The Correlator Control Computer

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Atacama Large Millimeter/submillimeter Array
Karl G. Jansky Very Large Array
Robert C. Byrd Green Bank Telescope
Very Long Baseline Array

CCC Functional Overview

- CONTROL commands/delay events gateway
  - Validation of commands/delay events
  - Transformation/generation of commands for the CDP and correlator hardware
  - Generation of configuration and calibration IDs to be used by CONTROL and CDP
  - Correlator and CDP error handling
- Control and monitor of the correlator hardware through the CAN bus
- Usage of correlator resources

Usage of correlator resources

- Each LTA has 16 configuration and 16 correlator state slots.
- LTA slots cannot be re-used during a subscan.
- The CCC uses the LTA slots as follows:

- This assignment allows the ordering of the data coming out of the DPIs as expected.
- SCCs have 16 configuration slots and also 16 scaling factor slots.
- SCCs have no knowledge of subarrays but could be negatively impacted by concurrent subarrays all having antennas served by the same SCC.

CAN communications

- Physical characteristics
- Special protocol requirements (broadcast commands, block reads)
- CAN message address = (node address + 1) * 2^18 + RCA
- Broadcast commands use absolute addresses:
  - Absolute address 5 -> setup message
    - Specifies which device(s) are to execute command as a 6- byte mask (device addresses 0 – 47)
  - Absolute address 8 -> header and data messages
    - Header blocks specify the nature of the command (e.g. apply configuration, etc.)
    - Data blocks specify the data to be used during the execution of the command.
  - Absolute address 9 -> end of broadcast message

CAN communications – cont'd

	Fixed length message payloads = 8 bytes		8 bytes	8 bytes
Message Payload Bytes	**Broadcast Setup Message** Transmit using Message ID 5	**Header Message** Transmit using Message ID 8	**First Data Message** Transmit using Message ID 8	**Last Data Message** Transmit using Message ID 9

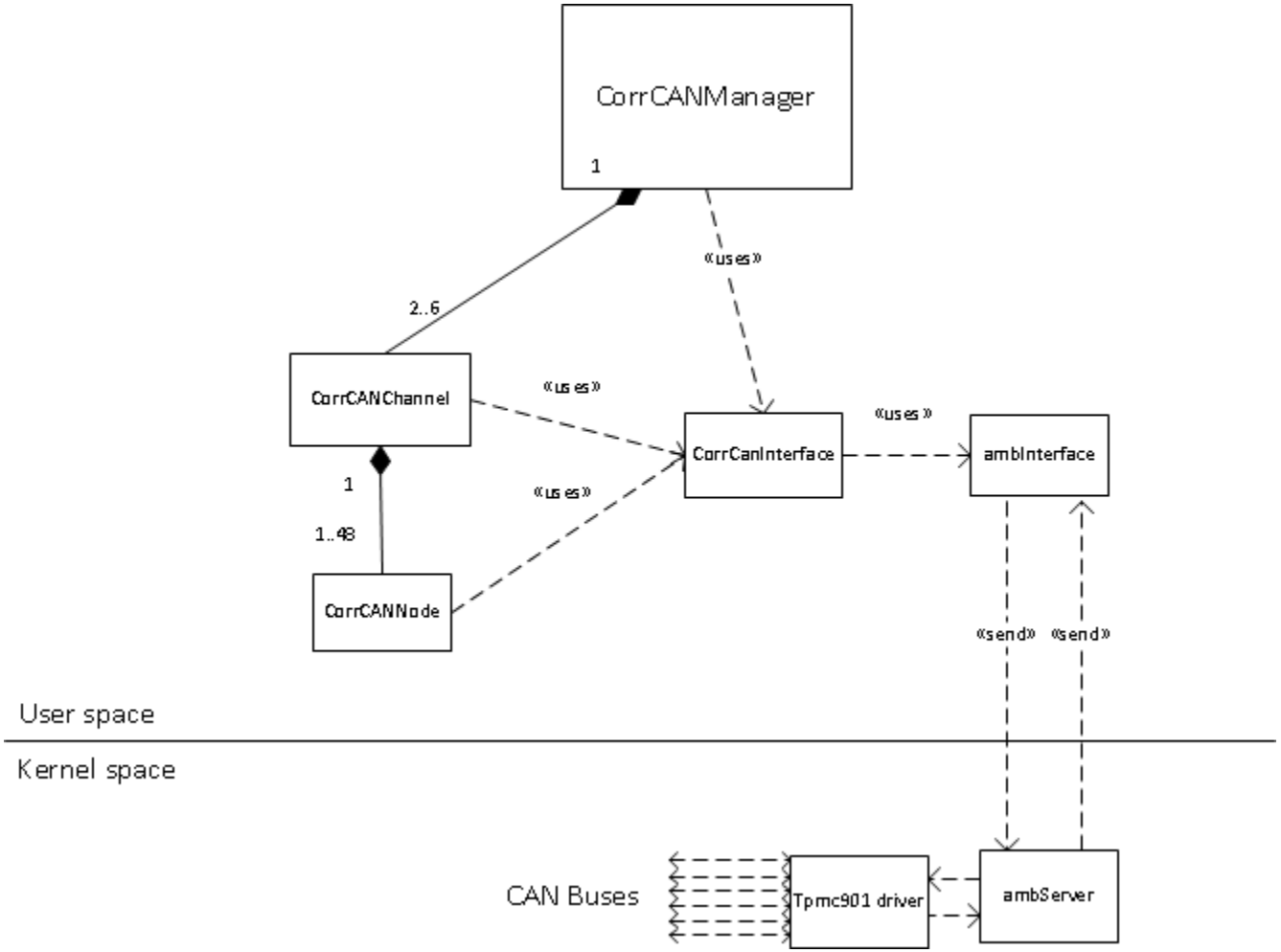
Data[0]	**Data_msg_ID = 8**	**Func_code=2**	byte 0	byte 56
Data[1]	0 (spare)	**Struct_type = 0**	byte 1	byte 57
Data[2]	Target mask 7 - 0	LS struct size (bytes)	byte 2	byte 58
Data[3]	Target mask 15 - 8	MS struct size (bytes)	byte 3	byte 59
Data[4]	Target mask 23 - 16	**0** ("block number")	byte 4	byte 60
Data[5]	Target mask 31 - 24	0 (spare)	byte 5	byte 61
Data[6]	Target mask 39 - 32	0 (spare)	byte 6	byte 62
Data[7]	Target mask 47 - 40	0 (spare)	byte 7	byte 63

- **Since all CAN packets making up a broadcast command have the same addresses there is no way to distinguish between two broadcast messages interleaving each other. This affects concurrent subarray scheduling as will be seen later.**

CAN communications – cont'd

- Block read commands do have RCAs (0x1000 and 0x1001).
- SCCs may be used by concurrent subarrays.
- Similar problem to broadcast commands.

CAN Communications – cont'd



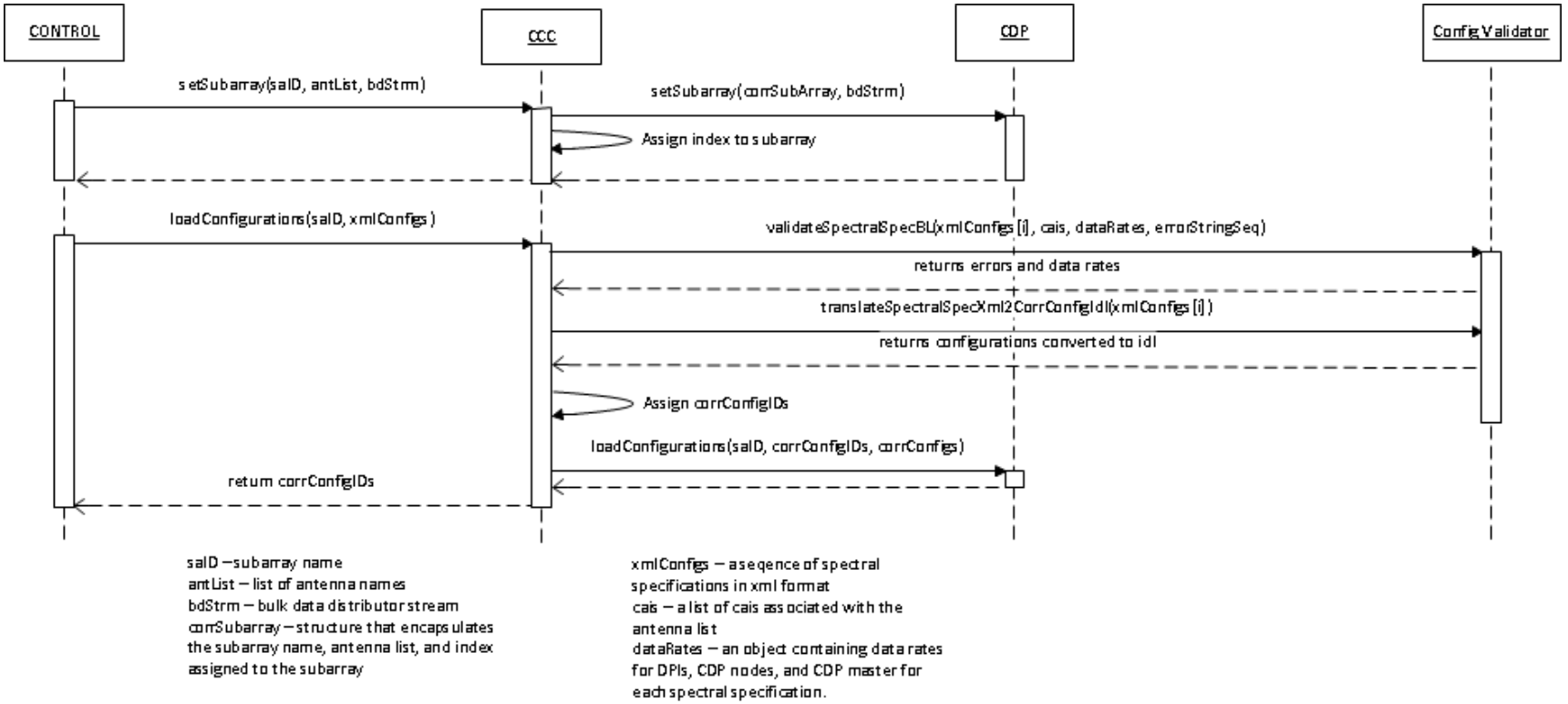
The CCC as command/event gateway (validating, generating, and passing commands/events/data to CDP as needed)

- Loading and validating spectral specifications
- Performing calibrations with pre-loaded configurations
- Running observations with pre-calibrated data
- Handling delays
- Aborting observations

Subarray creation and loading configurations

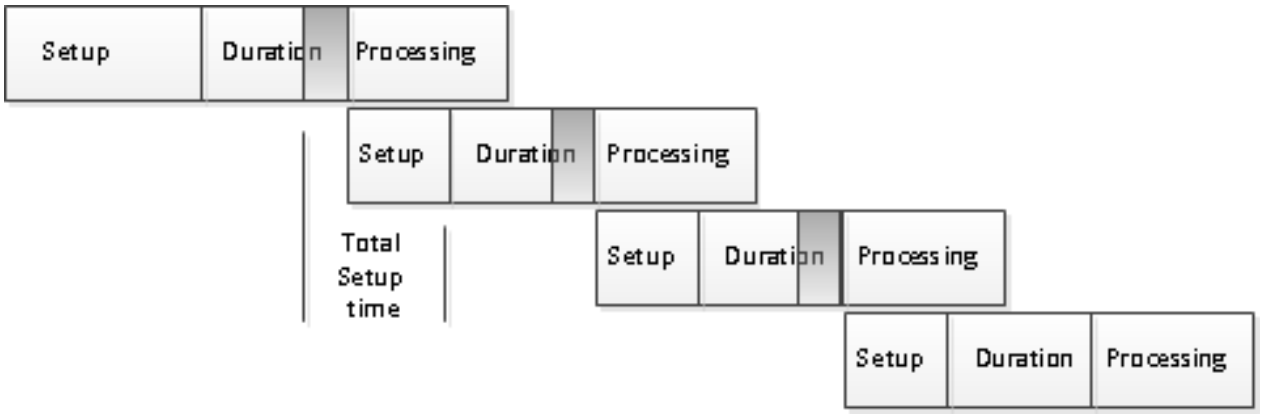
- Create and validate subarray
- Associating a set of spectral specifications with a given subarray
- Static validation of spectral specifications
- Conversion of spectral specifications into idl/c++ structures

Loading configurations



Calibration/subscan sequences

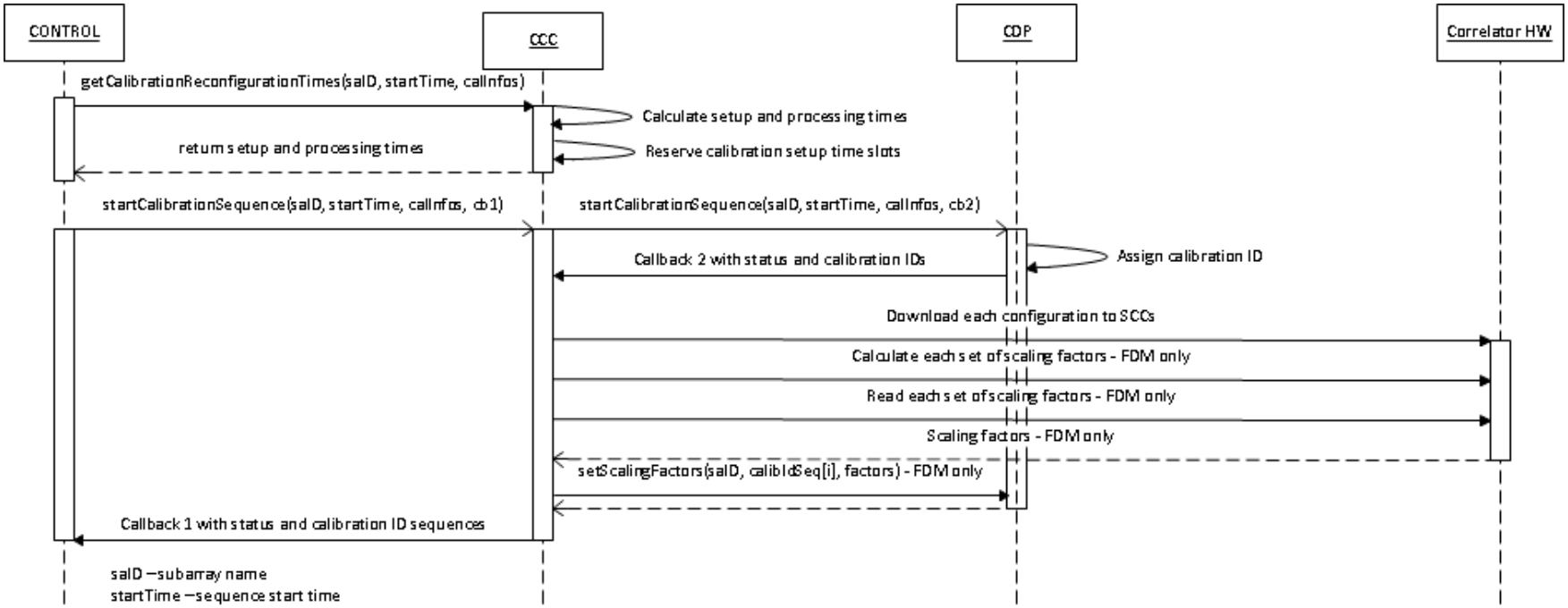
- Duration
- Processing time
- Setup time = inter-subscan period
- Borrowed time
- Total setup time = Setup time + borrowed time



Calibration preparation and execution

- Calibration types (TDM vs FDM)
- Scheduling
- Calibration IDs
- FDM scaling factors
- Callbacks
- Error handling

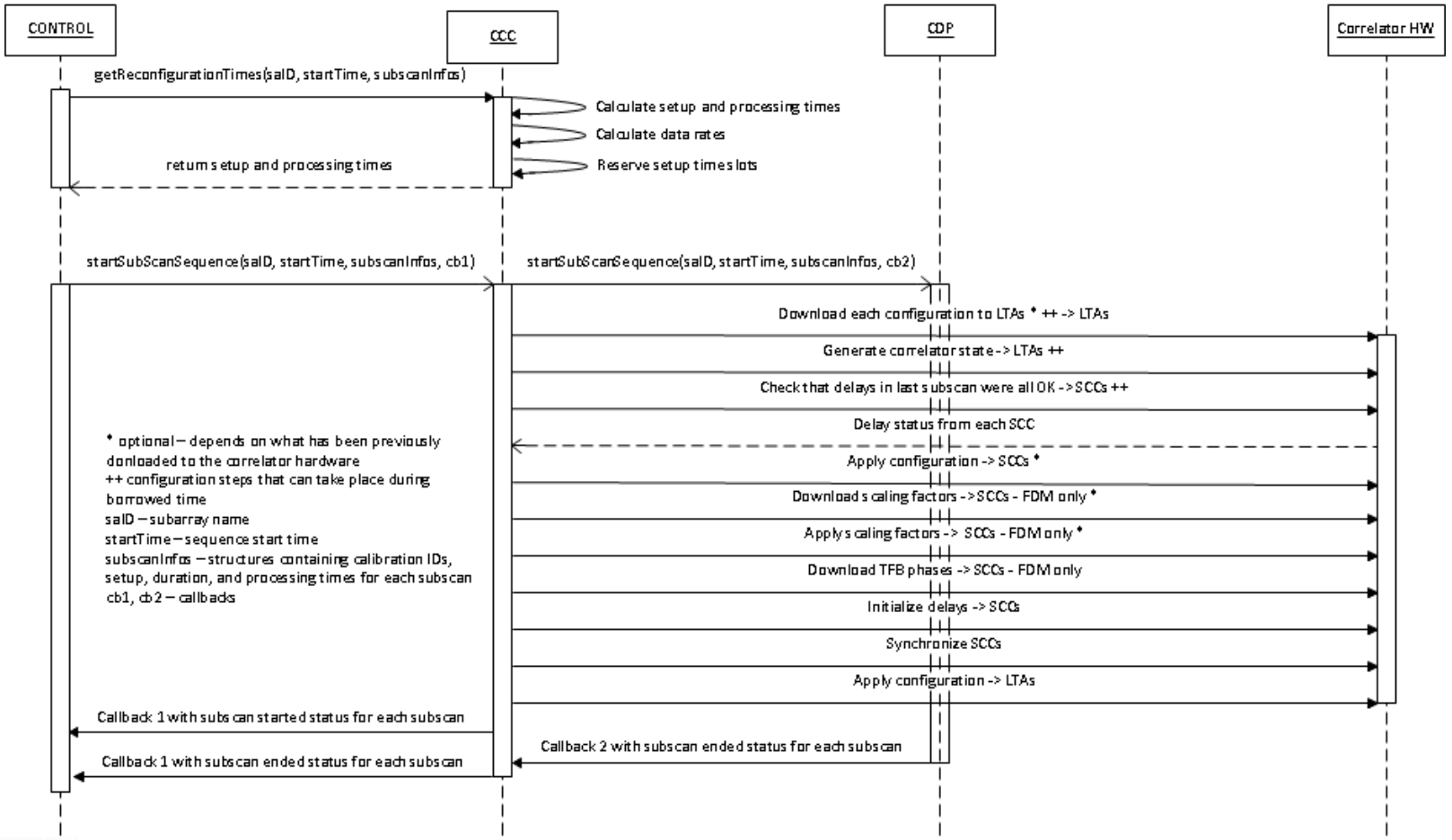
Calibration Sequences



Subscan sequence preparation and execution

- Sequence timings
- Dynamic validation of data rates
- Scheduling
- Error handling
- Callbacks

Subscan Sequences



Delay handling

- Terminology:
  - Bulk delay – applied by the station card – 8 us
  - Coarse delay – applied by the TFB – 250 ps
  - Fine delay – applied by the DGCK – 16 ps
  - Residual delay – corrected by the CDP nodes
- Consuming/validating/re-publishing delay events
- Delay application thread
- Baseband delay correction
- Coarse delay distribution (1 coarse delay = 8 CAN messages)
- Initialization delays
- Effect of delays in concurrent subarrays environments

Return-to-phase

- For FDM, TFB phases must be downloaded before and applied at the start of every subscan (except for VLBI).
- Calculation and downloading of phases must be done close enough to start of subscan to know which coarse and bulk delays will be in effect at that moment.

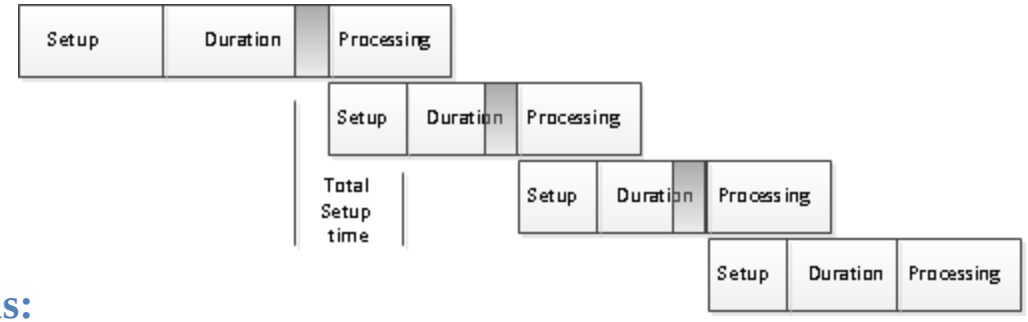
Aborting subscan sequences

- Subscan sequences on a given subarray may be aborted by:
  - CONTROL – due to issues external to correlator
  - CDP – e.g. due to intra-cluster communications, etc.
  - CCC – e.g. due to CAN communications, etc.
- CCC and CDP must be in precise agreement as to when the correlator state is changing to reflect the aborting subarray's missing data.

Scheduling concurrent subarrays

- First-in, first-out

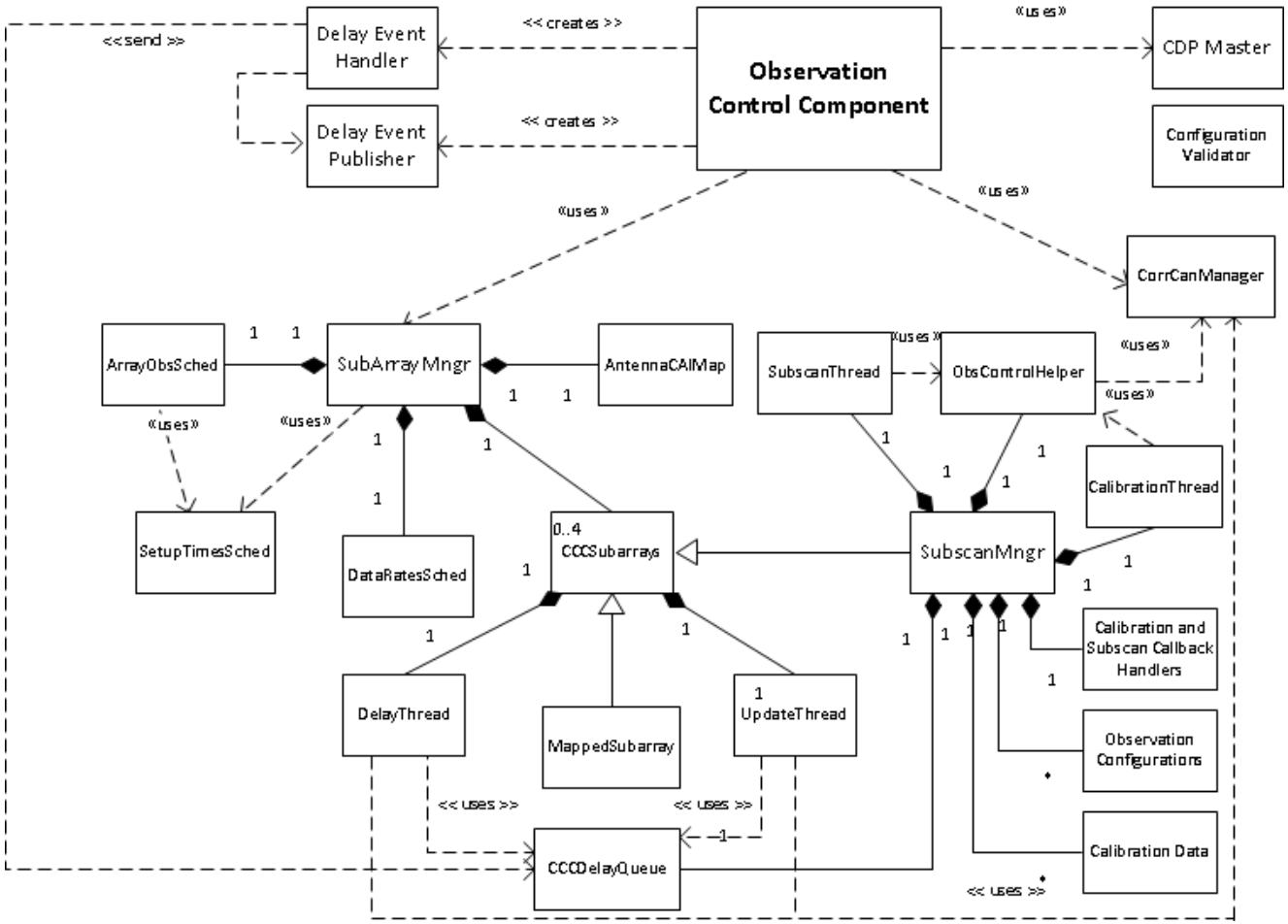
Array0:



CAN Bus:

Array1 CAN Bus:

Observation Control Component



Sideband separation with 90d Walsh functions

- Walsh sequences for all ALMA antennas with associated CAIs are downloaded to the LTAs when CORR comes operational. Offset into the sequence pertains to the TE at which the sequence
- Walsh sequences are only used if specified at the start of each subscan
- Data rate calculations are affected by binning

QCC monitors

- Thousands of monitor points for temperatures, voltages, etc. from QCCs.
- QCCs place on their own CAN bus so as not to interfere with setups for observation.
- Monitoring handled by separate components for each quadrant.
- Not completed and can use improvement.

Digitizer statistics

- Uses CORR's Maintenance interface.
- Not compatible with concurrent subarrays since no scheduling of CAN commanding is done.

VLBI

- New cards and protocols added (PIC, ONE_PPS).
- Return-to-phase is not done.
- Phases are produced outside CCC and applied on demand.