Cognitive Radio Experiment Design for the Space Communications and Navigation (SCaN) Testbed

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Outline

1. Introduction and Motivation
2. Scope
3. Cognitive Engines
4. Test Platform & Procedure
5. Results
6. Future Work

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Introduction

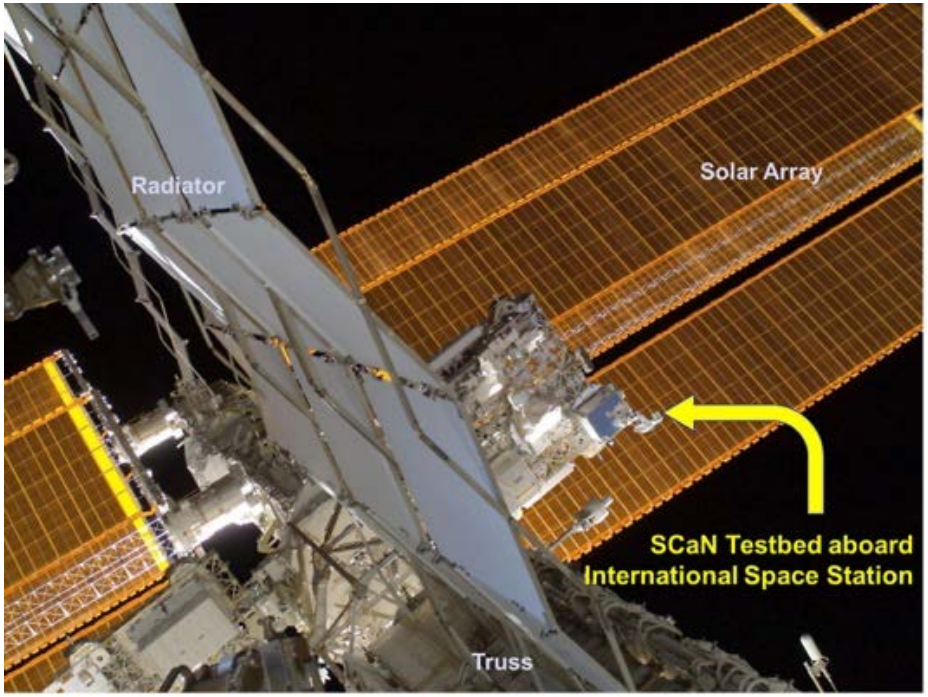
- Ground-to-space communications
  - Noisy
  - Fading
  - Short visibility duration
- Lowest Common Denominator
  - Worst case scenario
  - Robust modulation schemes
    - Low SNR

Motivation

- Channels aren't static
  - Exploit favorable conditions
  - High throughput for brief moments
- How do we exploit this?
  - Profile the system performance
  - Intelligence
- Adaptable system
  - Different objectives
  - Other applications

SCaN Testbed

- SDR platform on the ISS
- Experimental
  - Prototype novel SDR and Cognitive Radio techniques
  - Leverage developments



SCaN Testbed

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Scope of Platform

- Demonstrate an adaptable system
  - Optimize throughput
- Over-the-air transmission
  - 924 MHz
- Limitations
  - AWGN
  - Point-to-point
  - Performance metrics

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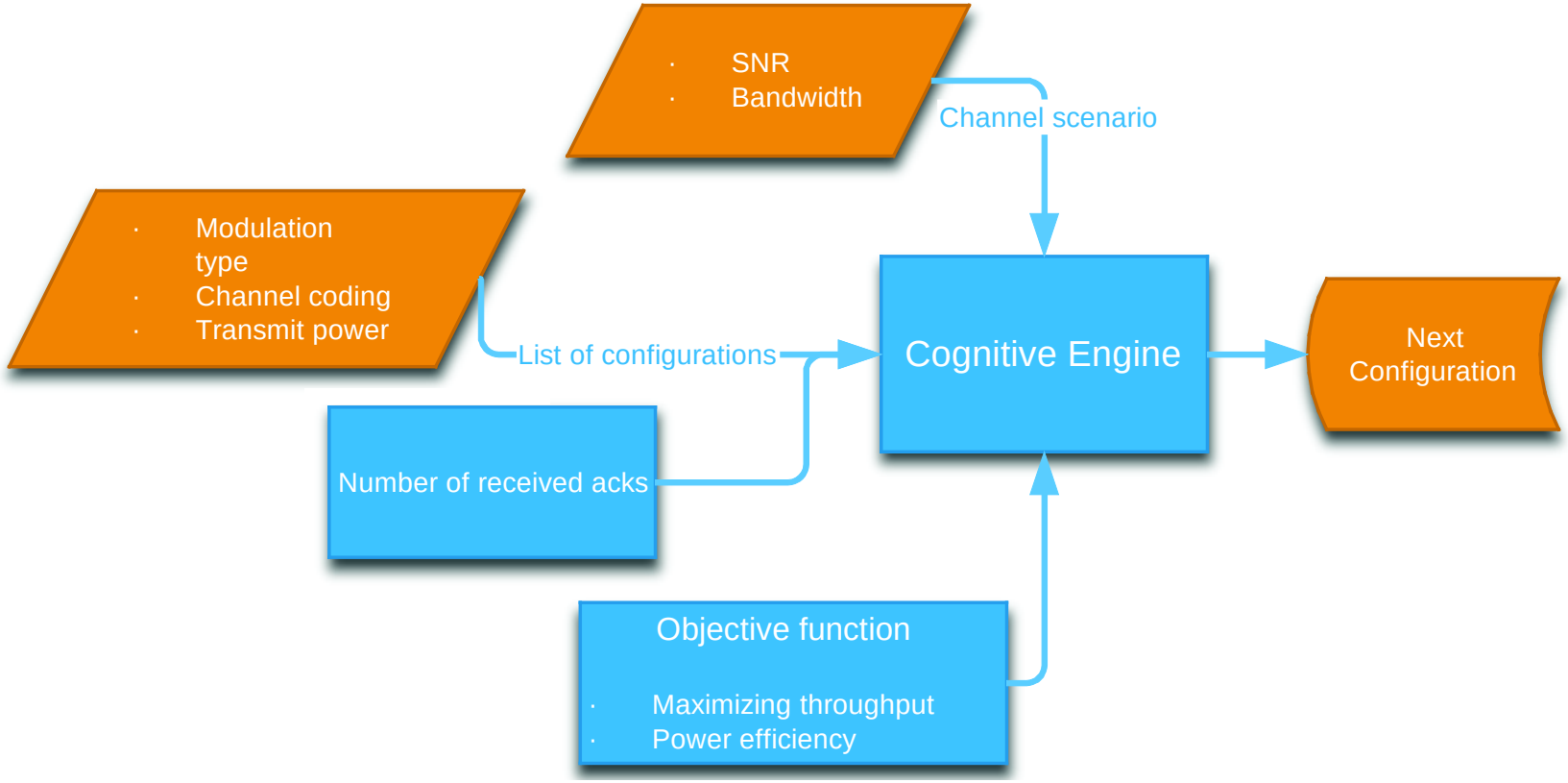
Cognitive Engines

- An algorithm that attempts to optimize a certain objective
- Intelligence
  - Exploration vs. Exploitation
- Different algorithms
  - ε-Greedy
  - Boltzmann
  - Gittins
- Two-layered

Cognitive Engines



Block diagram of the Cognitive Engine architecture.

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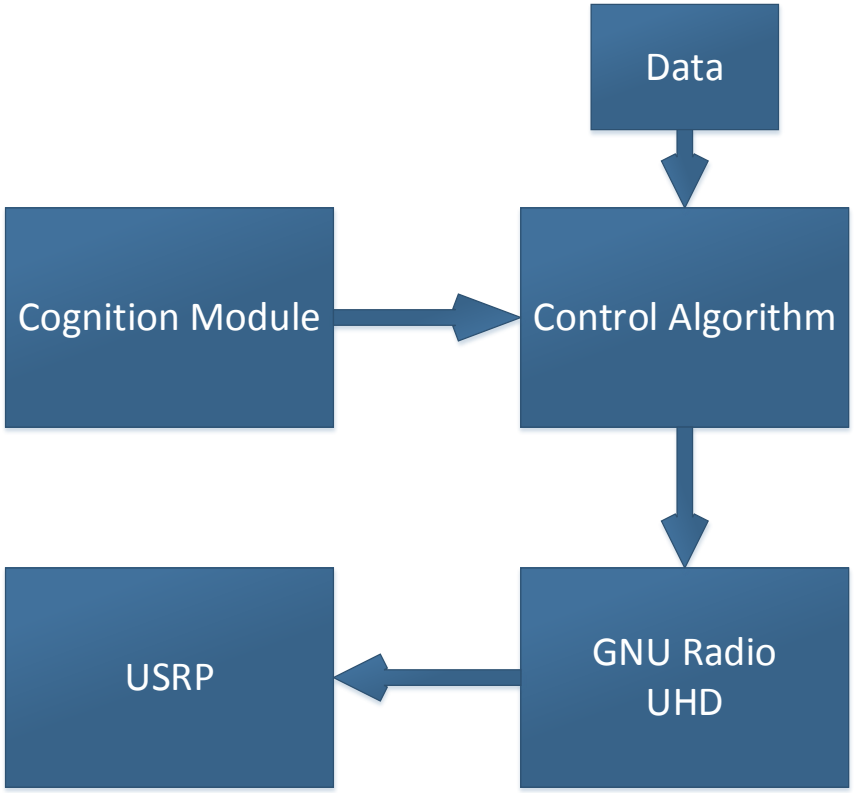
Test Platform

- Reconfigurable
  - Modulation path
- GNU Radio 3.7.5
- USRP Hardware Driver 3.8
- Fedora 20 & Ubuntu 14.04 LTS
- N200 USRPs
  - SBX daughterboards

Transmitter Overview



Block diagram of transmitter.

Test Procedure

- Transmitter sends frames
  - 1000 packets
  - System is stable during frame transmission
- Receiver acknowledges each packet individually
  - Full-duplex

System Configurations

Parameter	Values		
Modulation	Phase Shift Keying		
Constellation Points	2	4	8
Differential Coding & Grey Code			

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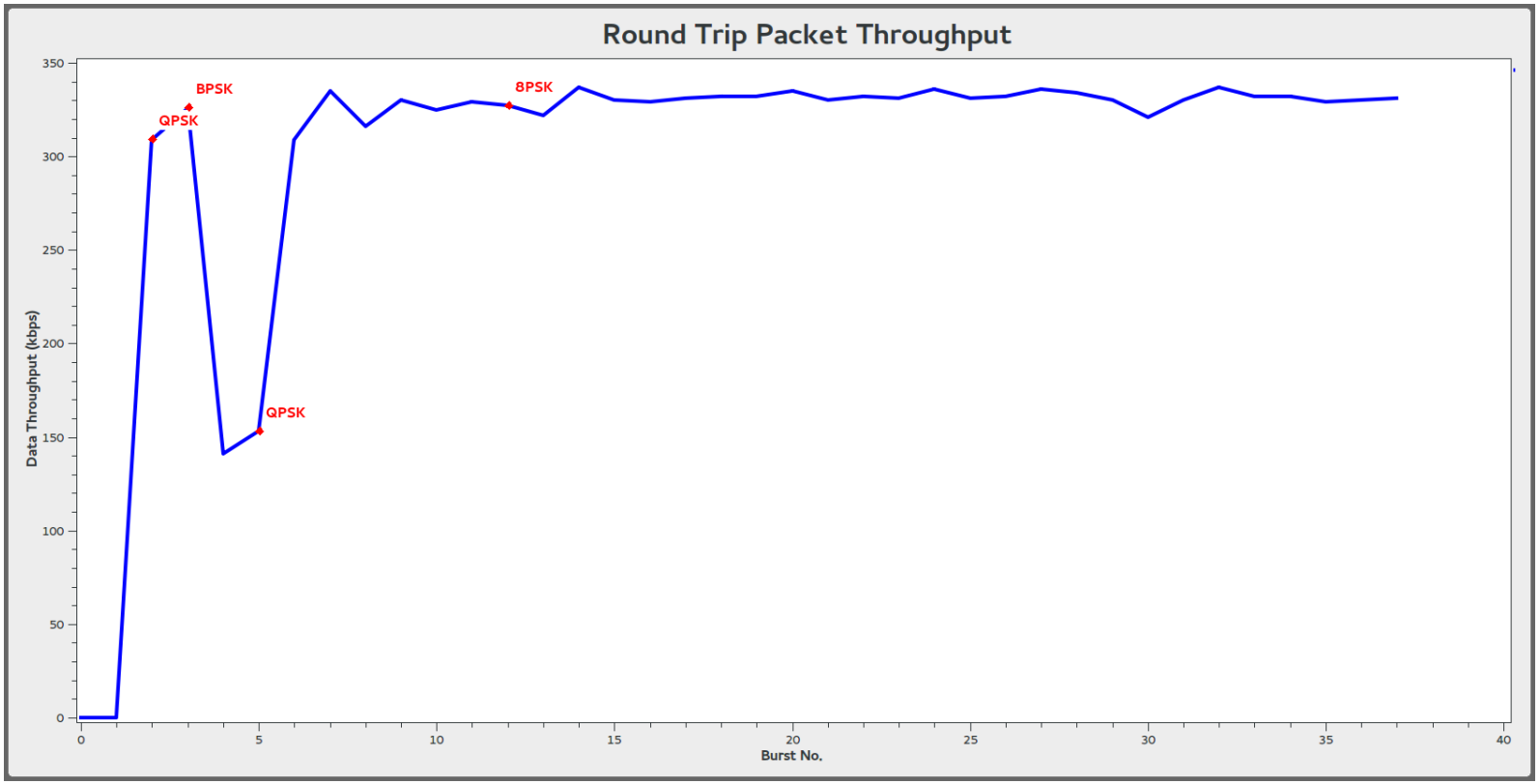
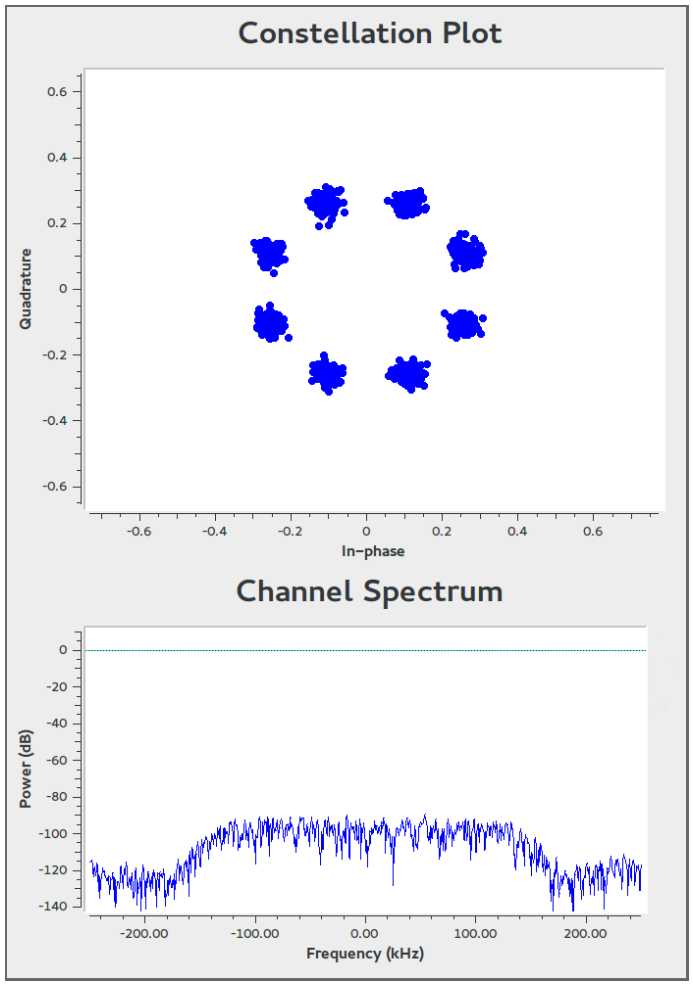
Results



Convergence to 8PSK in a noiseless channel.

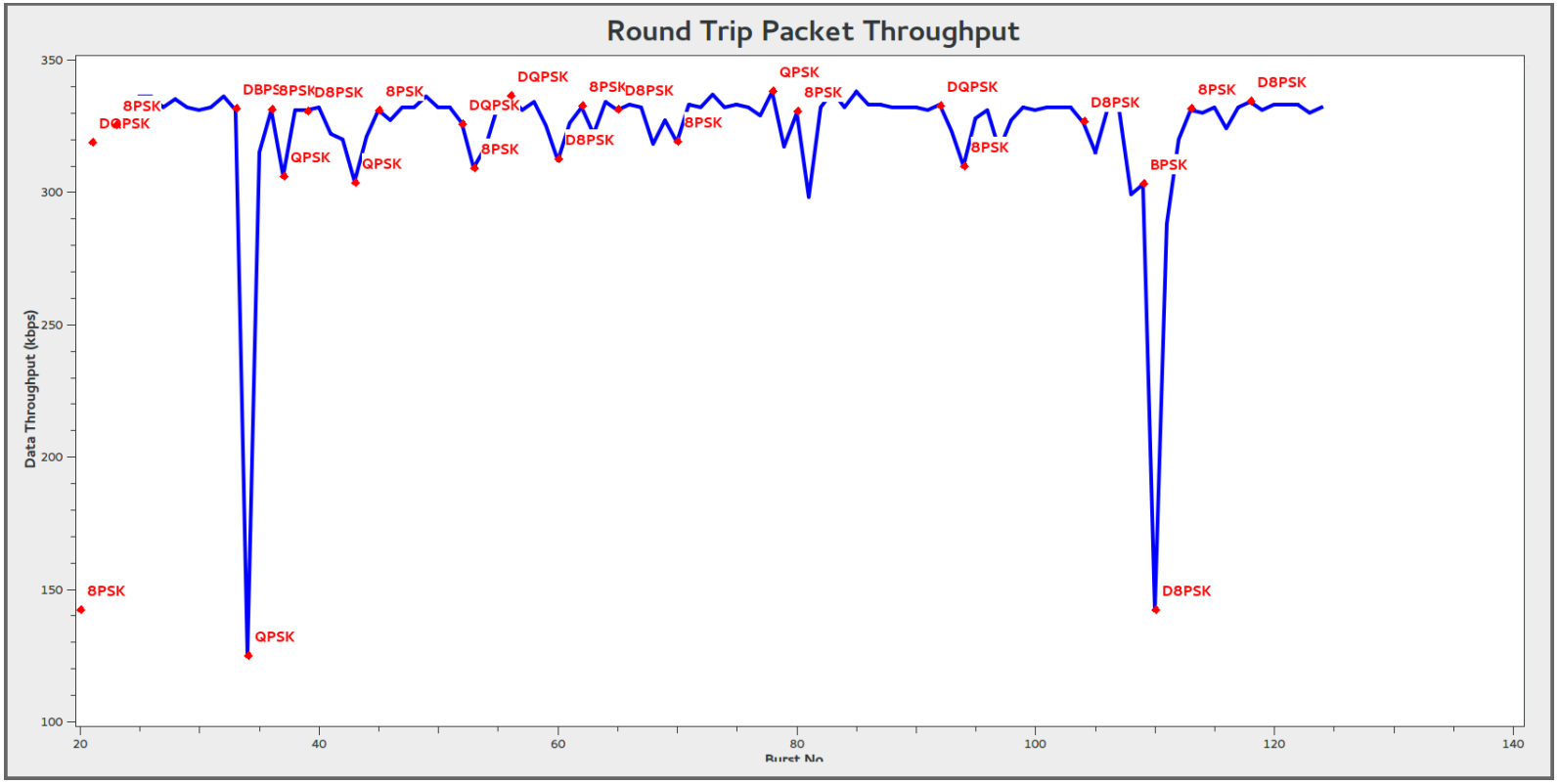
Results



Constellation and Spectrum plots for previous slide at receiver.

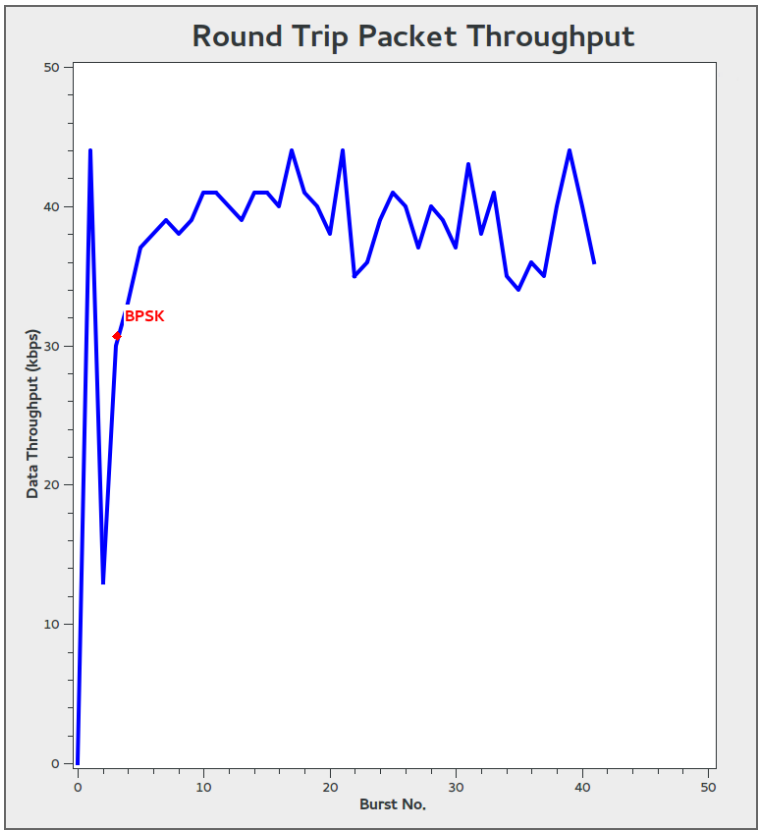
- Convergence to 8PSK
- Clean constellation
- High SNR
  - ~ 40 dB

Results

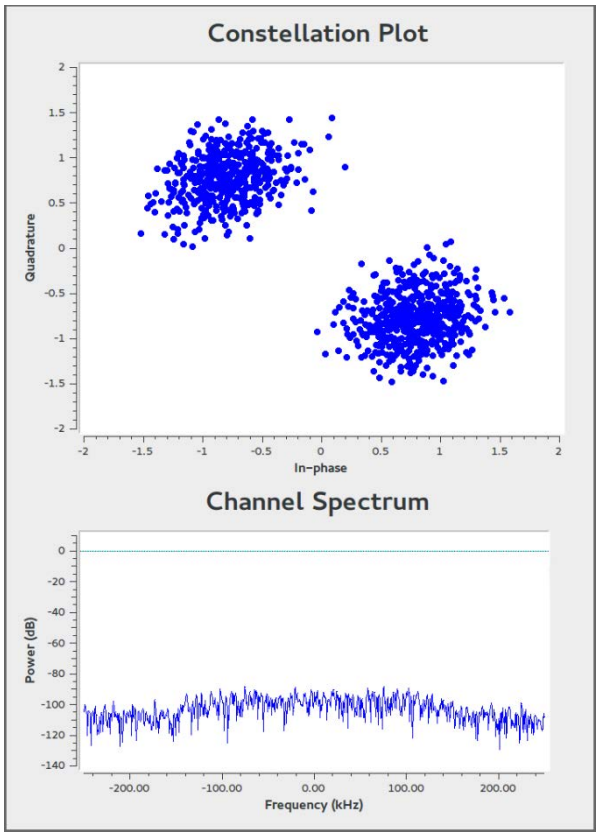


Exploratory nature of the Cognitive Engine algorithms.

Results



Operation in a noisy environment.



Corresponding plots.

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Future Work

- Meta-Cognition
  - Make a decision about making decisions
- RF Mapping
  - Knowledge of spectrum prior to exploration
- Modulation Classification
  - No meta data transfer

Conclusions

- Exploit momentarily favorable conditions
- Implemented an adaptable system
  - Favorable SNR allows use of higher modulation schemes
  - Noisy conditions forces the system to be conservative
- Tunable reconfiguration
  - Frame size dictates stability time
- Modular system
  - Additional subsystems to alter performance

References

H.I. Volos and R.M. Buehrer, “Cognitive Engine Design for Link Adaptation: An Application to Multi-Antenna Systems,” IEEE Transactions on Wireless Communications, vol. 9, no. 9, pp. 2902–2913, Sept. 2010.

H.I. Volos and R.M. Buehrer, “Cognitive Radio Engine Training,” Wireless Communications, IEEE Transactions on Wireless Communications, vol. 11, no. 11, pp. 3878–3889, 2012.

H. Asadi, H. I. Volos, M. Marefat, and T. Bose, “Learning Characterization Framework and Analysis for a Meta-Cognitive Radio Engine,” in Proceedings of SDR WInnComm 2014 Wireless Innovation Conference on Wireless Communications Technologies and Software Defined Radio, Mar. 2014, pp. 132–139.

“SCaN Testbed,” spaceflightsystems.grc.nasa.gov/SOPO/SCO/ SCaNTestbed/, accessed: 2014-12-19

Thank You!