



Making Dynamic Spectrum Access a Commercial Reality

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CEO

ABOUT VANU, INC.

HISTORY

- Founded in 1998
- Evolved from MIT software radio research
- Offices in Cambridge, MA, Bangalore & New Delhi, India

INDUSTRY AWARDS

- 50 Hottest Global Emerging Companies, TiE, 2009
- ComputerWorld Honors Program Laureate and Achievement Award Finalist, May, 2009
- Anywave® Base Station named Product of the Year, Mass NetComms Council, April 2008
- Chosen IEEE Spectrum Magazine's "Wireless Winner", January 2007
- GSM Association Technology Award for Most Innovative Infrastructure, 2005
- SDR Forum Industry Achievement Award for 2005
- Ten Coolest Companies Award by Telecommunication Magazine, 2005
- World Economic Forum Technology Pioneer, 2004
- Wall Street Journal Technology Innovation Awards: Runner Up, Wireless Category, 2004
- Mass High Tech All Star Award, 2003

EXTERNAL BOARD MEMBERS

- Clay Christenson, author of "The Innovator's Dilemma"
- Barry West, former CTO Sprint-Nextel and former President of XOHM

"...the first step in what may prove to be a radio technology revolution."

Michael Powell, FCC
Chairman commenting on
first ever FCC certification
for a software-defined radio
granted to Vanu, Inc.



MISSION

CREATE SOLUTIONS FOR PLACES THAT YOU DON'T HAVE GOOD CELLULAR COVERAGE TODAY

- Every carrier would love to color in the entire coverage map
- The only reason they don't is that current technology does not allow them to serve certain areas or markets in an economically viable manner
- The primary problem is OPEX, not CAPEX

Vanu, Inc. is focused on technical innovation to enable profitable cellular coverage in areas that cannot be covered with existing technology





PCAST Report

REALIZING THE FULL POTENTIAL OF GOVERNMENT-HELD SPECTRUM TO SPUR ECONOMIC GROWTH

- Clearing and Reallocation of Federal Spectrum is Not Sustainable
- More Efficient Use of Federal Spectrum will be Obtained through Sharing

THIS IS NOT A NEW STORY.....

WHAT IS DIFFERENT THIS TIME ?

What Has Changed in Spectrum Usage ?

FEDERAL SPECTRUM USAGE IS ALSO INCREASING

- Over 100 different uses of 1755 MHz band
- AWS auction relocated users to 1755 band in 2006

RESULT IS HIGHER COST TO CLEAR

- NTIA estimated \$18B and 10 years to clear 1755 MHz band
- Greater than projected auction revenue

COMMERCIAL WIRELESS DATA EXPLOSION FINALLY HAPPENED

- Hard to remember 3G success was in question before iPhone
- Smartphone penetration passed 50% in 2012 – Nielsen
- Wireless data grew 123% in 2011 – CTIA

What Has Changed in Usage Patterns ?

WiFi OFFLOAD

- 63% of smartphone and tablet wireless data carried over Wifi
 - Juniper Research
- 30% of AT&T wireless data traffic on WiFi
 - TMF Associates

EMERGENCE OF NEW APPLICATIONS

- M2M, Whispernet, Netflix, etc.
- Need a best effort wireless network, not best served by an *evolved* network that is designed for both voice and data
- These applications need different pricing and business models

The Argument Against Spectrum Sharing

INCUMBENT CARRIER ARGUMENT

“PCAST's report "invests a lot of faith" in spectrum-sharing technologies, few of which have been proven on a broad scale in the marketplace.”

– Joan Marsh, AT&T

IT IS A SELF FULFILLING ARGUMENT

- Investors won't fund technology that has no market under current rules
- Can't deploy at scale if rules don't create the market place
- Investment starts *after* rules are made

Main Barrier is the “Trust Gap”

INCUMBENT CONCERNS

- Potential interference, both real and *political*

NEW ENTRANT CONCERNS

- Potential new entrants are concerned that shared spectrum won't offer enough spectrum access to support a commercial business

HISTORY HAS NOT HELPED

- Garage door openers / Military radios
- Nextel / Public Safety
- Lightsquared / GPS

PCAST Approach

LONG TERM

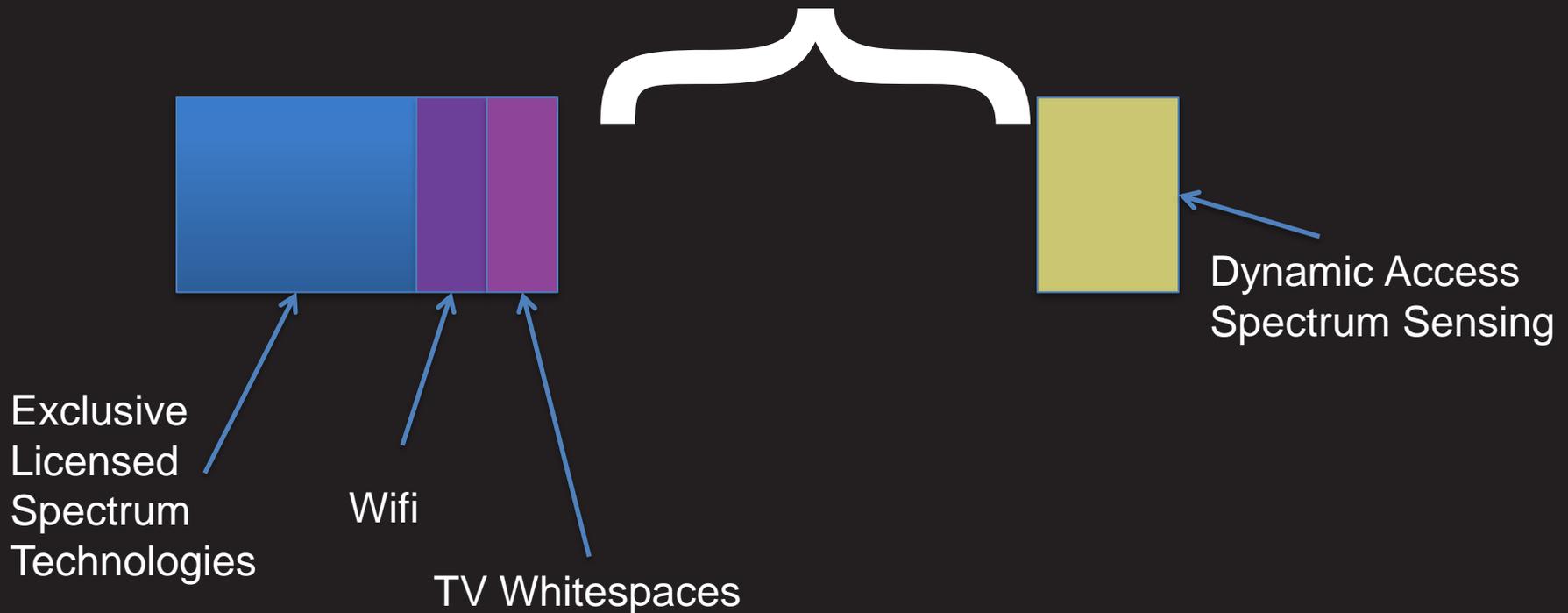
- Dynamic sensing, self configuring networks, cognitive radio, etc. are the solutions
- But....these technologies create fear, uncertainty and doubt which has prevented the necessary regulations from moving forward

START WITH THE SPECTRUM ACCESS SYSTEM

- Leave incumbent federal users in place
 - Migrate them to newer technologies on a federal funding timeline
- Database controlled dynamic spectrum access
- Provides a mechanism for control that provides comfort to all parties, but gets sharing started
- Conceptually extending whitespaces to other bands

Spectrum Sharing Chasm

Sharing Technology & Systems Gap



How do we bridge the gap?

DATABASE

- Accurate propagation information
- Incorporating *fuzzy* data from phones and devices that can sense environment
 - First baby step to dynamic access
 - DARPA RadioMap program
- Security & authentication of certificates
 - TTL or revocation mechanism is key to building trust

SHARING

- Must co-exist with existing systems
- Radar sharing will open up many GHz of new shared spectrum

SYSTEM DESIGN

- Future is interference limited, not noise limited

PCAST Chapter 6: Test City

GOAL: OVERCOMING THE TRUST BARRIER

- Prove operation at scale
 - Performance, interference, emergent behavior
- Test results in an urban RF environment
- Prove that there is sufficient spectrum access to run a commercial business

PROPOSED SOLUTION

- 600 node infrastructure
 - Each node supports 8 different bands
 - Cloud-based SDR backend for rapid prototyping
 - Simple API for accessing RF hardware

Characteristics of the Network of the Future

Cellular Networks	Shared Spectrum Networks
Exclusive licensed spectrum	Multiplicity of shared spectrum bands
Voice & data network	Best effort data network
Macro Network with small cell hotspot coverage	Small cell network with Macro to bridge connectivity
Channel access centrally controlled	Random access channel access
FDD spectrum	TDD spectrum
Vertically integrated equipment vendors	Horizontal PC-like industry structure
Industry dominated standards committees	Open source and non-profit mgmt entity

Summary

To Make Dynamic Spectrum Sharing a Commercial Reality we need to:

1. Focus R&D on the “spectrum sharing gap”
2. Build trust in both incumbent users and new entrants through real world testing in a scale urban environment.