Wireless Innovation Forum Webinar Series

Webinar #19: Spectrum Sharing Committee SAS to CBSD and SAS to SAS Protocols

23 February 2016

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Go To Webinar Interface
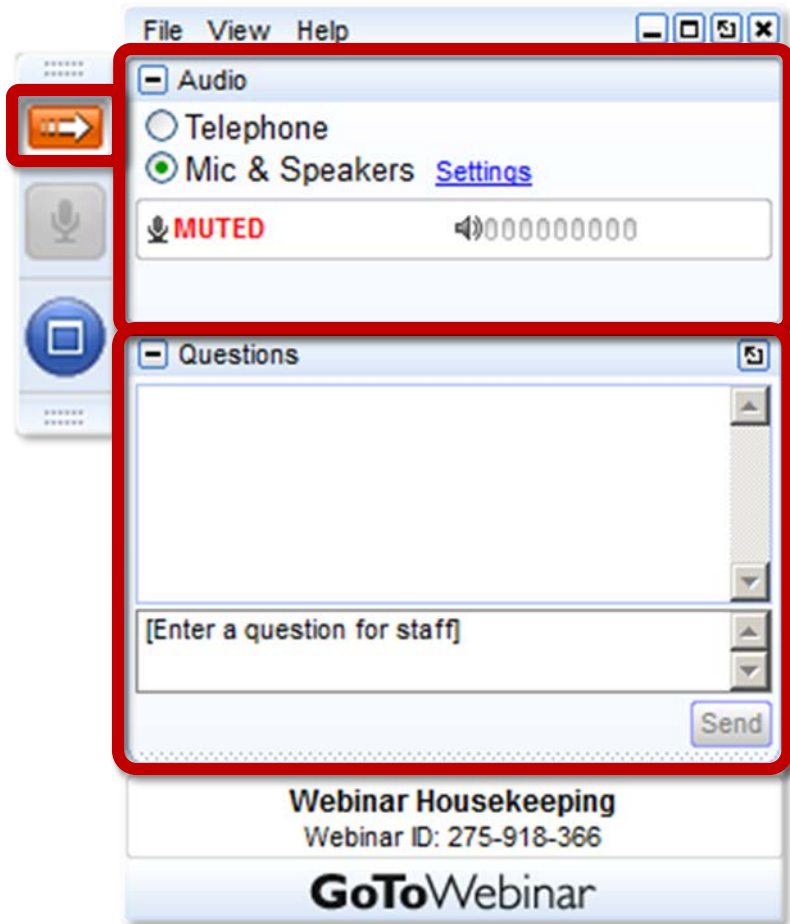
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Open and close your control panel

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Note: Today's presentation is being recorded and will be provided within 48 hours.

SPECTRUM SHARING COMMITTEE
WORK GROUP 3 (WG3) PROTOCOL WEBINAR

Agenda:

- **Introduction & Roadmap (10 minutes)- Prakash Moorut (Nokia, WG3 Co-chair)**

- **SAS-CBSD Protocol (45 minutes)- Mike Dolan (Nokia), Virgil Cimpu (Ericsson), Yi Hsuan (Google)**

- **SAS-SAS Protocol (30 minutes)- Masoud Olfat (Federated Wireless), Greg Billock (Google)**

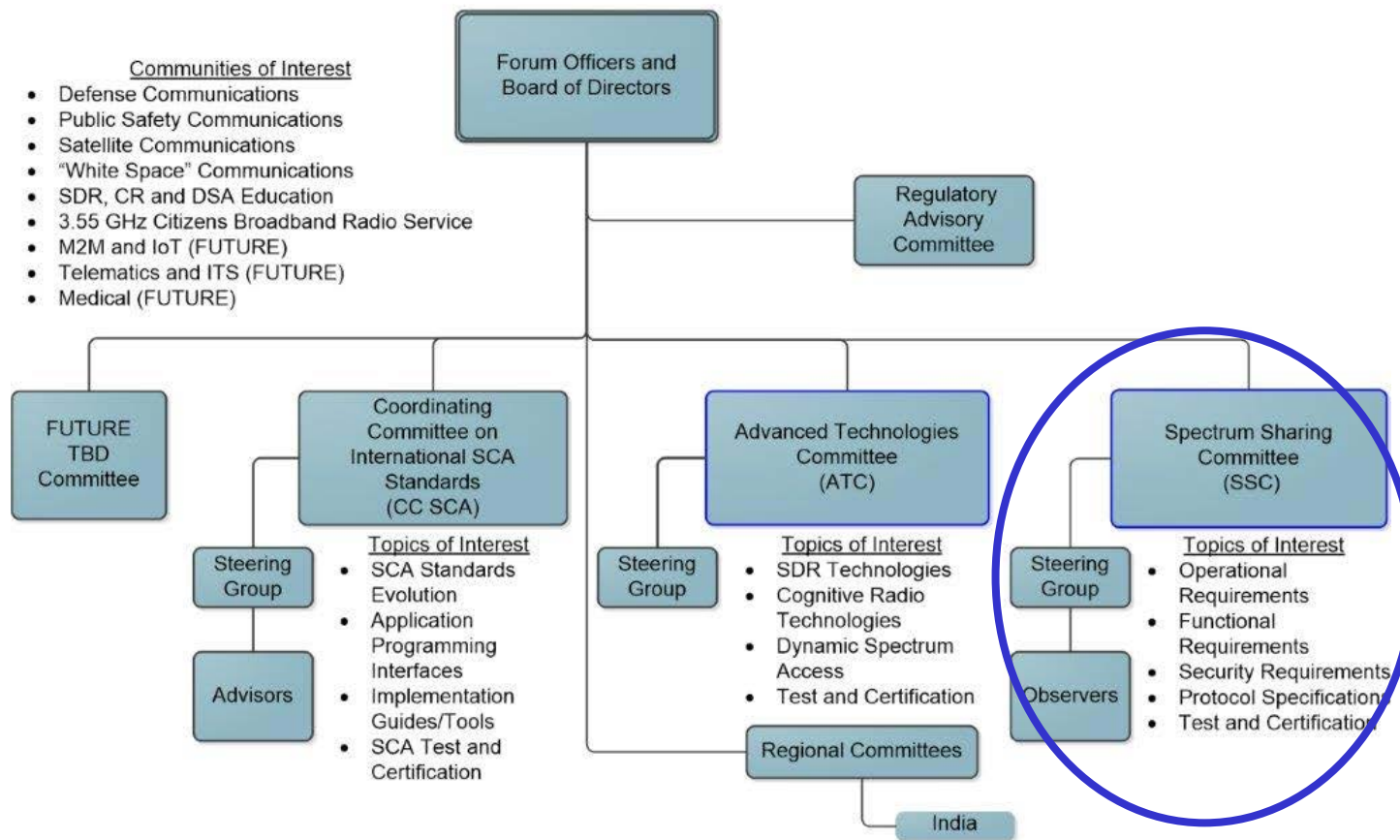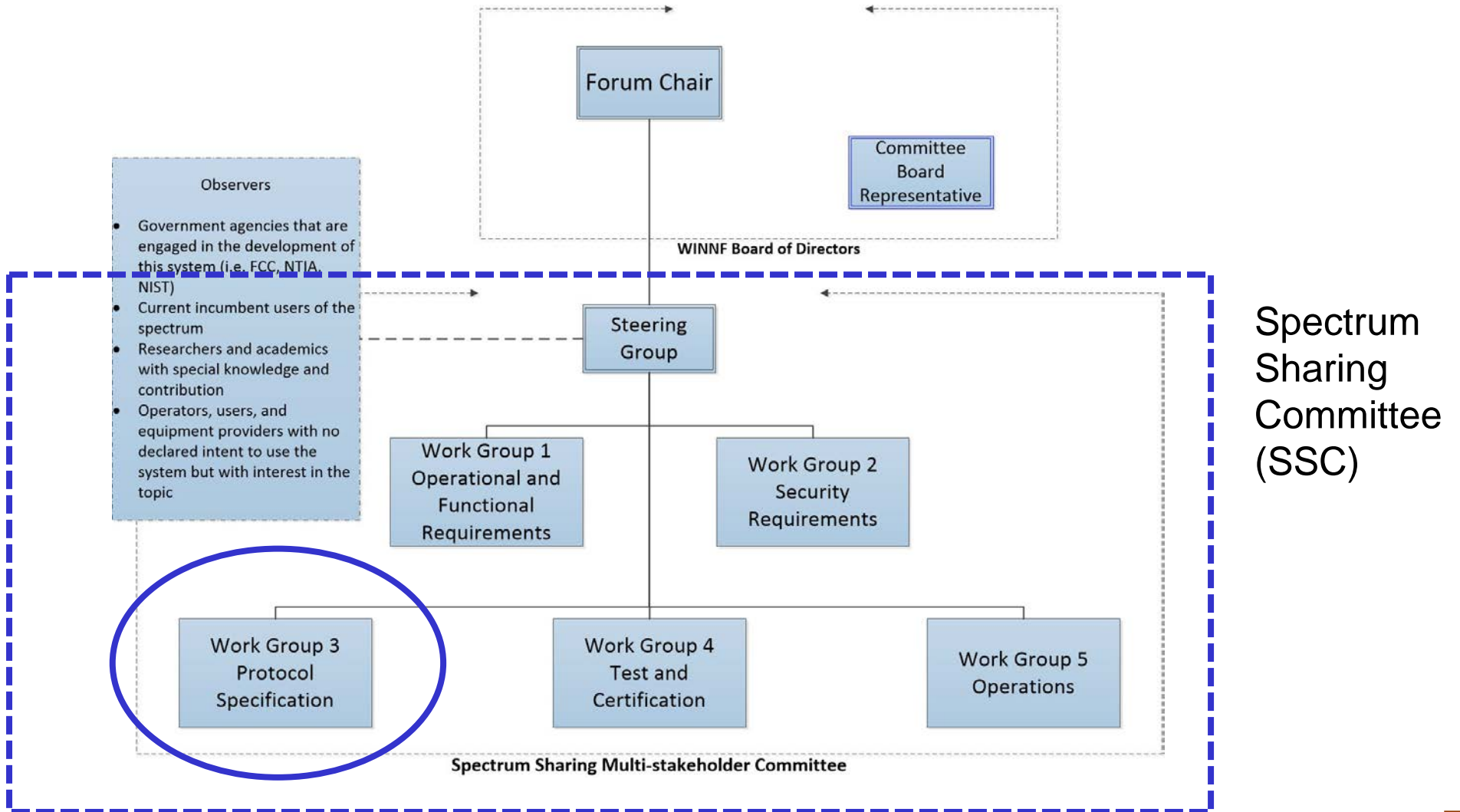- **Summary (5 minutes)- Prakash Moorut (Nokia)**

23 February, 2016

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Forum Structure

Organizational Structure for The Wireless Innovation Forum
10 November 2015

Committee Structure
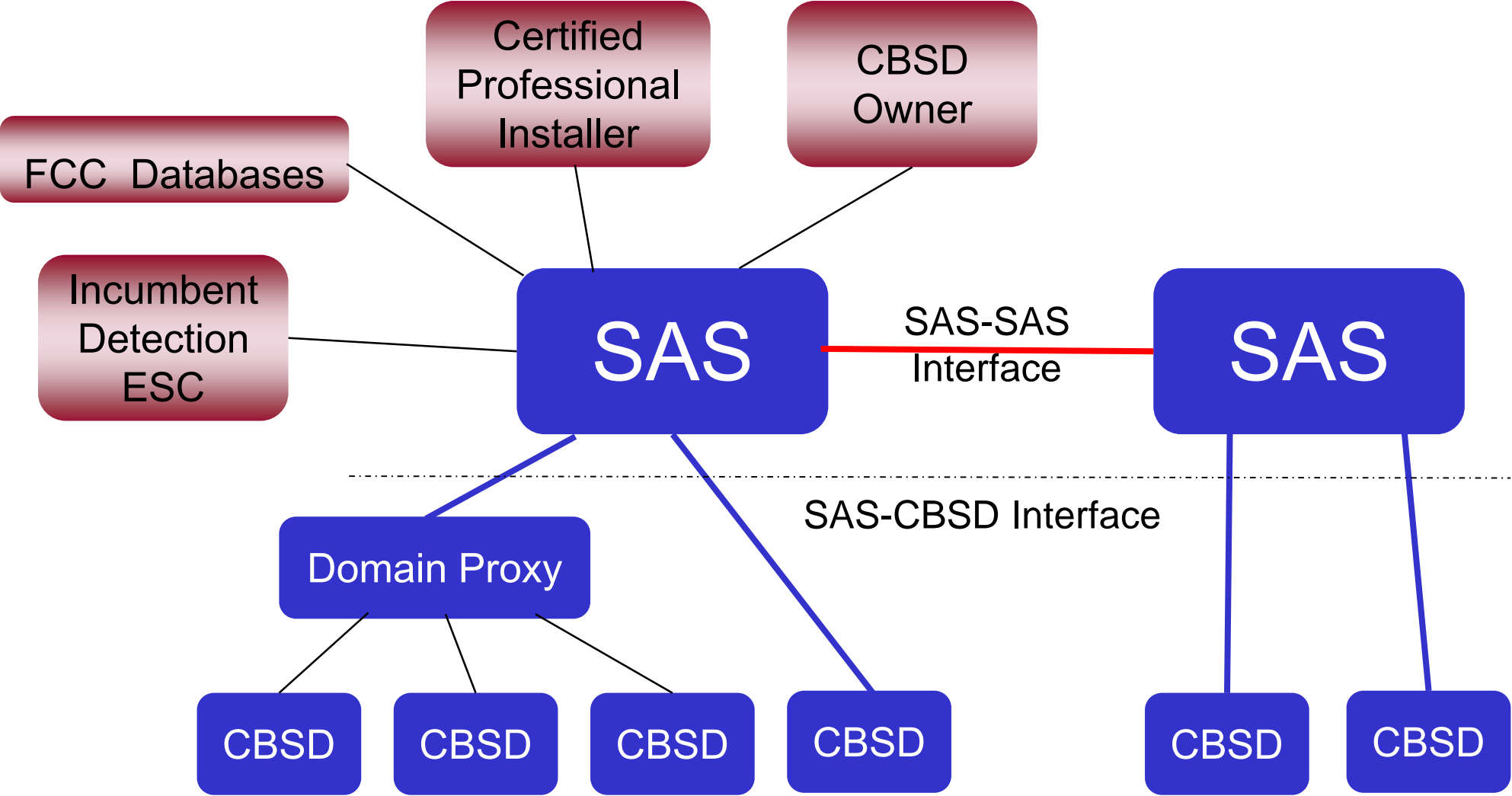

Spectrum Sharing Committee (SSC)

Charter: Define the detailed protocols for data and communications across the various open interfaces within the system

Spectrum Access System (SAS) interface specifications should be limited to the minimum requirements needed for an open and interoperable system.

CBRS entities

Certified Professional Installer

CBSD Owner

FCC Databases

Incumbent Detection ESC

SAS

SAS-SAS Interface

SAS

SAS-CBSD Interface

Domain Proxy

CBSD

CBSD

CBSD

CBSD

CBSD

CBSD

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Release 1 Publication Timeline (Revised)

✔ **Operational and Functional Requirements - V1.0.0**
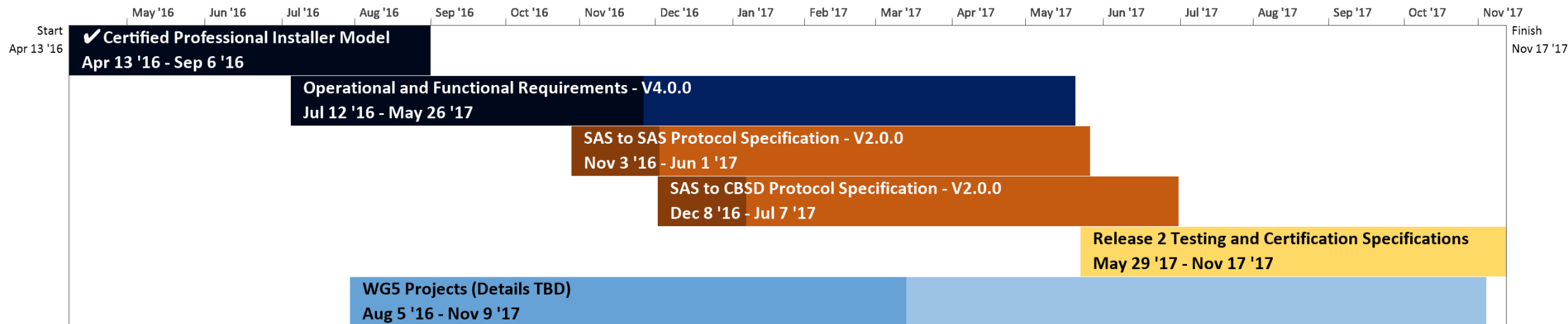Jan 27 '15 - May 13 '16

Operational and Functional Requirements - V2.0.0
Mar 31 '16 - Feb 8 '17

Operational and Functional Requirements - V3.0
Aug 3 '16 - Apr 7 '17

✔ **Cybersecurity Requirements (COMSEC) - V1.0.0**
Jan 27 '15 - Aug 2 '16

✔ **Operational Security Requirements (OPSEC) - V1.0.0**
Jan 27 '15 - Jun 21 '16

✔ **SAS to SAS Protocol Spec. - V1.**
Jun 29 '16 - Nov 29 '16

✔ **SAS to CBSD Protocol Specification - V1.0.0**
Feb 19 '16 - Nov 29 '16

Release 1 SAS Test and Certification Specification
Jul 24 '15 - Apr 21 '17

Release 1 SAS Test Code Development and Verification
Feb 1 '16 - May 26 '17

Release 1 CBSD Test and Cert. Spec.
Dec 5 '16 - May 30 '17

Release 1 CBSD Test Code
Mar 1 '17 - Jun 30 '17

PAL/PPA Database Specific
Nov 8 '16 - Mar 9 '17

Start
Jan 27 '15

Finish
Jun 30 '17

✔ Project Approved
Jan 27 '15

Release 1.0 Projects
Complete
Jun 30 '17
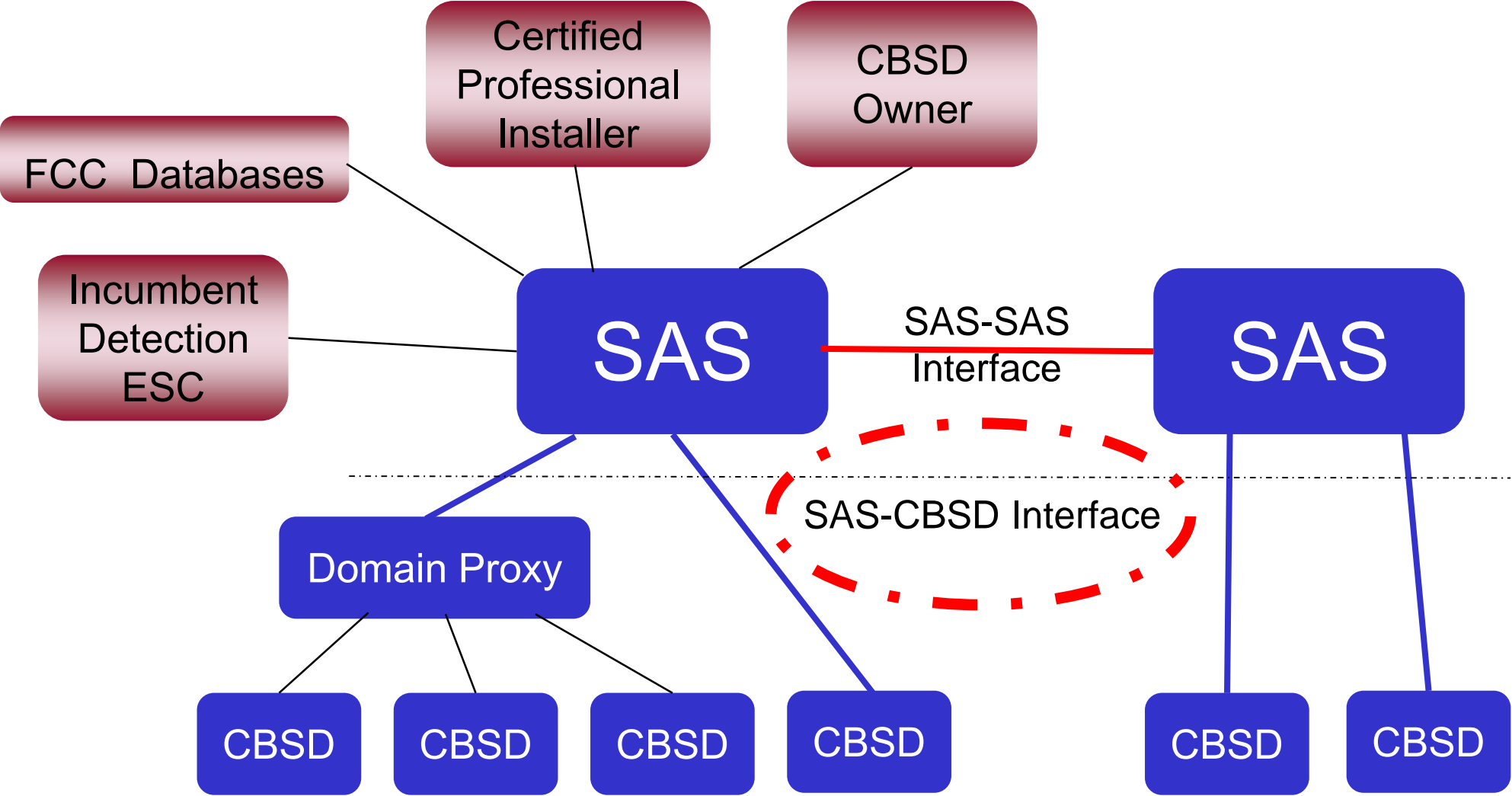
Release 2 Publication Timeline

SAS-CBSD PROTOCOL

Introduction / Scope / Architecture / State Transitions – Mike Dolan, Nokia

SAS-CBSD Procedures and Message Exchanges – Virgil Cimpu, Ericsson

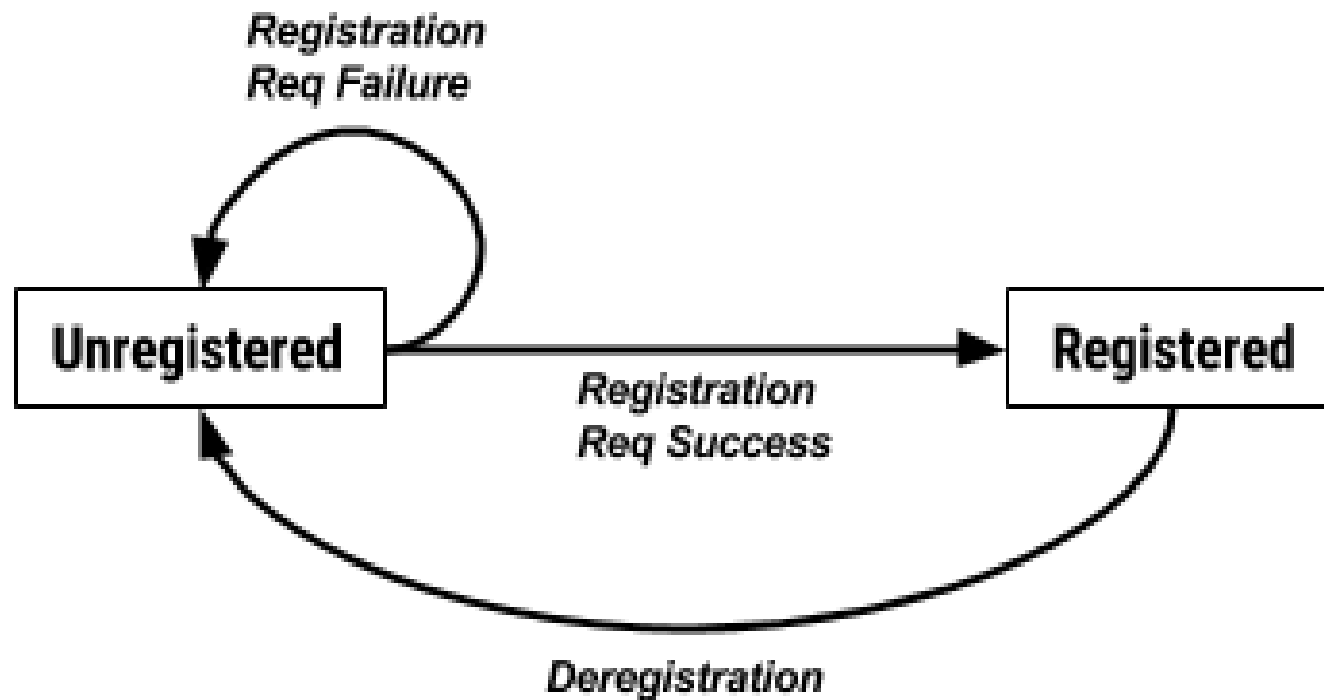**Message Encoding and Transport / Parameters – Yi Hsuan, Google**

SAS-CBSD Introduction & Scope

- **The SAS-CBSD protocol is the major link between the Spectrum Access System (SAS) and the Citizens Broadband Radio Service Device (CBSD).**
  - CBSD is a generic name for a base station device that uses the CBRS spectrum.
  - The CBSD is a non-mobile device.
- **The CBSD registers and obtains use of ranges of spectrum.**
- **The SAS controls the use of spectrum to manage:**
  - Interference with Incumbents.
  - Interference with Priority Access Licensees (PAL)
  - Fair sharing of spectrum among General Authorized Access (GAA) users.
- **A Domain Proxy (DP) may coordinate the access between the SAS and a set of CBSDs.**

CBRS entities

Certified Professional Installer

CBSD Owner

FCC Databases

Incumbent Detection ESC

SAS

SAS-SAS Interface

SAS

SAS-CBSD Interface

Domain Proxy

CBSD   CBSD   CBSD   CBSD   CBSD   CBSD

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The CBSD begins in an Unregistered state and enters the Registered state by providing required registration parameters to the SAS.

The CBSD may deregister itself or be deregistered by the SAS for a variety of reasons.

CBSD State Transitions - Grants
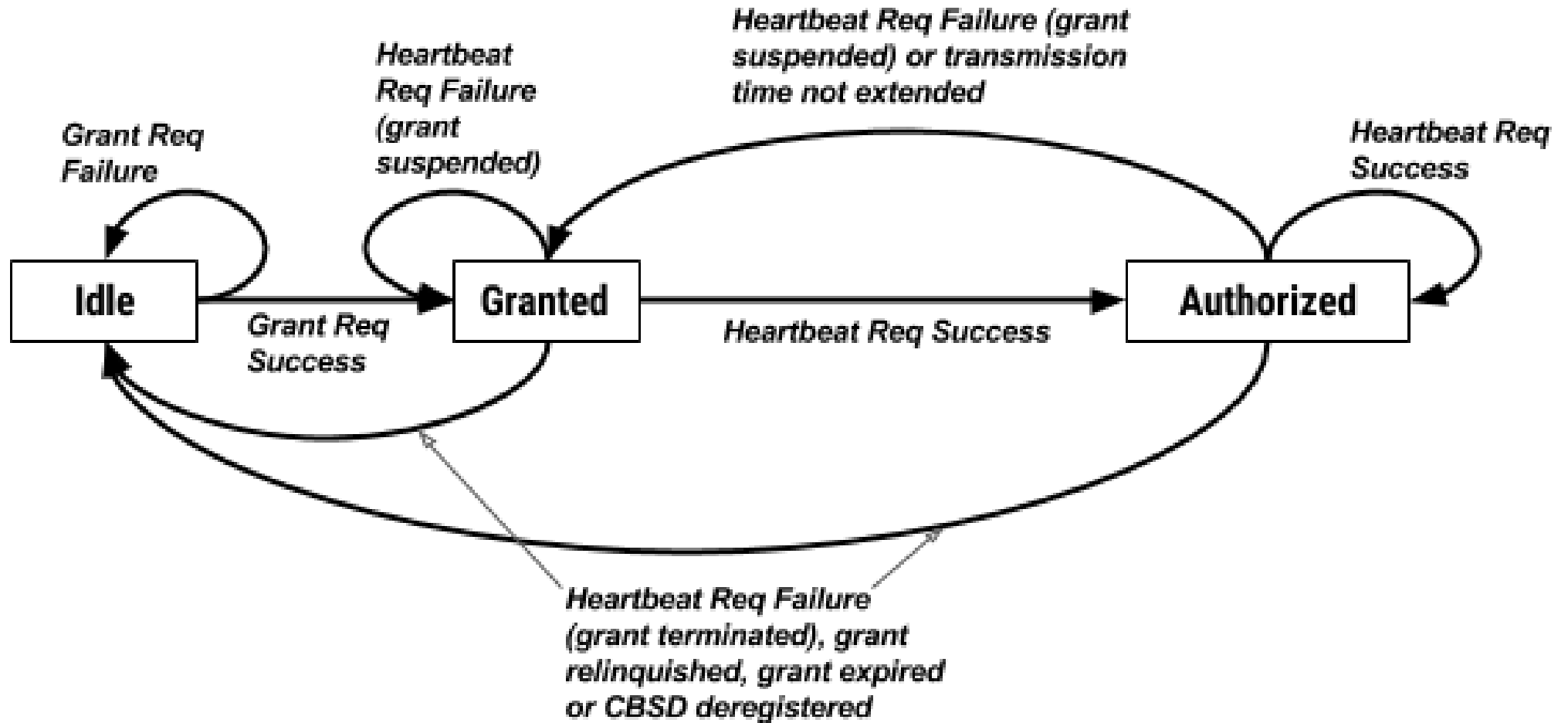
SAS-CBSD Procedures

1. **SAS Discovery Procedure**
2. **Authentication Procedure**
3. **CBSD Registration Procedure**
4. **CBSD Spectrum Inquiry Procedure**
5. **CBSD Grant Procedure**
6. **CBSD Heartbeat Procedure**
7. **CBSD Grant Relinquishment Procedure**
8. **CBSD Deregistration Procedure**

SAS-CBSD protocol is based on the HTTPS (HTTP over TLS)

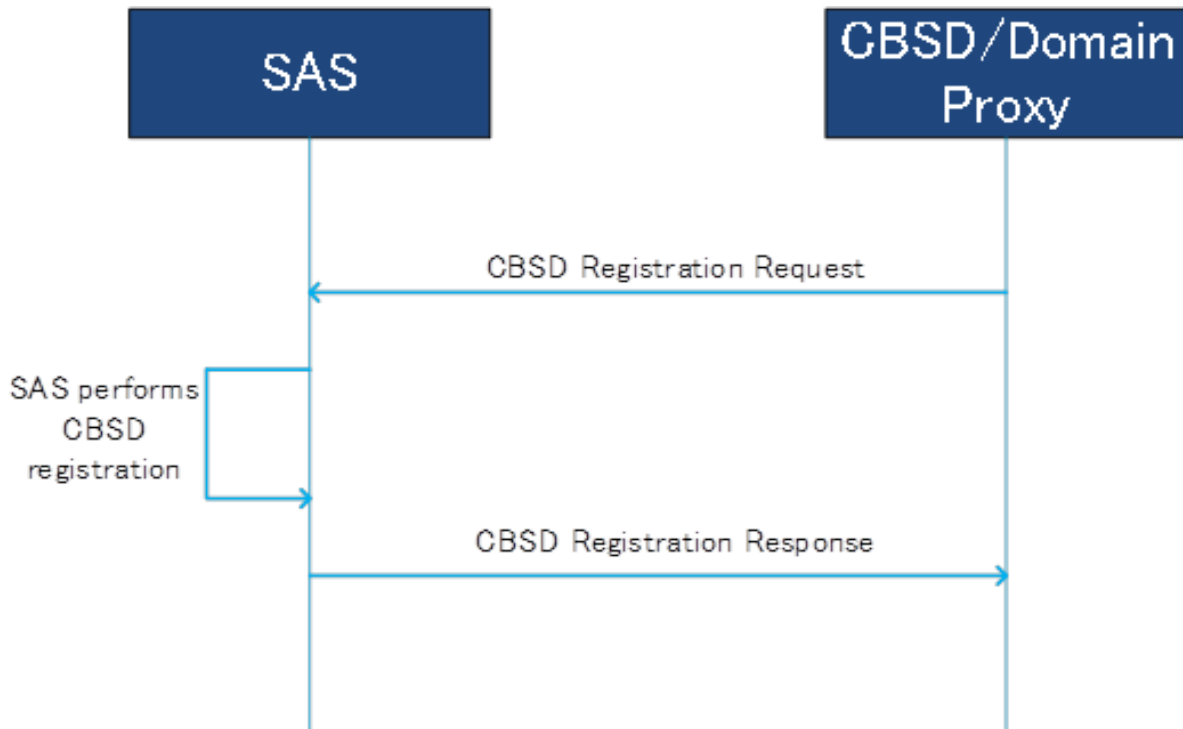# SAS-CBSD Discovery & Authentication Procedures

SAS Discovery Procedure

- SAS shall provide services using IPv4 and optionally IPv6
- SAS Administrators shall provide URLs for the offered services
- CBSDs/Domain Proxies are configured with the SAS URLs

Authentication Procedure

- TLS-v1.2 shall be used to perform authentication
- The CBSD/Domain Proxy initiating the TLS connection shall authenticate the SAS, and the SAS shall authenticate the CBSD/Domain Proxy
- All message exchanges involving communication between a CBSD or Domain Proxy and the SAS shall be performed in an established TLS connection context
  - If such a TLS connection is already open, the procedures may be performed within that context.
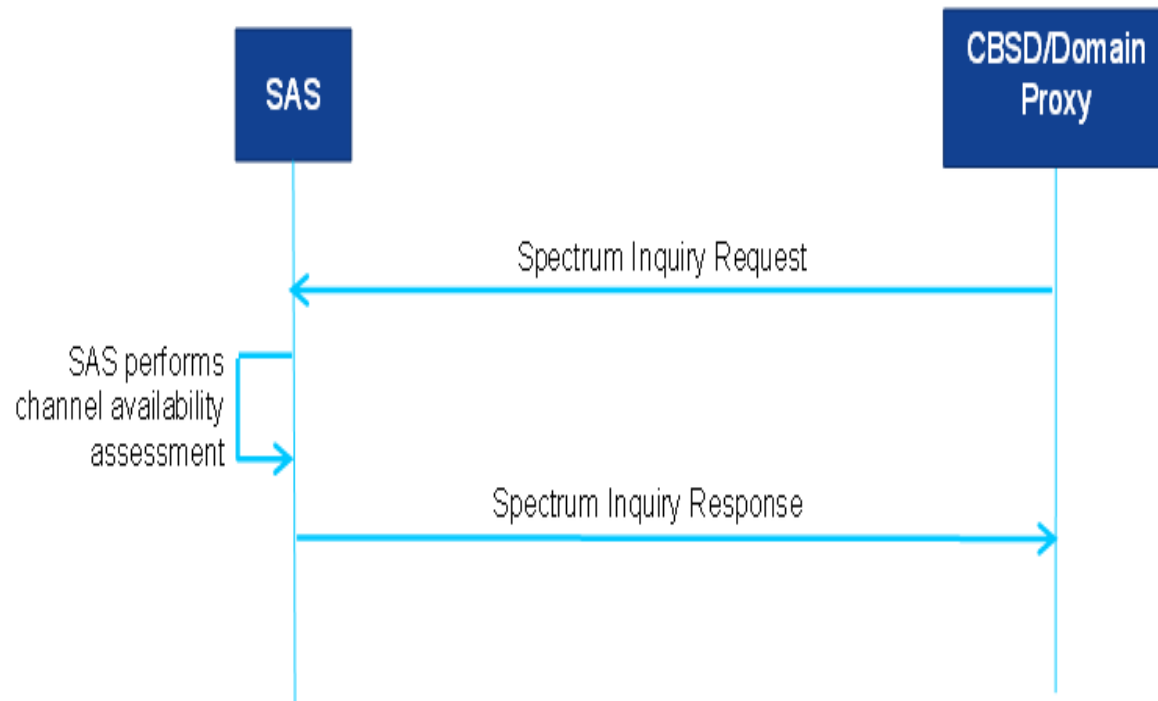
CBSD Registration Procedure

- This procedure is initiated after the CBSD has successfully discovered the SAS and performed Authentication

- The CBSD shall use the **cbsdId** parameter value for all subsequent procedures with the SAS.

- If the *measReportConfig* parameter is included in the *RegistrationResponse* object, the CBSD shall send the requested measurement report in the first *SpectrumInquiryRequest* object and in the first *GrantRequest* object to the SAS

- Domain Proxy can perform bulk CBSD registration

RegistrationRequest object *(userId, fccId, cbsdSerialNumber, callSign, cbsdCategory, cbsdInfo, airInterface, installationParam, measCapability, groupingParam)*

RegistrationResponse object *(cbsdId, measReportConfig, response)*

CBSD Spectrum Inquiry Procedure

SAS → Spectrum Inquiry Request → CBSD/Domain Proxy

SAS performs channel availability assessment

SAS → Spectrum Inquiry Response → CBSD/Domain Proxy

- Spectrum Inquiry allows Registered CBSDs to request information on available channels
- The CBSD may initiate this procedure any time after successfully registering with the SAS
- The *inquiredSpectrum* parameter is an array of *FrequencyRange* objects indicating the frequency range(s) for which the CBSD seeks information
- Domain Proxy can send bulk *SpectrumInquiryRequest* objects and receive an array of *SpectrumInquiryResponse* objects from the SAS

SpectrumInquiryRequest object *(cbsdId, inquiredSpectrum, measReport)*

SpectrumInquiryResponse object *(cbsdId, availableChannel, response)*

CBSD Grant Procedure

SAS

CBSD/Domain Proxy

Grant Request

SAS performs channel access assessment
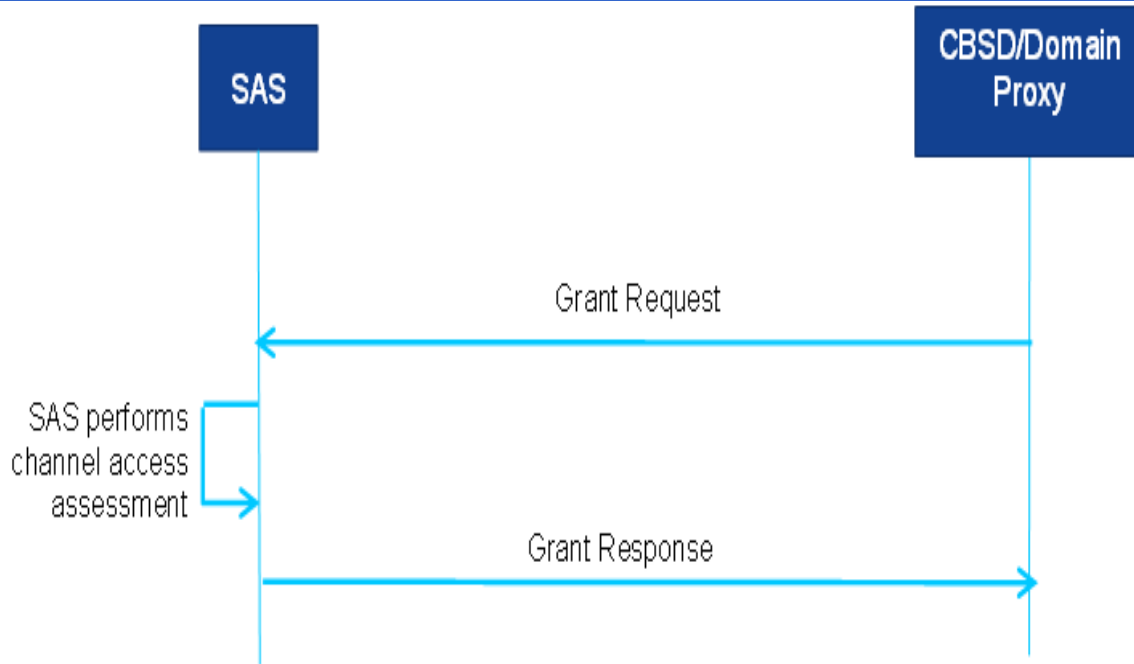
Grant Response

GrantRequest object *(cbsdId, operationParam, measReport)*

GrantResponse object *(cbsdId, grantId, grantExpireTime, heartbeatInterval, measReportConfig, operationParam, channelType, response)*

- The CBSD shall determine the frequency range and maximum EIRP parameters used in the Grant request
- If the SAS approves the Grant request, the SAS allocates spectrum according to the parameters in the *operationParam* parameter
- SAS shall determine the eligibility of the CBSD to use a PAL reserved channel
- If the *GrantResponse* object includes an *operationParam* parameter, the CBSD may elect to issue a new *GrantRequest* object using the operational parameters included from that *operationParam* parameter.
- The CBSD shall not use the spectrum (i.e., activate its radio transmitter) until successfully completing the Heartbeat procedure
- Domain Proxy can aggregate grant requests for multiple CBSDs and send a bulk *GrantRequest*
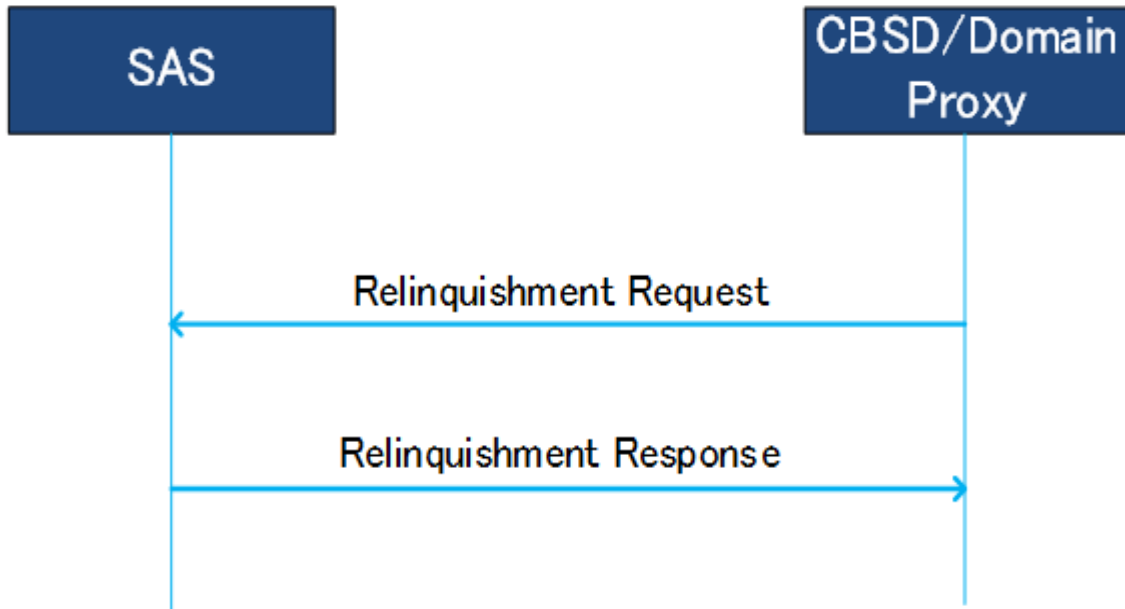
CBSD Heartbeat Procedure
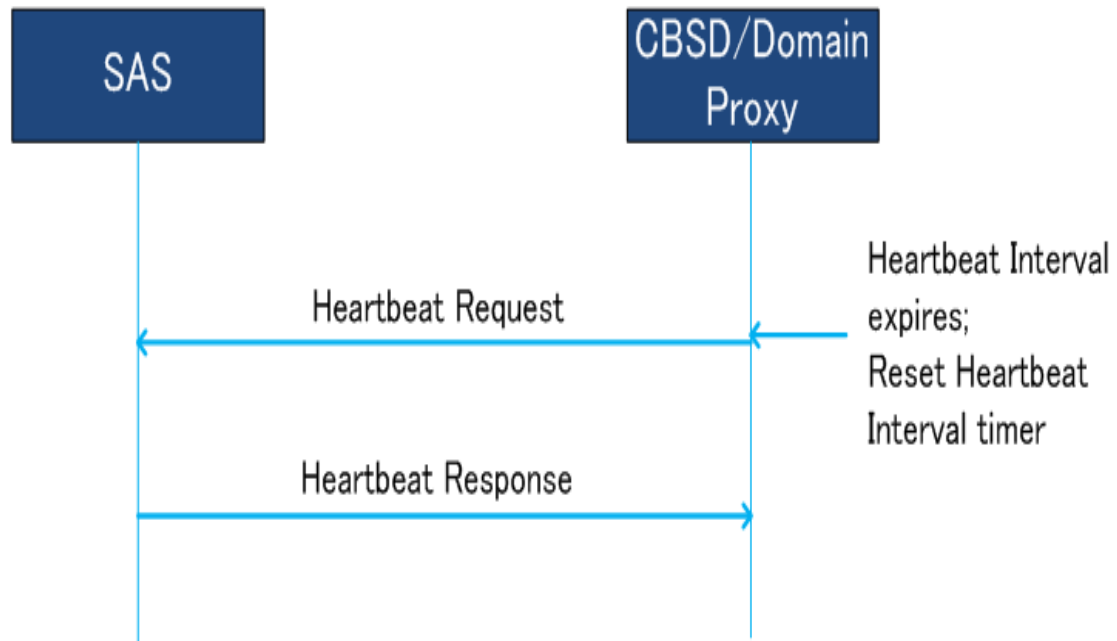
HeartbeatRequest object *(cbsdId, grantId, grantRenew, operationState, measReport)*

HeartbeatResponse object *(cbsdId, grantId, transmitExpireTime, grantExpireTime, heartbeatInterval, operationParam, measReportConfig, response)*

- The *HeartbeatRequest* informs the SAS that the CBSD needs access to the allocated spectrum for the specified *grantId*

- It also allows the SAS to suspend or terminate the Grant. The SAS has the option, within the *HeartbeatResponse* object, of suggesting that the CBSD request alternative spectrum based on the *operationParam* parameter

- If the transmit expiration timer expires prior to reception of a *HeartbeatResponse* object, the CBSD shall discontinue transmission for the Grant within 60 seconds after the value of the *transmitExpireTime* parameter expires

- SAS to CBSD connectivity is considered to be lost when, during a seven-day period, there is no successful Heartbeat procedure between the SAS and the CBSD

CBSD Grant Relinquishment Procedure

SAS → CBSD/Domain Proxy

Relinquishment Request

Relinquishment Response

RelinquishmentRequest object *(cbsdId, grantId)*

RelinquishmentResponse object *(cbsdId, grantId, response).*
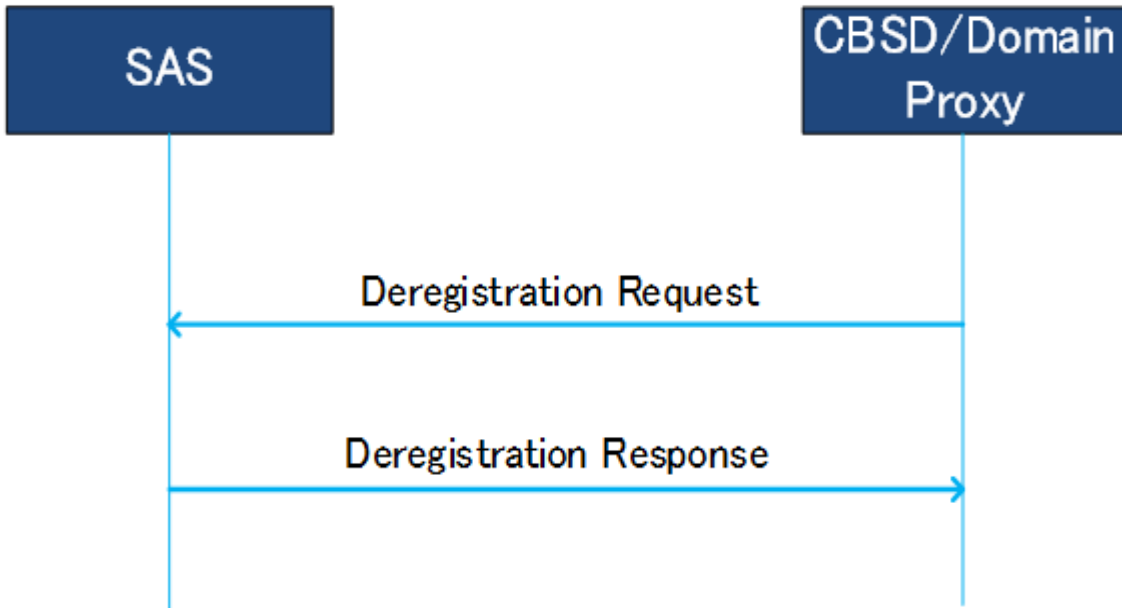
- The CBSD may initiate this procedure for an existing Grant after it has terminated radio operation associated with this Grant

- Upon reception of the *RelinquishmentRequest*, the SAS relinquishes the spectrum assigned to the CBSD

- In case of failure, regardless of the reason for the failure of *RelinquishmentRequest*, the CBSD no longer has authorization to use the spectrum associated with the Grant.

- Domain Proxy can aggregate relinquishment information for multiple CBSDs and send a bulk *RelinquishmentRequest*

CBSD Deregistration Procedure

SAS   CBSD/Domain Proxy

Deregistration Request

Deregistration Response

DeregistrationRequest object *(cbsdId)*

DeregistrationResponse object *(cbsdId, response)*

- When the CBSD determines that it should deregister from the SAS, it shall cease transmission associated with any Grants and then send a *DeregistrationRequest*

- The SAS marks the CBSD as Unregistered, removes any existing Grants, and responds with a *DeregistrationResponse*

- The CBSD should send a *RelinquishmentRequest* for each Grant prior to sending the *DeregistrationRequest*

- Domain Proxy can aggregate deregistration requests for multiple CBSDs and send a bulk *DeregistrationRequest*

SAS-CBSD Message Encoding and Transport

- **SAS service is a cloud service that protects higher tiers users and coordinates frequency use for users in the CBRS band**
- **HTTPS (HTTP+TLS) is used for communication between servers (SAS) and clients (CBSD)**
- **HTTP is a request-response protocol, where the client submits an HTTP request message to the server and the server returns a response message to the client**
- **A SAS-CBSD message is encoded using JSON (JavaScript Object Notation)**
- **A SAS-CBSD message can contain multiple requests or responses associated with different CBSDs for Domain Proxy operation**

Structure of a SAS-CBSD Message

```
POST /v1.0/registration HTTP/1.1
Host: www.sasadministratorapi.com
Content-type: application/json
Date: Mon, 03 Oct 2016 11:07:33 GMT
{
  "registrationRequest": [
    {
    …
  },
  {
    …
  }
  ]
}
```

Method Name	JSON Array Name of Request Message	JSON Array Name of Response Message
"registration"	registrationRequest	registrationResponse
"spectrumInquiry"	spectrumInquiryRequest	spectrumInquiryResponse
"grant"	grantRequest	grantResponse
"heartbeat"	heartbeatRequest	heartbeatResponse
"relinquishment"	relinquishmentRequest	relinquishmentResponse
"deregistration"	deregistrationRequest	deregistrationResponse

Parameter Types

Primitive JSON data types:

- **String (s)**
- **Number (n)**
- **Boolean (b)**
- **Array (a)**
- **Object (o)**

Required/Optional/Conditional

- <u>**Required (R):**</u> **The parameter shall always be included in the message**
- <u>**Optional (O):**</u> **The parameter may be included in the message**
- <u>**Conditional (C):**</u> **The parameter shall be included in the message, if and only if the specified conditions are satisfied**

Registration Messages

- **RegistrationRequest**
  - userId (s,R), fccId (s,R), cbsdSerialNumber(s,R), callSign(s,O), cbsdCategory(s,C), cbsdInfo (o,O), airInterface(o,C), installationParam(o,C), measCapability (s,C), groupingParam(o,O)
  - InstallationParam: latitude(n,C), longitude(n,C), height(n,C), heightType(s,C), horizontalAccuracy(n,O), verticalAccuracy(n,O), inddorDeployment(b,C), antennaAzimuth(n,C), antennaDowntilt(n,C), antennaGain(n,C), eirpCapability(n,O), antennaBeamwidth(n,C), antennaModel(s,O)

- **RegistrationResponse**
  - cbsdId (s,C), measReportConfig(s,O), response(o,R)
  - ResponseCode(o,R): responseCode(n,R), responseMessage(s,O), responseData(O)

s=string, n=number, b=Boolean, a=Array, o=Object
R=Required, O=Optional, C=Conditional

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Response Codes

responseCode Value	Name	responseCode Value	Name
0	SUCCESS	201	GROUP_ERROR
100	VERSION	202	CATEGORY_ERROR
101	BLACKLISTED	300	UNSUPPORTED_SPECTRUM
102	MISSING_PARAM	400	INTERFERENCE
103	INVALID_VALUE	401	GRANT_CONFLICT
104	CERT_ERROR	500	TERMINATED_GRANT
105	DEREGISTER	501	SUSPENDED_GRANT
200	REG_PENDING	502	UNSYNC_OP_PARAM

100-199: general errors
300-399: errors related to spectrum inquiry request
500-599: errors related to heartbeat

200-299: registration errors
400-499: errors related to grant

Spectrum Inquiry and Grant Messages

- **SpectrumInquiryRequest**
  - cbsdId(s,R), inquiredSpectrum(o,R), measReport(o,C)
- **SpectrumInquiryResponse**
  - cbsdId(s,C), availableChannel(o,C), response(o,R)
- **GrantRequest**
  - cbsdId(s,R), operationParam(o,R), measReport(o,C)
  - OperationParam: maxEirp(n,R), operationFrequencyRange(o,R)
- **GrantResponse**
  - cbsdId(s,C), grantId(s,C), grantExpireTime(s,C), heartbeatInterval(n,C), measReportConfig(s,O), operationParam(o,O), channelType(s,C), response(o,R)

s=string, n=number, b=Boolean, a=Array, o=Object
R=Required, O=Optional, C=Conditional

Heartbeat Messages

- **HeartbeatRequest**
  - cbsdId(s,R), grantId(s,R), grantRenew(b,O), operationState(s,R), measReport(o,C)
- **HeartbeatResponse**
  - cbsdId(s,C), grantId(s,C), transmitExpireTime(s,R), grantExpireTime(s,C), heartbeatInterval(n,O), operationParam(o,O), measReportConfig(s,O), response(o,R)

s=string, n=number, b=Boolean, a=Array, o=Object
R=Required, O=Optional, C=Conditional

# Relinquishment and Deregistration Messages

- **RelinquishmentRequest**
  - cbsdId(s,R), grantId(s,R)
- **RelinquishmentResponse**
  - cbsdId(s,C), grantId(s,C), response(o,R)
- **DeregistrationRequest**
  - cbsdId(s,R)
- **DeregistrationResponse**
  - cbsdId(s,C), response(o,R)

s=string, n=number, b=Boolean, a=Array, o=Object
R=Required, O=Optional, C=Conditional

SAS-SAS PROTOCOL

Objectives/Protocol/Information Sharing – Masoud Olfat, Federated Wireless

SAS-CBSD Procedures and Messages – Greg Billock, Google
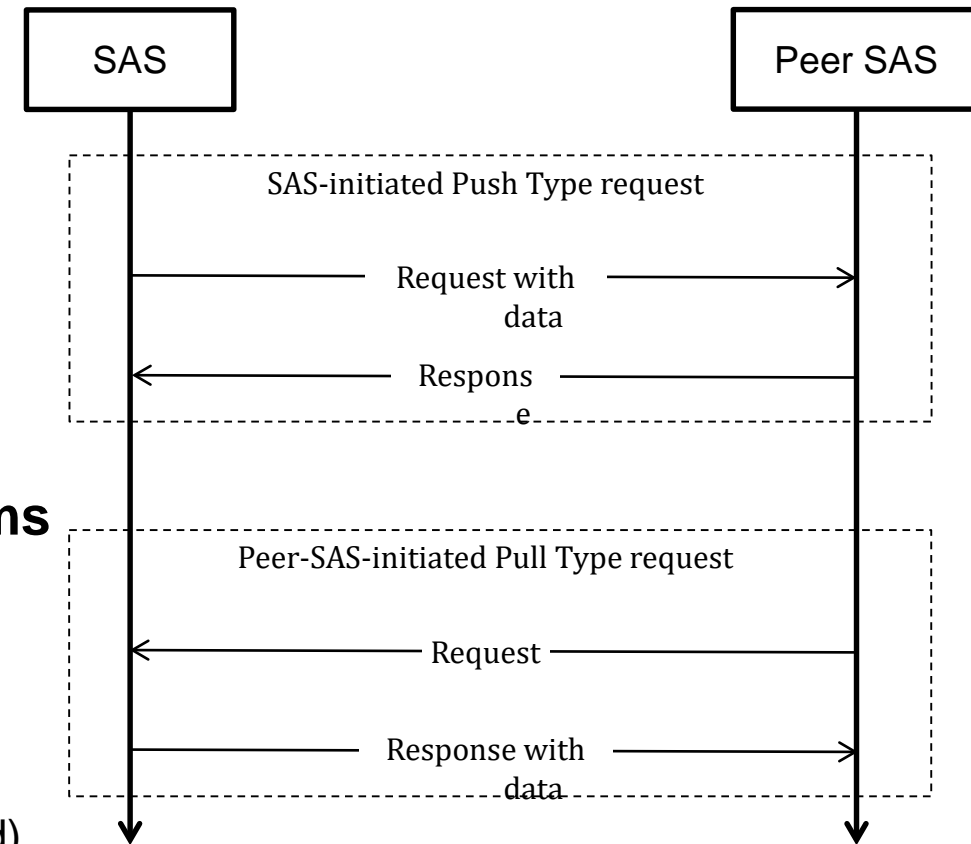
CBRS entities

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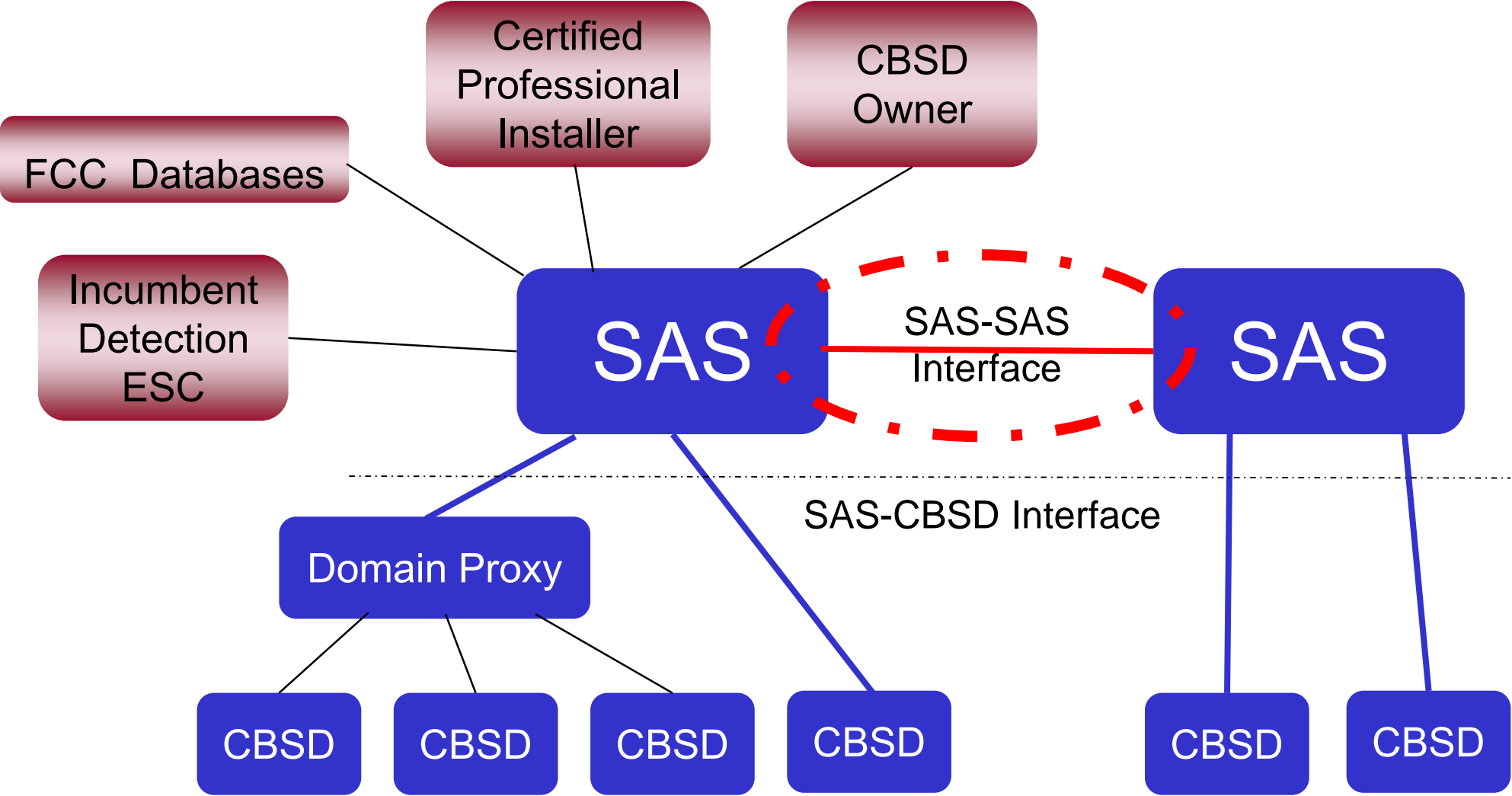
SAS-SAS Protocol Objectives

To meet the FCC requirements

  a. FCC required Information sharing

  b. Ensures communication Security/Authentication and SAS confidentiality

     a. Authentication using Certificates over TLS-vv1.2

     b. Data Encryption using 5 different ciphersuites

  c. Support aggregated interference protections for tier 1 and tier 2 users

  d. Supports GAA Co-existence functionalities

  e. Inter-SAS-operator coordination (e.g. on enforcement actions and alternative arrangements)

  f. Using common aggregate interference and propagation methods

SAS-SAS protocol basics

a. **Ensures SAS Autonomous operation**

b. **Supports real-time and non-real-time data exchange**

c. **Supports all different types of data exchange**
   - I. SAS-Essential
   - II. Public Data

d. **Supports different data exchange initiation mechanisms**
   - I. Push: A SAS pre-emptively exchange data with other SAS(s)
   - II. Pull: A SAS initiates data request from another SAS

e. **Supports different data exchange styles**
   - I. Bulk data exchange: A SAS shares all of its information (to be shared) with other SAS(s)
   - II. Incremental data exchange triggered by Events

SAS | Peer SAS

SAS-initiated Push Type request

Request with data

Response

Peer-SAS-initiated Pull Type request

Request

Response with data

Out of Scope of Winn Forum

Pre-requisites

- Communication Authentication / Security (data integrity).
- Data use restrictions agreements for non-public data exchange
- Peer SAS Discovery using URL endpoints
  - dynamic methods; Using protocols like Domain Name System (DNS)/ Dynamic Host Control Protocol (DHCP)
  - Static method

Information Sharing Principles

Instructions / notifications from FCC & Authorities shared; Push

No Sharing of ESC incumbent detection information from different ESCs, but CBSD data shall be exchanged.

SAS-Essential data shall be exchanged incrementally if requested by a peer SAS (in less than 10 seconds)

- ESC sensor location / characteristics, and their protection level records
- CBSD physical installation parameters (e.g., location, indoor/outdoor, antenna parameters,..), and their IDs
- CBSD coexistence parameters
- CBSD active grants:
- PAL Protection Area (PPA) records
- SAS-SAS Coordination Event records

Use of SAS-Essential Data by a SAS only for interference management

Information Sharing Principles

CBSD Registration Data:

- Publicly shared Registration Data; Would not result in CBSD licensee identification.
  - FCC ID
  - CBSD class
  - Indoor/outdoor
  - Air interface technology & sensing capabilities (if supported)
- Non-Public (obfuscated) Registration Data; shared with other SASs pursuant to confidential agreements.
  - CBSD antenna locations & characteristics max power
  - CBSD User & S/N & Call Sign (if any)
  - CBSD Max power

- **Any data shared to a SAS shall not be shared with public or other SASs**

Information Sharing Principles

SAS Public Data Set:

- SAS Admin. FCC registration records, (ID, contact info, SAS cert. date, etc.)
- Public Registration Data
- PAL Area information
- Federal Incumbent Exclusion Zone records
- Non-Federal Incumbent (FSS & GWBL) records

SAS-SAS information exchange procedures
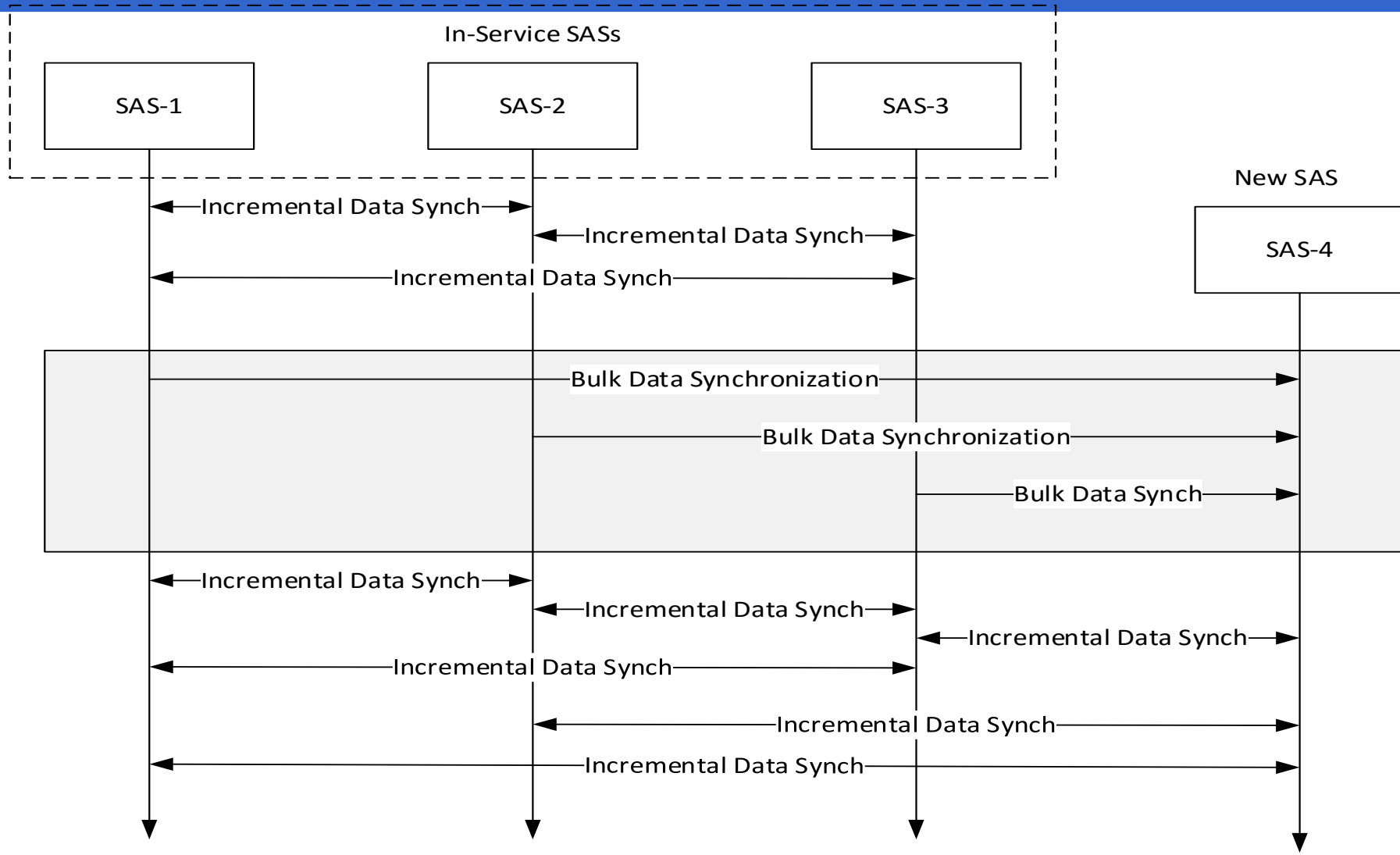
SAS-SAS Record Exchange Entities

Record	Description
SAS Administrators (PULL)	Exchanges the SAS Administrator, using an ID for SAS Admin.
SAS Implementations (PULL)	Exchanges SAS implementation, using SAS ID and an Implementation ID.
CBSD Device types (PULL)	A CBSD equipment device type certified by FCC to operation in the CBRS band, using a unique FCC_ID.
CBSD Registration & Grant (PULL & PUSH)	Registration & Grant of CBSDs registered in a SAS, using their cbsdIds. Could be pushed pre-emptively
Incumbents (PULL)	Information about incumbents known to SAS (FSS earth stations or GWBL installations, and Federal Incumbents) using their IDs
ESC Sensors (PULL)	ESC Sensor locations, antenna characteristics, and protection level required to protect ESC sensors
Zones (PULL & PUSH)	Geographical areas known to the SAS for protection or other objectives with various meanings within the SAS (e.g. PAL census tracts, PPAs, GWBL areas) using their IDs.
Coordination events (PULL & PUSH)	exchange of information regarding a wide range of events, such as GAA/FSS arrangements, PAL-to-PAL arrangements, GAA Coexistence, enforcement actions by FCC, etc
Full activity dump (PULL)	A full record dump by a SAS once every 7 days, including at least qualifying CBSD, Zone, and Coordination records and provide access to it to other SASs.

Time-Range Record Request

Pulled by A SAS

Includes all qualifying records modified (by the receiving SAS) in a certain time range (in UTC)
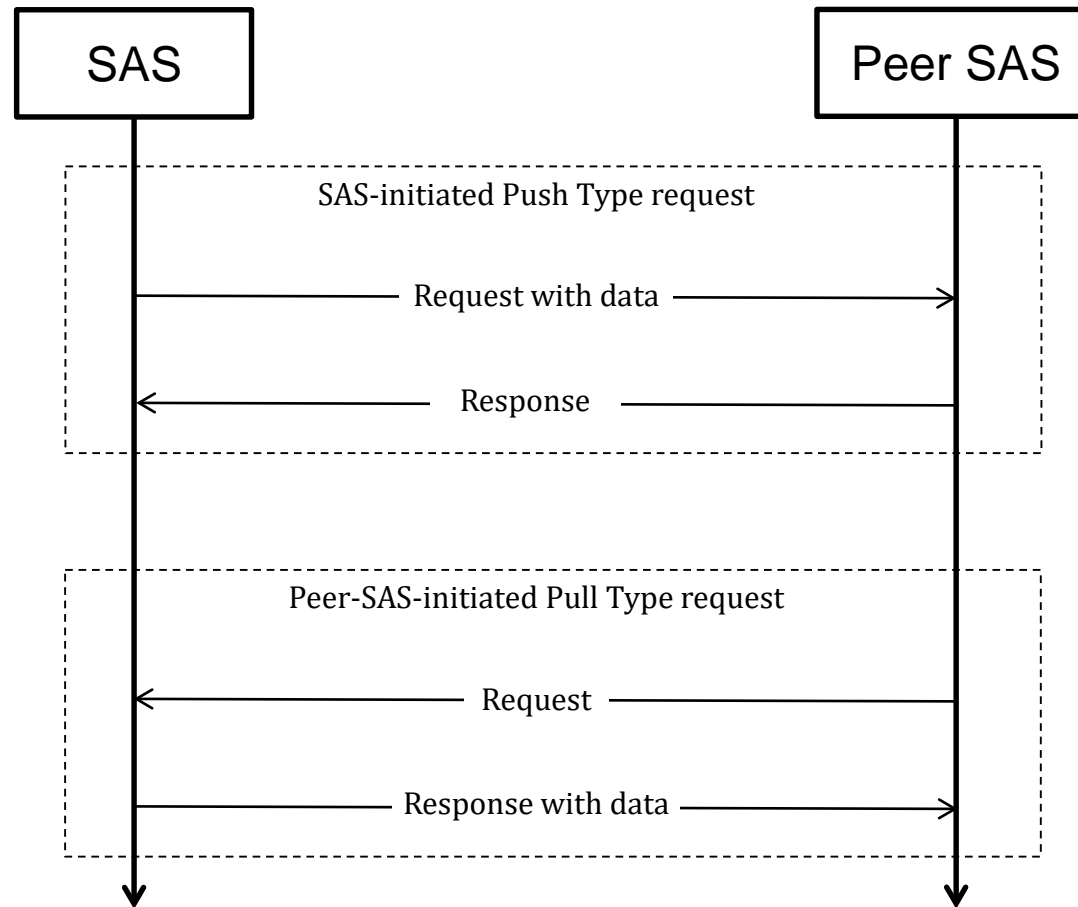
Includes

- CBSD
- Zone
- Coordination

Maximum time range is 3600 seconds

Allows each SAS to maintain most updated status of exchanged records with its peer SASs for these record types.

SAS-SAS Data Exchange

**SASs synchronize by exchanging data records with other SASs.**

SAS-SAS Data Records

**Data records are pulled by a requesting SAS from another SAS:**

All Activity in a Time Range	By ID
CBSD records	CBSD records
Zone records	Zone records
Coordination event records	Coordination event records
	SAS Administrator records
	SAS Implementation records
	Incumbent records
	CBSD Device-Type records
	ESC Sensor records

In addition a SAS may request a full activity dump from another SAS.
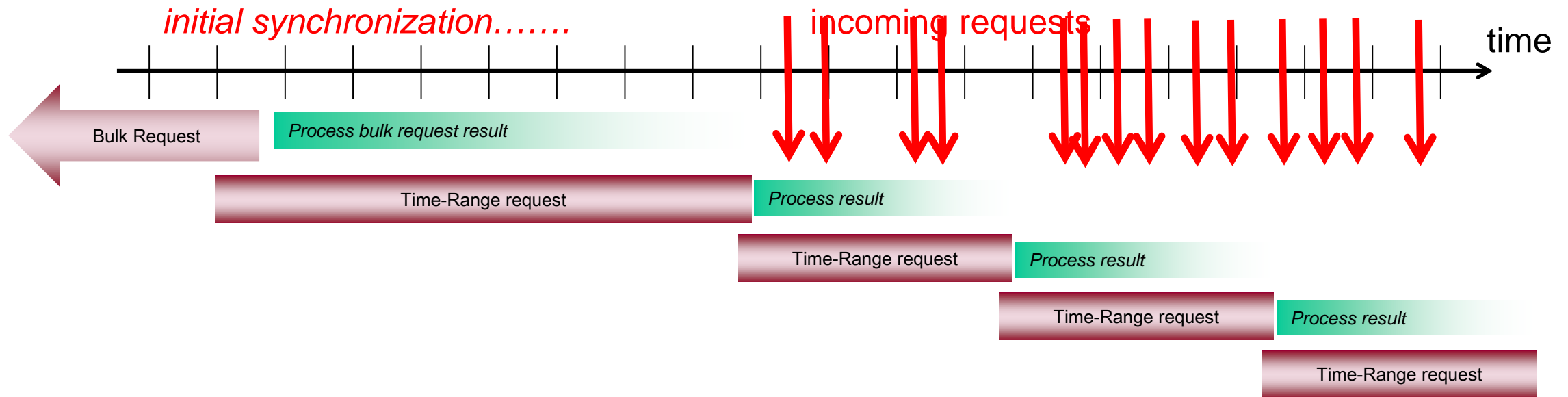
SAS-SAS Signaling Example
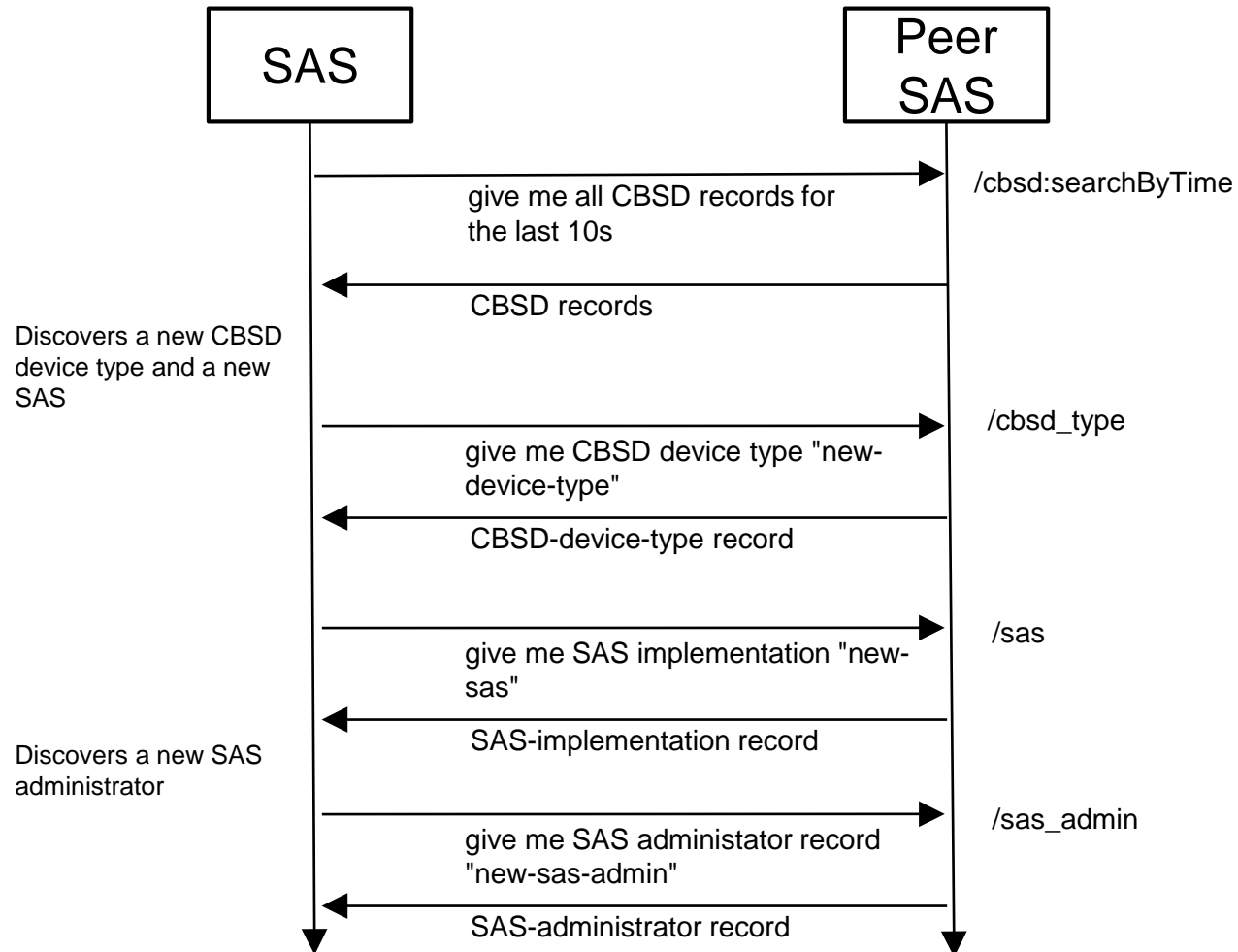
Time-range requests for maintaining synchronization
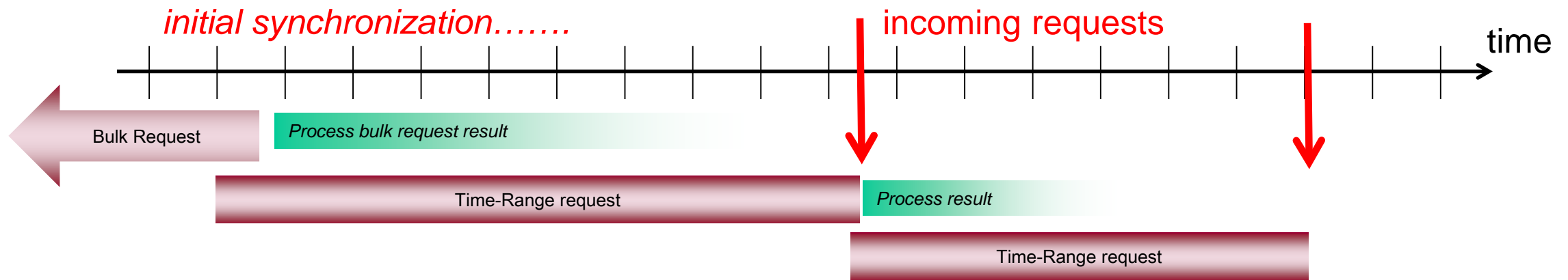
SAS can request synchronization on an as-needed basis when it receives incoming requests from CBSDs.

- Suitable for low-bandwidth operation
- Requires availability of SAS peers
- SAS-SAS time-range requests can be for periods of up to 3600s

Time-range requests for maintaining synchronization

initial synchronization…….

incoming requests

time

Bulk Request

Process bulk request result

Time-Range request

Process result

Time-Range request

Process result

Time-Range request

Process result

Time-Range request

SAS can manage its own synchronization cadence, maintaining sync with peers at regular intervals.
- More suitable for higher-bandwidth operation
- SAS remains autonomy in ability to handle incoming requests (synchronization is ongoing)
- SAS-SAS requests can be made independent of request traffic, for time ranges which will keep the SAS up-to-date

Push notifications for decreasing load

incoming requests

time

Push to peers
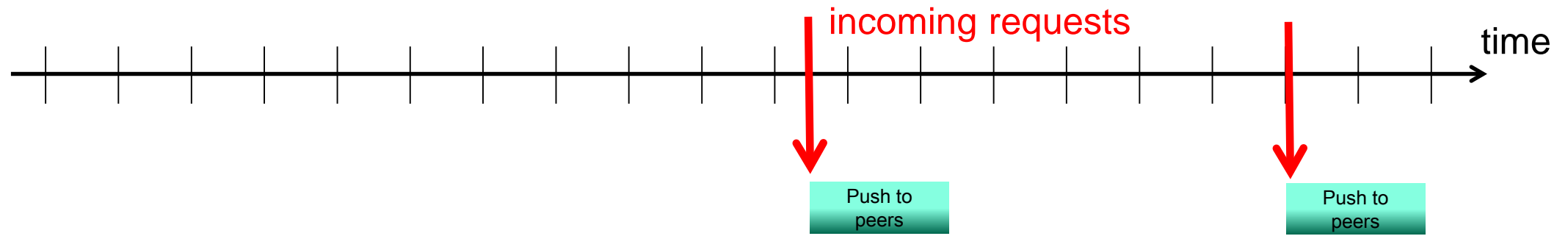
Push to peers

SAS can push notifications to peers on change to make any pull requests cheaper.
- Suitable for request traffic management in the SAS peer group
- Push notifications are optional

SAS receives the same records through SAS-SAS as it does from SAS-CBSD
- Eases ingestion of CBSD data
- Provides a simple way for SAS to understand the full RF environment
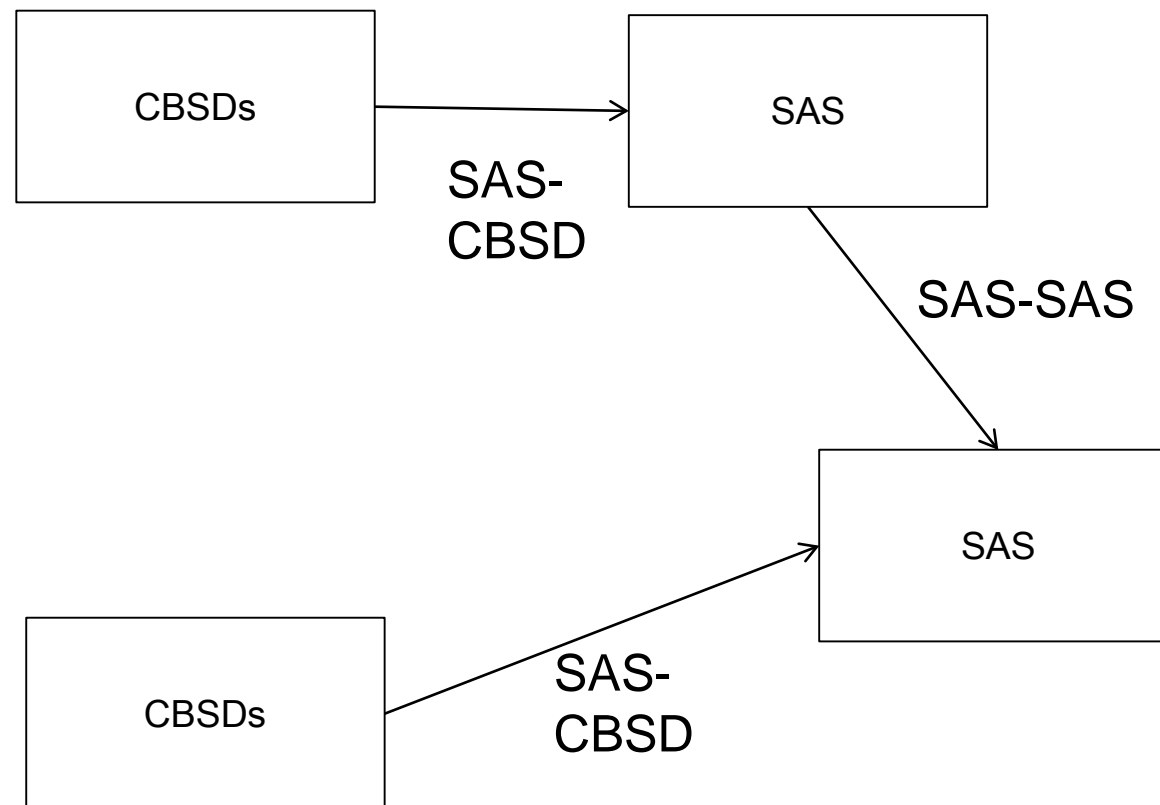
Summary

- WINN SSC WG3 is chartered to define the detailed protocols for data and communications across the various open interfaces within the CBRS system.

- Download SAS-CBSD and SAS-SAS protocol specs version 1 here: **http://www.wirelessinnovation.org/specifications**

- Technical Report that provides some explanation and best practices for the use of the SAS-SAS and SAS-CBSD protocol. http://www.wirelessinnovation.org/reports

- WINN SSC present at International Wireless Communications Expo/IWCE, Las Vegas
  - Keynote on March 29th
  - Workshop on March 30th

- Upcoming webinars on SAS and CBSD testing to be announced

Upcoming Workshop at IWCE

Building an Ecosystem for the CBRS Band
Thursday, March 30, 2017: 10:00 am - 5:00 pm

- Video presentation
- Tutorial with panel discussion
- Ecosystem presentations from industry leaders
- Roundtable discussion

More info. and to register: http://bit.ly/IWCEWorkshop