# Golf Course Wireless Network

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Purdue University
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# About Me

- Received undergraduate degree in CPT (May 2002)
  - Associates Degree in OLS (May 2002)
- Started Graduate school August 2002
- Worked for John Deere – Internship
  - Network Public Access Dept
  - Corporate Computer Security
  - Technology Integration
- Full time with John Deere (Aug 2004)

# Courses Taken

- TECH 646 – Research & Design Class
- TECH 581N – Optical Network Design
- TECH 581G – Computer Forensics
- TECH 507 – Statistics
- TECH 508 – Quality Control
- TECH 571 – Project Management
- TECH 554 – Organizational Impact of IT
- TECH 551 – IT Economics
- CPT 343 – Advanced System Admin
- CPT 455 – Network Security

# Purpose

- Desired to obtain a Masters degree so that I might be able to obtain a management position
- Interested in teaching at the college level
- Wanted to learn more about Networking & System Administration
- Never done learning

# Executive Summary

- To Discover what is required for a wireless network at the Ackerman Hills golf course.
- Proof-of Concept on two holes
- Determine if technically & economically feasible
- Using 802.11b equipment
- Hub & Spoke Design
- Maintenance Application

# Statement of the Problem

- 802.11b has a 300 ft outdoors range.
- Inexpensive equipment.
- Maintenance personnel currently contact office for tasks.
  - Could save time and money.
- No guidelines for deployment in this environment

# Significance of the Problem

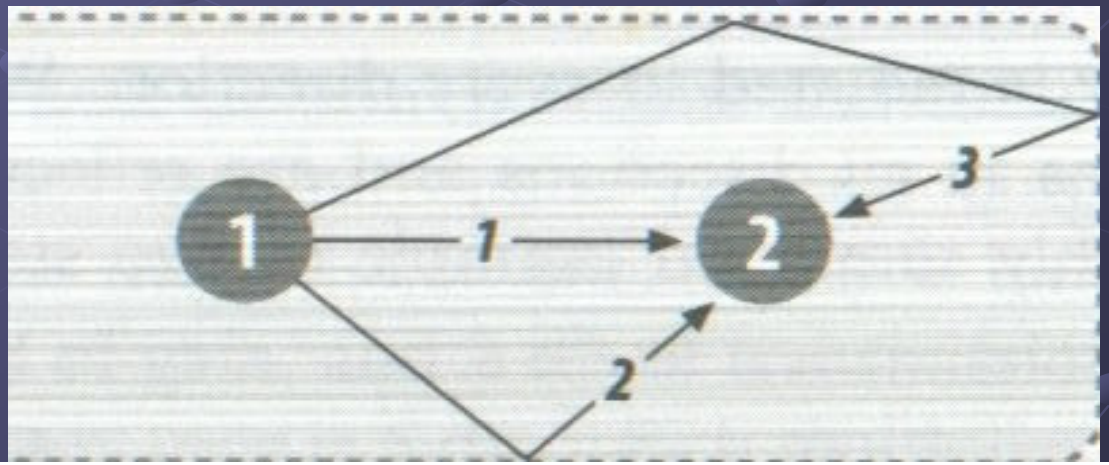
- No wireless solution currently created
- Maintenance dept looking for different way to handle work request
  - Main driving force
  - Could increase productivity level
  - Quicker response time
  - Use wireless device
- Other uses available

# Literature Review

- Outdoor IEEE 802.11 Implementations
  - eStadium Project
  - Area around campus buildings
- Range
  - Point-to-point can achieve 20 miles
  - Office Settings can reach 400 feet
- Multi-Path Signal Propagation
  - Occurs when RF signal takes different paths

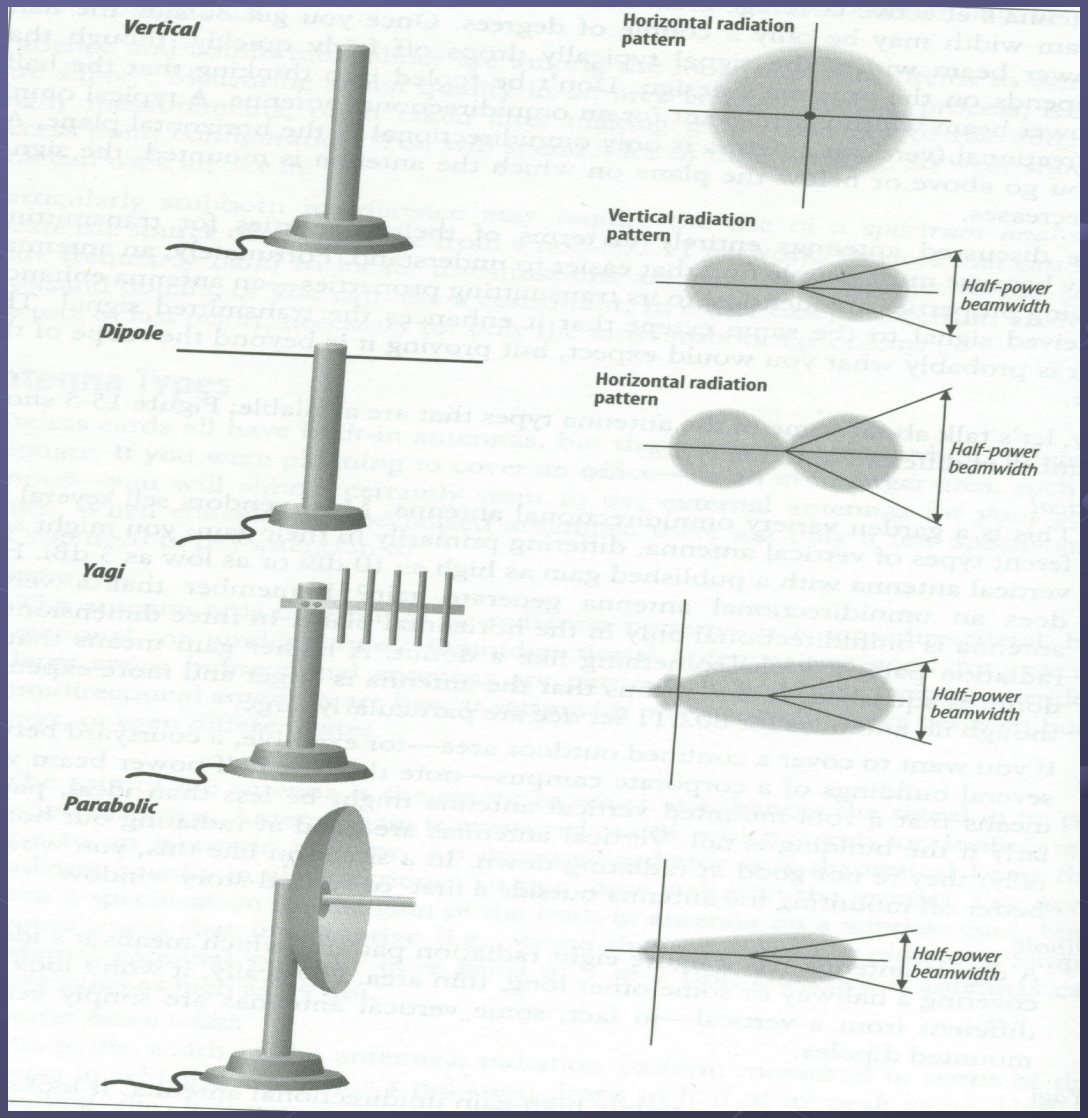
# Literature Review Cont.

- Multi-Path Signal Propagation
  - Occurs when RF signal takes different paths
  - Example
    - Src: From: 802.11 Wireless Networks: The Definitive Guide, Figure 9-5, Pg 162
  - Trees & Hilly areas can cause this
  - Confuses the receiver
  - Using two antennas on a receiver can help to reduce the problem



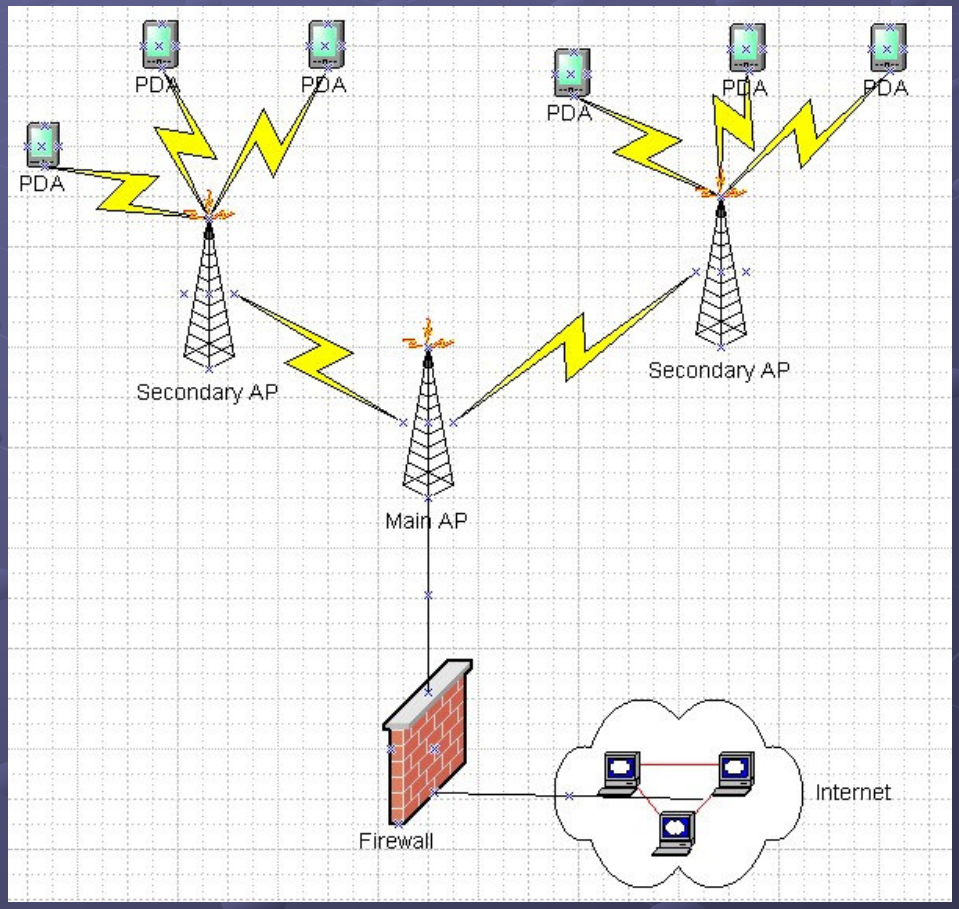
# Antenna Designs

Src: From: 802.11 Wireless Networks: The Definitive Guide, Figure 15-5, Pg 318



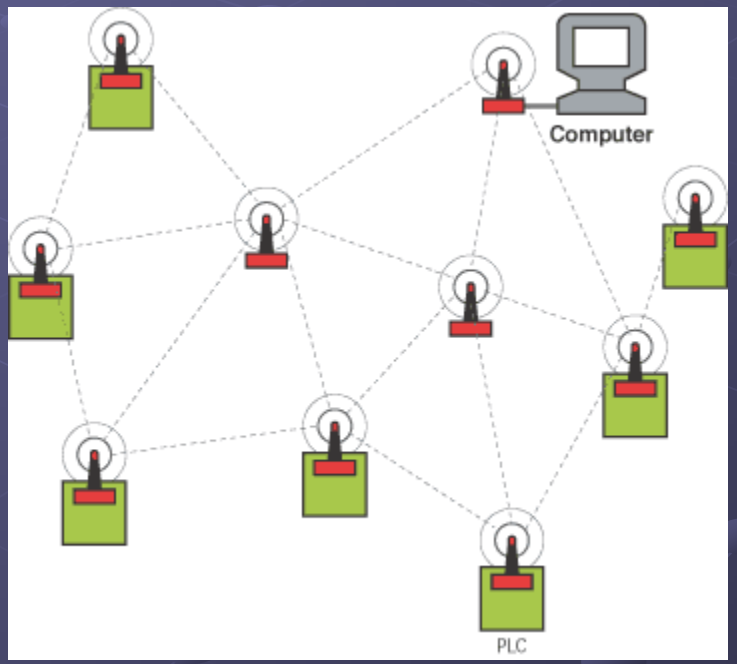
# Literature Review Cont.

- Hub & Spoke



# Literature Review Cont.

- Mesh Network
  - Access Points Communicate with each other
    - Src: From: Wireless Mesh Network (Poor, 2003)



# Equipment Used

- IPAQ PDA
- HP Laptop Computer
- Cisco 340 Series PCMCIA Cards
- Intel 2011B Access Points
- Cisco 350 Rugged Access Points
- Cisco Yagi Antennas – 12 dBi Gain
- Cisco Omni Antennas – 5.2 dBi Gain
- Multiple portable power units

# Procedures

- Yagi antennas and Omni antennas were tested
- Cisco APs were tested with Yagi's
- Intel APs were tested with both antennas
- APs were placed at different areas on the hole and tested for connectivity

# Procedures Cont.

- Testing for connectivity
  - Ping was used to verify connectivity
  - Access to the web interface on APs
  - Cisco Aironet Client Manager
    - Used to test for Signal Strength, Signal Quality & Overall Link Quality

# Procedures Cont

- Tri-pods were built to hold the antennas
  - Test were done to discover optimum height
- Why Holes 5 & 8?
  - Hills
  - Valleys
  - Trees
  - Any one can cover a flat par 3

# Procedures Cont.

- Yagi's on hole 8 were placed at one location and tested
- Yagi's on hole 5 were placed at 2 locations and tested
- Omnis on both holes were placed at 2 locations and tested
- The in-depth results can be found in the appendix of the report

# Example AP Placement

# Golf Cart

# Metrics

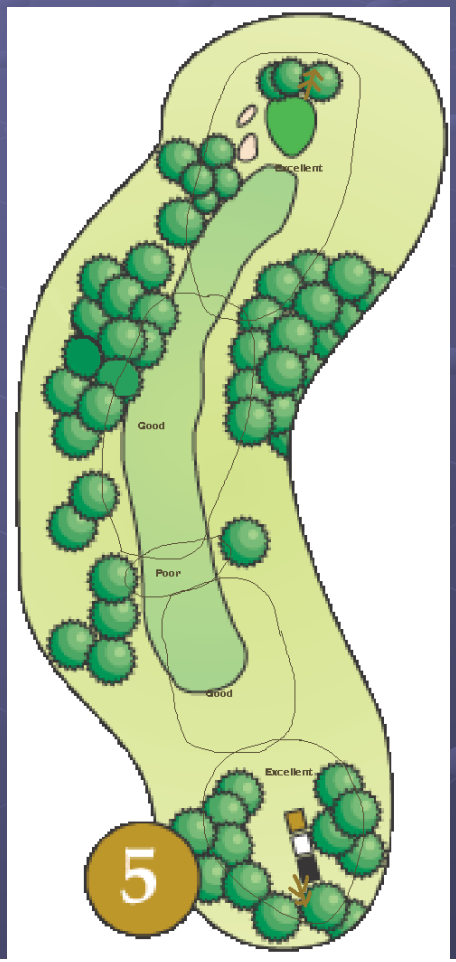
| Metric | Values | Cut-off |
|---|---|---|
| **Signal** | | |
| Signal Strength | Percentage of full strength | 25% |
| Signal Quality | Percentage of full strength | 31% |
| Overall Link Quality | Excellent, Good, Fair, Poor | Fair |
| **Wireless Ability** | | |
| Roaming | Yes/No | Yes |
| Number of Access Points | Integer | 2 |
| Redundancy | Amount of redundant connections | 0 links |
| **Installation & Setup** | | |
| Ease of Installation | Time to install | 2 days |
| Solution Cost | Money | $1140.00 |

# Expenses

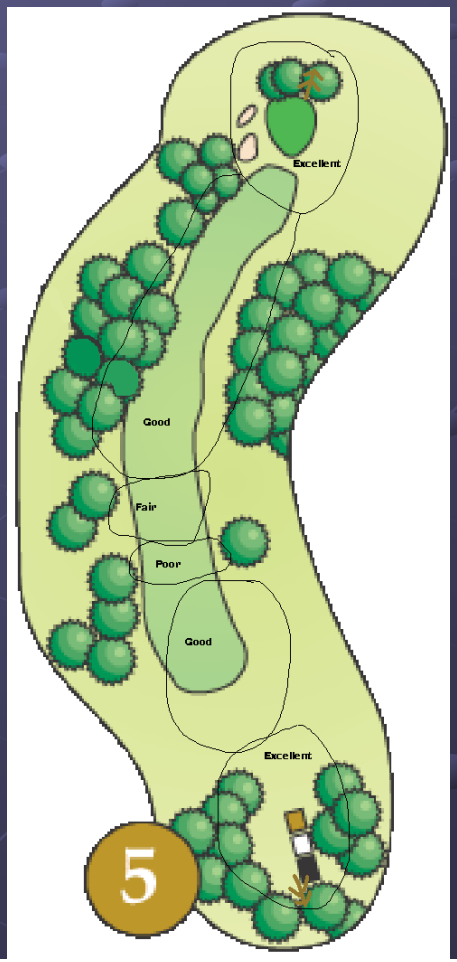
| Price | Description |
|---|---|
| $30 | Porta-power Unit |
| $40 | Power Adapter (Cigarette Lighter Type) |
| $100 | APC UPS Unit |
| $35 | Deep Cycle Battery |
| $45 | AC/DC Converter |
| $900 | Cisco 350 Rugged Access Point |
| $350 | Intel Wireless Access Point |
| $90 | Yagi Antennas |
| $90 | Omni Antennas |
| $100 | RP-BCN to RP-TNC Adapters |
| $100 | 2x2 & 2x4 wood products |
| $30 | Miscellaneous Screws and Bolts |
| $30 | Serial Cables & Adapters |

# Hole 5 – Intel AP & Yagi

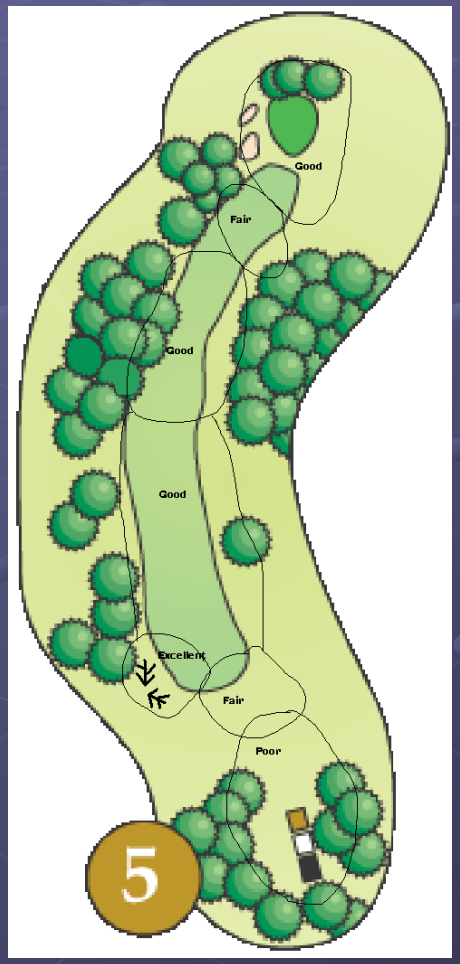
Laptop




PDA

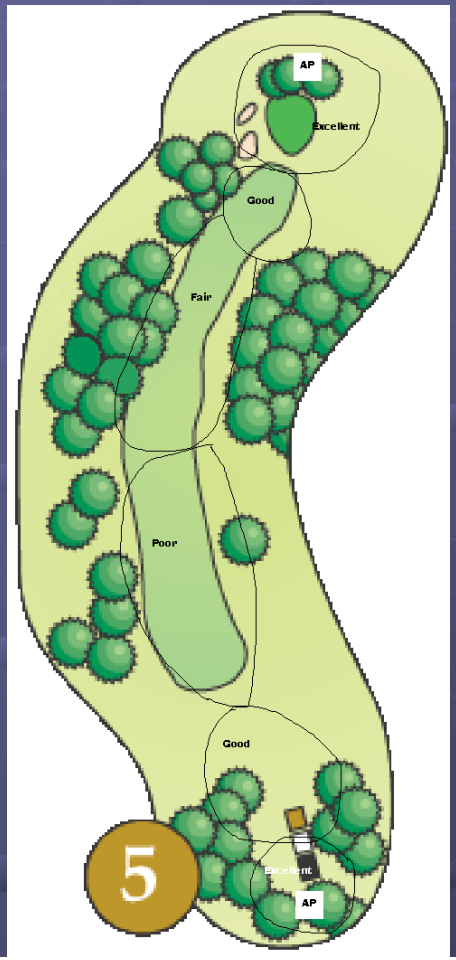


# Hole 5 – Cisco AP & Yagi

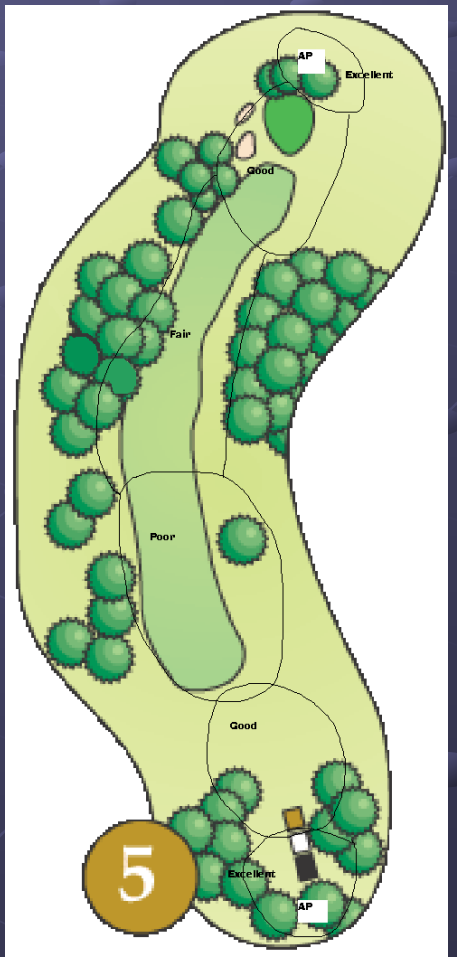


# Hole 5 – Intel AP & Omni (V1)

Laptop

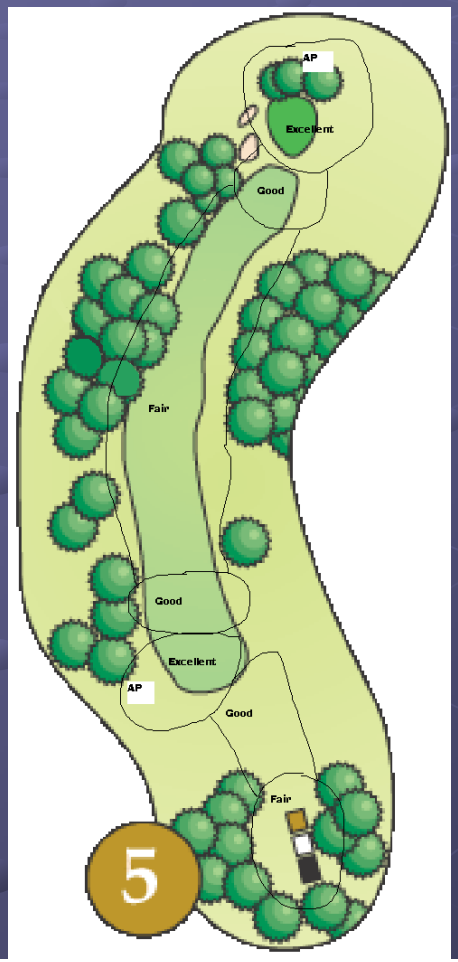



PDA



# Hole 5 – Intel AP & Omni (V2)

Laptop

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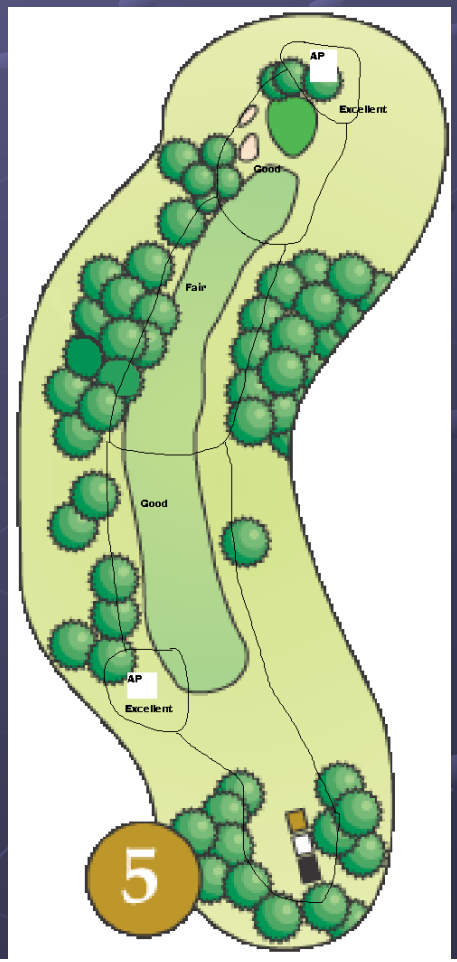
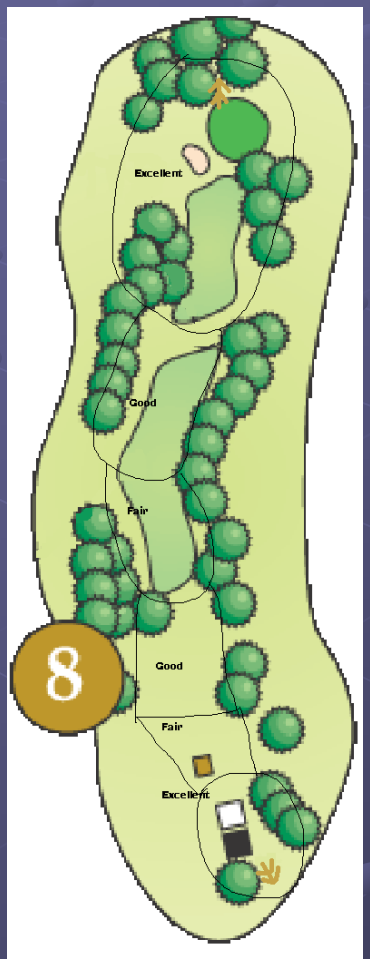
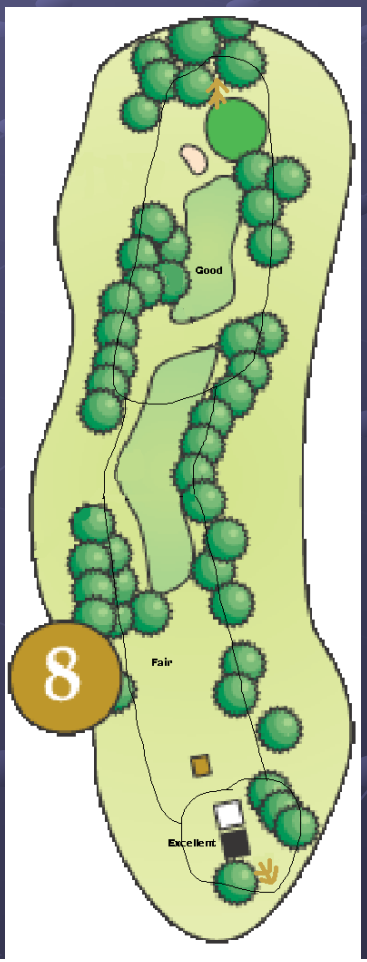


# Hole 8 – Intel AP & Yagi

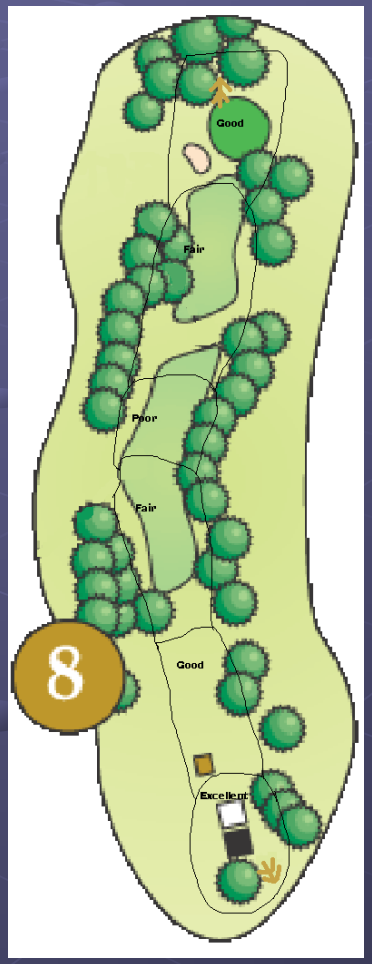
Laptop




PDA

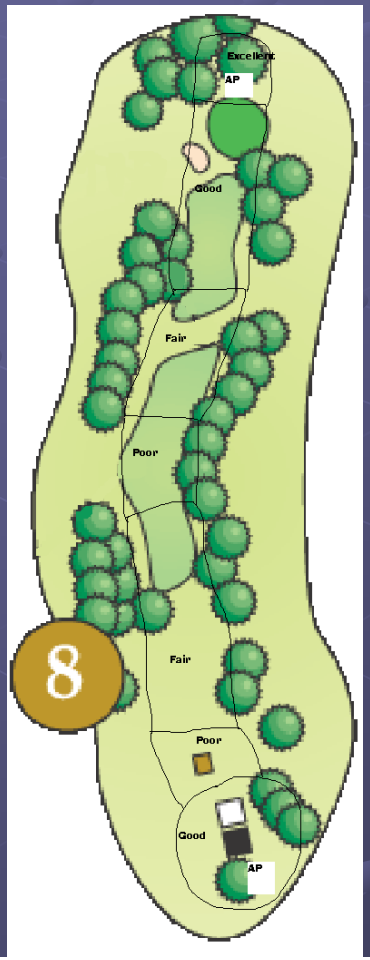


# Hole 8 – Cisco AP & Yagi

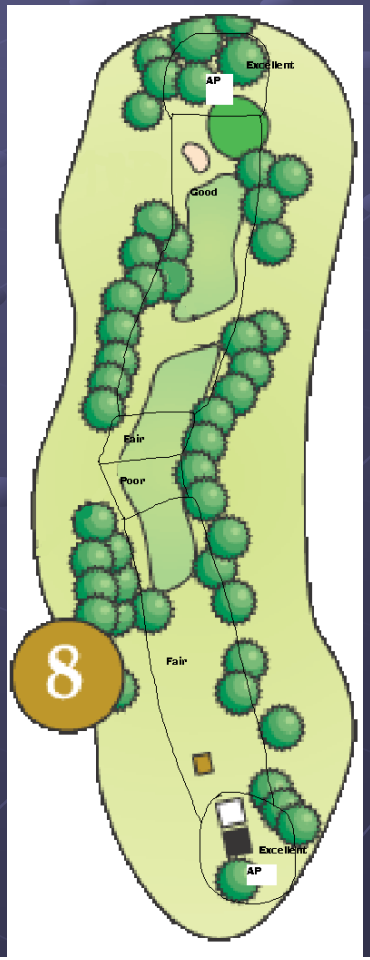


# Hole 8 – Intel AP & Omni (V1)

Laptop

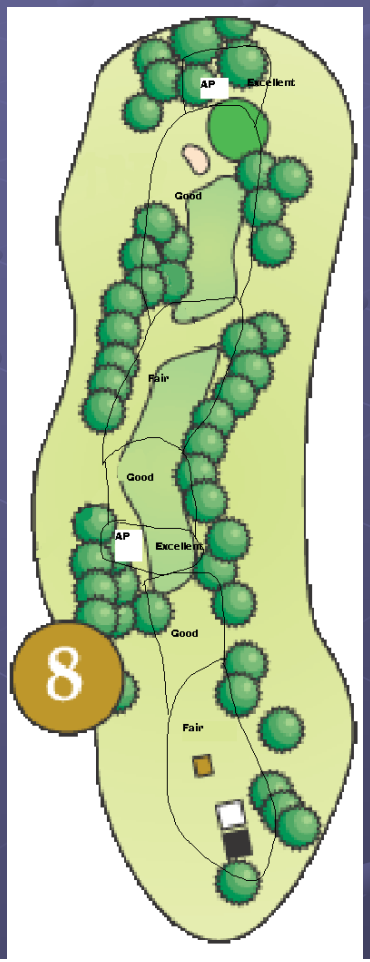



PDA

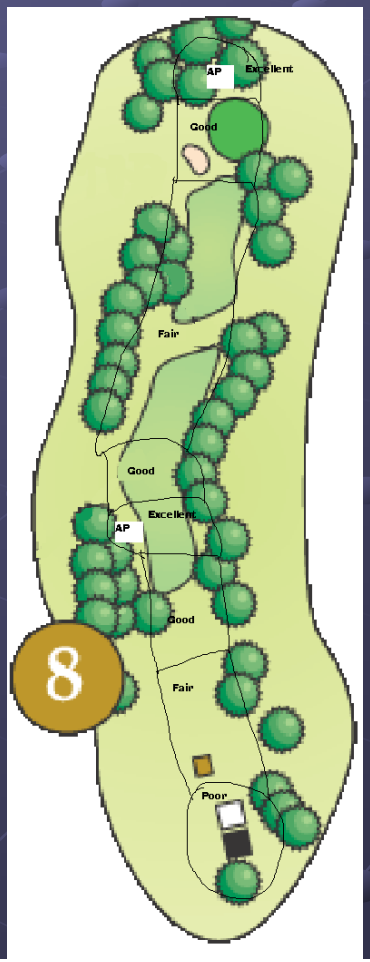


# Hole 8 – Intel AP & Omni (V2)

Laptop




PDA



# Conclusion

- PDA receives a weaker signal than the Laptop
- PDA power modes does not make a significant difference
- Results should be viewed with a ±5%
- Must provide Overall Link Quality of Fair or greater for reliable coverage

# Conclusion

- Yagi Antennas using Intel APs
  - Good Coverage
  - Reliable Connection
- Omni Antennas using Intel APs
  - Okay Coverage
  - Weak coverage in some areas
- Yagi Antennas using Cisco APs
  - Poor Coverage
  - Problems dropping clients

# Cisco vs. Intel

- Why did the Intel APs have better results?
  - Spec sheet shows better range for Cisco*
  - Both create for Industrial use, not home use
- Chip Sets?
  - Intel uses – Intersil Prisim 2.5 chipset
  - Cisco uses – Proprietary chipset**

# Cisco vs. Intel

- Range from spec sheets
  - Cisco Antenna = 2dBi
  - Intel Antenna = 1dBi

| Cisco - Indoors | Intel - Indoors | Cisco - Outdoors | Intel - Outdoors | Mbps |
|---|---|---|---|---|
| 350ft | 300ft | 2000ft | 1500ft | 1 |
| 130ft | 100ft | 800ft | 400ft | 11 |

# Omni vs. Yagi

- Yagi antennas
  - Used for point-to-point over 20 miles
  - Directed coverage area
- Omni antennas
  - Used for broad coverage over shorter areas

# Conclusions

- Able to provide wireless coverage at the golf course
  - Yagi Antenna
    - Needs to be 12 dBi or greater
  - AP
    - Needs to have similar range as Intel APs
- Using Yagi antennas and Intel APs can provide for the needed coverage at the golf course

# Further Study Areas

- Mesh Equipment
- How APs interact and provide coverage with multiple holes
- Nextel Cellular Coverage
- How to setup access to the Internet

# Acknowledgements


- Phil Rawles
- Kyle Lutes
- Julie Mariga
- Jeff Brewer
- Jim Scott
- Tony Smith
- Birch Boilermaker Golf Course Staff

# Questions & Answers