Design Principles and Candidate Architecture for a 3.5 GHz Spectrum Access System

Milind Buddhikot
Alcatel-Lucent Bell Labs
milind.buddhikot@alcatel-lucent.com

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Four SAS Design Principles

1. Provide precise spatio-temporal information about primary spectrum availability
   - Tradeoff: (a) primary protection, (b) information security and (c) spectrum utilization
2. Support multi-tier & multi-type secondary users (aka AUs) by providing dynamic information on amount & quality of available spectrum
   - Tradeoff: (a) No. of tiers and use types and (b) their concurrency in space, time and frequency
3. Manage secondary use among AUs to achieve high wireless capacity
4. Implement a monitoring & enforcement framework to refine above functions

Choice of principles instantiated and balance of associated tradeoffs impacts SAS design:

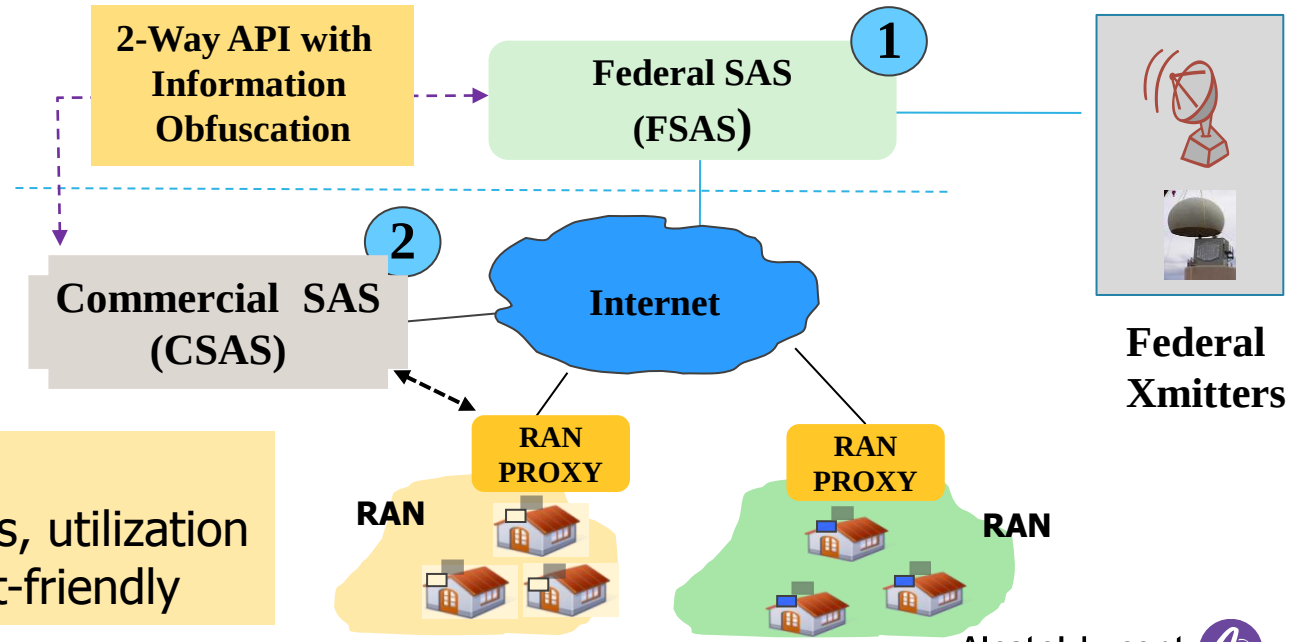
- Dictates resulting complexity, scalability, deployability & attractiveness for business investment

PR1, PR4: Primary Spectrum Availability Estimation

- **Split SAS for security, scalability and flexible business and deployment models**
  - Federal SAS: Interfaces to incumbents, computes exclusion zones and supplies availability info
  - Commercial SAS: Interfaces to secondary user AU networks (e.g. Radio Access Networks (RANs)
- **Secure access:** FSAS *knows full* incumbent info but provides a distorted version to CSAS

- **CSAS must track all secondary users (via direct heartbeat or their proxy)**
  - "Shut off AU" on primary interrupts the channel

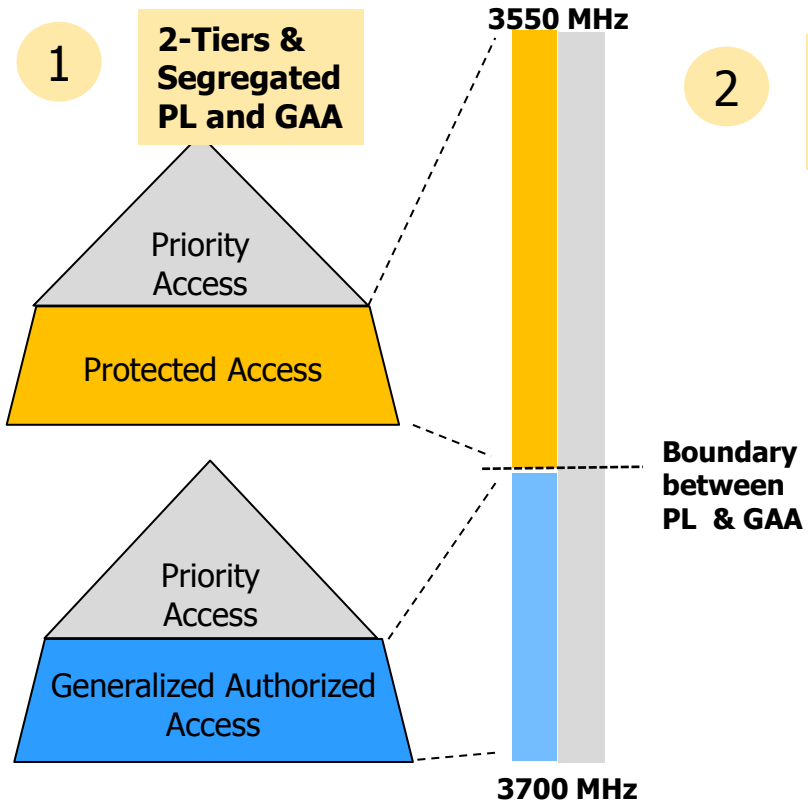
✓ **CSAS can collect measurements in in-use primary channels from AU RANs to improve spatial exclusion zone and channel availability**
  - ✘ Adds complexity



Spatial scope of Protected Access License
Smaller: better distortion (security), access fairness, utilization
Large scope: Certainty of availability & investment-friendly

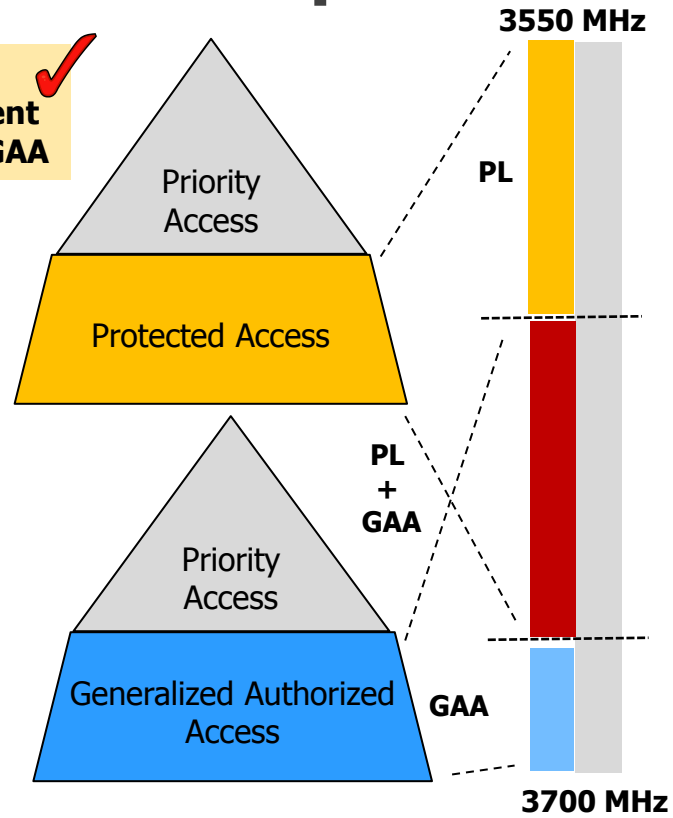
PR2: Type of Secondary AU Tiers Impacts SAS Design

1 **2-Tiers & Segregated PL and GAA**



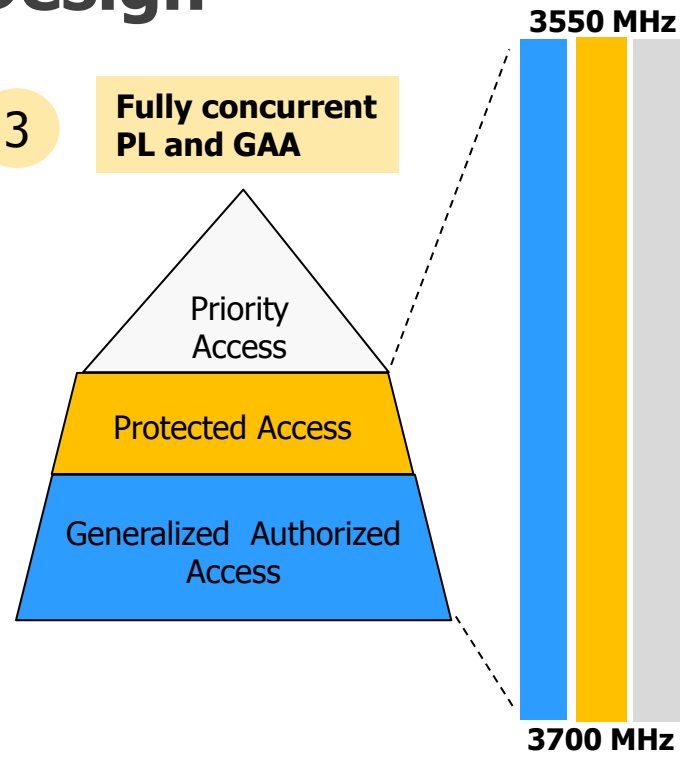
- **Incremental:** GAA and PL separated in frequency
- Independent business & monetization models
  - Two 2-tier SAS with differing complexity

2 **Partially concurrent PL and GAA** ✓



- **Hybrid:** GAA & PL devices co-exist in portion
- Greater dynamicity must be handled
- Allows greater experimentation with "shared use" and fail proof

3 **Fully concurrent PL and GAA**



- **PCAST model:** Greatest access fairness and spectrum utilization
- Most dynamicity
- Most complex and risky in near-term

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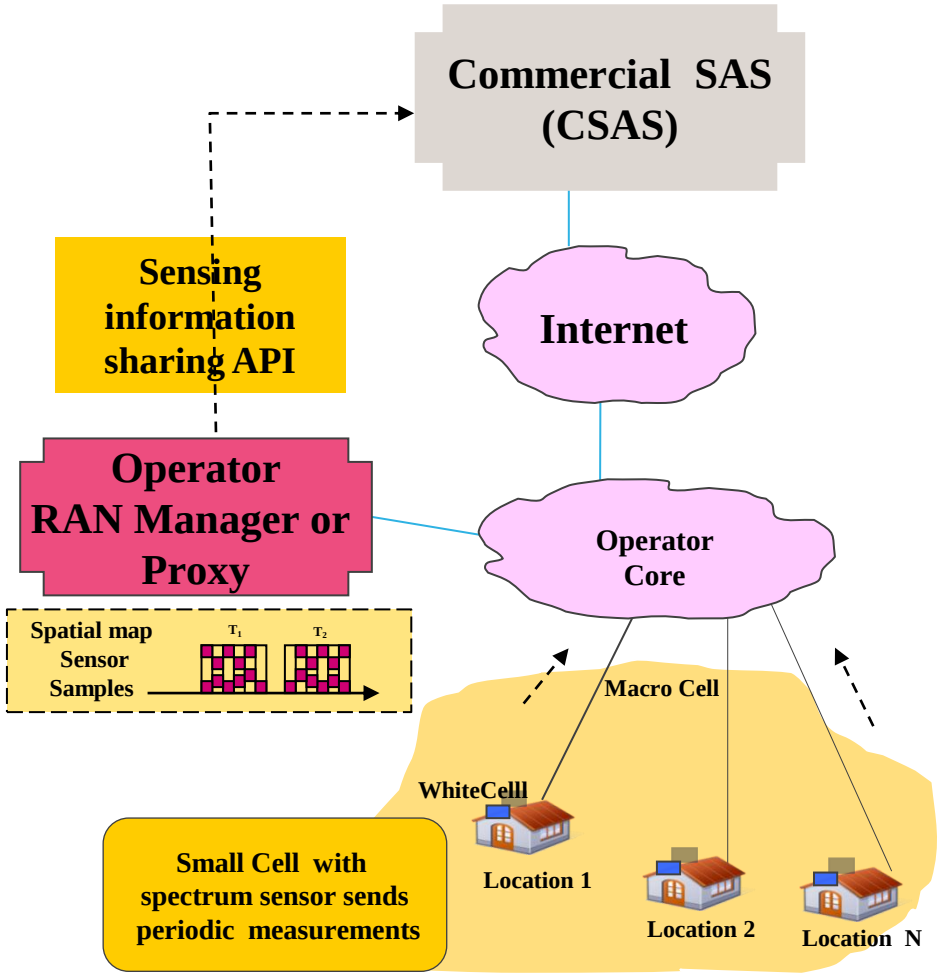
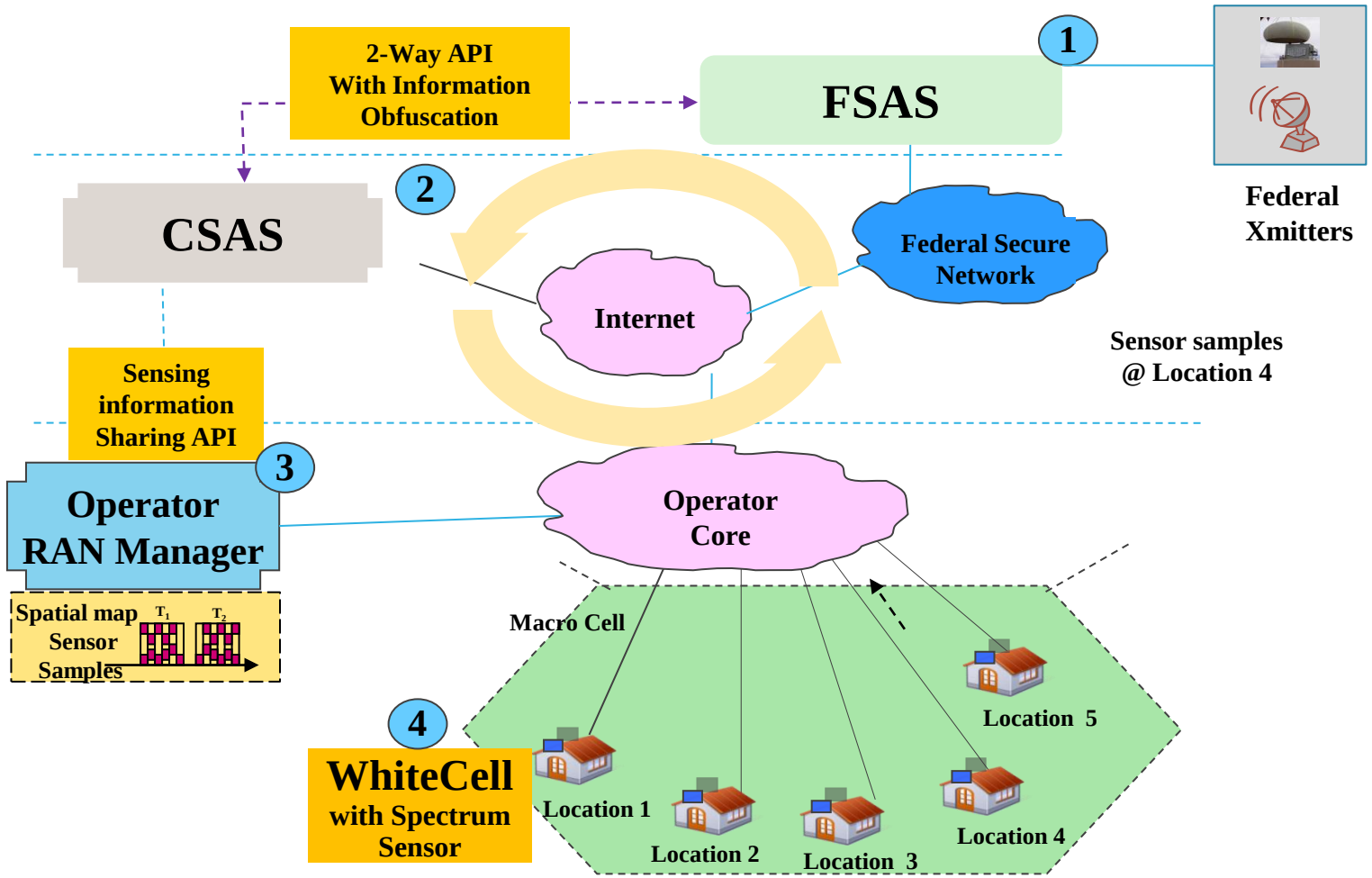
PR2, PR3, PR4: DREAM, Active Management of AUs and related functions



- Dynamic Radio Environment Activity Mapping (DREAM)
- **Channel ranking:** CSAS aggregates measurements from GAA networks to assess quality and rank channels.
  - ✓ Provides to AU s a ranked list instead of static list
- **Secondary Channel management:** Allocate channels to AUs in GAA mode to minimize aggregate interference to primary and maximize secondary capacity
- **Schedule DREAM sensing:** Manage sensing functions in the AUs to minimize sensing overhead
- **Detection of violation of primary rights**: DREAM can detect violation of primary rights
- **Monetization of channel access**: Implement priced transaction or auction to monetize Protected Access Licenses, allowing licenses to be smaller in time and spatial scope

→ Adding these functions adds more complexity and closed loop information flows

A Candidate Architecture for 3.5 GHz Ecosystem



- Four new entities
- Hierarchy to scale information handling
- Supports old and new business models
- Handles all forms access tiers

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