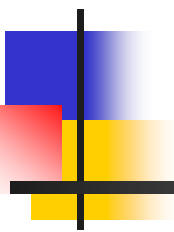


Cache Management Mechanisms for Internet-based Mobile Ad Hoc Networks (IMANETs)



Sunho Lim[†], Wang-Chien Lee[†],
Guohong Cao[†], Chita R. Das[†]

[†]Department of Computer Science and Engineering
The Pennsylvania State University
University Park, PA 16802, U.S.A.

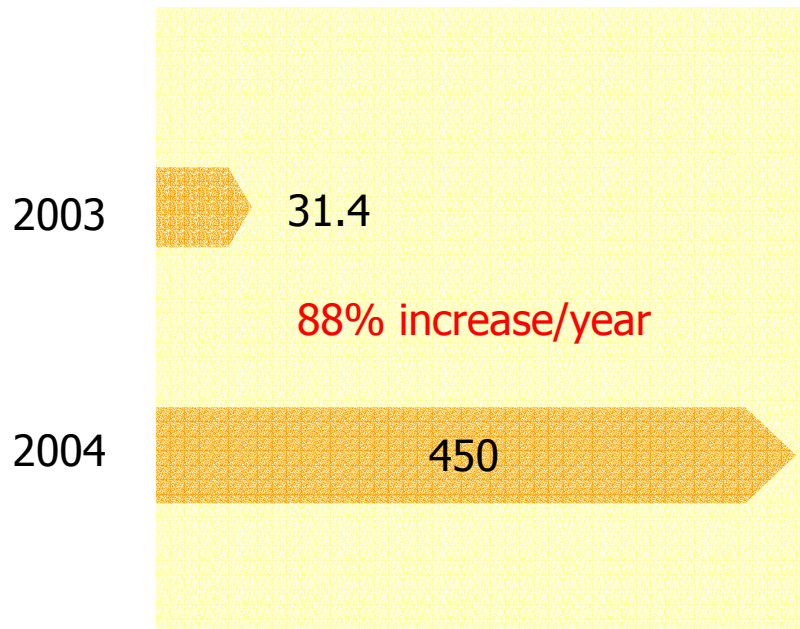


Introduction

- With the recent advent in wireless technology and mobile devices, wireless networks have become a ubiquitous communication infrastructure
- Growing interests in accessing the wired network or Internet
 - Mobile ad hoc network (MANET)
 - Internet-based MANET (IMANET)
 - Applications
 - Military
 - Emergency site
 - Education

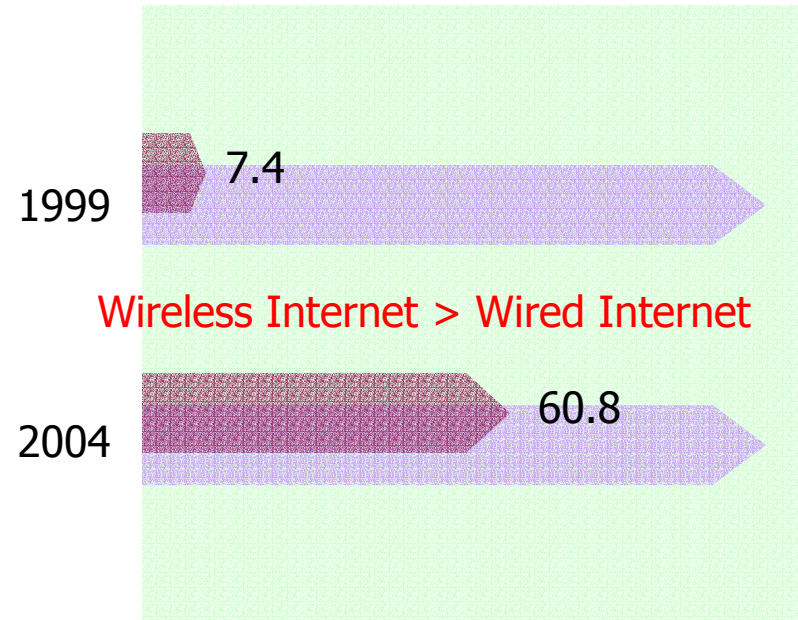
Introduction (cont.)

■ Number of Wireless Internet users



[unit: million]

■ Percent of wireless Internet users



[unit: %]

Users will be able to access Internet service anytime and anywhere !!



Motivation

- An mobile terminal (MT) may still have difficulty to connect to a wired network or Internet due to
 - Limited wireless bandwidth & accessibility
- Under heavy traffic, an MT has to content for bandwidth and may get blocked
- In some geographically remote area, an infrastructure may not even be available

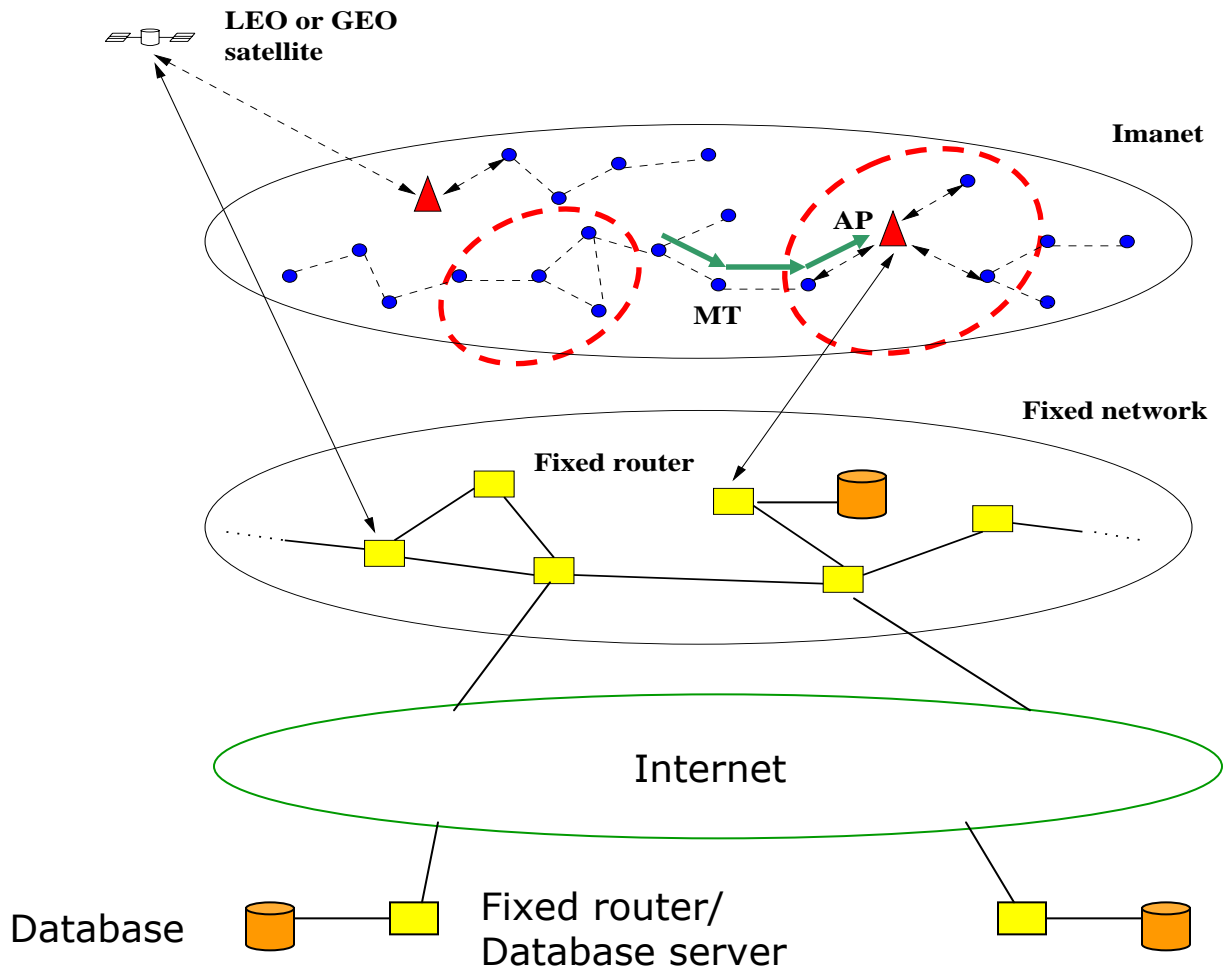
- A **mobile ad hoc network (MANET)** can address this concern
 - Low cost and ease of deployment



Motivation (cont.)

- Due to users' interests in accessing the Internet,
 - It is important requirement to consider the integration of MANET with the Internet
- Internet-based MANET (IMANET)
 - Evolving communication infrastructure
 - Combines the **wired Internet** and **wireless mobile ad hoc network**
 - Flexible accessibility and information availability

System Model of IMANET





IMANET Issues

- **Constraints**
 - Due to mobility of MTs, not all the MTs can access the Internet
 - Longer access delay
- We propose an aggregate caching mechanism to address these constraints.



An Aggregated Caching Scheme

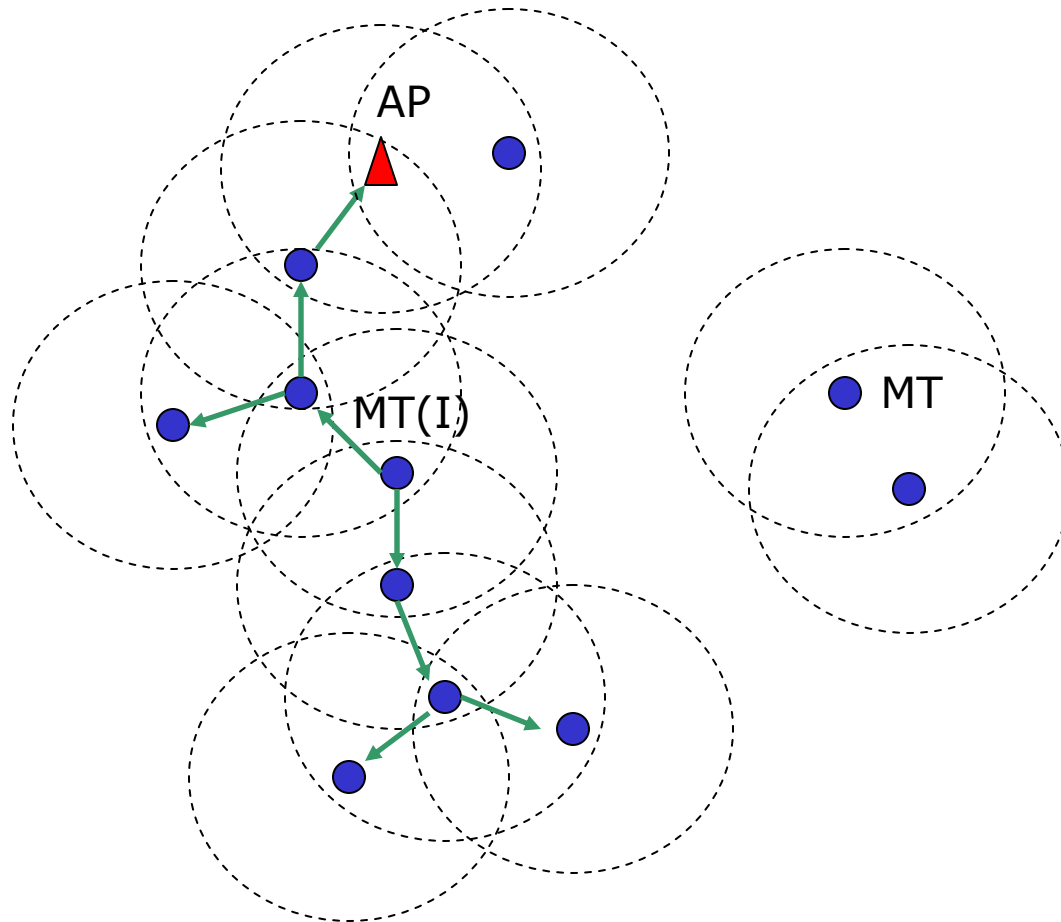
- **Basic idea**
 - By storing data items in the local caches of the MTs, members of the IMANET can access the required information
 - Aggregated local caches of the MTs virtually form an unified large cache
- **An aggregated caching mechanism**
 - Information search
 - Cache management



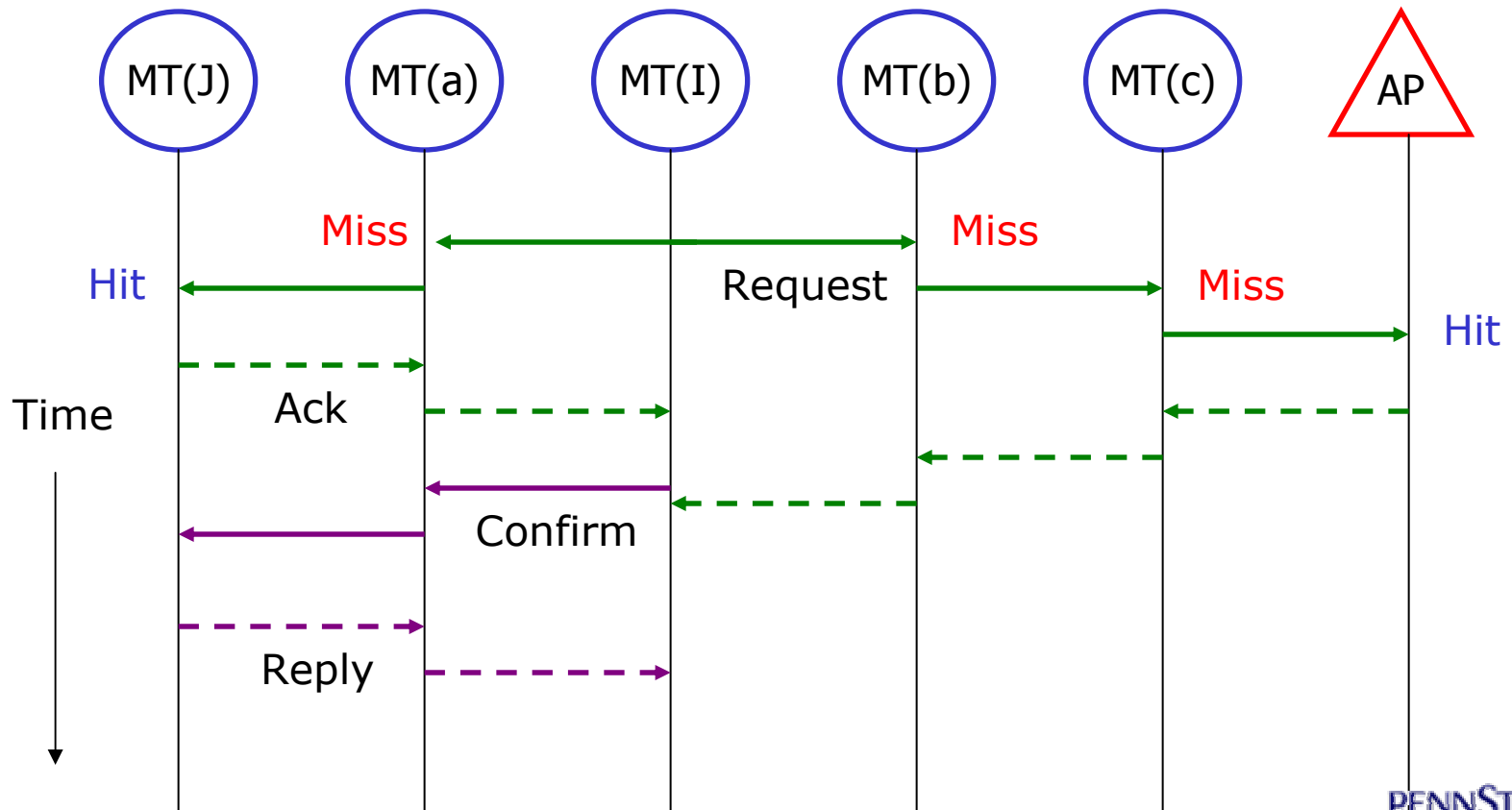
Information Search

- Simple Search (SS) protocol
 - Data item can be retrieved from local caches of the MTs or AP
 - Broadcast based
 - 4 control messages are used
 - *request, ack, confirm, & reply*
 - It can be implemented on top of an existing routing protocol for MANET

Information Search (cont.)



Information Search (cont.)





Cache Management

- **Basic idea**
 - Cache as many as data items without too much duplications to utilize the cache efficiency
- **Cache admission control**
 - Triggered when an MT receives requested data item
 - Determine whether the MT accepts the data item or not for caching
- **Cache replacement policy**
 - Triggered when an MT wants to cache a data item, but the cache is full
 - Select the data item as a victim

Cache Management: Cache Admission Control



- Cache admission control
 - Distance to other APs or MTs which have the requested data item
 - If the MT is located within Γ hops, then it cannot cache the data item
 - The same data items are cached at least Γ hops apart.
 - By adjusting Γ , it will control information accessibility and access latency

Cache Management: Cache Replacement Policy

- Cache replacement policy
 - Distance (δ)
 - Number of hops away from the AP or MTs, which has the requested data item
 - The data item with the least δ value is selected as the victim
 - Elapsed time (τ) of the last updated δ
 - As the topology varies, the δ values become obsolete
 - τ Is used as an indicator of δ to select a victim



Cache Management (cont.)

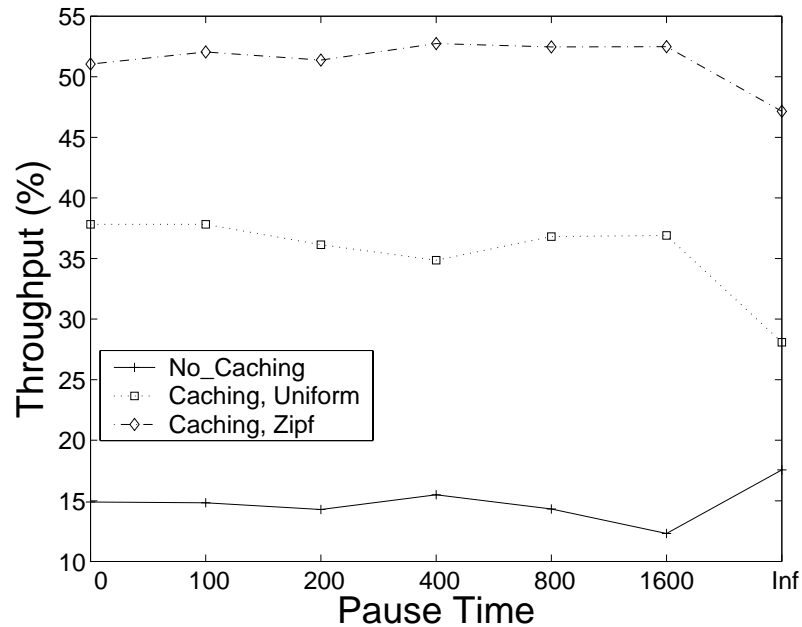
- Time and Distance Sensitive (TDS) replacement policy based on these two factors.
 - TDS_D:
 - Choose the data item which has the least value of $(\delta + \tau)$
 - TDS_T:
 - Victim is selected with the least τ value
 - TDS_N:
 - Select the data item with the least $(\delta \times \tau)$ value



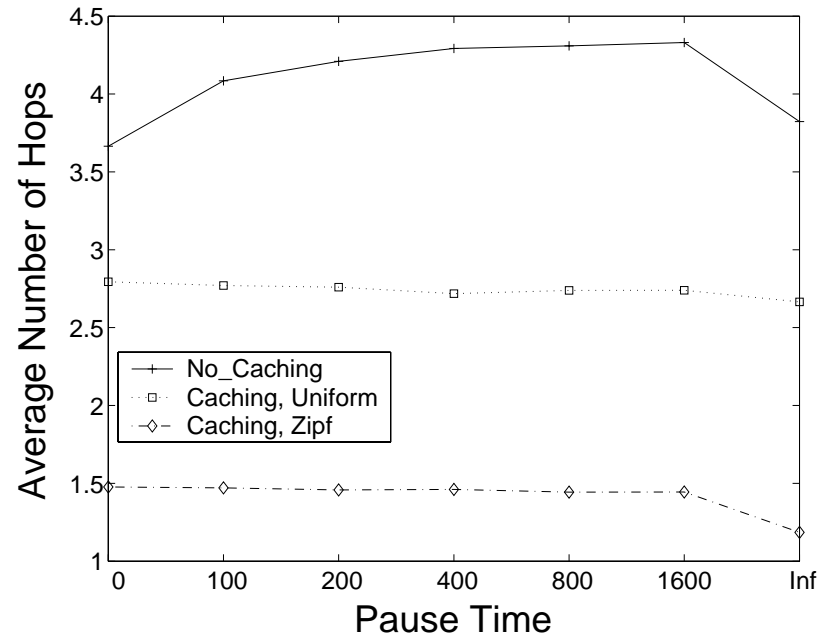
Simulation Testbed

- An AP is located in the center of an area
- MTs are randomly located in the network
- Random waypoint mobility
- Two different data item access patterns
 - Uniform distribution &
 - Zipf distribution to model a skewed access pattern

Simulation Results: Impact of Caching



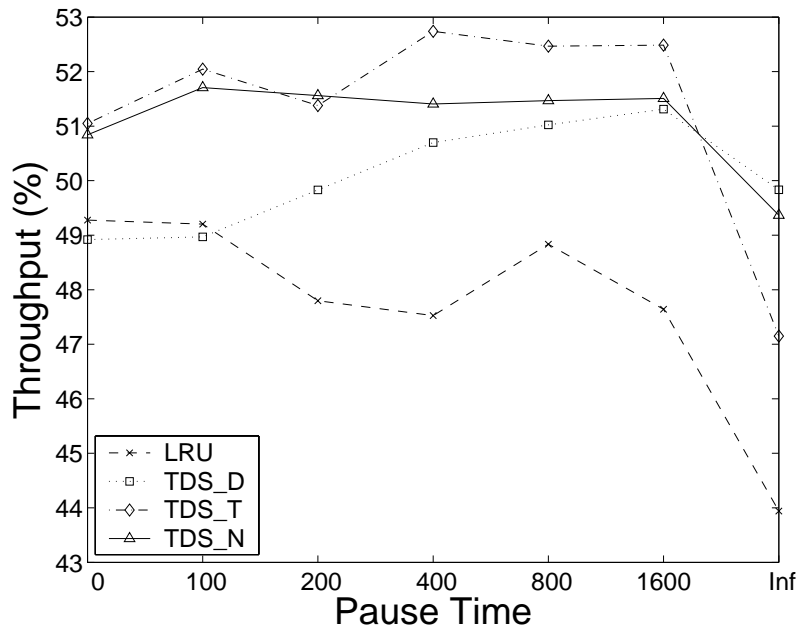
(a) Throughput



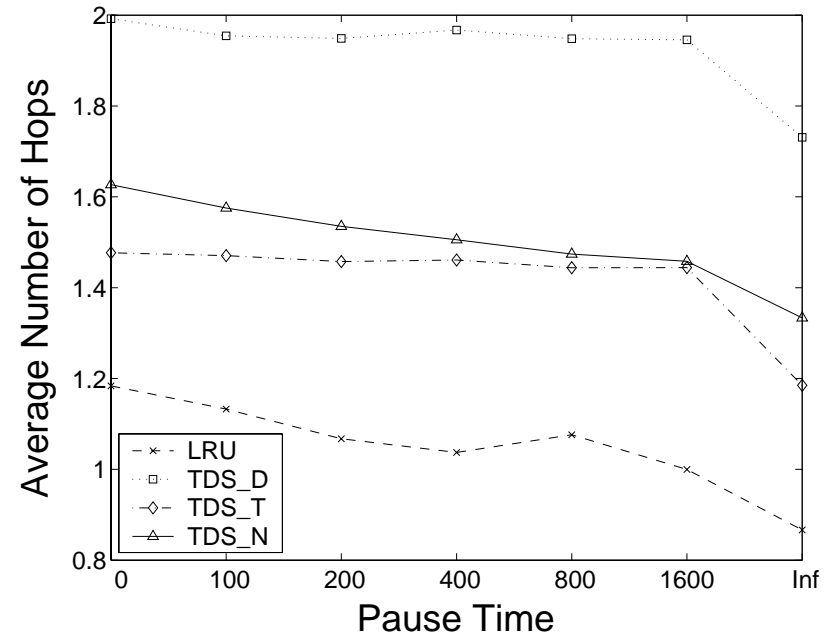
(b) Number of Hop

Simulation Results (cont.)

Impact of Cache Management (Zipf)



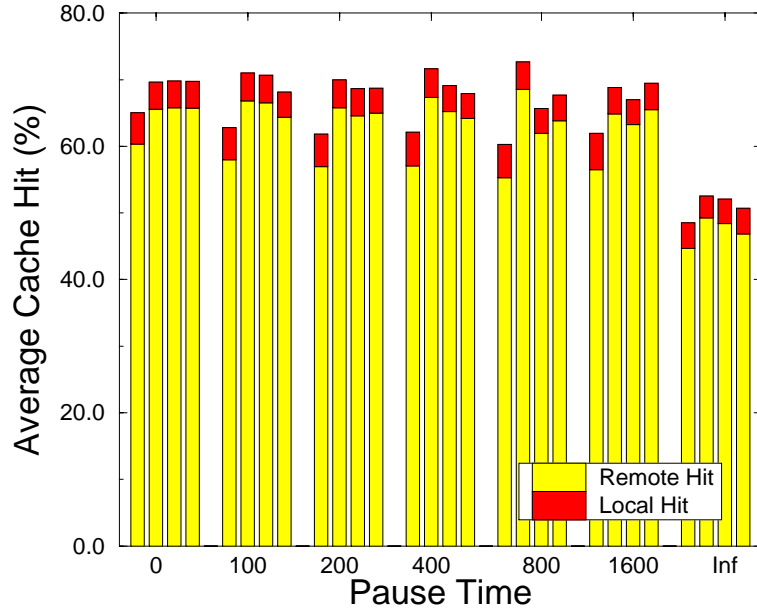
(a) Throughput



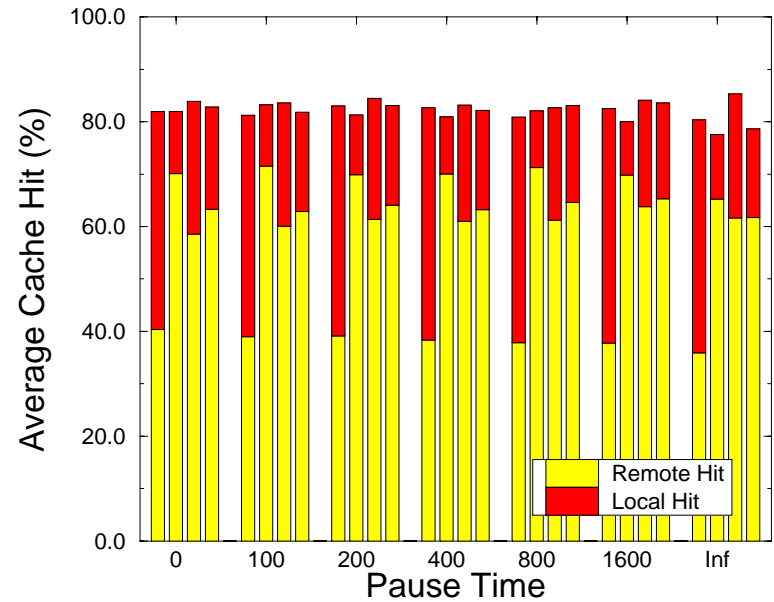
(b) Number of Hop

Simulation Results (cont.)

Impact of Cache Management



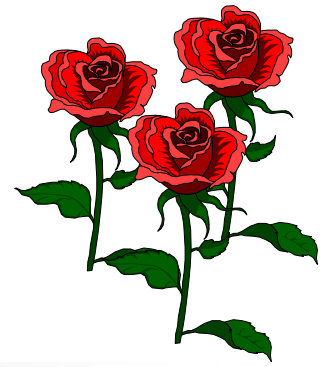
(a) Uniform



(b) Zipf



Concluding Remarks



- We proposed and aggregate caching scheme to improve the communication performance of IMANET, a ubiquitous communication infrastructure consisting of both wired Internet and wireless MANET.
 - Includes a broadcast based search and a cache management technique.
- Our research has brought together the MANET technology and realistic Internet applications.