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Performance Analysis Of Multi-Homed Hybrid Ad Hoc Network

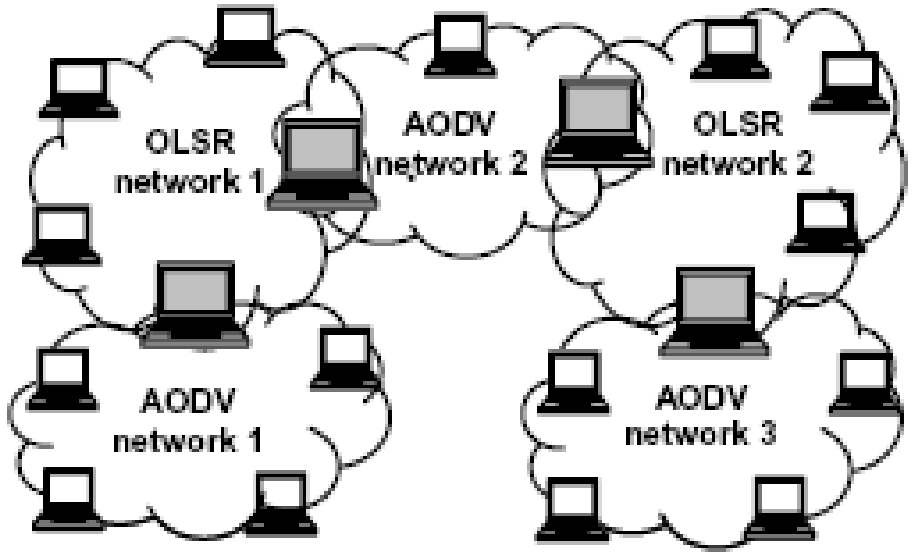
Bernardo Leal
DIEE- Cagliari University
bernardo.leal@diee.unica.it

Outline

- MANET Description
- Mobility Problem
- MANET Protocols
- The Multi-Homed Scenario
- Performance Evaluation
- Conclusions

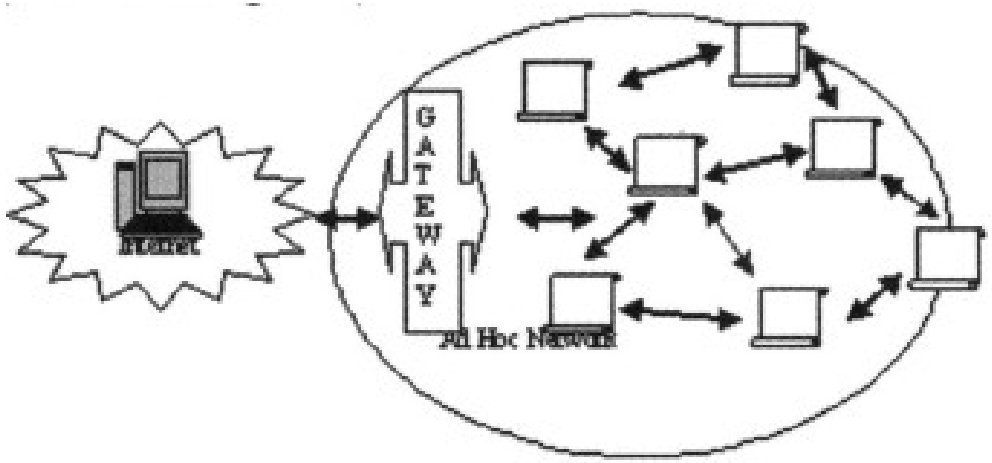
MANET (Mobile Ad Hoc Networks):

- A MANET consists of a number of self organized mobile nodes with routing capabilities forming a network without a predefined structure
- Mobile nodes use multi-hop routing protocols



Hybrid Ad Hoc Network

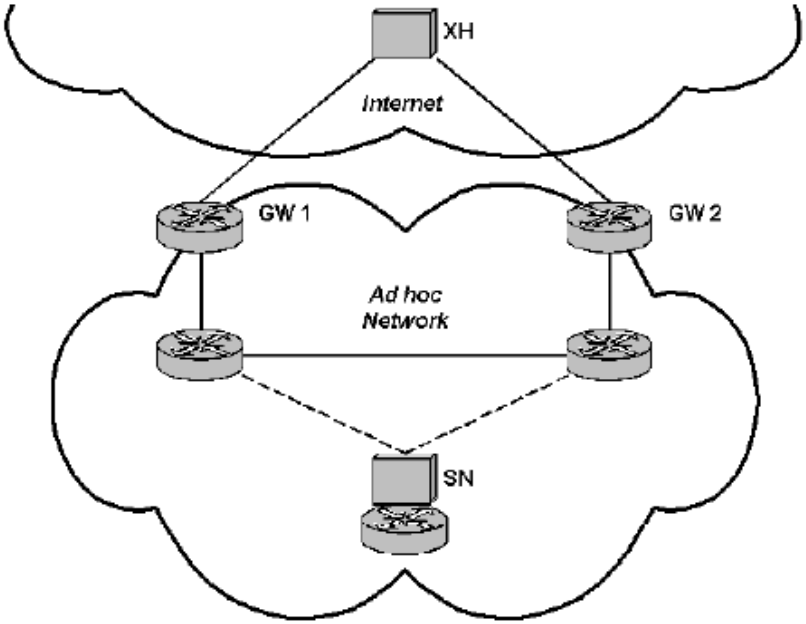
- Occurs when there is an integration of a MANET and a fixed infrastructure, as Internet.
- The MANET can be seen as an extension to the existing infrastructure
- MANET nodes may communicate to nodes on the fixed network by means of gateways found on the edge joining both type of networks



Node Mobility Effects

Most of the protocol performance research considers static MANET nodes. Routes to Gateways may be lost when nodes move, but if there are two or more available Gateways:

- Mobile nodes may need to change its actual Gateway
- Mobile nodes may also need to change its network address



Gateway Change Effects

Data packets are not transmitted while, with the help of the MANET routing protocol, a mobile node changes its gateway, and this may cause:

- Packet delivery Interruption
- Packet losses
- Communication connection losses

Network Address Change Effects

Data packets will have a different origin addresses than before, and this may cause that:

- Return packets in ongoing communications may be lost
- Active connections may be lost

MANET Routing Protocols (1)

MANET Routing Protocols are needed to find available gateways, but depending on its type, they perform differently when a gateway change is need:

- Proactive routing protocols permit mobile host to have routes to any possible destination at any time, as do traditional routing protocols. OLSR and OSPF with MANET Extensions are examples of proactive routing protocols
- Reactive routing protocols look up for a route only when it is needed. It produces less overhead, but they have longer packets delays when nodes don't move as much. AODV is an example of reactive routing protocol

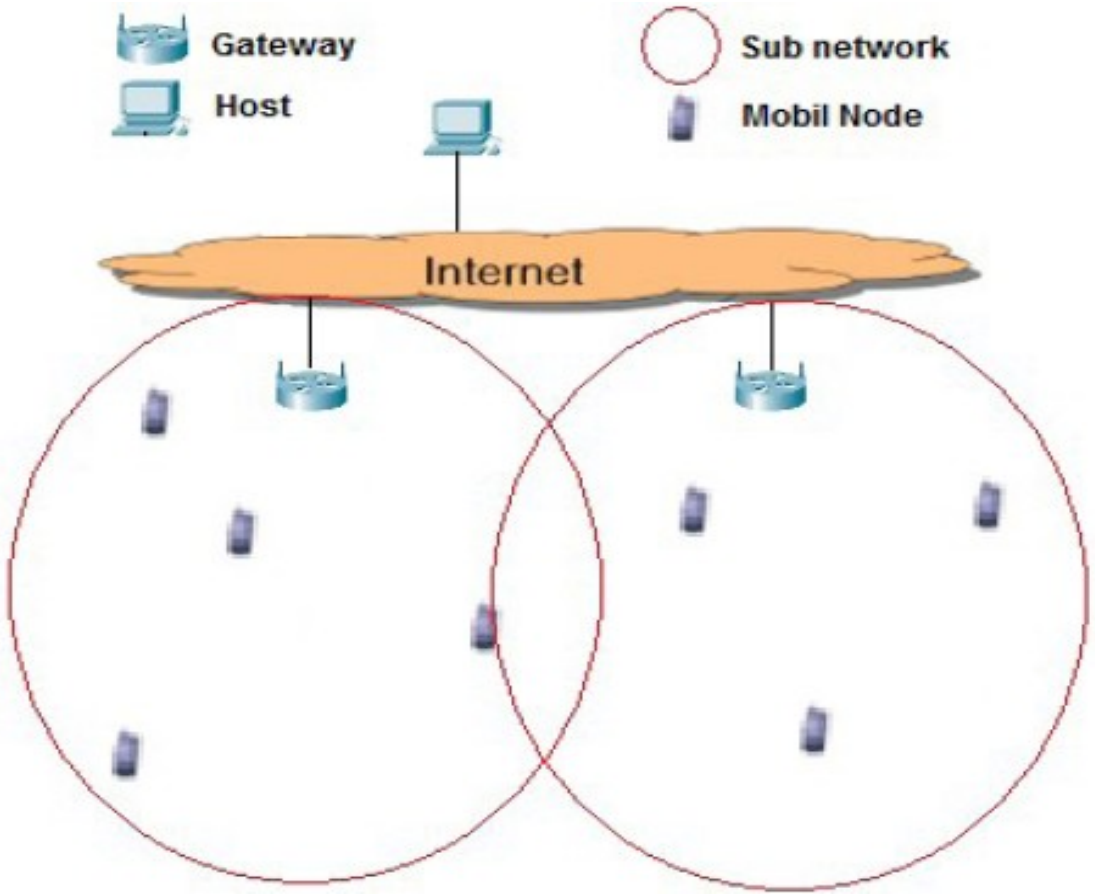
MANET Routing Protocols (2)

- Paradoxically, reactive protocols tend to take less time than proactive protocols to recover from the effects of route losses in the presence of node mobility
- OSPF with MANET Extensions was specially developed to deal with the integration issue with the fixed network, when OSPF is used as its routing protocol

MANET Routing Protocols (3)

	AODV	OLSR	OSPF
Route Discover	• Route Request • Route Reply • Hello (1 sec)	• Hello (2 sec) • TC (each 5 sec)	• Hello (2 sec) • LSA s (as needed)
Lost Route	No Hello within 2 seconds	No Hello within 6 seconds	No Hello within 6 seconds
Message	• Route Requests (24 bytes) • Route Replies (20 bytes) • Route Errors (20 bytes) • Hello messages (4-6 bytes)	• Hello (8 bytes + 4 bytes for each neighbor interface) • Topology Control (4 bytes + 4 bytes per advertised neighbor)	• Hello (36 bytes + 4 bytes per neighbor) • Router-LSAs (20 bytes + 40 bytes per neighbor)

The Multi-Homed Scenario



The Scenario Components

1. The fixed network, where hosts remain always in the same sub network without changing their address prefixes, and a traditional IGP protocol, like OSPF, is used to find usable routes
2. The MANET, where mobile hosts may move and change their sub network associations and their IP addresses, and find usable routes by means of a MANET routing protocol
3. The gateways, which are special routers that connect the MANET to the fixed network, allowing not only data packets traversing from one network to the other, but that the routing protocols from each of the networks may share their known routes
4. When more than one gateway links both type of networks, it is known as Muli-Homed Hybrid Ad Hoc Network

Gateway Selection (1)

- Mobile nodes choose from the available gateways the closest one.
- The simples criteria to define the closest gateway is the minimal hop distance, but others metrics may be used
- The “closest gateway” condition is more accurate when proactive routing protocols are used than when proactive ones
- Gateway routes may be saved on mobile nodes as a default route, or as multi-hop route

Gateway Selection (2)

Gateways discovery may be done using one of two mechanisms: a reactive one and a proactive one

- In the reactive version, when a node requires Internet connectivity, it issues a request message which is flooded throughout the MANET. When this request is received by a gateway, it sends a message which creates reverse routes to the gateway on its way back to the originator.
- The proactive approach is based on the periodic flooding of gateway advertisement messages, allowing mobile nodes to create routes to the Internet in an unsolicited manner

Address Allocation

Address allocation on MANET nodes may be done in tree different ways:

- Manual configuration, in which IP addresses are set one by one by an operator or the users themselves
- Stateful Auto-configuration Mechanism, in which a server is used to provide IP addresses
- Stateless Auto-configuration Mechanism, which is based on network prefixes advertised by one or more gateways nodes. This solution is the preferred one because it deals better with network partitions

Stateless Auto-configuration

- If there are available more than one gateway, each one announces a different network prefix, allowing the formation of subnets of nodes sharing a common network prefix
- Subnet formation helps on reducing routing table sizes, on facilitating packet forwarding, and also permits summarization on each gateway of the MANET routes propagated towards the fixed network
- Mobile nodes will set its addresses in correspondance to the gateway to which they register

Data Forwarding

- Packets forwarded to the Internet goes trough the selected gateway using its prefix on the origin address
- To avoid that the frequently MANET routing protocol updates affect the fixed network, it is recommended to use summarization, but this will reduce route granularity
- If return packets entre MANET using the wrong gateway, they may be lost unless mechanism as Virtual Tunnels and Mobil IP are used

Performance Evaluation (1)

The objective of this work is to compare traffic performance for three MANET routing protocols when a moving MANET node that changes gateway, maintains communications with a node on the fixed network. The scenario considers an hybrid ad hoc network with two gateways linking the MANET and the fixed network running OSPF. The MANET protocols considered are:

- Optimized Link State Routing Protocol (OLSR)
- Ad-hoc On-Demand Distance Vector (AODV)
- Open Shortest Path First (OSPF) with MANET Extensions

Performance Evaluation (2)

The considered metrics to evaluate the MANET protocol performance are:

- Packet Delivery Ratio (PDR), which is the ratio of the number of data packets received to the number of data packets transmitted
- End-to-End Delay, which is the time needed to deliver a packet from the data source to the data destination
- Jitter, which represents the variability of the End-to-End Delay

Performance Evaluation (3)

- In this scenario a mobile node moves slowly from one sub-network to the other maintaining a voice connection with a host in the fixed network. The power on the mobile node and gateways, and there positions are adjusted to produce a gateway change while moving
- Since OLSR and OSPF with MANET Extensions have similar characteristics, the simulations are done initially only for AODV and OLSR
- The simulator used was OPNET Modeler v.14.5

AODV Behavior

- When a mobile node needs to forward packets outside the MANET, it broadcast a route request
- Gateways, if present, will respond with a valid route
- The node chooses the closest gateway that answers, from which it also gets its address prefix
- If gateway route get lost, the node issues a new gateway requests after a 2 seconds wait.
- If a different gateway is used, the node will also have to use a different network prefix
- During the gateway change, data packets may be delayed or lost
- Address change may cause communication loss

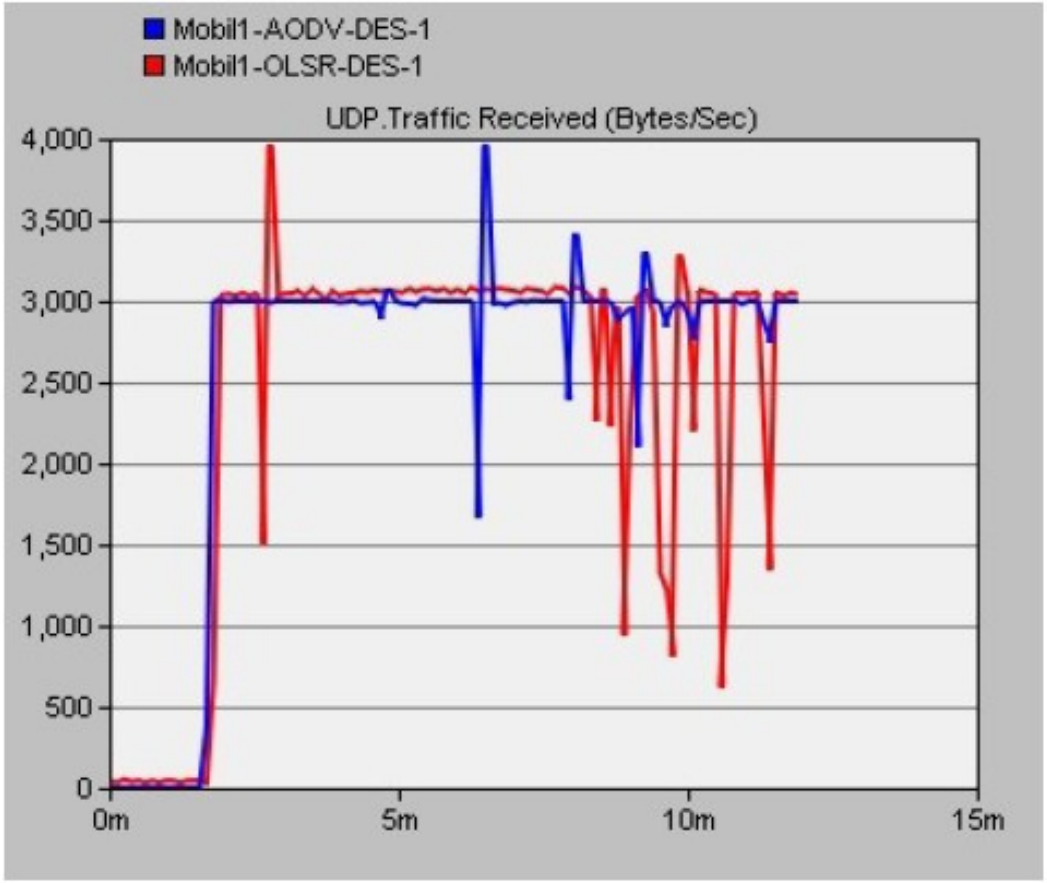
OLSR Behavior

- OLSR finds routes to any possible destination, including gateways, in an unsolicited manner
- The node chooses the closest gateway, from which it also gets its address prefix
- If any route, including gateway routes get lost, routes must be recalculated on the whole MANET after a 6 seconds wait.
- If a different gateway is used, the node will also have to use a different network prefix
- During the gateway change, data packets may be delayed or lost
- Address change may cause communication loss

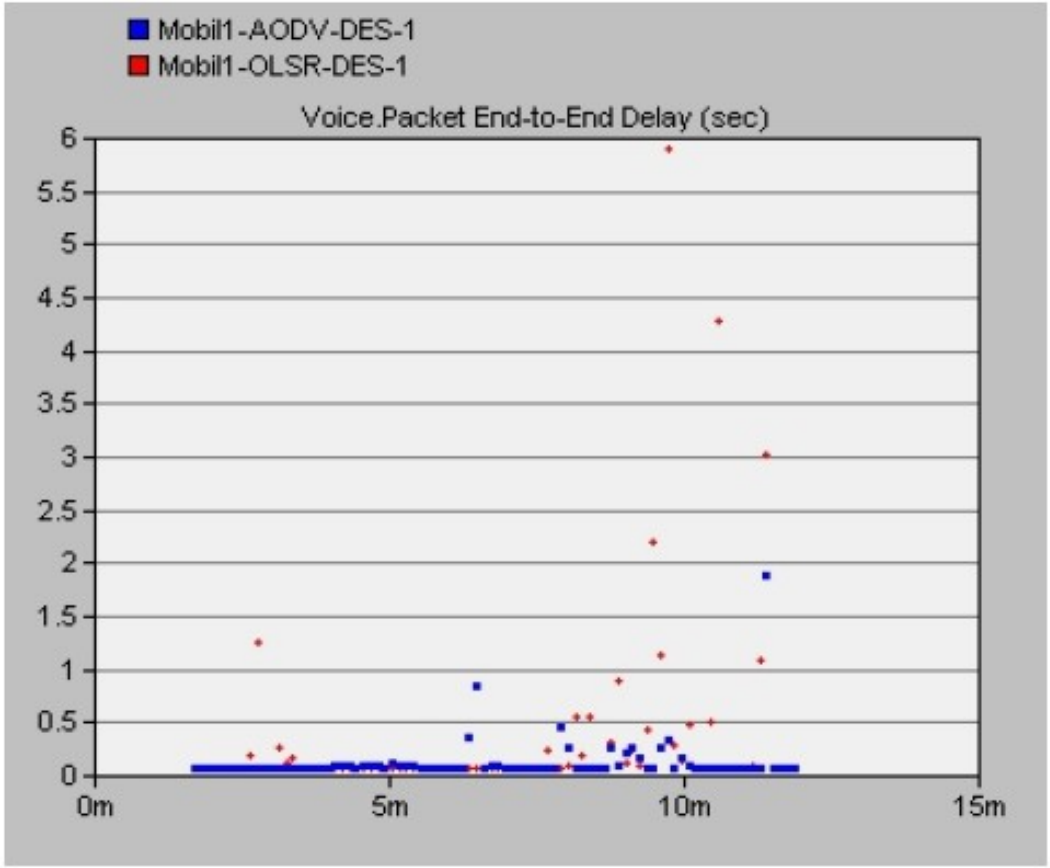
Behavior Confrontation

	AODV	OLSR and OSPF
Behavior	• 2 seconds to declare lost routes • Only rediscover lost routes • Minor routing congestion	• 6 seconds to declare lost routes • Rediscover every routes • Major routing congestion
Mobility Impact	• Do not require route summarization • Do not require gateway interlinks • PDR will be smaller • End-to-End Delay will be bigger • Jitter will be smaller	• Require route summarization • Require gateway interlinks • PDR will be bigger • End-to-End Delay will be slower • Jitter will be bigger

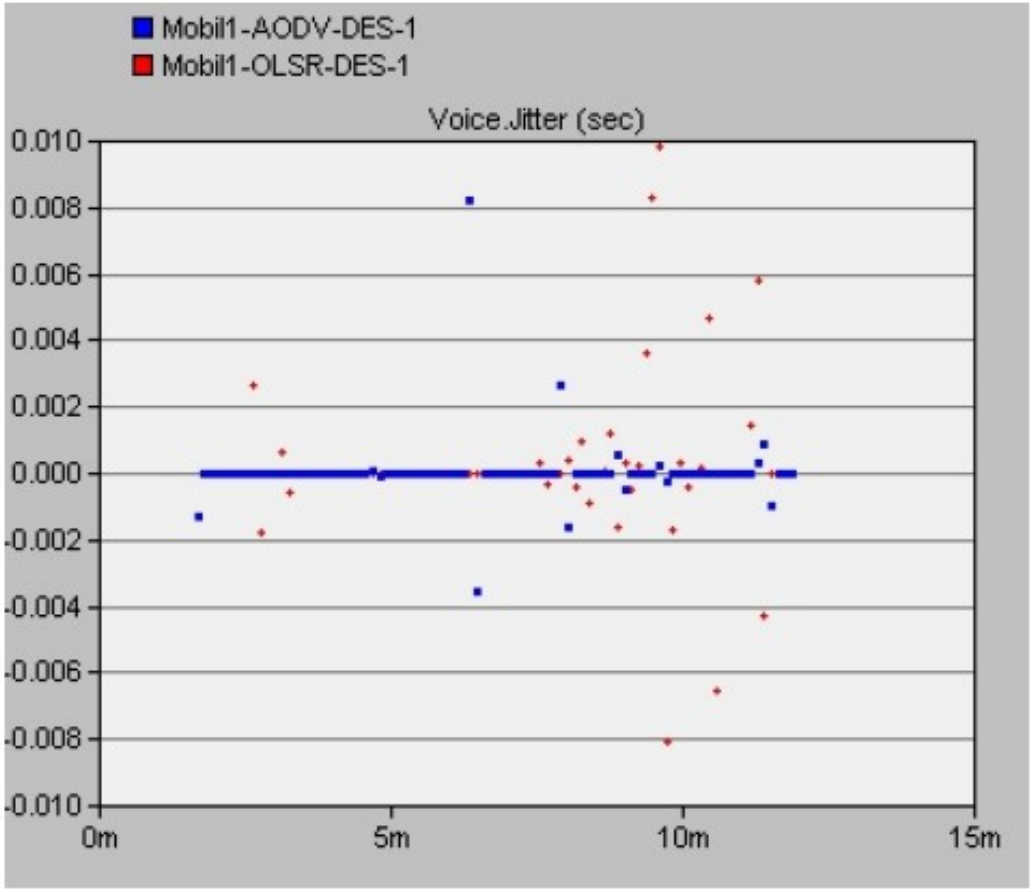
Results (Packets Received)



Results (End to end delay)



Results (Voice jitter)



Results Analysis

- It may be seen that, even though AODV takes longer to begin transferring packets, it will react faster to gateway route losses than OLSR and OSPF, not only because OLSR and OSPF will take 4 more seconds than AODV to declare a valid route as lost, but because AODV only recover that specific route that is lost. On the other hand, OLSR and OSPF recover every possible route that is lost
- This makes PDR bigger when AODV is used
- Also End-to-end delay will be lower when AODV is used
- Finally, Jitter will be lower when AODV is used

Conclusions

- It can be seen that when there is mobility of nodes in a Multi-homed Hybrid Ad Hoc Network, the normal performance behavior of traditional MANET routing protocols change
- OLSR and OSPF with MANET Extensions, which were designed to have better real time response and better integration with the fixed network respectively than AODV, resulted with a poorer performance in this connection
- This, summed with the fact that AODV introduces less overhead, makes it the recommended protocol to use in this particular condition

Future Work

There are other aspects that must be considered in a multi-homed hybrid gateway mobility scenario:

- Effects found over the fixed network routing protocol when nodes move from one MANET sub-network to another
- Transparent transitions between different MANET sub-networks