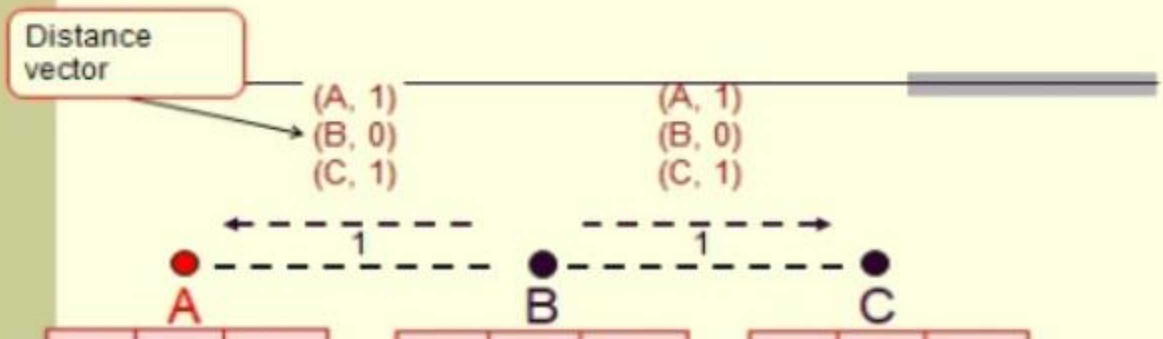
Than the route requests, most of this routing information is never used. This is a waste of the wireless network capacity.(ZRP, FSR, LANMAR,LAR, DREAM, RDMAR)

Routing - MANETs

- Proactive
  - evaluate continuously the routes within the network
    - when a packet needs to be forwarded, route is already known and can be immediately used
- Reactive
  - invoke route determination procedure only on demand
    - when a route is needed, global search procedure is initiated

Routing - MANETs

- Proactive
  - Exchange routing information between nodes and store in **routing table**
    - **Periodically or when topology changes**
  - When node has packet to send, it consults routing table, gets up-to-date route, and forwards packet
  - Negligible delay
  - Example: **Destination Sequenced Distance Vector Routing (DSDV)**



Dest.	Next	Metric
A	A	0
B	B	1
C	B	2

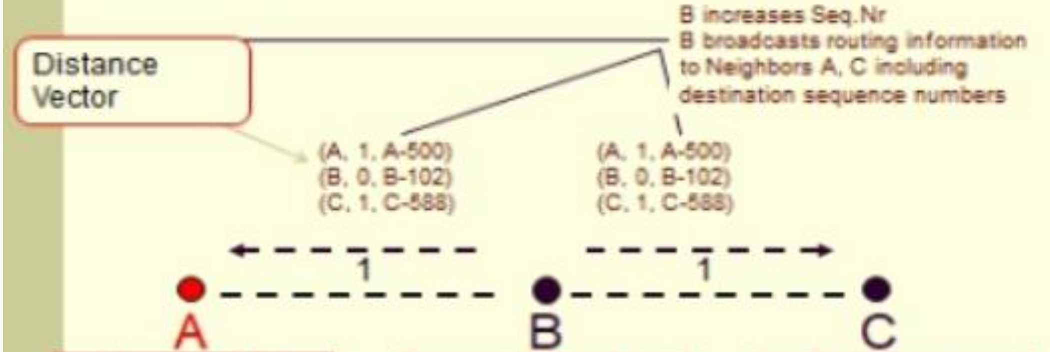
Dest.	Next	Metric
A	A	1
B	B	0
C	C	1

Dest.	Next	Metric
A	B	2
B	B	1
C	C	0

DSDV

- Each node maintains routing table
  - Table stores route to every possible destination + number of hops to destination + next node to reach destination + sequence number
- Each node **periodically** sends its routing table to its direct neighbors
  - Node receives information from its neighbors, updates routing table
- If destination has multiple route entries, entry with most recent sequence # is used
  - What to do if two entries have same sequence number

DSDV



Dest.	Next	Metric	Seq
A	A	0	A-550
B	B	1	B-102
C	B	2	C-588

Dest.	Next	Metric	Seq
A	A	1	A-550
B	B	0	B-102
C	C	1	C-588

Dest.	Next	Metric	Seq.
A	B	2	A-550
B	B	1	B-102
C	C	0	C-588

The node either sends the "full dump", or it just sends the "incremental update".

Routing - MANETs

- Reactive
  - Generate route only when a source demands a route to destination
  - Discovery terminates when route is discovered or no route is found
  - Example: **Dynamic Source Routing (DSR)**

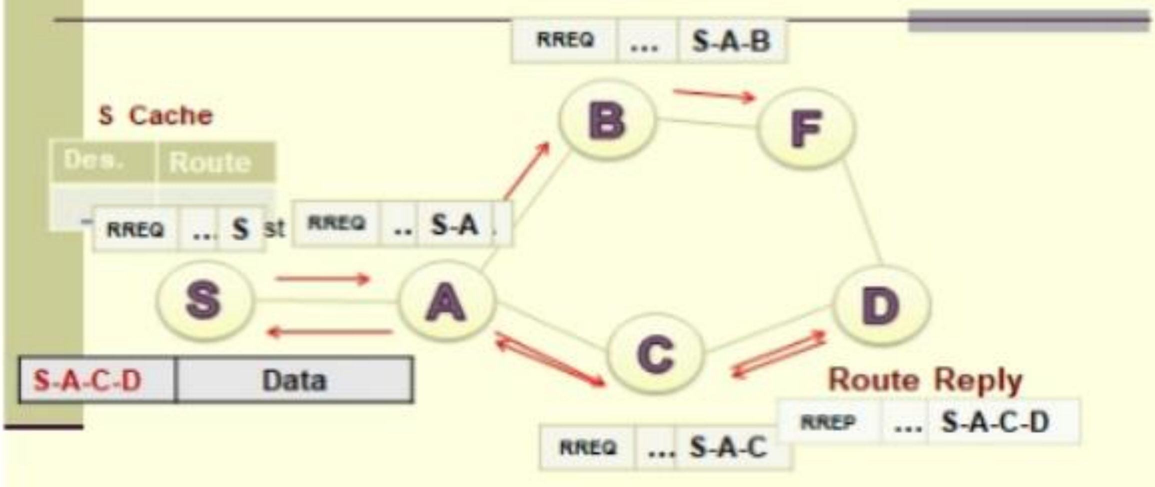
DSR

- Each node maintains a **cache**
  - Maintain source routes and update if new routes are discovered
- When node has message to send, it consults cache
  - If there is a route to destination, use it
  - Else, initiate route discovery – broadcast **route request packet (src_addr, dst_addr, ID)**
  - Each intermediate node that receives route request packet check its cache

DSR

- If no route is found, intermediate node appends its address to route request packet and sends it to neighbors
- Route request message either reaches destination or node with route to destination
- Route record has information about all hops taken to destination
- If destination is receiver, it sends route record in a **route reply packet**
- If intermediate node is receiver, it sends route record + route to *dst* in its cache

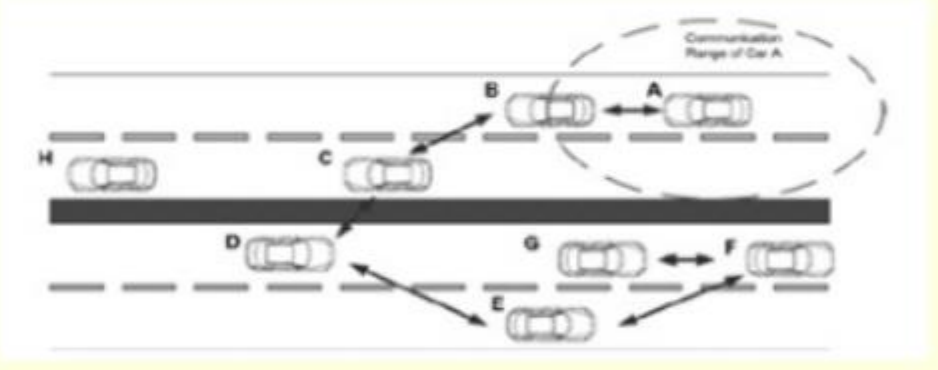
DSR



RREQ
...
S-A-B
S Cache
Des.
Route
RREQ
... S
RREQ
.. S-A
B
F
S
A
D
C
S-A-C-D
Data
Route Reply
RREP
... S-A-C-D
RREQ
... S-A-C

Vehicular Area Network (VANET)

- It is a novel application of MANETs. Connecting between close by vehicles



Network between various vehicles is formed on an ad hoc basis and changes dynamically as vehicles move at different speed, changing their relative distance.

The only difference is that the connecting will be relatively higher in an urban setup and vehicles may be connected to an ad hoc network for a longer period of time

The basic objective behind a VANET is to find some relevant local information, such as close by gas stations, restaurants, grocery stores, and hospitals, and the primary motivation is to obtain knowledge of local amenities

Routing - VANETs

VANET Routing Schemes

- Position-based Unicast
  - Non-Delay Tolerant
    - GSR
  - Delay Tolerant
    - VADD
- Geocast
  - IVG
- Broadcast
  - DV-CAST

Position-based Unicast Routing

Location Service + Forwarding strategy

Reactive Location Service (RLS)

Greedy Forwarding

No route setup or maintenance is required. Instead, forwarding hops are determined 'on the fly'

Reactive Location Service

- A node querying the geographical position of a certain node issues a **location query packet**,
  - Packet floods network until it reaches destination or TTL expires
- When destination receives a query packet, it creates a **location reply packet** with querying node's ID and location as destination information

Routing - VANETs

- Non-DT Position-based Routing
  - deliver packets as soon as possible
  - works best in city environments where there's plenty of nodes to relay traffic
  - Example: **Geographic Source Routing (GSR)**

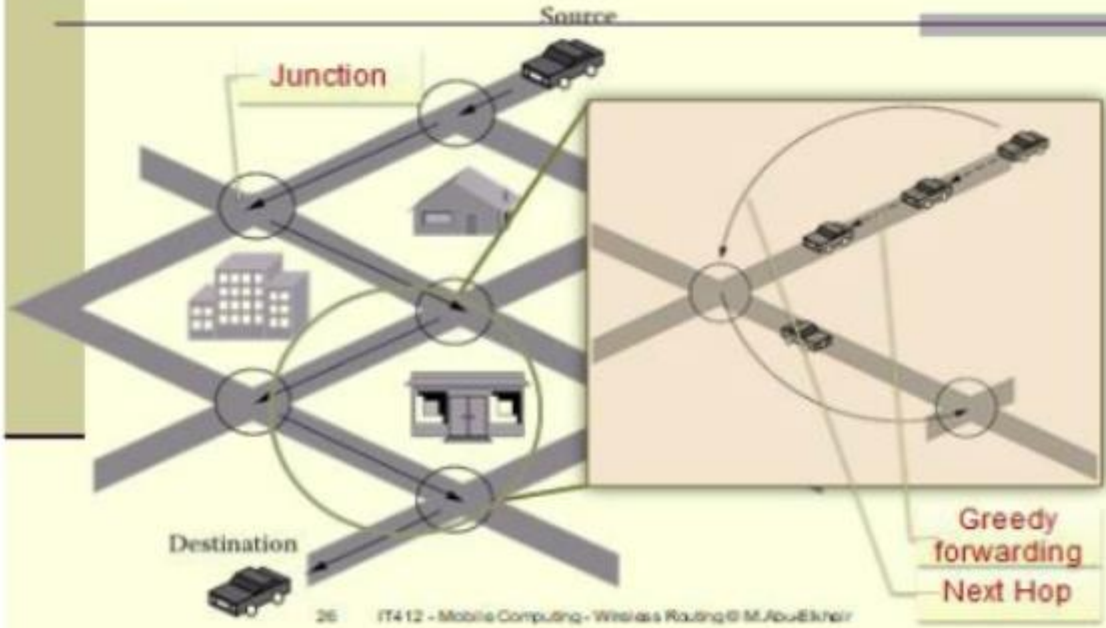
GSR

- Provide vehicular connectivity in two dimensional city environments
- Use street map to compute path to destination in terms of junctions (intersections)
- Sender uses RLS to get destination's position
- Node computes path to destination using streets map and Dijkstra's shortest path algorithm

GSR

- Sender computes a sequence of junctions on the path that the packet has to traverse in order to reach the destination
- Sequence of junctions is either put into the packet header or computed by each forwarding node
  - trade-off between bandwidth consumption and required processing performance
- Forwarding a packet between two successive junctions is done by greedy forwarding

GSR



GSR - Problems

- How do nodes decide if a certain junction has been reached or not?
- If the connectivity between vehicles is low many packets could be dropped

Routing Metrics

- Number of hops
- Distance
- Delay
- Packet loss rate
- Energy consumption
- Which metric to select to optimize route choice?
  - Depends on application – delay-sensitive, energy-critical, QoS-based, …

Thanks- Questions !