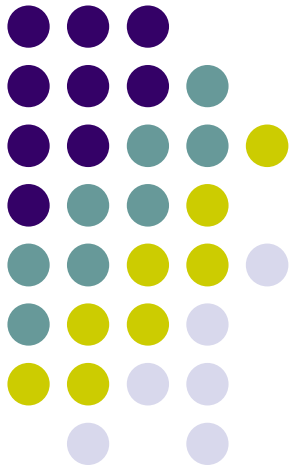
Cognitive Geolocation

Learning Location by Listening to the Radio



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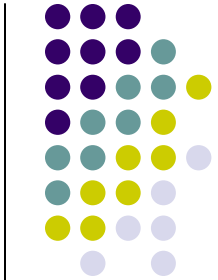
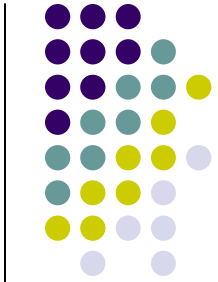
Overview

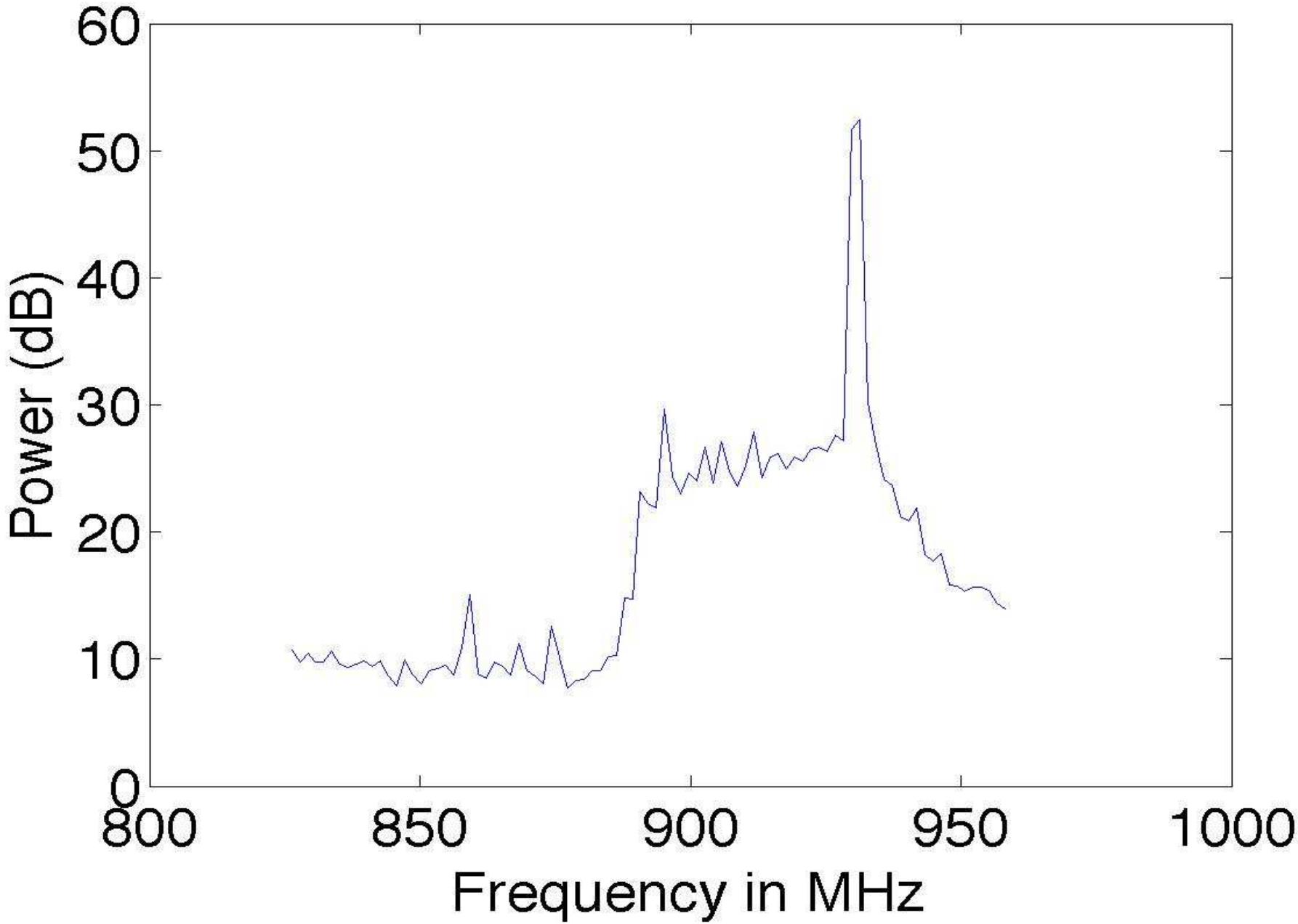


- Geolocation
- Cognitive Radios
- Cognitive Geolocation
- Methods
- Emulab
- Measurements and Database
- Analysis
- Results
- Conclusion

Geolocation



- What is Geolocation
- Disadvantages of GPS
  - Does not work well in urban areas
  - Disruption of signals by building walls
- Find an alternative for urban areas
- The electromagnetic spectrum


60
50
40
30
20
10
0
Power (dB)
800
850
900
950
1000
Frequency in MHz

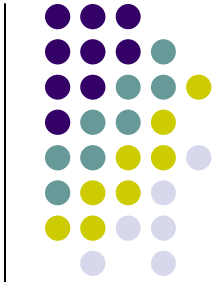
Cognitive Radios

- What is a cognitive radio
  - Smart radio
  - Makes use of unoccupied bands
- Need knowledge of band occupation
- Band occupation varies with position
- Need knowledge of position for allocation
- Cognitive Geolocation
  - Uses spectral activity to its advantage

Cognitive Geolocation

- Examines the spectrum
  - Signals differ from one position to another
  - Compare the measured spectrum to a database
- Uniqueness of the spectrum enables one to determine position

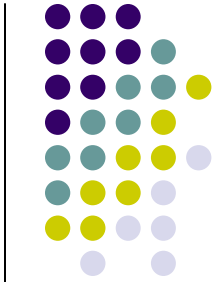
Methods



- Use a radio to scan the spectrum
- Typical spectrum analyzers are very expensive
- Use USRP (Universal Software Radio Peripheral) Devices, which are much cheaper
- Require GNU radio software
- Advantage of GNU radio
  - Software based
  - Programmable
  - Flexible

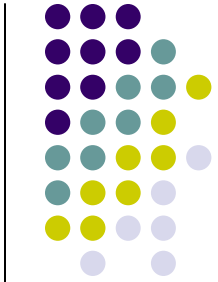
[1]

Methods Continued



- Need to build a database
- Need measurements from various locations
- Need many samples for a database
- Need simultaneous measurements

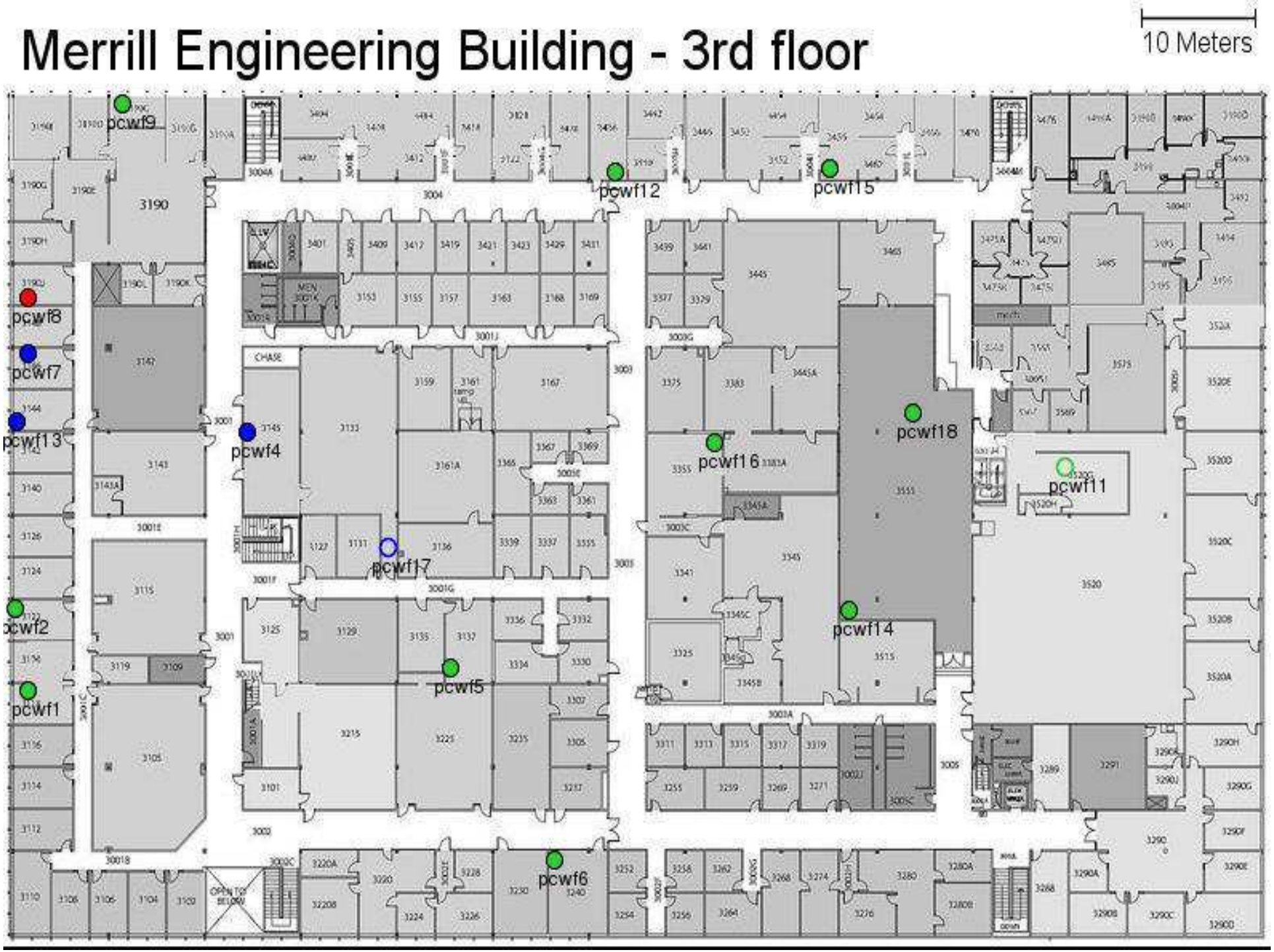
Emulab



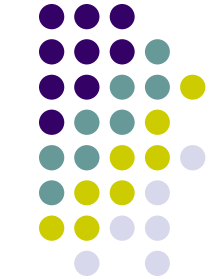
- Research lab provided by the CS department
- Has a network of USRP nodes
  - Can be controlled remotely
  - Can be programmed to take simultaneous measurements

[2]

Merrill Engineering Building - 3rd floor



Measurements and Database



- Taken using usrp_spectrum_sense.py
- Measurements are of the spectrum power
  - Complex value (real, imaginary)
  - 824-960MHz

$$power = \sqrt{r^2 + i^2}$$

- Organized for easy access
  - Date --> time --> location --> 10 measurements
- Database
  - Average of 530 measurements
  - 18th-20th of November of 2007 during morning and afternoon hours
  - Created for 9 locations

Analysis

- Additional measurements where taken
  - 9:30-11:15pm December 4, 2007
  - 10:00am-12:30pm December 5, 2007
- Matlab programs developed
  - Take the average of multiple measurements
- Difference between this average and the 9 database files is taken

$$d(x,y) = \sum_i 10 \cdot \left| \log_{10} x(i) - \log_{10} y(i) \right|$$

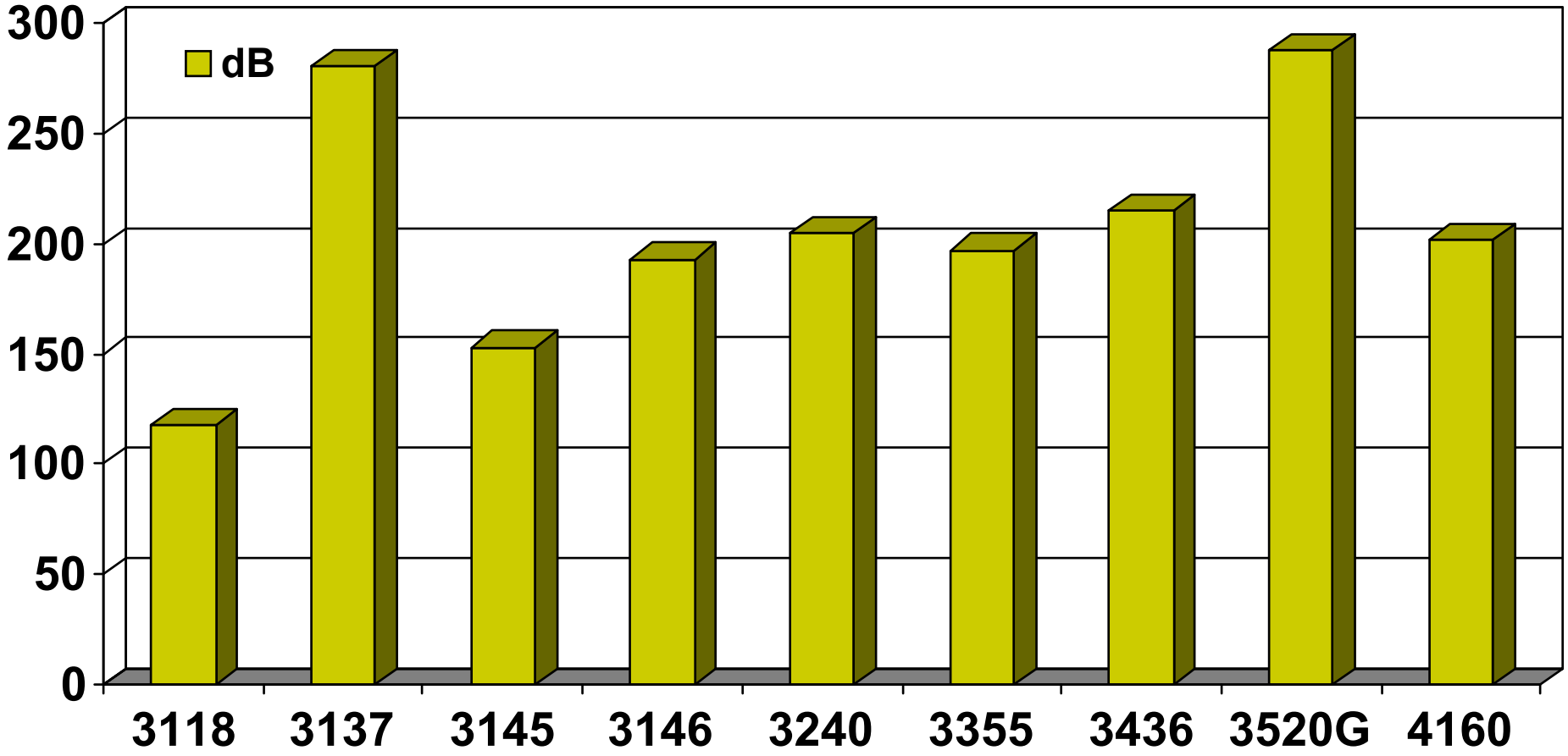
- Smallest difference is the match

Results

- Correct location determined
  - 91% of the time for day samples
  - 80% of the time for night samples
- Example: MEB 3118 vs. Database

MEB Room	3118	3137	3145	3146	3240	3355	3436	3520G	4160
Diff in dB	118	281	153	193	205	197	215	288	202

Results


300
250
200
150
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dB
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3145
3146
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3355
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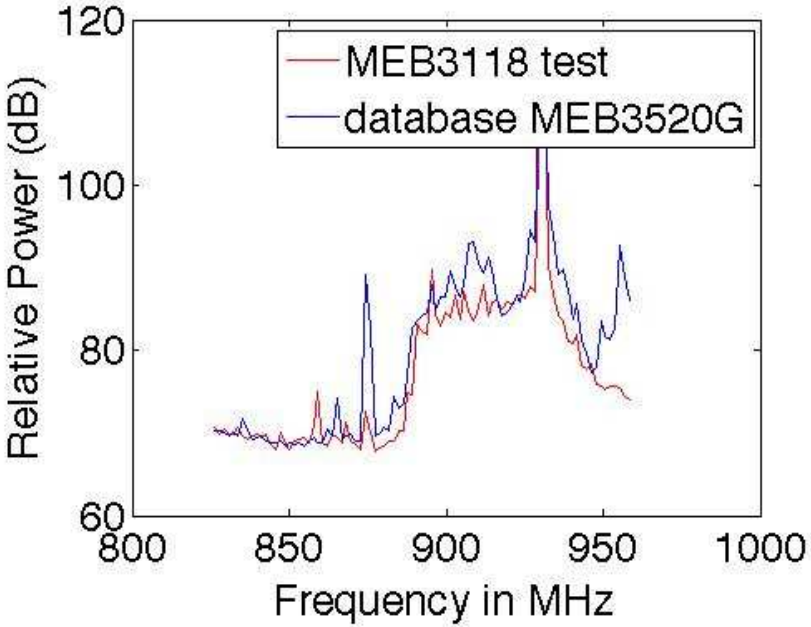
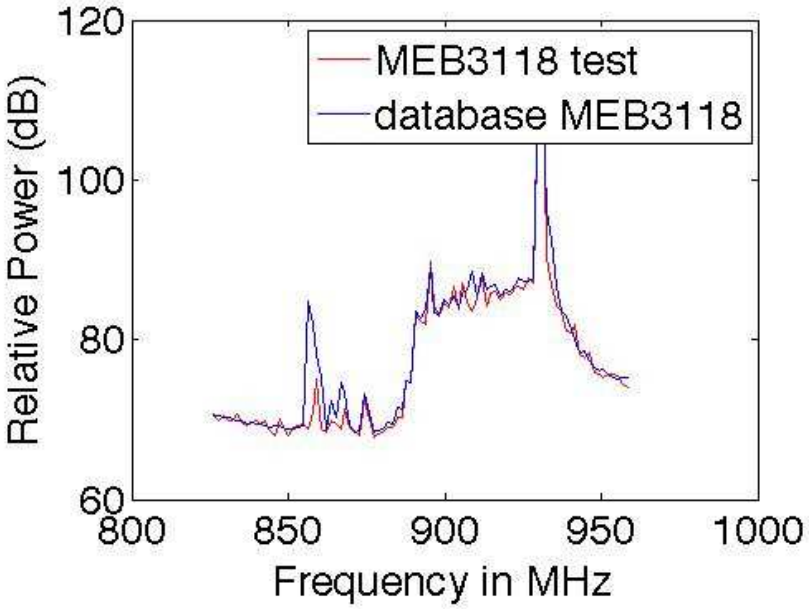
3520G
4160

Results

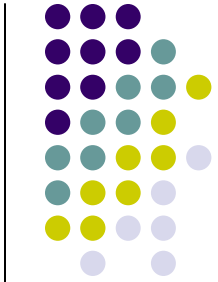


Mismatching location



Matching location

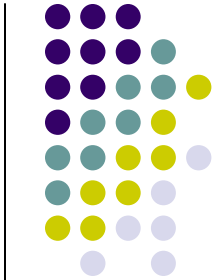
Conclusion



- Relatively constant spectrum over time
- Changing spectrum with location
- Customized database yields better results
- Cognitive Geolocation can be used

  to determine location

References



[1] GNU Radio, [Online]: http://gnuradio.org/trac

[2] B. White, J. Lepreau, L. Stoller, R. Ricci, S. Guruprasad, M. Newbold, M. Hibler, C. Barb, A. Joglekar, “An Integrated Experimental Environment for Distributed Systems and Networks,” In *Proc. 5th Symposium on Operating Systems Design and Implementation (OSDI 2002)*, pp. 255-270, Dec. 2002. [Online]: http://www.cs.utah.edu/flux/papers/netbed-osdi02-base.html