Enabling Wireless Access to Enterprise Data

Alexander M. Wyglinski, Ph.D.

Associate Professor, Electrical and Computer Engineering

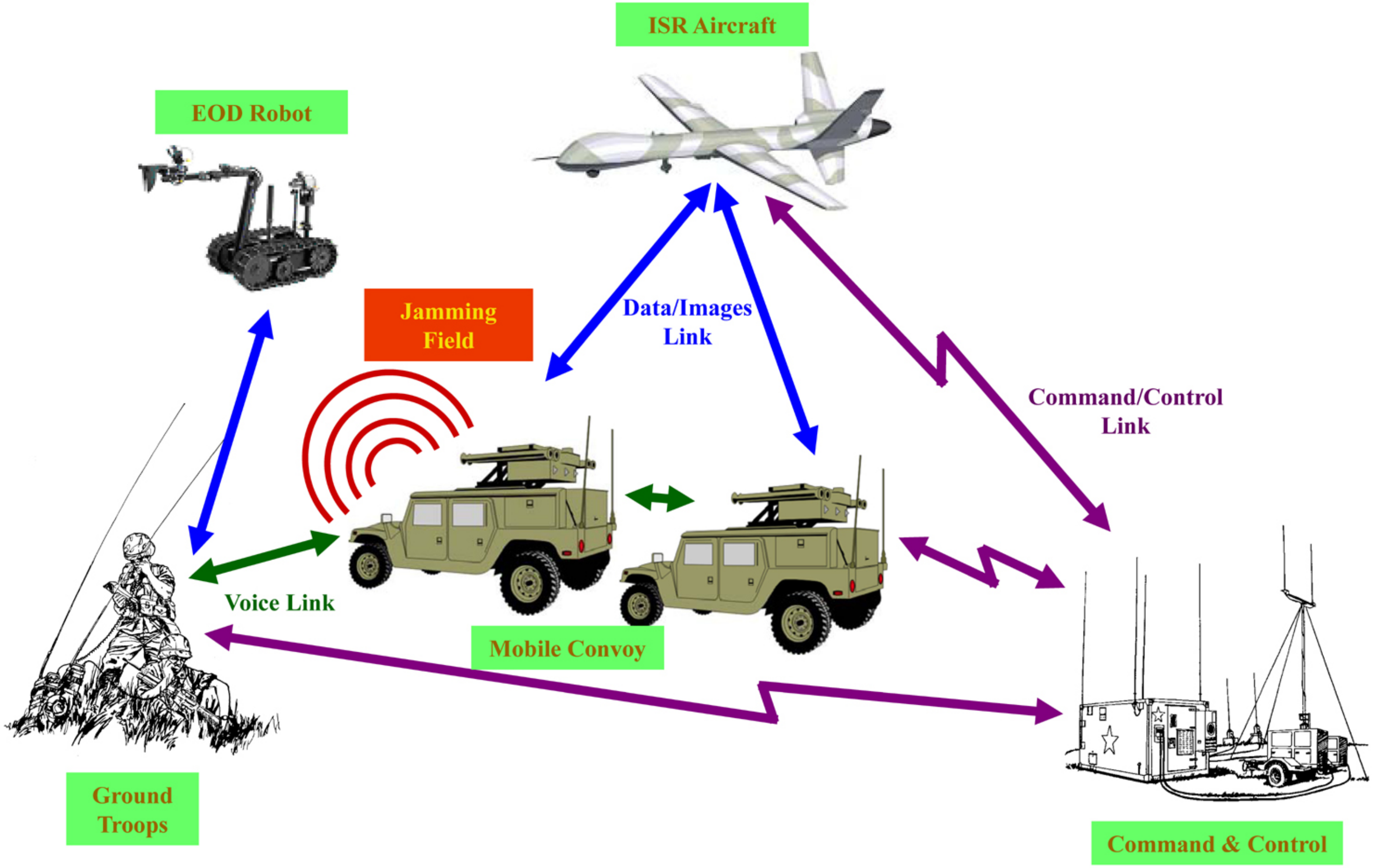
Director, Wireless Innovation Laboratory

Investigator, Cyber Physical and Secure Systems (CPASS) Initiative

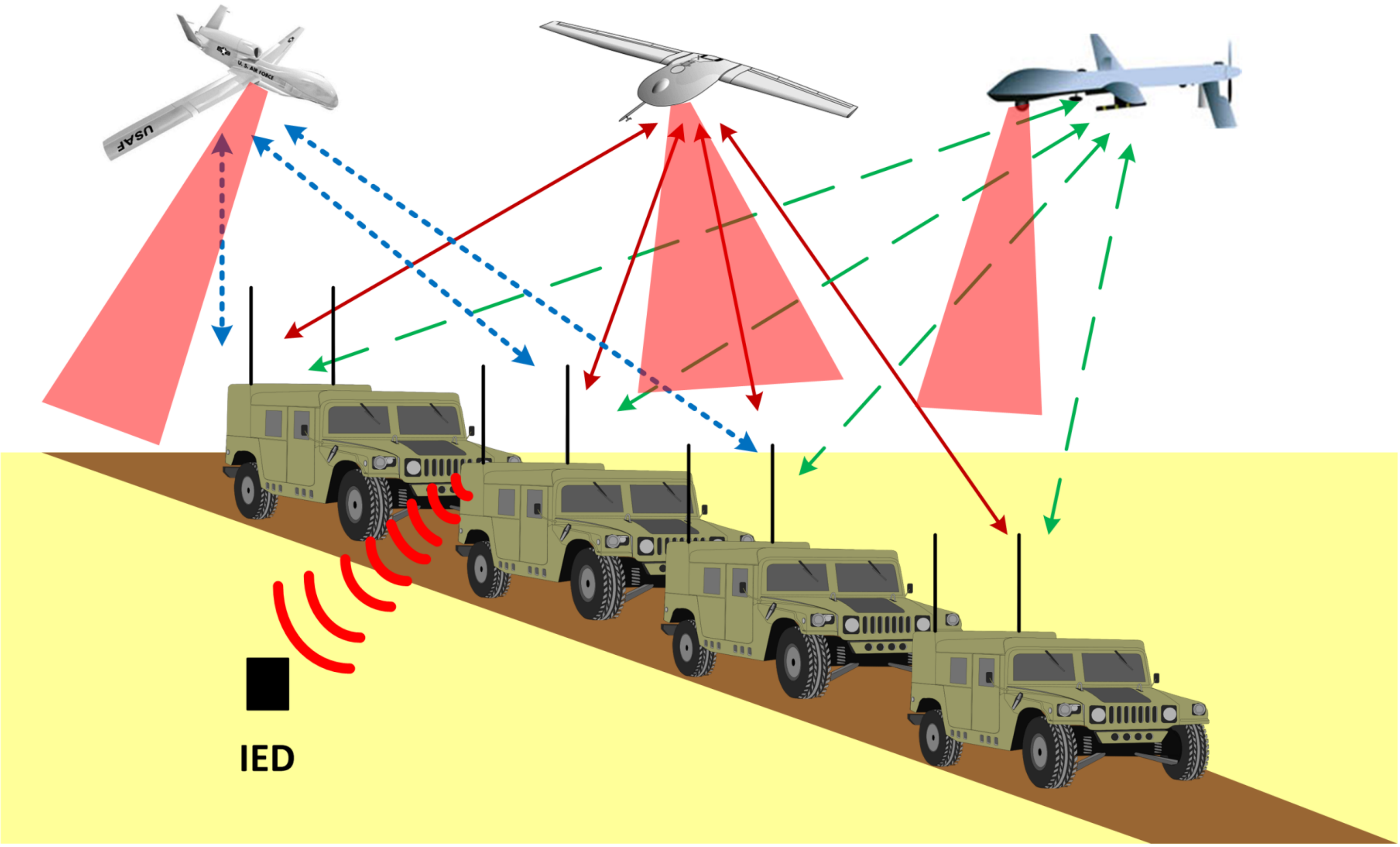
Motivation

- Good decisions are driven by information
  - Information integrity
  - Real-time
  - Shifting through various information sources
- Numerous applications require decision-making capabilities
- An increasing number of decisions are made automatically by robots, drones, etc…
  - Due to availability of capable embedded processor technology

Motivation

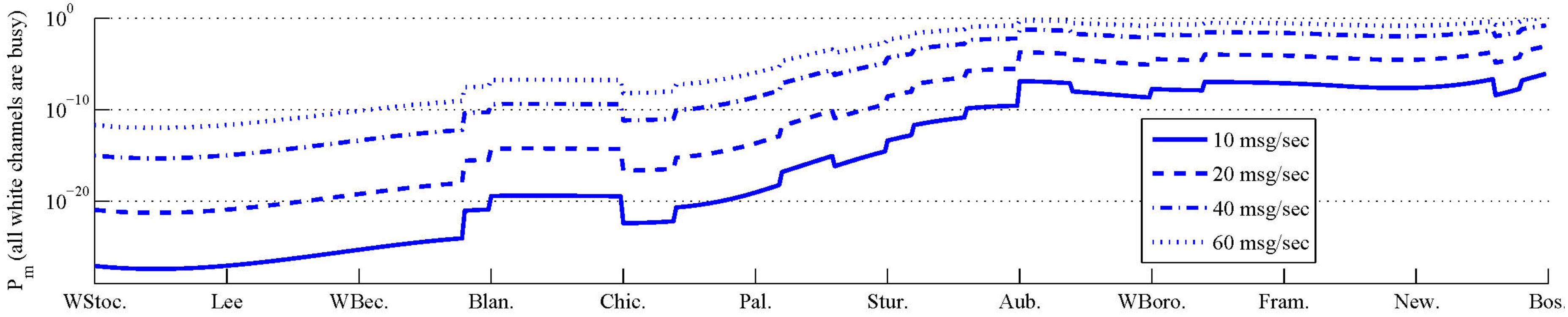

ISR Aircraft
EOD Robot
Jamming Field
Data/Images Link
Command/Control Link
Voice Link
Mobile Convoy
Ground Troops
Command & Control

Motivation



Challenges and Issues

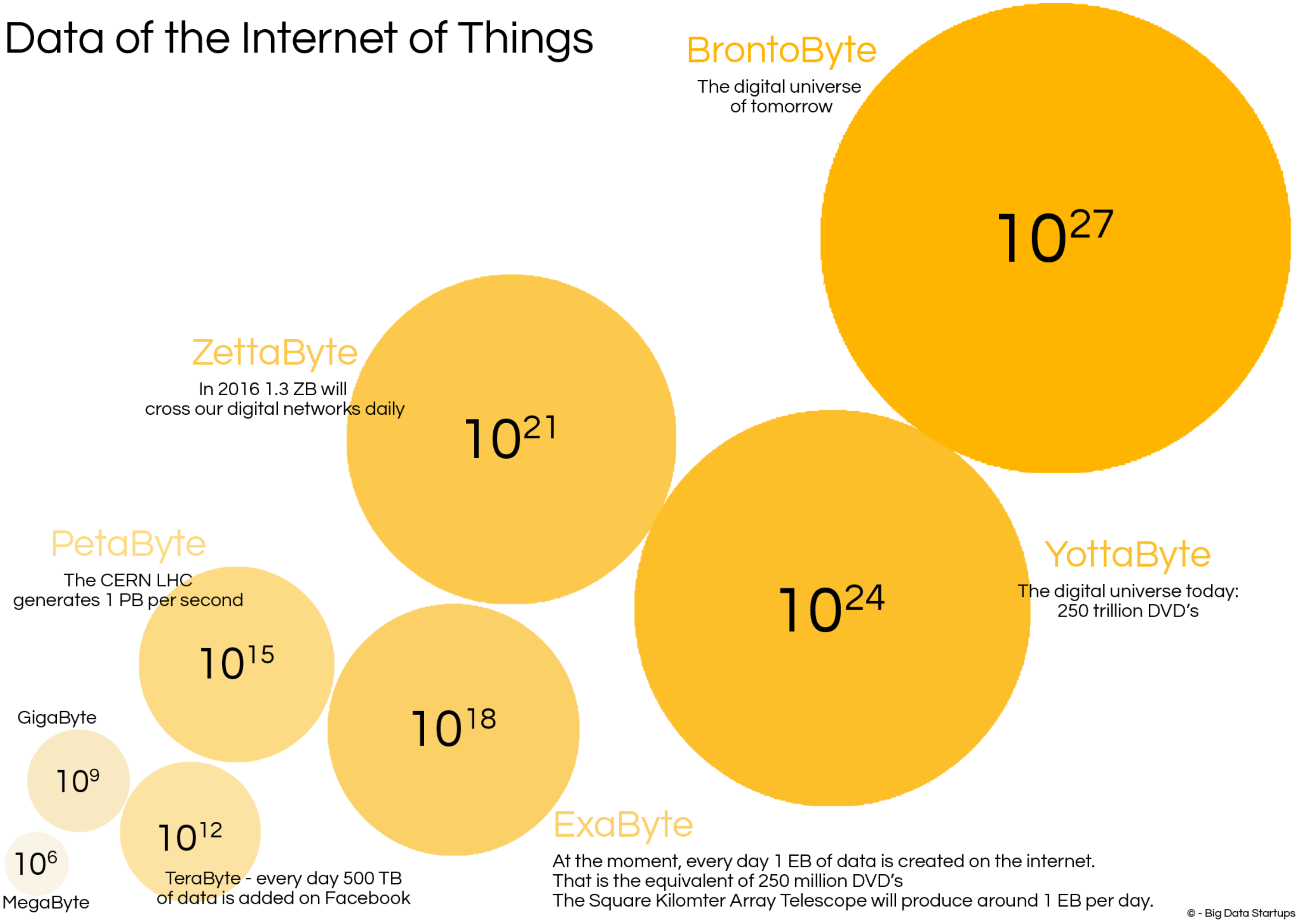
- Sharing of information ***does not*** scale well
  - Architectural considerations
    - Centralized versus distributed
  - Latency issues
    - Impact on real-time operations
  - Supported information
    - Bandwidth considerations
  - Available resources and infrastructure
    - Example: Unoccupied wireless spectrum



Si Chen, Rama Vuyyuru, Onur Altintas, Alexander M. Wyglinski. "On Optimizing Vehicular Dynamic Spectrum Access Networks: Automation and Learning in Mobile Wireless Environments." Proceedings of the IEEE Vehicular Network Conference (Amsterdam, The Netherlands), November 2011.

Challenges and Issues

Data of the Internet of Things



MegaByte

GigaByte

TeraByte - every day 500 TB of data is added on Facebook

PetaByte
The CERN LHC generates 1 PB per second

ExaByte
At the moment, every day 1 EB of data is created on the internet.
That is the equivalent of 250 million DVD's
The Square Kilomter Array Telescope will produce around 1 EB per day.

ZettaByte
In 2016 1.3 ZB will cross our digital networks daily

YottaByte
The digital universe today: 250 trillion DVD's

BrontoByte
The digital universe of tomorrow

© - Big Data Startups

http://bigdata.bigdatastartups.netdna-cdn.com/wp-content/uploads/2013/02/Big-data-infographic.png

Challenges and Issues

- Increasing dependence on sensor data
  - Various forms of sensor information
    - Video, ultrasonic, LIDAR, sound, infrared, …
  - Local decisions
    - Self-driving vehicles
  - Global decisions
    - Real-time situational awareness of an operation

Cyber Physical and Secure Systems

Embedded Systems

Wireless Access

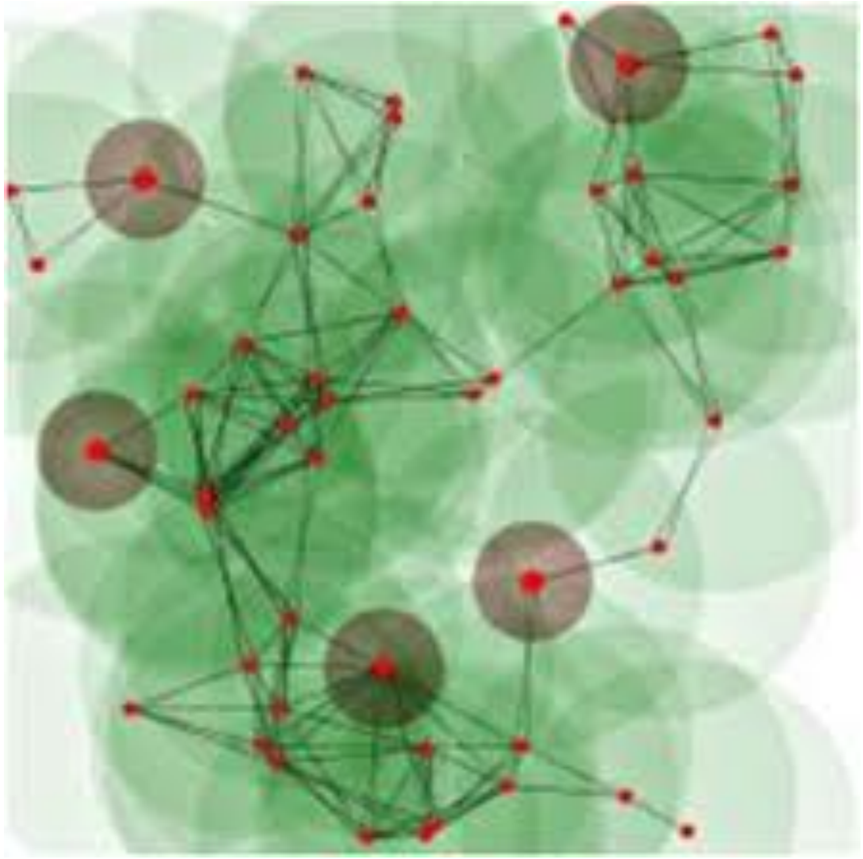
Hardware Security

Network Security

Robotics & Controls

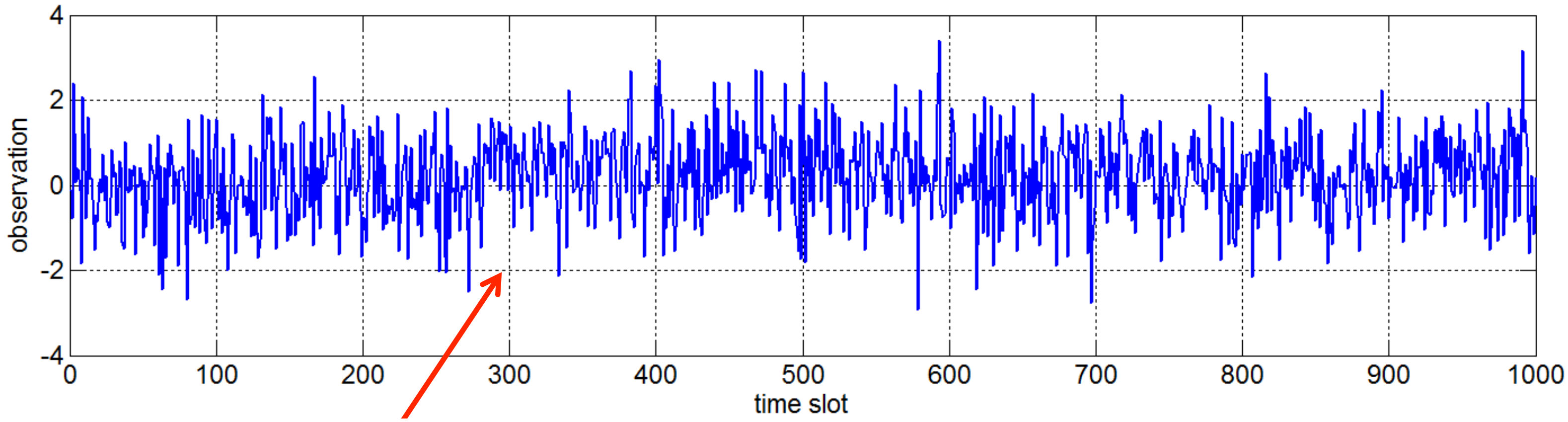
Cyber Physical Systems

Wireless Network Security

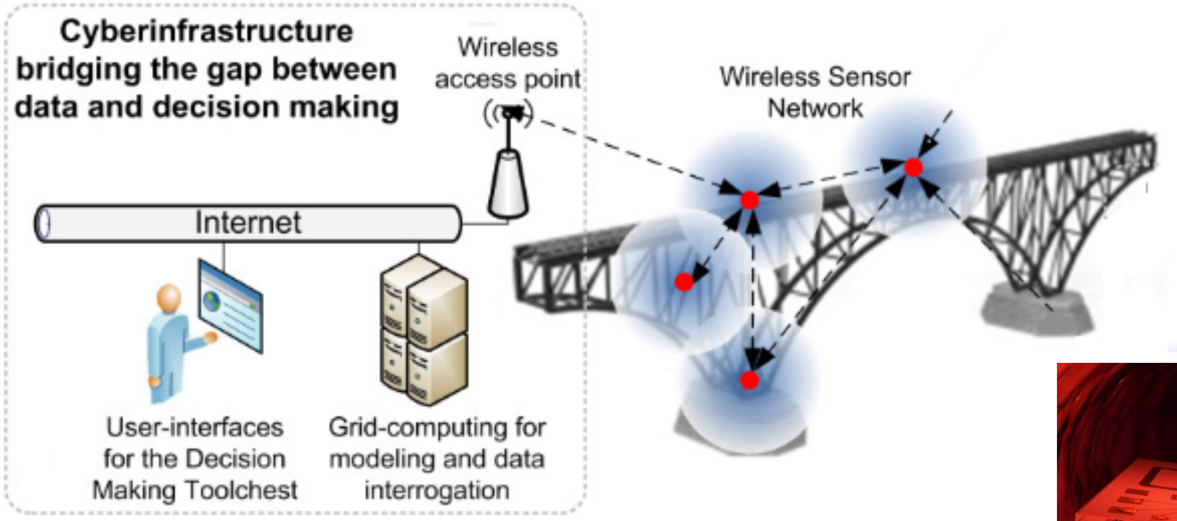


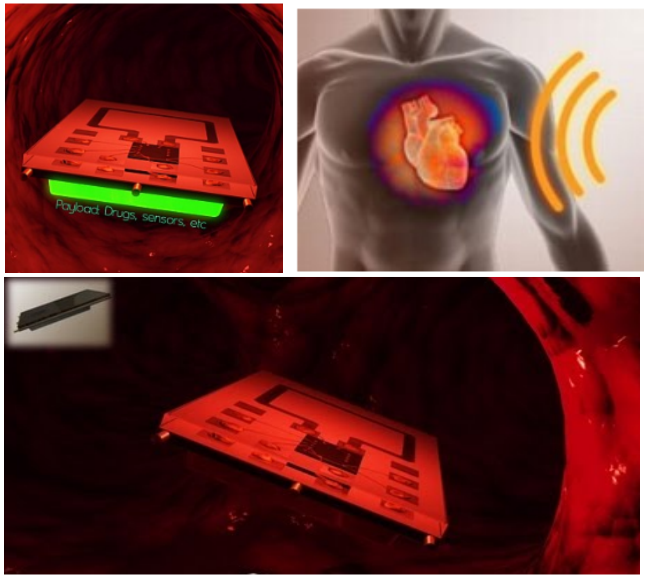
Large scale networks

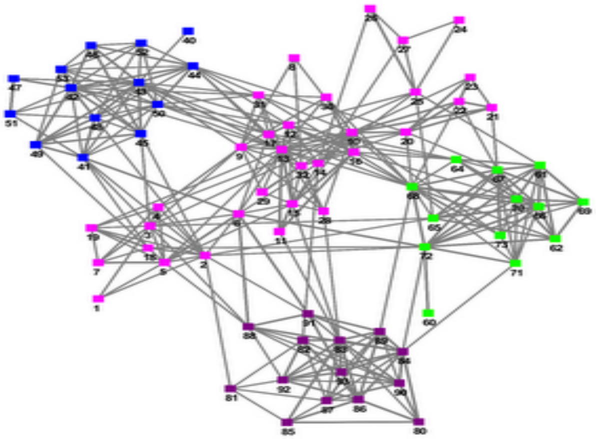
Statistical Signal Processing and Inference



Distributed Change Point Detection


Cyberinfrastructure bridging the gap between data and decision making
Wireless access point
Wireless Sensor Network
Internet
User-interfaces for the Decision Making Toolchest
Grid-computing for modeling and data interrogation



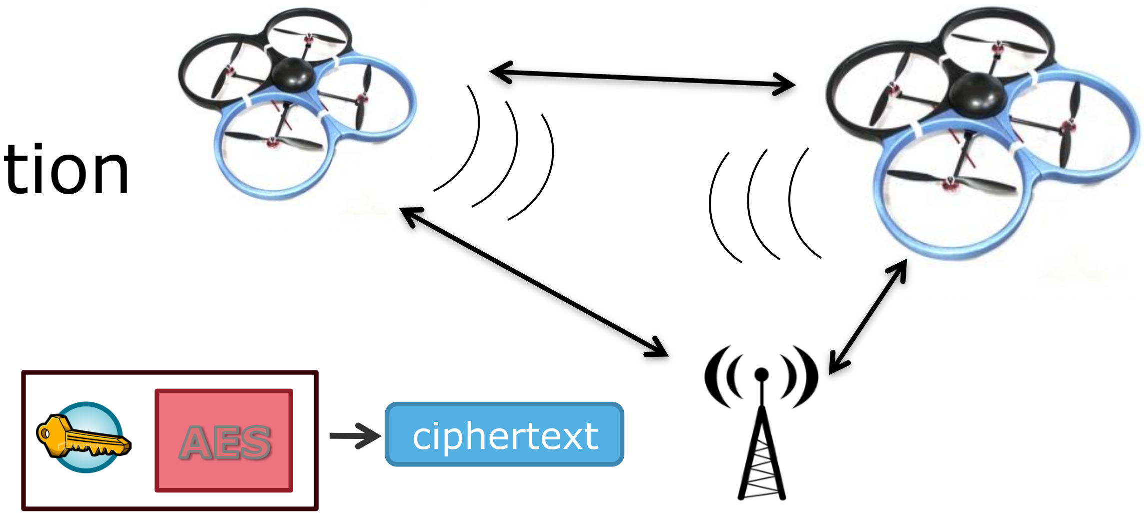


Network attack detection

Embedded Security

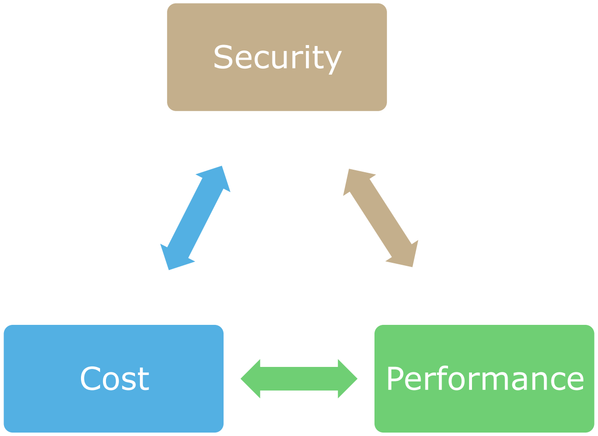
Features:

- Entity authentication
- Secure communication
- IP Protection

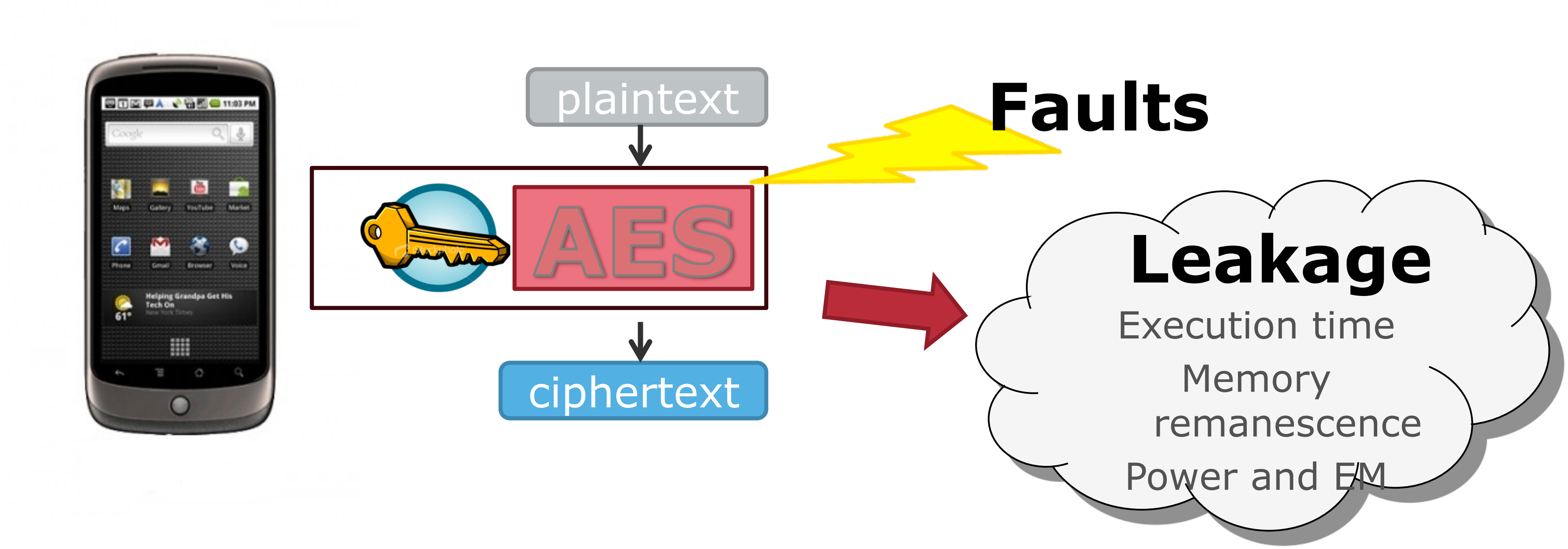


Challenges:

- Costly implementation
- Protocol weaknesses
- Physical attacks



Implementation Attacks



plaintext

AES

ciphertext

Faults

Leakage

Execution time

Memory remanescence

Power and EM

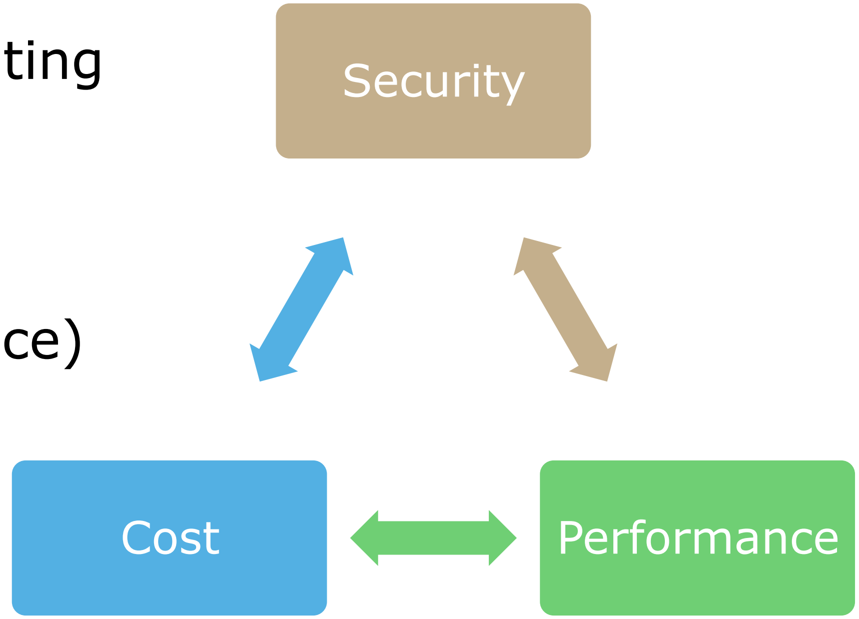
- Critical information leaked through side channels
- Adversary can extract critical secrets (keys etc.)
- Usually require physical access (proximity)

Embedded Crypto Implementations

Challenge: Constrains in computing power, Energy, Memory

Tradeoffs:

- Public vs. secret key crypto (a factor of 1000 in performance)
- Lightweight crypto vs. standard ciphers



Current Research:

- Alternative crypto schemes → new services
- Lightweight authentication for sensor nodes
- Countermeasures against implementation attacks & tampering

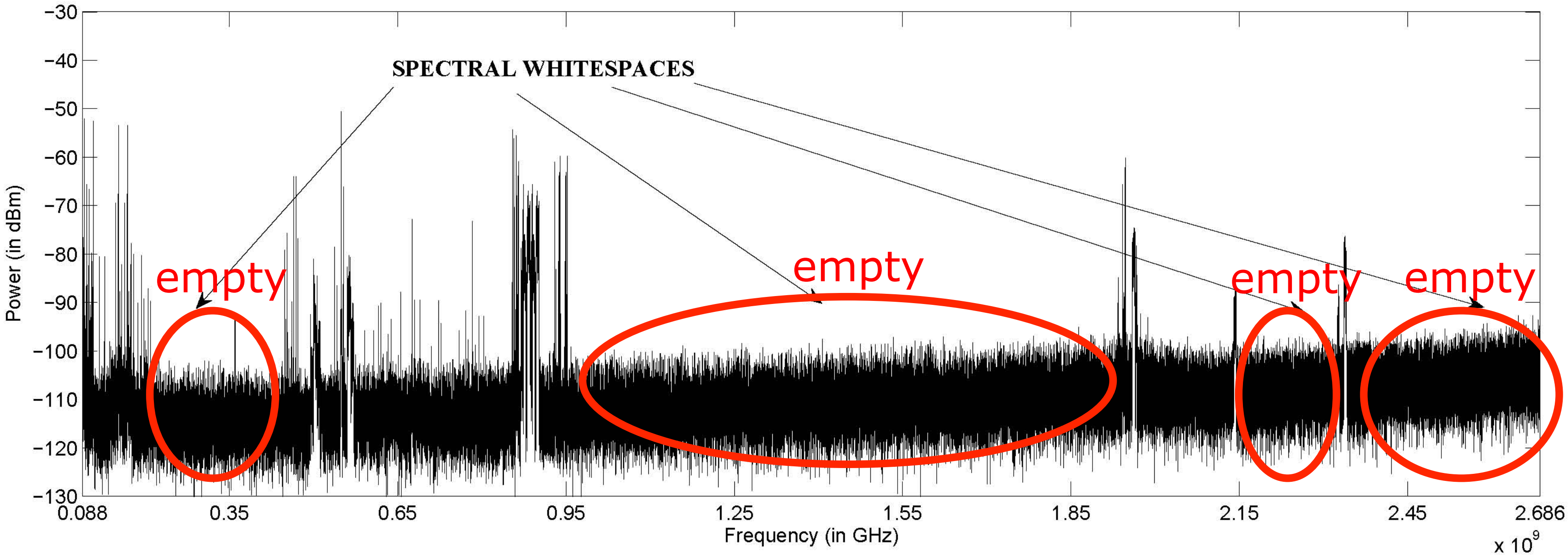
Opportunistic Spectrum Access

- Opportunistic spectrum access (OSA) is a significant paradigm shift in the way wireless spectrum is accessed
  - Instead of PUs possessing exclusive access to licensed spectrum, SUs can temporarily borrow unoccupied frequency bands
  - SUs must respect the incumbent rights of the PUs with respect to their licensed spectrum

- OSA enables greater spectral efficiency and facilitates greater user and bandwidth capacity

OSA Motivation

- The utilization efficiency of “prime” wireless spectrum has been shown to be poor

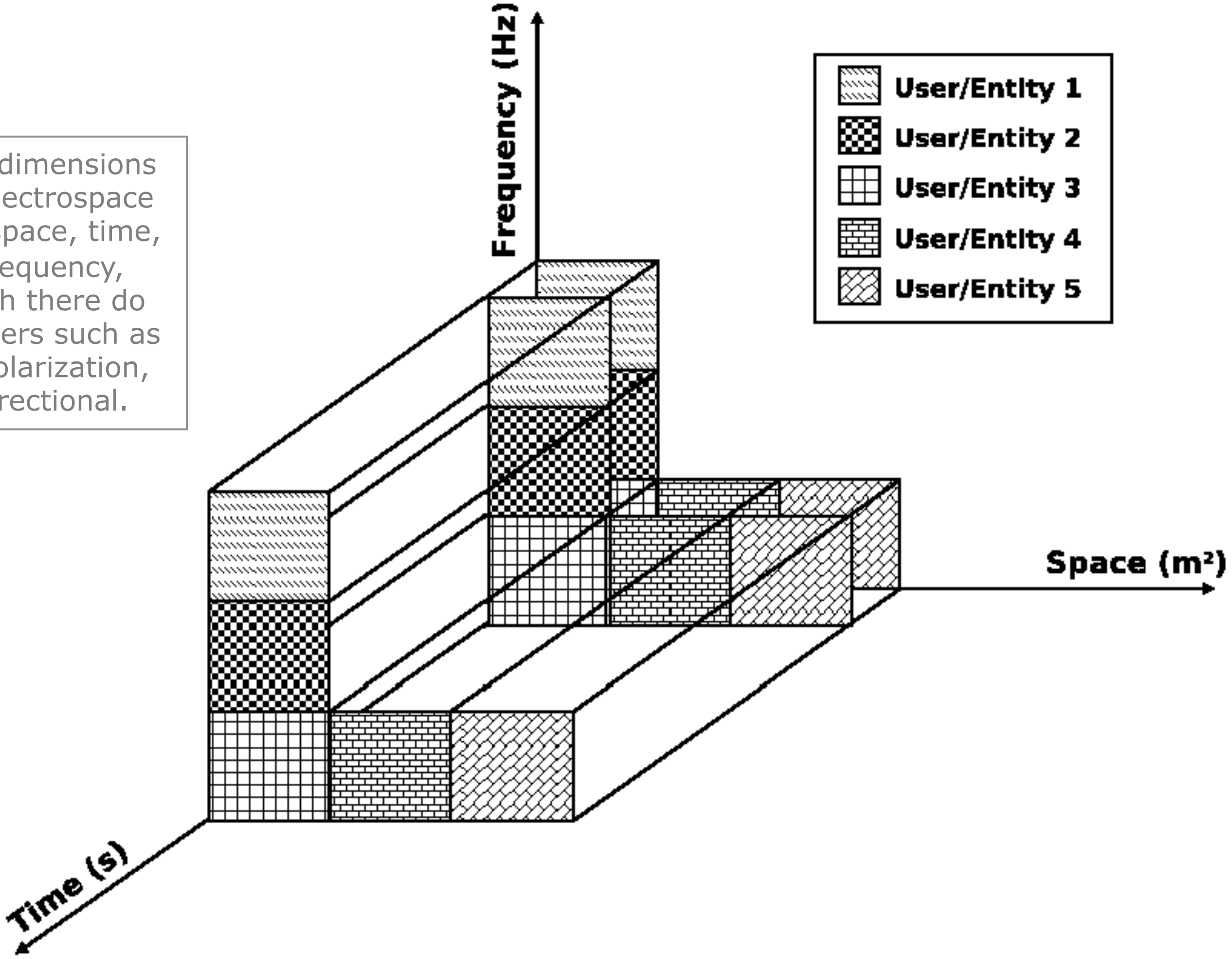


A snapshot of PSD from 88 MHz to 2686 MHz measured on July 11th 2008 in Worcester, MA (N42º16.36602, W71º48.46548)

A. M. Wyglinski, M. Nekovee, Y. T. Hou (Eds.). “*Cognitive Radio Communications and Networks: Principles and Practice.*” (Chapter 6) Academic Press, December 2009.

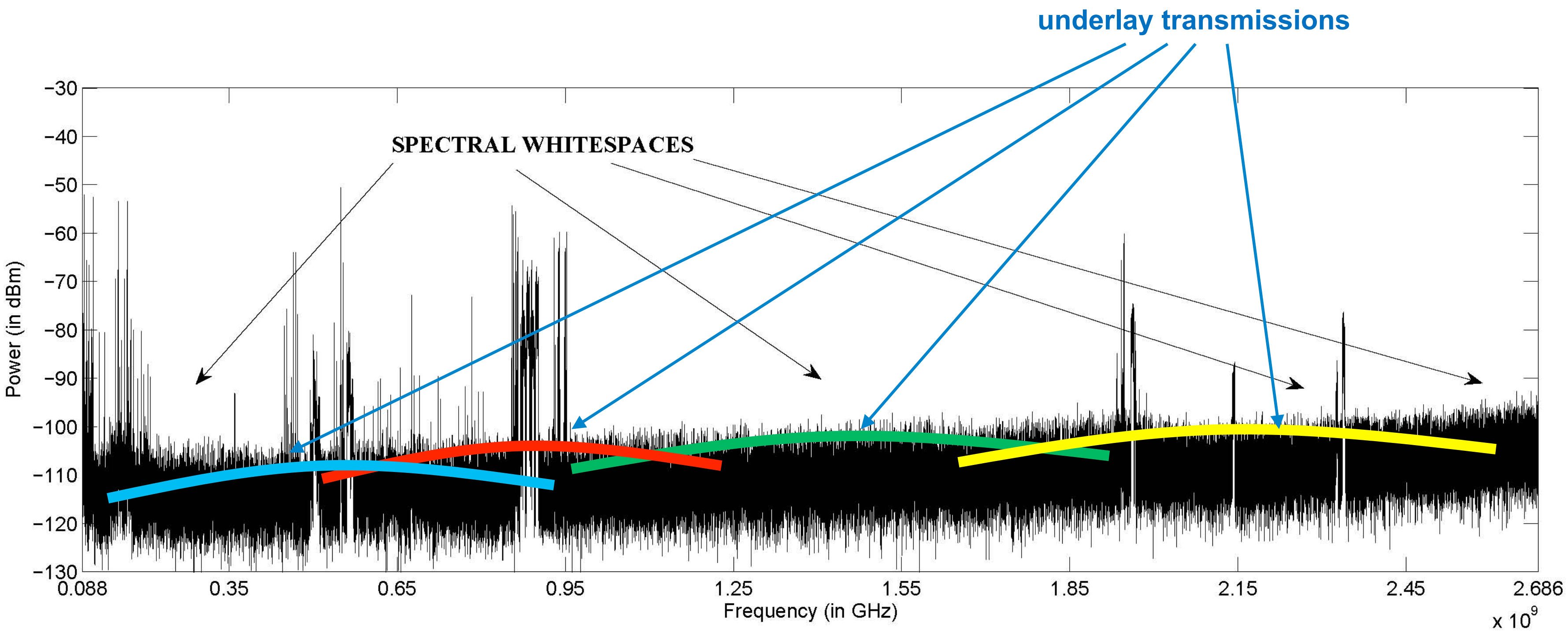
Leveraging the Electrospace

Several dimensions of the electrospace include space, time, and frequency, although there do exist others such as code, polarization, and directional.



“Cognitive Radio Communications and Networks: Principles and Practice”
By A. M. Wyglinski, M. Nekovee, Y. T. Hou (Elsevier, December 2009)

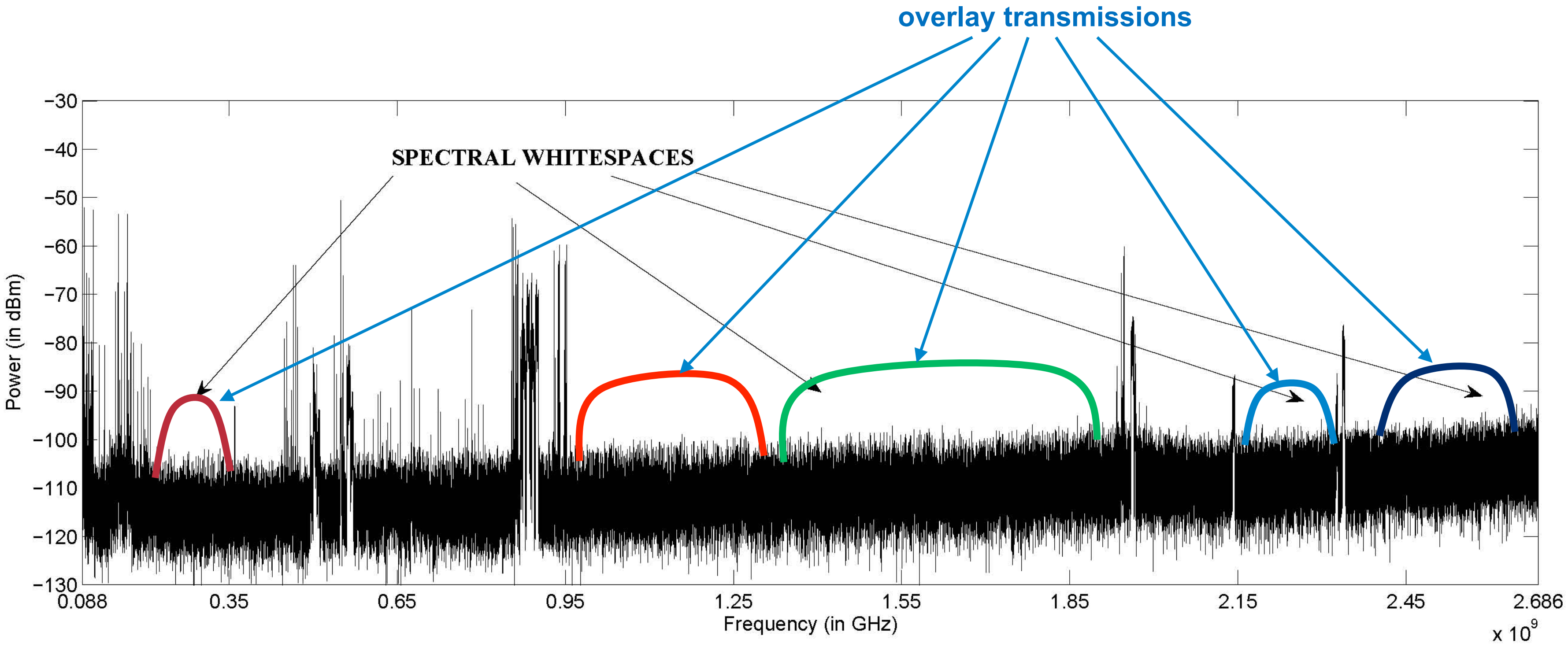
Underlay Solution



A snapshot of PSD from 88 MHz to 2686 MHz measured on July 11th 2008 in Worcester, MA (N42º16.36602, W71º48.46548)

A. M. Wyglinski, M. Nekovee, Y. T. Hou (Eds.). "*Cognitive Radio Communications and Networks: Principles and Practice.*" (Chapter 6) Academic Press, December 2009.

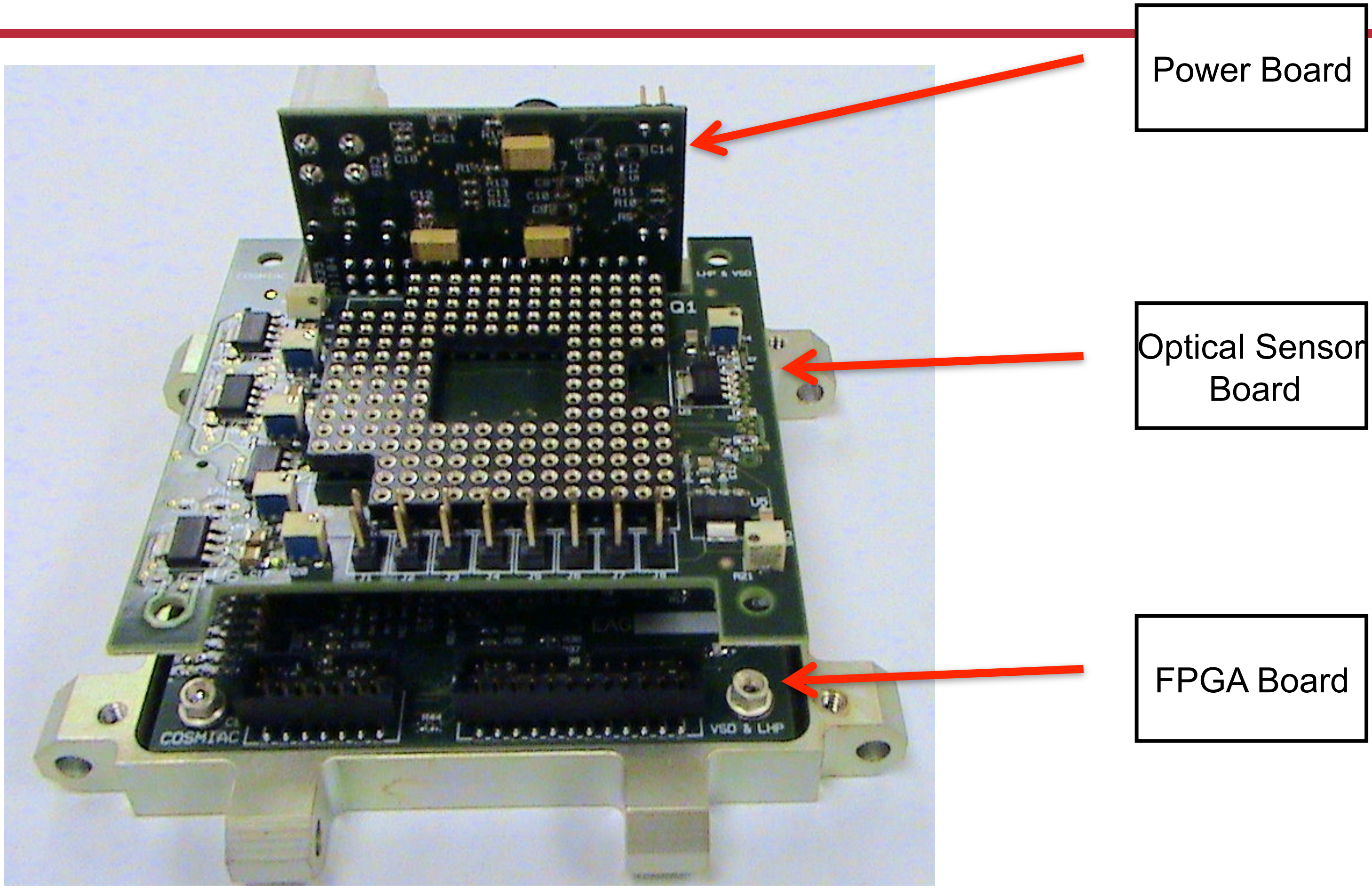
Overlay Solution



A snapshot of PSD from 88 MHz to 2686 MHz measured on July 11th 2008 in Worcester, MA (N42º16.36602, W71º48.46548)

A. M. Wyglinski, M. Nekovee, Y. T. Hou (Eds.). "*Cognitive Radio Communications and Networks: Principles and Practice.*" (Chapter 6) Academic Press, December 2009.

Software Defined Radio



Power Board

Optical Sensor Board

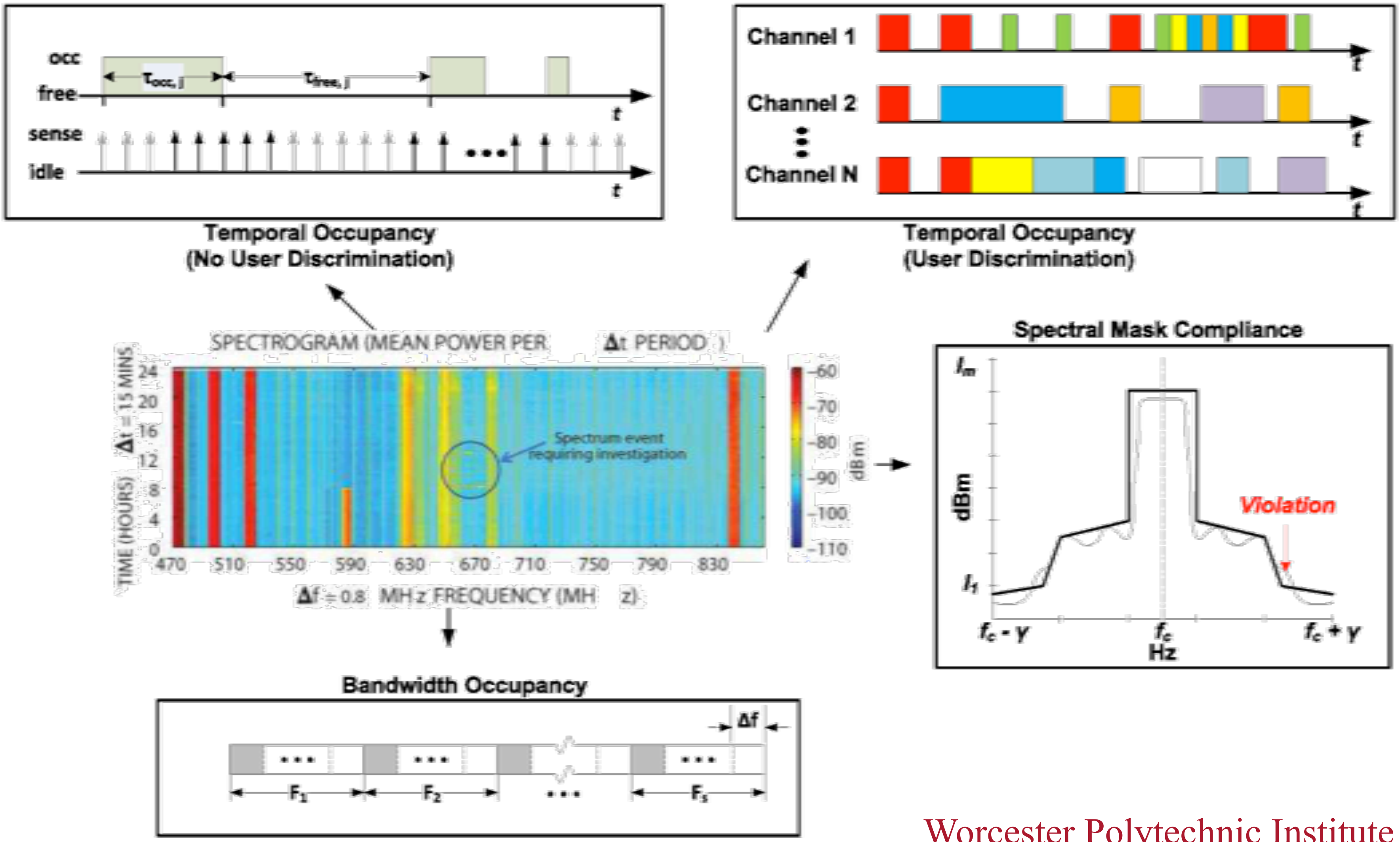
FPGA Board

COSMIAC CubeSat FPGA Board with Sensor and Power Daughtercards
(no RF daughtercards are present in this photo)

Current state of the art

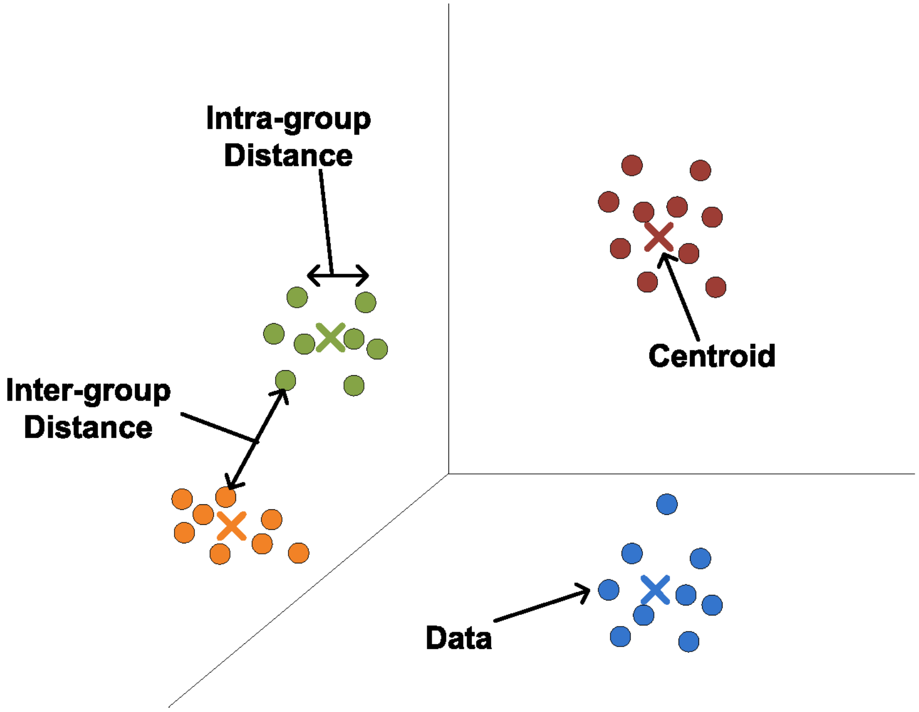
RFEye Spectrum Monitoring Solution

Probabilistic model

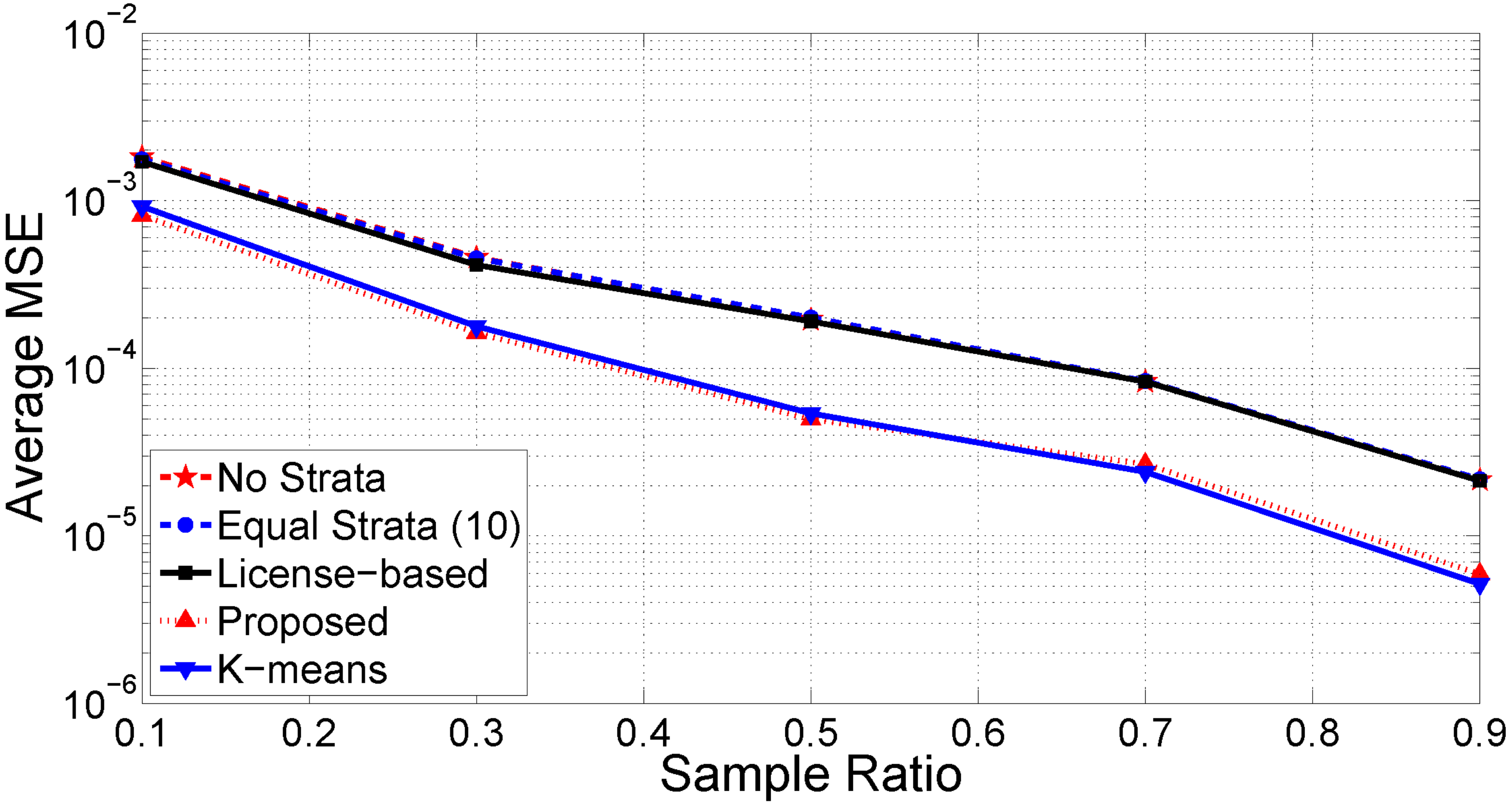


Random sampling concept

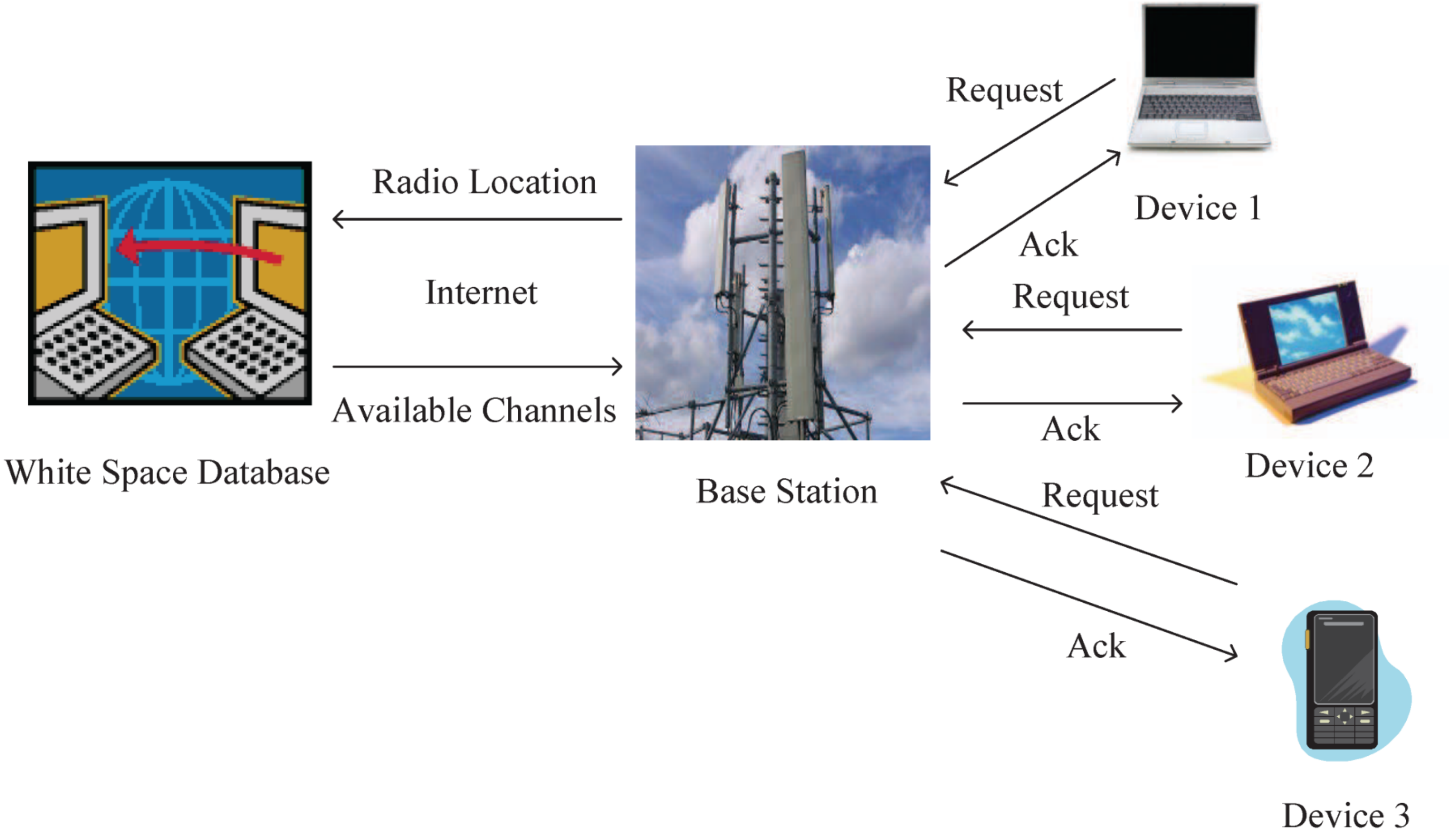
- Random sampling facilitates statistical characterization
- Random sampling designs
  - Systematic, SRS, stratified, cluster,...
- Data grouping and sample allocation are crucial to effective characterization
- Benefits
  - Dimensionality reduction, summarization, estimator variance reduction, sampling bias reduction



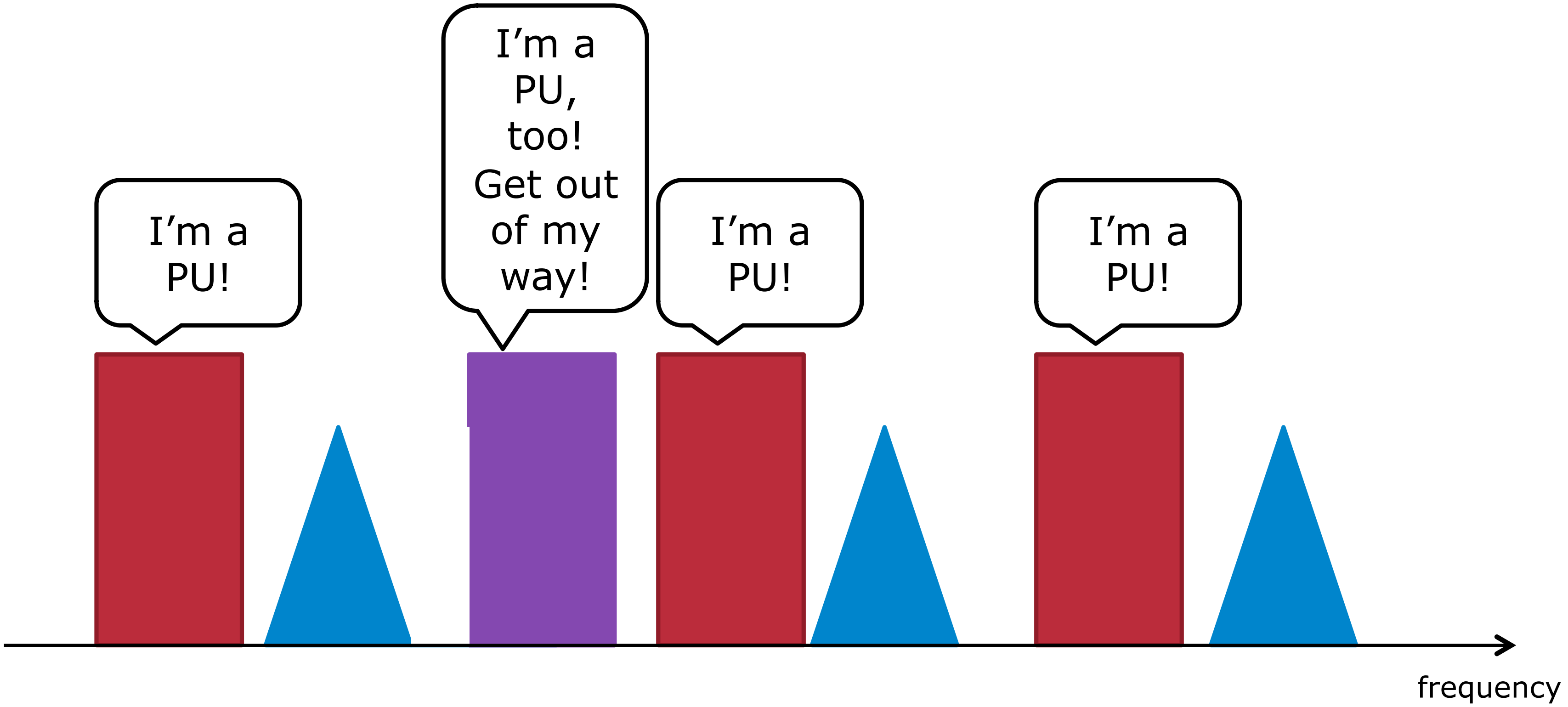
Results


Average MSE
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Sample Ratio
No Strata
Equal Strata (10)
License−based
Proposed
K−means

How is secondary wireless access currently managed?



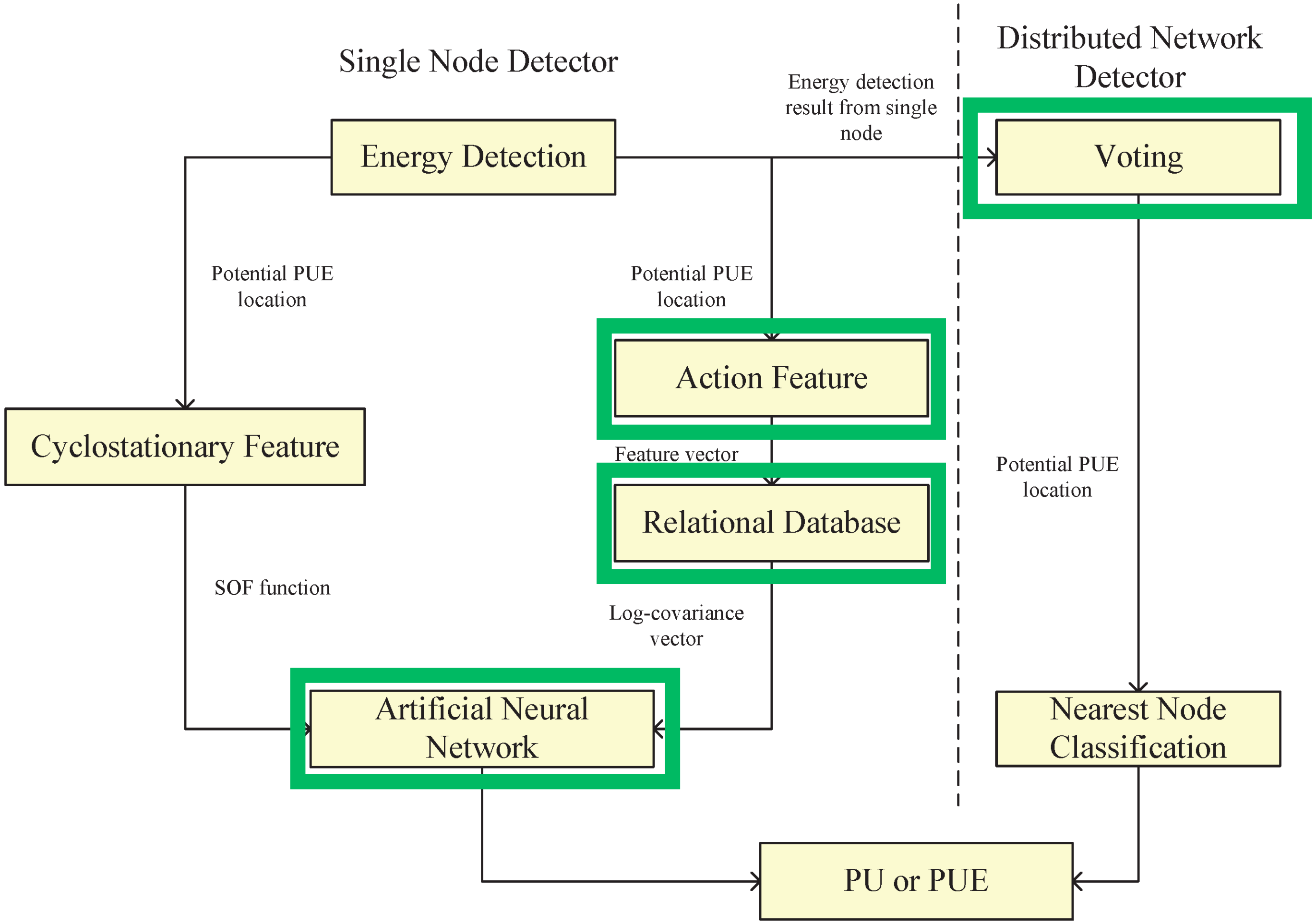
Potential vulnerability



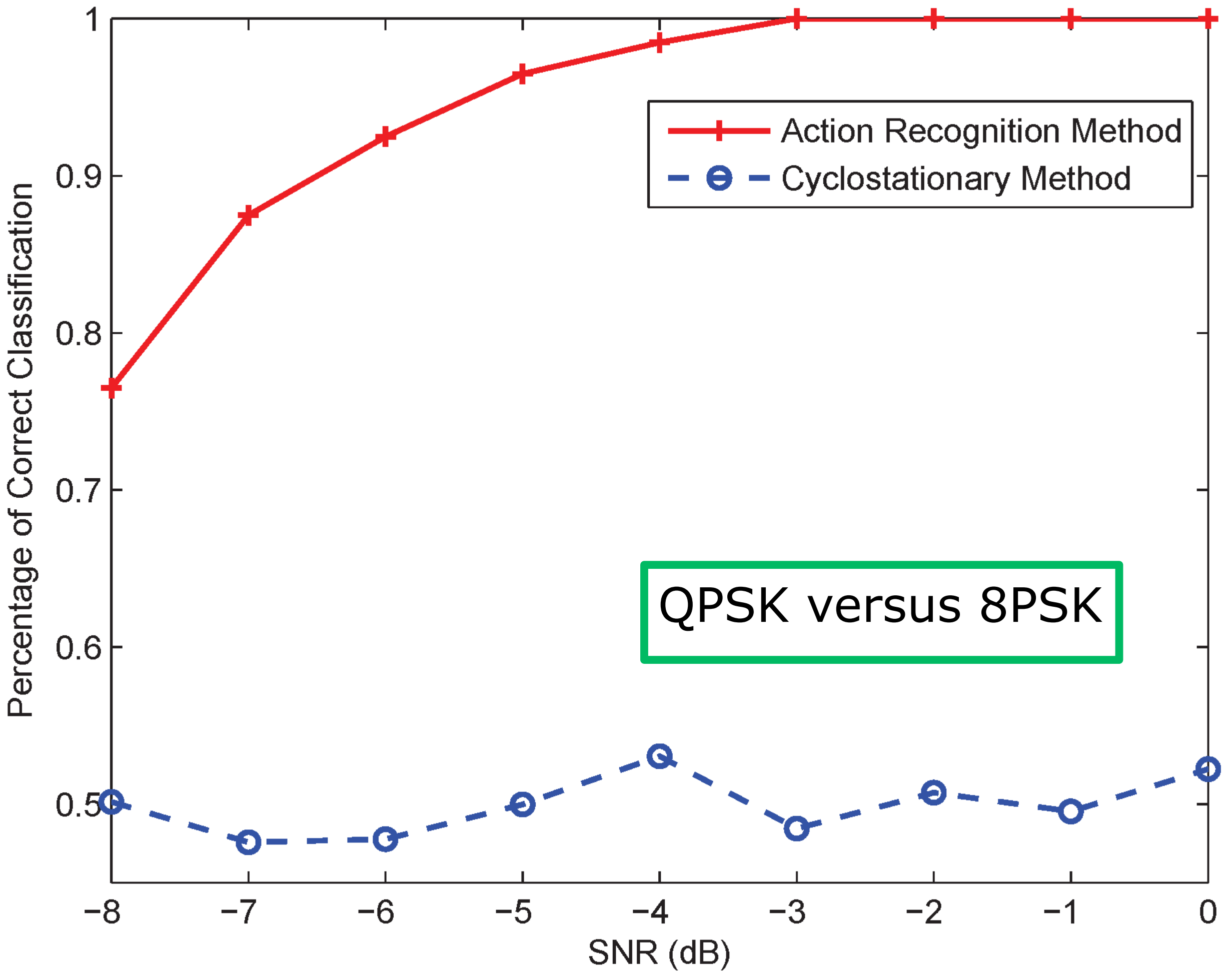
Existing techniques

- Energy Detection
  - Possess a significant probability of missed detection
- Localization-based Detection
  - Can only be employed for stationary primary transmitters with known coordinates
- Analytical Model-based Detection
  - Only works well for a specific network model
- Signature-based Detection
  - Require special hardware or software

Proposed approach

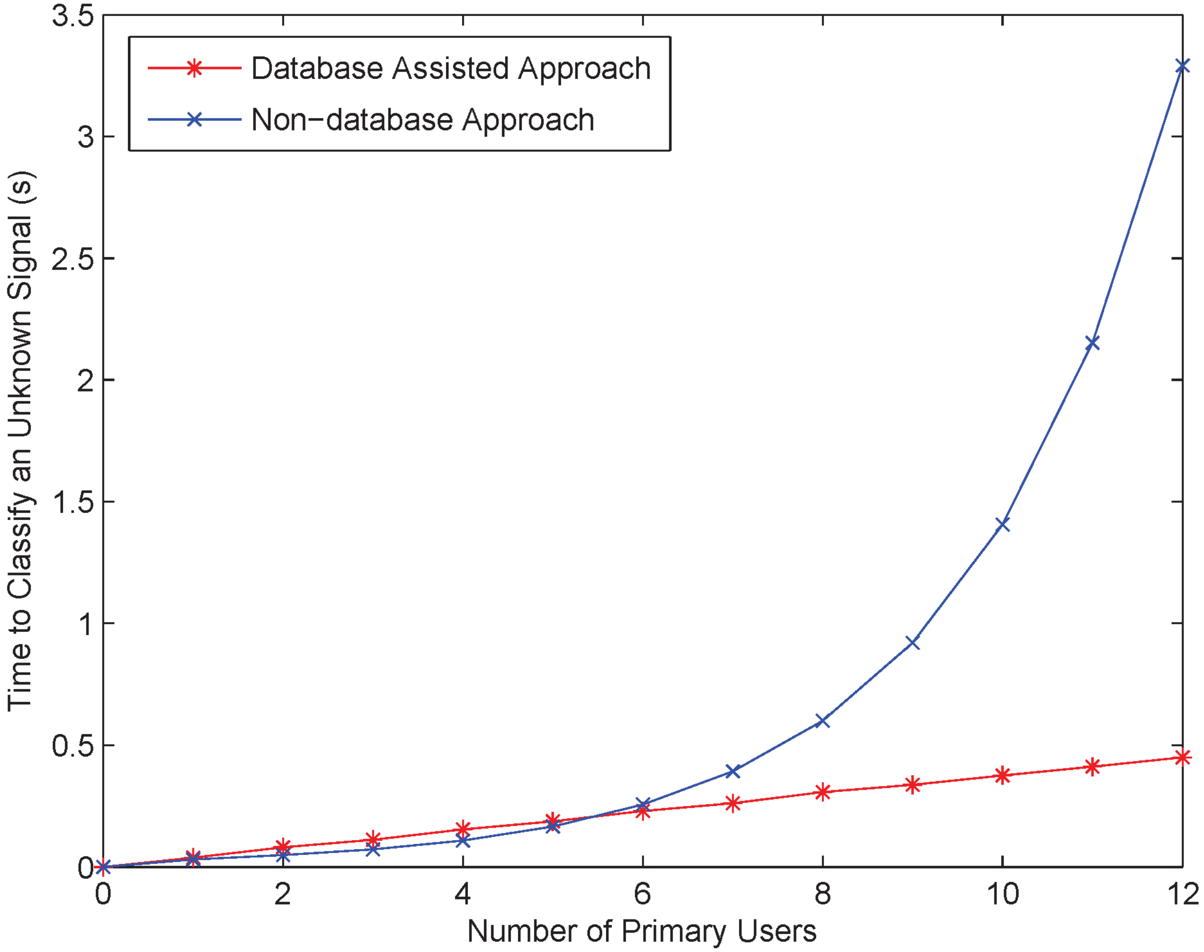


Results

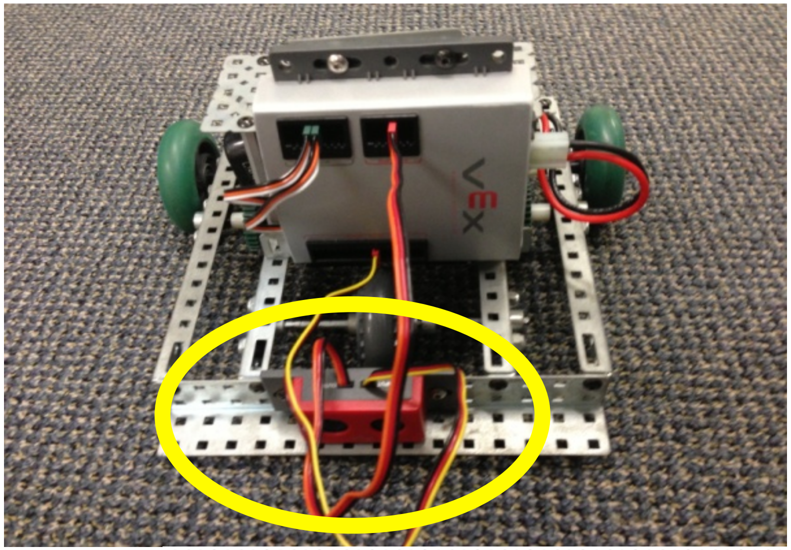


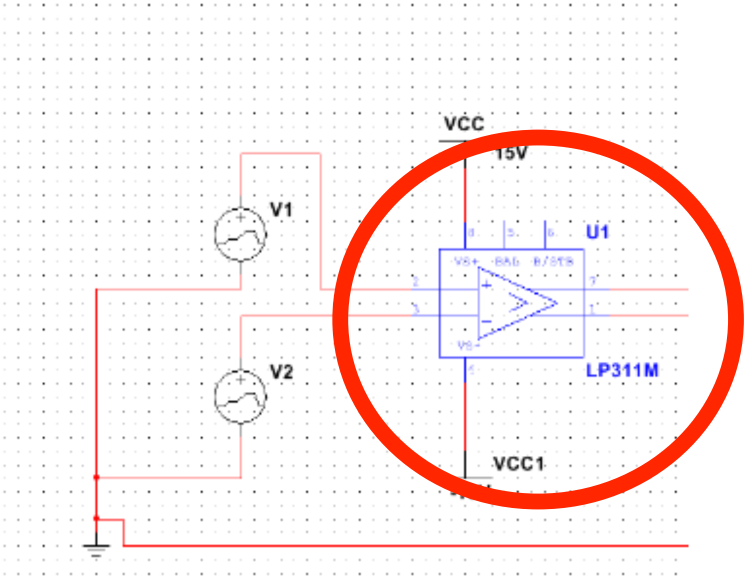
1
0.9
0.8
0.7
0.6
0.5
Percentage of Correct Classification
−8
−7
−6
−5
−4
−3
−2
−1
0
SNR (dB)
Action Recognition Method
Cyclostationary Method
QPSK versus 8PSK

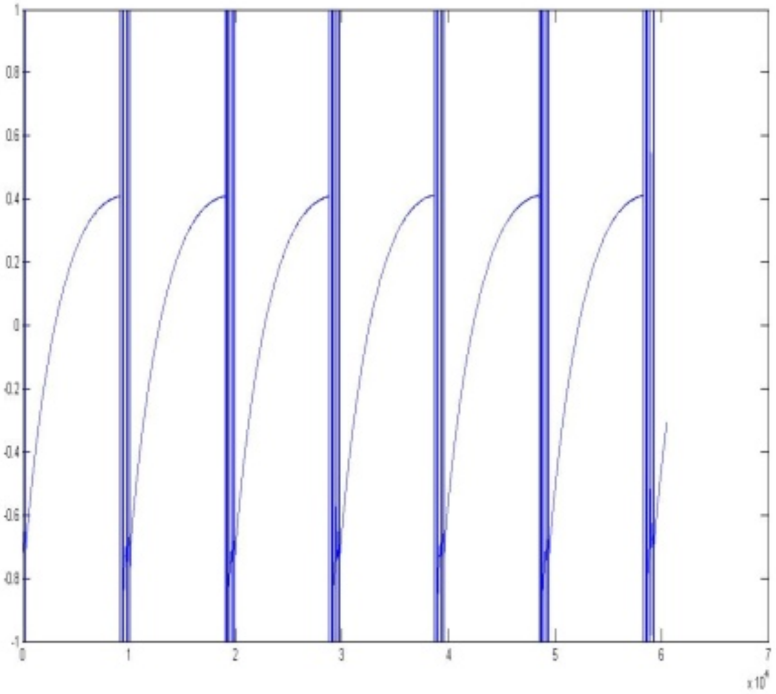
Results


Database Assisted Approach
Non−database Approach
Time to Classify an Unknown Signal (s)
Number of Primary Users
3.5
3
2.5
2
1.5
1
0.5
0
0
2
4
6
8
10
12

Sensor Attacks

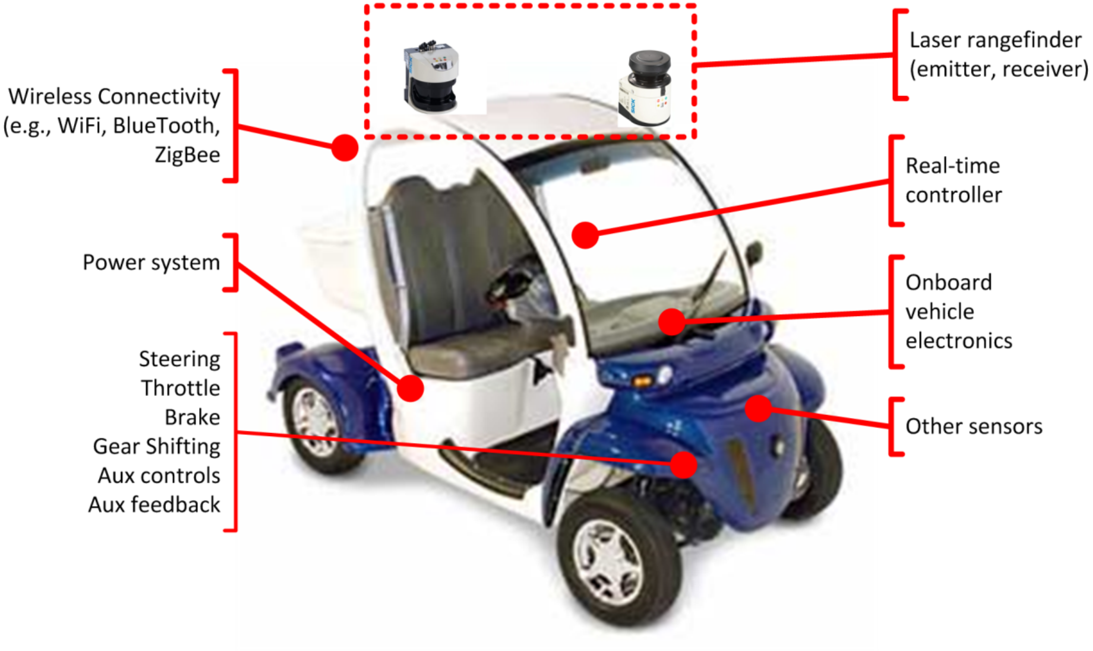






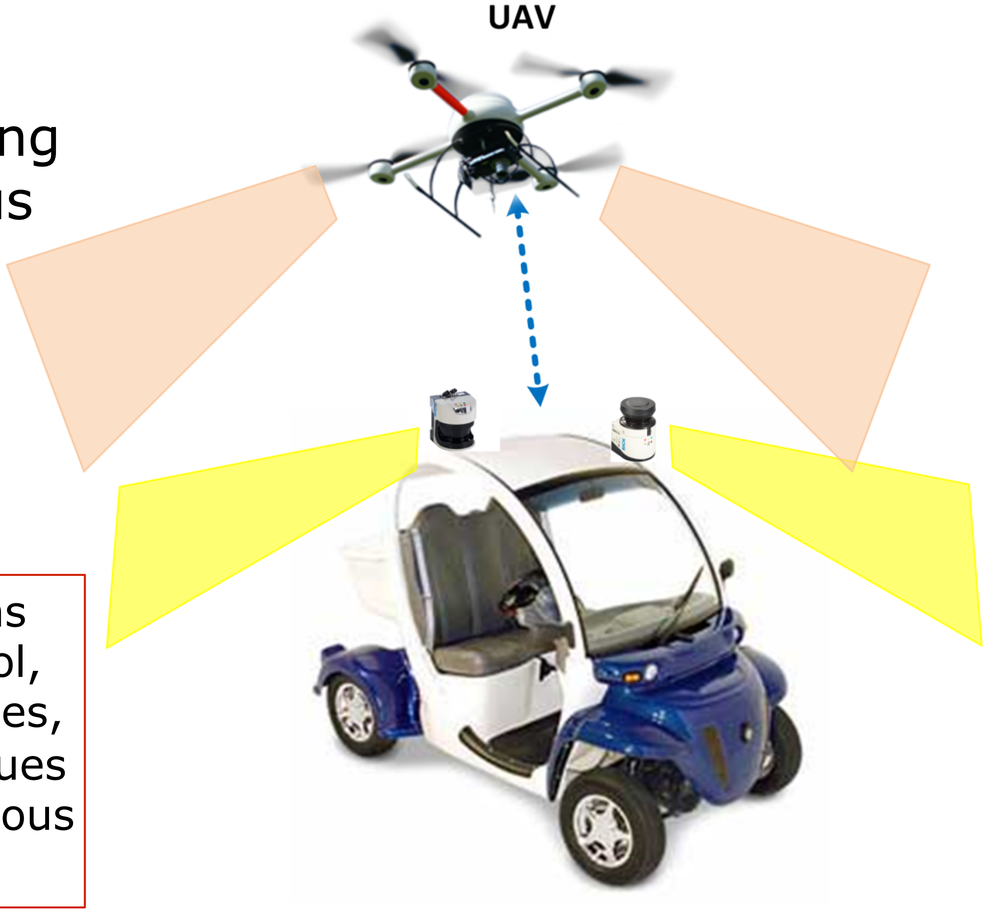
SAVES: Secure Autonomous Vehicle Embedded Computing and Sensing

- Full project plan invited for submission via NATO SPS programme
- Collaborators from Georgian Technical University and Ss. Cyril and Methodius University
- Three year project



Collaboratively Navigating Autonomous Systems

A 5-student MQP team focusing on collaborative autonomous vehicle networks



Combining wireless communications and networking, autonomous control, data fusion, decision making processes, image processing, and other techniques to form a simple network of autonomous vehicles that cooperate together.

Contact Information

Professor Alexander Wyglinski

Department of Electrical and Computer Engineering
Worcester Polytechnic Institute
Atwater Kent Laboratories, Room AK230

508-831-5061

alexw@ece.wpi.edu

http://www.wireless.wpi.edu/