HERA Monitor and Control Subsystem Definition

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1 Introduction

HERA is an international experiment to detect and characterize the Epoch of Reionization (EOR). The telescope is located at the South African SKA site in the Karoo Astronomy Reserve. This note summarizes Monitor and Control (M&C) subsystem for HERA.

Monitor and Control has two main tasks: configuration management and real time metadata logging. Configuration management involves tracking all the physical parts of the telescope and how they are all connected. Real time metadata logging tracks the performance, settings and communications of the subsystems.

The M&C system is built around a database with a well documented table schema and a python software layer to provide a simple developer framework. It also includes various online daemons for monitoring things, and both a front end web-based user interface and a command-line interface to support analysis code.

Software is contained in the repository https://github.com/HERA-Team/hera_mc.

The organization of this document is as follows: the high-level M&C requirements and the design specifications are in laid out in section 2, the configuration management is described in section 3, the database tables are detailed in section 4 and future plans are sketched out in section 5.

2 Requirements and Specifications

2.1 Requirements

These were developed and established in early 2016 in discussions among the subsystem leads.

1. Ability to fully reconstruct the historical state of the system.
2. All interactions between subsystems must go through or be logged by M&C.
    a. Both subsystems in an interaction are responsible for logging communications to M&C.
    b. Subsystems in an interaction are responsible for logging communications to M&C.
3. Operational metadata (e.g. temperatures, correlator bit occupancies) must be logged to M&C.
4. High availability (M&C must not limit uptime of telescope).
5. M&C is a provider of information about observations to end-users and must be available to them

2.2 Design Specification

These were developed and established in 2016 based on the requirements.

1. SQL database
    a. DB Design principle: every logical sub group has a group of tables. One adds tables to do more things. E.g. different versions of subsystems add new tables. Operations reference which tables they use.
    b. This document (and appendices) will contain all table definitions.

c. Use careful dB design to avoid duplicated data, make table links/data relationships clear, use many-to-one and many-to-many links.

d. Transactions must be used to ensure DB integrity.

e. Must be mirrored in some fashion to observer locations.

2. At least one SW interface layer will be provided.

   a. It's not required to interact with M&C.

   b. Must support relational db (i.e. multiple column primary and foreign keys) and transactions.

3. Hardware

   a. LOM capabilities

   b. Multi-teraByte mirrored disk RAID

   c. Backup machine available on site

3 Configuration Management

The HERA array/part configuration management database is a set of five tables within the larger hera_mc database, which is maintained on-site in the Karoo. The tables are detailed in the Appendix, but they are:

psql table	**in python file**	**with class name**
geo_location	hera_mc/geo_location.py	GeoLocation
station_type	hera_mc/geo_location.py	StationType
parts	hera_mc/cm_part_connect.py	Parts
part_info	hera_mc/cm_part_connect.py	PartInfo
connections	hera_mc/cm_part_connect.py	Connections
cm_version	hera_mc/cm_transfer.py	CMVersion
apriori_antenna	hera_mc/cm_part_connect.py	AprioriAntenna
part_rosetta	hera_mc/cm_part_connect.py	PartRosetta

The databases are structured primarily around *parts* and *connections*. *Parts* are meant to be single items that, in theory at least, are a thing that can be replaced as a unit. *Connections* define *ports* on a given part and connect two ports together. By convention, HERA part numbers (`hpn`) are all upper case and ports are all lower case.

All parts and connections are timed in that they have a start and stop time of operation. If stop is `None`, then it is active (it is given a date in the relatively far future). There are currently two special parts (one at each end of the signal chain) that are "geo_located" parts and have entries in the geo_location table: **station** and **node**.

Parts are hooked together via connections of their ports, as defined in the connection table. For the supporting code, architecture dependent parameters are set in the `cm_sysdef` module.

To capture the known readiness of antennas, an *a priori* antenna table has been defined to facilitate a work flow to incorporate new antennas into the array and capture and known recalcitrant antennas. The table provides an enumerated readiness level for each antenna station.

3.1 Operation Workflow

The work flow in this context relates to antenna migration between one of the *a priori* status states above. It is handled by the operations team, which will review the situation on a roughly monthly cadence. The enumerated states are:

- **dish_maintenance**: dish is either not completed or being repaired
- **dish_ok**: dish is ready for use
- **RF_maintenance**: receiver system is either not installed or being repaired

- **RF_ok**: receiver system ready for use
- **digital_maintenance**: digital system is either not installed or being repaired
- **digital_ok**: digital system is ready for use
- **calibration_maintenance**: calibration has not been conducted or current
- **calibration_ok**: ready to use in analysis
- **calibration_triage**: an issue is being worked on

3.2 Hookup Connections

Hookup connections are those that uniquely map the signal chain from the antenna to the node, including the specific correlator input. These are the connections used to generate the correlator hookup. The signal chain hookup for HERA is given below and shown in Fig. 1, shown in black. The list below describes the hookup connections.

- **Station**: geo_located position. See prefixes in table station_type (*e.g.* `HH` for herahex)
- **Antenna**: This is also the correlator number which now matches station number. **A**{#}
- **Feed**: element feed (Vivaldi). **FDV**{#}
- **FEM**: front-end module. **FEM**{#}
- **Node bulkhead plate**: bulkhead plate on node. **NBP**{#}
- **PAM**: post-amp module in node. **PAM**{#}
- **SNAP**: digitizer/channelizer in node. **SNP**{#}
- **Node**: field-deployed node as a part **N**{#}
- **Node**: geo_located position for node as a station **ND**{#}

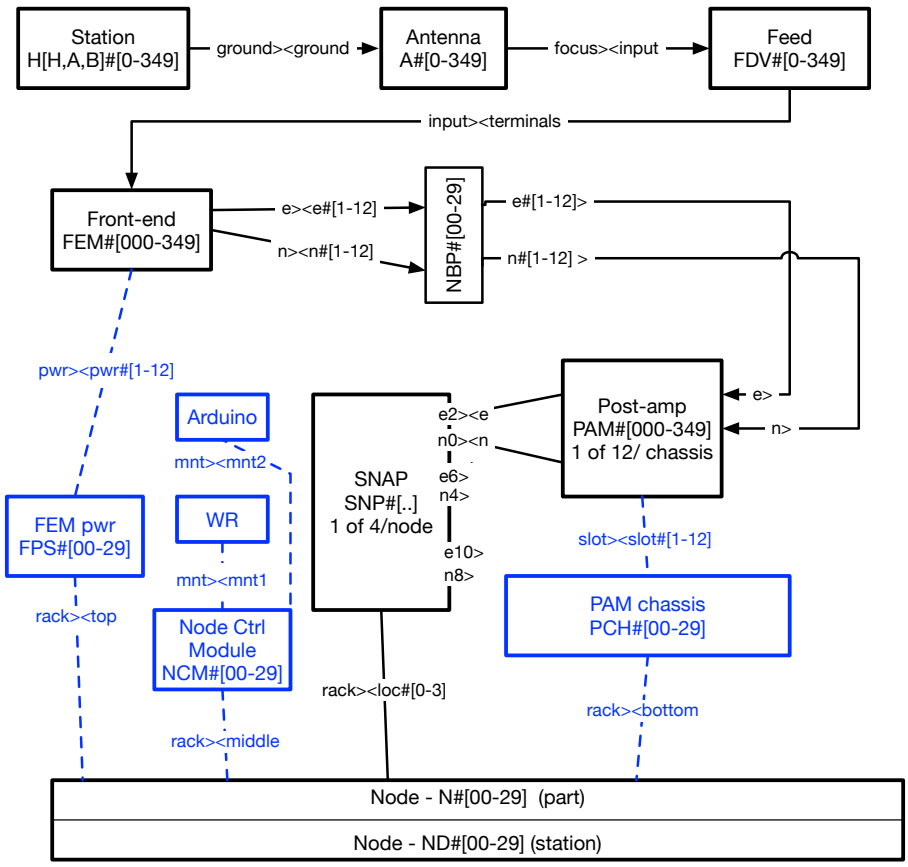

Figure 1: Block diagram of hookup. The line labels indicate the port names/connections. Black solid lines are the signal chain.

3.3 Package Modules

This section provides a high-level overview of the python configuration management package modules within hera_mc that are called from scripts or used in interactive sessions.

geo_location.py	Defines `station_type` and `geo_location`. Provides update utility for `geo_location`. Contains `is_in_geo_location` and `is_in_connections`.
geo_handling.py	Contains myriad defs that handle various geo functionalities.
cm_partconnect.py	Defines `parts_paper`, `part_info`, and `connections`. Provides update utilities for `parts_paper` and `connections`. Contains `__get_part_revisions`.
cm_table_info.py	Has mapping and order of tables and classes for initialization.
cm_handling.py	Defines the `Handling` class to handle various configuration management functionalities.
cm_active.py	Contains modules that load parts/connections active for given date.
cm_transfer.py	Contains myriad defs that help package and initialize the cm tables.
cm_revisions.py	Contains myriad defs that deal with finding revision numbers etc.
cm_hookup.py	Defines the `Hookup` class to help determine and show the full part hookup.
cm_dossier.py	Contains classes for the part/connection cm information.
cm_utils.py	Contains various defs called by other modules.
cm_redis_corr.py	Modules to get/read relevant cm info from/into redis.
cm_sysutils.py	Various system-wide modules
cm_sysdef	Architecture dependent definitions.

3.4 Scripts

This section provides a high-level overview of the high-level scripts: `geo.py`, `dossier.py` and `hookup.py`.

3.4.1 Geographical Information: `geo.py fg_action --arguments`

Has various plotting/printing options for station information. `fg_action` is the "foreground action", that is the locations that will get printed and shown on top if plotting. See `geo.py -h` for options. Available foregrounds are (note you need the first letter only):

- `a[ctive]`: those antennas that are shown as fully hooked up through the correlator
- `i[nstalled]`: those antennas whose structure is installed
- `p[osition] <csv-list>`: specified antennas in csv-list (e.g. HH1,HH4)
- `c[ofa]`: the center-of-the-array
- `s[ince]`: antennas installed since date/time supplied in arguments
- `n[one]`: no foreground, will just show the background (or nothing if not plotting)

3.4.2 Part/Connection Information: `dossier.py view --arguments`

Has various printing options for part information (part info, connections, hookup, types, etc). The available `views` are (first letter only needed): parts, connections, notes, revisions. See `dossier.py -h` for options.

3.4.3 Cascaded Connection Information: `hookup.py --arguments`

Displays the signal chain hookup information. See `hookup.py -h` for options.

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The formatting of the tables is as follows:

- **Bold font** = primary key
- *Italics* = foreign_key.
- * = NotNull entries

4.1 Observations

4.1.1 hera_obs

This is the primary observation definition table. It is written to by the correlator.

Column	Type	Description
obsid	long integer	start time in floor(GPS) seconds. GPS start adjusted to be within 1 second of LST to lock observations to LST for the night
starttime*	double	start time in gps seconds. The start time to full accuracy of the beginning of integration of first visibility
stoptime*	double	stop time in gps seconds. The stop time to full accuracy of the end of integration of last visibility
jd_start*	double	start time in JD. Calculated from starttime, provides a quick way to filter on JD times.
lst_start_hr*	double	decimal hours from start of sidereal day. Calculated from start-time, provides a quick search for matching LSTs
tag	string	String tag labelling the type of data. One of ["science", "main-tainence", "engineering", "junk"]. Added before the 2022-2023 observing season, so null in prior seasons.

4.2 Common tables

4.2.1 server_status (template)

Common table structure for server status info. **Note: There is no table named server_status. This is the structure used for several subsystem tables named <subsystem>_server_status**.

Column	Type	Description
hostname	string	name of server
mc_time	long	time report received by M&C in floor(gps seconds)
ip_address*	string	IP address of server (how should we handle multiples?)
mc_system_timediff*	float	difference between M&C time and time report sent by server in seconds
num_cores*	integer	number of cores on server
cpu_load_pct*	float	CPU load percent = total load / num_cores, 5 min average
uptime_days*	float	server uptime in days
memory_used_pct*	float	percent of memory used, 5 min average
memory_size_gb*	float	amount of memory on server in GB
disk_space_pct*	float	percent of disk used
disk_size_gb*	float	amount of disk space on server in GB
network_bandwidth_mps*	float	Network bandwidth in MB/s, 5 min average. Can be null

4.2.2 subsystem_errors

Subsystem errors/issues

Column	Type	Description
id	long	auto-incrementing error id
time*	long	error report time in floor(gps seconds)
subsystem*	string	name subsystem with error (e.g. 'librarian', 'rtp')
mc_time*	long	time report received by M&C in floor(gps seconds)
severity*	int	integer indicating severity level, 1 is most severe
log*	text	TBD on format, either a message or a file with the log

4.2.3 daemon_status

Status of M&C daemons that monitor various subsystems.

Column	Type	Description
name	string	daemon name
hostname	string	hostname where daemon is running (the same daemon can run on multiple hosts)
jd	integer	Julian Date. This allows for some history without keeping all history.
time*	long	most recent status report time in floor(gps seconds)
status*	string	most recent daemon status. One of 'good' or 'errored'

4.3 RTP Tables

4.3.1 rtp_server_status

RTP version of the server_status table, see 4.2.1.

4.3.2 rtp_status

High level RTP status

Column	Type	Description
time	long	status time in floor(gps seconds)
status*	string	status string, options TBD (might become an enum)
event_min_elapsed*	float	minutes elapsed since last event
num_processes*	integer	Number of processes running
restart_hours_elapsed*	float	hours elapsed since last restart

4.3.3 rtp_process_events

RTP Processing events (per obsid)

Column	Type	Description
time	long	event time in floor(gps seconds)
obsid	long integer	observation identifier, foreign key into hera_obs table
event*	string	one of: queued, started, finished, error

4.3.4 rtp_task_process_events

RTP Processing events (per task + per obsid)

Column	Type	Description
time	long	event time in floor(gps seconds)
obsid	long integer	observation identifier, foreign key into hera_obs table
task_name	string	name of specific task (e.g., `OMNICAL`)
event*	string	one of: started, finished, error

4.3.5 rtp_task_multiple_process_events

RTP Processing events that include multiple obsids (per task + per starting obsid)

Column	Type	Description
time	long	event time in floor(gps seconds)
obsid_start	long integer	observation identifier for the first file in the task, foreign key into hera_obs table
task_name	string	name of specific task (e.g., `OMNICAL`)
event*	string	one of: started, finished, error

4.3.6 rtp_process_record

RTP record of processed obsids (entry added when processing finished)

Column	Type	Description
time	long	record time in floor(gps seconds)
obsid	long integer	observation identifier, foreign key into hera_obs table
pipeline_list*	text	concatenated list of tasks
rtp_git_version*	string	git version of RTP code
rtp_git_hash*	string	git hash of RTP code
hera_qm_git_version*	string	git version of hera_qm code
hera_qm_git_hash*	string	git hash of hera_qm code
hera_cal_git_version*	string	git version of hera_cal code
hera_cal_git_hash*	string	git hash of hera_cal code
pyuvdata_git_version*	string	git version of pyuvdata code
pyuvdata_git_hash*	string	git hash of pyuvdata code

4.3.7 rtp_task_jobid

Holds the Slurm job id associated with each obsid/task so statistics can be associated with that obsid/task after the run completes (to fill out the rtp_task_resource_record table).

column	type	description
obsid	long integer	observation identifier, foreign key into hera_obs table
task_name	string	name of specific task (e.g., `OMNICAL`)
start_time	long	start time of task in floor(gps seconds)
job_id*	long	Slurm job ID for the obsid and task.

4.3.8 rtp_task_resource_record

RTP record of start and stop times for a task (e.g., omnical) for an obsid, as well as CPU and memory used (if available)

column	type	description
obsid	long integer	observation identifier, foreign key into hera_obs table
task_name	string	name of specific task (e.g., `OMNICAL`)
start_time*	long	start time of task in floor(gps seconds)
stop_time*	long	stop time of task in floor(gps seconds)
max_mem	float	maximum memory, in MB, consumed by the task; nullable column
avg_cpu_load	float	average CPU load, in number of CPUs, for task (e.g., 2.00 means 2 CPUs used); nullable column

4.3.9 rtp_task_multiple_track

A many to one mapping table that tracks which obsids are included in multiple obsid RTP tasks.

column	type	description
obsid_start	long integer	First obsid in the set of obsids included in the task, foreign key into hera_obs table
task_name	string	name of specific task (e.g., `rfi_notebook`)
obsid	long integer	observation identifier, foreign key into hera_obs table

4.3.10 rtp_task_multiple_jobid

Holds the Slurm job id associated with multiple obsid tasks so statistics can be associated with that obsid set and task after the run completes (to fill out the rtp_task_multiple_resource_record table).

column	type	description
obsid_start	long integer	First obsid in the set of obsids included in the task, foreign key into hera_obs table
task_name	string	name of specific task (e.g., `rfi_notebook`)
start_time	long	start time of task in floor(gps seconds)
job_id*	long	Slurm job ID for the obsid set and task.

4.3.11 rtp_task_multiple_resource_record

RTP record of start and stop times for a multiple obsid task (e.g., rfi_notebook), as well as CPU and memory used (if available)

column	type	description
obsid_start	long integer	First obsid in the set of obsids included in the task, foreign key into hera_obs table
task_name	string	name of specific task (e.g., `rfi_notebook`)
start_time*	long	start time of task in floor(gps seconds)
stop_time*	long	stop time of task in floor(gps seconds)
max_mem	float	maximum memory, in MB, consumed by the task; nullable column
avg_cpu_load	float	average CPU load, in number of CPUs, for task (e.g., 2.00 means 2 CPUs used); nullable column

4.3.12 rtp_launch_record

RTP record of the most recent time a particular observation was launched in RTP

column	type	description
obsid	long integer	observation identifier, foreign key into hera_obs table
submitted_time	long integer	record time in floor(gps seconds); should be `NULL` if job has not yet been submitted to RTP
rtp_attempts*	long integer	number of times the observation has been attempted in RTP; should be 0 if submitted_time is `NULL`
jd*	long integer	integer Julian Date of the observation
obs_tag*	string	"observation tag" of the observation file, saved as the `tag` in the metadata
filename*	string	the full filename of the observation file
prefix*	string	the prefix of the observation file, on `qmaster`

4.4 Librarian Tables

4.4.1 lib_server_status

Librarian version of the server_status table, see 4.2.1.

4.4.2 lib_status

High level Librarian status

Column	**Type**	**Description**
time	long	status time in floor(gps seconds)
num_files*	long	total number of files in librarian
data_volume_gb*	float	total data volume in gigabytes
free_space_gb*	float	available space in gigabytes
upload_min_elapsed*	float	minutes elapsed since last file upload
num_processes*	integer	number of running background tasks
git_version*	string	git version of Librarian code
git_hash*	string	git hash of Librarian code

4.4.3 lib_raid_status

RAID controller status

Column	**Type**	**Description**
time	long	status time in floor(gps seconds)
hostname	string	name of RAID server
num_disks*	int	number of disks in RAID server
info*	text	TBD – various info from megaraid controller, may be several columns

4.4.4 lib_raid_errors

RAID controller errors/issues

Column	Type	Description
id	long	auto-incrementing error id
time*	long	error report time in floor(gps seconds)
hostname*	string	name of RAID server with error
disk*	string	name of disk with error
log*	text	TBD on format, either a message or a file with the log

4.4.5 lib_remote_status

Network bandwidth/health to all remote librarians

Column	Type	Description
time	long	status time in floor(gps seconds)
remote_name	string	name of remote librarian
ping_time*	float	ping time in seconds
num_file_uploads*	int	number of files uploaded in last 15 minutes
bandwidth_mps*	float	bandwidth to remote in Mb/s, 15 minute average

4.4.6 lib_files

File creation log

Column	Type	Description
filename	string	name of file created
obsid	long integer	observation identifier, foreign key into hera_obs table. Can be null.
time*	long	file creation time in floor(gps seconds)
size_gb*	float	file size in gigabytes

4.5 Correlator Tables

The correlator tables are not all defined yet. Notes on future plans are in section 5.1.

4.5.1 array_signal_source

Array-wide information about the commanded signal source.

Column	Type	Description
time	long	time of the config status in floor(gps seconds)
source*	string	commanded data source, one of: "antenna", "load", "noise", "digital_same_seed", "digital_different_seed".

4.5.2 correlator_component_event_time

When correlator components had an event (related to normal observing). The currently allowed combinations of component and event are:

- "f_engine": "sync"
- "x_engine": "integration_start" (this is calculated from the Mcount)
- "catcher": "start", "stop" or "stop_timeout" (This last one is a stop determined because the redis key timed out, indicating that the catcher died or was killed)

Column	Type	Description
component	string	correlator component, one of :"f_engine", "x_engine" or "catcher".
event	string	event, one of: "sync" "integration_start", "start", "stop" or "stop_timeout".
time	float	time of the event in gps seconds (not floored)

4.5.3 correlator_catcher_file

Filenames written by the catcher with time that file was started.

Column	Type	Description
time	long	time the catcher started writing the file in floor(gps seconds)
filename	string	name of the file written by the catcher. Can be null when the catcher first starts.

4.5.4 correlator_config_file

List of correlator config files, which specify detailed correlator settings. All files in this table are in the Librarian.

Column	Type	Description
config_hash	string	unique hash for the config
filename*	string	name of the config file in the Librarian

4.5.5 correlator_config_params

Parameters in the correlator configuration, parsed from the configuration file, excluding those specifically captured in the correlator_config_active_snap, correlator_config_input_index, and correlator_config_phase_switch_index tables.

Column	Type	Description
config_hash	string	hash for the config in use, foreign key into correlator_config_file table.
parameter	string	Name of the the correlator configuration parameter.
value*	string	Value of the the correlator configuration parameter.

4.5.6 correlator_config_active_snap

Active snaps in the correlator configuration, parsed from the configuration file.

Column	Type	Description
config_hash	string	hash for the config in use, foreign key into correlator_config_file table.
hostname	string	Hostname of the SNAP (typically e.g. heraNode1Snap2).

4.5.7 correlator_config_input_index

Mapping of the correlator index to SNAP antenna position for the correlator configuration, parsed from the configuration file.

Column	Type	Description
config_hash	string	hash for the config in use, foreign key into correlator_config_file table.
correlator_index	integer	Correlator index value (in the range 0 - 349).
hostname*	string	Hostname of the SNAP (typically e.g. heraNode1Snap2).
antenna_index_position*	integer	Antenna index position within the SNAP (in the range 0 - 2).

4.5.8 correlator_config_phase_switch_index

Mapping of the phase switch index to SNAP antpol position for the correlator configuration, parsed from the configuration file.

Column	Type	Description
config_hash	string	hash for the config in use, foreign key into correlator_config_file table.
hostname	string	Hostname of the SNAP (typically e.g. heraNode1Snap2).
phase_switch_index*	integer	Phase switch index value (in the range 1 - 24).
antpol_index_position*	integer	Antpol index position within the SNAP (in the range 0 - 5).

4.5.9 correlator_config_status

Config status of the correlator, i.e. which config file is being used by the correlator.

Column	Type	Description
time	long	time of the config status in floor(gps seconds)
*config_hash**	string	hash for the config in use, foreign key into correlator_config_file table.

4.5.10 correlator_software_versions

Software version numbers for correlator software packages and scripts.

Column	Type	Description
time	long	time of the version report in floor(gps seconds)
package	string	name of the correlator software module or ⟨package⟩:⟨script⟩ for daemonized processes (e.g. 'hera_corr_cm', 'udpSender:hera_node_keep_alive.py').
version*	string	version string for this package or script

4.5.11 snap_config_version

SNAP initialization configuration and software versions.

Column	Type	Description
init_time	long	time when the SNAPs were last initialized with the 'hera_snap_feng_init.py' script in floor(gps seconds)
version*	string	version string for the hera_corr_f package
init_args*	string	arguments passed to the initialization script at runtime
*config_hash**	string	unique hash for the config, foreign key into correlator_config_file table

4.5.12 snap_status

SNAP status information (reported via the correlator redis DB).

Column	Type	Description
time	long	status time in floor(gps seconds)
hostname	string	SNAP hostname
serial_number	string	SNAP serial number
node	int	node number (derived from config. management tables using SNAP serial number)
snap_loc_num	int	snap location number within the node (derived from config. management tables using SNAP serial number)
psu_alert	bool	true if SNAP PSU (aka PMB) controllers have issued an alert, false otherwise.
pps_count	long	number of PPS pulses received since last programming cycle
fpga_temp	float	reported temperature of FPGA in degrees C
uptime_cycles	long	multiples of $500 \cdot 10^6$ ADC clocks since last programming cycle
last_programmed_time	long	last time this FPGA was programmed in floor(gps seconds)
is_programmed	bool	True if the host is programmed, false otherwise.
adc_is_configured	bool	True if the host adc is configured, false otherwise.
is_initialized	bool	True if the host is initialized, false otherwise.
dest_is_configured	bool	True if the ethernet destination is configured, false otherwise.
version	string	Version of firmware installed on the SNAP.
sample_rate	float	Sample rate in MHz.

4.5.13 snap_input

SNAP input information, either ADC or digital noise with seeding information (reported via the correlator redis DB).

Column	Type	Description
time	long	status time in floor(gps seconds), foreign key into snap_status.
hostname	string	SNAP hostname, foreign key into snap_status.
snap_channel_number	int	SNAP ADC channel number (0-5 which correspond to the n0, e2, n4, e6, n8, e10 ports on the SNAP).
antenna_number	int	antenna number that is connected to this snap channel number (from config management, can be null if not hooked up).
antenna_feed_pol	string	antenna feed polarization, either 'e' or 'n', that is connected to this snap channel number (from config management, can be null if not hooked up).
snap_input	string	Either "adc" or "noise-{d}" where {d} is the noise seed.

4.5.14 snap_feng_init_status

F-engine initialization status of the SNAP, status can be "working", "unconfig" (configuration did not work, so SNAP does not work), "commfail" (communications with snap not successfully set up), or "maxout" (snap configured properly but was excluded because there were too many SNAPs).

Column	Type	Description
time	long	status time in floor(gps seconds).
hostname	string	SNAP hostname.
status	string	One of "working" "unconfig" "commfail" or "maxout".

4.5.15 antenna_status

Antenna status information from the SNAP (reported via the correlator redis DB).

Column	Type	Description
time	long	status time in floor(gps seconds)
antenna_number	int	antenna number
antenna_feed_pol	string	antenna feed polarization, either 'e' or 'n'.
snap_hostname	string	SNAP hostname
snap_channel_number	int	SNAP ADC channel number (0-5 which correspond to the n0, e2, n4, e6, n8, e10 ports on the SNAP) to which this antenna is connected.
adc_mean	float	mean ADC value, in ADC units (raw ADC integer values between -128 and +127). Typically $\sim$ -0.5.
adc_rms	float	RMS ADC value, in ADC units (raw ADC integer values between -128 and +127). Should be $\sim$ 10-20.
adc_power	float	mean ADC power, in ADC units squared (raw ADC integer values between -128 and +127, squared). Since mean should be close to zero, this should just be adc_rms^2.
pam_atten	int	PAM attenuation setting for this antenna, in dB
pam_power	float	PAM power sensor reading for this antenna pol, in dBm.
pam_voltage	float	PAM voltage sensor reading for this antenna pol, in Volts.
pam_current	float	PAM current sensor reading for this antenna pol, in Amps.
pam_id	string	Serial number of the PAM for this antenna pol.
fem_voltage	float	FEM voltage sensor reading for this antenna pol, in Volts.
fem_current	float	FEM current sensor reading for this antenna pol, in Amps.
fem_id	string	Serial number of the FEM for this antenna pol.
fem_switch	string	Switch state the FEM, one of 'antenna', 'load' or 'noise'.
fem_lna_power	boolean	Power state of the FEM, 'True' means it is powered.
fem_imu_theta	float	IMU-reported theta, in degrees.
fem_imu_phi	float	IMU-reported phi, in degrees.
fem_temp	float	EM temperature sensor reading for this FEM in degrees Celcius.
fft_overflow	boolean	Indicator of an FFT overflow for this antenna pol, set to 'True' if there was an overflow.
eq_coeffs	string	digital EQ coefficients for this antenna, used for keeping the bit occupancy in the correct range. list of floats (one per freq. channel) represented as a string. Note this these are not divided out anywhere in the DSP chain (!).
histogram_bin_counts	string	ADC histogram bin counts, list of ints stored as a string.

4.5.16 hera_autos

Antenna autocorrelation statistics (currently just the median over the frequency axis).

Column	Type	Description
time	long	status time in floor(gps seconds)
antenna_number	int	antenna number
antenna_feed_pol	string	antenna feed polarization, either 'e' or 'n'.
measurement_type*	string	Currently can only be 'median'.
value*	float	Measured value.

4.5.17 node_sensor

Node temperature and humidity sensor readings

Column	Type	Description
time	long	measurement time in floor(gps seconds)
node	int	integer identifying the node
top_sensor_temp	float	temperature of top sensor reported by node in degrees C
middle_sensor_temp	float	temperature of middle sensor reported by node in degrees C
bottom_sensor_temp	float	temperature of bottom sensor reported by node in degrees C
humidity_sensor_temp	float	temperature of humidity sensor reported by node in degrees C
humidity	float	percent humidity measurement reported by node

4.5.18 node_power_status

Power status for SNAPs, FEMs and PAMs (monitored by nodes)

Column	Type	Description
time	long	measurement time in floor(gps seconds)
node	int	integer identifying the node
snap_relay_powered*	bool	power status of the snap relay, True = powered
snap0_powered*	bool	power status of the SNAP 0 board, True = powered
snap1_powered*	bool	power status of the SNAP 1 board, True = powered
snap2_powered*	bool	power status of the SNAP 2 board, True = powered
snap3_powered*	bool	power status of the SNAP 3 board, True = powered
fem_powered*	bool	power status of the FEM, True = powered
pam_powered*	bool	power status of the PAM, True = powered

4.5.19 node_power_command

Commands issued to change the power status for SNAPs, FEMs and PAMs (via the nodes).

Column	Type	Description
time	long	time the command was sent in floor(gps seconds)
node	int	integer identifying the node commanded
part	string	part commanded, one of 'snap_relay', 'snap0', 'snap1', 'snap2', 'snap3', 'pam', 'fem'.
command*	string	command sent, 'on' or 'off'.

4.5.20 node_white_rabbit_status

Node white rabbit status. There are a duplicate set of columns for the two ports which start with 'port0' and 'port1'. We list them jointly below as 'port[0,1]'.

Column	Type	Description
node_time	long	time of the status reported by the node in floor(gps seconds)
node	int	integer identifying the node.
board_info_str	string	A raw string representing the WR-LEN's response to the 'ver' command. Relevant parts of this string are individually unpacked in other entries.
aliases	string	Hostname aliases of this node's WR-LEN (comma separated if more than one).
ip	string	IP address of this node's WR-LEN.
mode	string	WR-LEN operating mode (eg. "WRC_SLAVE_WR0").
serial	string	Canonical HERA hostname (related to serial number) of this node's WR-LEN.
temperature	float	WR-LEN temperature in degrees Celcius.
build_date	long	Build date of WR-LEN software in floor(gps seconds).
gw_date	long	WR-LEN gateware build date in floor(gps seconds).
gw_version	string	WR-LEN gateware version number.
gw_id	string	WR-LEN gateware ID number.
build_hash	string	WR-LEN build git hash.
manufacture_tag	string	Custom manufacturer tag.
manufacture_device	string	Manufacturer device name designation.
manufacture_date	long	Manufacturer invoice(?) date in floor(gps seconds).
manufacture_serial	string	Manufacturer serial number.
manufacture_vendor	string	Vendor name.
port[0,1]_ad	int	Meaning unknown.
port[0,1]_link_asymmetry_ps	int	Port [0,1] total link asymmetry in picosec.
port[0,1]_manual_phase_ps	int	Not well understood, believed to be Port [0,1] manual phase adjustment in picosec.
port[0,1]_clock_offset_ps	int	Port [0,1] clock offset in picosec.
port[0,1]_cable_rt_delay_ps	int	Port [0,1] cable round trip delay in picosec.
port[0,1]_master_slave_delay_ps	int	Port [0,1] master-slave delay in picosec.
port[0,1]_master_rx_phy_delay_ps	int	Port [0,1] master RX PHY delay in picosec.
port[0,1]_slave_rx_phy_delay_ps	int	Port [0,1] slave RX PHY delay in picosec.
port[0,1]_master_tx_phy_delay_ps	int	Port [0,1] master TX PHY delay in picosec.
port[0,1]_slave_tx_phy_delay_ps	int	Port [0,1] slave TX PHY delay in picosec.
port[0,1]_hd	int	Meaning unknown.
port[0,1]_link	boolean	Port [0,1] link up state.
port[0,1]_lock	boolean	Port [0,1] timing lock state.
port[0,1]_md	int	Meaning unknown.
port[0,1]_rt_time_ps	int	Port [0,1] round-trip time in picosec.
port[0,1]_nsec	int	Meaning unknown.
port[0,1]_packets_received	int	Port [0,1] number of packets received.
port[0,1]_phase_setpoint_ps	int	Port [0,1] phase setpoint in picosec.
port[0,1]_servo_state	string	Port [0,1] servo state.
port[0,1]_sv	int	Meaning unknown.
port[0,1]_sync_source	string	Port [0,1] source of synchronization (either 'wr0' or 'wr1').
port[0,1]_packets_sent	int	Port [0,1] number of packets transmitted.
port[0,1]_update_counter	int	Port [0,1] update counter.
port[0,1]_time	long	Port [0,1] current time in GPS seconds. in floor(gps seconds).

4.5.21 roach_temperature (deprecated)

Roach (correlator fpga board) temperatures (deprecated 8/2018)

Column	Type	Description
time	long	measurement time in floor(gps seconds)
roach	string	name of roach (correlator fpga board)
ambient_temp	float	ambient temperature reported by the roach in degrees C
inlet_temp	float	inlet temperature reported by the roach in degrees C
oulet_temp	float	oulet temperature reported by the roach in degrees C
fpga_temp	float	fpga temperature reported by the roach in degrees C
ppc_temp	float	ppc temperature reported by the roach in degrees C

4.6 QA Info Tables

The QA tables are not all defined yet. Notes on future plans are in section 5.2.

4.6.1 metric_list

List and descriptions of metrics used in antenna or array metrics.

Column	Type	Description
metric	string	name of metric
desc*	string	description of metric

4.6.2 ant_metrics

Antenna metrics, by polarization and obsid. These are metrics, generally generated by hera_qm, which are keyed to individual antennas. For example, hera_qm.ant_metrics will flag individual antennas as bad.

Column	Type	Description
obsid	long integer	observation identifier, foreign key into hera_obs table.
ant	integer	antenna number (≥ 0)
pol	string	polarization, 'x' or 'y'
metric	string	name of metric, foreign key into metric_list table.
mc_time*	long integer	time report received by M&C in floor(gps seconds)
val*	double	value of metric

4.6.3 array_metrics

Array metrics, by obsid. These are metrics, generally generated by hera_qm, which are keyed to the overall array. For example, hera_qm.firstcal_metrics generates an overall decision whether the firstcal solutions were "good".

Column	Type	Description
obsid	long integer	observation identifier, foreign key into hera_obs table.
metric	string	name of metric, foreign key into metric_list table.
mc_time	long integer	time report received by M&C in floor(gps seconds)
val*	double	value of metric

4.7 Site Info Tables

The Site Info tables are not all defined yet.. Notes on future plans are in section 5.3.

4.7.1 weather_data

Weather data from KAT sensors

Column	Type	Description
time	long	status time in floor(gps seconds)
variable	string	name of weather variable (e.g. wind_speed, wind_direction, temperature)
value*	float	value of the variable at this time

4.8 Configuration Management Tables

As described in section 3, there are five tables in the configuration management section of the database: (1) geo_location, (2) station_meta, (3) parts_paper, (4) part_info, (5) connections. The following tables summarize them with the following key:

4.8.1 geo_location

Column	Type	Description
station_name*	character varying(64)	Name of position - never changes
*station_type_name**	character varying(64)	Type of station
datum	character varying(64)	UTM datum
tile	character varying(64)	UTM tile
northing	double precision	UTM coordinate
easting	double precision	UTM coordinate
elevation	double precision	Elevation
created_gpstime*	BigInt	GPS second of creation.

4.8.2 station_type

Column	Type	Description
station_type_name*	character varying(64)	Station type name
prefix*	character varying(64)	1-2 letter prefix for part station_name
description	character varying(64)	Short description
plot_marker	character varying(64)	Type of matplotlib marker

4.8.3 parts

Column	Type	Description
hpn*	character varying(64)	HERA part number
hpn_rev*	character varying(32)	HPN revision letter (A-Z)
hptype*	character varying(64)	HPN part type category
manufacturer_number	character varying(64)	Unique serial number for each part
start_gpstime*	BigInt	GPS second when part/rev is activated.
stop_gpstime	BigInt	GPS second when part/rev is de-activated

4.8.4 part_info

Column	Type	Description
hpn*	character varying(64)	HERA part number
hpn_rev*	character varying(32)	HPN revision letter (A-Z)
posting_gpstime*	BigInt	GPS second information was posted
comment*	character varying(1024)	Comment
library_file	character varying(256)	Librarian filename (how to get it there?)

4.8.5 connections

Column	Type	Description
upstream_part*	character varying(64)	Hera part number of upstream connection
up_part_rev*	character varying(32)	Hera part revision of upstream connection
upstream_output_port*	character varying(64)	Output port on upstream part
downstream_part*	character varying(64)	Hera part number of downstream connection
down_part_rev*	character varying(32)	Hera part revision of downstream connection
downstream_input_port*	character varying(64)	Input port on downstream part
start_gpstime*	BigInt	GPS second when connection started
stop_gpstime	BigInt	GPS second when connection ended

4.8.6 apriori_antenna

Column	Type	Description
antenna*	text	antenna for which status holds
start_gpstime*	BigInt	GPS second when status change becomes valid
stop_gpstime	BigInt	GPS second at end of status. None for last
status*	text	status enum message, one of 'passed_checks', 'needs_checking', 'known_bad', 'not_connected'

4.8.7 part_rosetta

Column	Type	Description
hpn	text	HERA part number (*e.g.* SNPC000072)
syspn*	text	System-dependent part number (*e.g.* heraNode0Snap0)
start_gpstime*	BigInt	GPS second when started
stop_gpstime	BigInt	GPS second when stopped. None for last

4.8.8 cm_version

Column	Type	Description
update_time*	BigInt	GPS second when version set
git_hash*	character varying(64)	git hash number for version

5 Future Plans

5.1 Correlator Table plans

The correlator tables are not all defined yet, the following are notes about suggestions and plans for correlator tables. Most of the correlator data will be recorded in a Redis database (a rolling log, ephemeral), that info needs to be grabbed and put in M&Ctables.

corr_server_status: Correlator version of the server_status table, see 4.2.1, not yet implemented.

1. correlator on/off? **this is a control**
2. Bit statistics (overflows, ADC clipping, bit statistics after bit selects)
3. correlator network stats (dropped packets)
4. Firmware git hash
5. Fengine status
6. Xengine status (might be covered in corr_server_status)
7. Walsh on/off **this is a control** (correlator propagates to node)
8. Noise diode **this is a control** (correlator propagates to node)
9. correlator config (walsh patterns; scaling functions for FFT, bit selection)
10. Test mode outputs (results not control) – very notional
    a. Fengine sync test
    b. Xengine test
    c. Do at beginning and end of night.
    d. Analog tests
        1. Noise diode status
        2. Temperature (i2c device)
        3. Walsh switching (on/off control. Make sure bit pattern is known and put into data set.)
11. SNAP information: all info reported through the correlator
    a. Feed status
    b. PAM status

12. Node information (from Arduino) (Dave, Jack, Zara, Matt Dexter (mdexter@berkeley.edu), Nima) All node info will be reported through the correlator.
    a. Clock status info – syncing
    b. Temperatures (outside + inside, feed?)
    c. Node M&Csoftware git hash

5.1.1 Correlator interfaces complete:

These are done:

1. M&Cinformation the correlator needs to get and write into files
    a. Antenna positions
2. New info added to correlator files (recorded in hera_obs table)
    a. obsid
    b. duration
3. Node information (from Arduino) (Dave, Jack, Zara, Matt Dexter (mdexter@berkeley.edu), Nima) All node info will be reported through the correlator.
    a. SNAP power states
    b. Temperatures in nodes
    c. Power PAM, FEM status (binary)

5.2 QA Future Plans

These are some suggestions for the future, things we might like to see.

1. RTP/online systems
    a. RFI statistics/info (this might be in ant_metrics and array_metrics now)
    b. Calibration statistics (this might be in ant_metrics and array_metrics now)
    c. LST repeatability
    d. TBD other things that come up
2. Offline codes (Major work on how to implement this!! Not on the critical path):
    a. TBD from offline analysis codes

5.3 Site Info Future Plans

The following are suggestions for the future, things we might like to see.

1. site power
2. network status

5.4 Other Future Ideas

1. Basic ionospheric monitoring
2. RFI monitoring