

eStadium – The “Living Lab”

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Goals of the eStadium Project

- Create the most technologically advanced stadium in collegiate athletics
- Create a “Living Lab” for research + education in wireless networking
- Identify and solve problems in the delivery of on-demand multimedia applications over wireless channels.





Research Motivation

- Multimedia services and applications are difficult to develop in an 802.11b wireless network
 - Limited bandwidth, high bit-error rate
 - Lack of built-in support for QoS
- New technologies such as 802.11n can achieve higher bandwidth, 802.11e (WMM) can achieve QoS, but 802.11b (WiFi) has already gained popularity
- Deliver videos to small mobile devices
 - Power constraints, limited storage, etc.

Cisco C1200 Access Points provide 802.11B wireless (Green) support for e-stadium fans, 802.11A wireless support (Black) from the same Access Point for PAL in future announcements

SSID: "estadium" (802.11B)
 SSID: "PAL" (802.11B)

Wireless Handheld Data Devices for Fan in the stands (FITS) and in future announcement (PAL)

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Web Server Console located in STDM 3019 IDF (TBD)

128.210.154.2/24 IAF Subnet
 Stdm-3019-c2950h-01, port 24
 16/100T-SW-A-128.210.154.0

Cisco switches located in stadium IDF's. Only data will need to be ran to each AP location. AP's will be powered with power injectors.

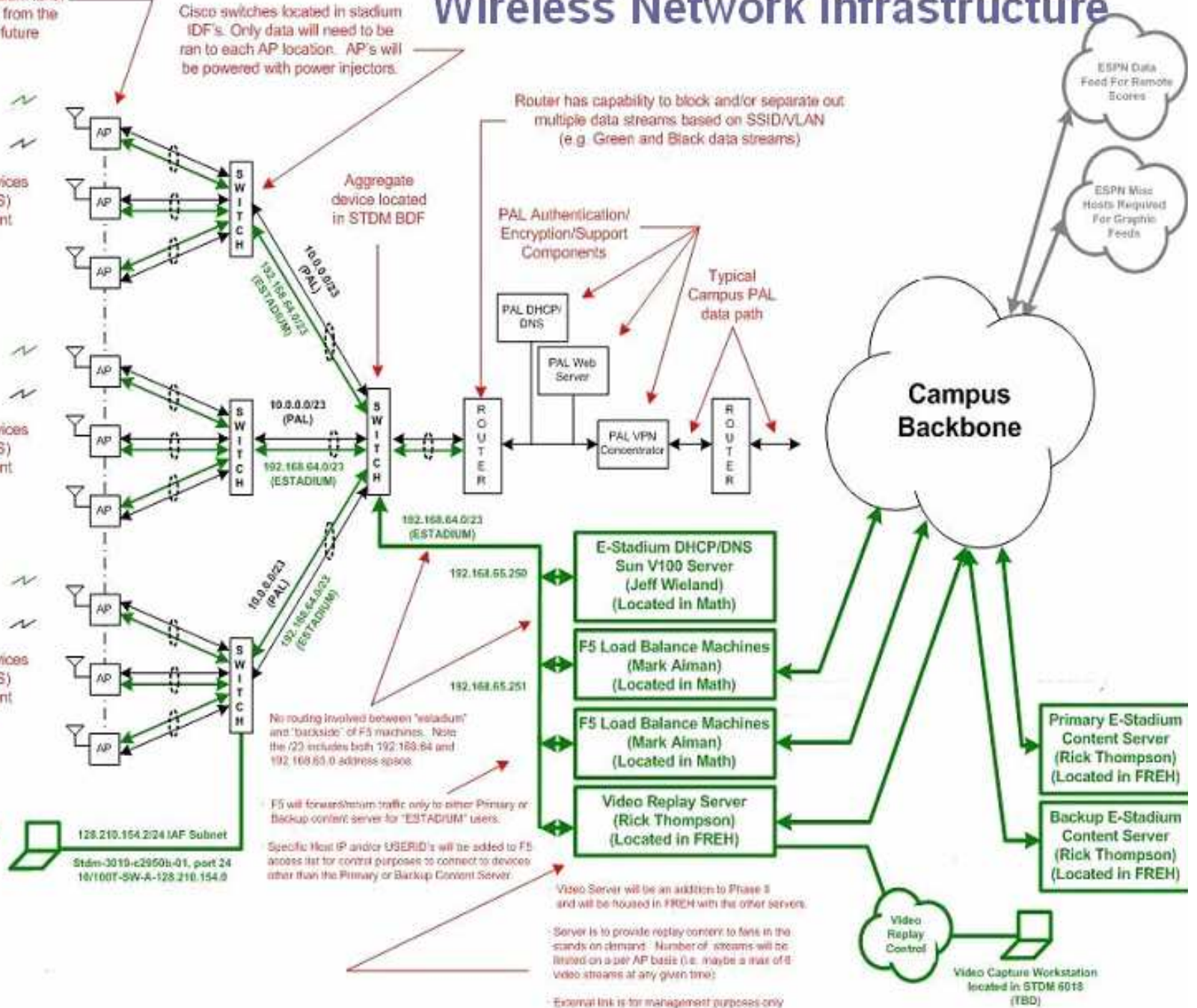
Aggregate device located in STDM BDF

Router has capability to block and/or separate out multiple data streams based on SSID/VLAN (e.g. Green and Black data streams)

PAL Authentication/Encryption/Support Components

Typical Campus PAL data path

Wireless Network Infrastructure



No routing involved between "estadium" and "backside" of F5 machines. Note the (2) includes both 192.168.64 and 192.168.65 address space.

F5 will forward/return traffic only to either Primary or Backup content server for "ESTADIUM" users. Specific Host IP and/or USERID's will be added to F5 access list for control purposes to connect to devices other than the Primary or Backup Content Server.

Video Server will be an addition to Phase 3 and will be housed in FREH with the other servers.

Server is to provide replay content to fans in the stands on demand. Number of streams will be limited on a per AP basis (i.e. maybe a max of 6 video streams at any given time).

External link is for management purposes only

Primary E-Stadium Content Server (Rick Thompson) (Located in FREH)

Backup E-Stadium Content Server (Rick Thompson) (Located in FREH)

Video Replay Control

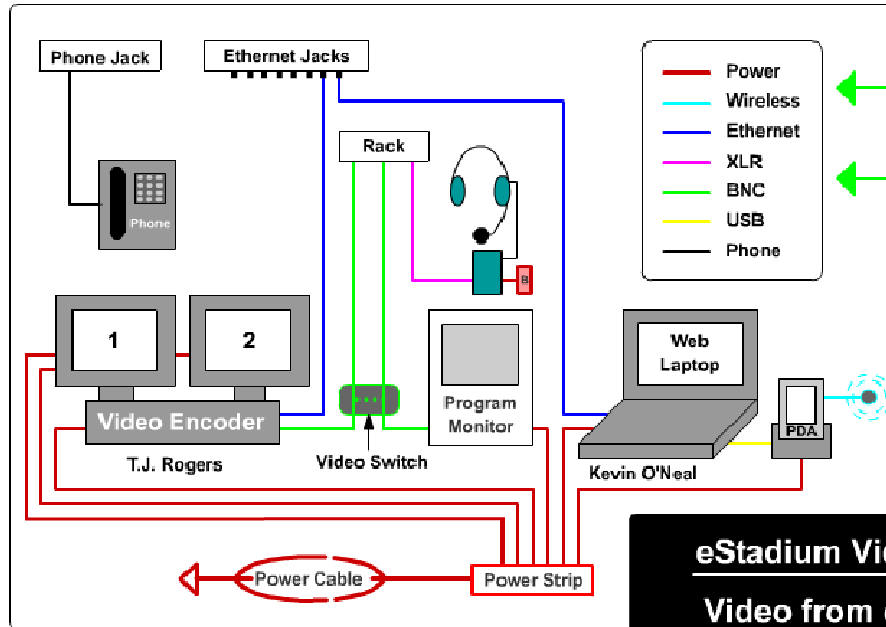
Video Capture Workstation located in STDM 6018 (TBD)

ESPN Data Feed For Remote Scores

ESPN Mac Hosts Required For Graphic Feeds

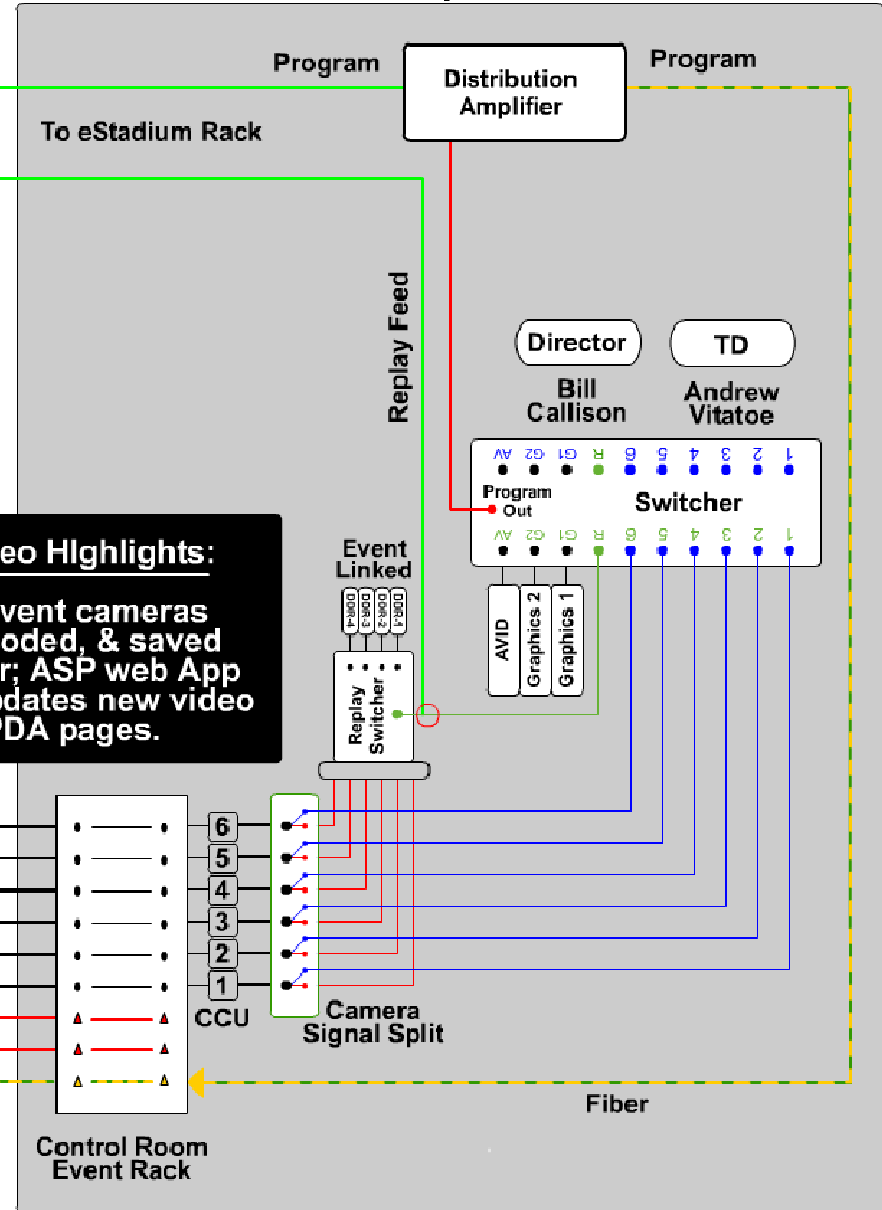
eStadium Video Production Layout

Ross-Ade Stadium Room 6030

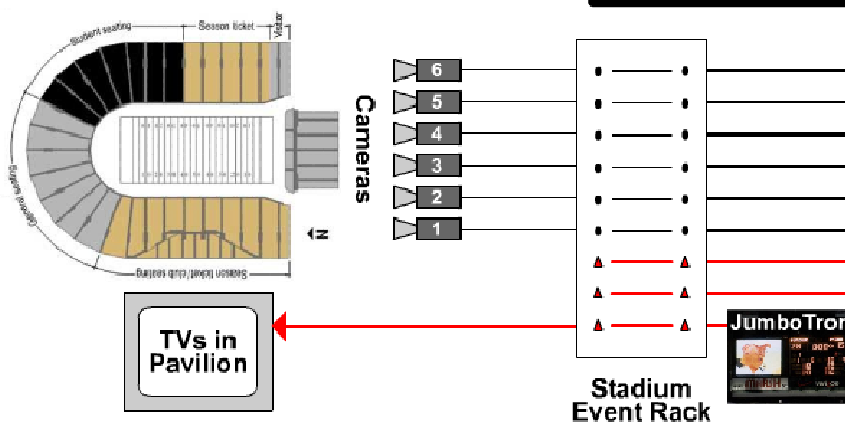


Purdue Football Media Production Configuration

Mackey Room 17

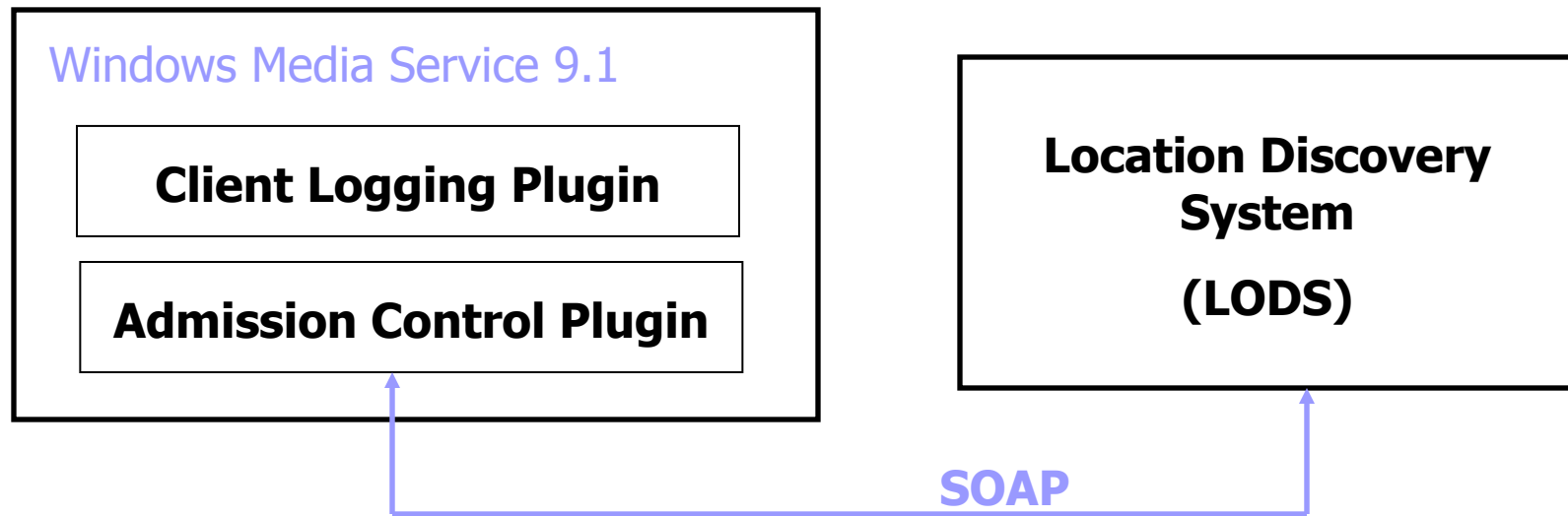


eStadium Video Highlights:
 Video from event cameras captured, encoded, & saved to media server; ASP web App associates & updates new video links on PDA pages.



eStadium & Hall of Music Media Configuration

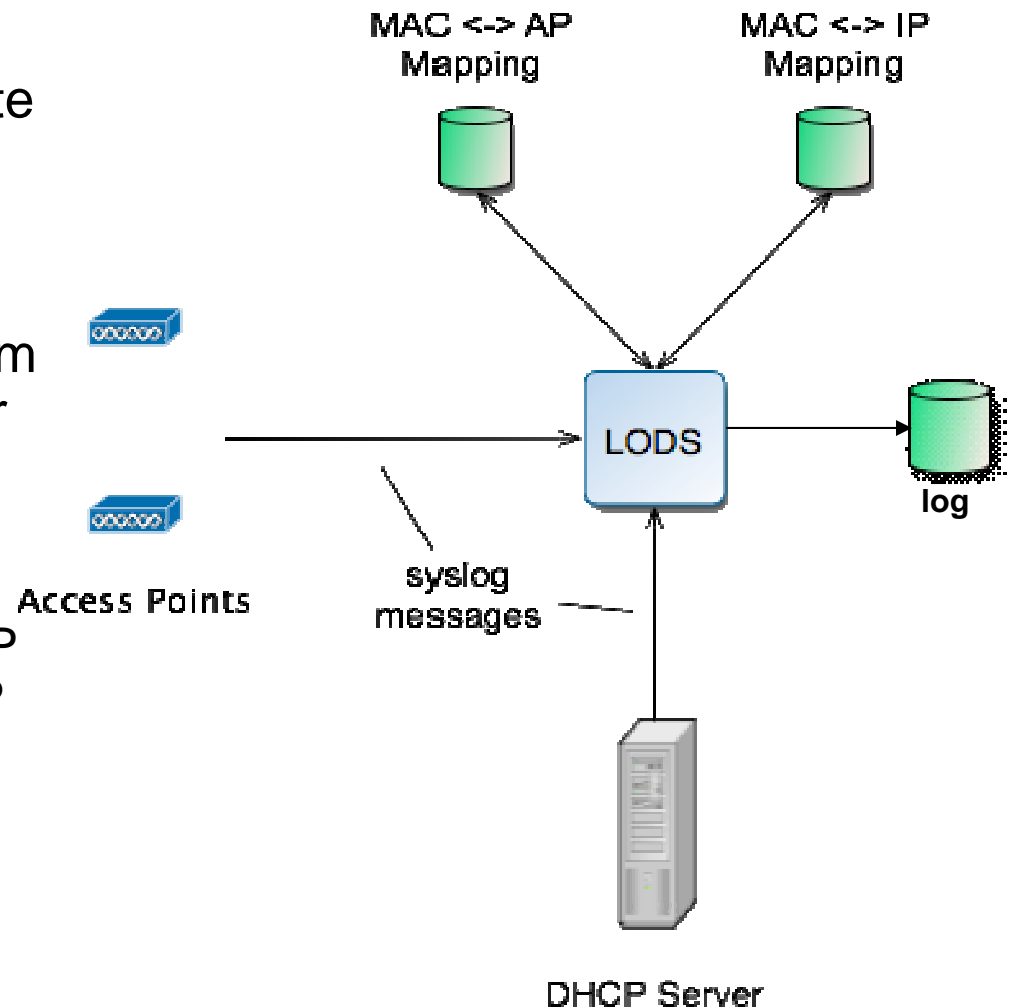
Video Streaming System



- ✦ Unicast Video-on-Demand (VOD)
- ✦ LODS provides an IP-to-AP translation
- ✦ Admission control plugin limits the video traffic on a per-AP basis
- ✦ Client logging plugin provides client perceived streaming performance

LODS Implementation

- Use syslog messages to locate a device – finding which AP it belongs to based on its IP address
- Process syslog messages from the APs and the DHCP server
 - Syslog messages from APs provide the MAC-to-AP mapping
 - Syslog messages from DHCP server provide the MAC-to-IP mapping
 - Join the two tables to get the IP-to-AP mapping
- Store detailed system log information in log table



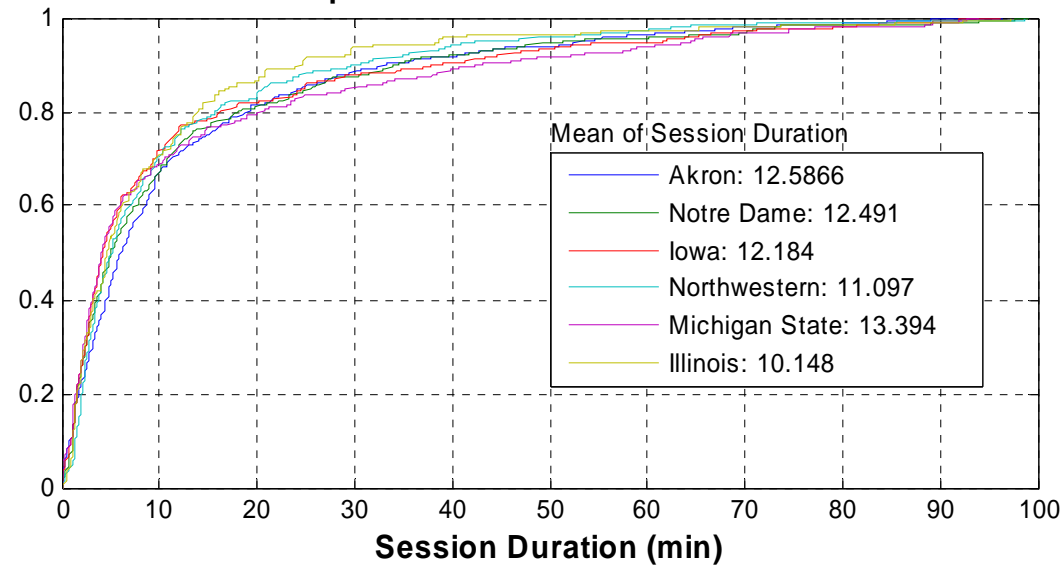


Measurement Study

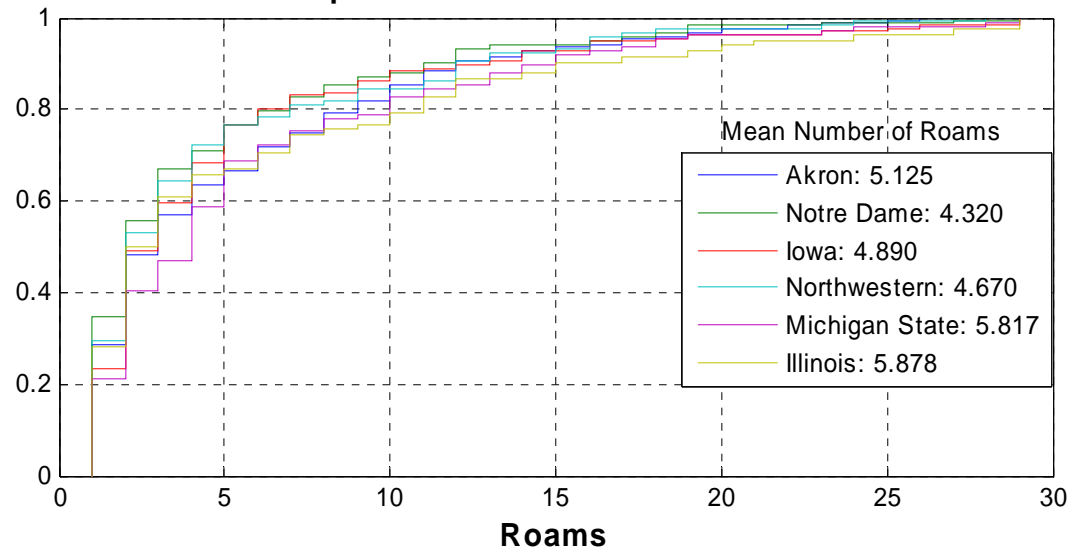
- **Syslog Messages**
 - Session
 - Roam
- **SNMP Polls**
 - Inbound/Outbound traffic and error statistics
- **Wireless Sniffers**
 - Packet-level statistics
- **Client Receive Logs**
 - Client-perceived multimedia performance



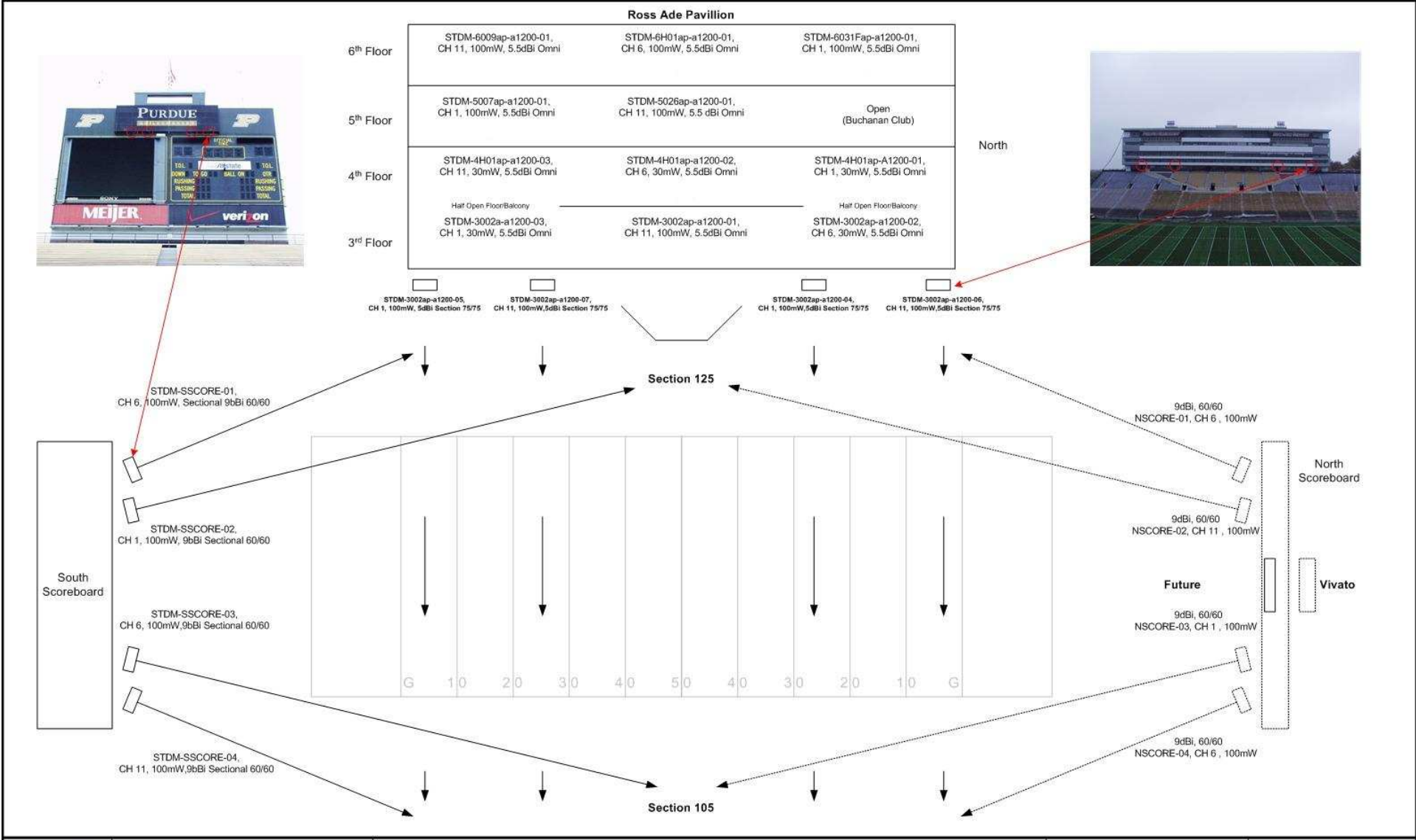
Empirical CDF for Session Duration

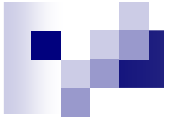


Empirical CDF for Number of Roams

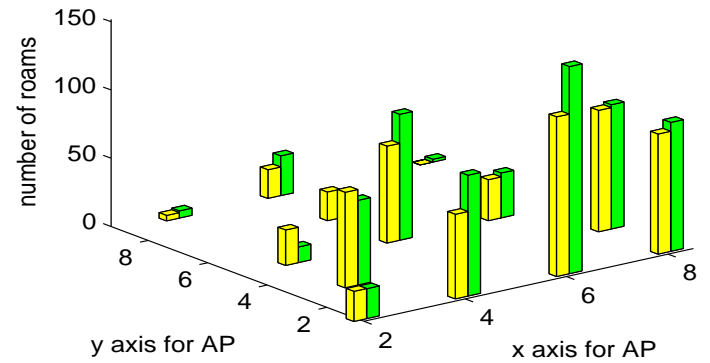
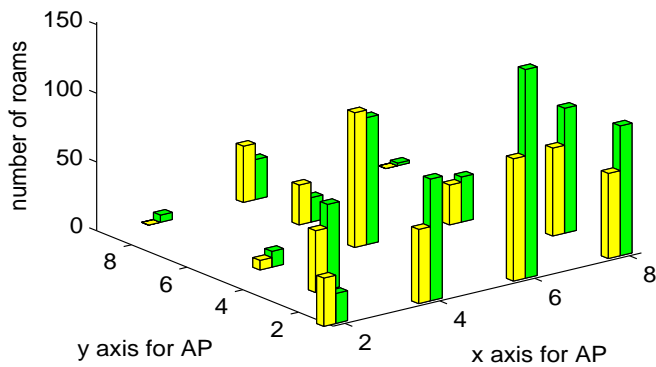
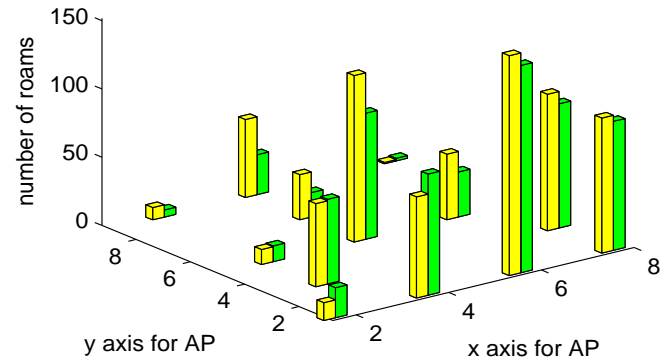
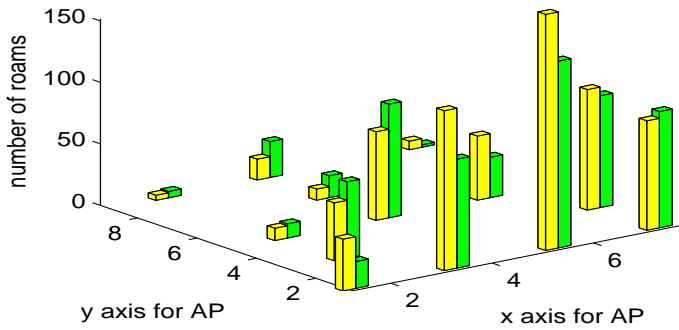
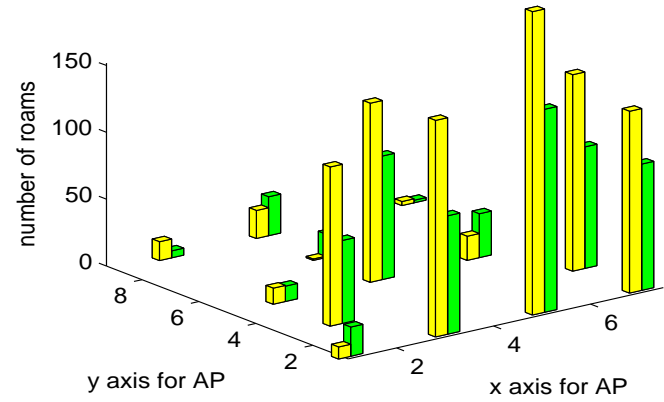
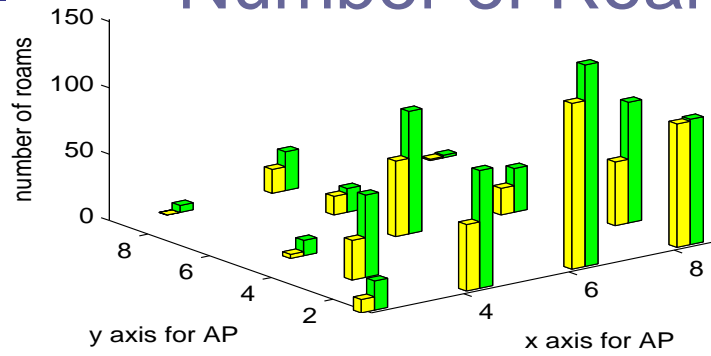


eStadium AP Layout





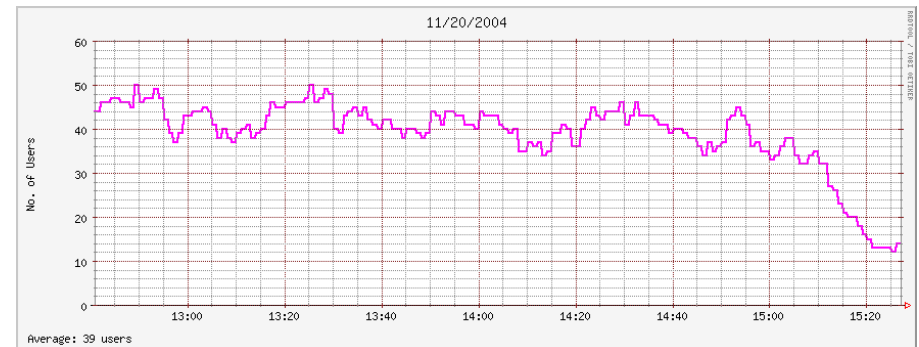
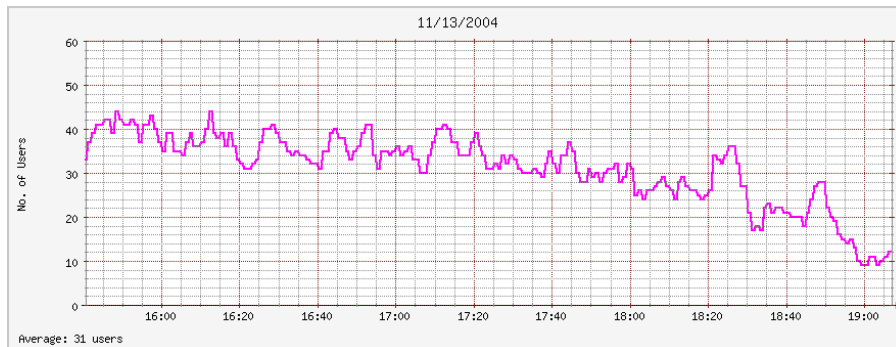
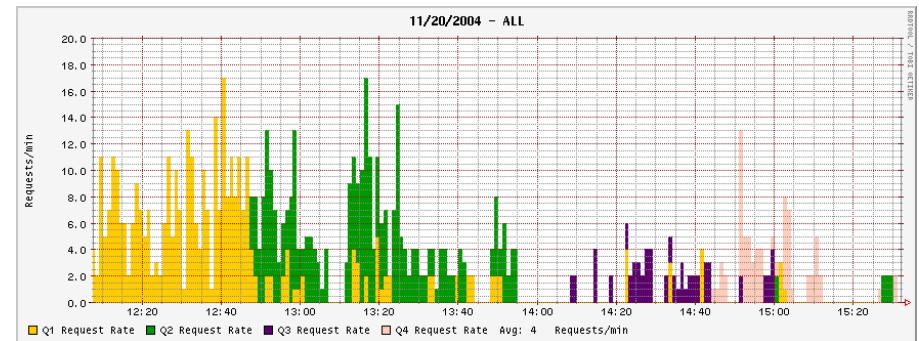
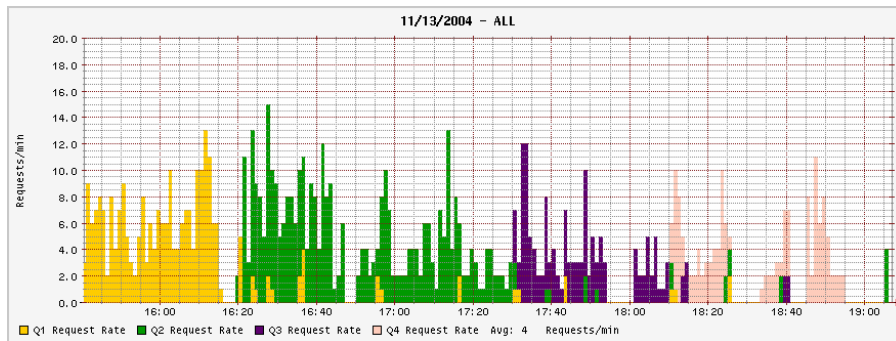
Number of Roams

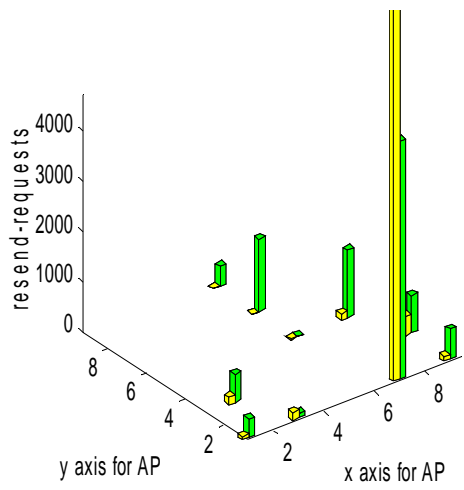


Video Request Patterns

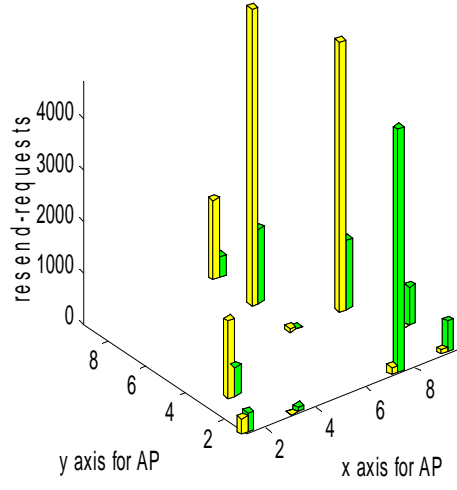
Ohio State

Indiana

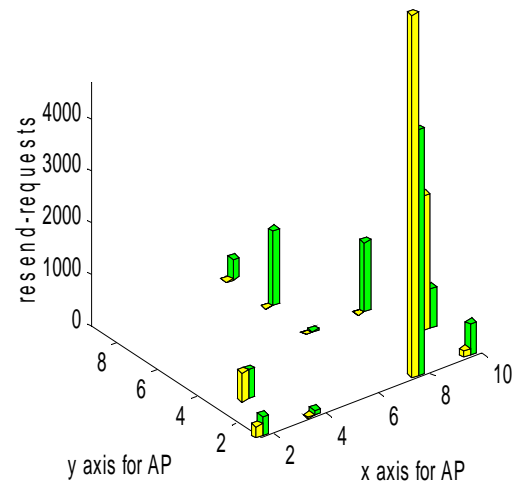




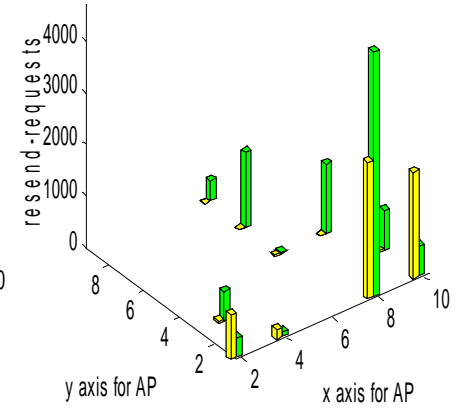
Iowa



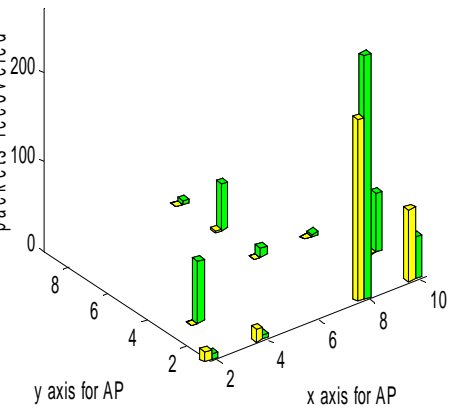
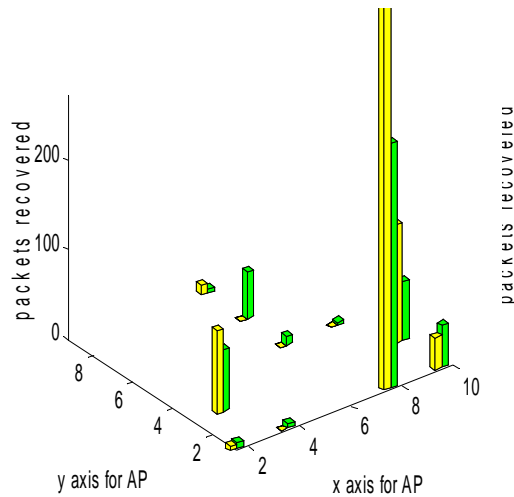
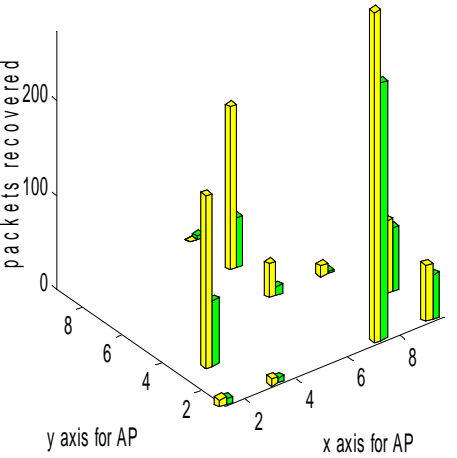
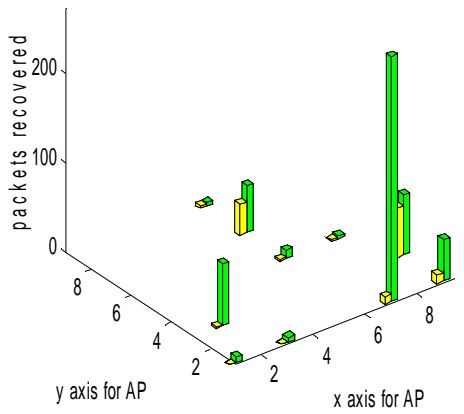
Northwestern



Michigan State



Illinois





Lessons learned

- Perform comprehensive experimental evaluation for wireless multimedia application performance via different measurements techniques.
- Solve existing eStadium video distribution problems
 - video streaming instead of downloading video
 - AP deployment issues (channel, power level, etc.)
- Develop an advanced admission control module based on real-time network conditions and QoS requirements



Future Work

- Enable application support for smart phones
 - Cellular / WLAN interoperability
- Hybrid operation mode
 - Ad-hoc / Infrastructure
 - When to switch?
- WiMAX feasibility study with eStadium scenario
 - Bandwidth allocation (QoS)
 - Cross-layer optimization