

# Context Aware Cognitive Radio for Automated Wireless Systems Management

## An Introduction to Big RF

**James Neel**<sup>1</sup>, Shaswar Baban<sup>2</sup>, Pete Cook<sup>1,3</sup>,  
Ihsan Akbar<sup>4</sup>, Charles Sheehe<sup>5</sup>, Neal Mellen<sup>6</sup>,  
Bob Schutz<sup>7</sup>

1. **Cognitive Radio Technologies**
2. King's College London
3. Peter G. Cook Consultancy
4. Harris Corporation
5. NASA
6. Wireless Spectrum Management, LLC
7. Artisan Wireless Solutions

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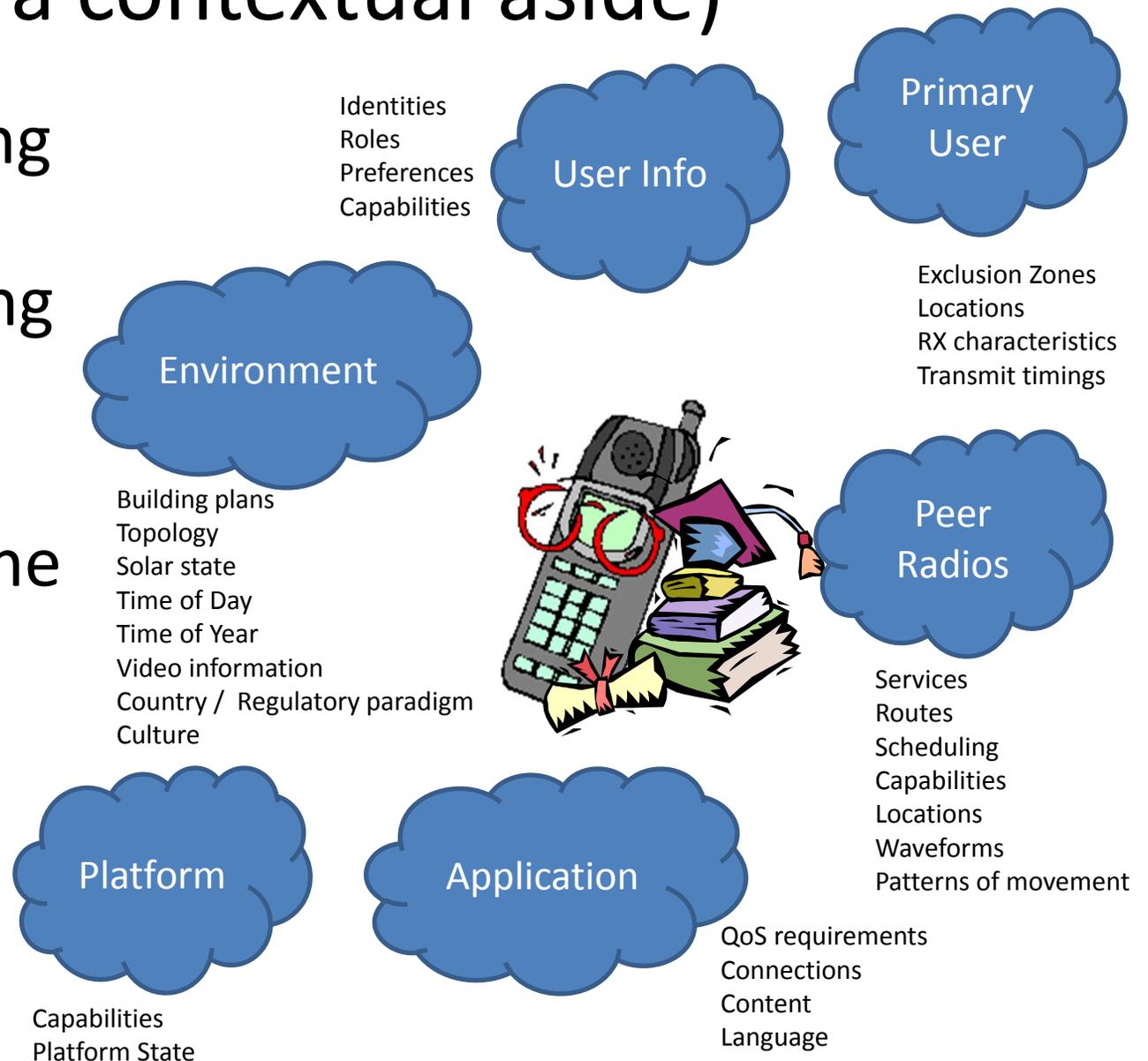
# Presentation Outline

- What is Big RF?
- CRWG Big RF Activities in the Paper
  - Adapting Big Data architectures to Big RF
  - Use Cases
  - WISDM Analysis
- Future and Related Work

# What is Big RF?

## (By way of a contextual aside)

- Understanding something implies placing it in proper context.
- But what is the context of a cognitive radio?



# The challenges in achieving contextual awareness led us to Big RF

- **Volume** Number of sources can be quite large
- **Velocity** Many different timescales – channel coherence time to the pace of regulatory change
- **Variety** Context almost always requires information from external sources with different formats
- **Veracity** – trust and corruption of observations due to wireless medium

# Big RF

Making use of a real time spectrum dashboard gets complex quickly

- **Big Data (loosely defined)**
  1. a collection of emerging techniques and processes for rapidly acquiring, classifying, and synthesizing meaning from Terabytes or Petabytes of data
  2. the data itself.
- **Big RF (loosely defined)**
  1. the application of Big Data tools / techniques / approaches to address RF-domain problems

**Velocity** A single spectrum logger, such as D-TA's RFVision 2 logs data at the rate of 19.2 Gbps [5]. To maintain a nationwide network of such sensors mounted at each cell tower in the US (260,000 towers) [6] would generate approximately 5 Petabits of data per second.

**Volume** To analyze trends over a single year without loss of data, this would then require 15.7 Zetabits of storage

**Variety** More realistically, spectrum measurements would come from a variety of sources, such as cell phones, base stations, and access points, which would have differing data formats and often duplicate observations of the same phenomena though with seemingly disparate measurements.

**Veracity** An important aspect of many communication links and networks is verification of the identity of the radio to determine the validity of the data being transmitted.

# Current CRWG Big RF Activities

- **Refine the concept** - Differences and similarities between Big Data and Big RF
- **Survey the landscape** - enabling tools, technologies to identify gaps and development opportunities
  - Hadoop, SDN, NVF, TVDB, SSRF, representation languages, context toolkit
- **Use cases** - Refine and test our designs and to estimate benefits and risks
  - Commercial, military, public safety, CR-related
  - Poisoned databases, quasi-identifier privacy / security
- **Different project management approach**
  - Work for a couple months, write a paper
  - Knit together 7-8 publications at the end into a more traditional WinnF report

# A Big Data Architecture (Informally)

- **Data Sources** – inputs from a variety of sources depending on application
- **Initial Analysis** – analysis performed on the input data via a mix of streaming and batch processing (though Figure 1 only indicates streaming analysis) for real-time or near-real time intelligence.
- **Retrospective Analysis** - after initial storage in a presumably large database, new predictive models or processes tailored to specific applications (business logic)

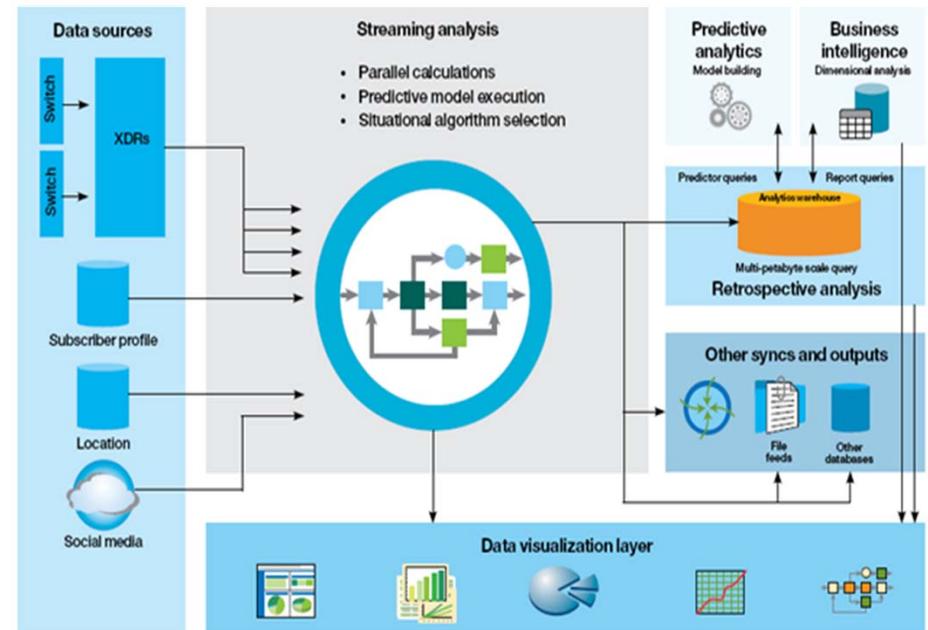
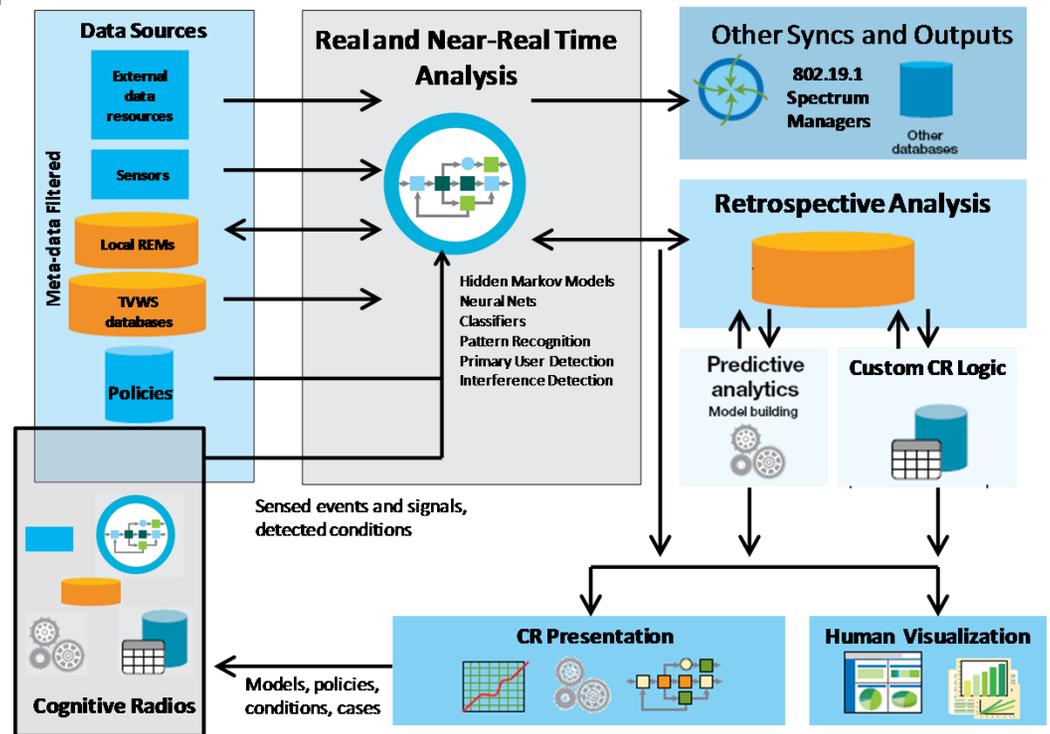


Fig 2 in IBM Corp, "Big data analytics for communications service providers," white paper, Oct. 2012.

- **Visualization** – For most Big Data systems, the aim is to better inform **human** decision makers of key insights that may derive from different points in the analysis process

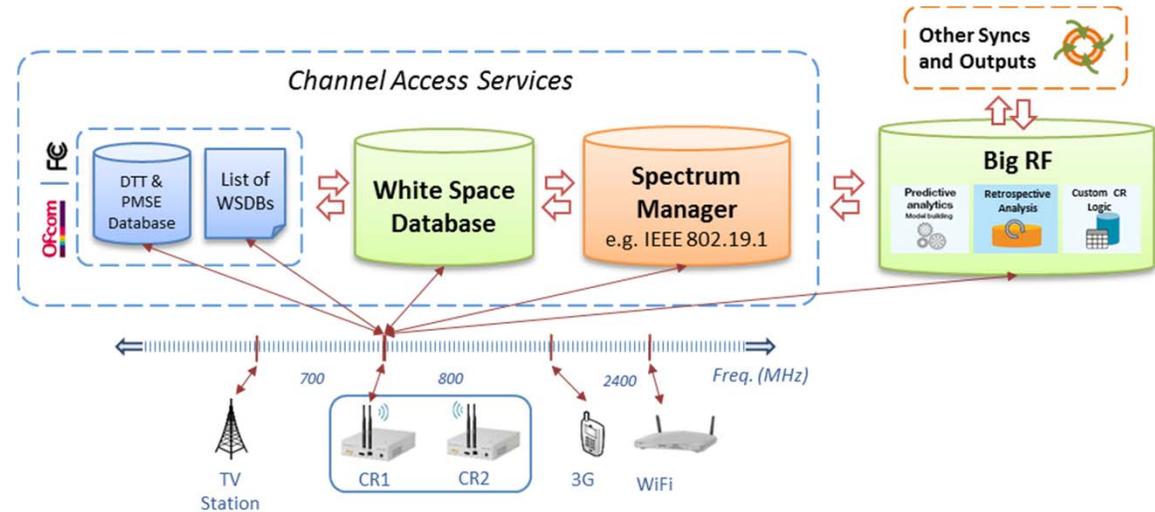
# Big RF vs Big Data

- **RF Focus**
  - Data sources are more focused on RF
  - Customized RF-specific logic
- **Multiple analysis consumers**
  - CR and human
  - Implies CR “presentation” layer for Big RF results
  - Could assist each other
- **Looping data flow** –
  - CR is both consumer and source
  - Feedback loops => stability concern
    - And security!



- **Self-similarity** –
  - Loosely, CR and Big RF are implementing the same processes
  - Implies
    - means to scale up
    - Possibility of distributed implementation

# Use Cases

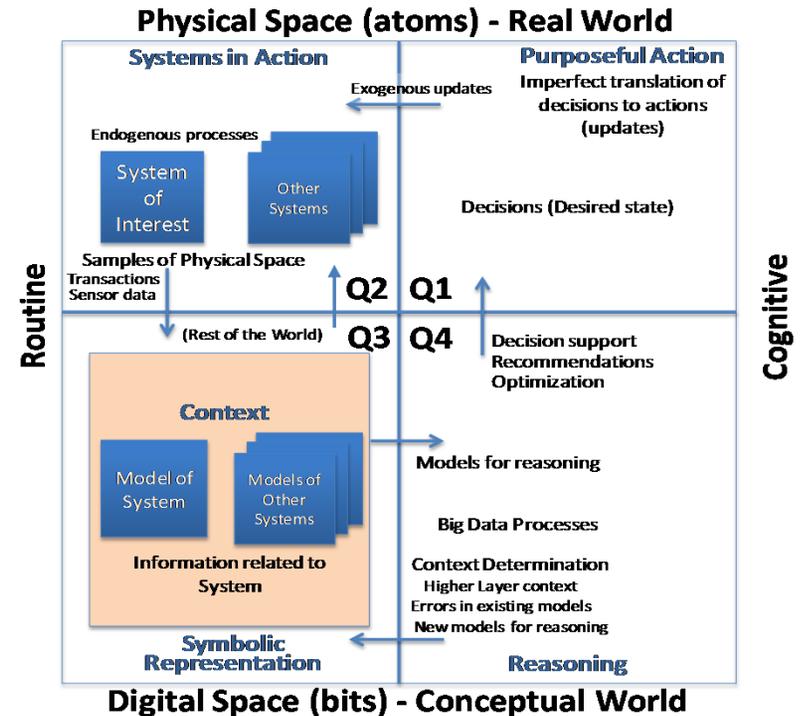
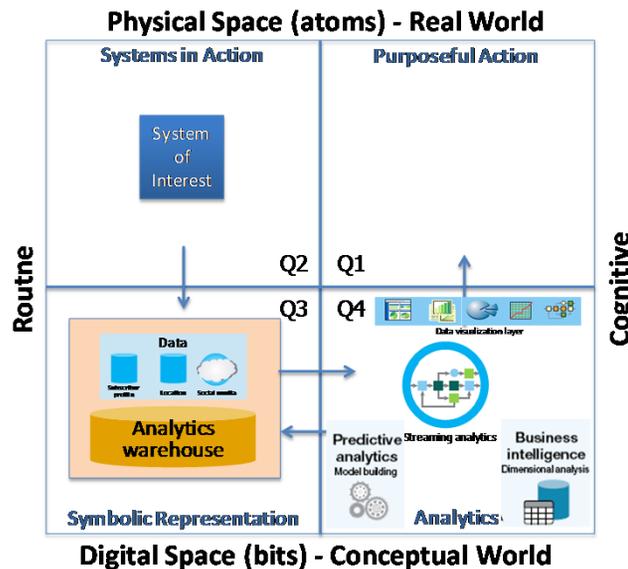


- Cellular
  - Learn about network characteristics and optimize capacity or address coverage holes
- Public Safety
  - Closely related to PSSIG context-aware CR activities
- NASA ELectronic Radio Database Systems (NERDS)
  - Track and manage a large diverse set of spectrum using resources

# WISDM

## Wireless Information System Descriptive Model

- Model developed in CRWG to better understand processes involved with an intelligent wireless system
  - Really applies to any intelligent system



- Mapping Big Data / Big RF into WISDM
  - Emphasized lack of closed decision loop in typical Big Data
  - “Routine / Reactive” processes related to immediate CR adaptations
  - “Cognitive” may leverage Big RF analysis resources

# Future and Related Forum Work

- Refining scope and definition
- Implementation approaches
  - Languages
  - Architectures
  - Tools
- Security
  - Database poisoning
  - Privacy concerns
  - In presence of noise
- Dynamics
  - Looping
  - Accommodating multiple time scales
- Public Safety SIG
  - Elements of context in public safety communications
- Open Standard Spectrum Resource Format (SSRF)
  - Exchanging RF-related information between databases and devices
  - TVDB extension
  - SSRF was one of the context languages studied in earlier Phase of this project

# Want to Help?

- Weekly Virtual Meetings
  - Wednesday 11:30-12:30 (Eastern)
  - +1 (626) 521-0010
  - Go To Meeting ID: **950203273**
- “Meat-space” Meeting Tomorrow (Wednesday)
  - 10:30 – 12:00 (By the cafeteria)
  - CBC Café 611
  - Virtual Meeting Info above still holds
- Have an existing document we should be aware of?
  - Email: [james.neel@crtwireless.com](mailto:james.neel@crtwireless.com)
- Want to write something new related, but outside the group?
  - Soliciting Big RF related papers for SDR Europe 2014
  - (Great excuse to go to Rome)