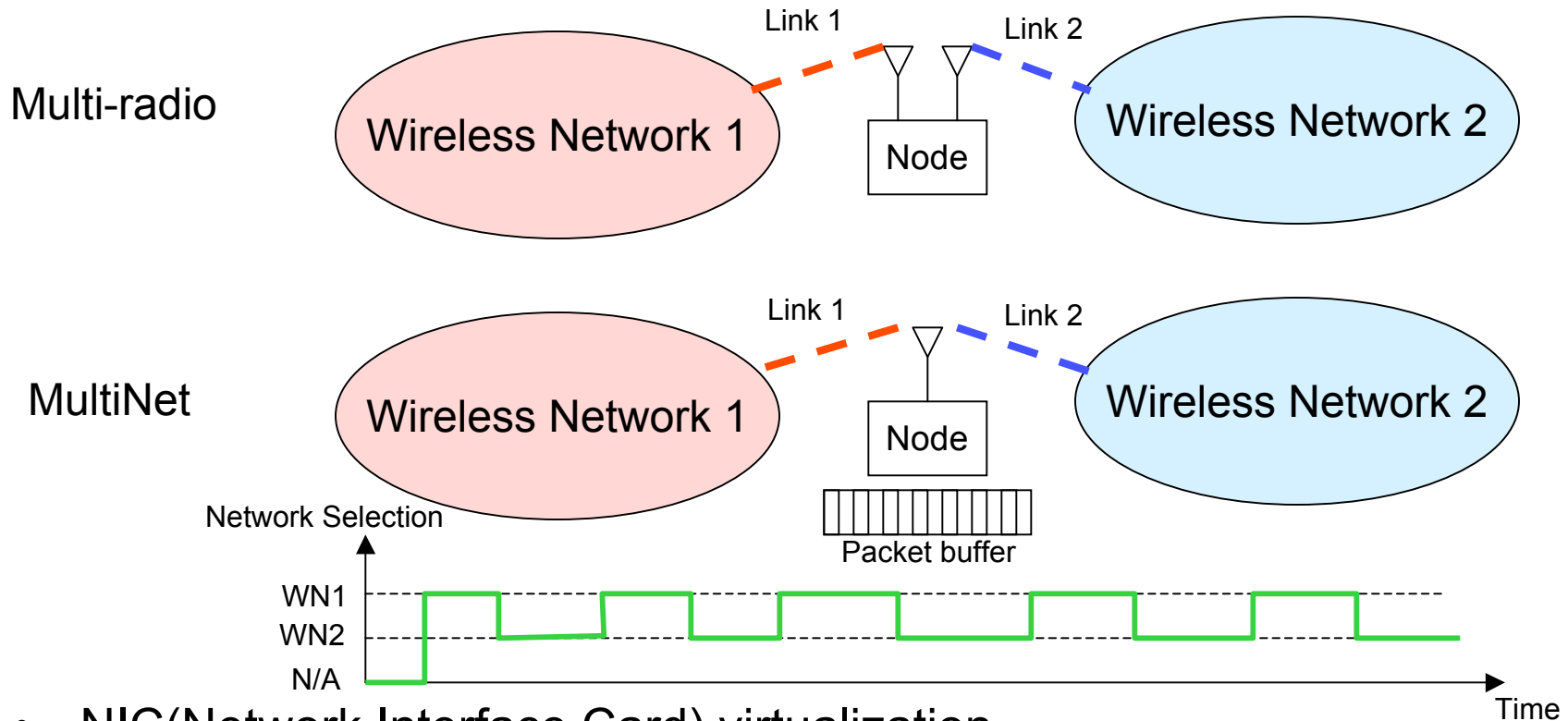


MultiNet: Connecting to Multiple IEEE 802.11 Networks Using a Single Wireless Card

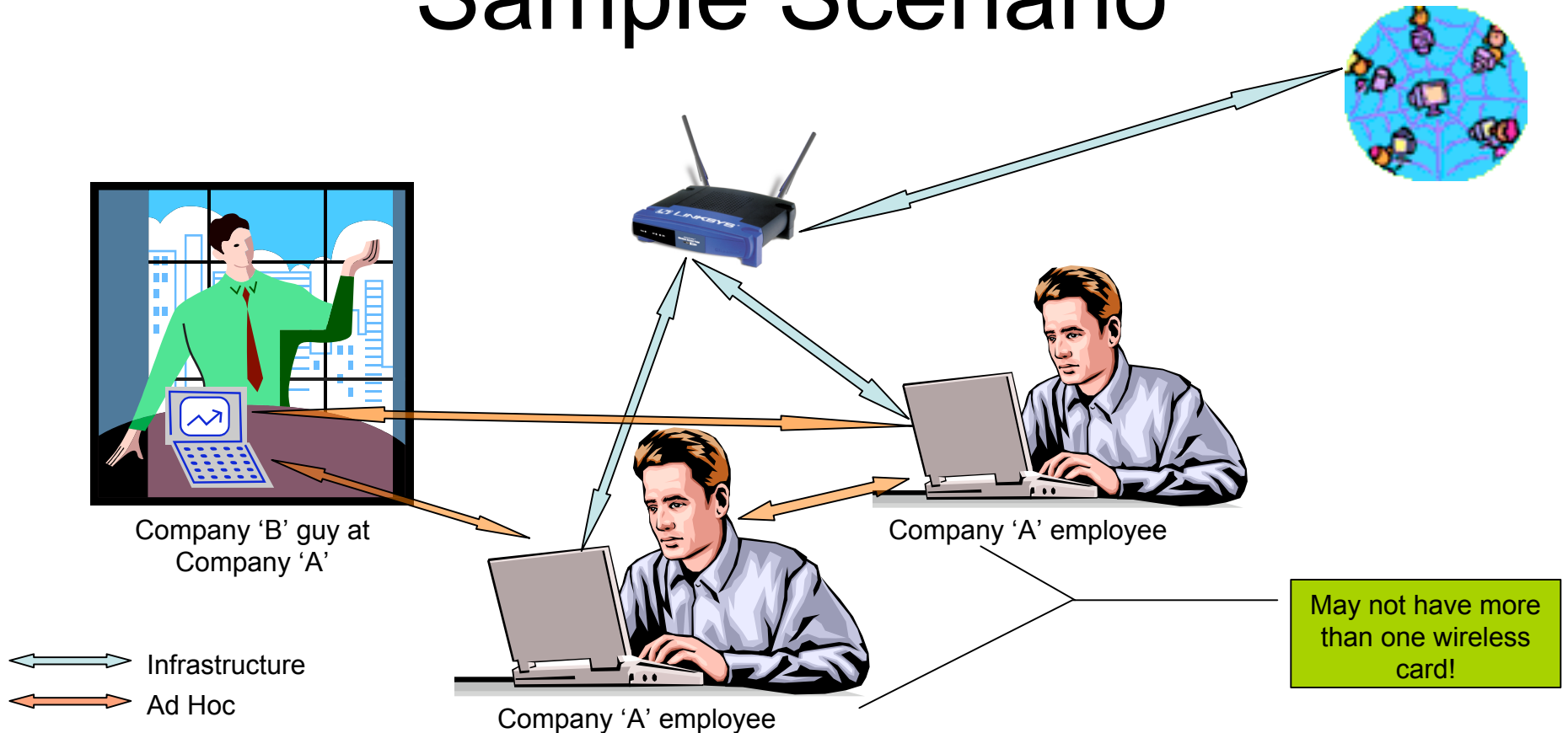
Ranveer Chandra, Paramvir Pahl, Pradeep Bahl
Cornell University & Microsoft Corp.
Presented by Liang Chen

Ideas



- NIC(Network Interface Card) virtualization
- Use one NIC to connect multiple wireless network as multiple network interface
- Save more power and hardware cost than multi-radio

Sample Scenario



Other applications:

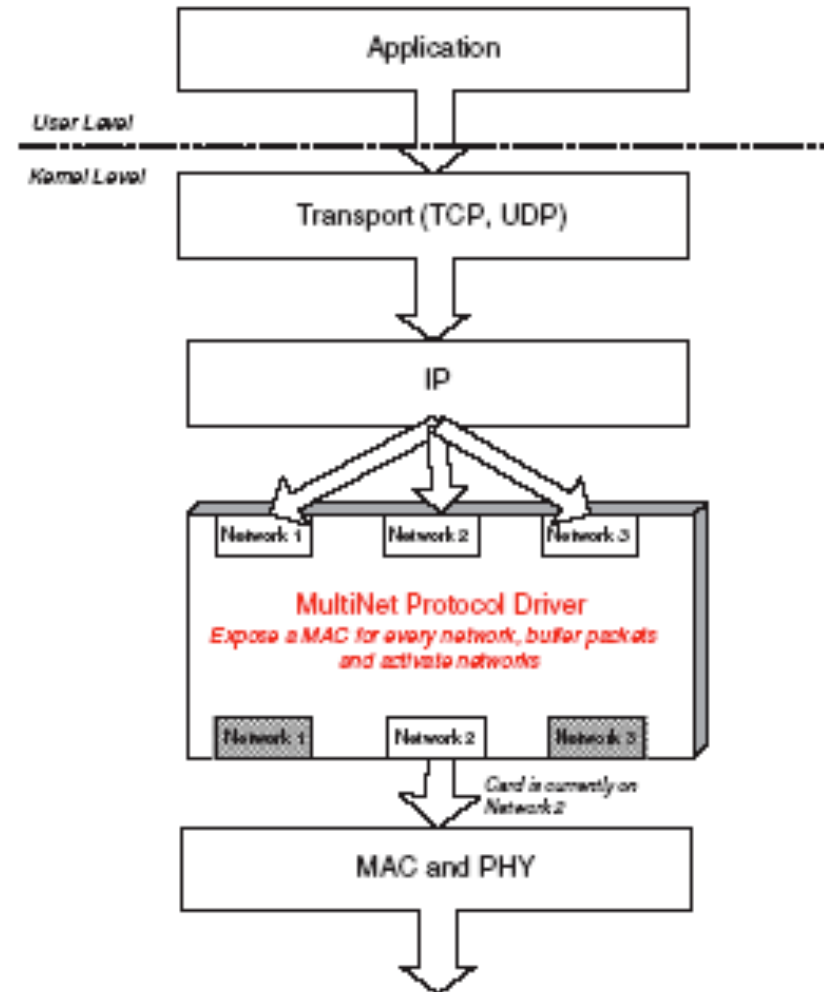
- Gateway node of a wireless ad hoc network
- Extending the range of an infrastructure network

Problems

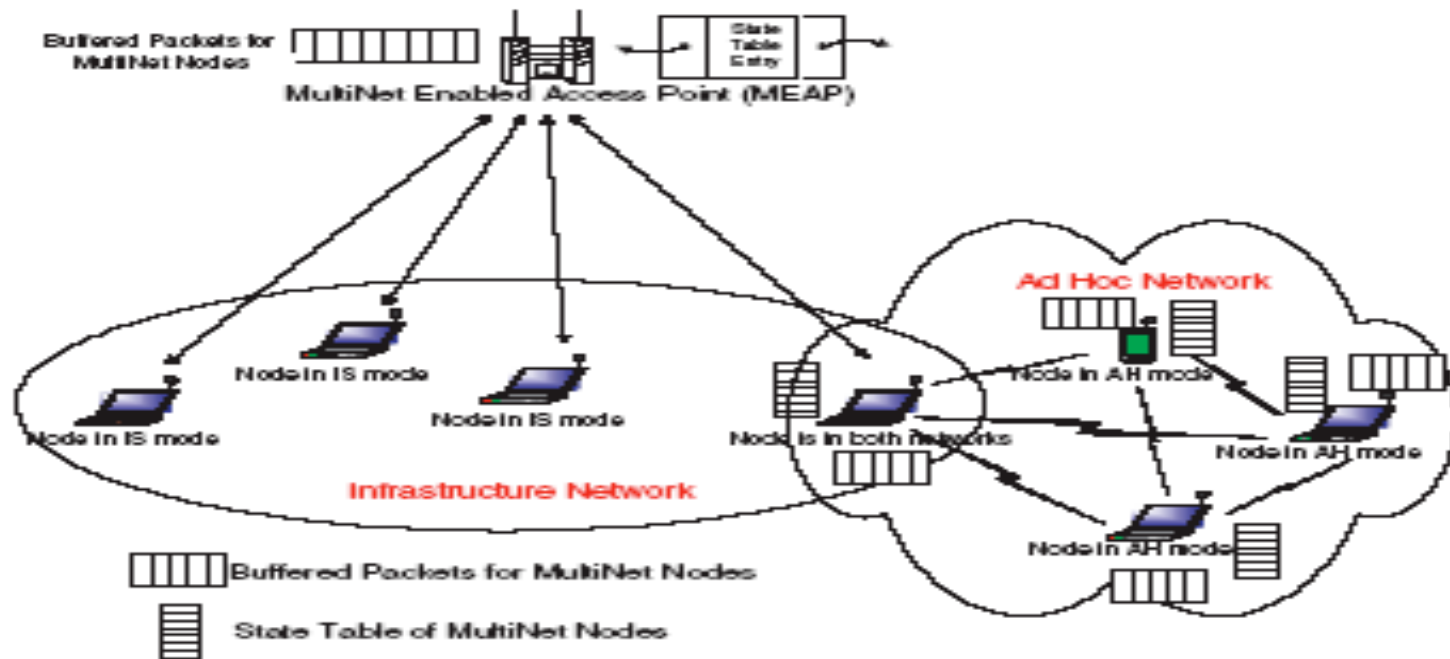
- Network interface virtualization
- Buffering protocol
- Switching algorithm
- Synchronization of multiple switching nodes in an ad hoc network

NIC Virtualization

- Implement a MPD (MultiNet Protocol Driver) between IP layers and 802.11 MAC
 - MPD provides multiple virtual NICs to IP layer. Each virtual NIC corresponds to a wireless network
 - MPD instructs 802.11 MAC to associate each wireless network periodically. When a wireless network is associated, it correspond virtual NIC is **active**.
 - When a virtual NIC is active, MPD schedules the downlink packets through it to the 802.11 MAC and transfer the packets received from 802.11 MAC to the active virtual NIC.
 - MPD buffers packets sent to the inactive virtual NICs.
 - MPD filters out the disassociation interrupt to IP layer when it switches network



Buffering protocol

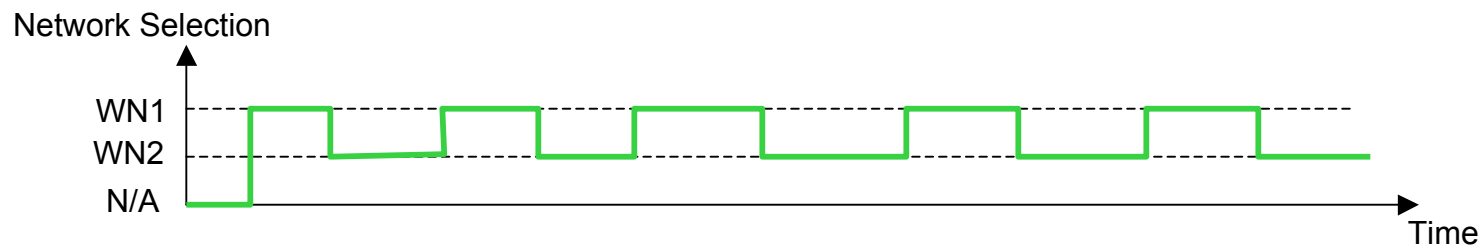


Issues:

- Delivery packets sent by the MultiNet node when network is not active
 - MultiNet node buffers packets until the network is active
- Delivery packets sent to the MultiNet node when the node is not active
 - Other nodes buffer packets until the MultiNet node is active
 - Notify its neighboring when it leaves and comes back so that its neighboring buffer its packet until it's active again.

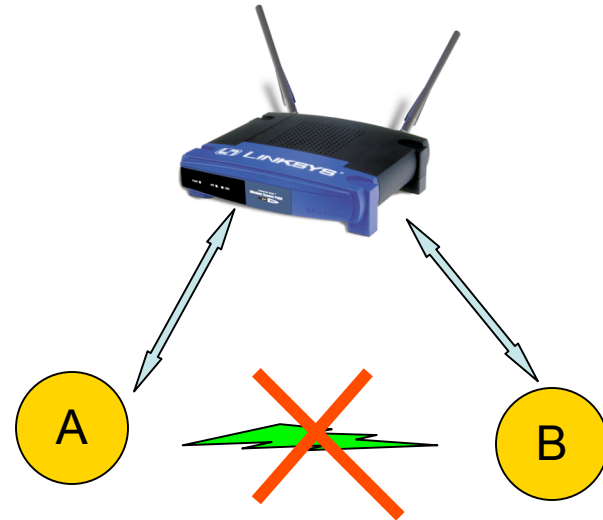
Switching Algorithms

- Decide how much time the MultiNet node stays in a network
 - Fixed priority
 - Adaptive Schemes
 - Give more time to the network with more traffic.

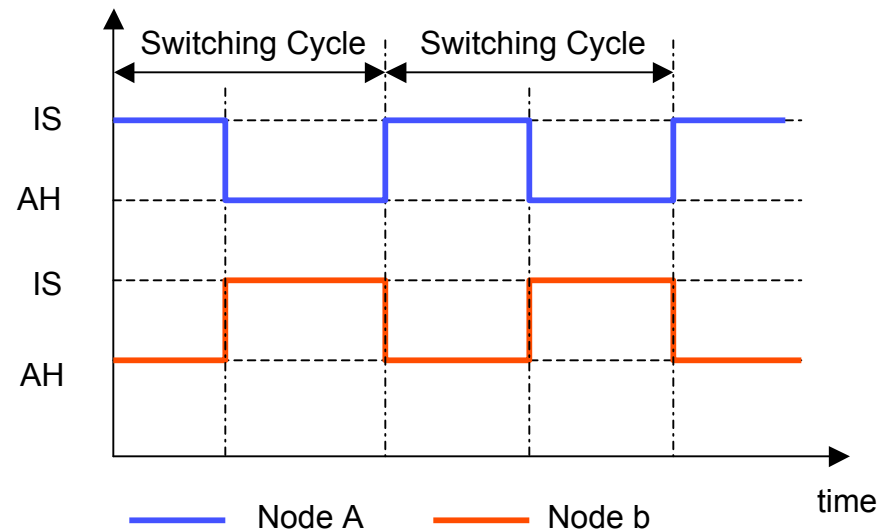


Synchronization

- Problem
 - No active overlap between 2 MultiNet nodes in ad hoc mode
 - They can not discovery each other
- Solution
 - Stay long enough to listen to other nodes when MultiNet node joins an ad hoc network
 - Synchronize with other ad hoc nodes by the announcement of ad hoc network



Network selection



Evaluation

- Switching Delay
- Switching Strategies
- Adaptive Switching
- MultiNet versus Multiple Radios

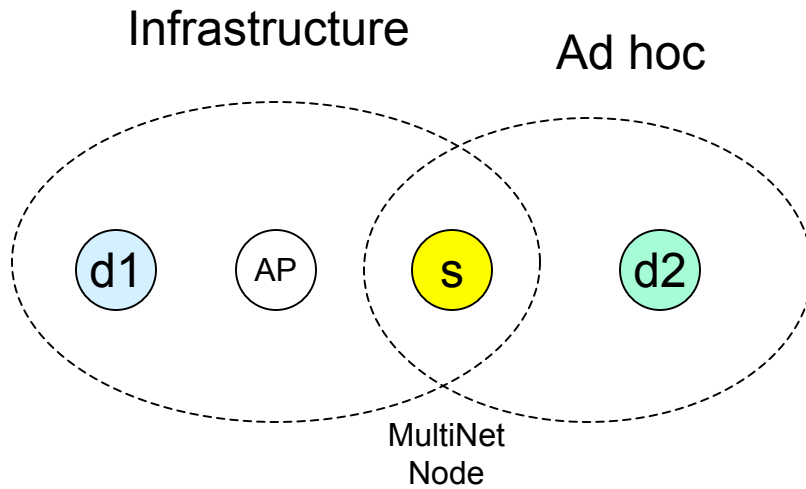
Switching Delay

TABLE I

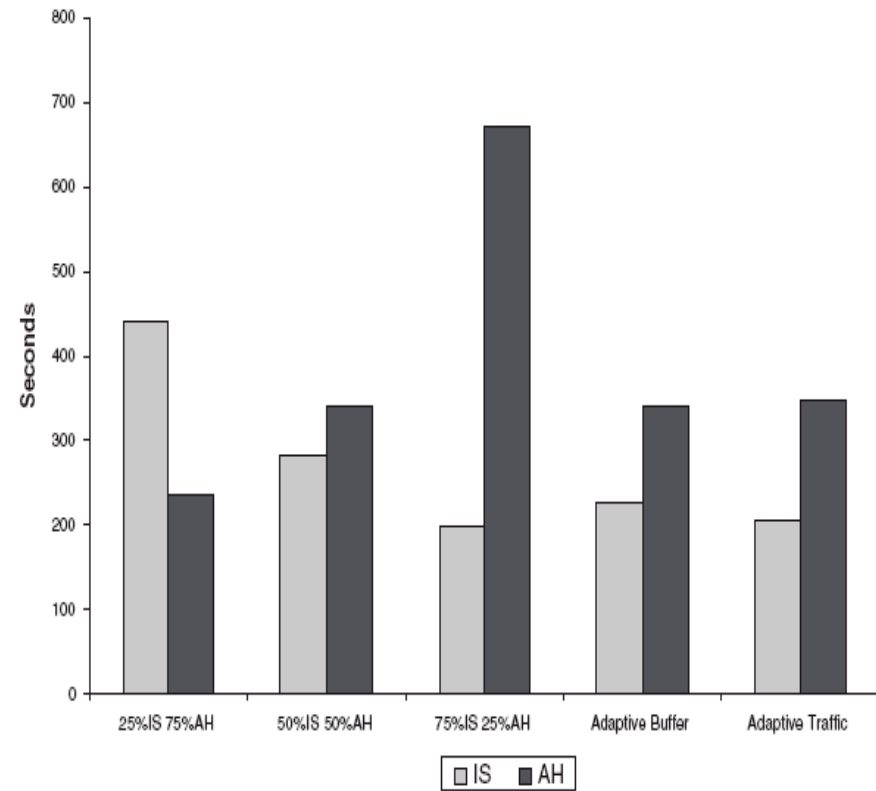
THE DELAYS ON SWITCHING BETWEEN IS AND AH NETWORKS FOR IEEE 802.11 CARDS WITH AND WITHOUT THE OPTIMIZATION OF TRAPPING MEDIA CONNECT AND DISCONNECT MESSAGES.

Switching From	Unoptimized Legacy	Optimized Legacy	Optimized Native WiFi
IS to AH	3.9 s	170 ms	25 ms
AH to IS	2.8 s	300 ms	30 ms

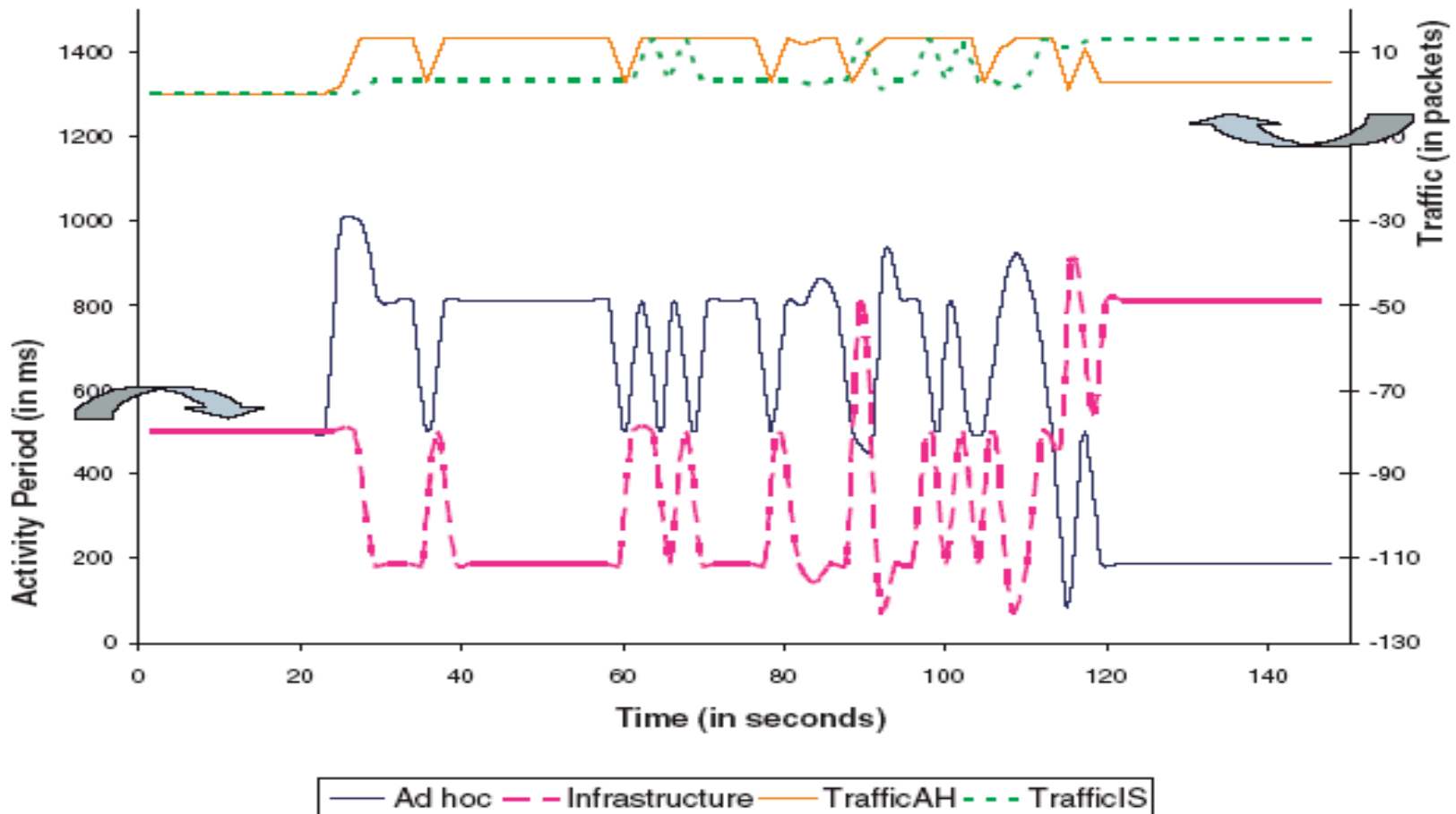
Switching Strategies



Simultaneously transfer a 47MB file
over MultiNet by FTP.

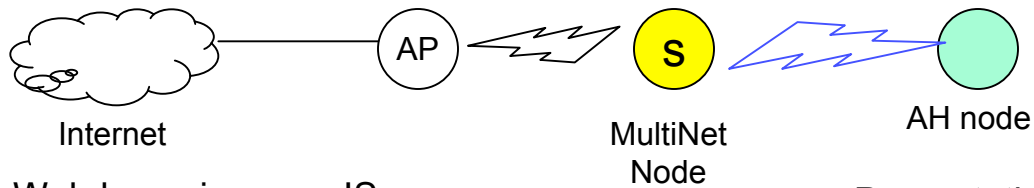


Adaptive Switching



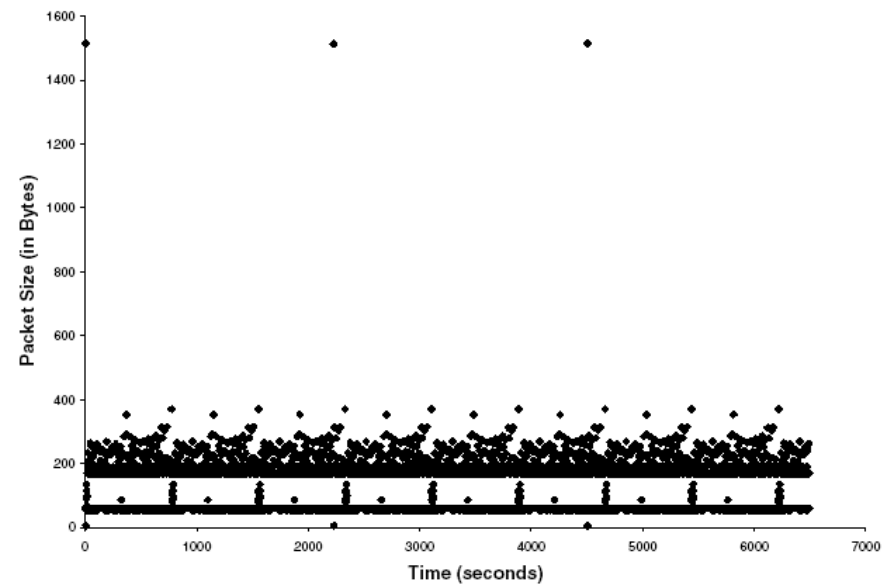
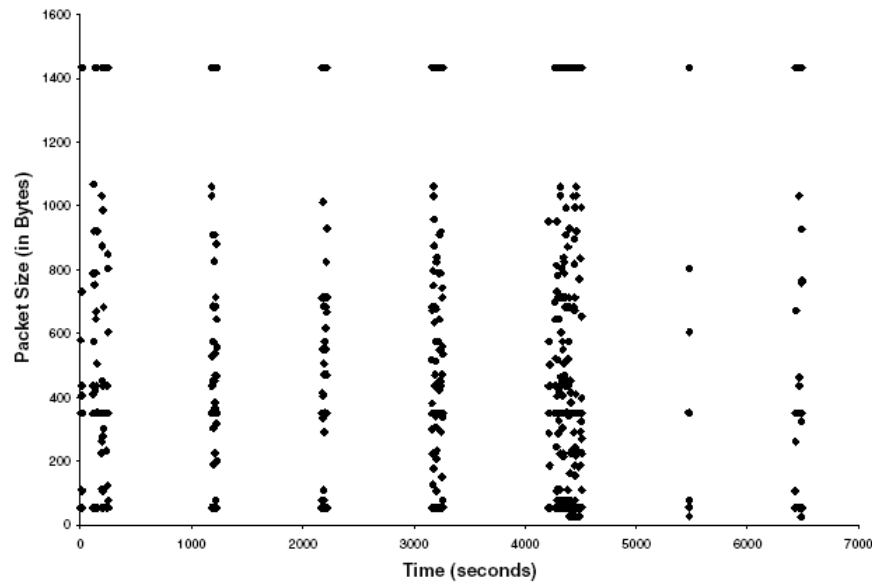
MultiNet v.s. Multi-Radio

- Simulation Scenario



Web browsing over IS

Presentation and chat traffic over AH



Results(1)

Throughput

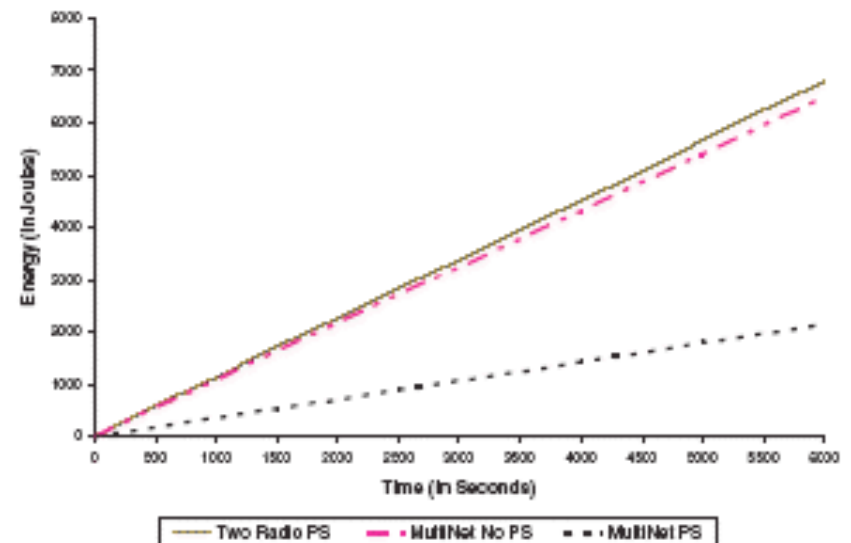
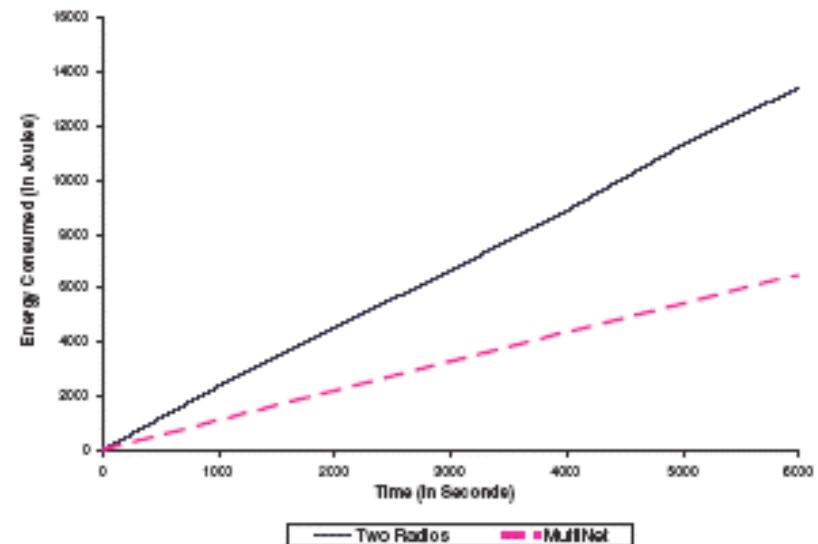
Delay

Network	Two Radio	MultiNet
Ad Hoc	4.4 Mbps	1.1 Mbps
Infrastructure	5.8 Mbps	4.35 Mbps

Scheme	Avg Delay (in Seconds)
Two Radio	0.001
MultiNet	0.157
Two Radio PS	0.156
MultiNet PS	0.167

Result(2)

- Power Consumption
 - Two Radios
 - Both radios is no PS
 - MultiNet/MultiNet No PS
 - MultiNet Radio is no PS
 - Two radio PS
 - IS radio is in PS
 - AH radio is not specified
 - MultiNet PS
 - MultiNet Radio is in PS



Maximal Connective in MultiNet

TABLE IV

THE AVERAGE PACKET DELAY IN INFRASTRUCTURE MODE ON VARYING
THE NUMBER OF MULTINET CONNECTED NETWORKS

Num Networks	Avg Delay (in Seconds)
2	0.191
3	0.261
4	0.332
5	0.410
6	0.485

Conclusion

- MultiNet provides an alternative way for multi-radio implementation by TDMA (time division multiple access)
- NIC virtualization in OS integrates the virtual multi-radio interface into network stack gracefully.

Discussion

- The accuracy of power consumption obtained from simulation
- The AH radio of Two Radio PS scenario may be in no PS mode, since most commercial 802.11 NIC does not support AH PS mode.
- The network delay introduced by MultiNet if an ad hoc node uses MultiNet node as the gateway.