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

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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**
   - Priority Access
   - Protected Access
   - Generalized Authorized Access
   - Boundary between PL & GAA
   - Frequency: 3550 MHz
   - Partially concurrent PL and GAA

2. **Fully concurrent PL and GAA**
   - Priority Access
   - Protected Access
   - Generalized Authorized Access
   - GAA
   - Frequency: 3550 MHz
   - Fully concurrent PL and GAA

3. **Hybrid: GAA & PL devices co-exist in portion**
   - Priority Access
   - Protected Access
   - Generalized Authorized Access
   - PL + GAA
   - Frequency: 3700 MHz
   - Partially concurrent PL and GAA

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

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

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