Ad Hoc Networks

Performance and Design

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Basic Concept

- Infrastructure networks. Uses base station responsible for communication between mobile hosts.
- Mobile IP technology support s nomadic roaming. Requires address management and protocol interoperability
- Core network functions (hop-by –hop routing) rely upon existing fixed network.

Basic Concept

- Ad hoc networks. Consists of mobile hosts which communicate each other through wireless medium. Mobile Ad hoc Network (MANET) based on IEEE 802.11x
- Extends mobility into realm of autonomous, mobile wireless domains.
- Set of nodes (routers and hosts) form routing infrastructure at place 'for the purpose only'
- Effectively managed ad hoc clusters can operate autonomously or be attached to the fixed Internet

Applications

- Cooperative mobile data exchange (industrial and commercial applications)
- Alternative to cell-based infrastructure
- Fire/safety/rescue operations
- Environmental and scientific monitoring
- Civilian environments: meeting rooms, stadiums, boats, aircrafts etc.
- Military application

Characteristics and Tradeoffs

- Characteristics: decentralized, self-organizes (infrastructure independent), self-deployed, dynamic topology
- Tradeoffs: limited bandwidth, multi-hop router needed, energy consumption, security

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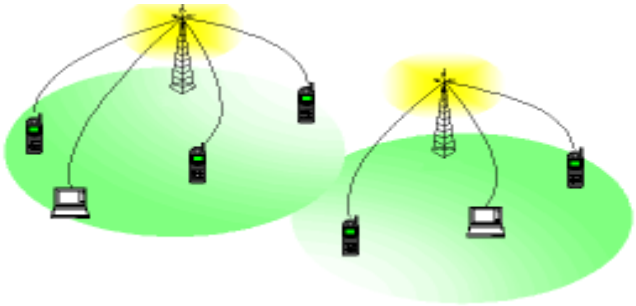
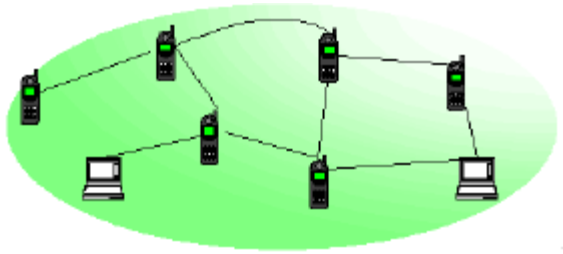


Infrastructure based



MANET

Routing Protocols

- Proactive or Table Driven.
- Each node maintains one or more tables to store
- Relies on routing table that involves constant propagation and routing information
- Packets can be forwarded immediately
- Cause substantial signaling traffic
- Examples: DSDV, WRP, OLSR

Routing Protocols

- Reactive. On-Demand Routing
- Creates routing when desired
- Packets must wait until route is discovered. Discovered routed are stored in cache
- Periodic updates are not required
- Exapmlpes: AODV, DSR, ABD, SSR
- Also! Gybrid, Hierarchical, Geographical and more

Optimized Link State Routing (OLSR)

- Proactive, table-driven. Exchanges topology information with other nodes regularly
- Only nodes selected as MPRs (multipoint relays) are forwarding control traffic
- Each node selects MPRs from its neighbors
- MPRs provide efficient mechanism for flooding control traffic reducing the number of transmissions
- MPRs declare link-state information to their MPR selectors
- MPRs are used to form the route from a given source to destination

Optimized Link State Routing (OLSR)

- Each node maintains routing table which allows to destine data to other nodes
- RT is based on link information and topology set
- RT is recalculated (shortest path algorithm)if a change is detected either link set neighbor set, 2-hop neighbor set, topology set.
- OLSR suits well to large and dense mobile networks with random and sporadic traffic between larger sets of nodes
- For more details see RFC 3626 2003, Experimental

Ad Hoc on Demand Distance Vector(AODV)

- Enables dynamic, self-staring, multihop routing, obtains routes quickly and does not maintain routes to inactive destinations
- When link break notifies affected set of nodes using the lost link
- AODV uses destination sequence number for each route entry which ensures loop freedom and is simple to program
- Nodes monitor link status of next hops in active routes. It keeps 'precursor list' with IP addresses of neighbors which are likely to use it as next hop

Ad Hoc on Demand Distance Vector(AODV)

- Messages types are RREQs RREPs RERRs. They are received via UDP and processed as IP headers
- Node broadcast RREQ to find new route to destination
- Route becomes available by unicasting RREP back to originator of RREQ. Each node receiving request caches route back to the originator
- Nodes monitor link status of next hops in active routes. When link breaks RERR notifies other nodes . The message indicates those destinations which are no longer reachable

Ad Hoc on Demand Distance Vector(AODV)

- AODV is designed for MANETs with population of tens to thousands nodes. Nodes of network can trust each other (using keys or no intruders assumed)
- AODV handles different mobility rates and variety of traffic data and reduces dissemination of control traffic
- More details: RFC 3561 2003, Experimental

Dynamic Source Routing Protocol (DSR)

- Designed specially for MANETs to make them completely self-organizing and self configuring
- Route Discovery obtains route from source to destination if it is not known and there is data to send
- Route Maintenance allows sender to detect if network topology has changed and its route to destination cannot be used anymore. Then sender can use any route or start route discovery
- Both mechanism operate on strictly demand. There is no periodic activity

Dynamic Source Routing Protocol (DSR)

- A node may learn and cache multiple routes to any destination that allows reaction to routing change
- RD and RM are designed to allow unidirectional link and asymmetric routes
- DSR protocol is designed for MANETs up to about 200 nodes with very high rates of mobility. Enhancements may protocol to scale. Diameter of the is assumed to be 5 to 10
- More details: RFC 4728 2007, Experimental

Routing Performance Issues

Qualitative merits

- Distributed operation, loop-freedom
- Demand-based vs. Proactive operation
- Security and sleep period operation
- Unidirectional link support

Quantitative metrics

- End-to-end throughput and delay
- Route Acquisition Time
- Out-of-order delivery (%), Efficiency
- Overhead metrics

Routing Performance Issues

Context measures

- Network size
- Network connectivity (average number of neighbors)
- Topological rate of change
- Link capacity
- Fraction of unidirectional links
- Traffic pattern (non-uniform, burst etc.)
- Mobility

Mobility Model

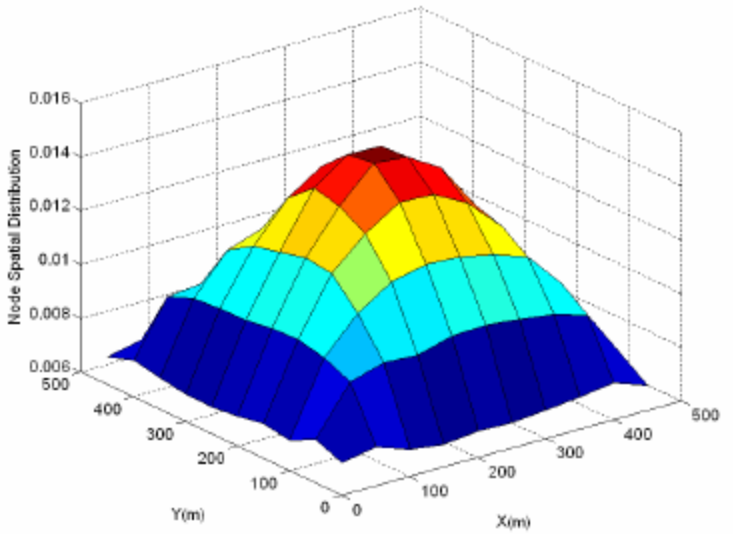
- Mobility model plays essential role in MANET protocol performance
- Movement patterns and nodes velocity have significant impact on routing and communication processes
- There exists typical movement patterns
- Ad hoc routing protocol performance may vary drastically across mobility models
- Mobility characteristics interact with connectivity graph properties

Random Waypoints

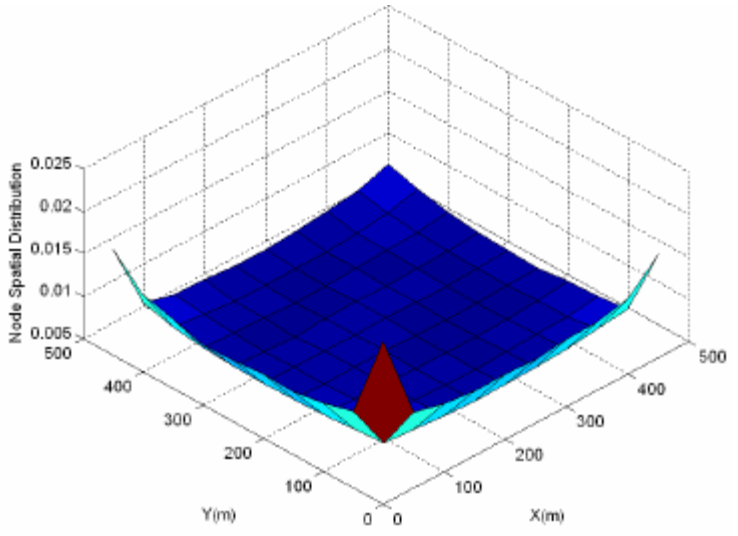
- Each mobile node randomly select destination on the simulation field
- Nodes travels toward selected destination with constant velocity $[0, V_{Max}]$
- After reaching destination nodes stops for time T_{pause} and then chooses new random destination and moves towards it
- Nodes choose destination and velocity independently
- Nodes concentrate in the central area. Non-uniform distribution problem

Random Direction

- Each node randomly and uniformly selects direction to which it moves along it reaches the boundary
- Then it selects new random direction



Random Waypoint



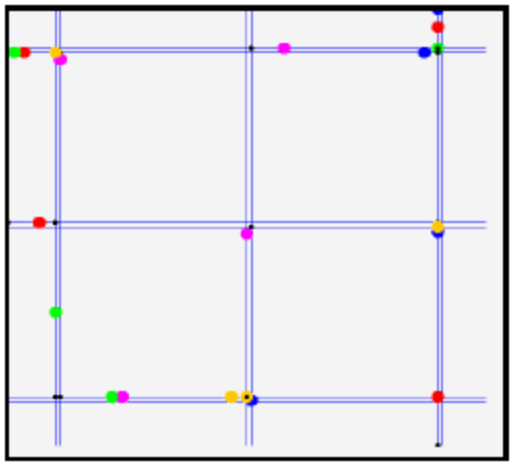
Random Direction

Random Walk

- Originally proposed in physics and Mathematics
- Mimics unexpected way of movements of mobile nodes
- Nodes change speed and direction each time interval and chooses new values from given intervals
- Boundary behavior is reflection

Manhattan

- Emulates movement pattern on streets defined by maps
- Useful for modeling urban area
- Map is composed of horizontal and vertical bidirectional streets
- Node moves along street and may turn at crossing with probabilities 0.5, 0.25, 0.25
- Velocity imitates driving rules



Gauss-Markov

- Adapts different levels of randomness via one tuning parameter
- At fixed intervals of time n movement occurs by updating speed and direction of each mobile node. New value is based on the previous one
- α is tuning parameter. $\alpha = 0$ is Brownian motion and $\alpha = 1$ is linear motion

$$s_n = as_{n-1} + (1-\alpha)\bar{s} + \sqrt{(1-\alpha)^2}\, s_{x_{n-1}}$$

$$d_n = ad_{n-1} + (1-\alpha)\bar{d} + \sqrt{(1-\alpha)^2}\, d_{x_{n-1}}$$

Reference Point Group Model (RPGM)

- Mobile nodes in MANET tend to coordinate their movements (conference, meeting, rescue crew)
- Each group has a center – group leader node. The movement of the group leader determines mobility behavior of the entire group
- Initially group members are uniformly distributed around group leader. Then group members randomly deviate
- Leader ‘s mobility is defined by other pattern

Freeway

- Several freeways on the map have lanes in both directions
- Each mobile node is restricted to its lane
- The velocity of mobile node is temporally dependent on its previous velocity
- The velocity of following node can not exceed velocity of preceding node on the same lane