

CSP.LMC Prototype Proposed Design

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LMC harmonization through Telescopes
Step2: LMC Peer Review
Meeting 1

Madrid, 11-13 April 2016

Main Topics

- General introduction.
- CSP.LMC architecture and functionalities.
- CSP.LMC Prototype structure.
- CSP.LMC Prototype Tango Devices and Tango Classes.
- Prototype Tango Attributes and Commands.
- Prototype monitoring strategy.
- Logging and Alarms.

Reference framework

The reference framework is established by:

- SKA1_MID Telescope Interface Control Document CSP to TM (EICD)
- Interface Control Document LMC to CSP Sub-elements (IICD)
- SKA CSP Local Monitor and Control Sub-element Detailed Design Description
- LMC Interface Guidelines Document (LIG)
- Tango Interface Guidelines

The Tango Control System Manual version 8.1 and 9.1

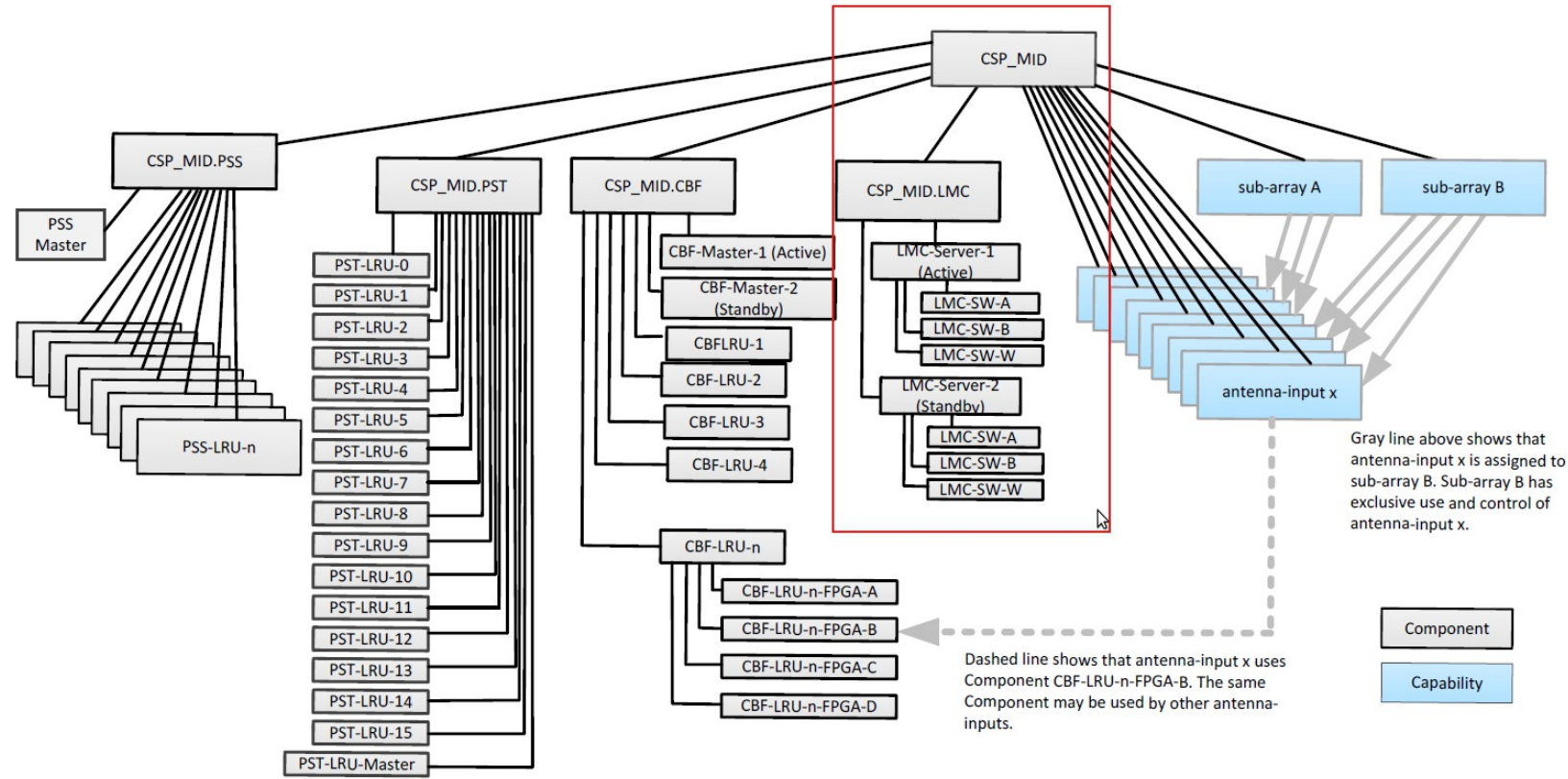
Horizontal Prototype & boundary conditions

- A prototype with a nearly complete interface towards TM.
- Prototype development performed in the MID mental framework but the functionalities are in common with LOW.
- TM has an unique point of access to CSP.LMC during normal operations.
- All CSP SubElements have an unique point of access to CSP.LMC during normal operations.
- **Use of Tango as control framework.**

Why to develop a prototype?

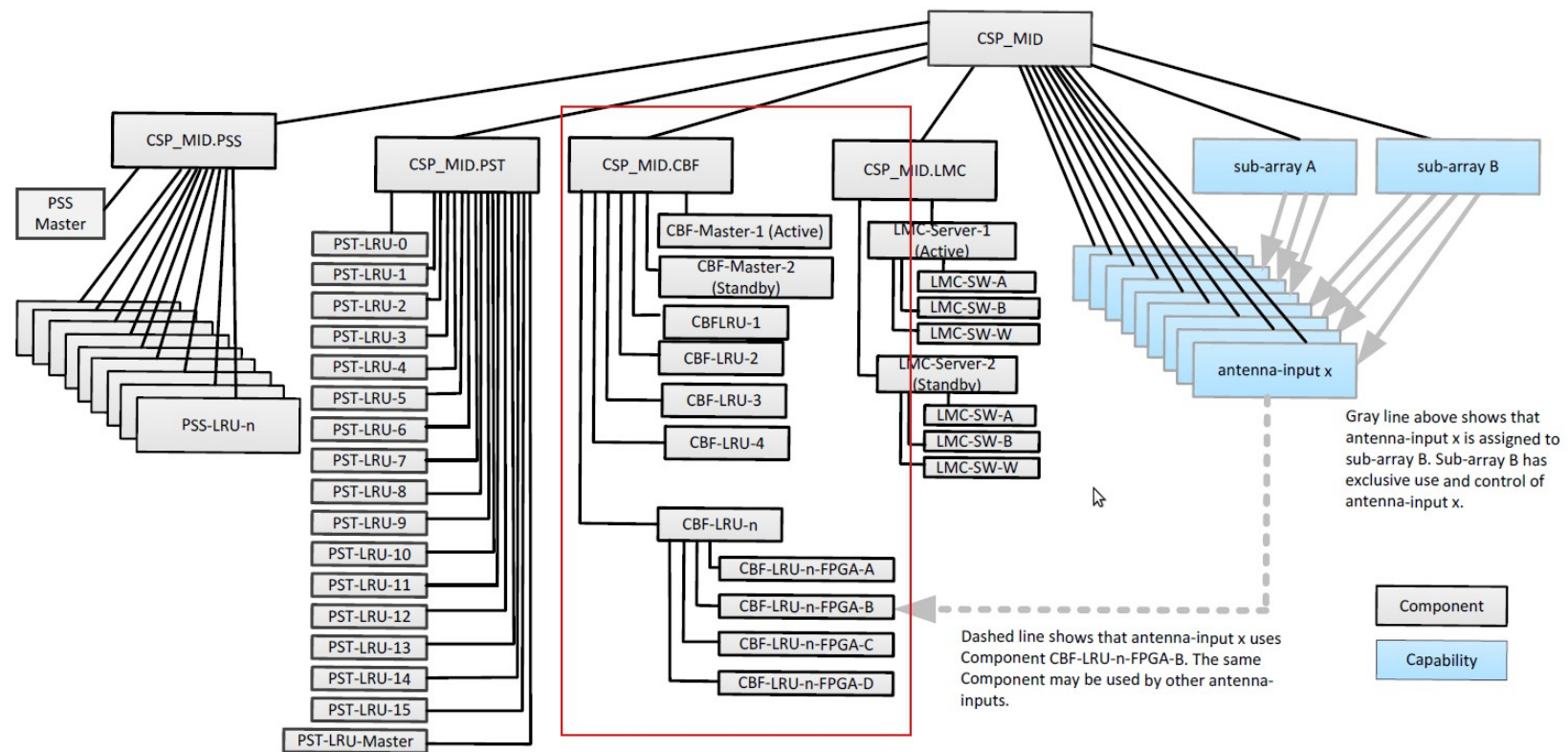
- Test the Tango ability and find the best approaches to implement the main **CSP.LMC** functionalities.
- Reduce the risks of the requirements.
- Verify the compliance with the requirements of timings in critical operations.
- Test, if possible, a small subset of design alternatives.

CSP M&C Hierarchical Structure



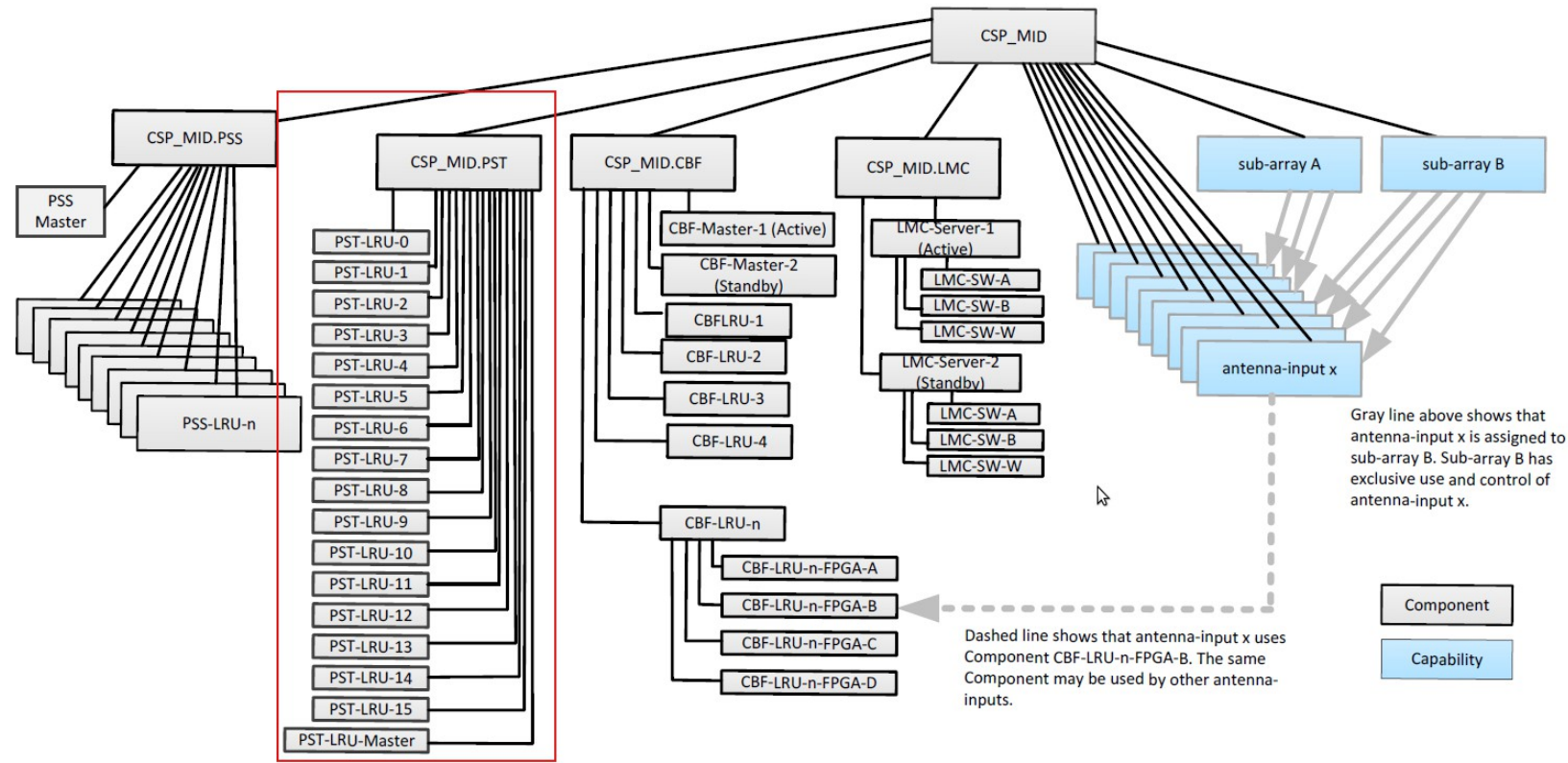
From: S.Vrcjc SKA ICD SKA Document

CSP M&C Hierarchical Structure



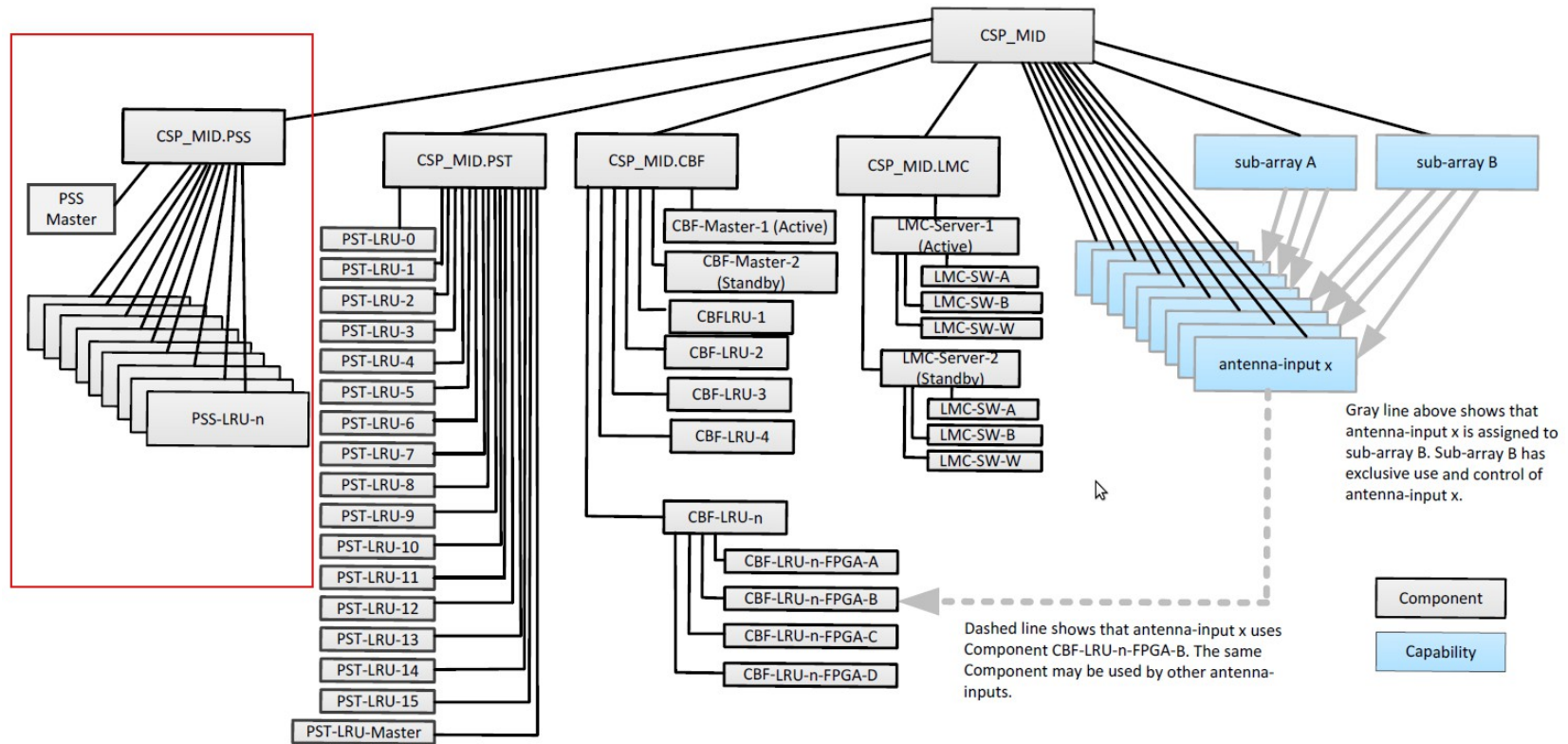
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CSP M&C Hierarchical Structure



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The Prototype M & C Functions

The Prototype will implement some **CSP** M&C functionalities. In particular, it will:

- Implement the interface with TM and SubElements.
- Maintain and control the overall CSP status.
- Receive, execute TM commands and generate replies.
- Perform mapping of TM commands to command for individual CSP SubElements.

- Handle timed commands.
- On the behalf of TM configure *SubArrays* and allocate the *Capabilities* to them.
- Collect and forward to TM the alarms, events and other messages generated by CSP SubElements.
- Maintain a log of all the activities.

The prototype structure (1)

The modeling of an equipment is the first step to implement a Tango Device.

The Prototype structure is modeled on the CSP architecture:

- Each M&C entity is implemented as a TDS (Tango Device Server) running one or more TDs (Tango Devices)



- ✓ One TDS for CSP Element
- ✓ One TDS for each SubElement: CBF, PSS and PST
- ✓ Each TDS runs on a separate PC (Master Node)

- The Prototype will implement as TDs all its M&C functionalities (but the logging).
- The Prototype will use the TLS (Tango System Logging) for logging.

The prototype structure (2)

Tango Device (CSP Master Node)	Functionality
CSP.LMC	Monitor & control the CSP
CSP.SYS	Monitor & Control of the Master Node
Scheduler	Handle the command queue for timed command received from TM
Alarm Handler	Handle of alarms generated by the whole CSP
SubArray	Maintain status and configuration of SubArrays
Capability	Maintain status and configuration of Capabilities

The prototype structure (3)

Tango Device (PSS Master Node)	Functionality
PSS.LMC	Monitor & control the PSS
PSS.SYS	Monitor & Control of the Master Node
Scheduler	Handle the command queue for timed command received from CSP.LMC
Alarm Handler	Handling of alarms generated by PSS

These devices may run in a single TDS (as a multiclass device) or in separate TDSs. From the point of view of the Prototype implementation, this means little changes. It is a matter of logical grouping.

Taxonomy of the prototype classes (1)

The functionalities of a *Tango Device* are described by a *Tango Class*. The CSP.LMC Prototype defines four different families of *Tango Classes*:

1. **TopCsp Class**: implement interface for M&C functionalities CSP Entity.
2. **Capability Class**: implement interface for CSP.LMC capabilities.
3. **Alarm Class**: implement interface for alarm handling.
4. **Scheduler Class**: implement interface for delayed commands.

The last two classes were borrowed from external Tango Projects.

Inside the prototype Tango Classes

The interface of a Tango Class is defined by the Tango attributes and Tango commands.

The Prototype Tango Classes are organized into a classification hierarchy: from more general classes (abstract) to specialized ones (concrete).

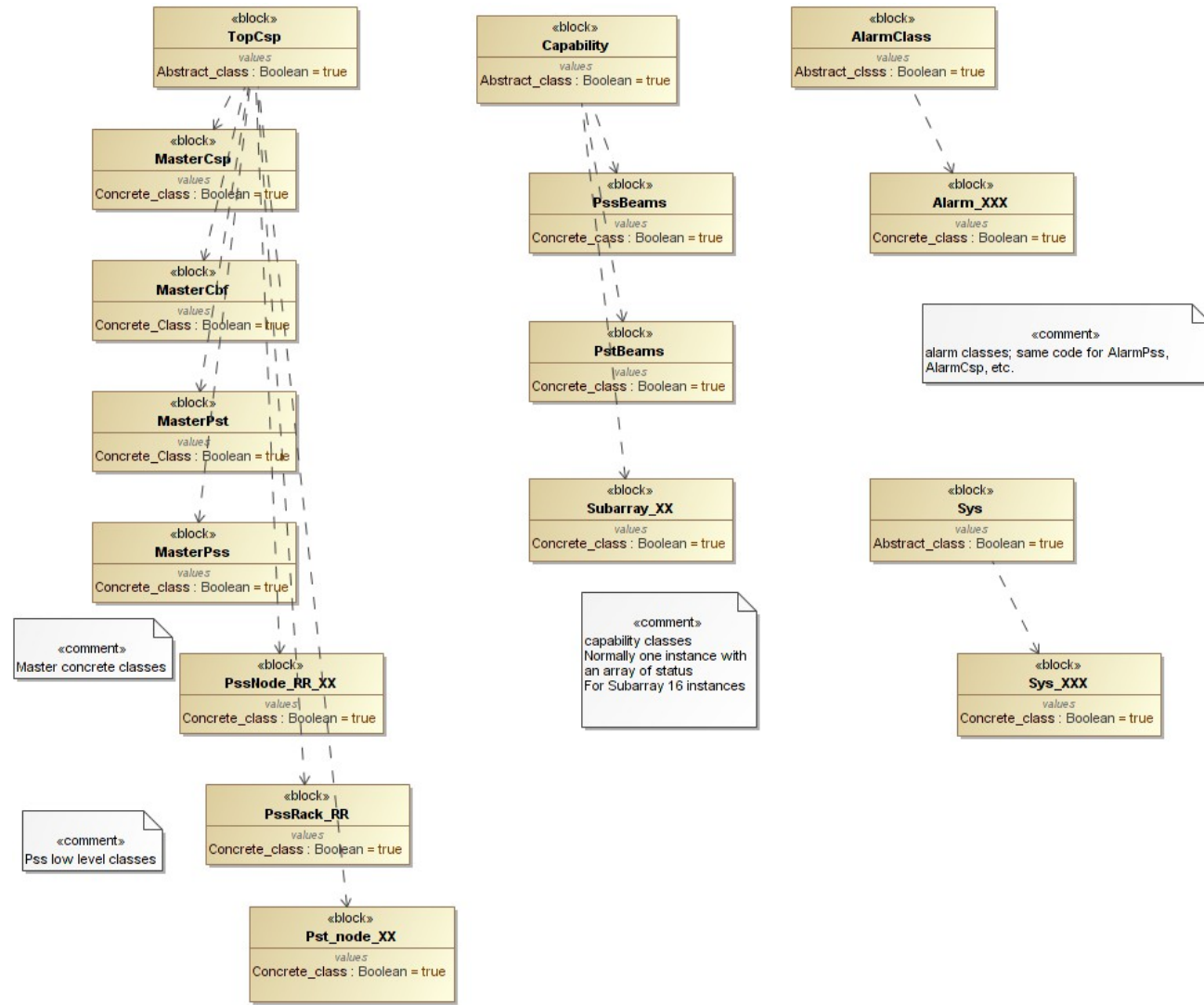
From the *EICD*

- Attributes and methods common to all elements, sub-elements and capabilities → generated few *abstract* classes.

From the *IICD*

- Attributes and methods specific to each SubElement and Capabilities → generated all the concrete Tango Classes.

Taxonomy of the prototype classes (2)



EICD / IICD Parameters

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Table 9-2 Legend for Table 9-3

Mode	
AT	All
JT	Public Tracking
ST	Dynamic Spectrum (proposed - TRC)
FT	Flow Through (proposed - TRC)
When is the parameter required (When):	
SC	Scan Configuration - to be received in advance of the 'sub-travel' specified in the message.
Start	At the beginning of the scan.
Intg	To be received after each successful integration.
MC	May change, i.e. may be updated during an observation (scan).
Implementation (support) priority (P):	
H	High
M	Medium
L	Low
C	Not known if required until calibration model of the telescope is defined.
D	To be defined (EUI)

Table 9-3 CSP_MidPST - Observing Mode Parameters

CSP_MidPST Parameter (KeyWord)	Type	Units, valid values or range (all TRC)	Mode	When	Description	P
Activation Time	String	UTC	All	SC	Date & Time when to start PST re-configuration	H
PST Beam-ID	TBD	TBD	All	SC	Identifier assigned by CSP_MidLAC (or TM) used to identify beam configuration.	H
CSP_PST-Beam-ID	TBD	TBD	All	SC	Identifier of the Capability CSP-PST Beam to be used for this scan and PST Beam ID, as previously assigned from the PST Beam ID provided by TM to PST Node ID (Capability ID).	H
Scan-ID	64 bit	TBD	All	SC	64-bit Scan ID inserted in the CSP output data.	H

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CSP_MidPST Parameter (KeyWord)	Type	Units, valid values or range (all TRC)	Mode	When	Description	P
Type of observation to be performed (OBSOBSMODE)	String	PULSAR_TRACKING	All	SC	The observing mode that the given PST server should operate in. In the future, two more Observing Modes may be added if EUP has been approved to allow Observing Mode(s) Dynamic Spectrum and Flow Through.	H
Observer ID (OBSOBSID)	String		All	SC	Observer in charge of observations.	L
Project-ID (PROJECT)	String		All	SC	Project that the observations are for.	L
Pointing ID (PTID_2)	String		All	SC	ID for sub-array pointing.	H
Sub-array ID (SUBARRAY_ID)	String		All	SC		H
Source (SRC_NAME)	String		All	SC	Name or ID of source.	H
IFM (IFM)	double	[0, infinity]	All	SC	IFM coordinates of the telescope delay centres.	H
Receiver ID (RECEIVER)	String		All	SC	Receiver name or ID (instrument).	H
Number of observation channels (OBSCHANNEL)	int	[1, 2]	All	SC		H
Native production of feed (FEED_PROD)	String	[ALL, NONE]	All	SC		H
Feed handshakes (FEED_HANDSHAKE)	int	[1, 1]	All	SC	Code for sense of feed FEED_HAND < 1 for WZ forming bit set with Z in the direction of propagation. Looking up into the feed of a prime focus receiver at the PA. For FEED_HAND = 1, the rotation formula for FEED_Beam ID is reversed (clockwise or the direction of increasing feed angle). For FEED_HAND = 1 for EELP on the PA for SPDR. See van Straten et al. (2015), Table 10.1, for details on the polarisation coordinates adopted for PSRFs and PSRFICs.	H
Feed angle (FEED_ANGLE)	degrees	[180, 180]	All	SC	Feed angle of the scanner for an end-on phase response from the A20 and B19 beams, measured in the direction of the prime focus receiver and in the range -180 deg.	H

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CSP_MidPST Parameter (KeyWord)	Type	Units, valid values or range (all TRC)	Mode	When	Description	P
Feed tracking mode (FEED_TRACKING)	String	[PA, CPA, SPA, TRA]	All	SC	During an observation: 'PA' means constant PA, i.e., that the feed axis feed with respect to the telescope reference frame. 'CPA' means that the feed rotates to maintain a constant PA, i.e., it tracks the variation of parallactic angle. Note that COORD_MID = 'SALACTIC' PA with respect to Galactic north and/or to COORD_MID = 'SCALACTIC' PA with respect to Galactic north. For SPA the PA is held fixed at an angle such that the required PA is obtained at the mid-point of the observation. 'TRA' is relevant only for scan observations. The feed is rotated to maintain a constant angle with respect to the scan direction.	H
Feed position (FEED_POS)	double	[0, 180, 180]	All	SC	The requested angle of the feed reference, for FEED_ANGLE = 'PA', with respect to the telescope reference frame (PA = 0), and for FEED_ANGLE = 'CPA', with respect to celestial north (PA = 0) with respect to Galactic north for COORD_MID = 'SALACTIC'.	H
Centre frequency (OBSFREQ)	double	MHz	All	SC	Centre frequency of observation.	H
Total (integrated) bandwidth (OBSBW)	double	MHz	All	SC	Total (integrated) bandwidth of observation.	H
Number of channels (OBSCHANNEL)	double	All	All	SC		H
Overlapping ratio (OVERLAP)	double	All	All	SC	Numerator and denominator for the overlapping ratio.	H
Beam major axis (BMAJ)	double	Deg.	All	SC	Beam major axis (BMAJ)	L
Beam minor axis (BMIN)	double	Deg.	All	SC	Beam minor axis (BMIN)	L
Beam position angle (BPA)	double	Deg.	All	SC	Beam position angle (BPA)	L
Frame of coordinates (COORD_MID)	String	[SALACTIC, EQUATORIAL, GALACTIC]	All	SC	Frame of coordinates.	H
Coordinate system (COORDSYS)	String	[J2000, MJD]	All	SC		H
STT_CRD1	String	[hh:mm:ss.sss or dd:dd:dd]	All	Start	X component of starting coordinates in COORD_MID frame.	H
STT_CRD2	String	[hh:mm:ss.sss or dd:dd:dd]	All	Start	Y component of starting coordinates in COORD_MID frame.	H

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CSP_MidPST Parameter (KeyWord)	Type	Units, valid values or range (all TRC)	Mode	When	Description	P
Track mode (TRC_MODE)	String	[TRACK, SCALACT, SCANACT]	All	SC	For 'TRACK' the beam axis tracks a fixed point on the sky. For 'SCALACT' the beam axis tracks at a uniform rate along a great circle on the sky. For 'SCANACT' the beam axis tracks at a uniform rate along a line of constant latitude or declination (depending on COORD_MID).	H
STP_CRD1	String	[hh:mm:ss.sss or dd:dd:dd]	All	Intg	X component of the final coordinates in COORD_MID frame. Required at the end of each sub-integration (not the end of each observation). Required for non-tracking observations only. This could be every 1 second to every hour, but would only be needed in the case of non-tracked scans. Currently there is no use case for non-tracked scans with the PSF, so this is unlikely to be used.	H
STP_CRD2	String	[hh:mm:ss.sss or dd:dd:dd]	All	Intg	Y component of the final coordinates in COORD_MID frame. Required at the end of each sub-integration (not the end of each observation). Required for non-tracking observations only. This could be every 1 second to every hour, but would only be needed in the case of non-tracked scans. Currently there is no use case for non-tracked scans with the PSF, so this is unlikely to be used.	H
De-dispersion measure (DM)	double	pc cm ⁻³ [0, 10,000]	All	SC	De-dispersion measure for coherent/beamwidth de-dispersion.	H
Rotation measure (RM)	double	rad m ⁻² [1, 7]	All	SC	Rotation measure for coherent de-faraday rotation. To de-faraday rotate low frequency signals while maintaining high time resolution may imply that we need to perform coherent rotation measure correction. This is not a requirement of the moment but may be implicitly derived from existing requirements. To be Defined (EUI).	D
Maximum length of observation (SCANLEN_MAX)	float	Seconds [0, 43200]	All	SC	Maximum length of observation.	H
Pulsar ephemeris (EPHEMERIS)	ASCII text	All	All	SC	Pulsar ephemeris for pulsar being observed. The ephemeris files should be of the order a few kilobytes.	H
Pulsar phase predictor (PREDICTOR)	ASCII text	All	All	SC	Pulsar phase predictor generated from ephemeris (T2 format). The predictor received from the DSP must have enough coefficients to represent the phase of the pulsar to better than 1 ns RMS over the full bandwidth of the scan and up to SCANLEN_MAX. More information related to predictors is provided below this table.	H
Output frequency channels (OBSCHANNEL)	int	[1, 255]	All	SC	The number of output frequency channels.	H
Output phase bins (OBSPHASE)	int	[4, 2048]	All	SC	The number of phase bins in output.	H
The integration time for each output bin (OUTTBIN)	double	Seconds [0, 00002.000]	All	SC	The integration time for each output bin.	H

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Centre frequency (OBSFREQ)	double	MHz	All	SC	Centre frequency of observation.	H
Total (integrated) bandwidth (OBSBW)	double	MHz	All	SC	Total (integrated) bandwidth of observation.	H
Number of channels (OBSCHANNEL)	double	All	All	SC		H
Overlapping ratio (OVERLAP)	double	All	All	SC	Numerator and denominator for the overlapping ratio.	H
Beam major axis (BMAJ)	double	Deg.	All	SC	Beam major axis (BMAJ)	L
Beam minor axis (BMIN)	double	Deg.	All	SC	Beam minor axis (BMIN)	L
Beam position angle (BPA)	double	Deg.	All	SC	Beam position angle (BPA)	L
Frame of coordinates (COORD_MID)	String	[SALACTIC, EQUATORIAL, GALACTIC]	All	SC	Frame of coordinates.	H
Coordinate system (COORDSYS)	String	[J2000, MJD]	All	SC		H
STT_CRD1	String	[hh:mm:ss.sss or dd:dd:dd]	All	Start	X component of starting coordinates in COORD_MID frame.	H
STT_CRD2	String	[hh:mm:ss.sss or dd:dd:dd]	All	Start	Y component of starting coordinates in COORD_MID frame.	H

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STP_CRD2	String	[hh:mm:ss.sss or dd:dd:dd]	All	Intg	Y component of the final coordinates in COORD_MID frame. Required at the end of each sub-integration (not the end of each observation). See STP_CRD1 for more comments.	H
De-dispersion measure (DM)	double	pc cm ⁻³ [0, 10,000]	All	SC	De-dispersion measure for coherent/beamwidth de-dispersion.	H
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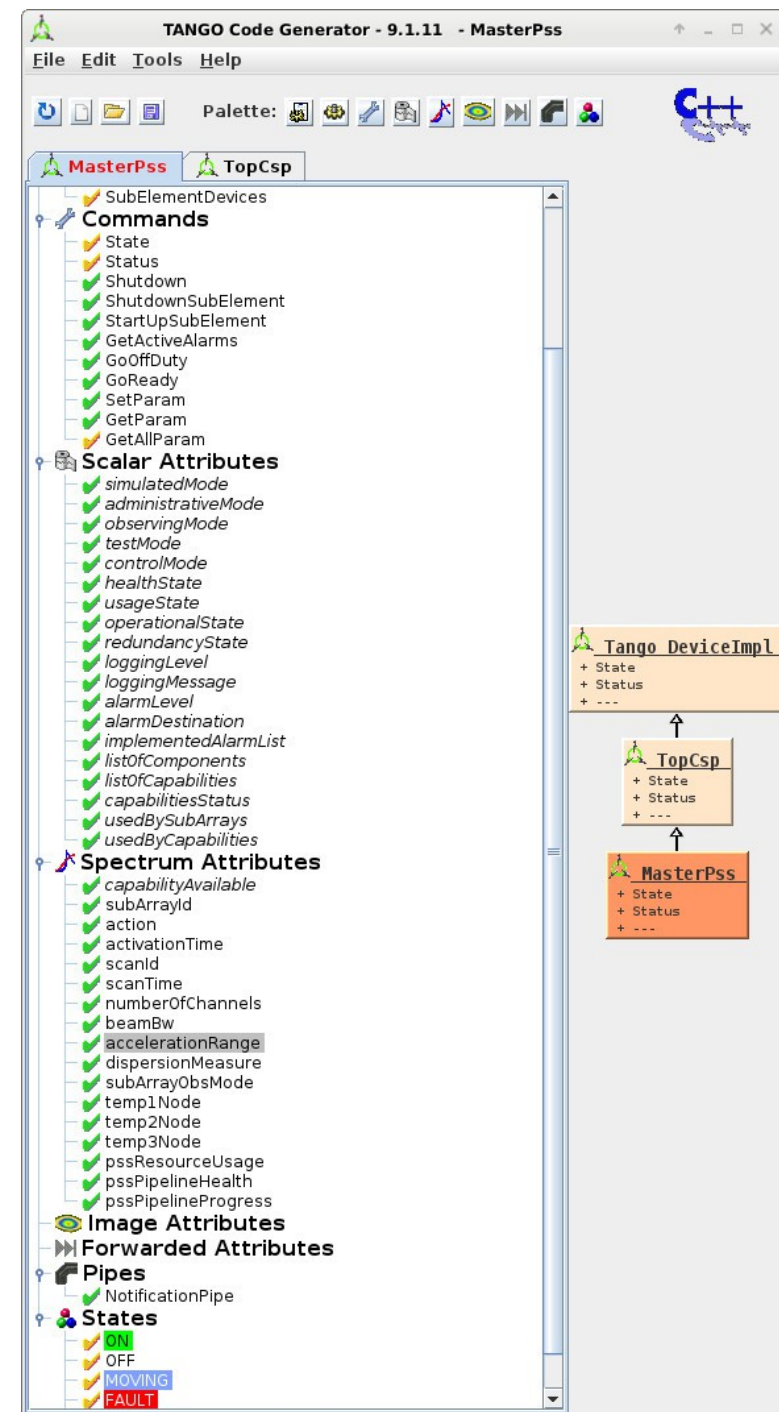
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Parameters

- Modes and States attributes defined by the SCM (SKA Control Model)
- Configuration specific attributes for each entity.
 - Specified on SubArray base.
 - Specified on Capability base (PssBeams, PstBeams).
- Engineering specific attributes for each entity.
- Monitoring specific attributes for each entity.



Commands (1)

There is no definition of a common set of control commands to be implemented by all TM elements.

From LIG and Tango Guidelines:

- A preliminary list: power-down, power-up, upgrade software...

From ICDs:

- Two general commands common to CSP_Mid entities:
 - GetParam: to get CSP elements configuration attributes and status
 - SetParam: to specify a single message to configure one or more parameters. It can specify also an *action* as R/W parameters (es: Observing Mode).

Basic assumptions

- TM sends coherent and complete commands to CSP.LMC.
 - CSP.LMC performs syntactic and minimum safety checks, not extensive one.
- TM sends detailed configurations for scan programming (EICD and IICD).
- TM can send compounded settings for parameters and compounded commands.

Example:

- Setting the observing mode for PSS.
- Creation of a sub-array and the allocation of receptors and beams.

Commands (2)


Issues:

- A massive scan reconfiguration can require to specify a high number of parameters.
- Tango accepts/returns only one argument.
- Parameters configuration pass through several layers of hierarchy.


Questions:

How can do it in Tango?

Prototype Proposal:

- I/O arguments for commands are string in Json format. (as in Tango LMC Guidelines) 
- Can this solution be considered a Tango anti-pattern?

Capability Strategy

- Capabilities as a different view to the real hardware, more like a mental organization tool.
- Most of processing intelligence inside the CSP.LMC
 - Centralized control.
 - Capabilities as information and configuration container
 - Capabilities can be updated and interrogated by CSP.LMC. 



This approach separates hardware handling from logical entities handling, as per Tango approach.

Monitoring Points (1)

From ICD:

- CSP Monitor Points (MPs) are parameters that are periodically monitored.
- CSP report status of MPs on request, periodically on on changes.
- The CSP (entities) shall implement Health State as MPs.

From Tango Guidelines:

- Each MP is implemented as a Tango Attribute.
- A preliminary list of MPs.

At the moment, there is no uniform monitoring policy.

Monitoring Points (2)

Need to understand what is really useful at higher level, which attributes need to be subscribed and which only read on TM requests.

- Health State: how is it?
- Operational State: what is it doing?
- Usage State: is busy?
- Progress Status: at what point?
-
- Detailed status of all components? No thanks!

	CSP SubElement	Number of monitor points
To be Tango compliant → build a hierarchy	PST	~ 300
	PSS	Up to 30.000
	CBF	Up to 3.000.000

Monitoring Points Strategy

Analyze Pulsar Search case:

- 750 Nodes - ~ 60 racks - 1500 beams.
- 10 monitoring points for each node.
- 10 monitoring point for each rack of computers.
- ~16 monitoring points for each beam.

Single PSS Node	PSS.LMC	CSP.LMC
sensor1	sensor1[750]	sensor1_max sensor1_min sensor1_mean
sensor2	sensor2[750]	sensor2_max sensor2_min sensor2_mean

Logging (1)

From ICD & LIG:

- CSP.LMC should be required to log to a Central Log file and keep a limited number of latest logs (10).
- CSP Central Log file with Alarms and Events with at least 10.000 most recent records.
- Each CSP Component that has a capacity, maintains own log file.
- Log file rotation when capacity is reached
- Access to TM for copy, search, configuring level, destination.
- Remote logging.
- Use of a standard format, content and logging level as defined in LIG

Logging (2)

What does Tango offer?

Tango includes a logging service (TLS)

- Different targets: console, file, device (Log Consumer -LC)
- Several output layouts (log4tango library)
- Logging levels.
- A graphical interface (LogViewer) based on log4j package, associated to a LC device.
- Log file rotation on dimension basis. Saved only the last one.

Issues:

- Rotation of log files: more than one save.
- All logging targets share the same log level.

Logging (3)

Generally is useful a more verbose output for the log file.

Alternatives:

- Two different files with different logging level (see LIG):
 - Central Log less verbose (> INFO).
 - Local one more verbose (DEBUG).
- Only the Central Log and a Tango LC device which:
 - Acts as a device target for the SubElement devices.
 - Filters out logging messages with DEBUG level.

Prototype proposal:

- The Prototype will log on device and file.
- Implement a log level attribute to configure the logging level.
- Implement a LC Device to filter out the DEBUG level messages.

Alarms handling (1)

No alarm policy defined.

From the LIG & ICD:

- Classification of alarms.
- List Element LMC responsibilities: generation, suppression, filtering, clear, list, add, update.
- Define levels of alarms and messages format.
- Alarm level configurable by TM.
- Define a preliminary list of a Common alarms.
- Logs all CSP Alarms and Events in the Central Log file.

From Tango LIG:

- Use pipe to signal alarms.

Alarms handling (2)

From CSP Requirements:

- Alarm Reporting Latency: CSP.LMC shall send an alarm message within 3 sec.
- Alarm Forwarding Latency: CSP.LMC shall forward alarm message to TM within 1 sec.

Alarm management is critical for the performance and maintenance of any complex system, such as the SKA components.

Alarm handling not possible with only pipes.

Alarms handling (3)

What do we need?

Perhaps an Alarm System that generally provides:

- Generation of basic and key alarms
- Definition of actions to take and of escalation procedures.
- Definition of a system of alarm acceptance.
- Advanced alarm handling techniques:
 - Suppression:
 - › Alarm shelving, alarm flood, state based alarms.
 - Alarm reduction.
- Tools for analysis and statistics of alarms log.

Alarms handling (4)


What does Tango offer?

- Generation of basic alarms. No Alarm engine in Tango core.

Tango Community has developed two Alarm Handler devices:

- Alarm System by *Elettra*
- PyAlarm by *Alba*

Prototype Proposal:

- Implementation of the Alarm System.
- Use of a hierarchical structure with CSP.LMC Alarm Handler as central supervisor. 

Question:

- Should alarm messages log into the standard log file?
- Is alarm logs policy on file rotation the same of ordinary log file?

Alarms handling (5)

What does the Tango Alarm System offer?

- A read attribute: arrays of alarms strings present in the alarm table.
 - Alarm string defined by several fields are partially equivalent to the LIG ones.
- Alarms log and alarms configuration stored in a MySQL DB.
- A set of commands to ack, list alarms, load/remove.
- Alarm formula, time threshold, actions.
- It can be appropriately configured to support handling of:
 - Nuisance alarms, state-base alarms, escalation procedures.
- No support for Alarm shelving and reduction.

Comments and Suggestions?

Thank you!

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