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Motivation

- Public Safety responders need **ALWAYS ON**, mission-critical radio systems.
- Infrastructure, including radio networks, can be damaged during disaster scenarios.
- Blizzard of 2011**

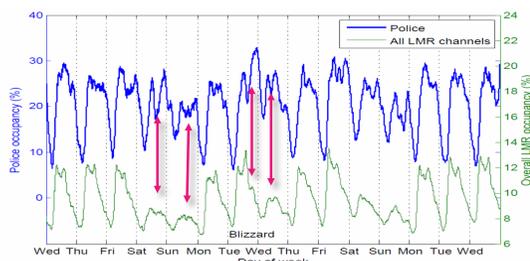


1st Feb., 2011 (Tues.) PM 2nd Feb., 2011 (Wed.)

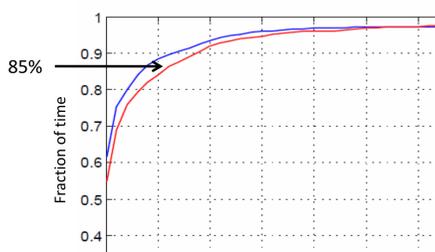
- Record Chicago Snowfall of ~0.75 m.

DSA Opportunities

- Effect of blizzard on public safety communications observed at the IIT spectrum observatory



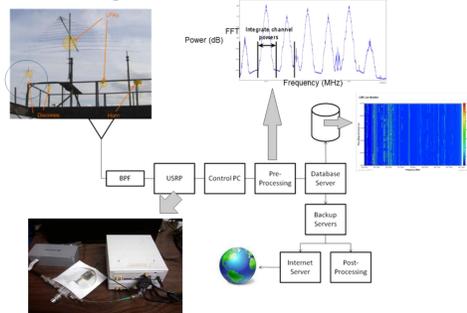
- High public safety occupancy and low commercial occupancy during:
 - weekends
 - record snow-storm (Feb. 1-2, 2011)
- Favorable opportunity for DSA in LMR Bands**
- Cumulative distribution of channel occupancies:



- ~85% of channels have occupancy < 10% over 24 hours, meaning **favorable DSA opportunity**

Dedicated PSR system

- Custom design based on USRP platform

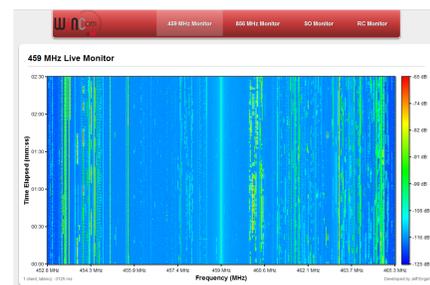


- Located at IIT Tower in Chicago



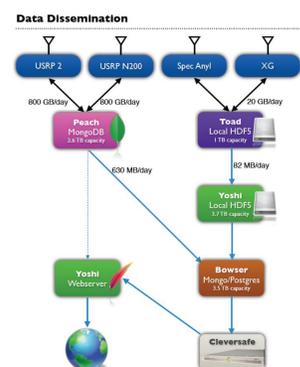
Measurements

- Real-time data streamed over internet for quick, remote visualization

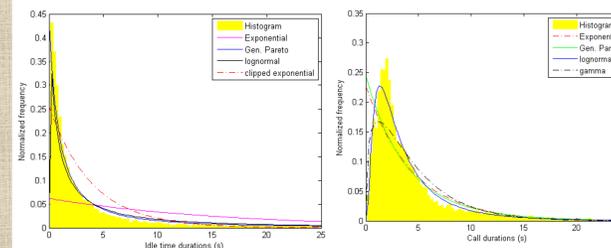


Data Storage

- Non-trivial amounts of data (order of terabytes)
- Currently using MongoDB and Cleversafe's DSNet

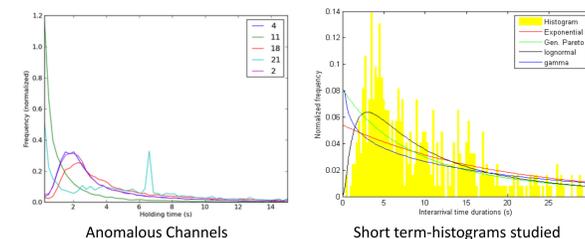


CPD Traffic Statistics



Histograms of call **idle** and **hold** times over a week of data. The histograms were fitted with **model PDFs** and the distribution parameters were estimated.

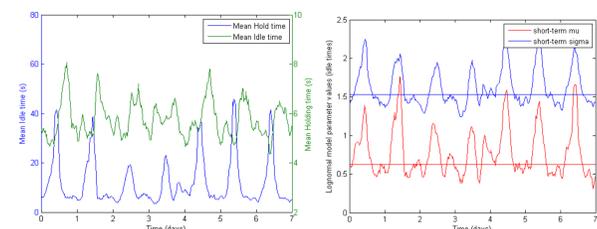
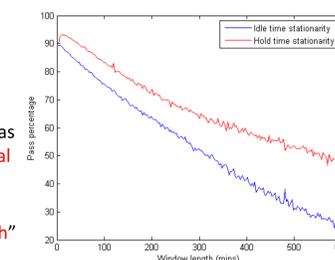
NORMALIZED MSE: BETWEEN HISTOGRAM OF IDLE TIMES AND MODEL FITS			NORMALIZED MSE BETWEEN HISTOGRAM OF HOLD TIMES AND MODEL FITS		
Distribution	MSE (1 week duration)	MSE (2 hour duration)	Distribution	MSE (1 week duration)	MSE (2 hour duration)
Exponential	1.000	1.000	Exponential	0.855	0.951
Generalized Pareto	0.917	0.960	Generalized Pareto	1.000	1.000
Lognormal	0.809	0.858	Lognormal	0.100	0.324
Clipped exponential	0.611	0.524	Gamma	0.274	0.524



Models

Stationarity:

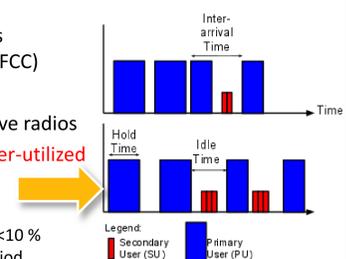
- Most previous studies of public safety voice traffic assume **Stationarity** over short 1 or 2 hour windows.
- KPSS test for stationarity was applied on **5 weeks of actual voice traffic data**
- "Probability of stationary window" vs "window length" plot suggests otherwise



- Since data is inherently non-stationary, **30 minute windows** of voice traffic were taken
- The **model parameters** were estimated for each window
- Result is time-series of parameters that tracks channel traffic in the **long-term**

Applications

- Traffic model for simulations (Equipment manufacturers, FCC)
- Network planning
- Spectrum sensing by cognitive radios
- Opportunistic access of under-utilized channels by Public Safety during emergencies**
 - Recall, 85% of channels have <10% occupancy over a 24 hour period



Future Work

- DSA Feasibility study
- Analyze 850 and 700 MHz channels
- Planning and network forecast
- Policy (FCC)
- Compare business and public safety users

Acknowledgements

- Database design due to Jeff Engel.
- Hardware and software assistance provided by Philip Felber, George Noorts and Jesse Taylor.
- Dr. William Lane and John Healy from the Public safety and Homeland Security Bureau of the FCC for providing valuable feedback.
- Access to the DSNet file storage system provided by Cleversafe; additional feedback and hardware support provided by Motorola Corp.
- Research funding thanks to NSF.



Publications

- Taher, T; Bacchus, R; Zdunek, K; Roberson, D; " **Dynamic Spectrum Access Opportunity for Public Safety in the Land Mobile Radio Bands**", presented at **IEEE Crowncom** conference, **Osaka**, Japan, June 2011.
- Taher, T; Bacchus, R; Roberson, D; Zdunek, K; " **Empirical Modeling of Public Safety Voice Traffic in the Land Mobile Radio Bands**", accepted for publication at **IEEE Crowncom** conference, **Stockholm**, Sweden, June 2012.