# An End-to-End Approach for Transparent Mobility across Heterogeneous Wireless Networks

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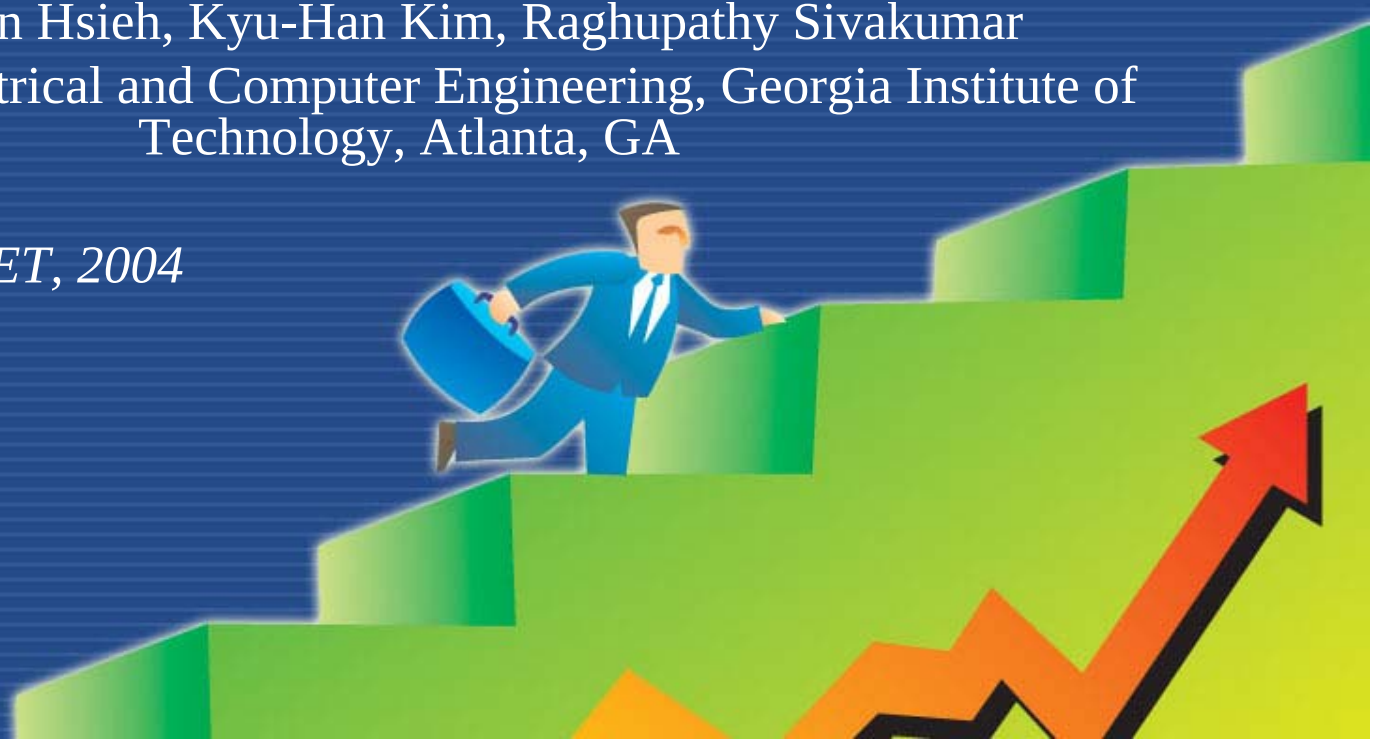
*ACM MONET, 2004*



# Outline

- Introduction
- pTCP design
- Performance evaluation
- Conclusions

# Introduction

- Reasons behind the mushrooming of heterogeneous wireless access technologies
  - mobility support, network capacity, coverage area

- A mobile host today is equipped with multiple wireless interfaces that have access to different wireless networks

# Introduction (cont.)

- Propose an end-to-end solution that enables the seamless use of heterogeneous wireless access technologies and achieves transparent host mobility

- Target environment:
  - Different access technologies
  - Different administrative domains
  - Different network models

# Introduction (cont.)

- Unique features of the proposed solution:
  - An end-to-end approach for host mobility
  - Provision for seamless handoffs
  - Support for multiple congestion control schemes
  - A flexible framework for bandwidth aggregation

# pTCP design

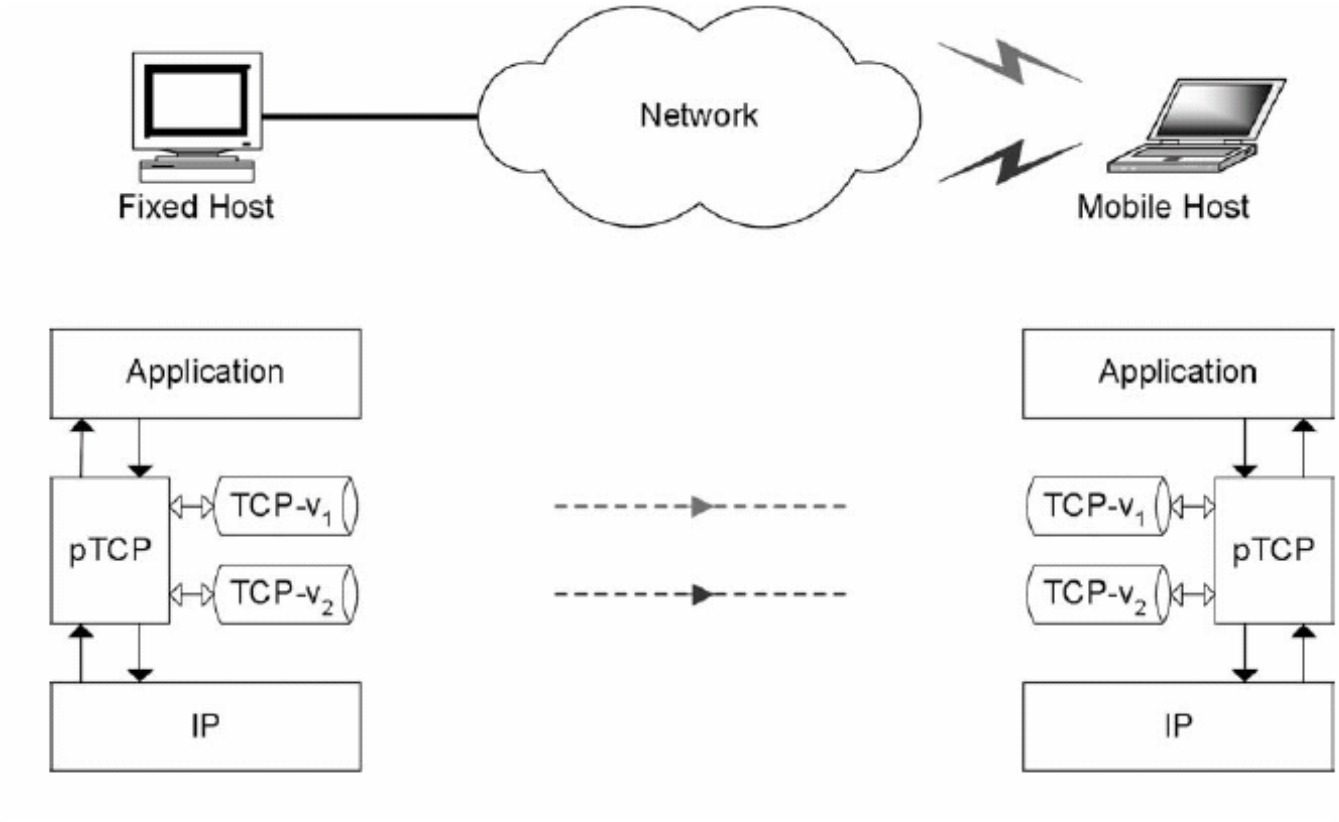



Figure 1. Multiple states in a pTCP connection.

# pTCP design (cont.)

- *Dynamic state management*
  - A TCP-v pipe is created for each *active interface* used in a pTCP connection
  - A TCP-v pipe manages the per-path TCP state including the pair of IP addresses, TCP ports, and congestion control parameters

# pTCP design (cont.)

- *Decoupling of functionalities*
  - The TCP-v handles the per-path state, while the pTCP handles the aggregate connection
    - TCP-v: congestion control
    - pTCP: buffer management, flow control
  - TCP-v is a slightly modified version of TCP that handles only “virtual packets”
    - virtual packet: a skeletal packet with only TCP packet header
  - Binding

# pTCP design (cont.)

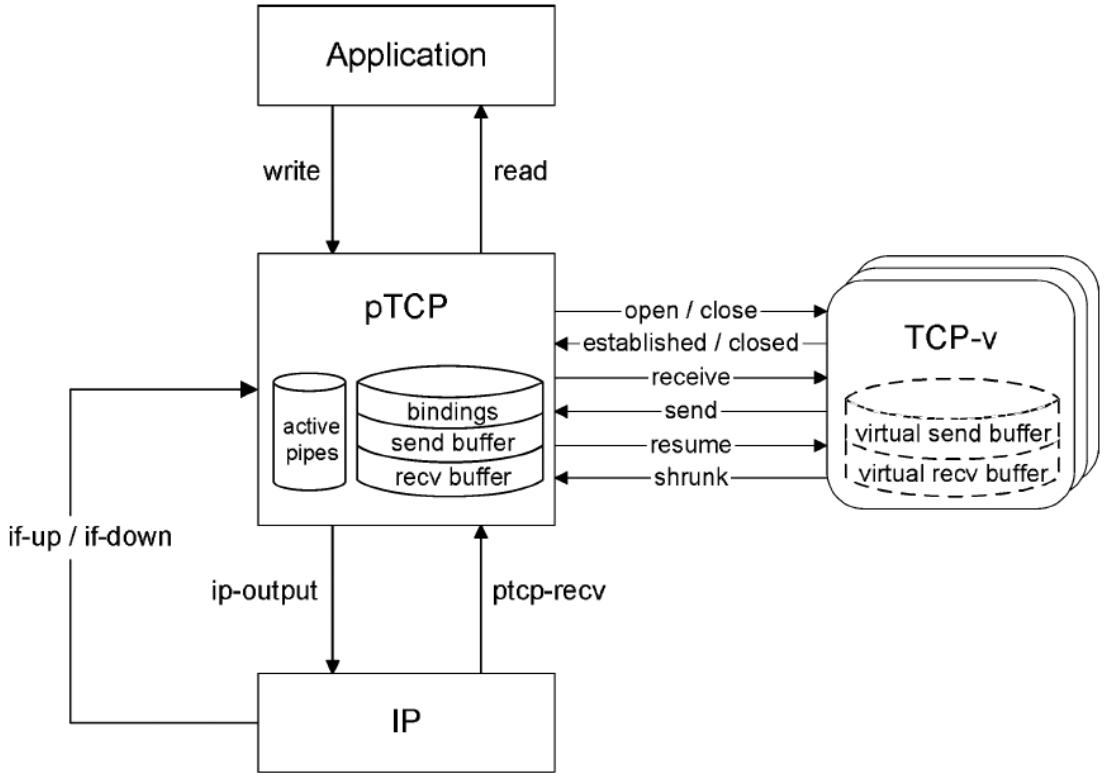



Figure 2. pTCP architecture and key data structures.

# pTCP design (cont.)

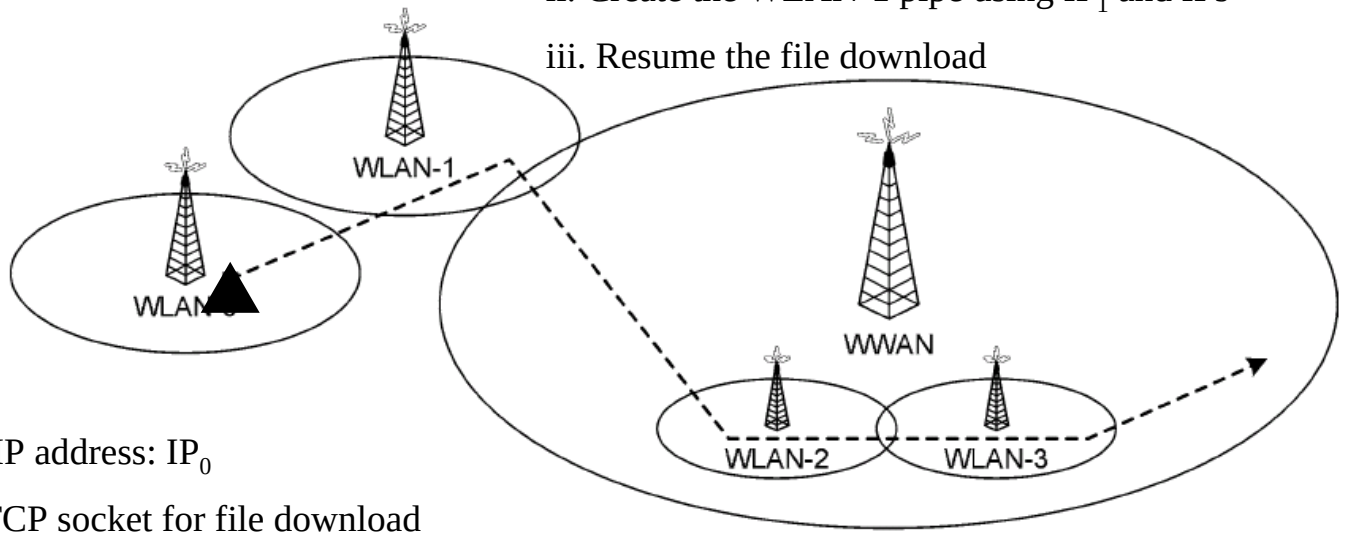
- *Well-defined interface*
- *Effective bandwidth aggregation*
  - Head-of-line blocking degrade the performance
  - avoidance:
    - Delayed binding
    - Dynamic reassignment
    - Redundant striping

# pTCP design (cont.)

i. Assign a new IP address: $IP_1$

ii. Create the WLAN-1 pipe using $IP_1$ and IPs

iii. Resume the file download




i. Assign an IP address: $IP_0$

ii. Open a pTCP socket for file download

iii. Create the first TCP-v pipe using $IP_0$ and IPs


Figure 3. An illustration of mobility trajectory.

# pTCP design (cont.)

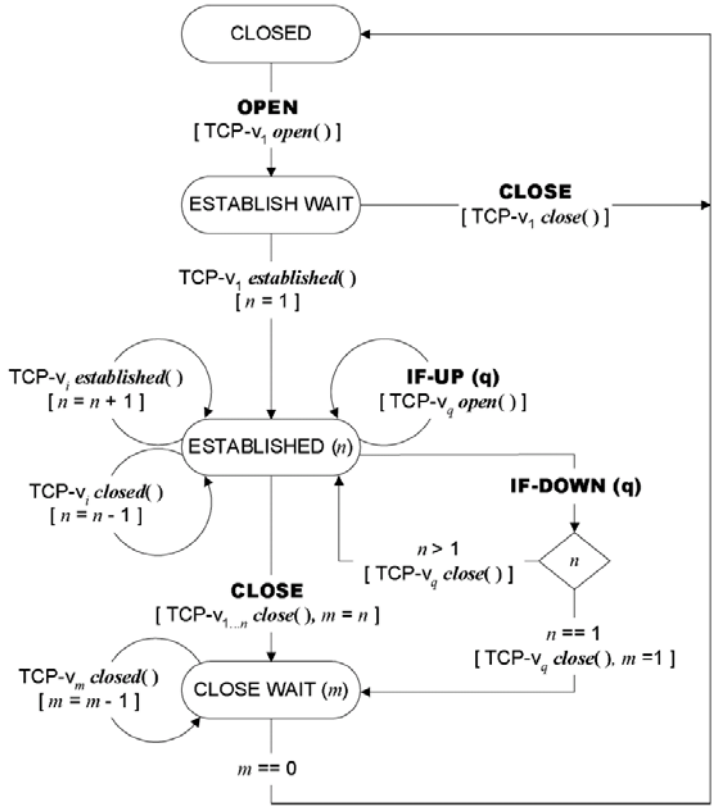



Figure 4. pTCP state machine

# Performance evaluation

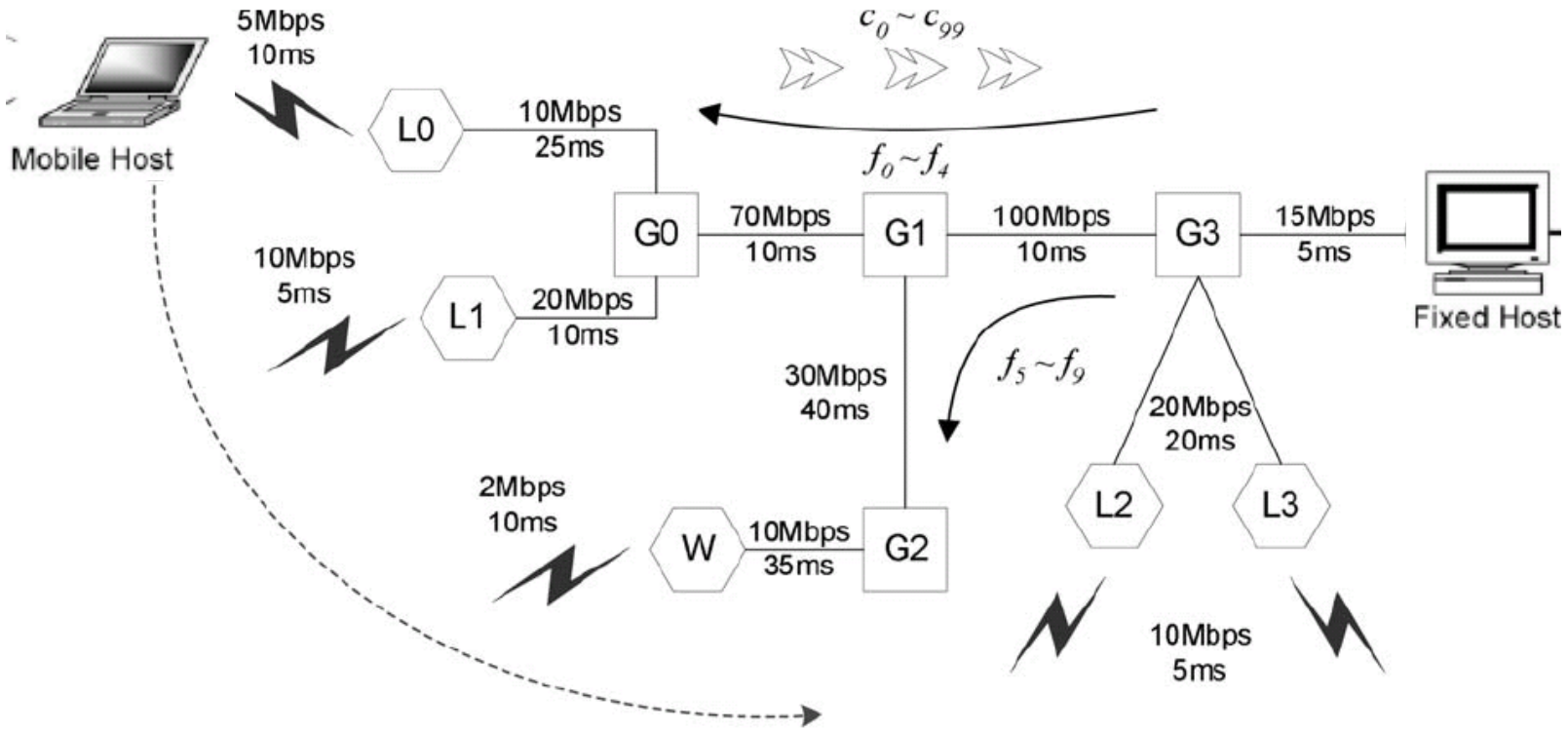



Figure 5. Network topology.

# Performance evaluation (cont.)

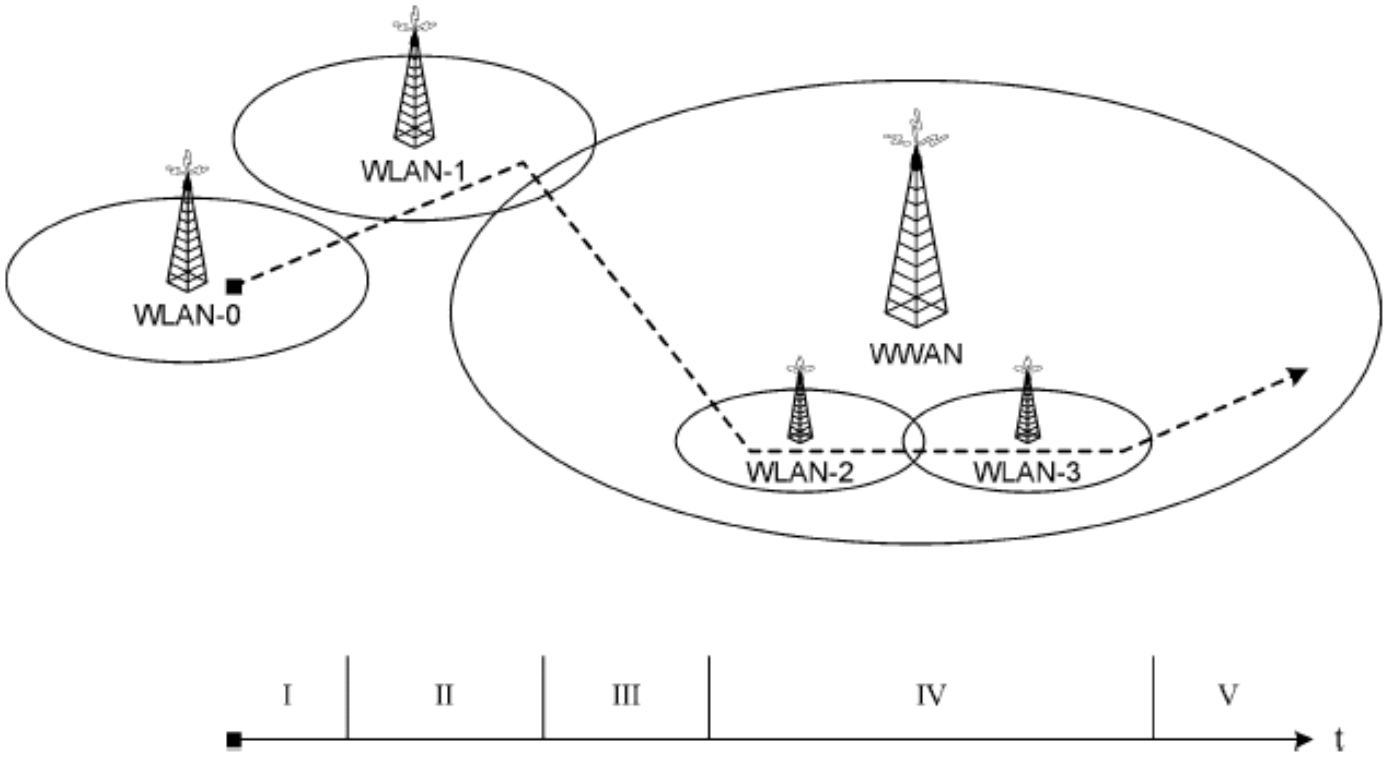



Figure 6. An illustration of mobility trajectory.

# Performance evaluation (cont.)

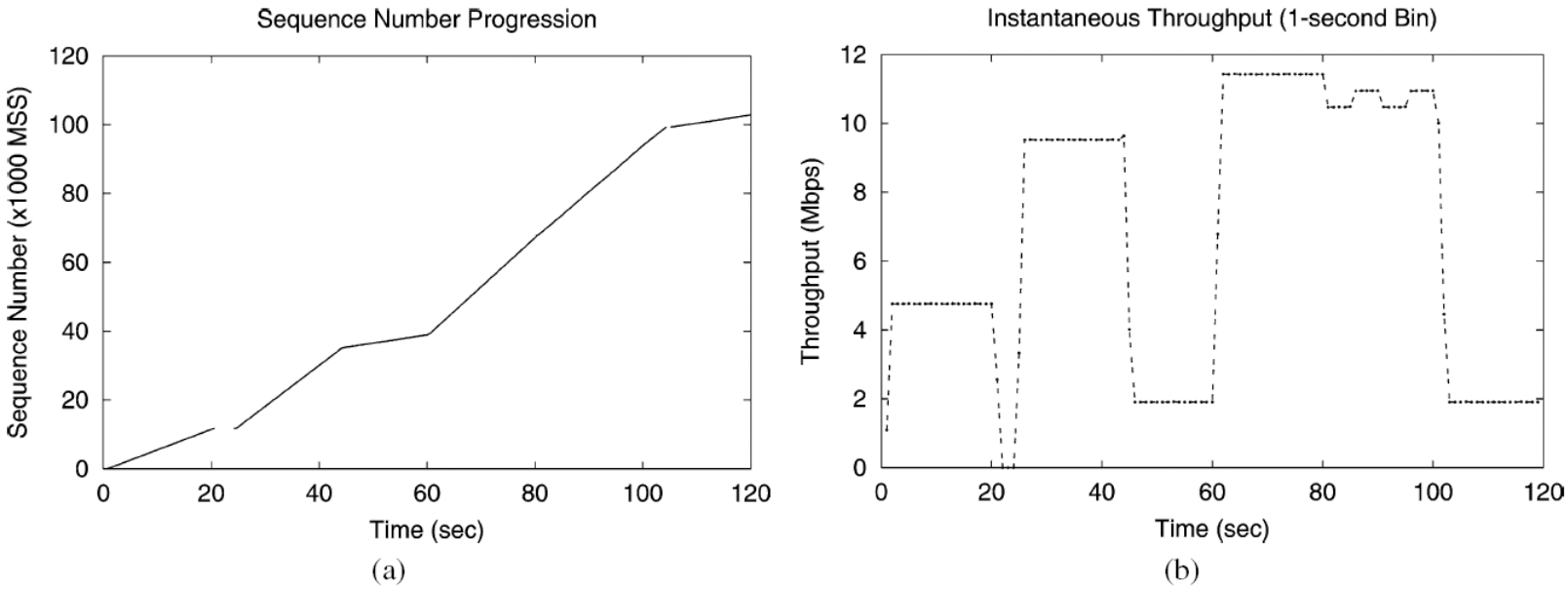



Figure 7. Performance of pTCP: an overview. (a) Sequence number progression. (b) Instantaneous throughput.

# Performance evaluation (cont.)

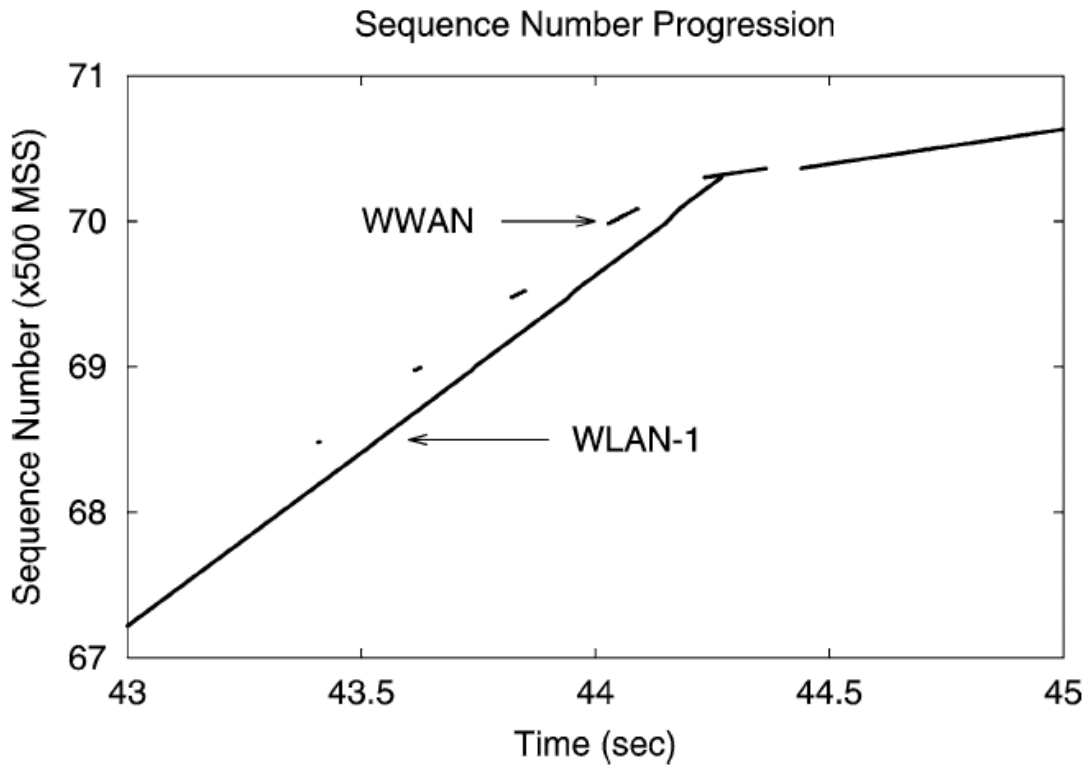
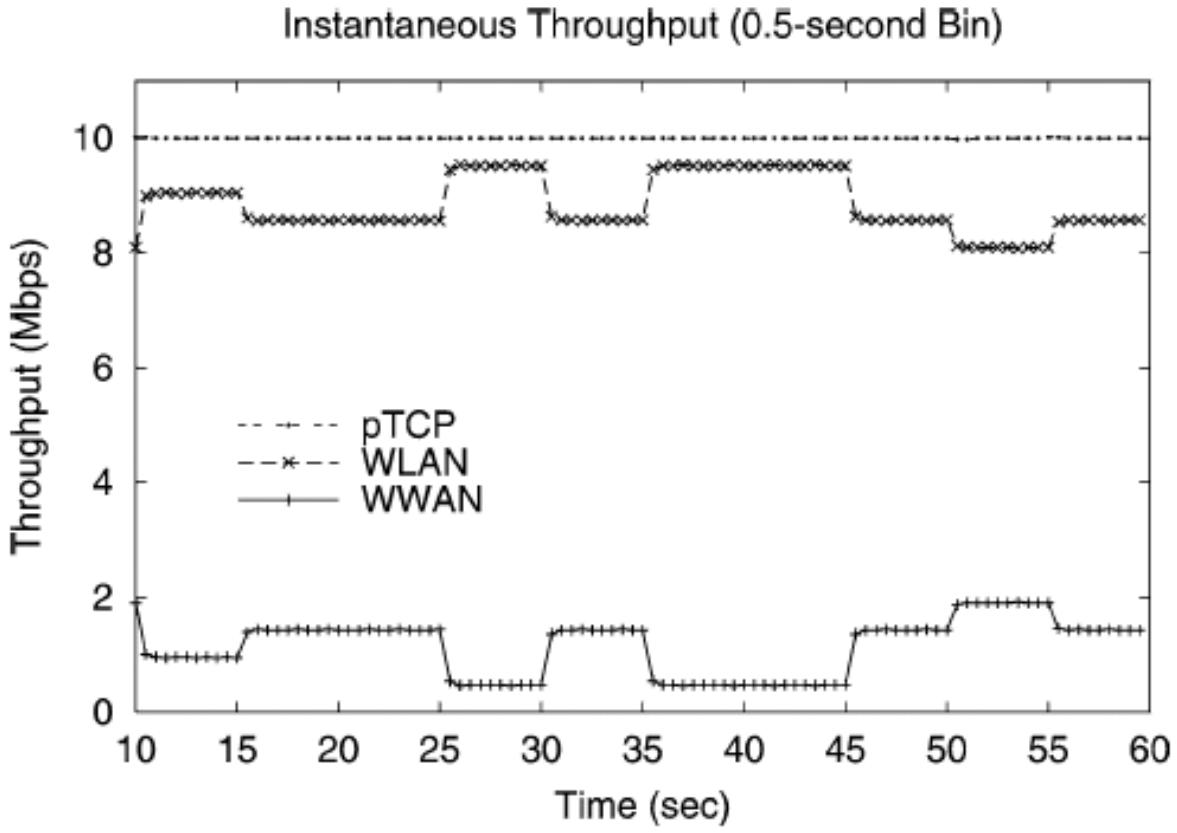



Figure 8. pTCP sequence number progression during soft handoffs.

# Performance evaluation (cont.)

- Policy-based bandwidth aggregation in pTCP



# Performance evaluation (cont.)

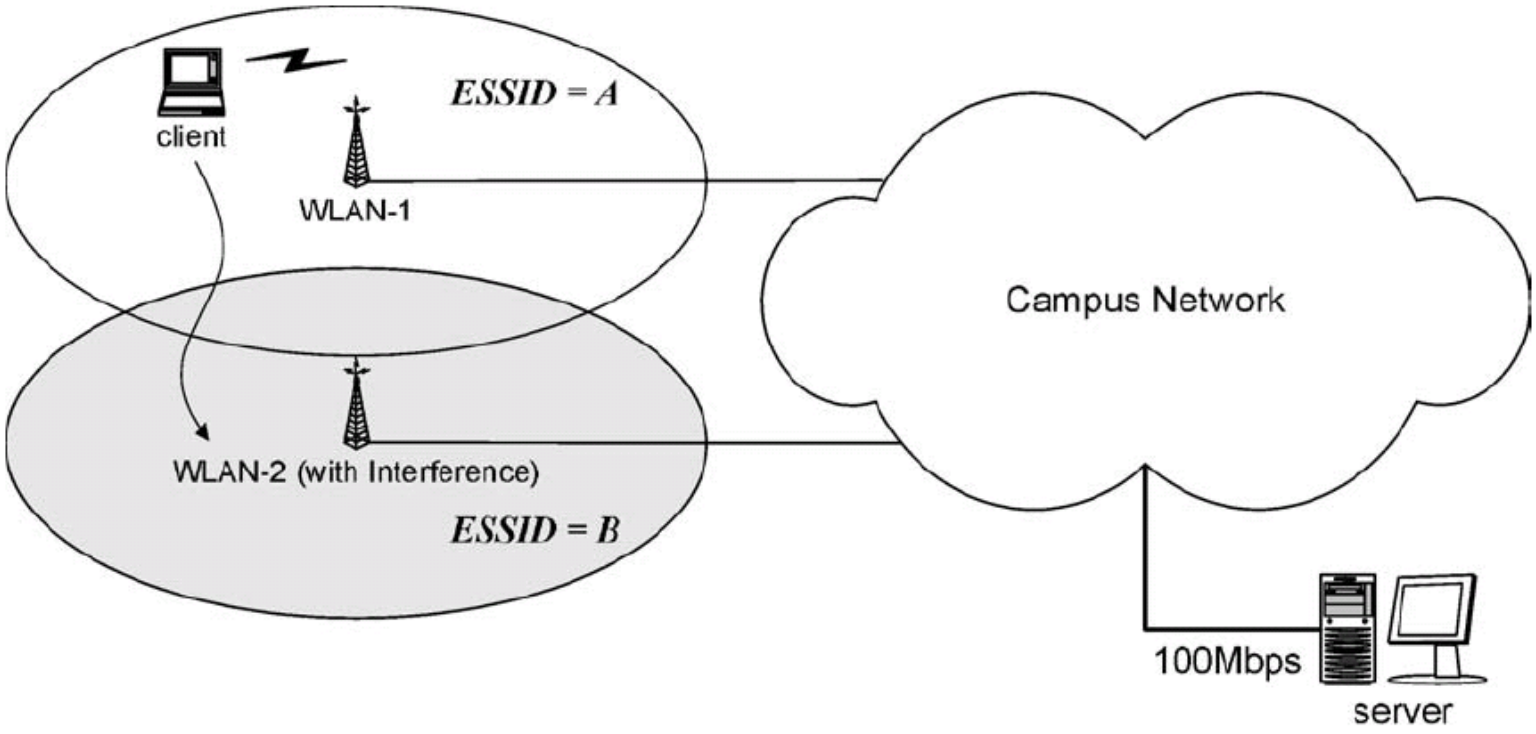



Figure 10. Testbed topology.

# Performance evaluation (cont.)

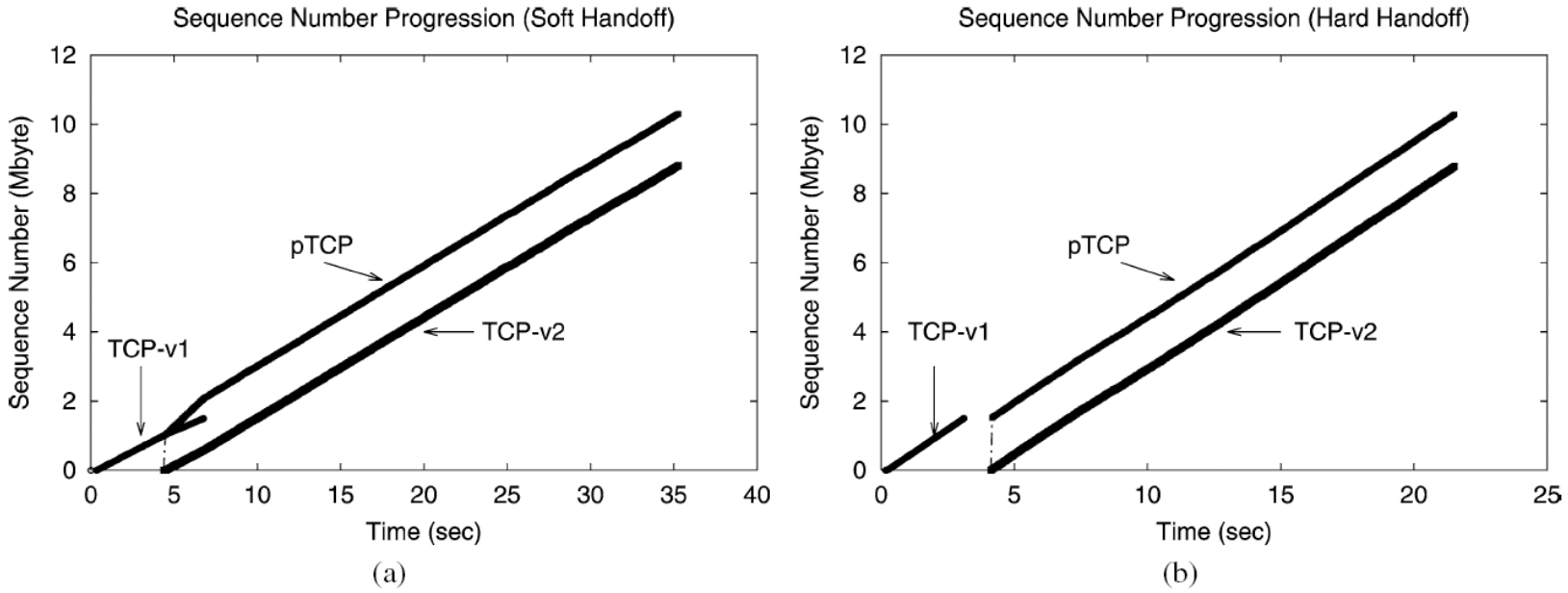



Figure 11. Performance of pTCP during handoffs. (a) Soft handoff. (b) Hard handoff.

# Performance evaluation (cont.)

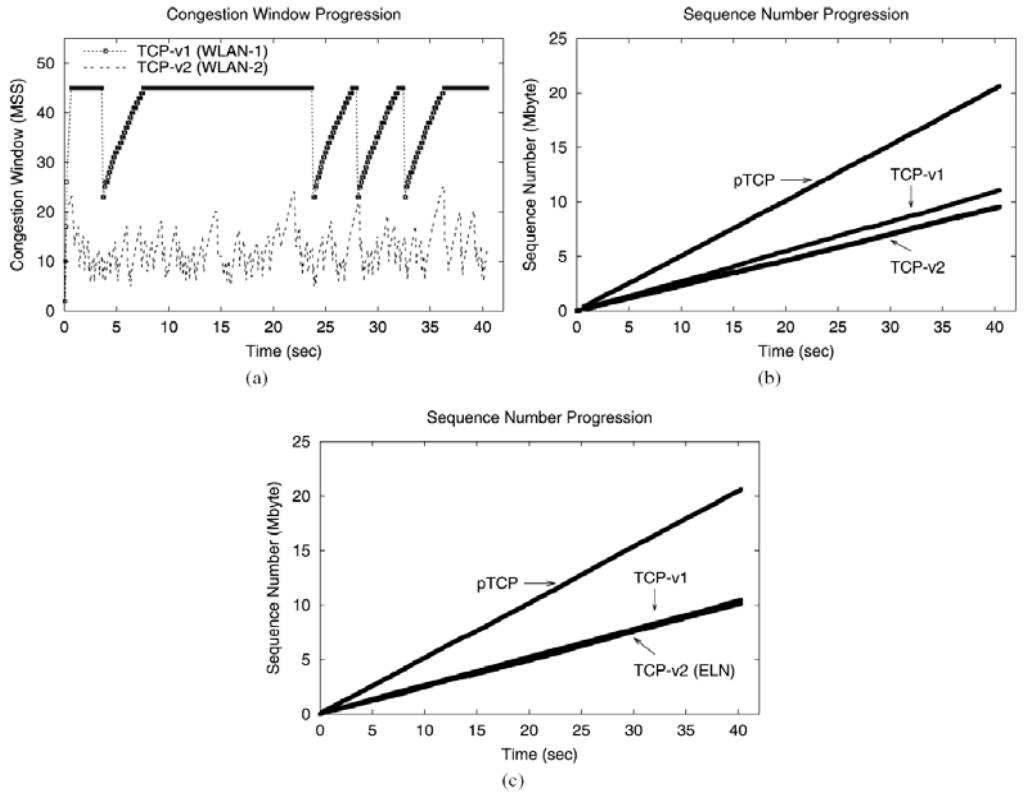



Figure 12. Performance of pTCP for bandwidth aggregation. (a) Individual congestion windows. (b) One congestion control scheme. (c) Two congestion control schemes.

# Conclusions

- We propose a transport layer protocol that enables the seamless use of heterogeneous access technologies and achieves transparent host mobility

- The unique features are
  - An end-to-end approach for host mobility
  - Provision for seamless handoffs
  - Support for multiple congestion control schemes
  - A flexible framework for bandwidth aggregation