A View of the Google 3.5 GHz Spectrum Access System

Dr. Preston Marshall
Principal Wireless Architect, Google Access
pres@google.com

Vertical Market Use Case for 3.5 GHz

Kurt Schaubach
CTO, Federated Wireless
kurt.schaubach@federatedwireless.com

A View of the Google 3.5 GHz Spectrum Access System

ISART 2015

May 13, 2015

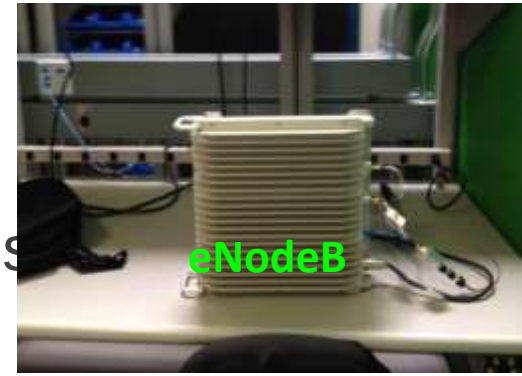
Dr. Preston Marshall
Principal Wireless Architect
Google Access
pres@google.com

Summary of Spectrum Sharing Actions

- Final Report and Order Issued for 3.5 GHz
  - 150 MHz of Sharable Spectrum
  - Basically Implements the PCAST Principles
- Two Kinds of Sharing Protection
  1. Federal/Civil Incumbents with new civil usage
  2. Civil protected licenses with unprotected licenses
- Provides for a mix of time-varying, and static protections

Why We Built SAS so Early!

- Many questioned the PCAST and FCC proposals as too complex to be implemented and operated
  - Thousands of sensitive adjacent band users, millions of protected devices, complex terrain, ….
  - LTE to complex to interface with SAS
- Google believed important to show viability of the SAS concept, and its implementation
  - Obtain feedback for our regulatory positions
- Integrated SAS with LTE NMS/EPC to show
  - Spectrum reclaim
  - Managed handset transfer
  - Setup on new channel
- Demo'ed to FCC Commissioner, FCC and NTIA Staff, DoD, Aspen Conference Attendees …



How Does SAS go Beyond TV White Space Data Bases?

- Large Number of incumbent users, with varying protection levels:
  - ≈ 47,000 Sectors of incumbent broadband (mostly WISPs)
  - ≈ 6,000 C-Band TVROs in adjacent Band (Protection TBD)
  - 51 dishes at 35 In-band C-Band International Service Sites
  - 20 Naval Vessels with SPN-43
  - 3 Fixed Radar Ground Facilities for test
  - Future military systems
- CBSD Users can receive protection from each other
  - Priority licenses purchased at auction for protection within a census tract
  - We estimate 1 to 5 million devices ultimately receiving protection
  - n^2 --10 million entrants checked against 5 million prior PAL entrants is at least $5x10^{13}$ checks over initial 3 years (50 trillion!)

Current Google SAS

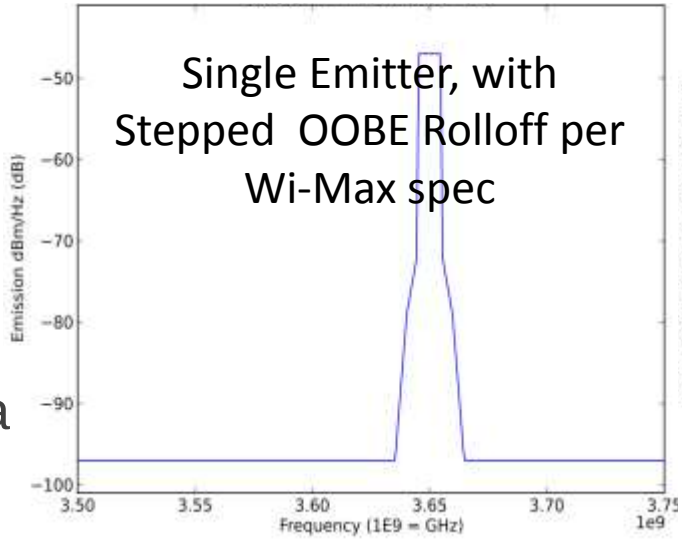
- Built to pre-R&O assumptions about specific protection criteria
- Operates on Google scalable, replicated infrastructure
  - Same as Google search, which handles three billion+ searches/day in fractions of seconds each
- Most design assumptions impacted
  - 3 tiers of Operation
  - "*Use it or Share it*" principle
  - Radar sensing devices
  - Device heartbeats
  - Protection against aggregate interference
  - Move GAA from PAL spectrum upon PAL use

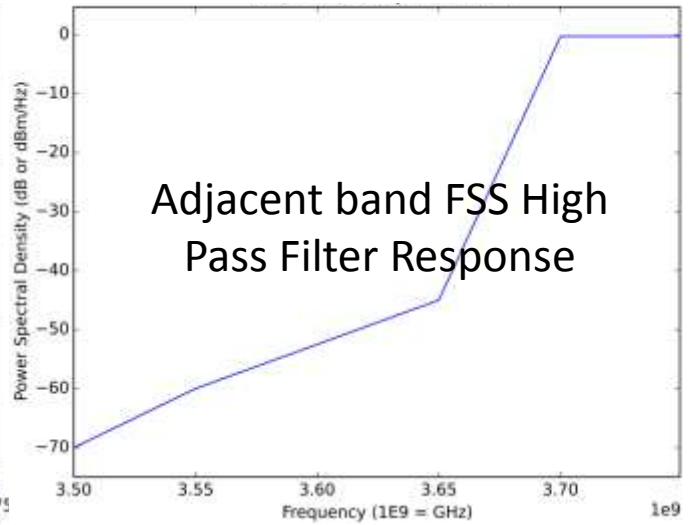
Current Google SAS -- Differences from R&O

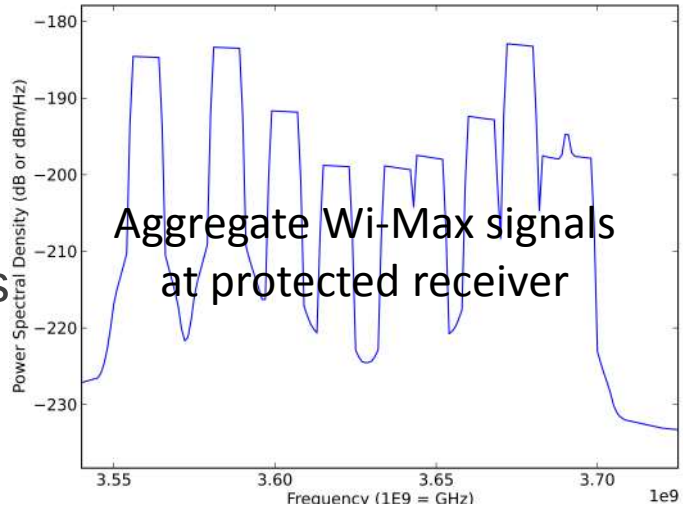
- Fully implements PAL protection
  - Protects PAL user devices from aggregated interference to the FCC criteria, not boundaries (as per the R&O)
- Protects adjacent FSS for aggregated emissions from 3.55 to 3.7
  - Overkill in comparison to R&O requirements
- Implements ITU criteria for in-band FSS sites
  - FCC has criteria as TBD

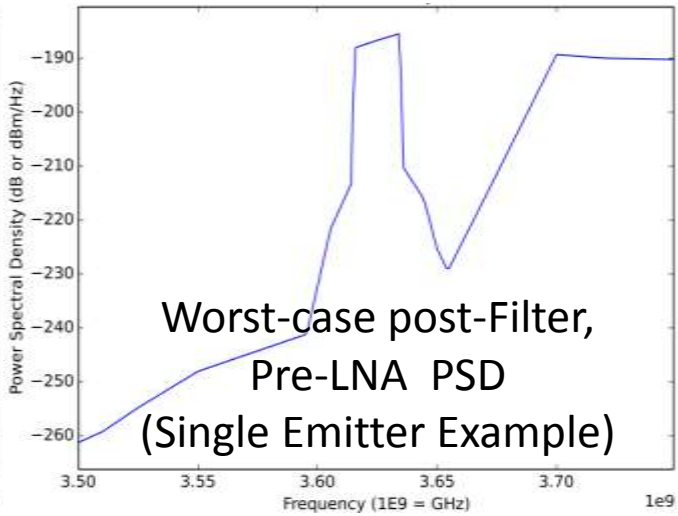
Some Key Protection Methods -- PSD-Based Operation

- SAS Processes each emitter's entire emission (main carrier + OOBE)
- Aggregates all devices impacting a specific location
- For adjacent band protection, characterizes RF filtering
- Computes interference metrics



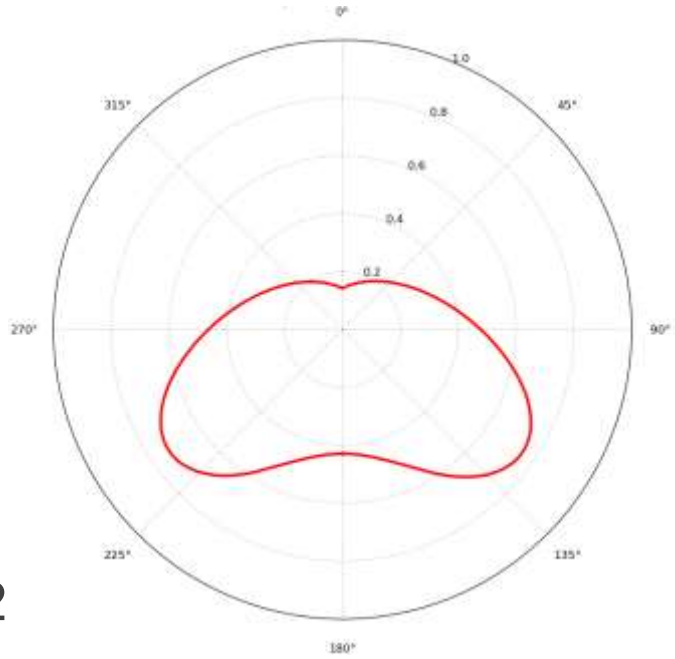






Some Key Protection Methods -- FSS Operation

- SAS aggregates maximum possible interference power to:
  - Each FSS site,
  - Each of their potential satellite orbit slot pointing antenna pattern (elevation & azimuth)
- Total computations (adjacent band FSS):
  - $5x10^3$ FSS x 10^7 3.5 devices x 39 slots ≈ 2 X 10^{12}
- Blocking power determined by convolving filter passband with each incoming emission PSD



Single node (30dBmEIRP) exclusion area in central US

SAS Planning Tool

Google

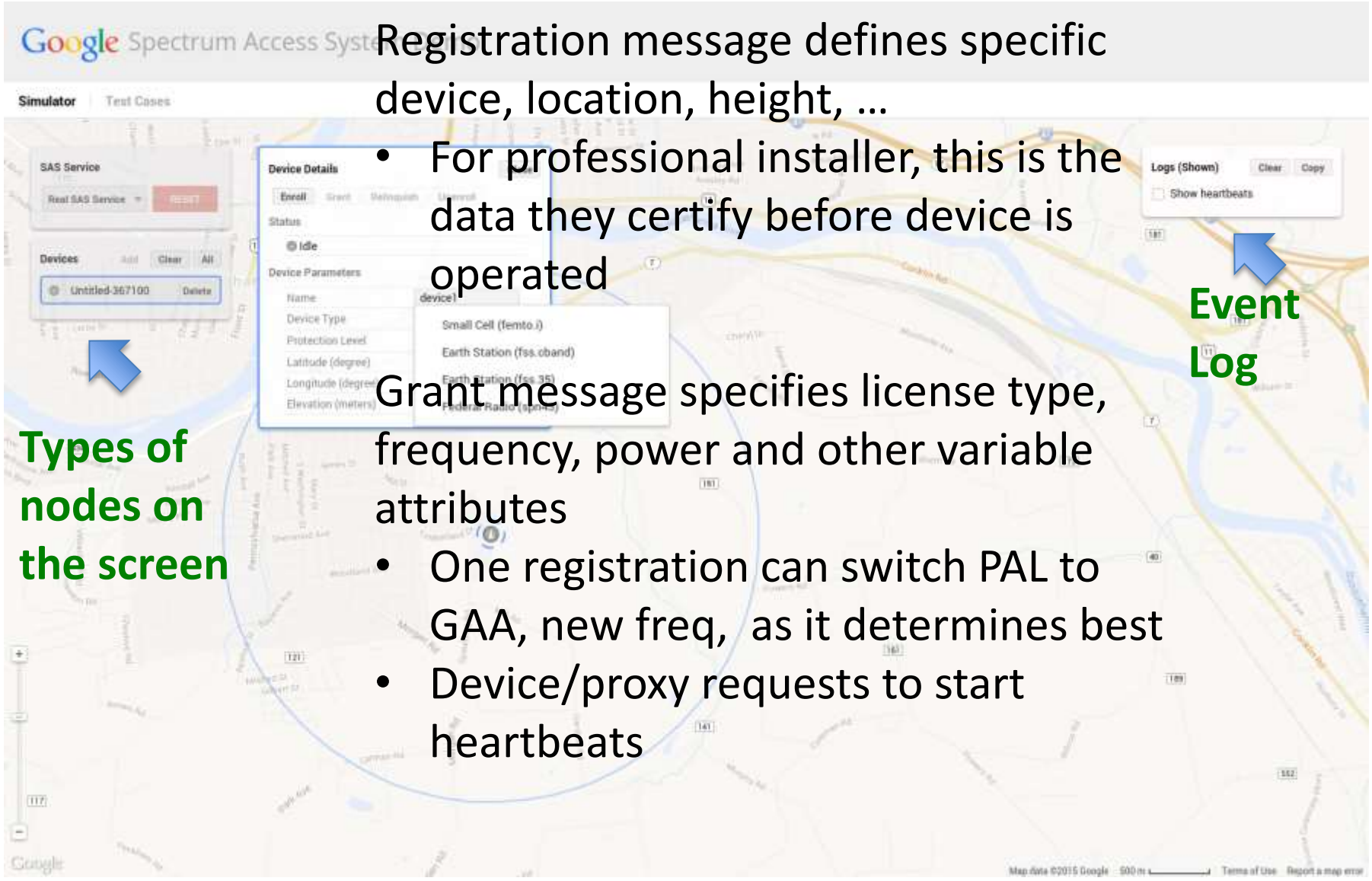
- SAS has an automated interface between a CBSD and the SAS
  - Assume non-professional, consumer enrollments automated without human input
- Google SAS Planning Tool enables simulated devices to be inserted into real or virtual environments to judge spectrum availability, interference levels, …
- Interaction conforms to message structure for device to SAS interaction
- Google demo and these slides show planning tool interface, not raw SAS interactions

Demo Setup

Google

- Showing just a few key aspects of the SAS operation
- Realize hard to see detail
- Greg Billock will do hands on demos during ISART
- Please walk up and ask for more details, and describe your test cases

Initial Registration of a Device in Band (no Grant yet!)



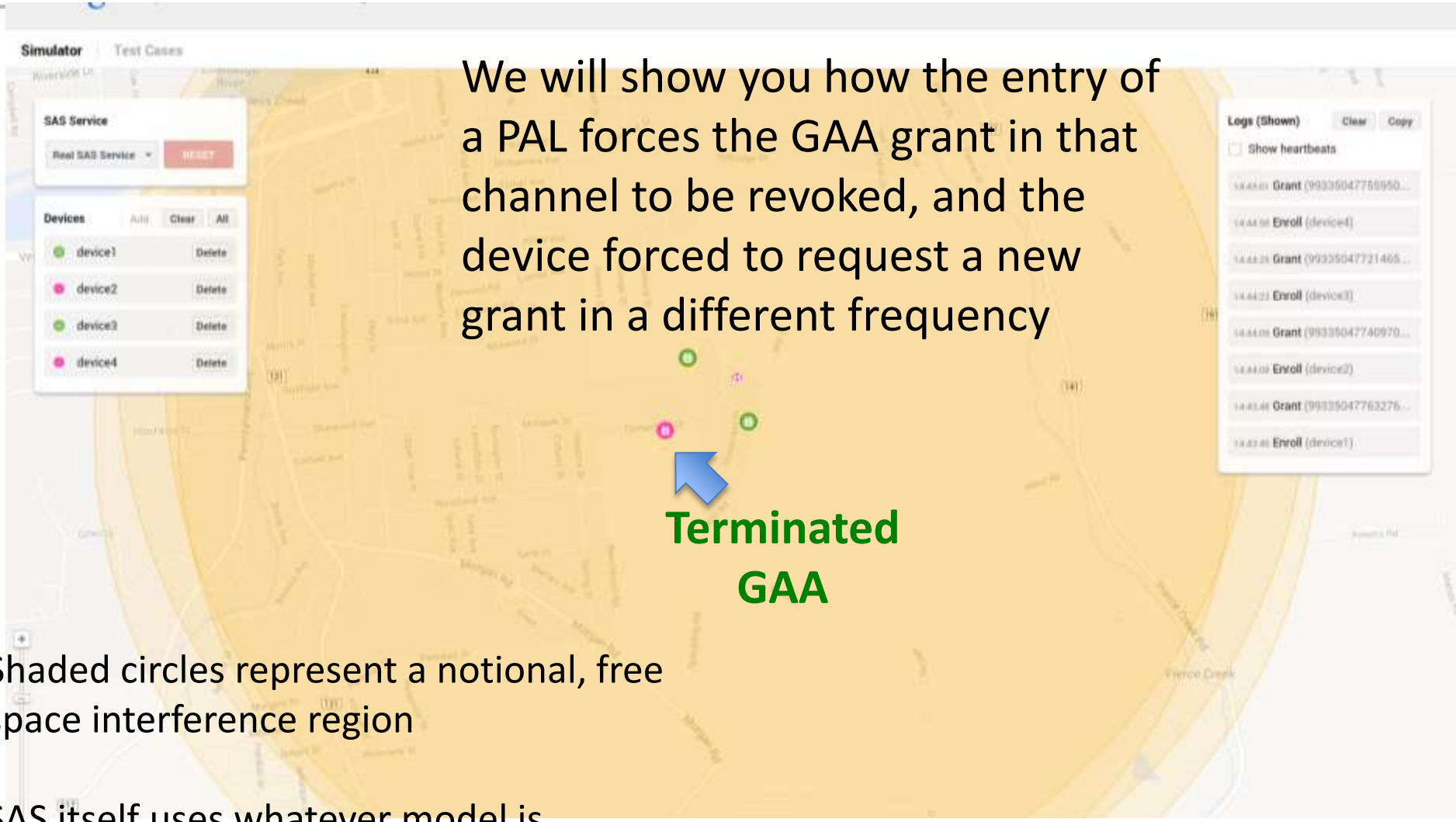
Registration message defines specific device, location, height, …

- For professional installer, this is the data they certify before device is operated

Grant message specifies license type, frequency, power and other variable attributes

- One registration can switch PAL to GAA, new freq, as it determines best
- Device/proxy requests to start heartbeats

PAL Protection from GAA

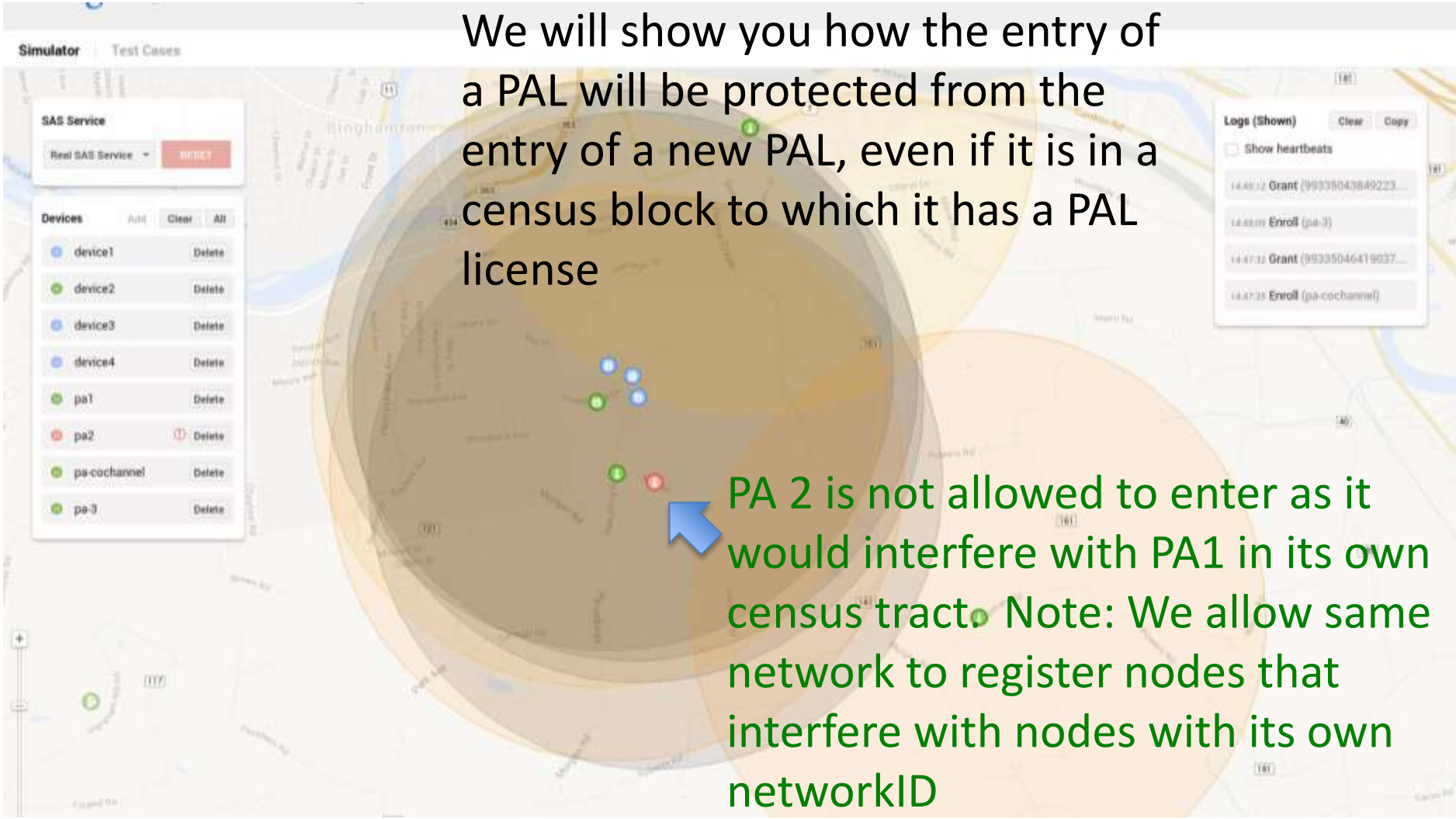


We will show you how the entry of a PAL forces the GAA grant in that channel to be revoked, and the device forced to request a new grant in a different frequency

Shaded circles represent a notional, free space interference region

SAS itself uses whatever model is approved, including terrain-based

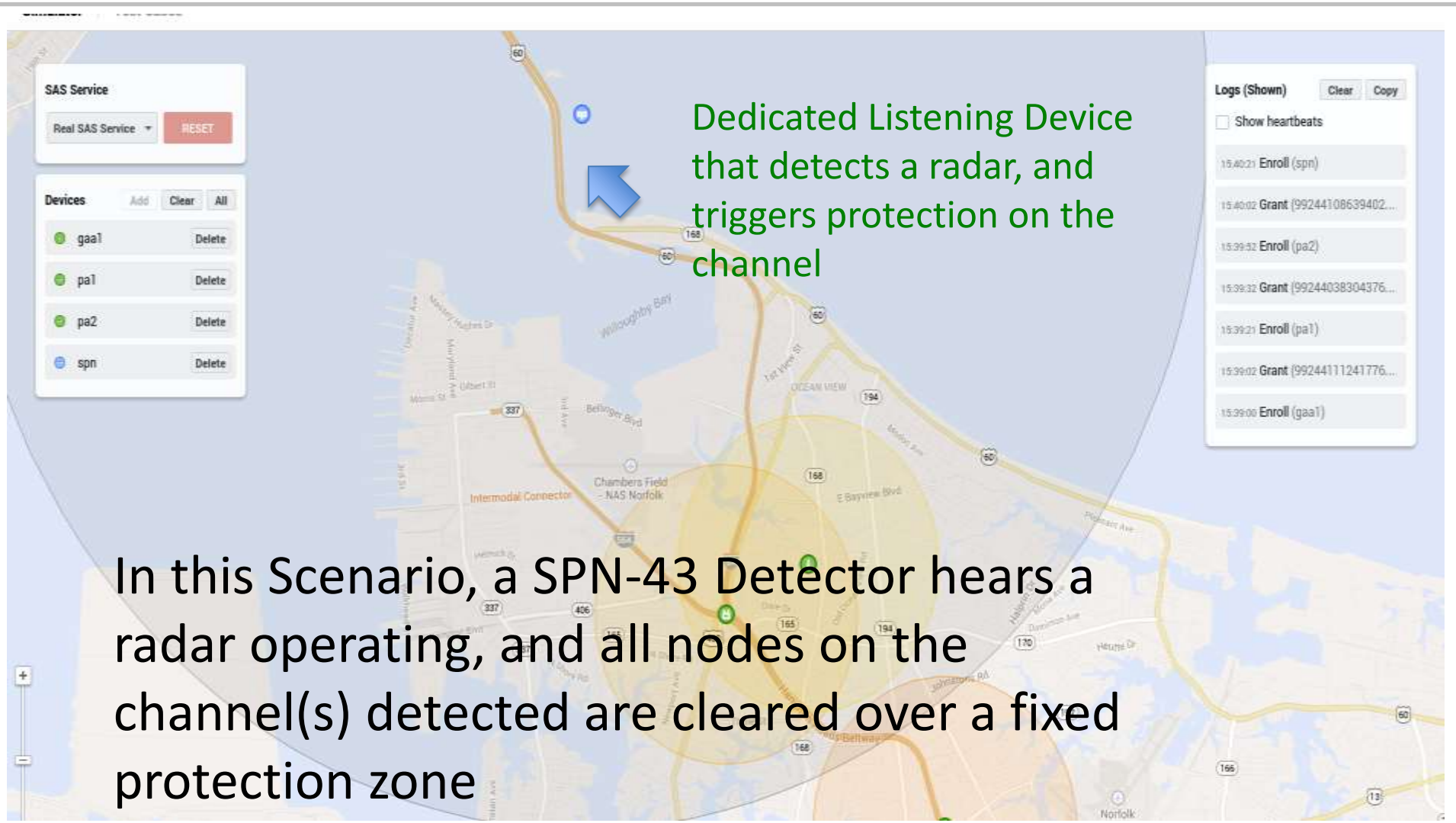
PAL to PAL Protection



We will show you how the entry of a PAL will be protected from the entry of a new PAL, even if it is in a census block to which it has a PAL license

PA 2 is not allowed to enter as it would interfere with PA1 in its own census tract. Note: We allow same network to register nodes that interfere with nodes with its own networkID

SPN-43 Protection

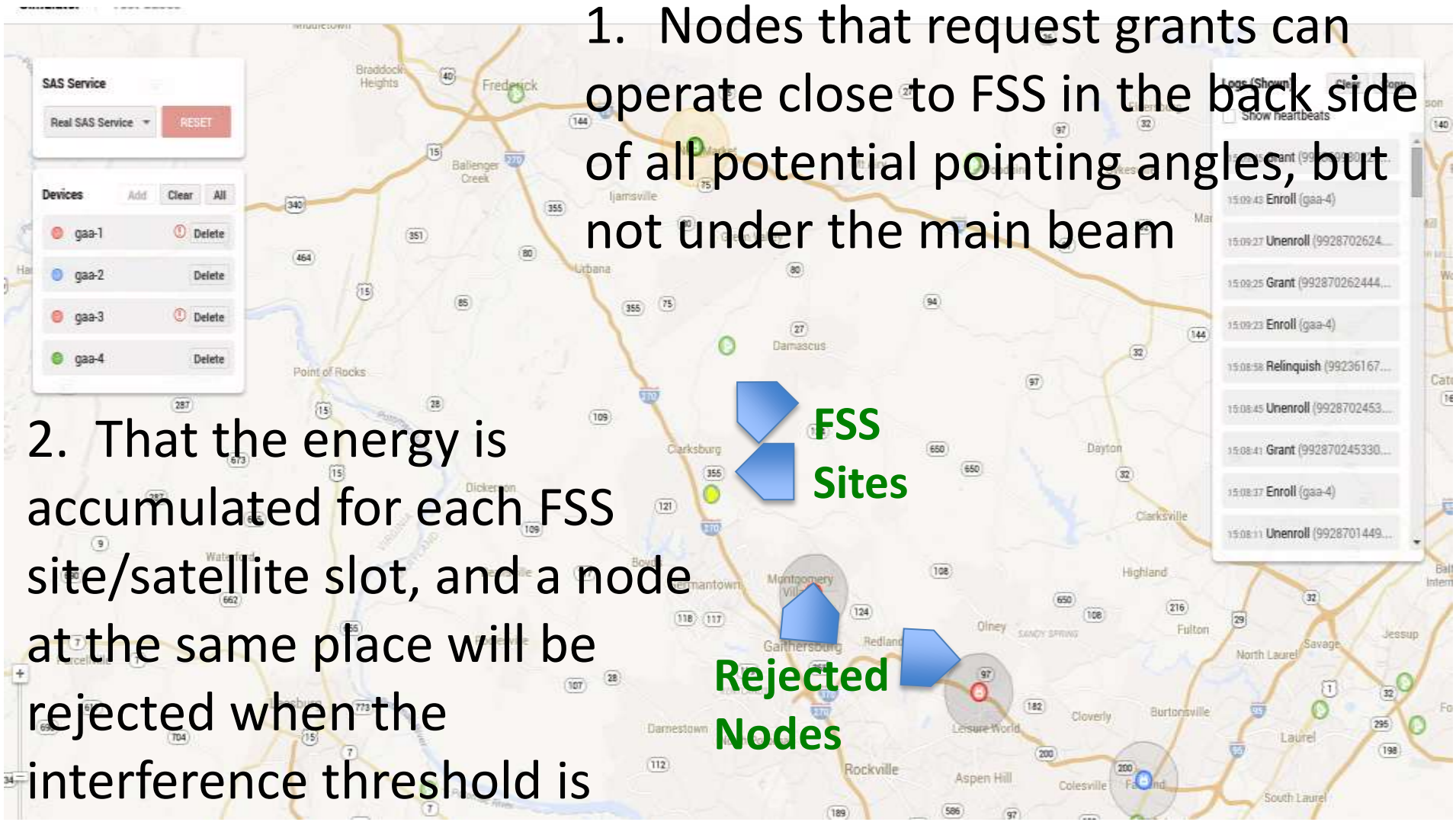


In this Scenario, a SPN-43 Detector hears a radar operating, and all nodes on the channel(s) detected are cleared over a fixed protection zone

FSS Site Protection: Shows that--

Google

1. Nodes that request grants can operate close to FSS in the back side of all potential pointing angles, but not under the main beam



2. That the energy is accumulated for each FSS site/satellite slot, and a node at the same place will be rejected when the interference threshold is reached

Industry Consensus Process to Finalize SAS Requirements

- Multi-stakeholder group formed by Wireless Innovation Forum
- Membership includes:
  - Potential SAS Providers (Google, COMSEARCH, KeyBridge, ..)
  - US Carriers (Verizon, AT&T, …)
  - Equipment Providers (Nokia, Alcatel-Lucent, Huawei, …)
  - Non-Carrier Community (Federated Wireless)

Industry Consensus Process to Finalize SAS Requirements

- Working Groups on
  - Overall Architecture and Policy inputs to FCC, DoD, NTIA, …
  - Security/Privacy Consideration
  - Certification & Testing Process and Requirements
  - Interfaces (both SAS to SAS and SAS to Device/Proxy)
- Objectives:
  - Consolidated Industry positions to assist FCC in moving rapidly
  - Industry interoperability and transparency
  - Confidence building in viability of Part 96!

Google Plans

- We need to update SAS Code to match the R&O, and work with FCC to define the remaining protection criteria
- Expand to a new set of public interfaces using standards developed by the WinnForum 3.5 Multi-stakeholder Group (MSG)
  - Massively more complex than those in TVWS
  - Recognize LTE has management layer “Proxies”
  - Short cut off requirements (60 secs), and many devices may use dynamic IP addresses

Google Plans (Continued)

- Work with DoD & NTIA (via MSG) to define radar detection criteria, and deploy detector network
- All involved (DoD & NTIA, FCC, Industry) need to commit to have certification in time to support first UE availability
  - Give confidence to carriers that the equipment they deploy will be usable
  - Less than 12-16 months if carriers request in handsets

Thank You

ISART 2015

May 13, 2015

Dr. Preston Marshall
Principal Wireless Architect
Google Access
pres@google.com