Microsoft Spectrum Observatory

Ranveer Chandra

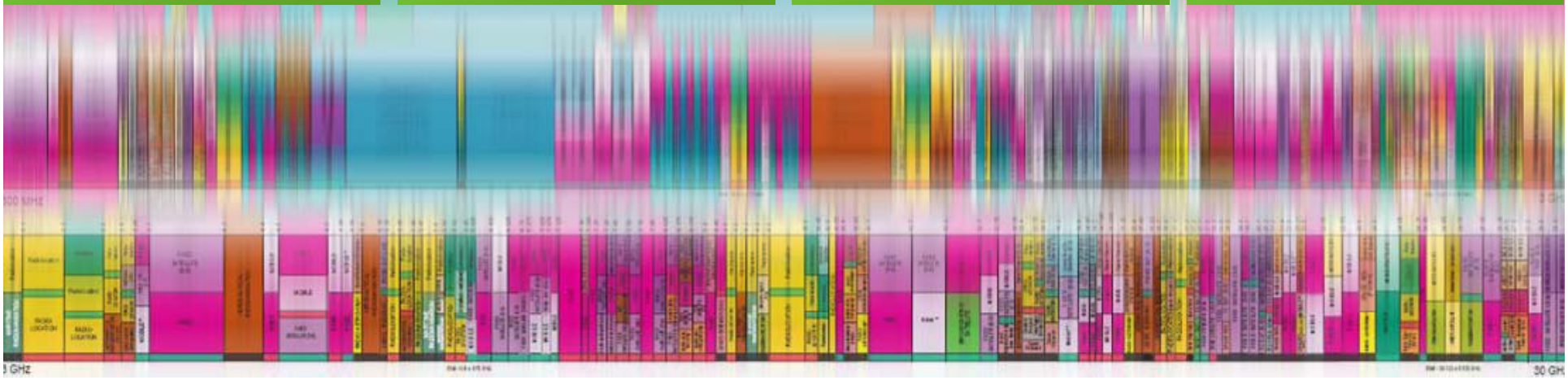
Microsoft Research

Joint work with Technology & Policy Group

p Gupta, Jason van Eaton, Matt Valerio, Paul Garnett, Paul Mitchell, David Tennenh

owing Demand

24 HOURS UPLOADED EVERY **60 SECONDS**	**20X - 40X** OVER THE NEXT **FIVE YEARS**	**50 BILLION** CONNECTED DEVICES **BY 2020**	**35X** 2009 LEVELS **BY 2014**
Video Uploads	Streaming Video Increasing Wireless Demand	Devices Proliferation*	Mobile Data Traffic**



∗*See* Ericsson Press Release, quoting its President and Chief Executive Officer Hans Vestberg, April 13, 2010, available at http://www.ericsson.com/thecompany/press/releases/2010/04/1403231

**. Federal Communications Commission, Staff Technical Paper, Mobile Broadband: The Benefits of Additional Spectrum, OBI Technical Paper No. 6 (Oct. 2010).

owing Demand

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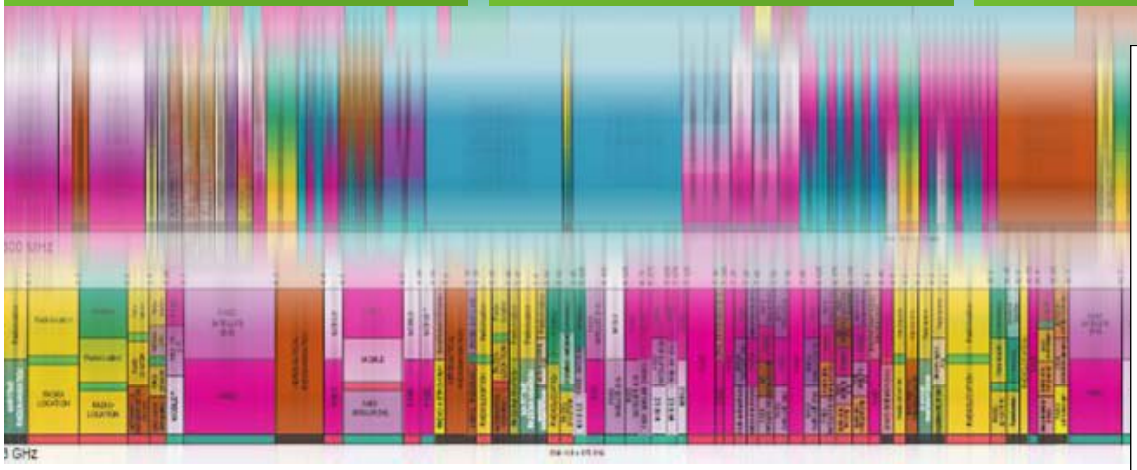

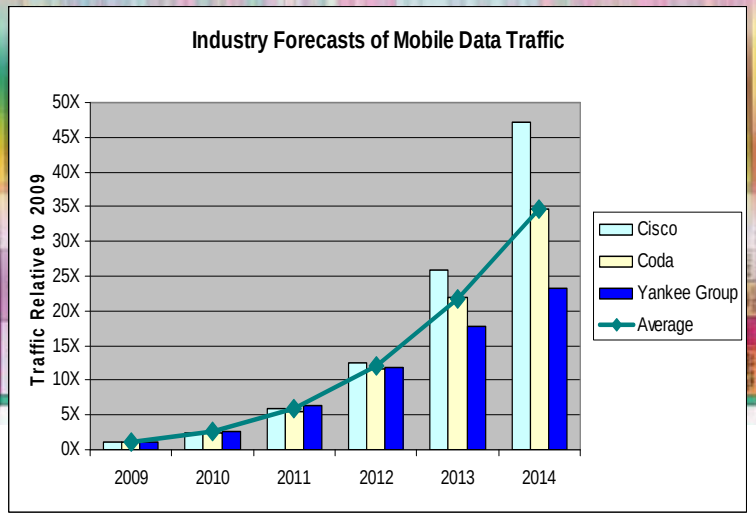

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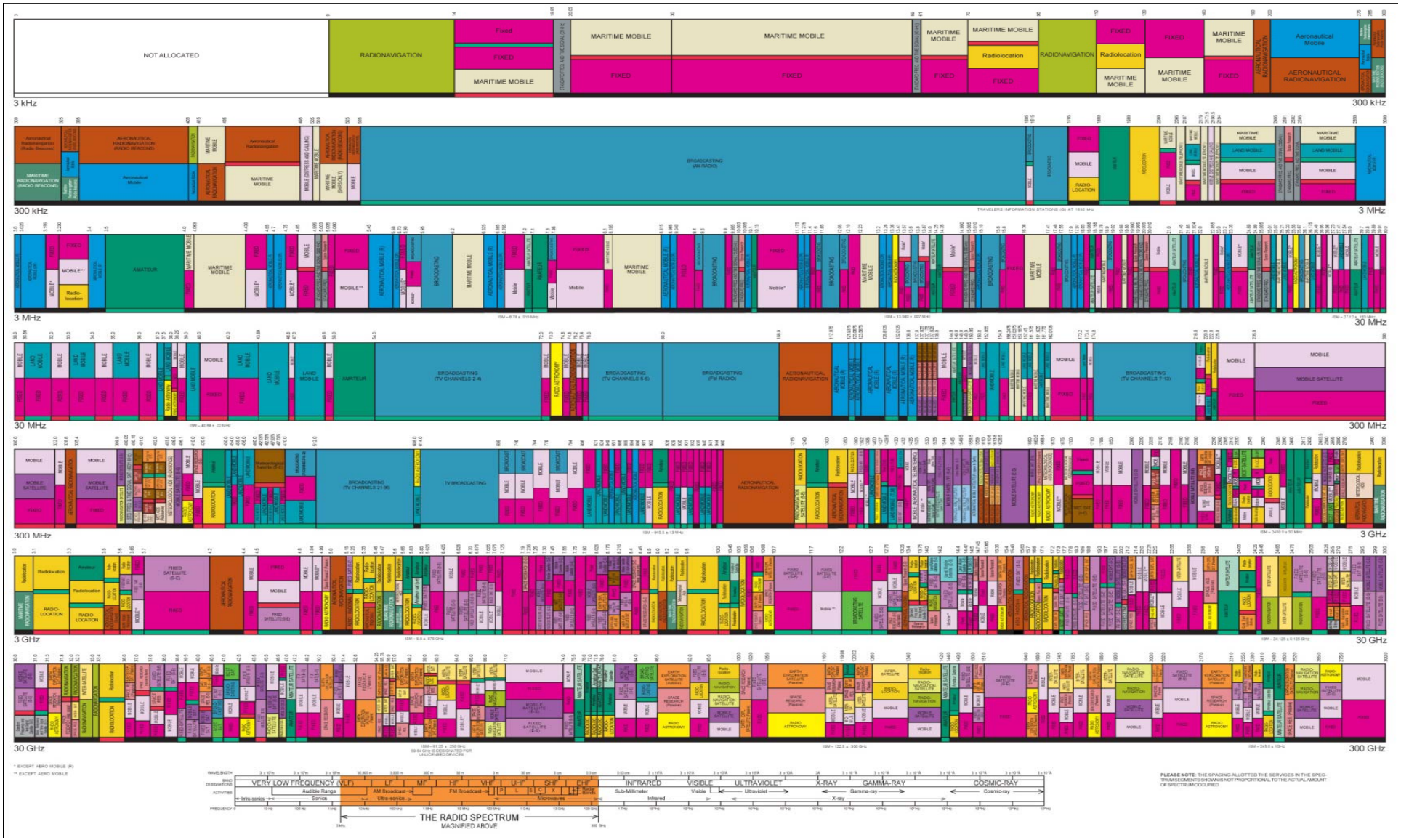
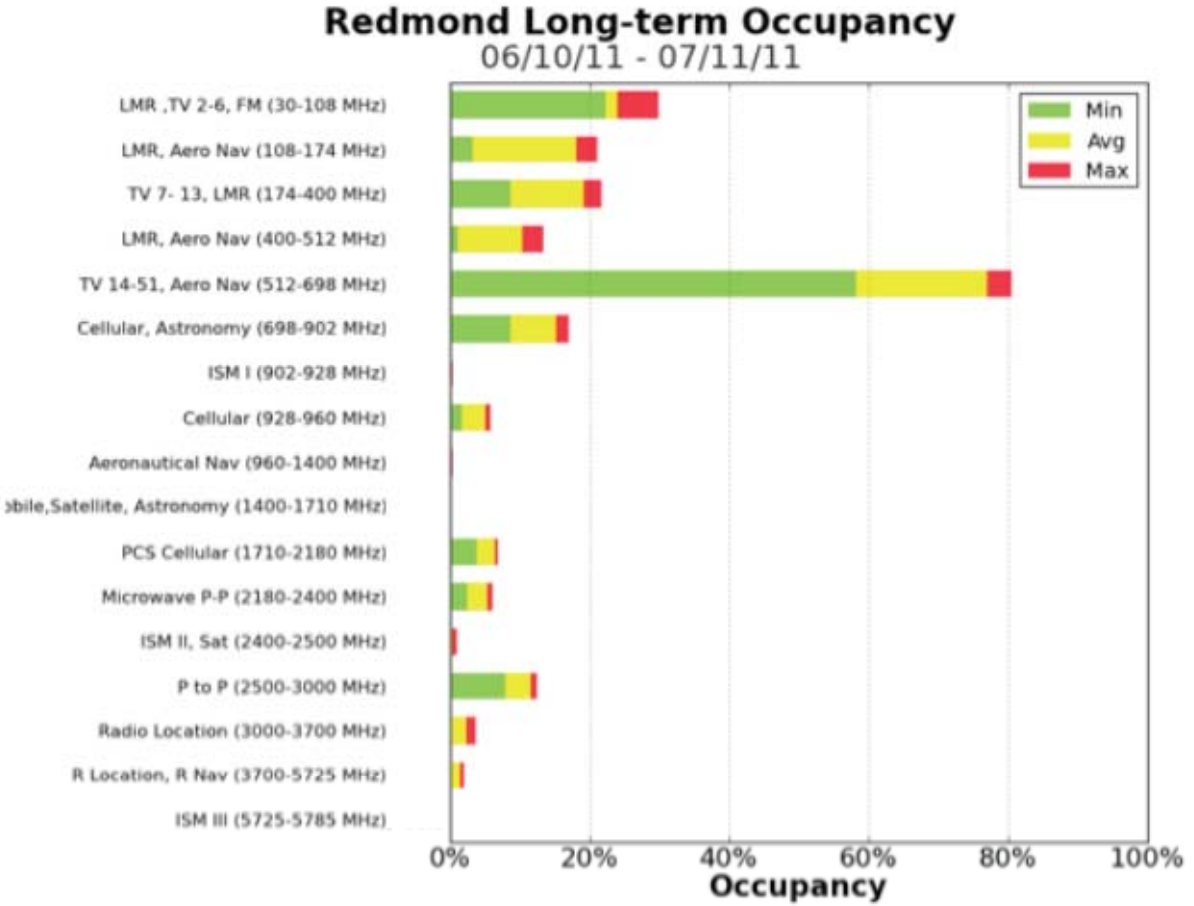
ectrum Allocation in the US

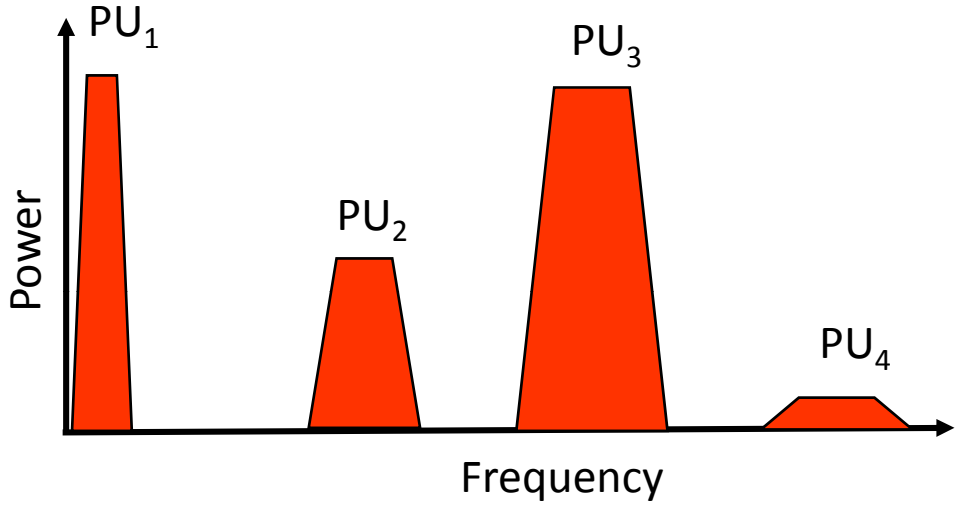


contrast...

Large portions of spectrum is unutilized



namic Spectrum Access (DSA)



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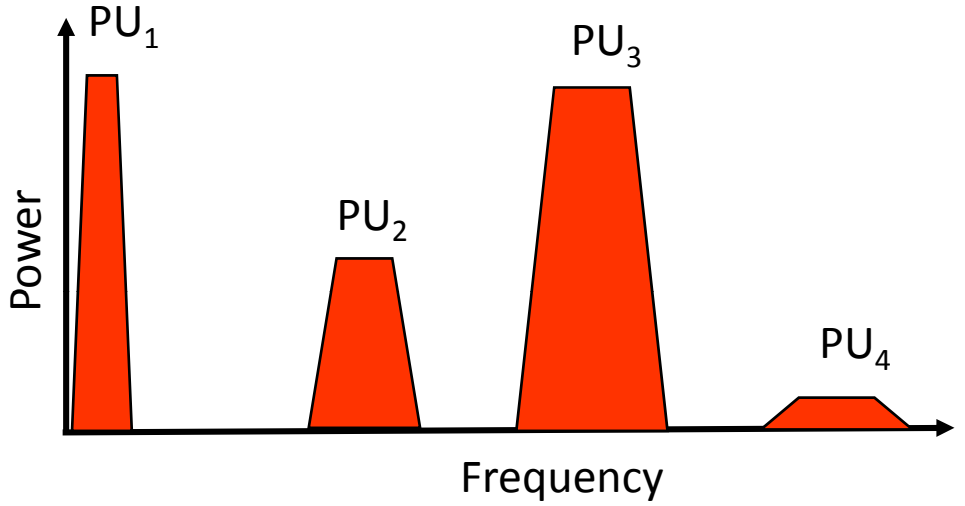

- **Determine** available spectrum (**white spaces**)

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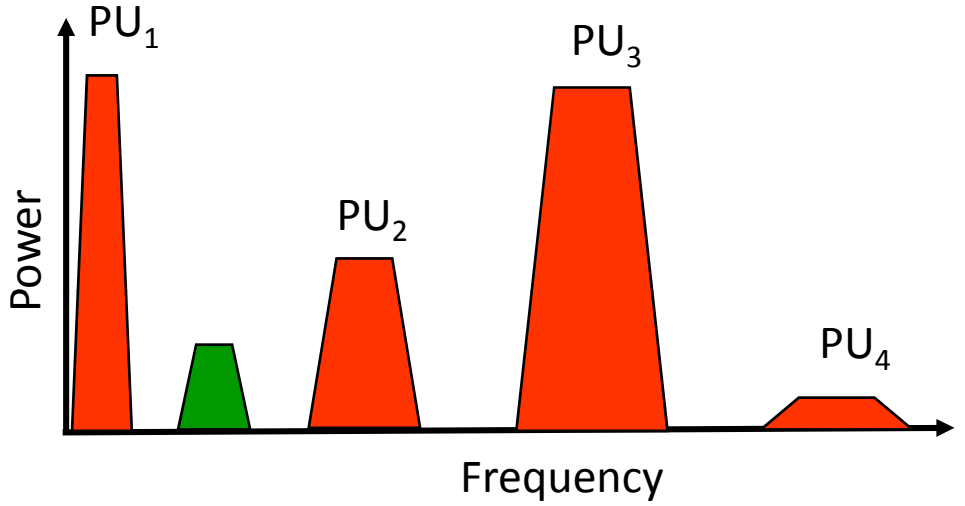

- **Determine** available spectrum (**white spaces**)
- **Transmit** in "available frequencies"

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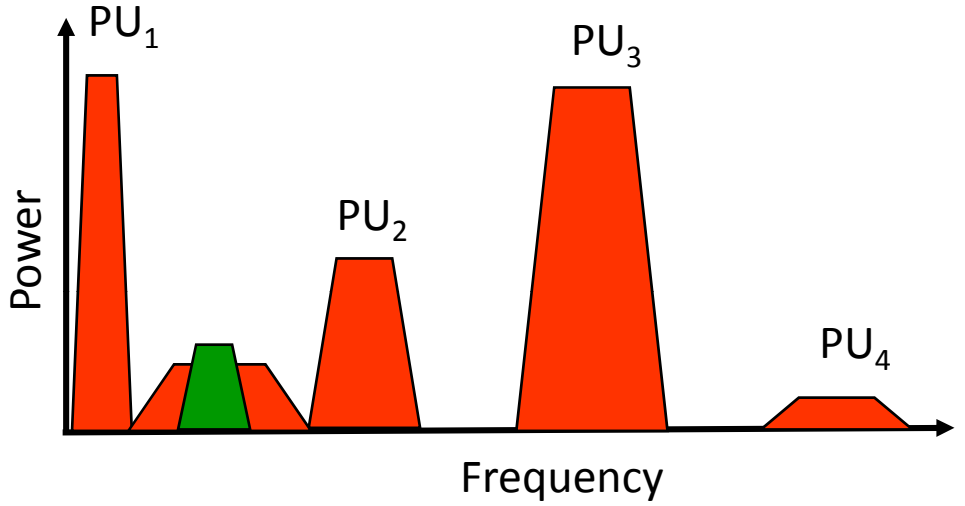

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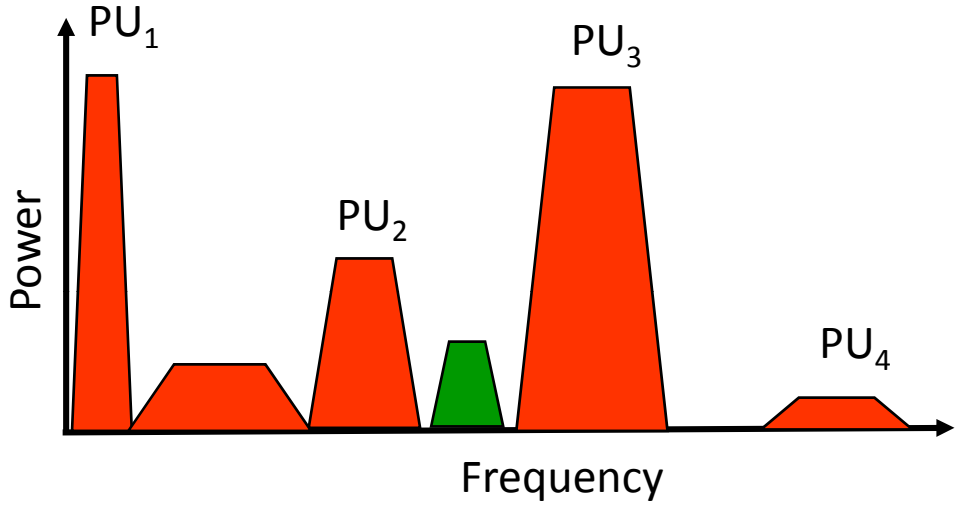

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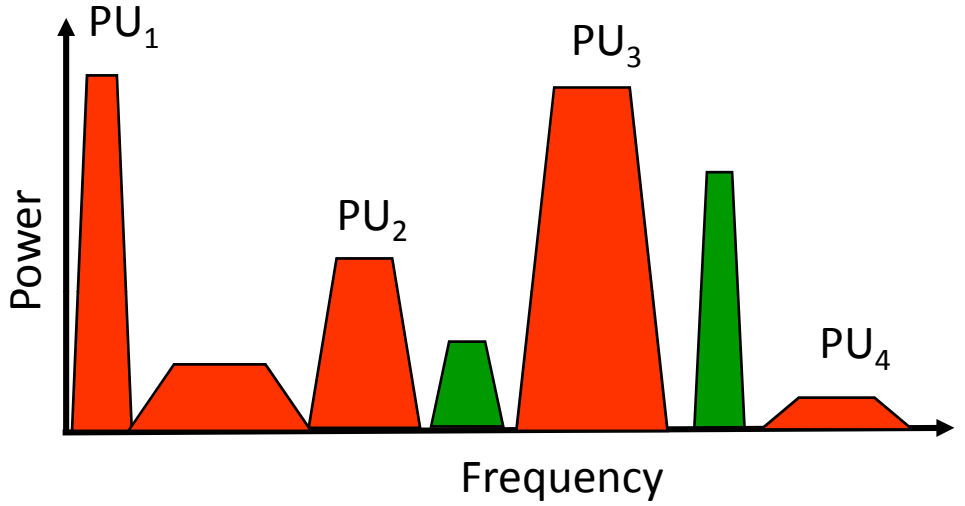

- **Determine** available spectrum (**white spaces**)
- **Transmit** in "available frequencies"
- **Detect** if primary user appears
- **Move** to new frequencies
- **Adapt** bandwidth and power levels

SR KNOWS Program (2005 – …)

1: Ad hoc networking in TV white spaces

DySPAN 2007, MobiHoc 2007, LANMAN

Capable of sensing TV signals, hardware functionality

2: Infrastructure based networking **(WhiteFi)**

Capable of sensing TV signals & microphones, deployed in lab

SIGCOMM 2008, SIGCOMM 2009 (Best

3: Campus-wide WhiteFi network + geolocation

Deployed on campus, and provide coverage in MS Shuttles

DySPAN 2010 (Top 3 paper), CoNEXT 2011 (Top

4: White spaces beyond TV spectrum

Spectrum measurements to identify additional white spaces

oblem Statement

For a given region, which spectrum bands are best to form DSA
networks?

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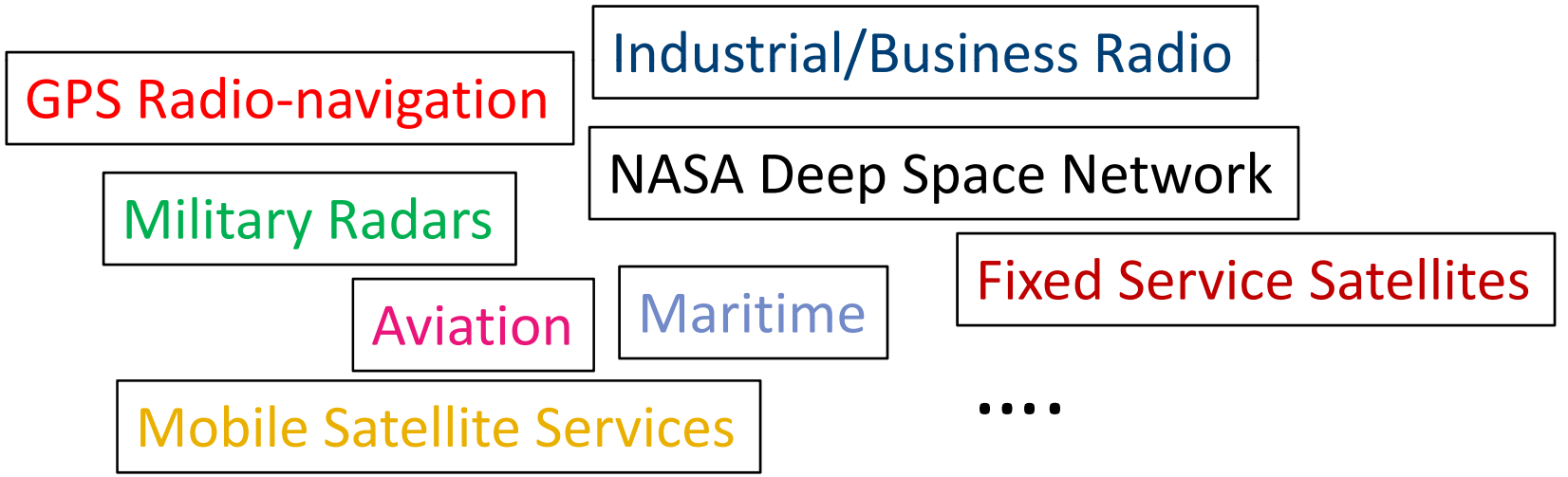
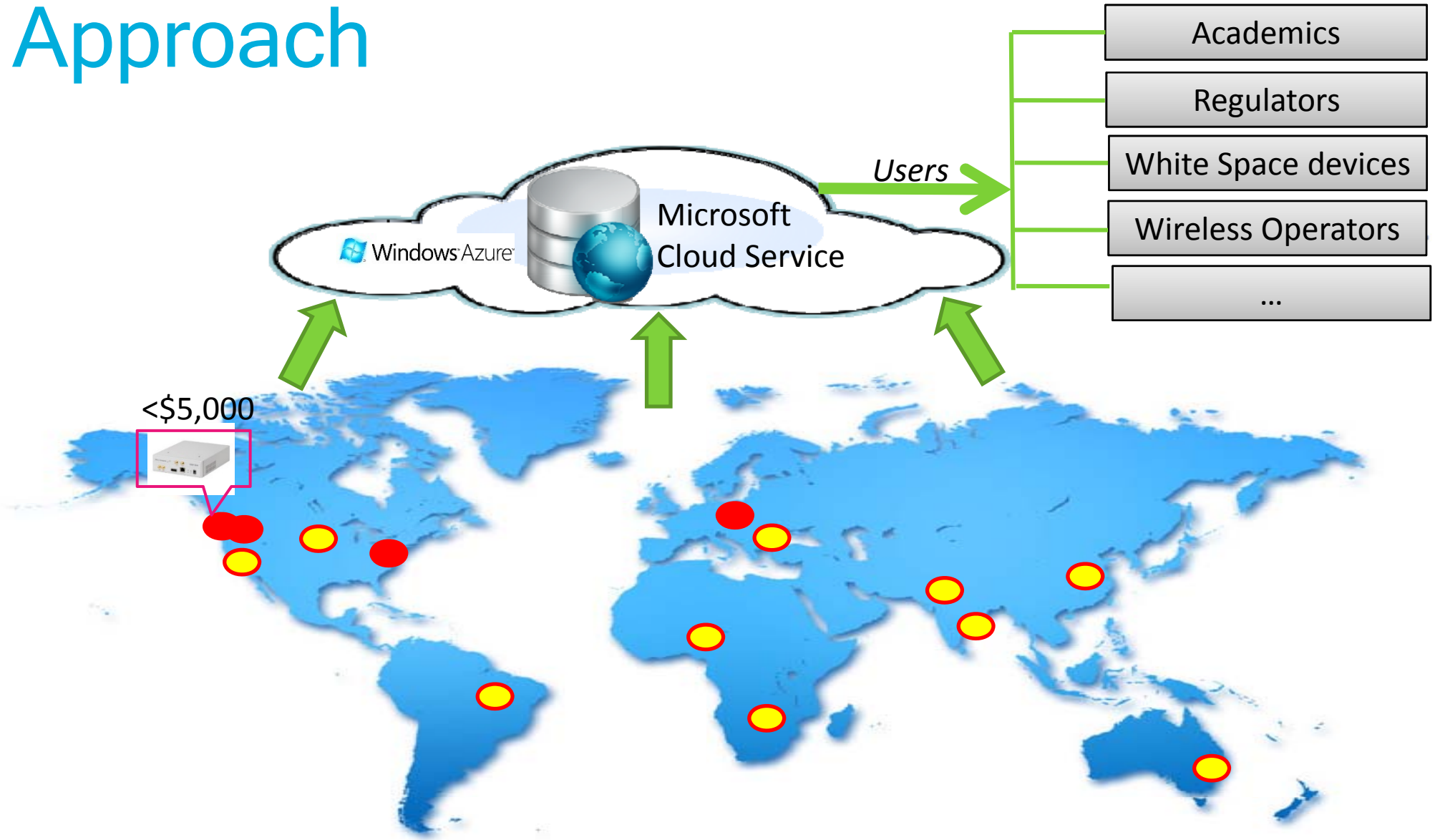
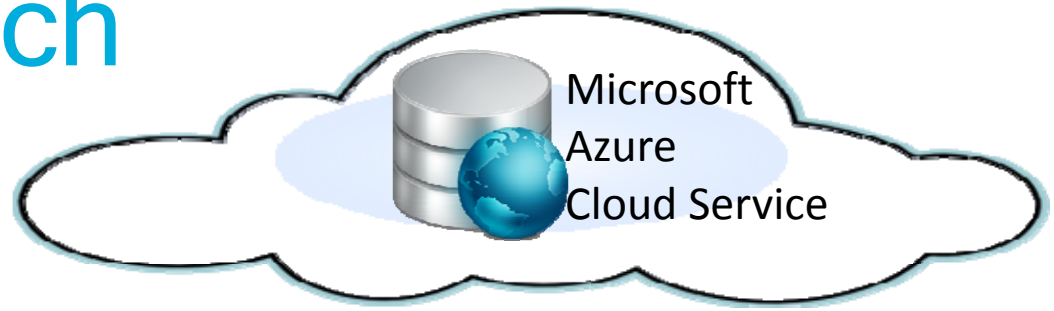


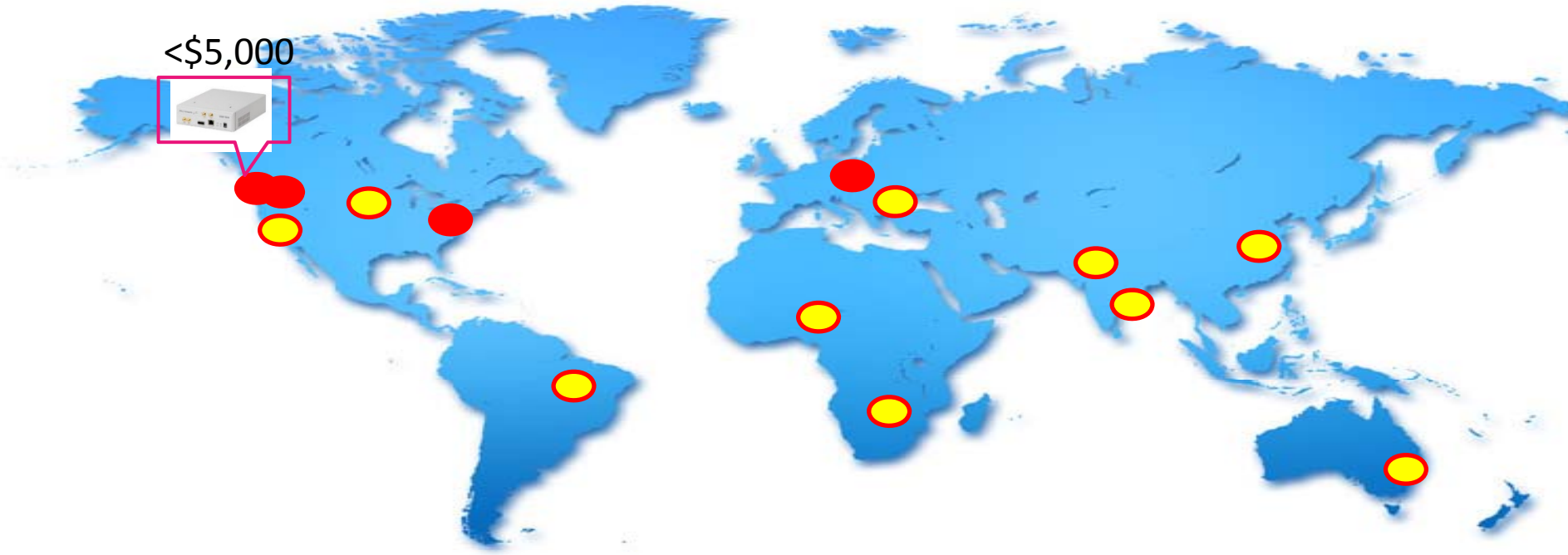
Diverse set of primary licensees, different transmission schemes, coverage regions etc…

ır Approach


Academics
Regulators
White Space devices
Wireless Operators
...
Users
Windows Azure
Microsoft
Cloud Service
<$5,000

ır Approach





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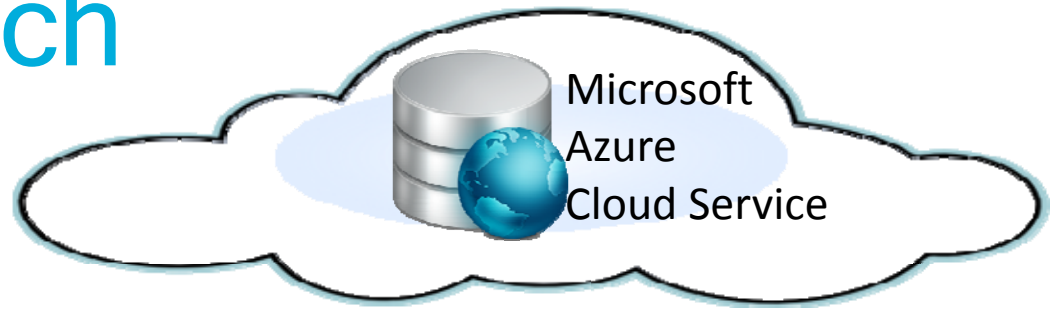
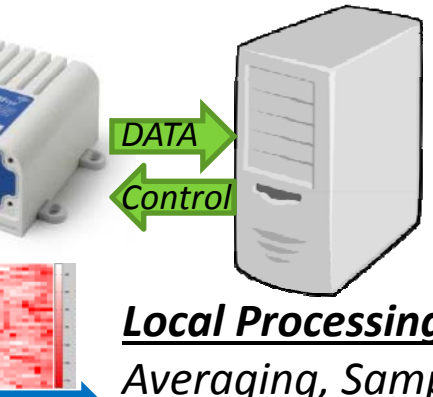
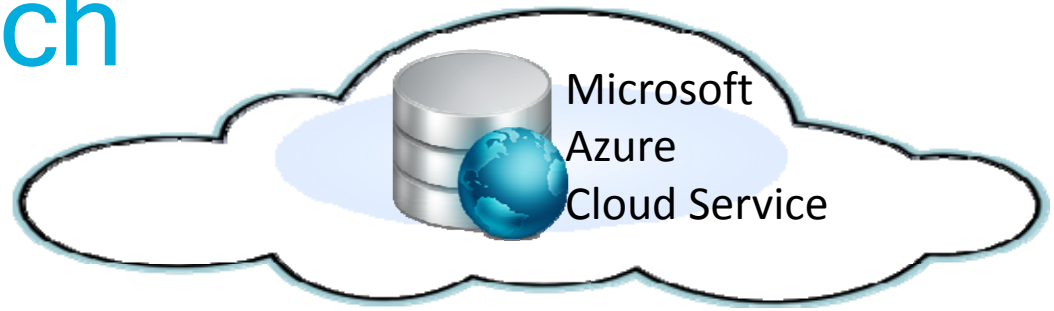


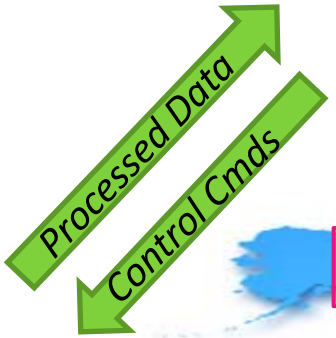
Local Station



Local Processing:
Averaging, Sampling,
Feature extraction

ur Approach





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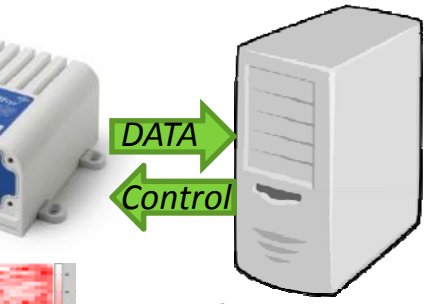

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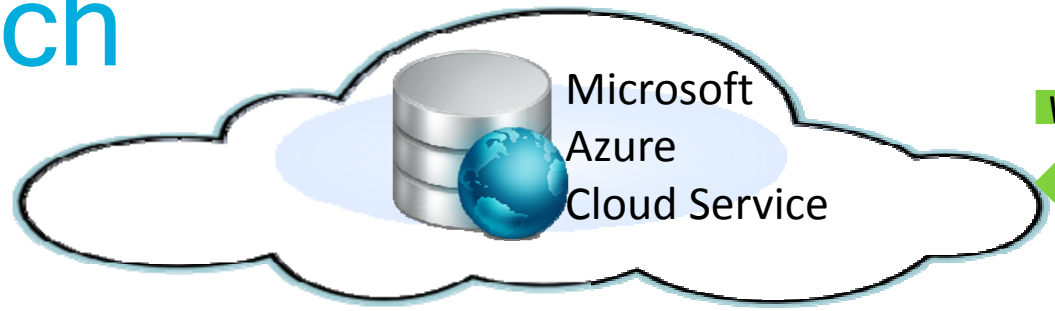


Visualize

Cmds

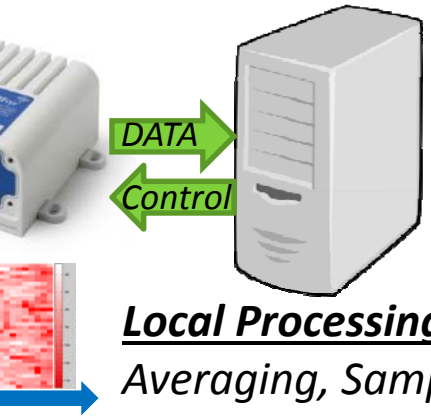
End User

Processed Data

Control Cmds

<$5,000

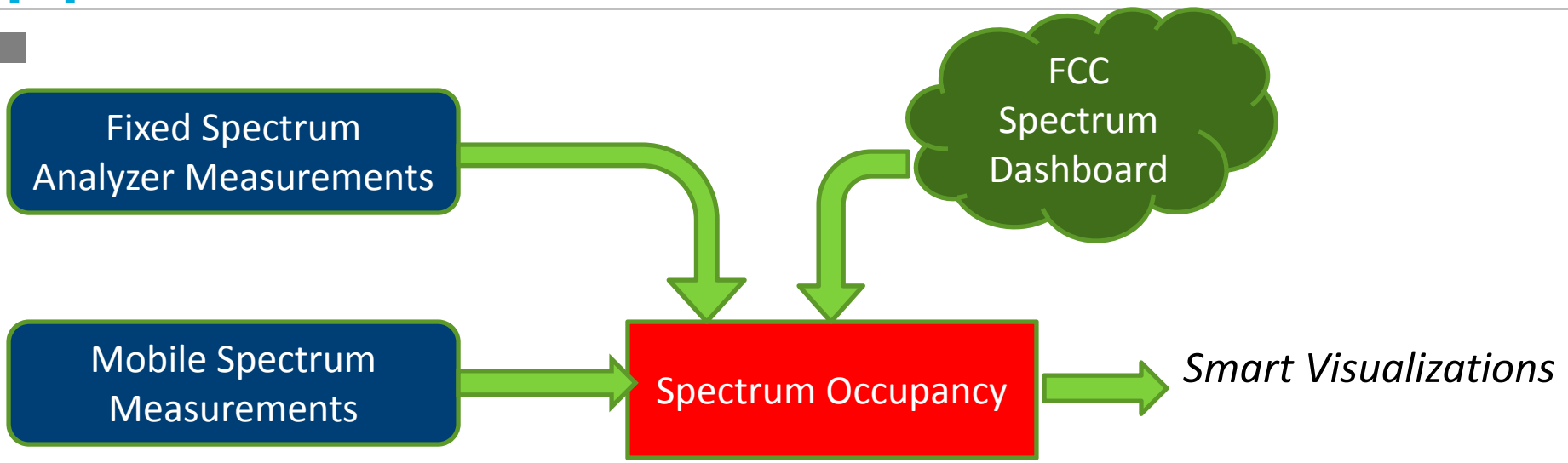
Local Station



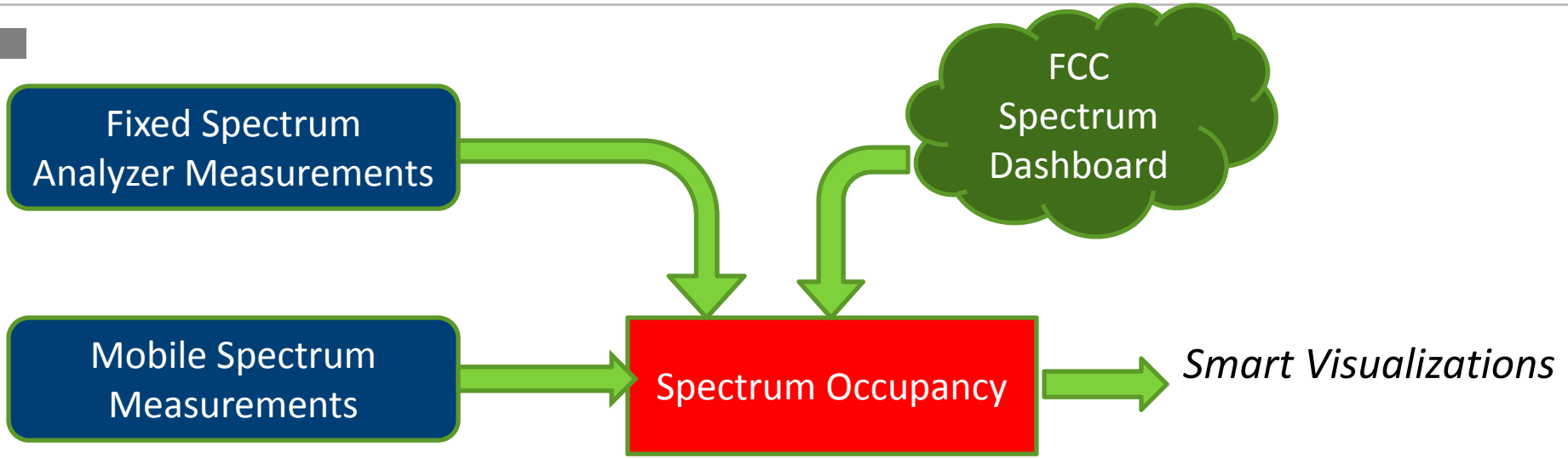
Local Processing:

Averaging, Sampling, Feature extraction

r Approach


Fixed Spectrum Analyzer Measurements
Mobile Spectrum Measurements
FCC Spectrum Dashboard
Spectrum Occupancy
Smart Visualizations

r Approach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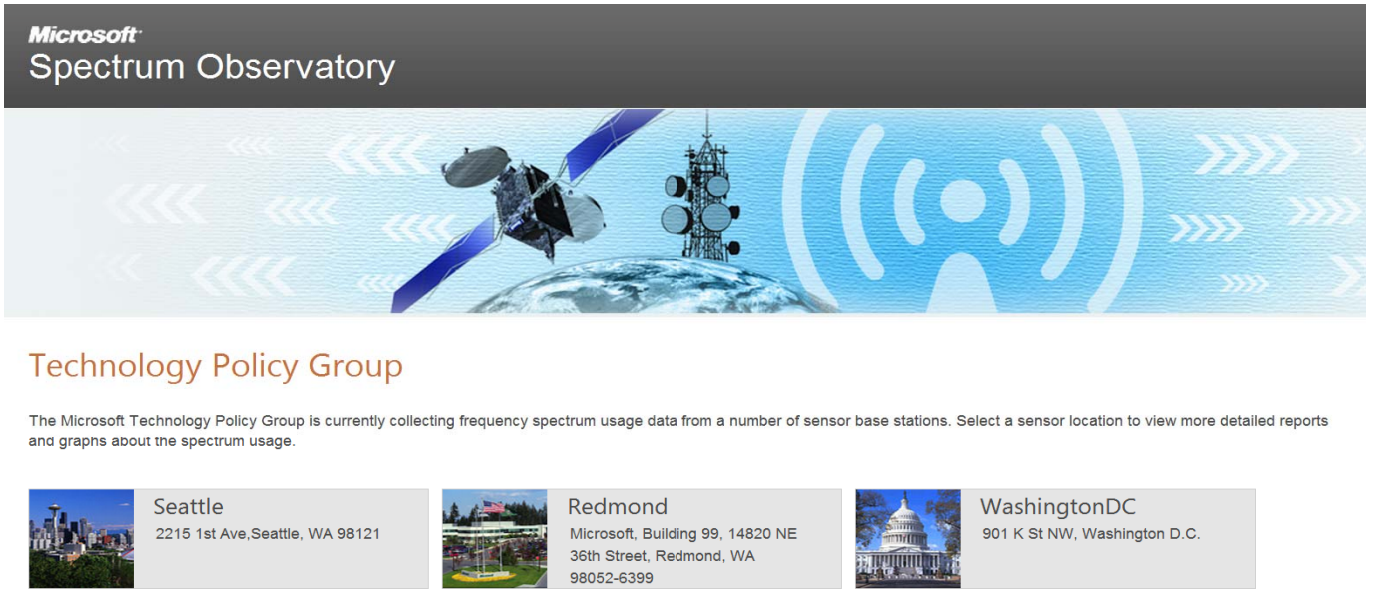

Microsoft
Spectrum Observatory
Technology Policy Group
The Microsoft Technology Policy Group is currently collecting frequency spectrum usage data from a number of sensor base stations. Select a sensor location to view more detailed reports and graphs about the spectrum usage.
Seattle
2215 1st Ave,Seattle, WA 98121
Redmond
Microsoft, Building 99, 14820 NE 36th Street, Redmond, WA 98052-6399
WashingtonDC
901 K St NW, Washington D.C.

mo

http://observatory.microsoftspectrum.com

e cases

Policy makers:

- Identify unused portions of spectrum, i.e. good for DSA
- Detect rogue transmissions
- Identify locations of transmitters (in developing countries)

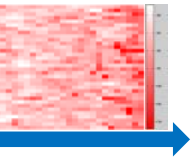
White space devices:

- Dynamically consult with database to decide spectrum for communicatio

Academics/Researchers:

- Modeling the real world

ta-driven DSA: System Design



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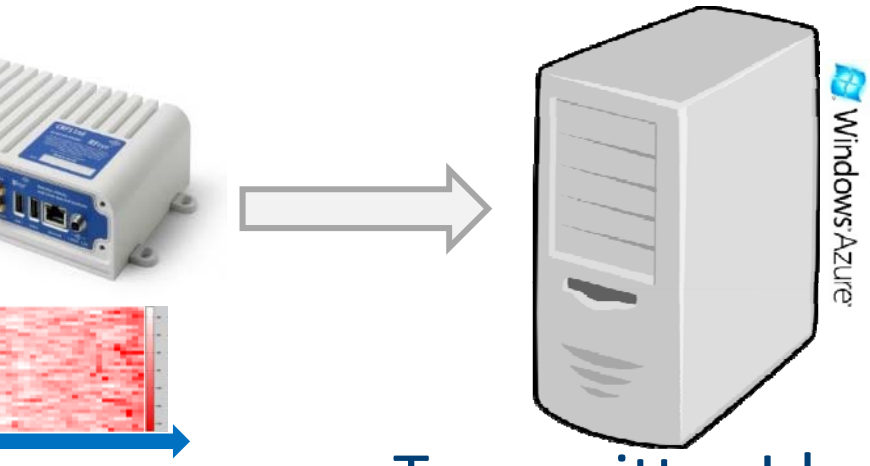

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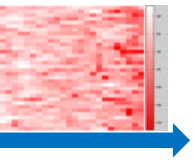

Transmitter Identifier

DSA Database

- Transmitter periodicity
- Transmitter bandwidth
- Mobile transmitters ov

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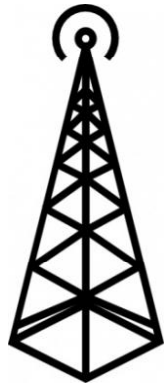
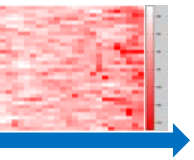


Secondary user

ta-driven DSA: System Design



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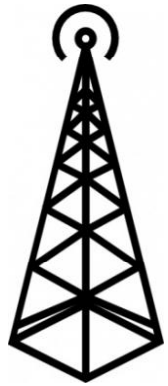
Frequency?



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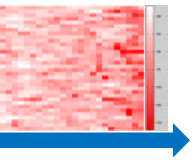

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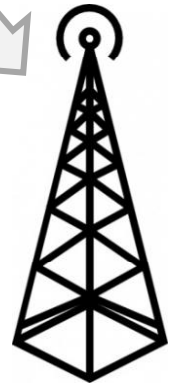
Frequency?

Freq. range X
Freq. range Y
Freq. range Z



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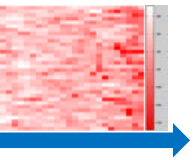

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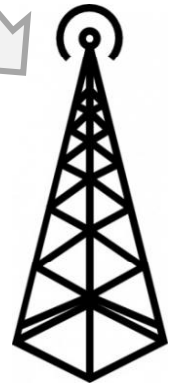
Frequency?

Frequency X satisfies application requirements.
Transmit at frequency X.



Secondary user

mmary

ttp://observatory.microsoftspectrum.com

- 6+ active stations, many more in the future
  - Please contact us if you are willing to host a station, or interested in analysis
- *Exciting announcement coming next week at WSRD workshop!*

Ongoing Research

- Fast scanning algorithms (with MIT)
- Detecting unknown transmitters (with UCSB)
- Space-Time-Frequency occupancy using mobile spectrum measurements (with IIT-Delhi)
- DSA metric to identify spectrum most suitable for DSA (with Stanford)
- …