Testing Wireless LANs: *Notes from the Field*

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A Little About Me…

- Principal, Farpoint Group
  - Since 1991
  - Advisory services in wireless networking and mobile computing
- Engineer (OK, applied math/computer science)
- Member, IEEE and Society of Sigma Xi
- Columnist and product reviewer for the *CIO Executive Council* (IDG) and various sites at *TechTarget* and others
- Product reviews, testing, and features for *Network World*
- Blog: networkworld.com/community/mathias
- *Analyst* - in the business of predicting the future
  - Conclusions aren't always important, but the reasoning behind them *is!*
  - *You've got to show your work…*

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Our Topics for Today…

- Testing wireless LANs – objectives, issues, methodologies
- Benchmarking wireless LANs – options, techniques, pitfalls, best practices, and why this may matters less in the future
- Future directions and opportunities
  - *Virtual* benchmarking?
  - A (conceptual) practical tool

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WLAN Testing and Benchmarking - Objectives

- Understanding both technologies and implementations
- Product development
- Product verification, tuning, optimization, compliance
  - Understanding what's really going on…
- Comparative analysis
  - Product feature evaluation
  - Purchasing decisions
- Post-installation analysis and tuning
- A rich history of computer/network performance evaluation to build on

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Testing and Benchmarking: Options

- Freespace – a statistical medium
  - Clients
  - Environment
  - Tools
  - Important to control variables; multiple runs and averaging
- Isolation – Chambers
  - Modeled environments
- Digital Modeling – the “virtual radio channel”
  - Theoretical
  - Virtual - based on behavioral analysis
- Key Variables
  - It’s never rate or range alone, but rather rate vs. range
  - In a particular environment (radio and physical)
  - For a particular application or application mix (load)
  - With a particular combination of transmitters and receivers
  - Location and motion

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Benchmarking: An End-to-End Look

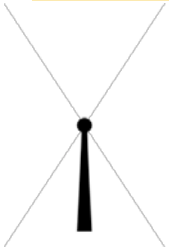
Scale

Transmitter

Workload

Duty Cycle

Radio Channel



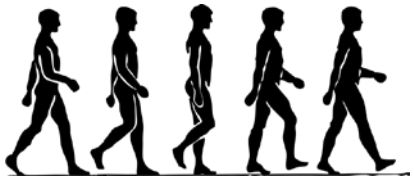
Antennas

Range
- Propagation
- Obstructions
- Fading

Transmit Power

Interference

Receiver



Motion

Source: Farpoint Group

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Roaming: Large-Scale (N/G) Electric Trains

- Required for notebook PCs
- Could use HO-gauge with smartphones

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Roaming/Fairness: Turntables

- Of the type found in jewelry cases and etc.
- Factors in motion (to some degree)
- Factors out antenna orientation (to a great degree)

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Roaming: Evolution Robotics ev1 (2002)

- Robots could be used to pre-program travel paths and rates

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Chambers

- Reasonably simple in concept and execution
- Easy to use
- Channel models and analytics
  - The real value
  - Is reality represented?
- Reproducible and consistent
  - Great for comparative work
  - And verification
- Auditable

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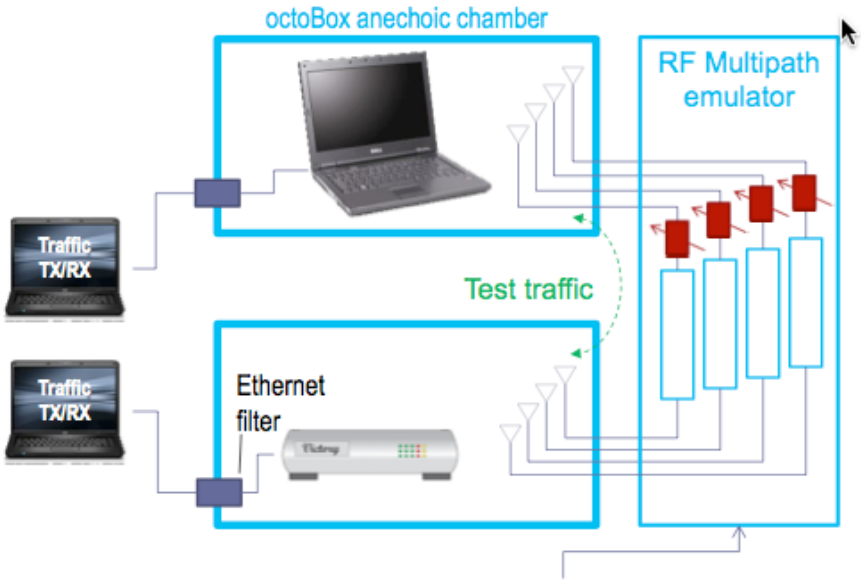
Chambers: octoScope octoBox MPE



Multipath emulator introduces de-correlation bringing MIMO gains into a small anechoic testbed.

- Complete isolation – emulates environment

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Digital: Virtual Benchmarking

- Given an analytical model of a wireless system, and a model of a given workload (type of traffic, duty cycles, etc.), do all evaluation and analysis in the *digital* domain
  - Example: Computational fluid dynamics
    - The *digital wind tunnel*
  - Example: Digital physics, molecular modeling
  - Example: Circuit simulation tools
- But is this possible given the large number of variables and the fundamentally statistical (unpredictable) nature of wireless systems?
- Merits further investigation

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Issues and Opportunities

- Cost/ROI
  - It may be easier to consider loads, geographic regions of demand (“hot spots”), and average/typical performance of an AP/system and then simply deploy, measure, evaluate, correct, and augment as required
  - As is already the case with benchmarking tools and site surveys…
- Ability to model inherently complex systems
- Increasing density, complexity
  - Architectural, features, options settings, application mix, …
- Synthetic workload characterization - tools
- Should we build basic benchmarking/verification into the standard?

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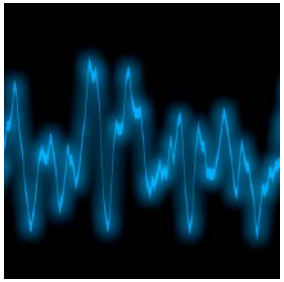
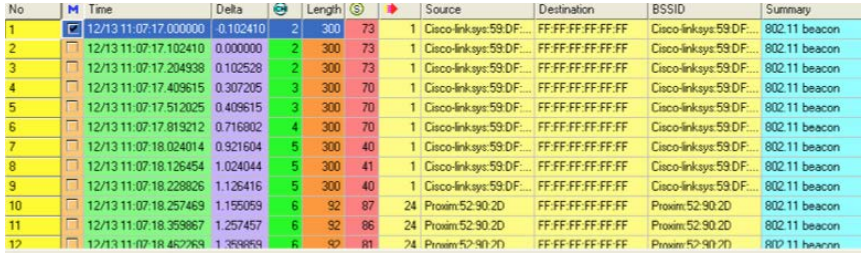
What I Want…

Multi-Client Emulator
- 1-n Clients
- Simulate Contention
- Simulate Range



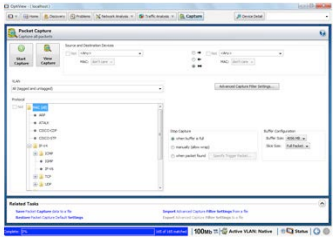
Layer 1:
Spectral Analysis



No	Time	Delta	Length	Source	Destination	BSSID	Summary
1	12/13 11:07:17.000000	0.102410	300	Cisco-linksys:59:DF:...	FF:FF:FF:FF:FF:FF	Cisco-linksys:59:DF:...	802.11 beacon
2	12/13 11:07:17.102410	0.000000	300	Cisco-linksys:59:DF:...	FF:FF:FF:FF:FF:FF	Cisco-linksys:59:DF:...	802.11 beacon
3	12/13 11:07:17.204938	0.102528	300	Cisco-linksys:59:DF:...	FF:FF:FF:FF:FF:FF	Cisco-linksys:59:DF:...	802.11 beacon
4	12/13 11:07:17.409615	0.307205	300	Cisco-linksys:59:DF:...	FF:FF:FF:FF:FF:FF	Cisco-linksys:59:DF:...	802.11 beacon
5	12/13 11:07:17.512025	0.409615	300	Cisco-linksys:59:DF:...	FF:FF:FF:FF:FF:FF	Cisco-linksys:59:DF:...	802.11 beacon
6	12/13 11:07:17.819212	0.716802	300	Cisco-linksys:59:DF:...	FF:FF:FF:FF:FF:FF	Cisco-linksys:59:DF:...	802.11 beacon
7	12/13 11:07:18.024014	0.921604	300	Cisco-linksys:59:DF:...	FF:FF:FF:FF:FF:FF	Cisco-linksys:59:DF:...	802.11 beacon
8	12/13 11:07:18.126454	1.024044	300	Cisco-linksys:59:DF:...	FF:FF:FF:FF:FF:FF	Cisco-linksys:59:DF:...	802.11 beacon
9	12/13 11:07:18.228826	1.126416	300	Cisco-linksys:59:DF:...	FF:FF:FF:FF:FF:FF	Cisco-linksys:59:DF:...	802.11 beacon
10	12/13 11:07:18.257469	1.155059	92	Proxim:52:90:2D	FF:FF:FF:FF:FF:FF	Proxim:52:90:2D	802.11 beacon
11	12/13 11:07:18.359867	1.257457	92	Proxim:52:90:2D	FF:FF:FF:FF:FF:FF	Proxim:52:90:2D	802.11 beacon
12	12/13 11:07:18.462269	1.359859	92	Proxim:52:90:2D	FF:FF:FF:FF:FF:FF	Proxim:52:90:2D	802.11 beacon

Layer 2: Protocol Analysis
(Packet Capture)

Server
- Correlation Analysis



Layer 3:
IP Traffic Generator

Source: Farpoint Group

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Conclusions

- Benchmarking and performance evaluation will remain *interesting* for the foreseeable future
  - All aspects of computer and communication technologies, not just wireless
  - Excellent tool for education, understanding, and innovation
  - Some value in product design and verification
- Not clear, however, if end-user production deployments will benefit
  - Like site surveys…
  - Cost/benefit analysis/justification required – labor-intensive
  - Better tools might help, though…
- Always – more variables than equations

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Thank You!

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