REMCOM® Electromagnetic Simulation Solutions

Comparison of Indoor Propagation Modeling of WiFi Coverage Using Wireless InSite® and Measurements

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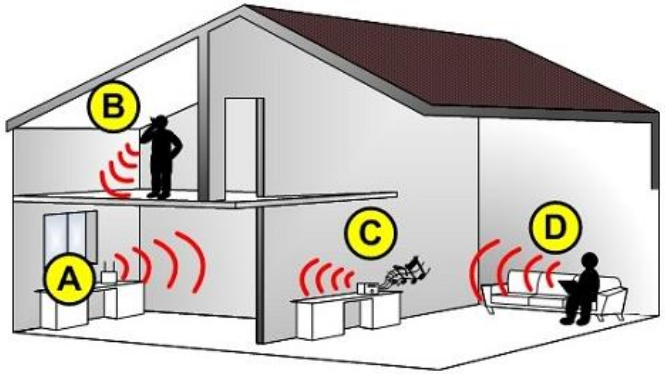
Overview

- Discuss validation of propagation modeling through the use of laptop measurements
  - In this case the scenario is focused on WiFi
- Present the measurement procedure
- Discuss and compare results
- Conclusion

WiFi Measurements



A = WiFi Router C = WiFi Radio
B = WiFi Phone D= WiFi Laptop

http://www.countrymilewifi.com/what_is_wifi.aspx

- WiFi common in every day life
  - Homes, offices, coffee shops
  - Cell phones, tablets, computers, game consoles
  - Home automation
- Allows for easy scenario evaluation
  - Indoor, outdoor, indoor-to-outdoor
- Requirements
  - A device that sends a signal (router)
  - A device to detect the signal (laptop)
  - Some overlay or map to coordinate results

WiFi Background*

- Laptops are not designed to produce accurate power measurements
  - Provide feedback to user to determine if signal level is strong enough to transmit/receive signal
- Chipset maps received power signal to integer RSSI value between 0 and 256
  - Standard does not require manufacturers to use entire span
    - Some may use 0 to 30
    - Others may use 0 to 100
  - Sensitivity will therefore vary depending manufacturer's choice
    - A one integer change in received power could be 3 dBm in one chipset and 6 dBm in another
- There is potential for multiple values to be mapped to a single value

*Citation [5]

Setup 1: Physical Measurements

- Equipment
  - Linksys WRT54 GS Wireless G router [1]
  - HP ProBook [2]
  - Acer Aspire 5742 [3]

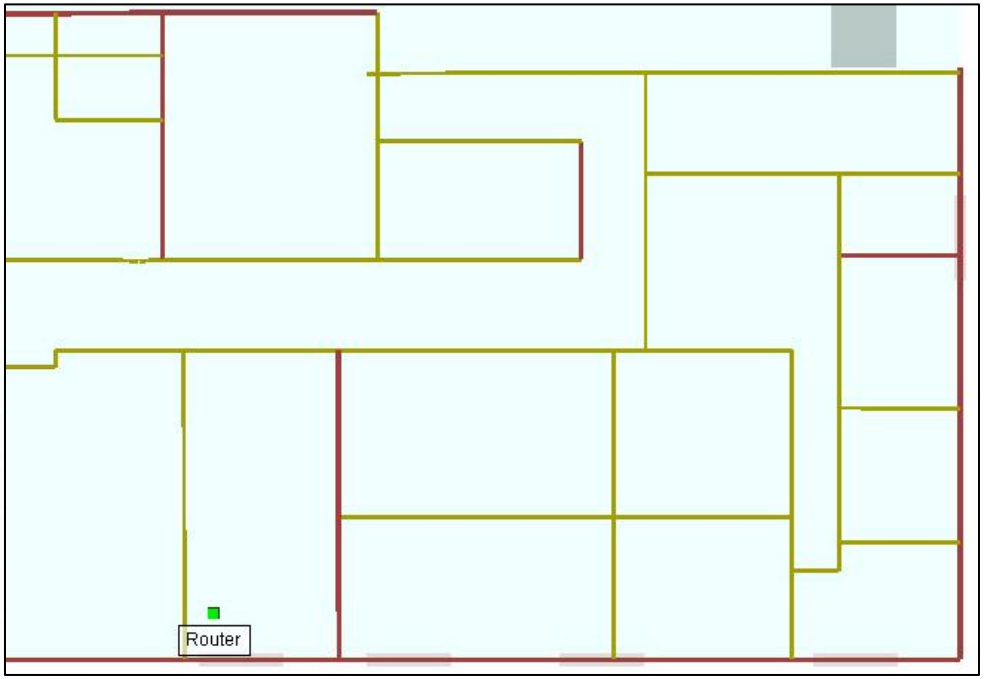
- Software
  - Ekahau Heatmapper software [4]
    - Not associated with Remcom

- Location
  - Office building

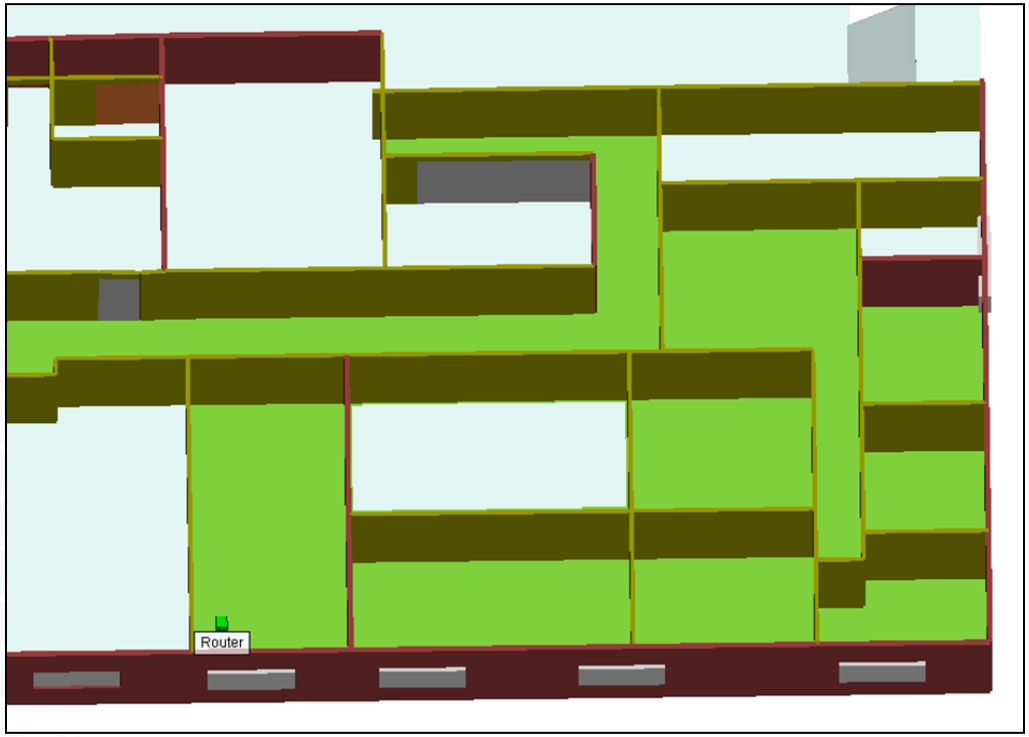
Ekahau Heatmapper Software

- The user provides a picture of their floorplan or layout
- The user clicks on the map at their current location which records the received power as detected by the computer's WiFi card
- As they walk, they continue to click on their position on the map
- When they are done, the software generates coverage zones based on measurement locations and power roll off
  - Keep in mind this software has no concept of the floorplan, only where you clicked

Office Building Floorplan



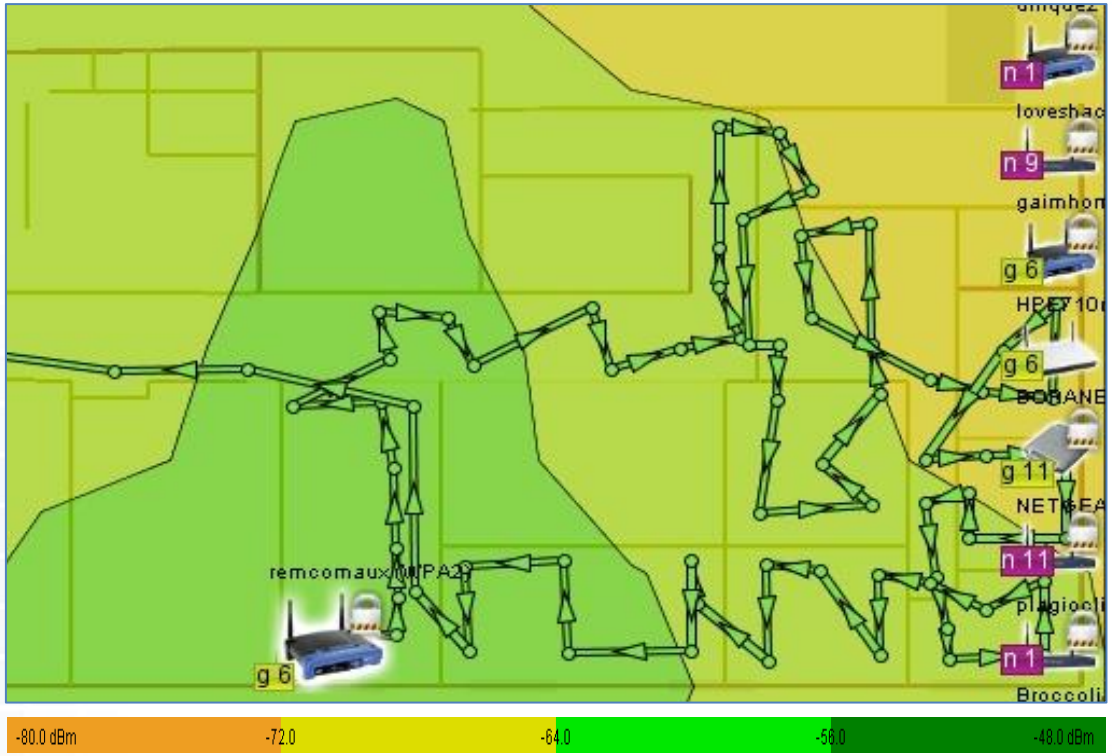
3D View of Office Floorplan



Setup

- Transmitter: Linksys WRT54 GS Wireless G router
- Receiver: HP ProBook
- Procedure:
  - Import map into software
  - Slowly walk around office area clicking periodically to record values, avoiding obstacles
- All detected WiFi signals will be recorded along with approximate location of source
  - Icons showing extraneous detected router locations cannot be turned off in software

Measured Results: Ekahau Heatmapper



Setup 2: Simulation Setup

- Equipment
  - Custom computer from Exxact Corporation
  - Quad core i7 cpu
  - 12 GB CPU RAM
- Software
  - Wireless InSite propagation software from Remcom

Wireless InSite Software

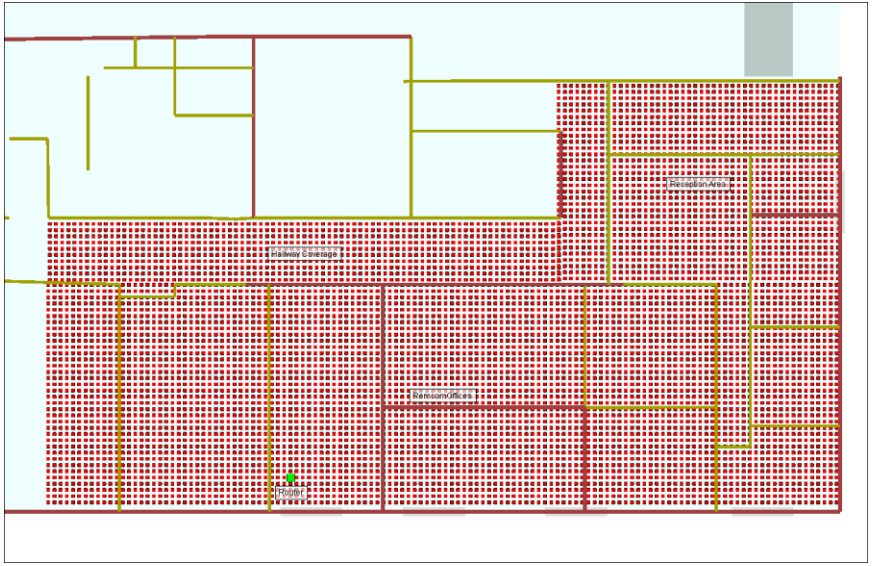
- Suite of propagation models based on ray tracing, FDTD, or empirical concepts
- 3D ray tracer uses shooting and bouncing ray method
  - User has control over number of transmissions, reflections, and diffractions in the scene
  - Interactions use material properties and UTD/GTD theory to accurately determine power, phase, and angle of path after interaction
- User creates scene via importation of CAD model or through the GUI
  - Pictures can be used to quickly trace out the scene
  - May include terrain, buildings, floorplan, foliage

Wireless InSite Software (cont'd)

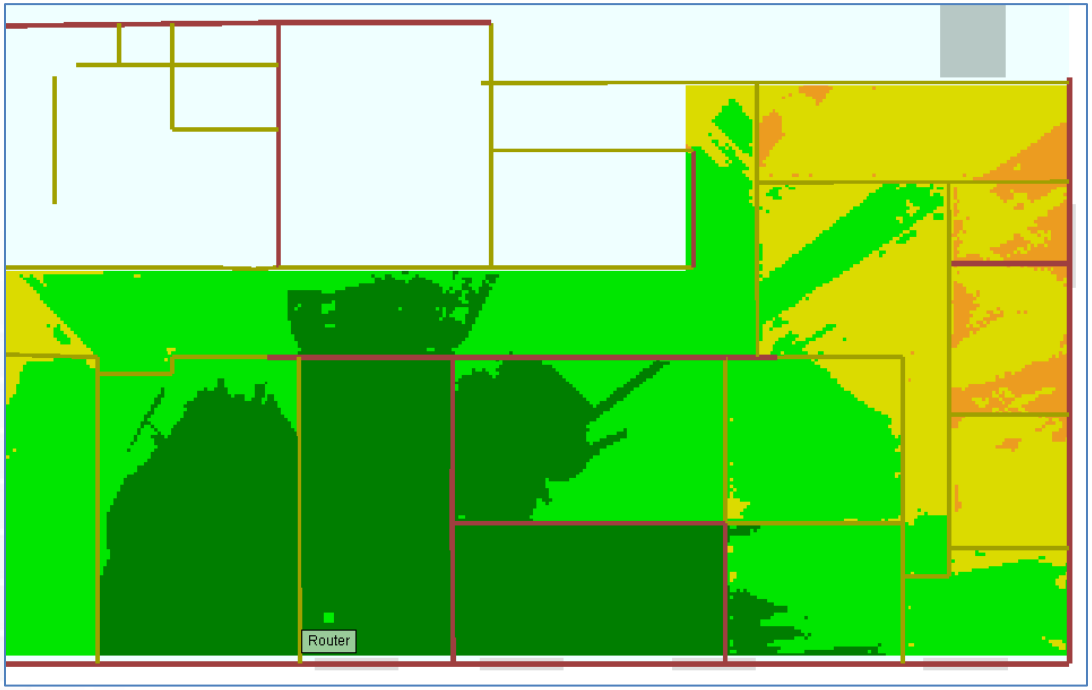
- Antennas
  - Patterns can be imported from other software or created with built in numeric models
- Transmitters and Receivers are then placed in the scene and oriented appropriately
- A grid of receivers was used to capture data throughout the offices

Simulation Setup

- Propagation Model: Full 3D
- Transmitter: Isotropic
- Receivers: Isotropic
- Red Dots: Grids of receivers
  - Grids have 0.08 m spacing
  - Chosen for high resolution images
  - 42,387 total receiver locations
- Settings:
  - 6 Reflections
  - 6 Transmissions
  - 1 Diffraction



Simulated Results Full 3D



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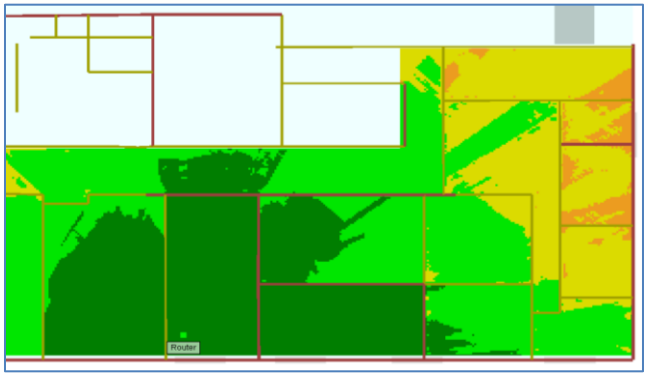
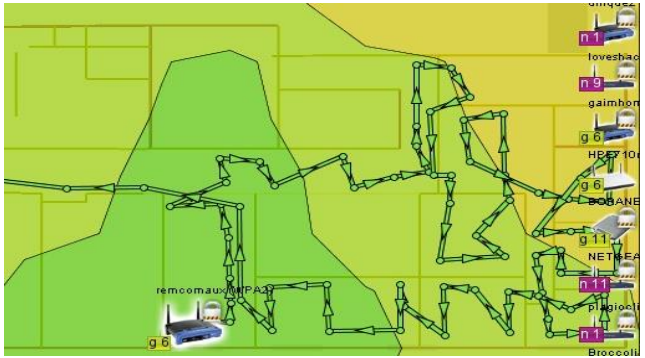
Comparison

- Similarities
  - Color scales are matched
    - Trends are captured
  - Affects of walls similar
  - Attenuation with distance similar



- Differences
  - Simulation shows more energy further out (lower rooms)
  - 45° beam in predicted results
    - Artifact of discretized color scale
    - Only 2 dBm different then nearest neighbor



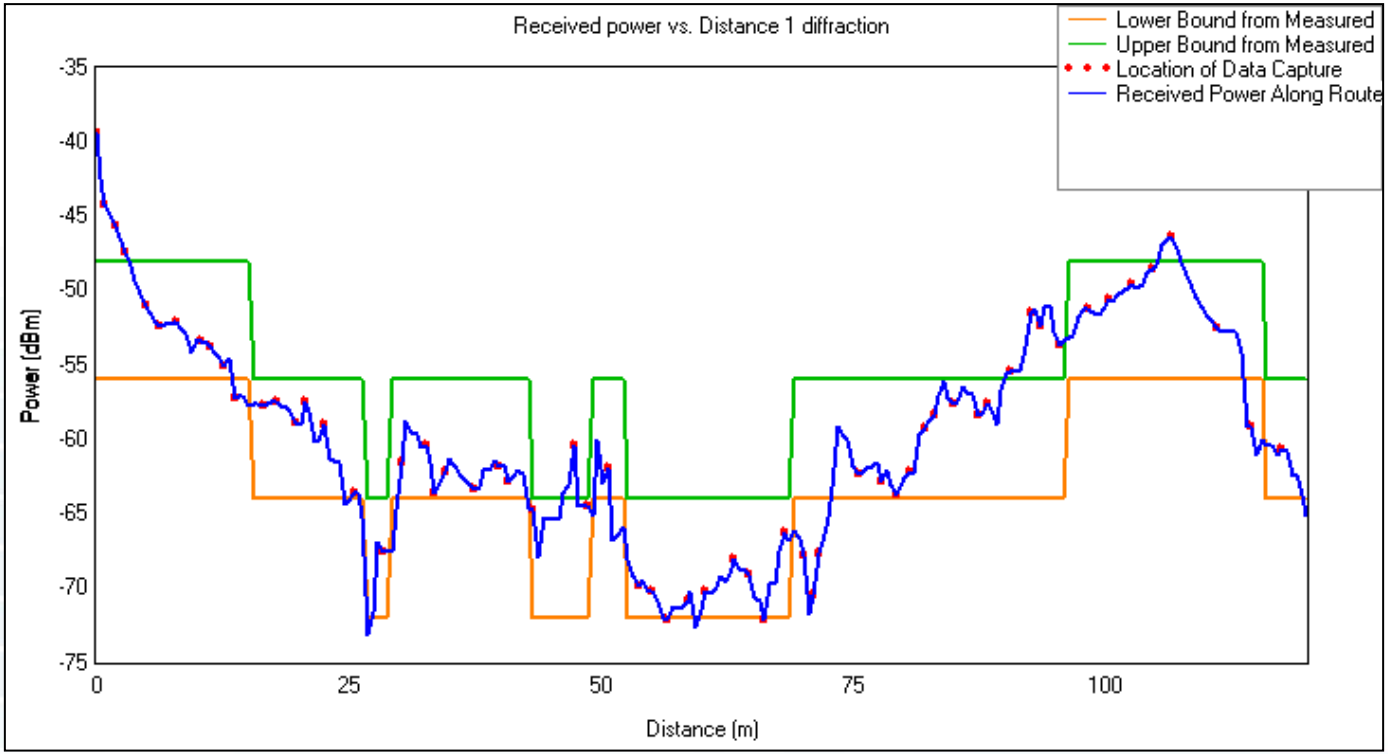
Considerations

- The color scale is only valid where measurements were taken
  - i.e. along the green path
- Color scale is discretized
- The exact values from laptop card were not recorded
  - The resulting color map is the only available output
- An estimated attenuation is applied to the data outside of the measured area

Examining the Actual Route

- Picture from Ekahau Heatmapper overlaid InSite Floor plan
- Exact route traced as route of receivers
  - 0.5 m spaced isotropic receivers (red dots on picture)
  - 250 receiver points
- We don't have exact measured values for comparison, only ranges

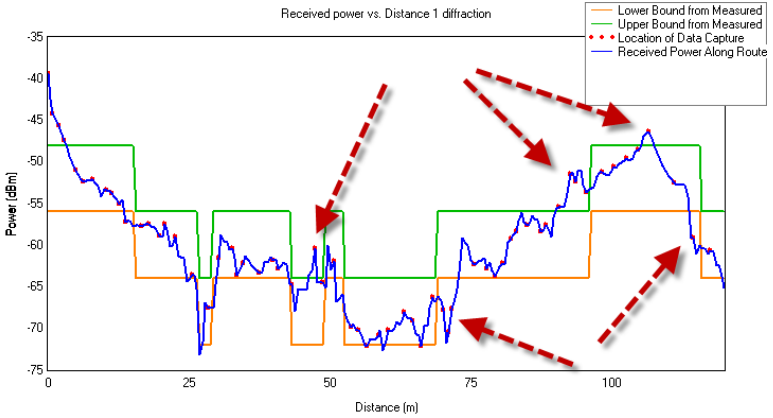
Measured Values Along Route



Note1: The red dots correspond to measured data locations
Note2: Bounds taken from Ekahau Heatmapper coverage plot

Measured Values Along Route

- Most of the 250 calculated points are within bounds from Heatmapper software
- 68 measured points total were used
- Red arrows indicate locations where calculated values differ from measured color ranges
  - 10 points outside of range
  - All 10 within 6 dBm of measured range



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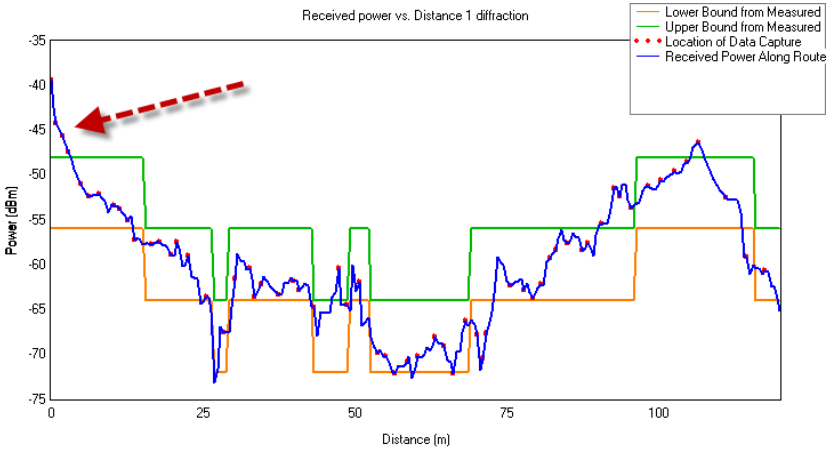
Initial Value Evaluation

- The Heatmapper results show a -48 dBm lower bound
- Calculated values go down to -39 dBm
- Distance along path for the -48 dBm value was suspiciously long
  - HP ProBook
  - Violated Friis transmission equation
- Acer laptop showed higher power closer to transmitter
  - Verified Wireless Insite values were valid
  - Points to HP ProBook having a lower bound of -48 dBm
    - Works for intended use



Conclusion

- Simple measurement techniques can be used to validate complex propagation models in Wireless InSite
  - Focused on first cut evaluations and validation on relatively simple scenarios
  - Similar techniques can be applied to more complex scenarios
    - Multiple floors
    - Directional Antennas
  - Not intended to replace more accurate measurement techniques
- Benefits of simulation include:
  - Cheaper then full measurement campaigns due to lower personnel and equipment costs
  - Faster then measurement campaigns
  - Allows multiple configuration analysis
    - Shows full coverage, not discrete points
    - Find shadow regions prior to installation of equipment
    - Test antenna patterns in scenario to determine effectiveness

Conclusion

- Overall accuracy good
- Coverage plots compared favorably between calculated and measured values
  - Same trends in both data sets
- Route analysis determined:
  - Most of the 250 calculated points within 10 dBm ranges created by Ekahau Heatmapper software
  - Looking at 68 locations corresponding to where data was measured
    - Outlying points still within 6 dBm of the measured range
- Close to transmitter low power measurements traced back to the dynamic range of laptop WiFi chipset

References

1. http://support.linksys.com/en-us/support/routers/WRT54GS
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