Self-Managing Wireless Networks

“Are self managing networks in our Future?”
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• Net-Health Project
  – Helping Users Help Themselves
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User Complaints & IT Headaches

• Microsoft’s IT Dept. logs several hundred complaints / month  
  – 70% calls are about client connectivity issues  
  – 30% (and growing) are about performance problems due to interference

• End-users complain about  
  – Lack of RF coverage, performance & reliability  
  – Connectivity & authentication problems

• Network administrators worry about  
  – Providing adequate coverage, performance  
  – Security and unauthorized access

• Corporations spend lots of $$ on WLAN infrastructure  
  – WLAN hardware business to reach $2.6 billion in 2007. (Forester 2006)  
  – Heavy VC funding in this area (e.g. AirTight $36M in the last 16 months)
WLAN Management is hard

- Heterogeneous world
- Problems can occur anywhere
- No standard monitoring technique
- Users have very limited understanding & control
  - Don’t want to have to call anyone, just want the problem fixed and / or told when it will be fixed!
- Unpredictable RF propagation
- Many tunable parameters & parameter sensitivity is high
- Cross-Industry cooperation is difficult to achieve
- Topology discovery is hard
- No standard metrics for noise, power level, etc
March towards Self-Managing Networks

Timeline

- ACM CCR ’06
- Mesh Management
- HotNets’05, MobiSys’06, NSDI ’07
- Enterprise Wireless LAN Management (DAIR)
- Wireless Office

- 2002
  - Cooperative WLAN Management (Client Conduit)
  - MobiCom’04
- 2003
- 2004
- 2005
  - Cooperative WiFi Diagnostics (WiFi Profiler)
- 2006
  - Access Point Replacement (Dense AP)
  - MobiSys’06
  - EdgeNet2006
- 2007
NetHealth

NetHealth
• End-node based framework for the management of enterprise networks
• Integrate peer cooperation
• Complimentary to existing technologies
• Detect, alert, diagnoses & repair problems
• Root cause analysis / What-if analysis

Projects
• Tools to Help Users Help Themselves
  – VirtualWiFi, Client Conduit, WiFiProfiler, SoftRepeater Projects
• System & Tools for Managing Enterprise Wireless LAN
  – The DAIR WiFi Network Management Project
• Systems & Tools for Managing Wireless Meshes
  – Online simulation based root cause fault analysis
  – What-if Analysis
VirtualWifi & Client Conduit

- **VirtualWifi (InfoCom 04)**
  - A single NIC appears as multiple cards
  - Each virtual card can connect to any network

- **Client Conduit (MobiCom 04)**
  - Helping disconnected clients
WifiProfiler

• WifiProfiler (MobiSys 06)
  – Cooperative Diagnosis in WLANs
  – Sensing: Collect local “health” info
  – Communication: Send info to peers
  – Diagnosis: Use info to diagnose faults
**SoftwareRepeater**

- SoftwareRepeater
  - 802.11 data rate depends on RF distance
  - Solving Performance Problems
Tools to Help Users Help Themselves Using Mobile Hosts for Management

The Good
• No infrastructure required
• Provides quick and effective diagnosis
• Incurs low overhead for connected (healthy) clients
• Lets users help themselves

The Bad
• Difficult to provide predictable coverage
• Dependent on battery & energy constraints

….what if we have infrastructure support
Tools for Managing Enterprise Wireless Networks

- Cooperative Client-Server Network Diagnosis & Recovery
- Manage the effects of RF propagation
- Integrate location into the management system
- Determine problems & provide meaningful analysis
- Should resolve problems automatically

Desktop PC + 802.11: inexpensive
=> Dense Array of Inexpensive Radios
DAIR Management System

Diagram showing a network architecture with AirMonitors, Commands, Summarized Data, Inference Engine, Database, and Load on desktops.
DAIR Management System

Algorithmic Innovations:
• Self-configuring determination system
• Detecting performance anomalies and RF holes
• Detecting & responding to DoS attacks
• Assigning channel & power; managing handoff

Systems Innovations:
• Scaling to the size of an enterprise
• Introducing new techniques while remaining backward compatible

60-node system operational for over 8 months, MS-IT & DELL Deployment discussions (on-going)
**Self-Configuring Indoor Location System**

AirMonitor (AM) locate themselves

- Look up Directory Services (e.g. Active Directory) to determine office number
- Parse office map to determine coordinates of the office
- Improve estimates by verifying & adjusting coordinates by observing which AMs are nearby

AM locate Wi-Fi transmitter

- AMs collectively profile the RF environment by measuring the signal propagation characteristics between one another
- Inference Engine uses the RF profiles and signal strength observations at multiple AMs to locate Wi-Fi transmitters
Managing Meshes

Broadband Connectivity
- Rural & developing areas
- Neighborhoods / Communities
- Wireless Office
- City-Wide
Control Flow

1. Mesh Configuration & Setup (scope out network)
2. Gather & Distribute Data
3. Clean & Analyze Data
4. Determine Physical Topology
5. Model Network Behavior
6. "What-if" Analysis
7. Detect Anomaly
8. Improve Routing/Capacity
9. Diagnose Problem
10. Locate Hot Spots & Inform
11. Suspect software/hardware
12. Poor local connectivity
13. Suspect attack
14. Congestion
15. Inform/Fix
16. Reconfigure Topology
17. Rate Limit
18. Perform Security Analysis
Step 3 & 4: Model Network & Perform Root Cause Analysis

Agent Module
- SNMP MIBs
- Performance Counters
- Routing Table
- Native WiFi

Diagnosis Module

Collect Data
Clean Data
Simulate Network Perf.
Delay
Compare

Raw Data
Faults Directory
Inject Candidate Faults
Link Layer Performance Estimate
Measured Link Layer Performance

Topology Link Loads Signal Strength

Root Cause
Conclusion

Management & performance is key
• Wireless networks are difficult to diagnose
• However diagnostics are critical to wireless deployments
• Billions of Device will have to be managed

Opportunity to conduct seminal research
• Make networks more deployable in IT-poor markets
• Reduce IT costs in the enterprise

Tradeoff between management and loss
Q&A