The Changing Usage of a Mature Campus-wide Wireless Network

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CS525m – Mobile and Ubiquitous Computing

Overview

- **Project Goal**
- **Data Collection Methods**
- **Findings and Data Analysis**
- **Conclusions and Recommendations**

Project Goal

- **Compare WLAN network usage statistics at Dartmouth college from fall 2001 and 2003/2004**
  - **Number and type of devices**
  - **Applications in use**
- **Better understand user behavior**

Networked Devices

- Voice over IP
  - PBX converted to VoIP in 2003
  - Softphones and VoIP phones
- Client Devices
  - Laptops, PDAs, phones, etc identified by using tcpdump traces and an OS fingerprinting tool (p0f)

Networked Devices

Table 1: Devices seen on the wireless network

Guessed OS/Device	*Number of MAC addresses*	
Windows	3627	50.8%
MacOS	1838	25.8%
Unidentified	1468	20.6%
Vocera	70	0.98%
PalmOS	41	0.057%
Cisco 7920 VoIP phone	27	0.038%
Linux	27	0.038%
Dualboot Windows/Linux	24	0.034%
PocketPC	11	0.015%
Dualboot MacOS/Linux	1	0.00014%
total	7134	100.0%

Data Collection (2001)

- Analysis of a Campus-wide Wireless Network (2001)
  http://users.wpi.edu/~astone/mobilecomputing/kotzwlananalysis.pdf
- 476 802.11b APs over 161 buildings
  - 430 were tracked
- 115 Subnets
- Syslog tracking started before
  - Contains authentication, association, and roaming information
- AP SNMP Polling for Client specific counters
  - MAC, IP, Signal Strength, traffic info

Data Collection (2003)

- 566 APs over 188 buildings
- <115 Subnets (started using VLANs)
- >75% of undergrads own laptops
- VOIP phone records
- 18 sniffers covering 121 APs (most popular areas from 2001)

Data Collection

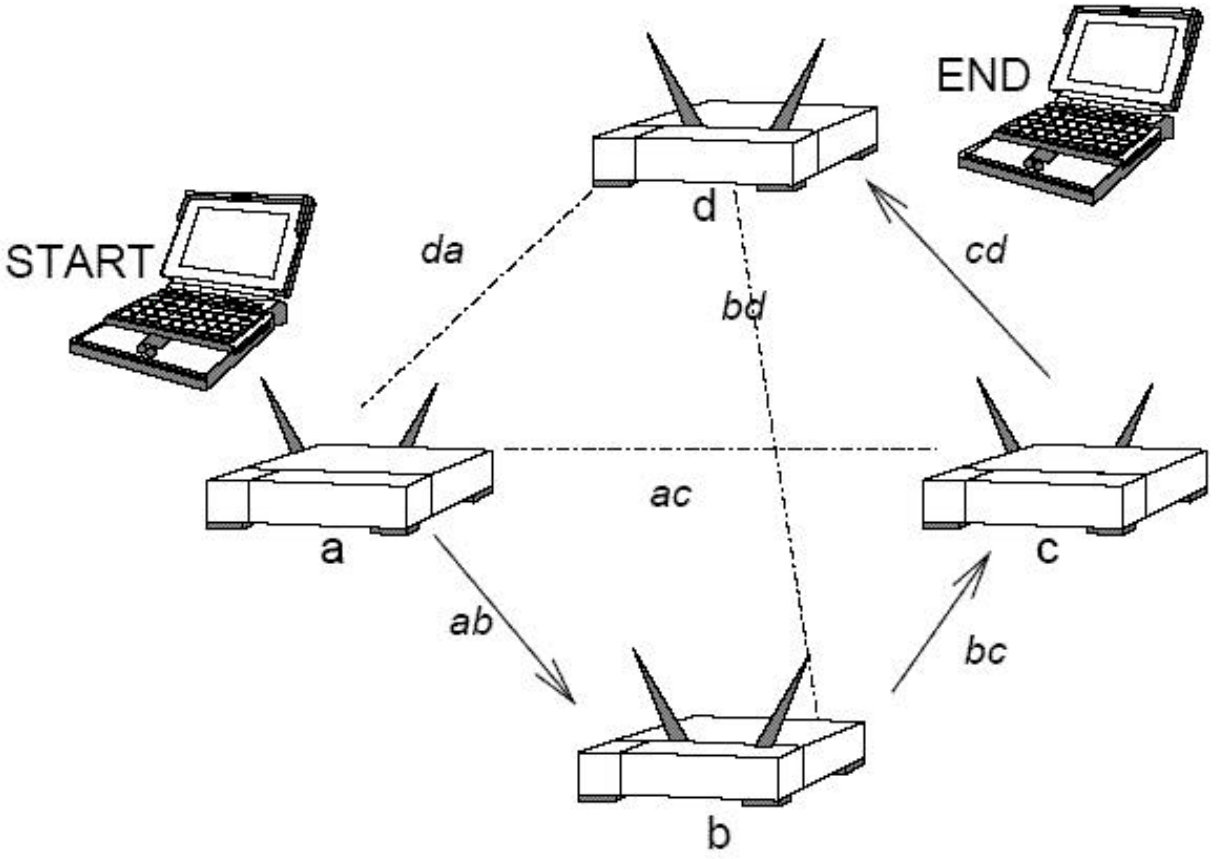
- **2001**
  - **Over 1700 different wireless cards**
  - **11 week period**
- **2003**
  - **Over 7000 different wireless cards**
  - **17 week period**

Definitions

- **Card, Session, Active card, Active AP, Roam, Roaming Session, Roamer Card, Inbound, Outbound**
- **Mobile session, Mobile card**

Mobile Session

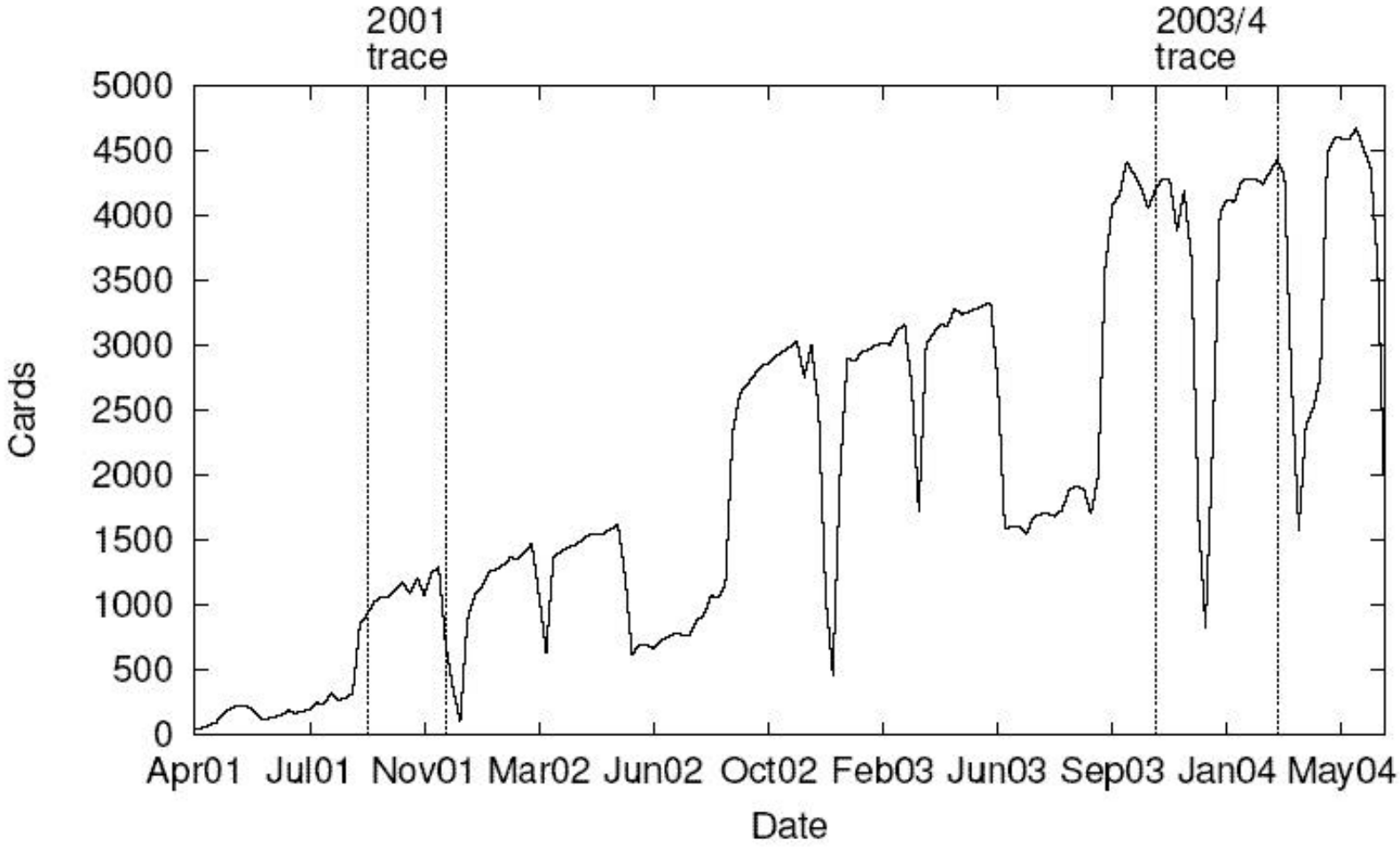
Distance between any two APs in a session > ab, bc, cd, da, ac, or bd



Questions asked

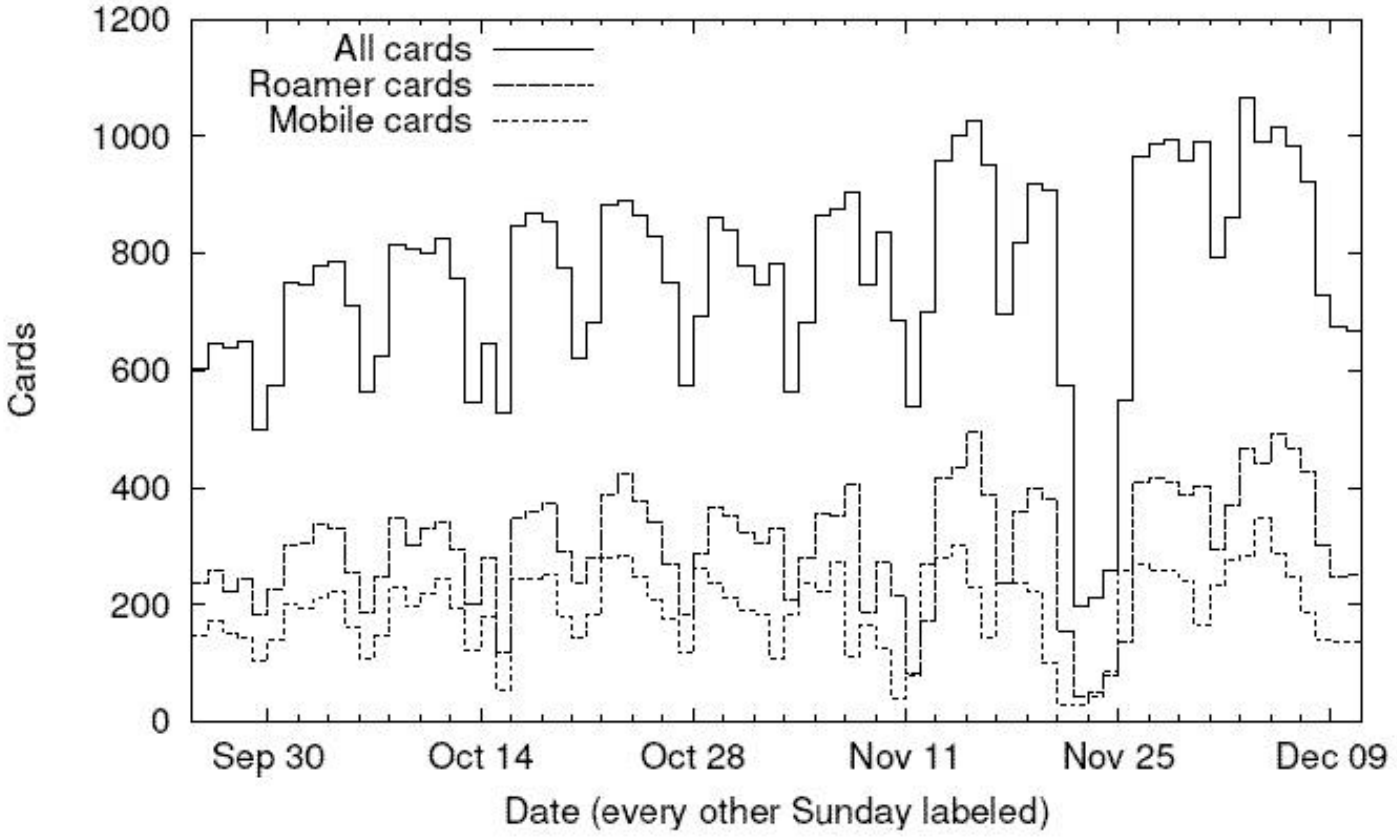
- Has the population grown?
- Have usage patterns changed?
- Where do users visit?

Has the population grown?



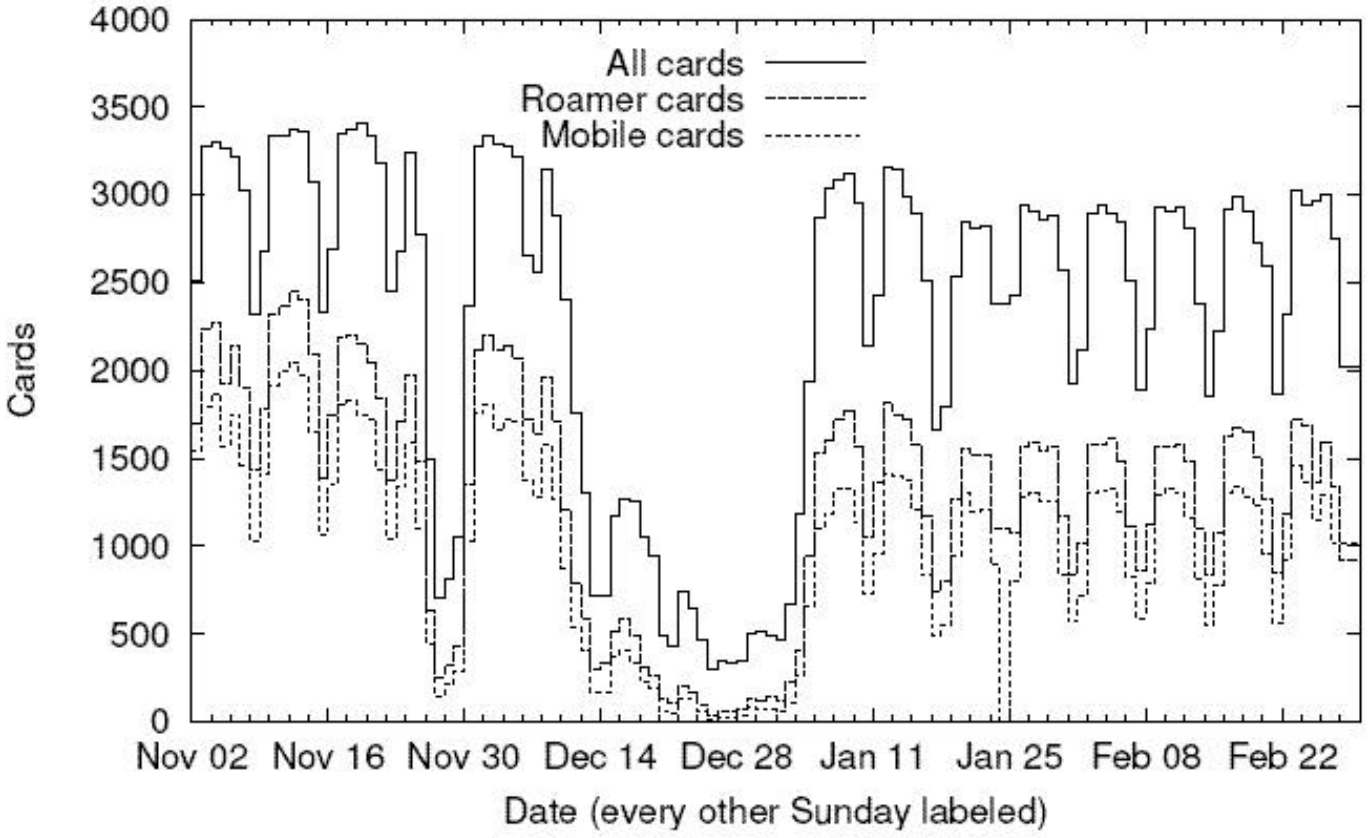
Active cards per day (2001)

(b) Fall 2001



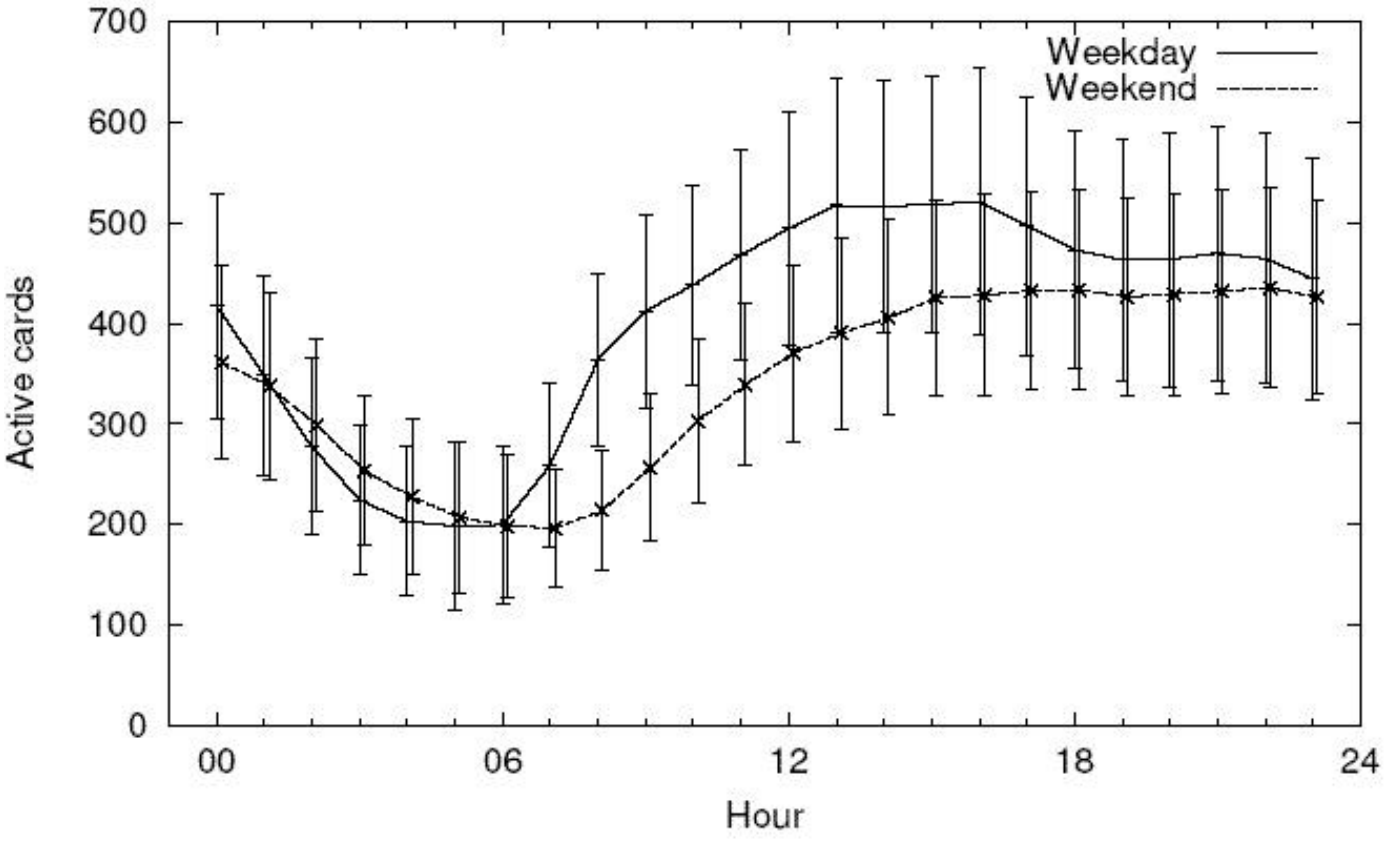
Active cards per day (2003)

(a) Fall/Winter 2003/4



Active cards per hour (2001)

(b) Fall 2001



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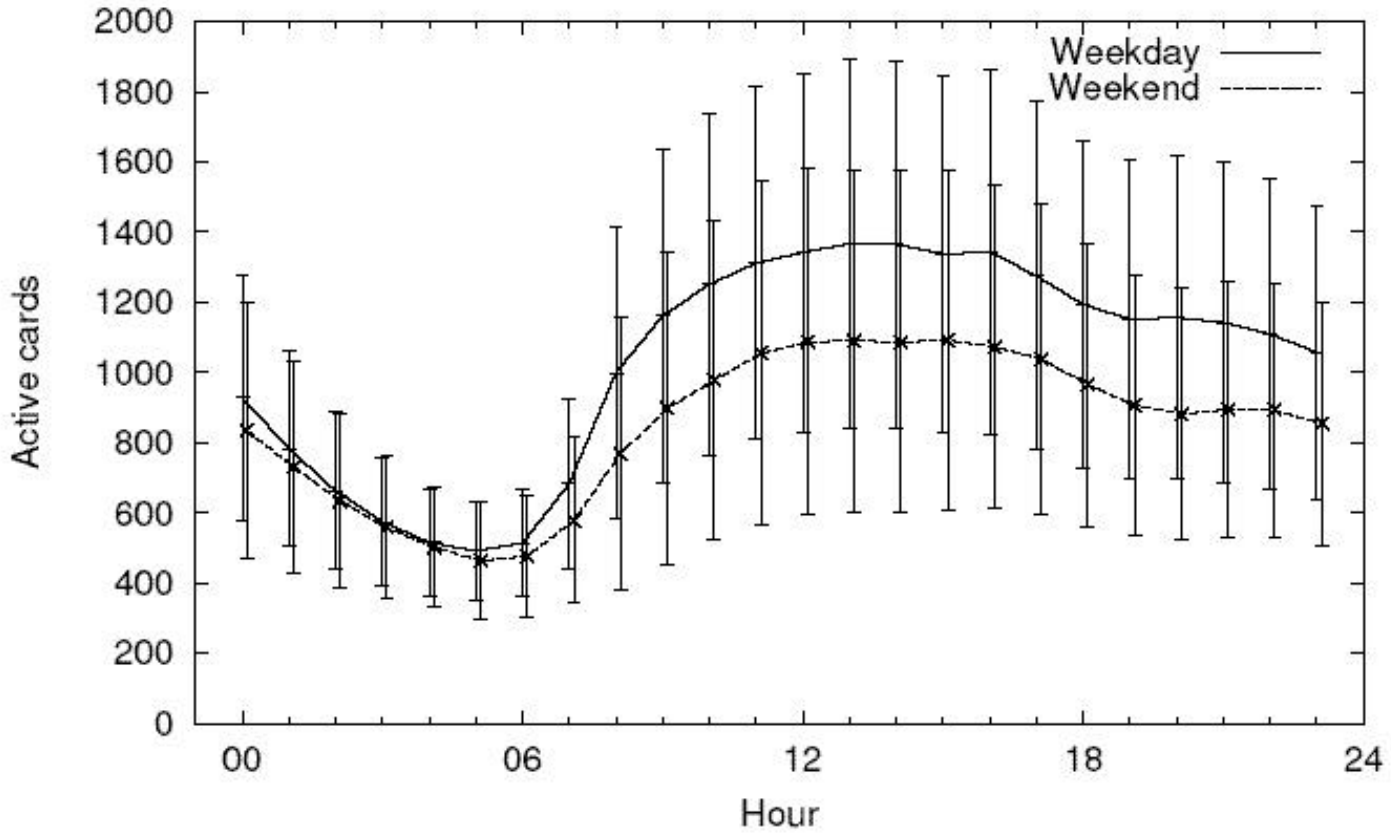
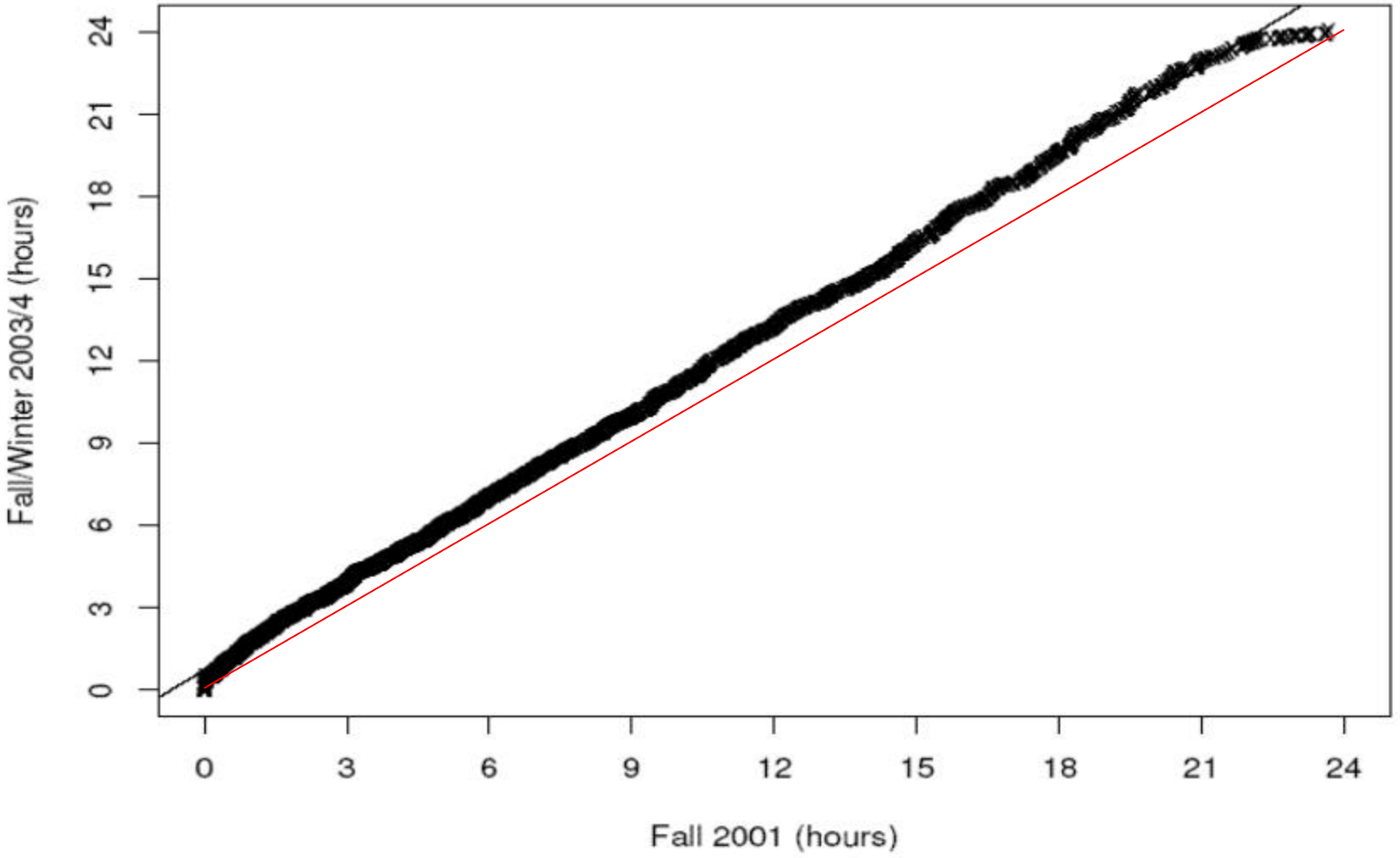
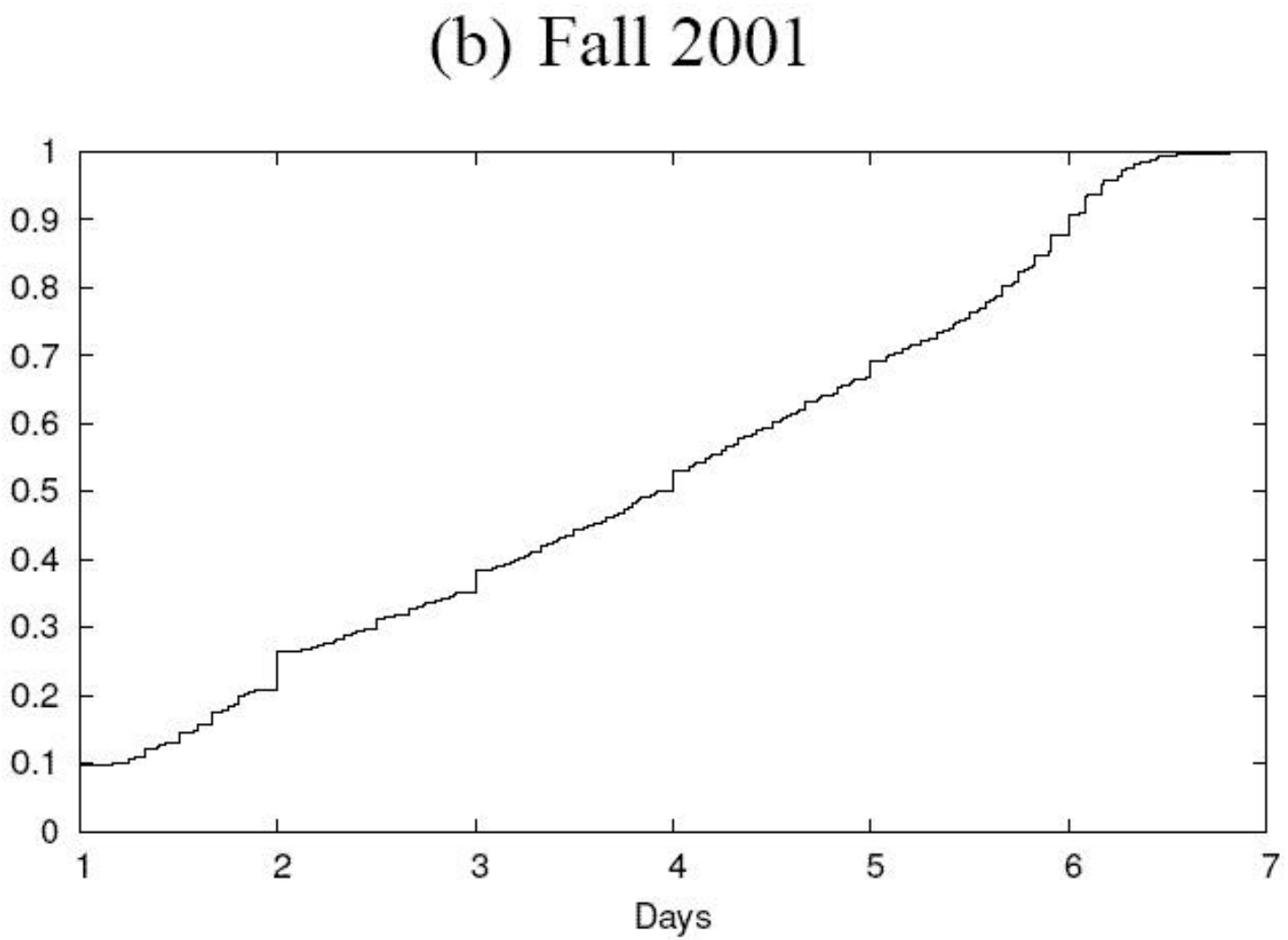


Heavy User Distribution



Average active days per week per user



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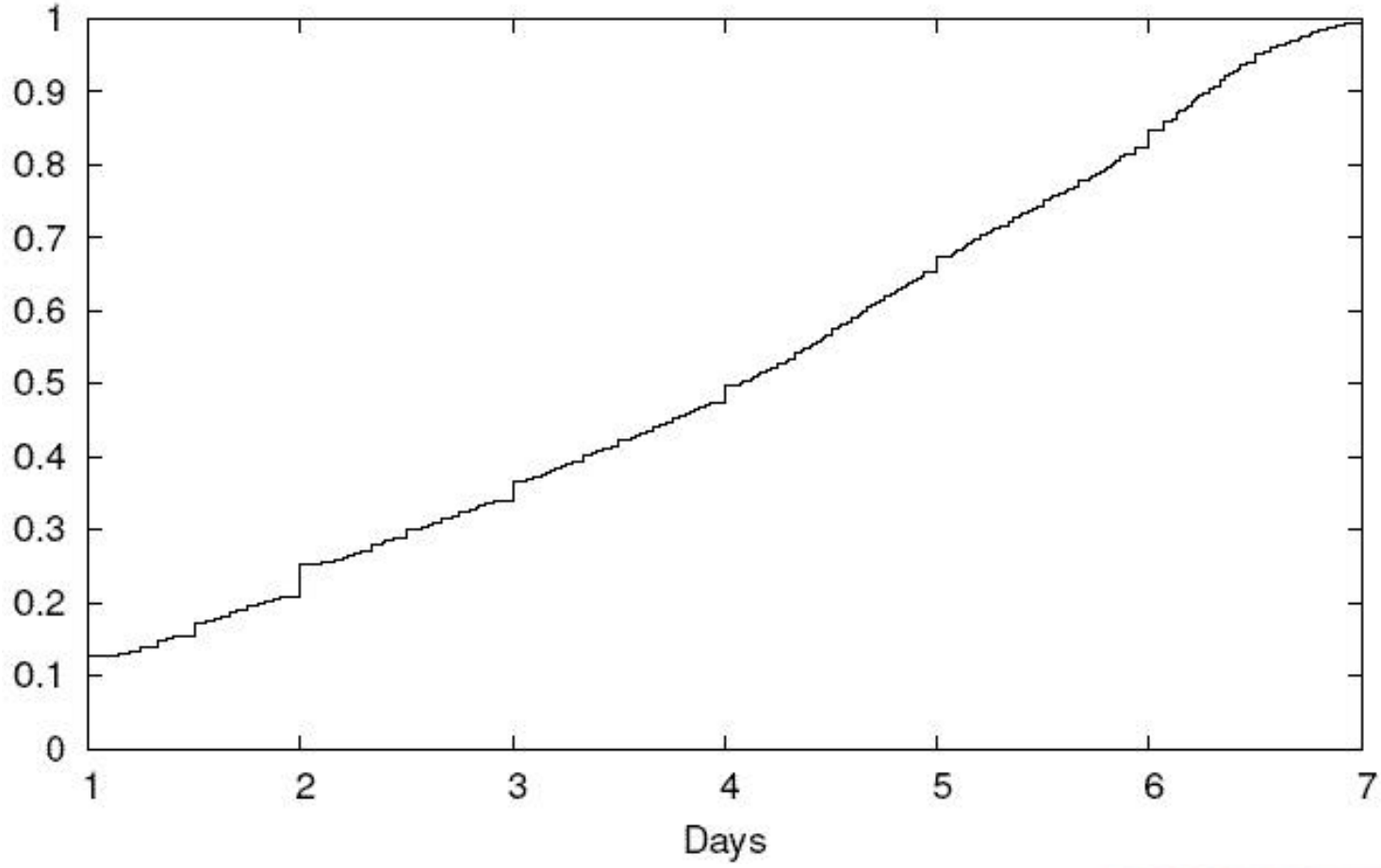
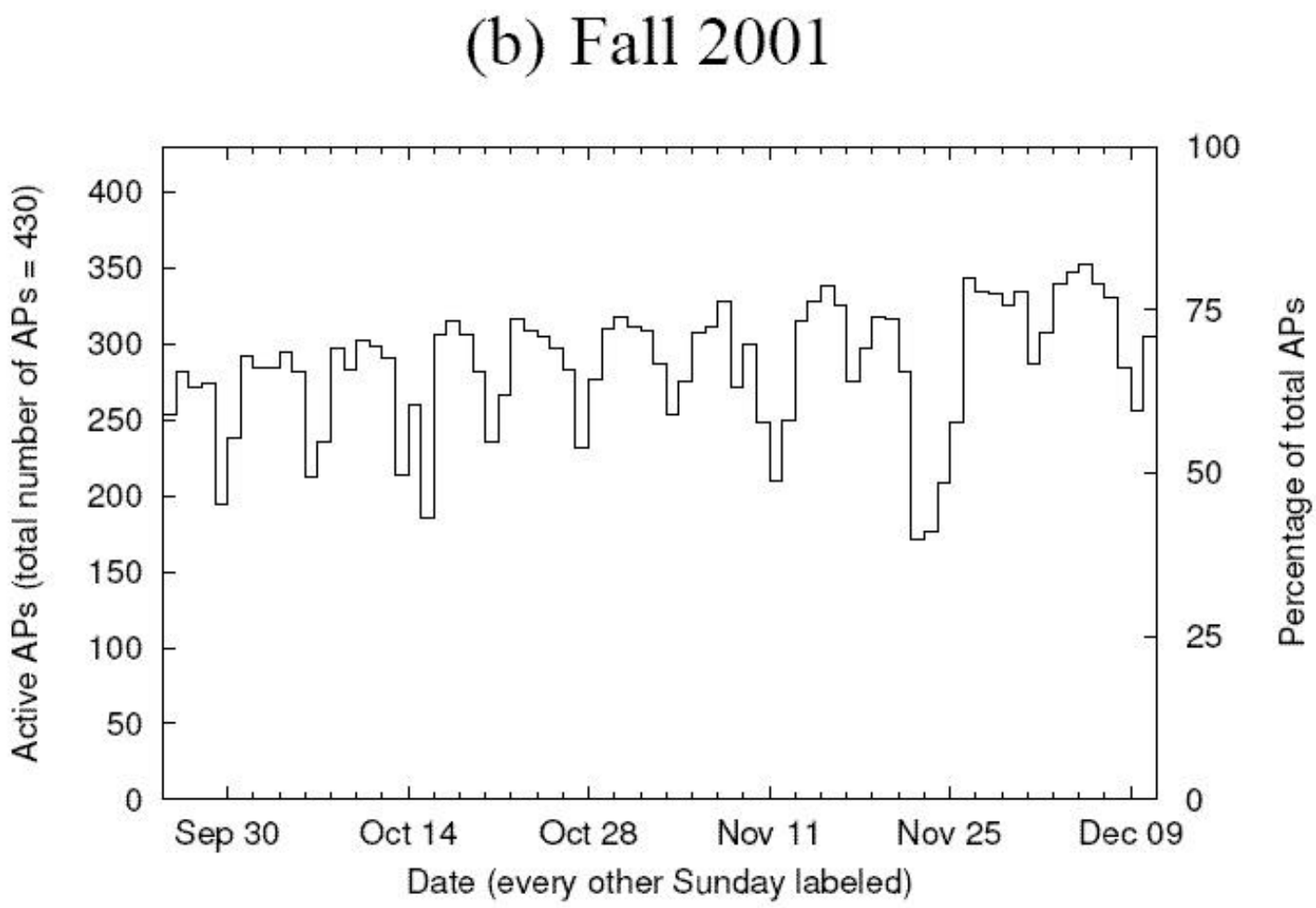


Active APs per day



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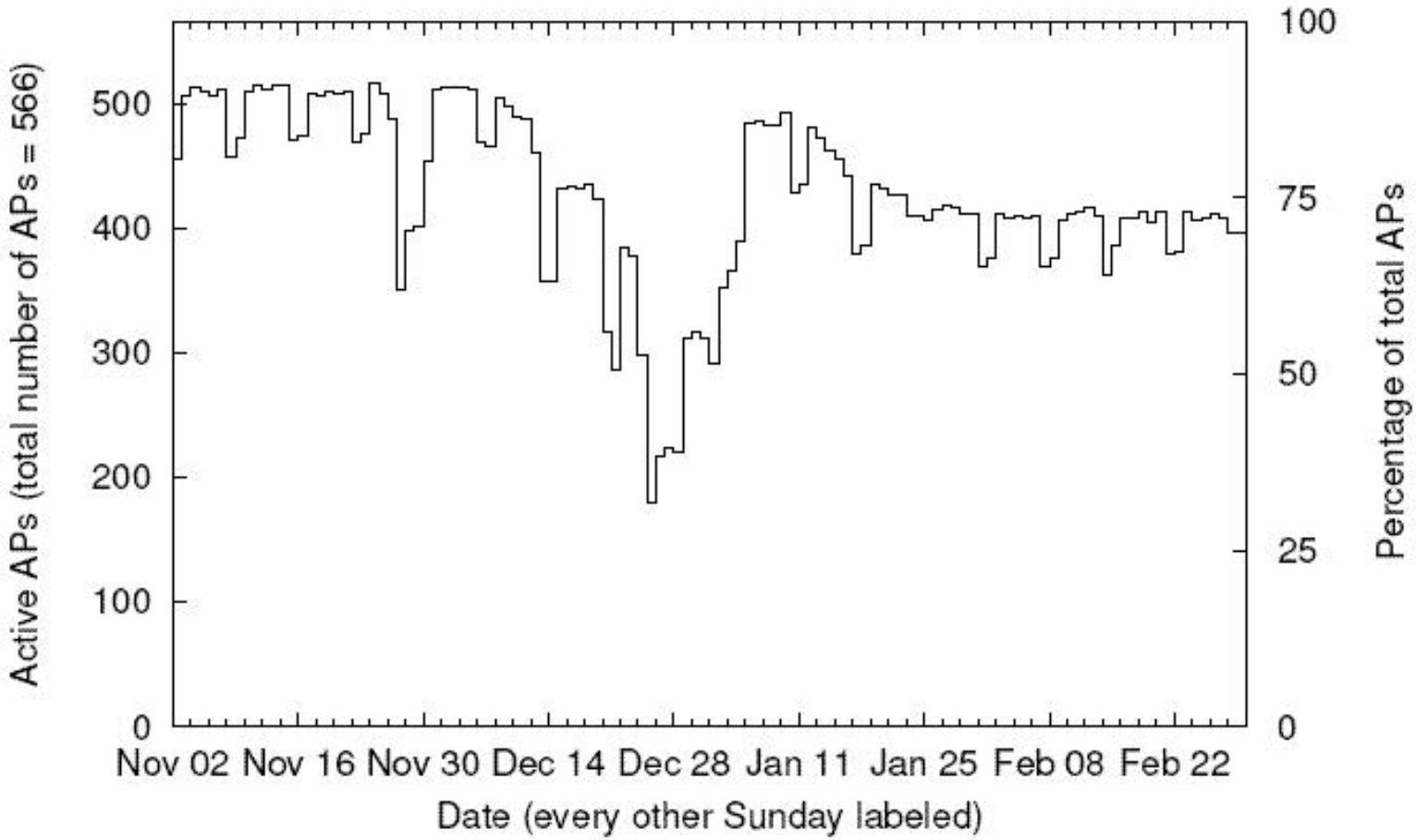
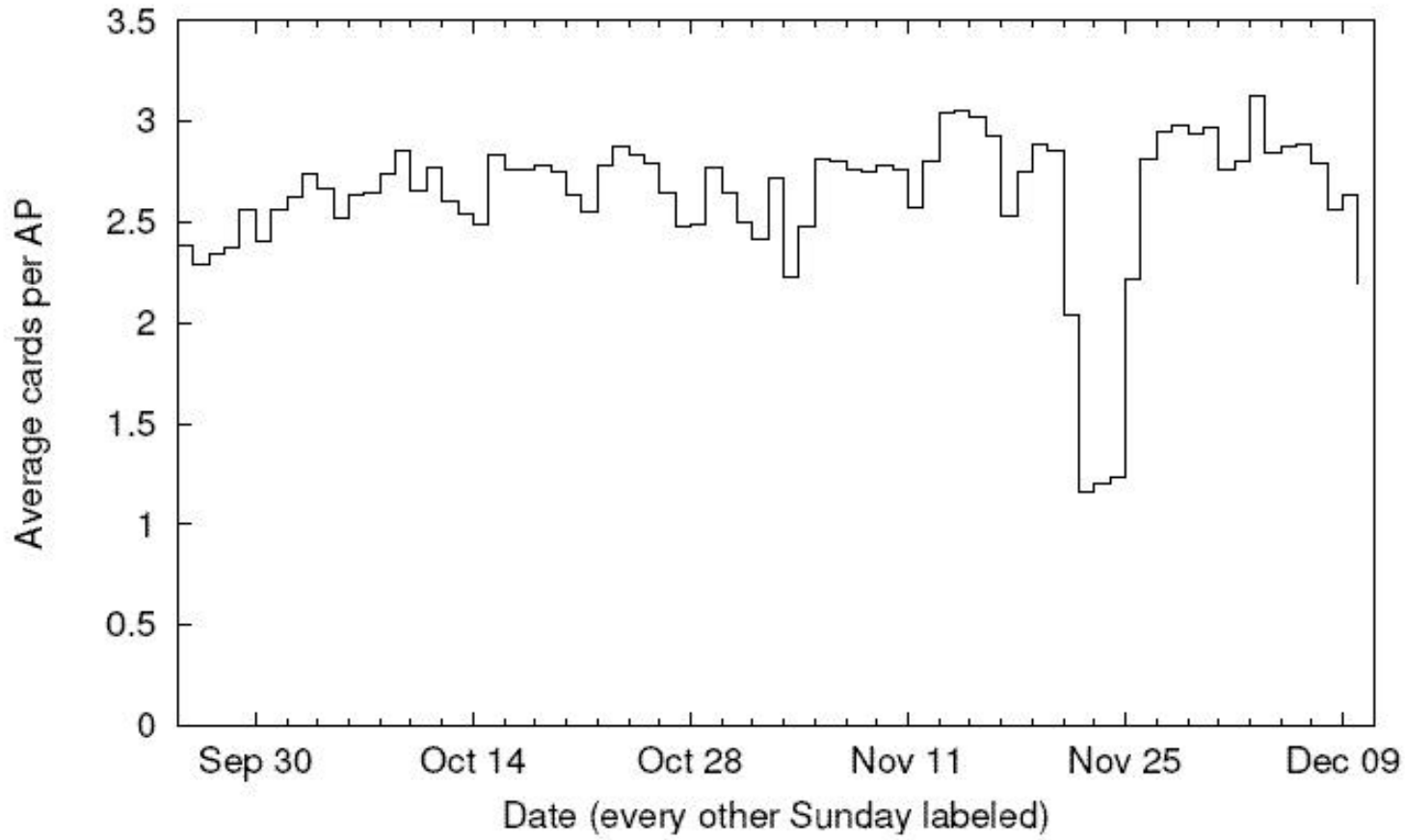


Average Active cards per active AP per day

(b) Fall 2001



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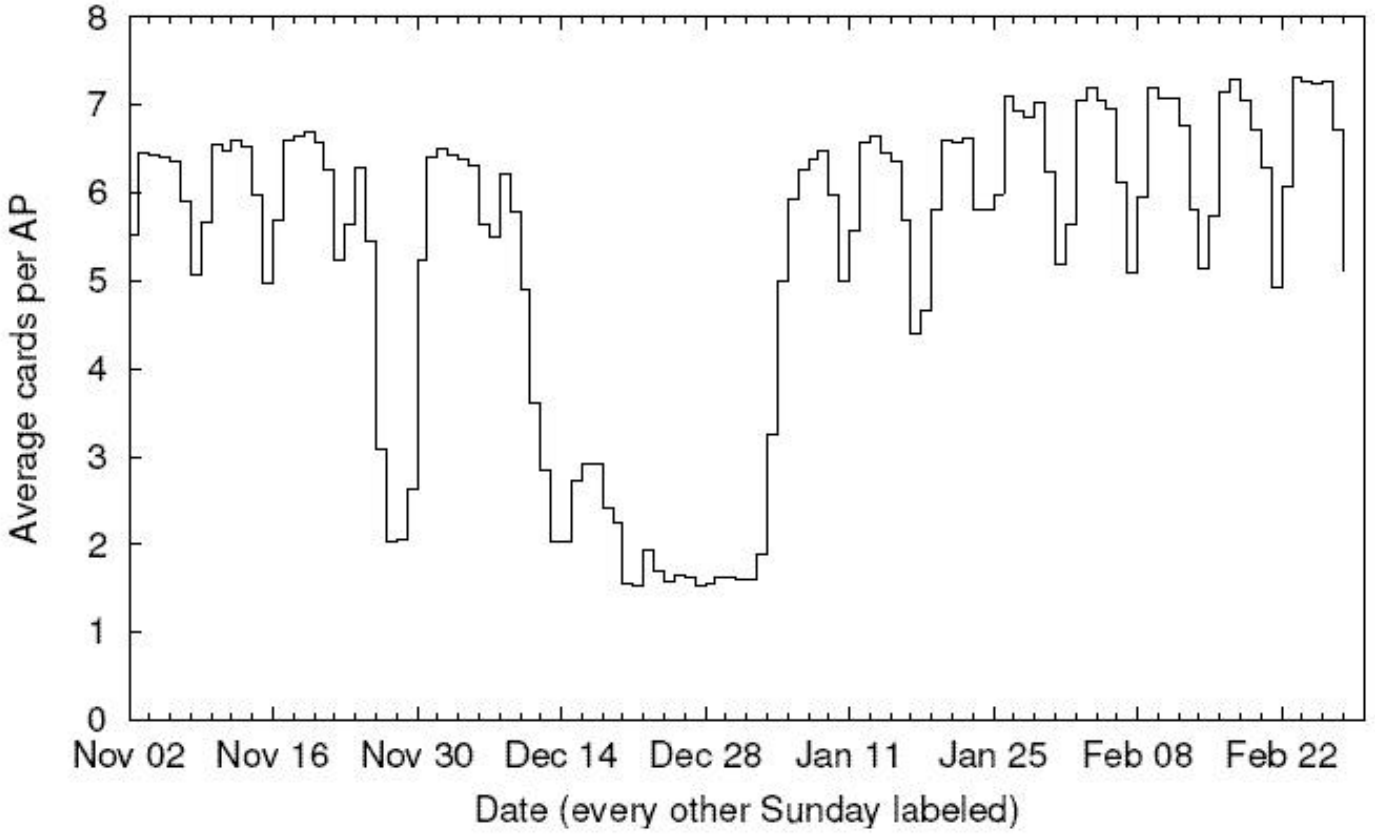
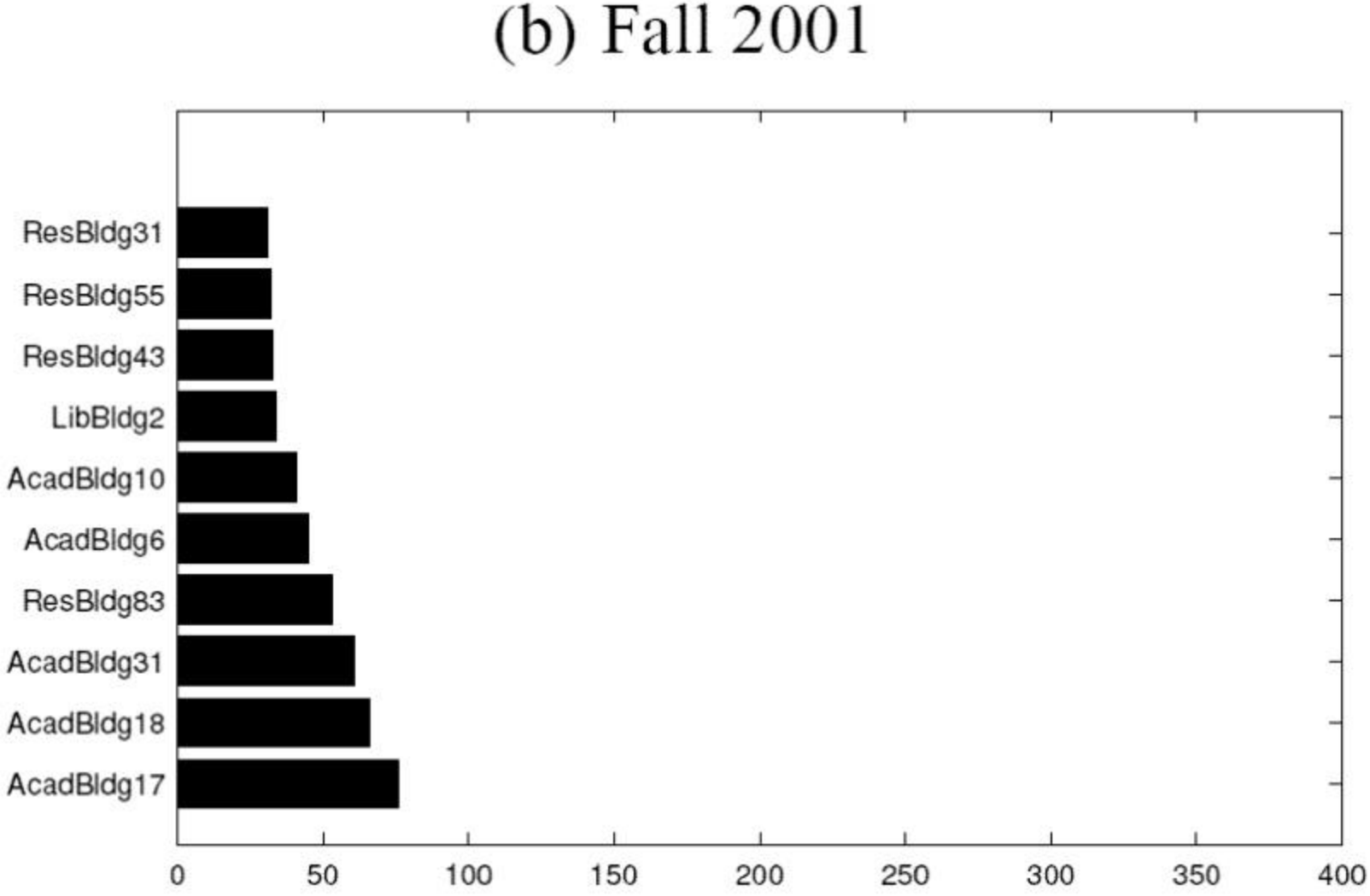


Max cards per hour, for busiest buildings



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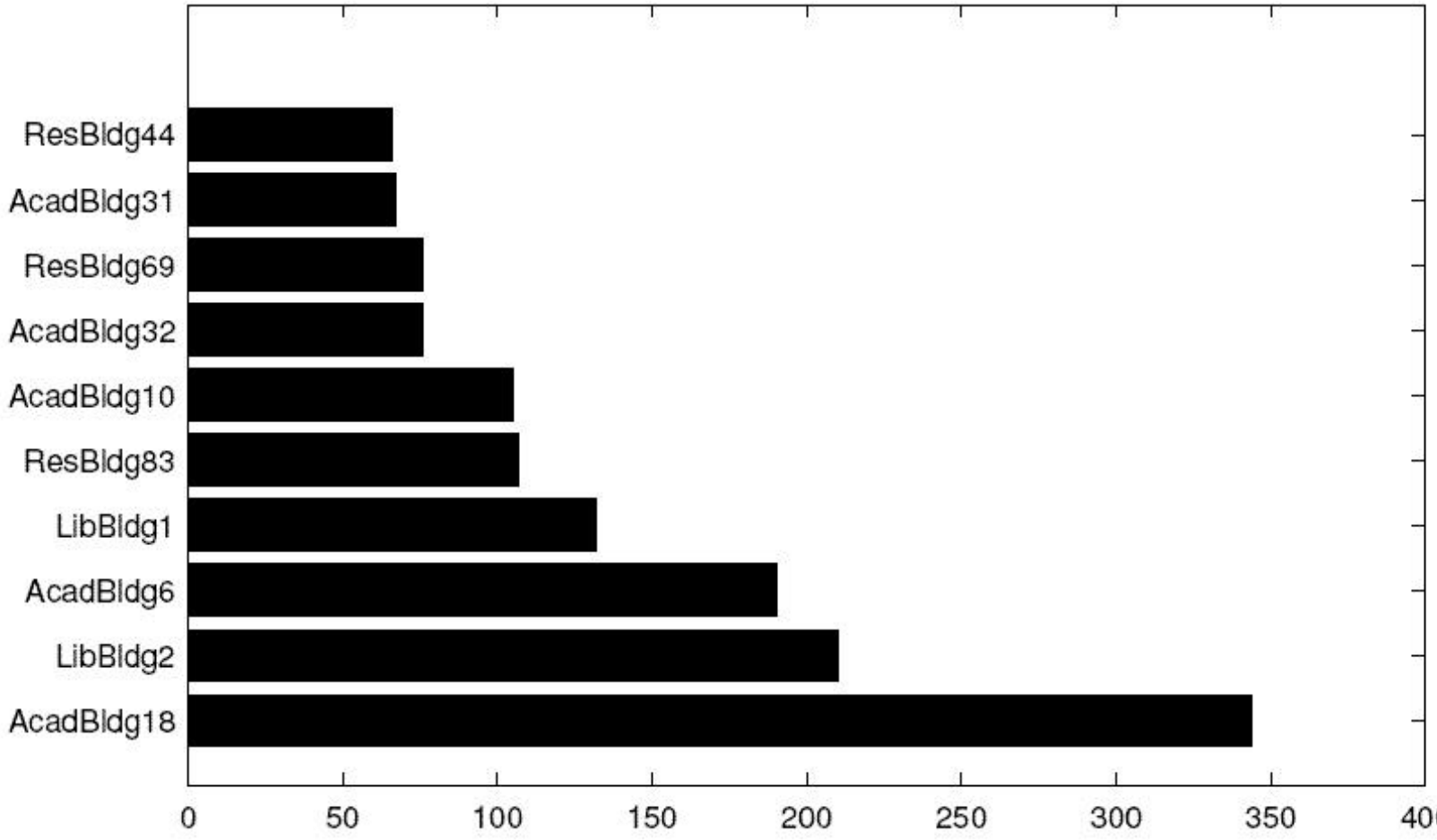
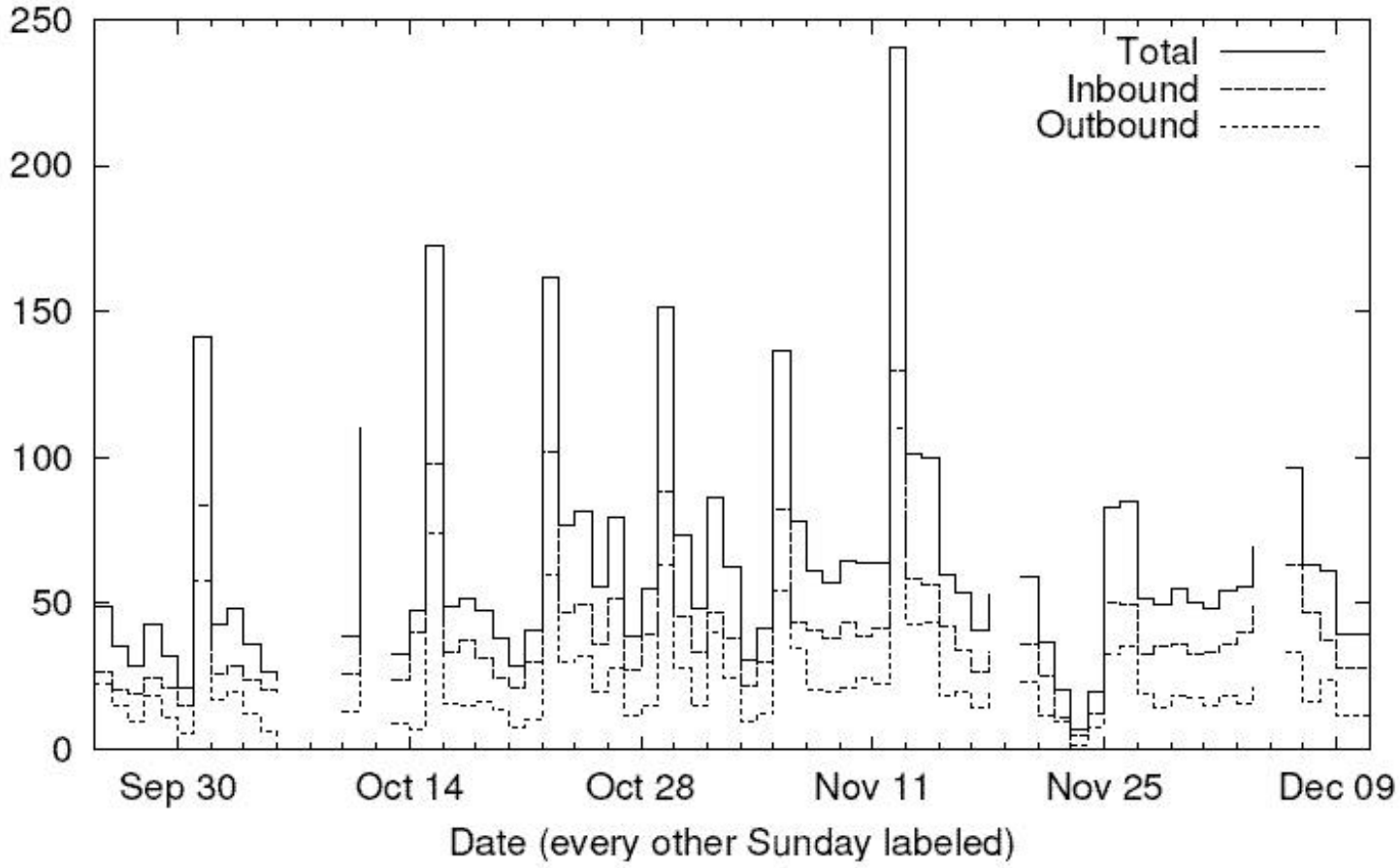


Daily Traffic (GB)

(b) Fall 2001



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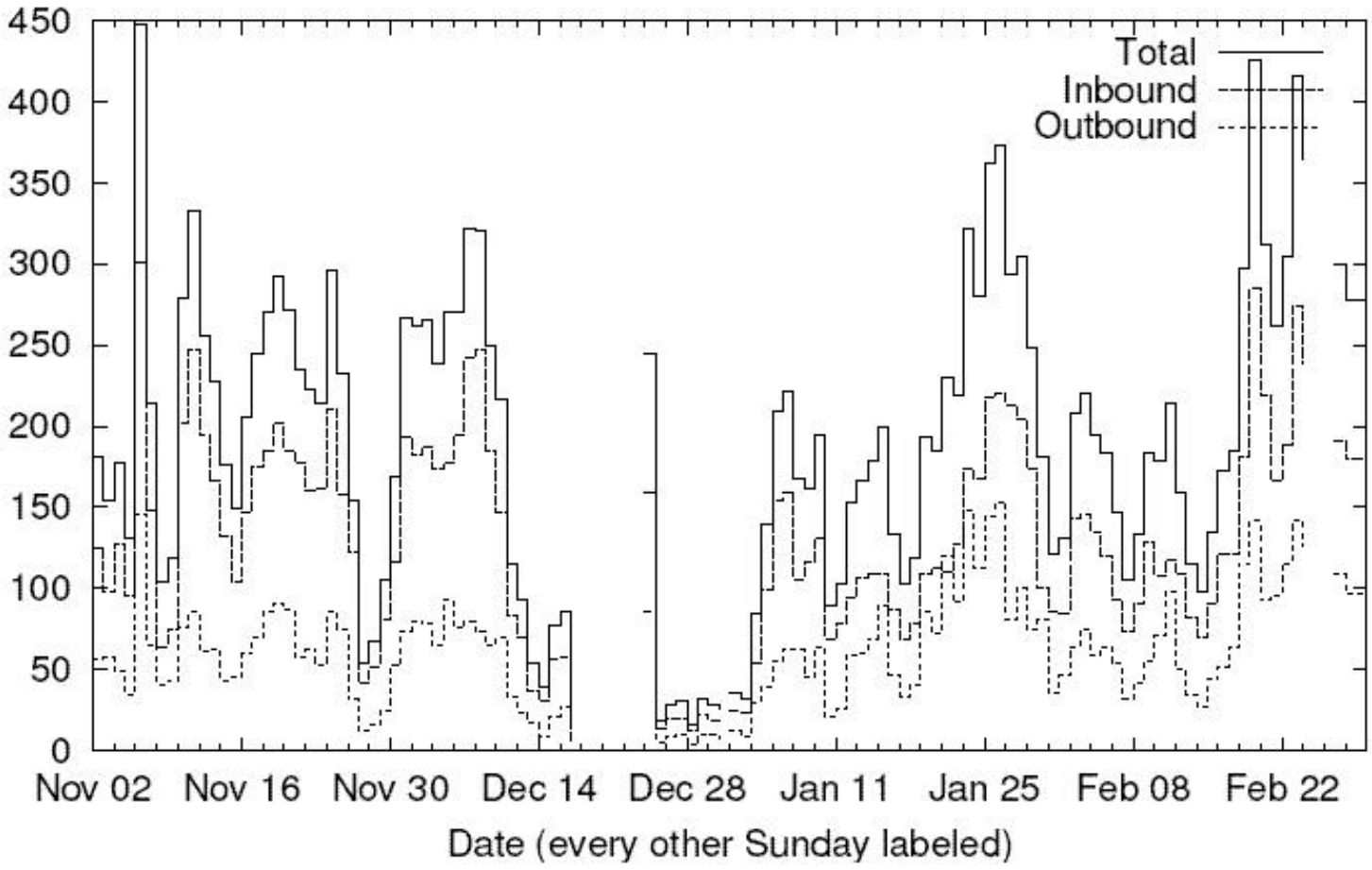
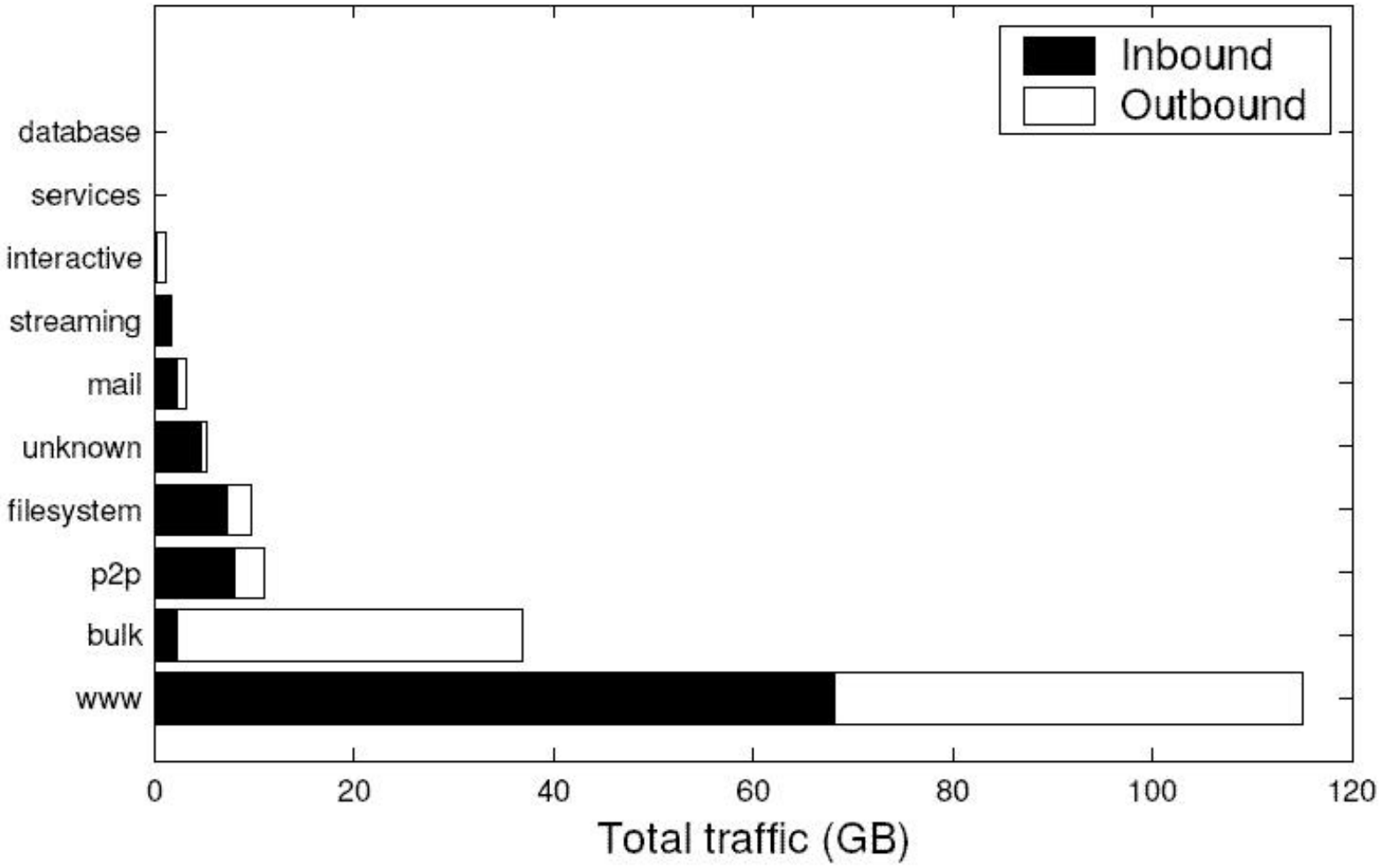


Table 3: Classification of applications

Category	*Applications*
bulk	FTP, backup
database	Oracle, PostgreSQL, SQLnet
interactive	IRC, AIM, iChat, klogin, rlogin, ssh, telnet
mail	POP, SMTP, IMAP, NNTP, BlitzMail
p2p	DirectConnect, Gnutella, Kazaa, BitTorrent, eDonkey, Napster
services	X11, DNS, finger, ident, DND, Kerberos, LDAP, NTP, printer, BOOTP, Rendezvous/ZeroConf
filesystem	SMB/CIFS, NetBIOS, AppleShare, NFS, AFS
streaming	RealAudio, QuickTime, ShoutCast, RTSP, Windows Media
voip	Cisco CallManager, SCCP, Vocera
www	HTTP, HTTPS
unknown	All unnamed and unidentified ports

Total traffic

(b) Fall 2001



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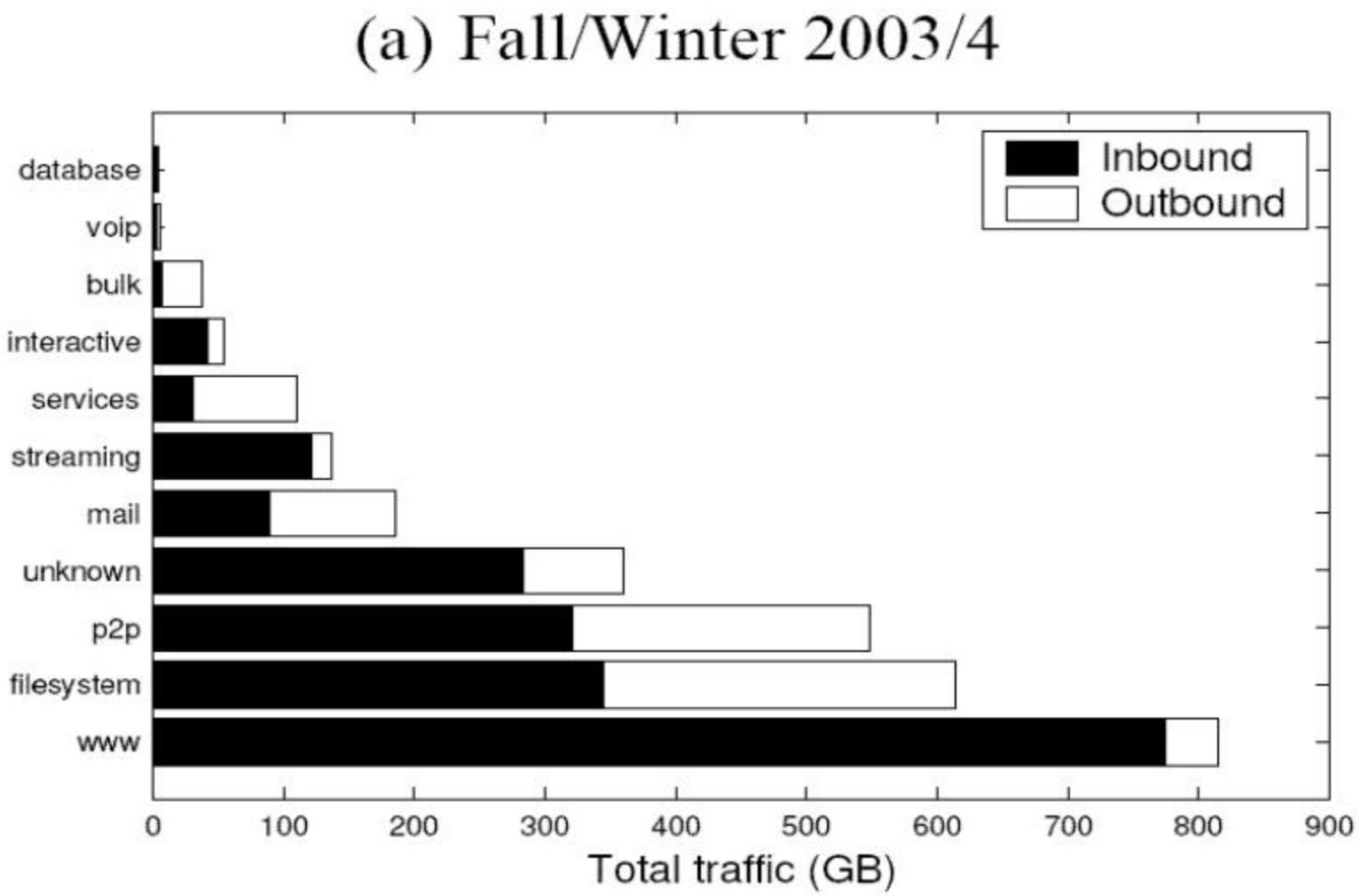
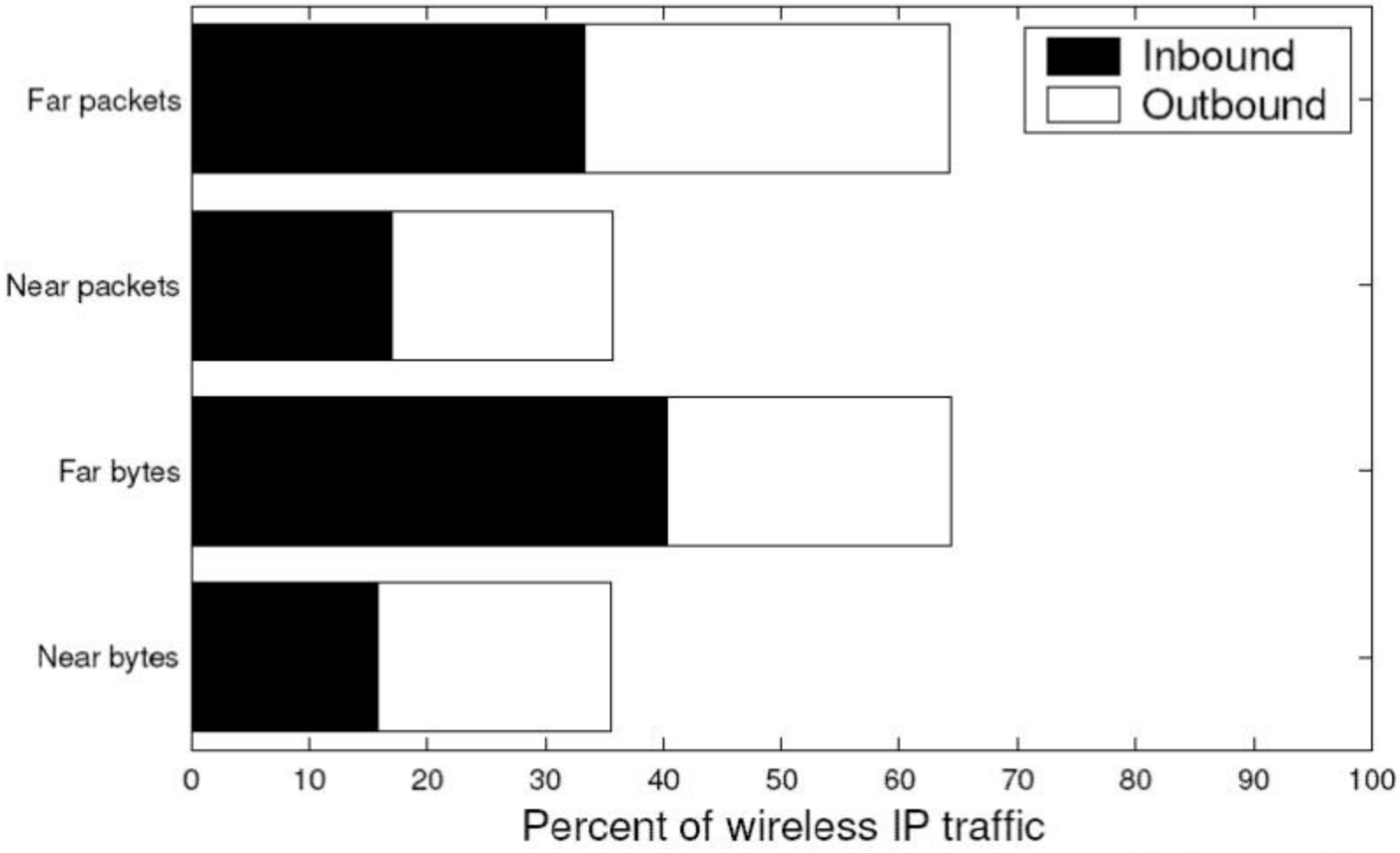


Near/Far Traffic

(b) Fall 2001



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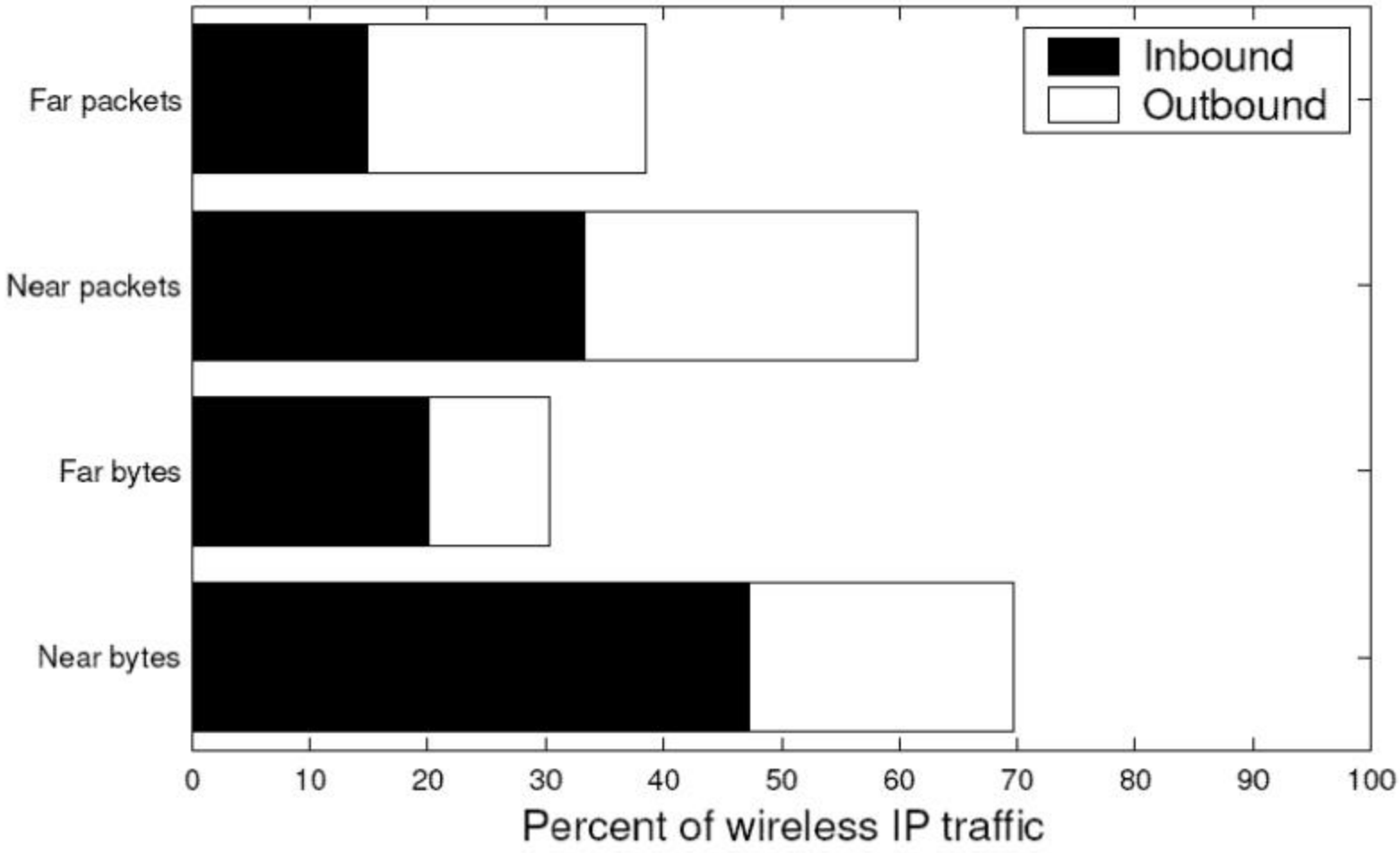
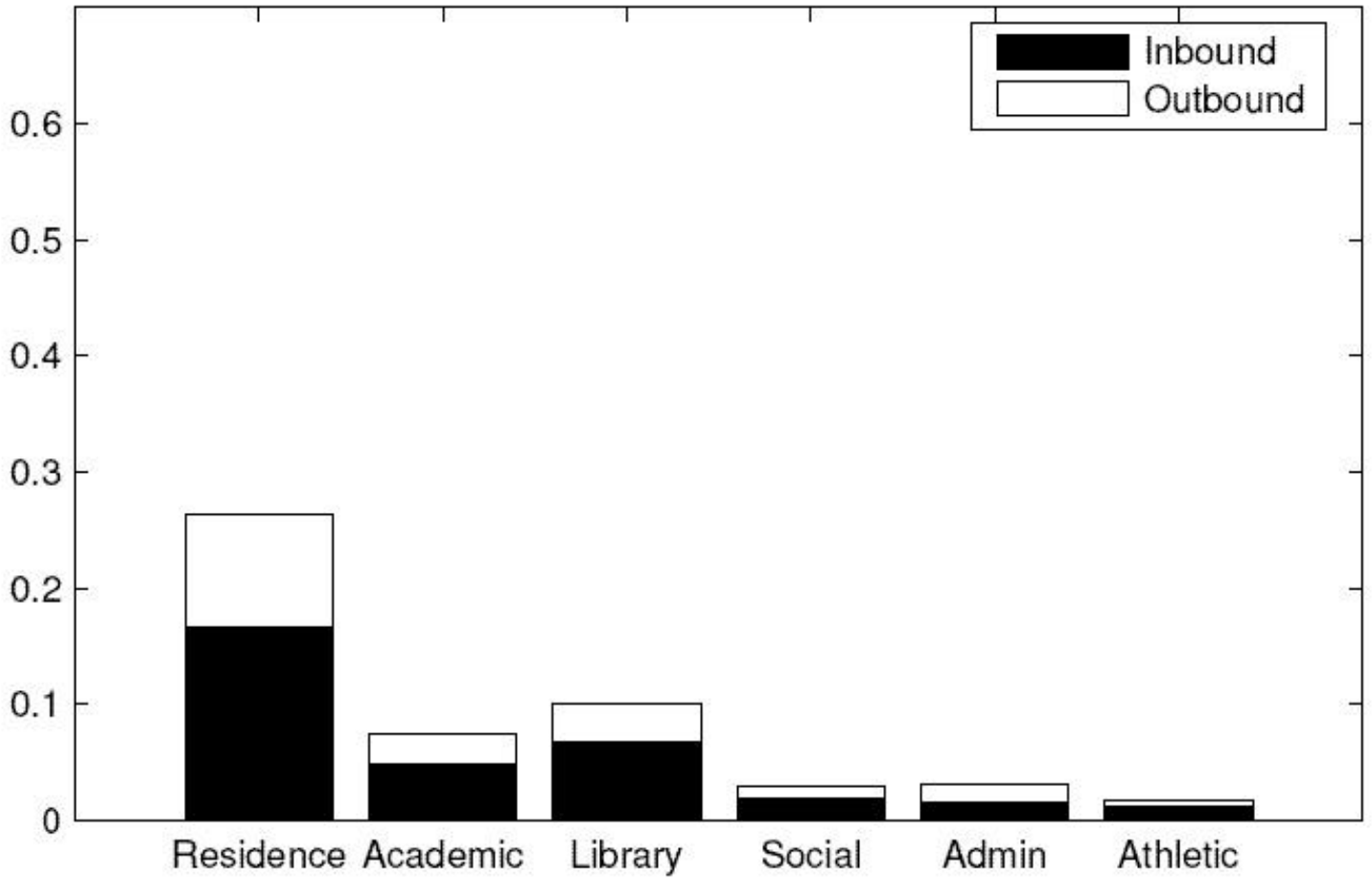


Average daily traffic per AP, by AP category

(b) Fall 2001



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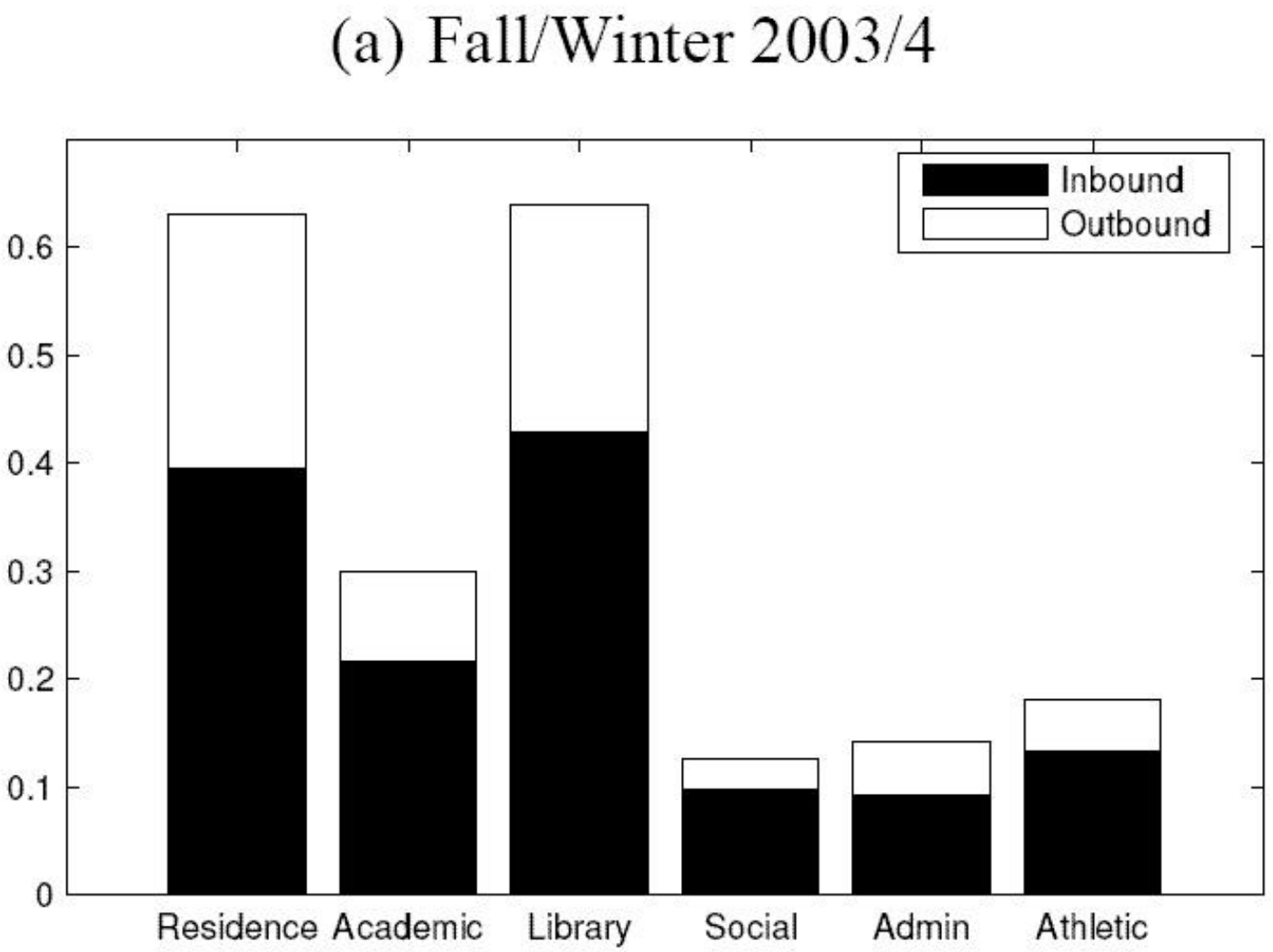
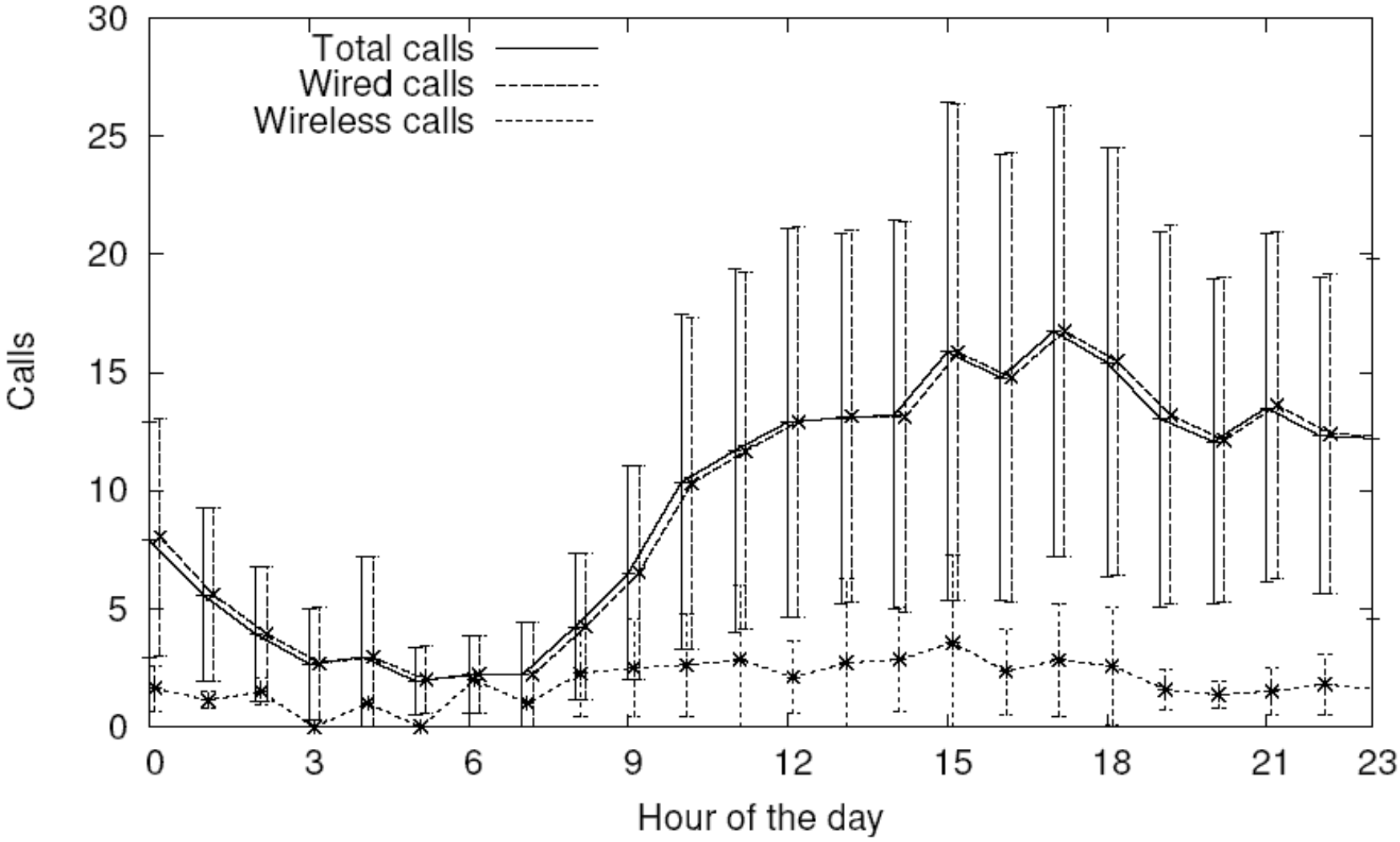
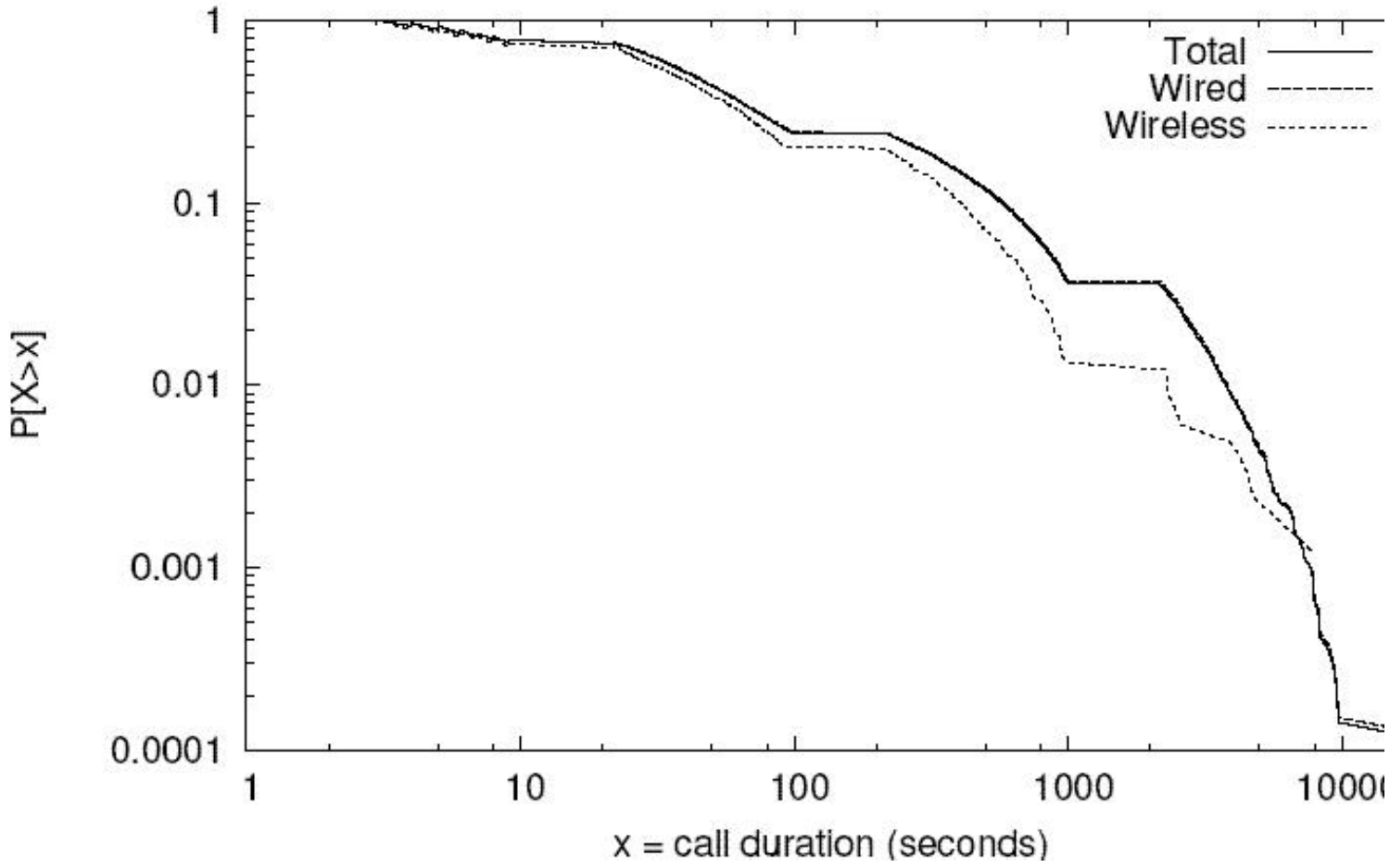


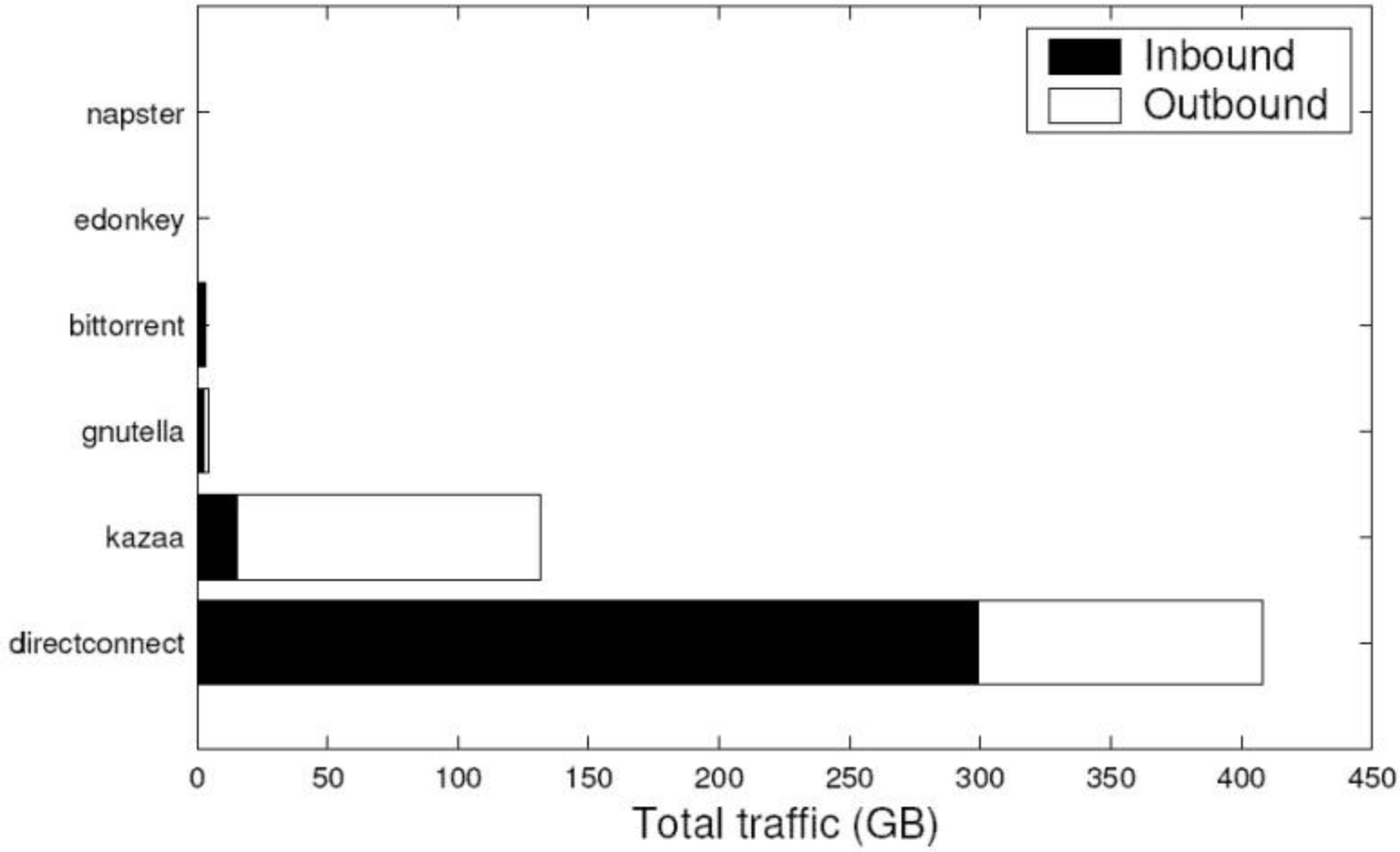
VoIP calls by hour



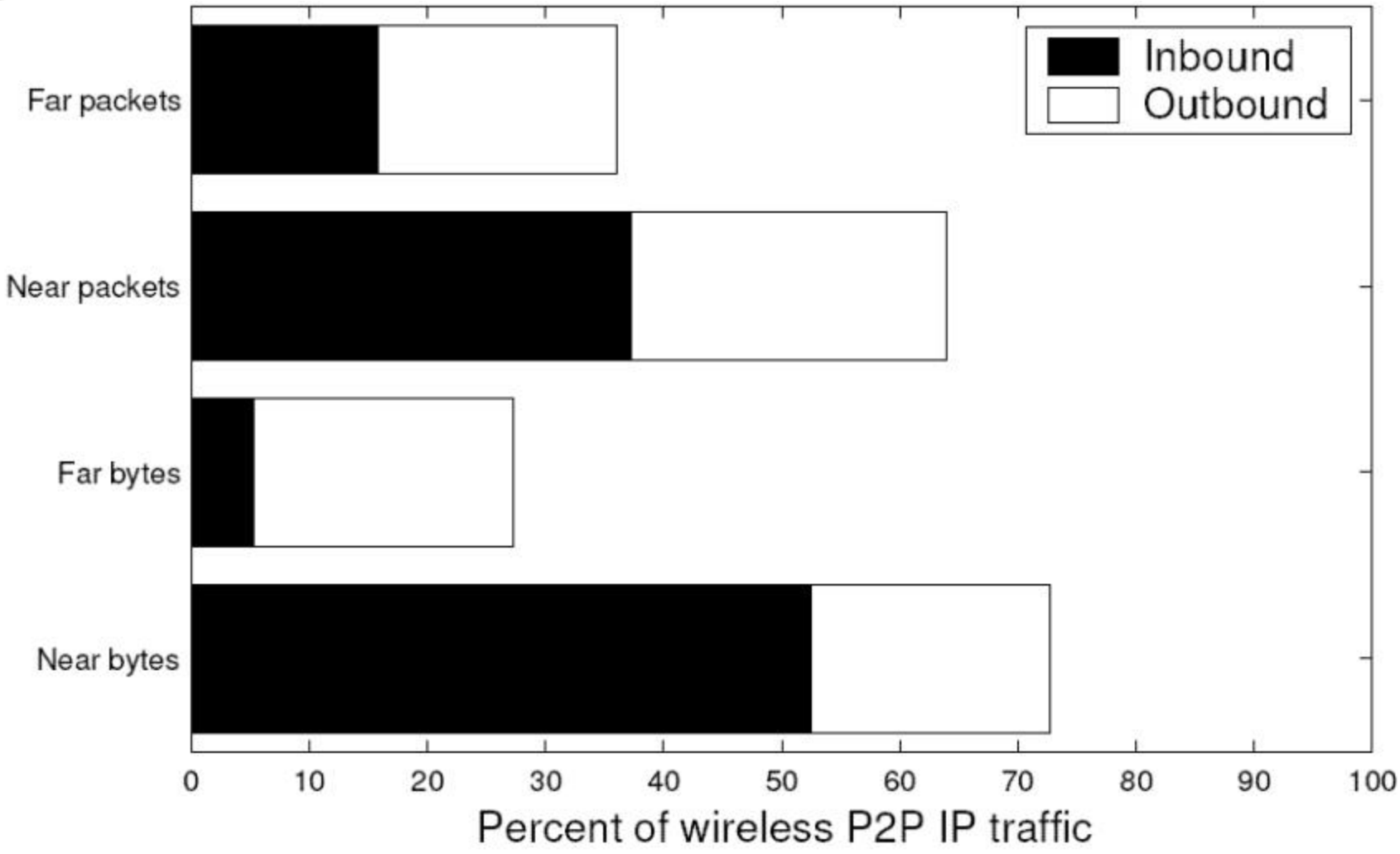
VoIP CCDF of call duration



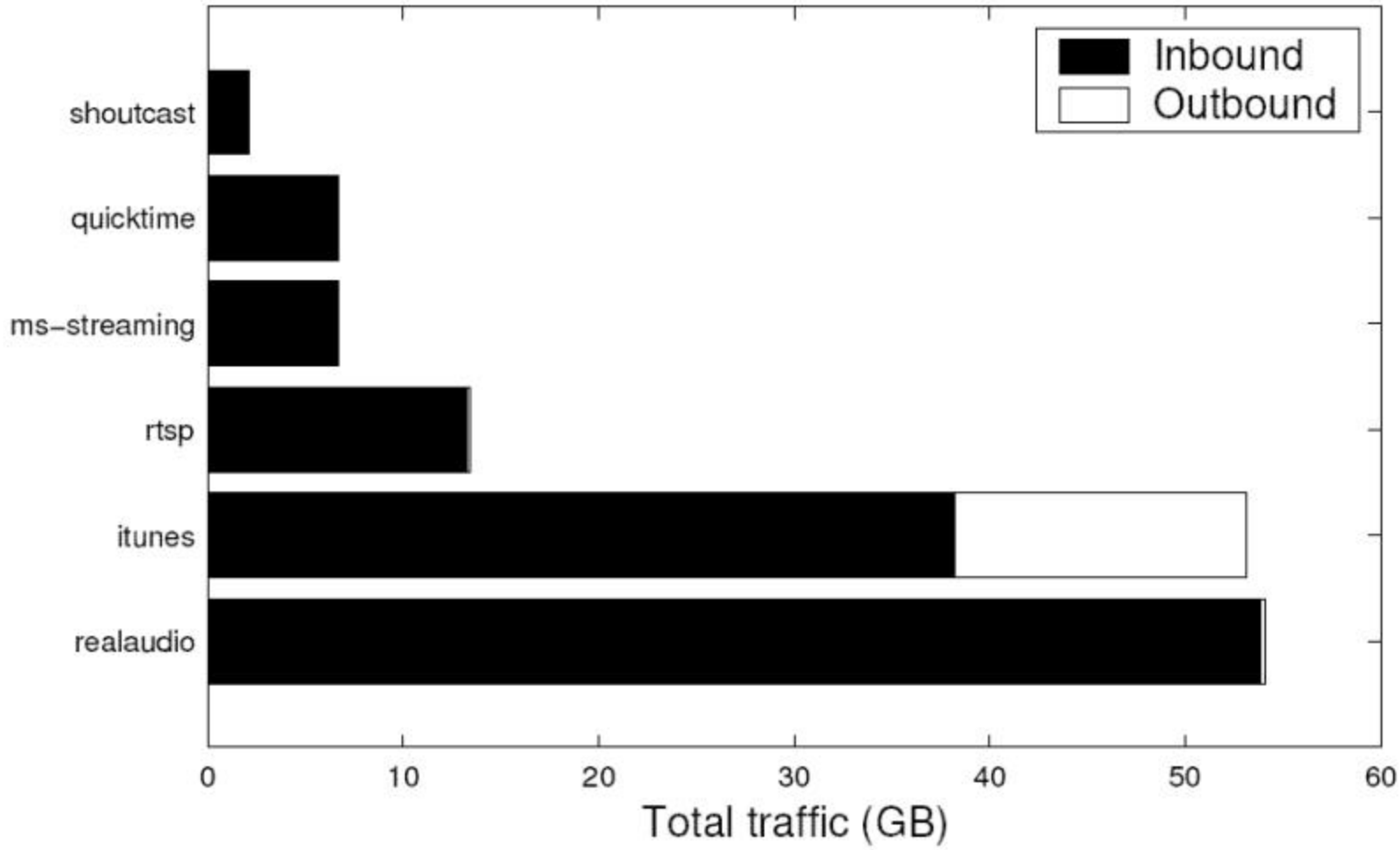
P2P Total Traffic



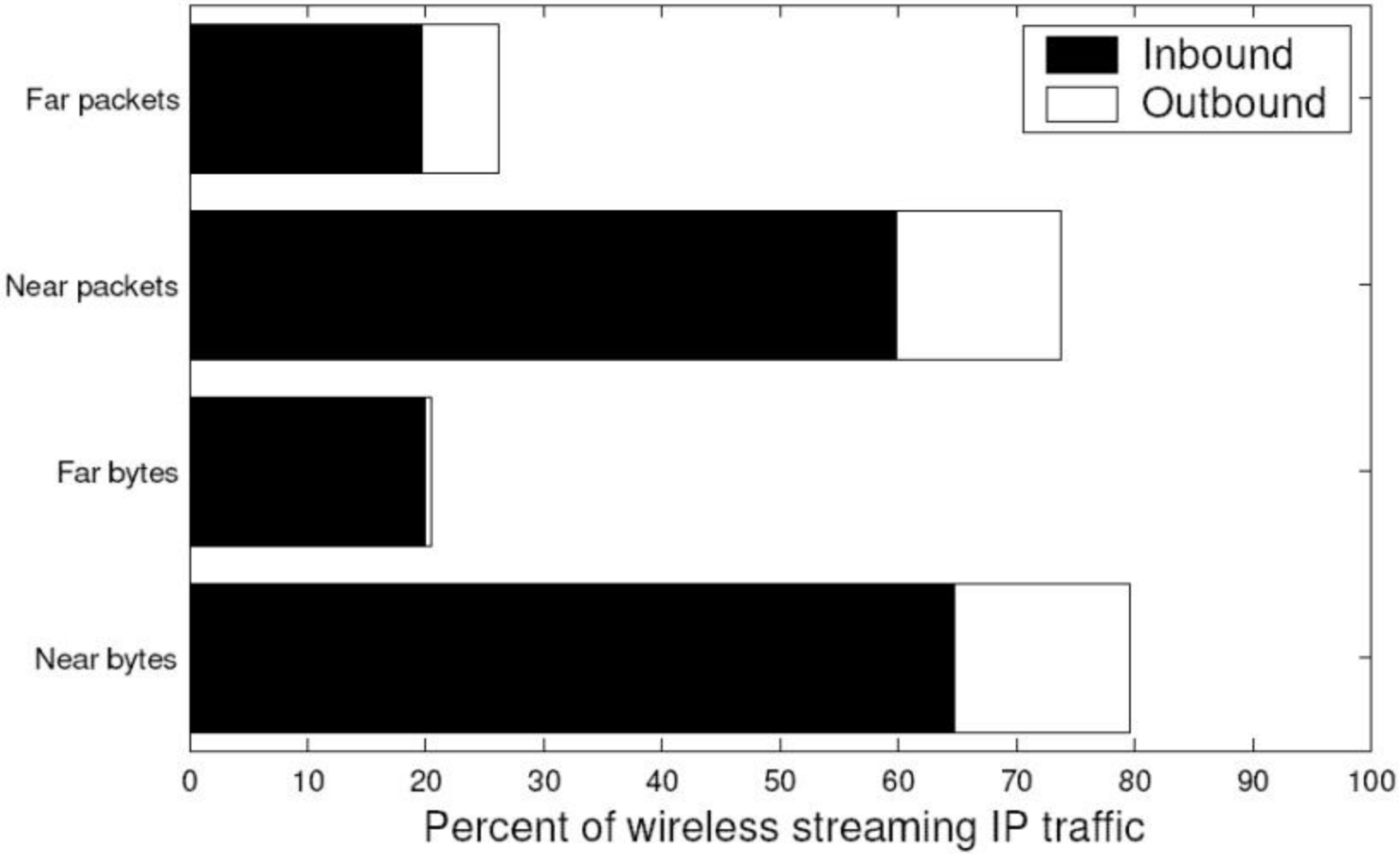
P2P Near/Far Traffic



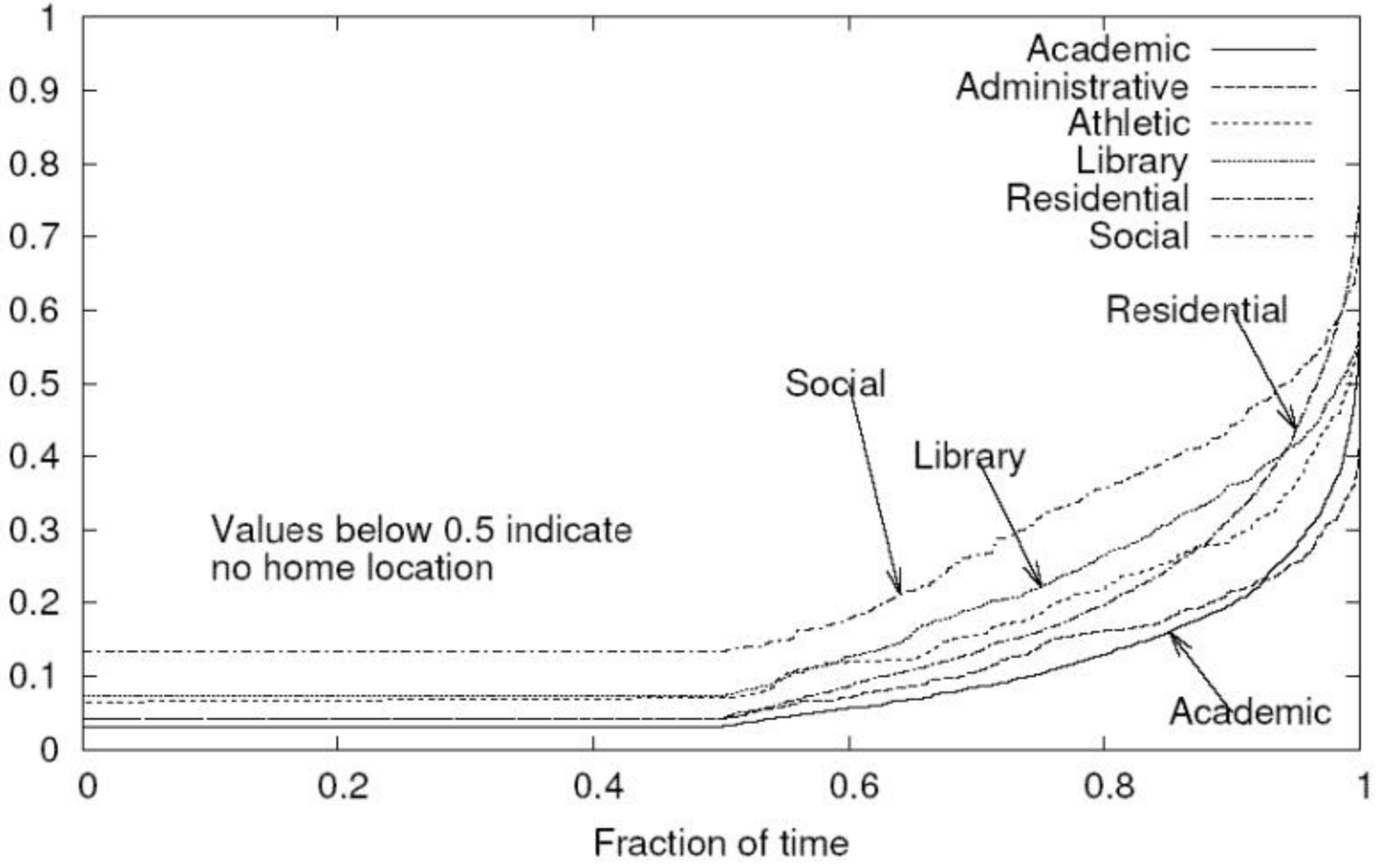
Streaming Media Total Traffic



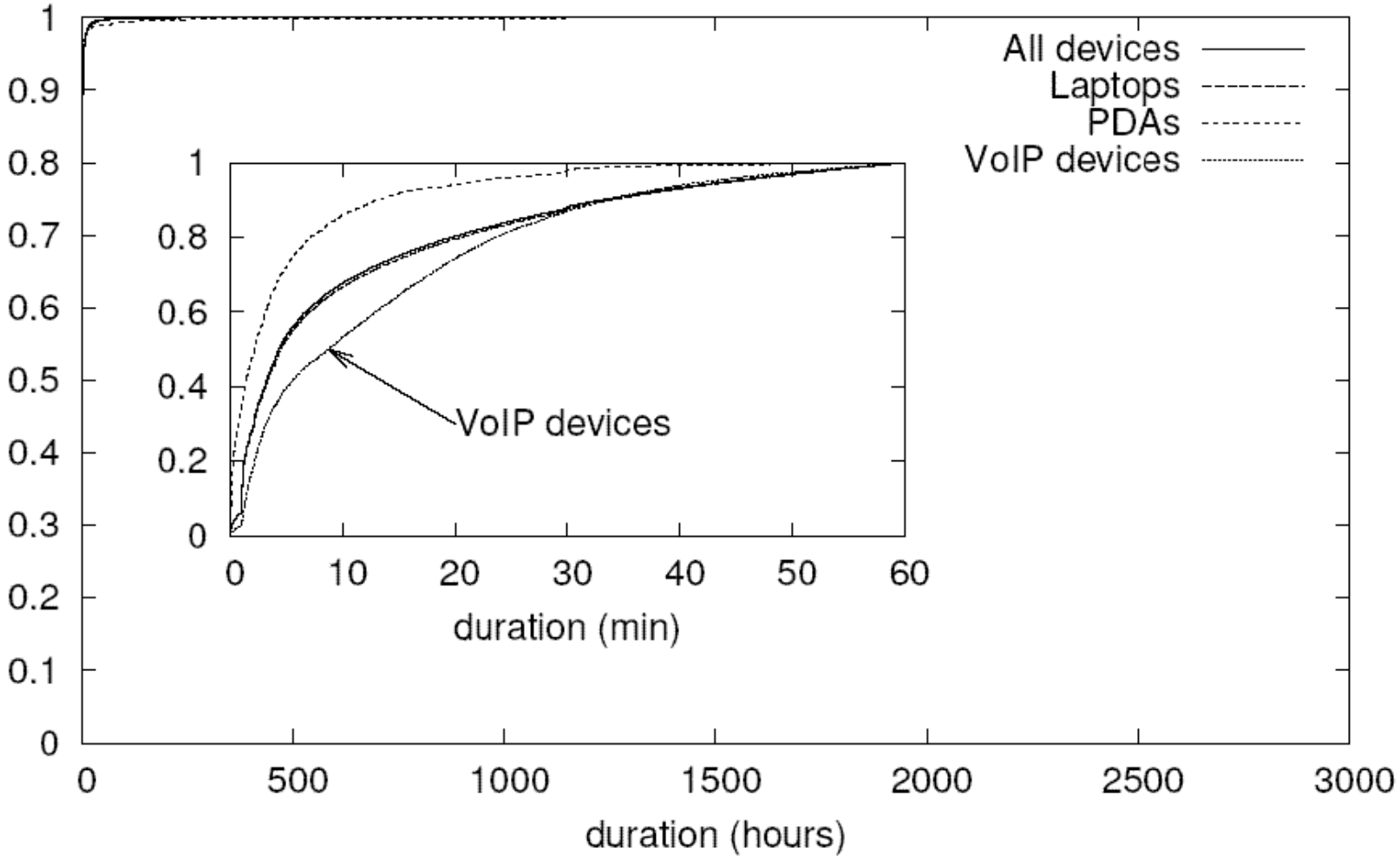
Streaming Media Near/Far Traffic



Mobility
Time spent at home location

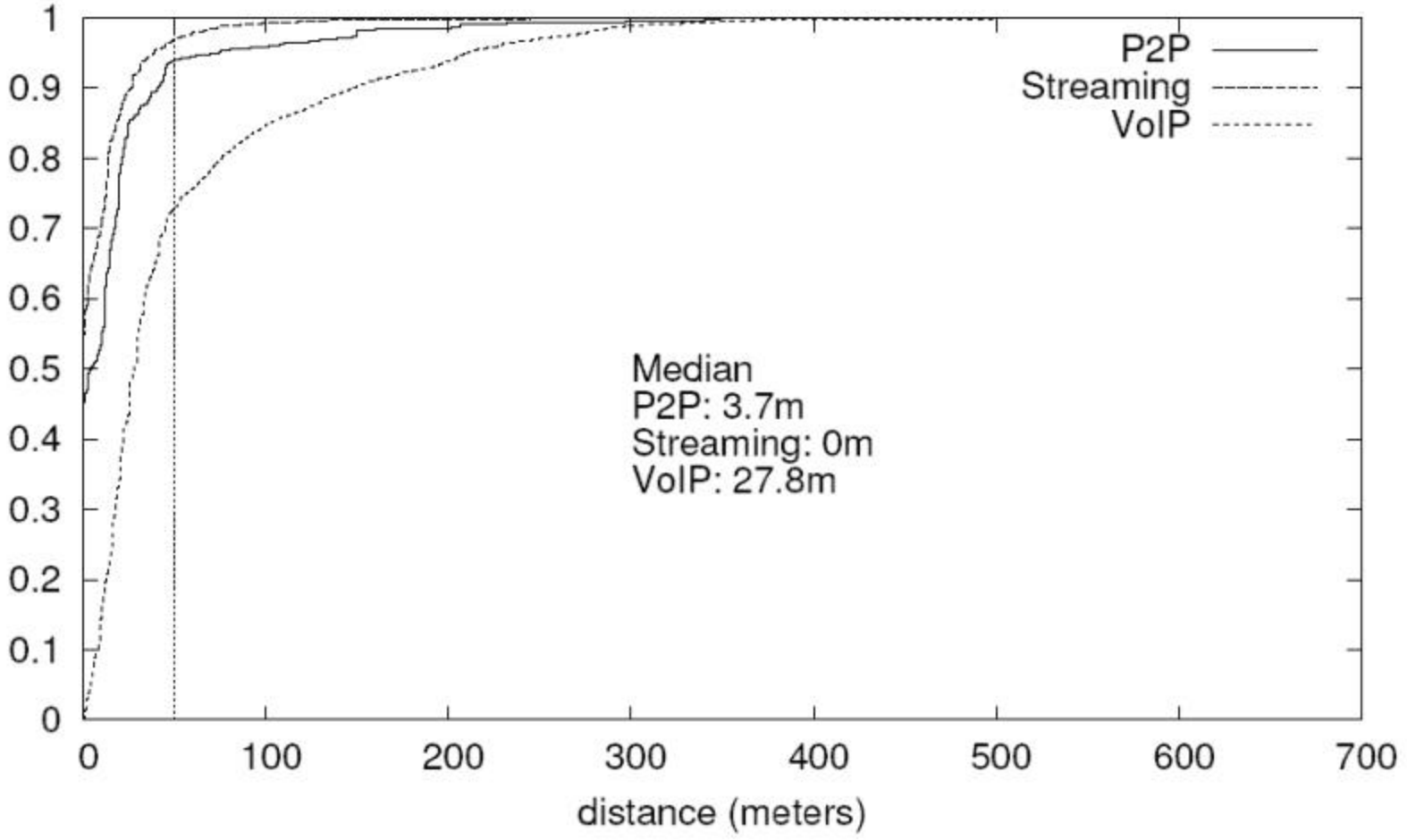


Mobile Session duration



Mobility

Session diameter, distribution across sessions, by application



Conclusions and Recommendations

- Found dramatic increase in usage and change in applications
- Because the majority of users stay in their home location network caching and prediction-based schemes may be beneficial
- Device profiling: single VLAN campus wide for VoIP and PDA devices and building subnets for laptops
- Compare wireless usage against wired usage

Future Work

- WLAN moving to 802.11a/b/g
- Campus Cable TV network migrating to IP-based streaming video
- Wireless sniffers

Thoughts and Questions?