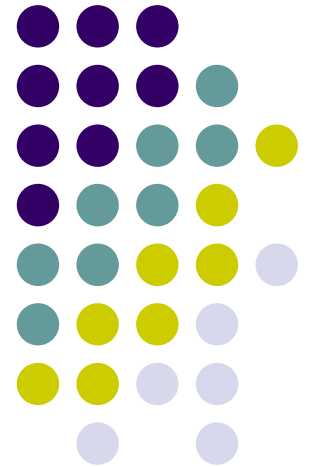


# MultiNet: Connecting to Multiple IEEE 802.11 Networks Using a Single Wireless Card

INFOCOM 2004

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# Outline



- Introduction
- MultiNet
  - Virtualization Architecture
  - Buffering Protocol
  - Switching Algorithms
  - Synchronization Protocol
- Implementation
- System Evaluation
- Discussion
- Conclusion



# Introduction

- A Microsoft research project
- Virtualization architecture that abstracts a single WLAN card to appear as multiple virtual cards to the user
- MultiNet permits simultaneous connectivity to multiple networks with only one WLAN card
  - Multiplexing the wireless card across multiple networks



# Introduction

- When connected to multiple networks:
  - Concurrent connectivity
  - Network elasticity
  - Gateway node
  - Virtual machines
- Why not multiple physical cards?
  - Excessive energy drain

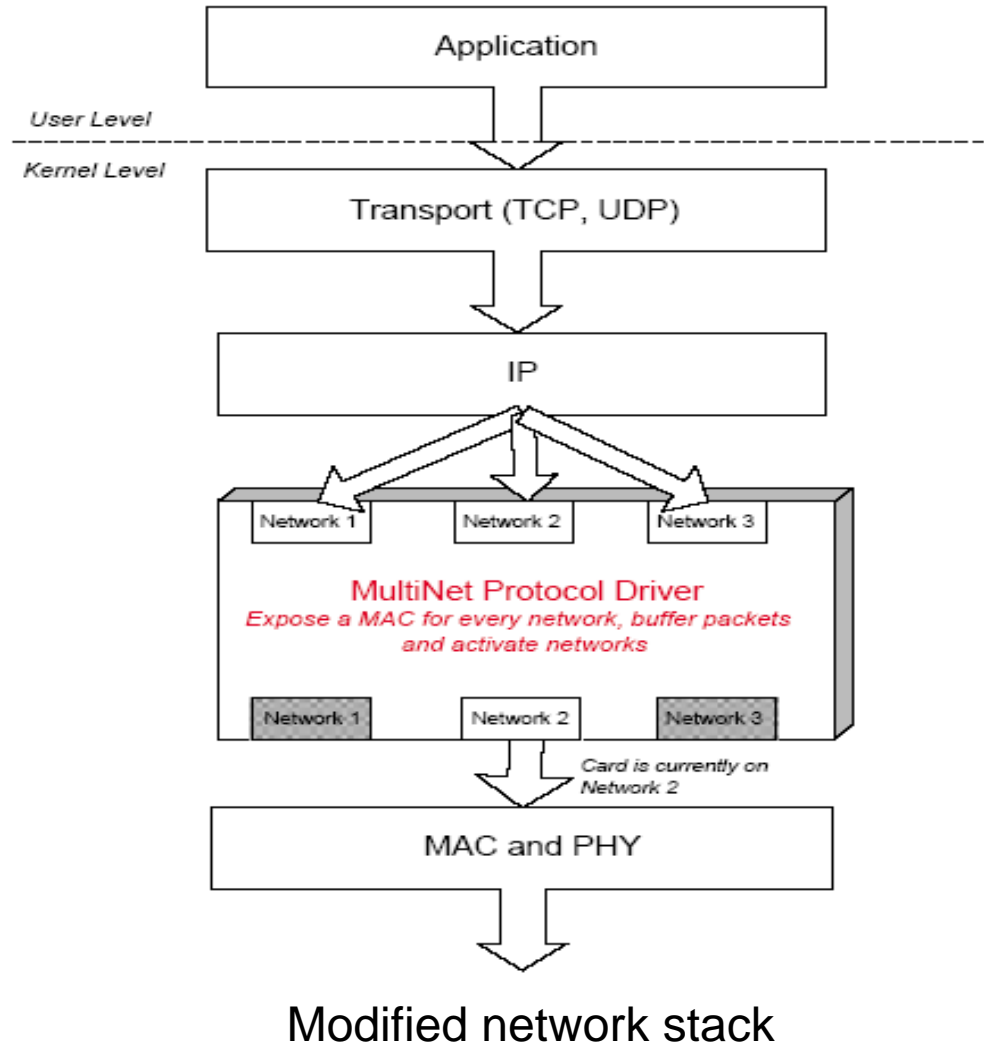
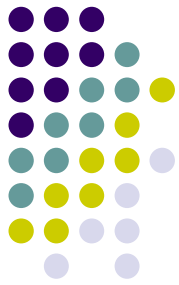
# MultiNet

## Virtualization Architecture



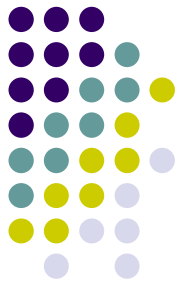
- MultiNet Protocol Driver (MPD) is placed as an intermediate layer between IP (layer 3) and the MAC (layer 2)
- The WLAN media adapter is exposed by the MPD as multiple always active virtual WLAN media adapters
  - Actually only one adapter is active at driver level at any given moment
- MPD is responsible for switching across different networks and buffering

# MultiNet Virtualization Architecture



# MultiNet

## Buffering Protocol



- Packets sent from the MultiNet card
  - If the adapter  $i$  is going to send a packet and adapter  $i$  is active at driver level then packet will be sent
  - Otherwise the packet will be buffered until the adapter  $i$  is active

# MultiNet

## Buffering Protocol



- Packets sent to the MultiNet card
  - If in network  $i$  a node  $x$  is sending a packet to a MultiNet node  $y$ , and  $y$ 's adapter  $i$  is active, then  $y$  will receive the packet
  - Otherwise  $x$  will buffer the packet until  $y$  switches back to network  $i$



# MultiNet

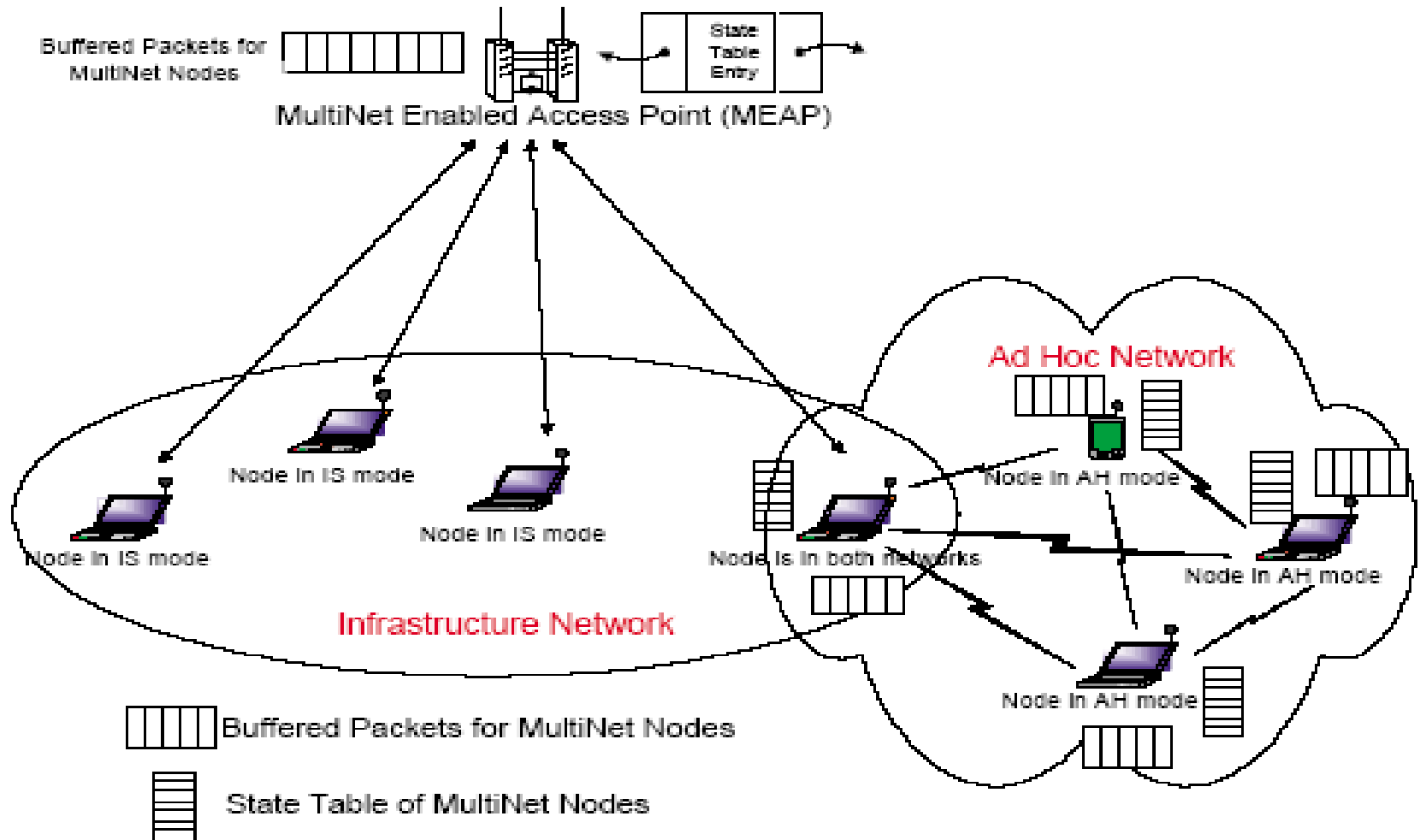
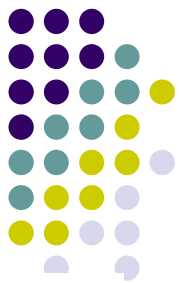
## Buffering Protocol



- APs and nodes store state info of nodes connected to them
  - The state info tells when the node will switch back to the network
- Buffering on 802.11 APs
  - Use Power Saving Mode (PSM)

# MultiNet

## Buffering Protocol



Buffering in MultiNet

# MultiNet

## Switching Algorithms



- Activity Period: the time a node stay in a particular network
- Switching Cycle: the sum of all Activity Periods of a node
- Switching algorithms:
  - Fixed Priority
  - Adaptive Schemes
    - Adaptive Buffer
    - Adaptive Traffic

# MultiNet

## Synchronization Protocol



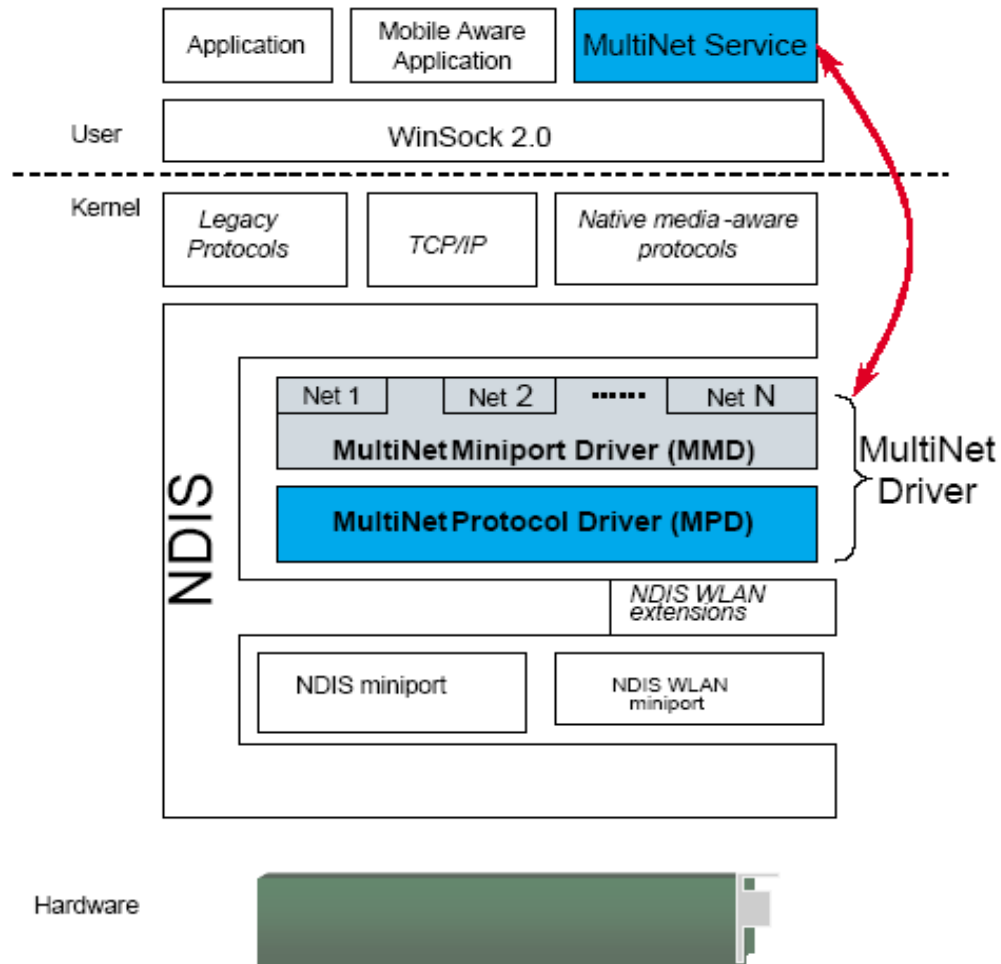
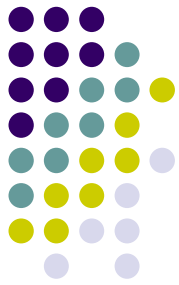
- No synchronization problem in infrastructure mode
- In Ad Hoc network:
  - Two nodes that want to communicate may never be in the same network at the same time → no overlap exists
  - Synchronization is needed for the overlap
  - Every node in ad hoc network synchronizes with the leader node
    - Leader node: node with largest MAC address



# Implementation

- No modification is needed for wired nodes
- No modification is needed for APs (by using PSM)
- Modifications are transparent to layers above IP (layer 3)
- Already implemented on Windows XP for over 12 months

# Implementation





# System Evaluation

- Delay of the switch between infrastructure and ad hoc networks

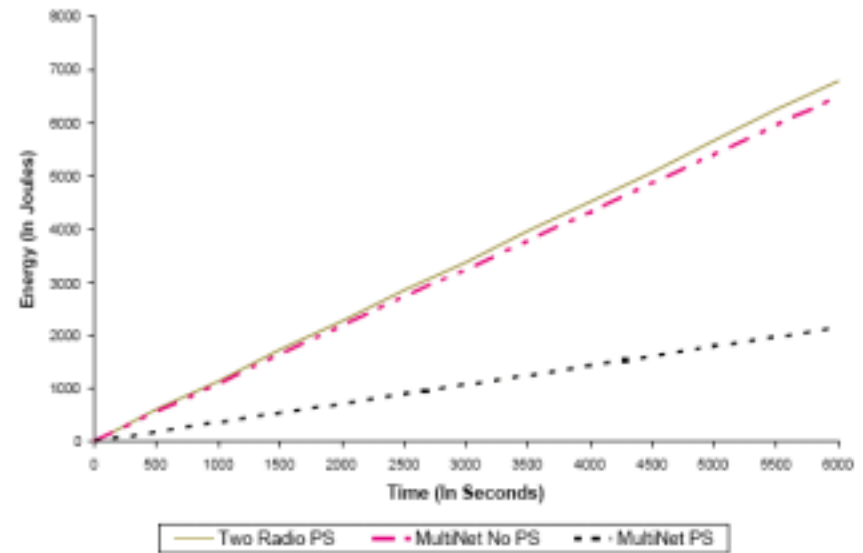
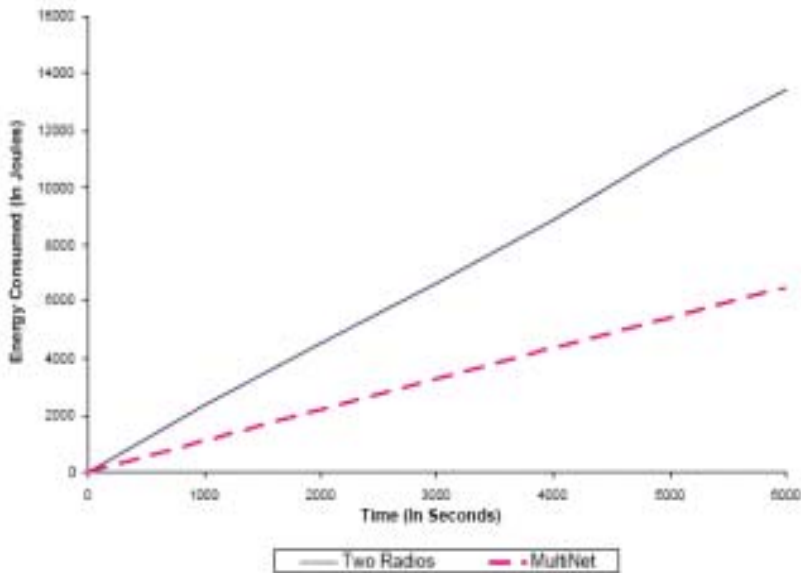
Switching From	Unoptimized Legacy	Optimized Legacy	Optimized Native WiFi
IS to AH	3.9 s	170 ms	25 ms
AH to IS	2.8 s	300 ms	30 ms

- Legacy cards: all functions are stored in the microcontroller (firmware)
- Native WiFi cards: only minimum time-critical MAC functions are stored in the firmware, leave the rest to the OS

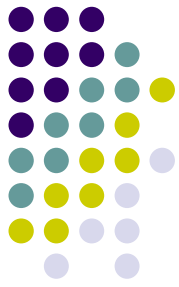


# System Evaluation

- Energy consumption between MultiNet and multiple radios







# System Evaluation

- Throughput in infrastructure and ad hoc networks

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

- Average packet delay in infrastructure mode

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

# Discussion



- Reducing the switching overhead
- Security
- Performance in ad hoc network
- Single hop vs. multihop

# Conclusion



- A new virtualization architecture which allows user to connect to multiple wireless networks simultaneously
- Only a little change to MN is needed, and no changes to current apps and protocol like TCP/IP
- MultiNet enables a framework for the design of a new class of systems and applications