Outline

How the Array Does What You Tell It

How to Figure Out What the Array is Doing

Where Have All the Data Gone?

How You Interact With the Array
Control
(How the Array Does What You Tell It)
The Control System

- Software that is nexus for communication to all subsystems
- A subarray is a collection of 0 to 23 antennas that act together
- 5 independent subarrays supported
  - 2 Science, 2 Engineering, 1 Maintenance
  - All subarrays operational all the time
  - This requires over 200 programs running simultaneously and a system to keep it all straight (ask if you really want to know).
- Observers' interface is through Python commands & scripting
  - extremely flexible, leverages Python's power and ease-of-use
  - you can control the array from any computer, including your laptop @

TM
Lots of Computers

CARMA's design uses distributed computing, wherein multiple machines share the computational load, overseen by the master Array Control Computer (acc). There are 50 computers involved (23 antenna, 18 correlator, 1 acc, 1 alarm, 1 sdp, several others).

Most computers are diskless – they load their operating system image to RAM on bootup from the boot server.
- Fewer hard drives to fail
- Easier to upgrade OS on many machines – just do it on the boot server
- Mount non-OS filesystems via NFS
CARMA Computer System Overview

Correlator "crates" (sicor1 ... sicor8, wbcor1 ... wbcor8) → Array Control Computer (acc)

Device Control Computers (weather station, linelength, phase monitor, tipper, master clock, alarm) → Array Control Computer (acc)

Observer + workstation (cedarflat1-5) → Array Control Computer (acc)

Array Control Computer (acc) → Monitor Point Store (s2) → File Server (storage) → CAN devices (Rx, Optics, etc)

Antenna Computer → CAN devices (Rx, Optics, etc)

C1 - C6

C7 - C15

C16 - C23

MWP 2012-June-14
CARMA Computer System Overview

DO NOT TOUCH ACC

Device Control Computers
(weather station, linelength, phase monitor, tipper, master clock, alarm)

Correlator "crates" (sicor1, sicor8, wbcor1, wbcor8)

Observer + workstation (cedarflat1-5)

Monitor Data

COMMANDS

File Server (storage)

CAN devices (Rx, Optics, etc)

Antenna Computer

C1 - C6

C7 - C15

C16 - C23

MWP 2012-June-14
In a nutshell

- You send commands to the array via the control system
  - Either at the keyboard or through scripts (Python)
  - Most commands are *asynchronous*, meaning you get the command prompt back immediately.
- The commanded subsystem either does what you say or fails to do it.
- Either way, the state of the subsystem is returned by the Monitor System (aka telemetry)
- Humans view monitor data with Real Time Displays (RTDs)
- Some error conditions will cause data to be *flagged* or *blanked*
- Some error conditions will set off the alarm
Monitoring
(How to Figure Out What the Array is Doing)
The Monitor System

How do we know what's happening in the system? *Monitor everything!*
The Monitor System

How do we know what's happening in the system? *Monitor everything!*

**Analogy:**
The Monitor System

How do we know what's happening in the system? **Monitor everything!**

Analogy:
The Monitor System

How do we know what's happening in the system? *Monitor everything!*  
Analogy:
The Monitor System

How do we know what's happening in the system?  
*Monitor everything!*
The Monitor System

How do we know what's happening in the system? *Monitor everything!*

- Currently, ~100,000 **monitor points**
  - physical measurement, e.g. voltage or temperature
  - status of a system, e.g. good, bad, enabled, disabled
  - astronomical value – RA, DEC, Az, El, frequency
  - status of pure software process, e.g. spectral pipeline
  - a few 1000 per antenna; a few 10,000 for correlators; several 1000 for Control system
  - Those vital for science and go into MIRIAD data

- Hierarchical naming convention to access values, e.g.

  **Control.Subarray1.loFreq**

  But this can get cumbersome:

The Monitor System

- Data sent from each subsystem to acc in every half-second, which collates it into a *frame*
The Monitor System

- Data sent from each subsystem to acc in every half-second, which collates it into a frame

I NEED MORE COWBELL !!!
The Monitor System

• Data sent from each subsystem to acc in every half-second, which collates it into a *frame*

• Averages/min/max stored into “MPStore” database on several timescales:
  • frame rate; 1 minute; astronomical integration time.
  • database goes back several months

• Monitor data are queryable from Python, web, or Linux shell

• Monitor data displayed graphically in realtime displays (RTDs)
Real Time Displays
Science Data Flow
(Where Have All The Data Gone?)
1. PI's proposal information goes into project database.
2. Observer runs observing script and assesses data quality.
3. PI retrieves superb data from archive
4. Write paper
5. Fame & Fortune!
Science Data Flow

- Starts with proposal and continues through observing to archive.
- Proposal preparation tool extracts initial information for Project Database
  - e.g. PI, source, requested time, frequency, array config, abstract text
- Control system writes monitor data; spectral pipeline writes “visbricks”
- The “filler” creates MIRIAD data in real time at the telescope
- Observers do data quality assessment with automated script
- Project Database gets info about the observation from the data themselves (what was observed, for how long, at what quality, etc.)
- Routine transfer of monitor data, astronomy metadata, and visbricks to NCSA archive. (MIRIAD data recreated at NCSA).
- Web-based retrieval of archived data
  - http://carma-server.ncsa.uiuc.edu:8181
Observing Basics
(How You Interact With the Array)
Programs/Commands you'll use regularly

- **carmaSystem [start | stop]**
  - starts and stops entire observing system (~ 200 programs)
- **sac** – SubArray Control: The Python interface to the array.
  - **sci1, sci2, eng1, eng2** – aliases for each subarray
  - run will run observing scripts, e.g.
    ```python
    run('c0937_1D_224OrionH', endtrack='09:30')
    ```
  - queue will run a list of projects from a file in order
  - processRestart will stop and restart individual server program
  - add/removeAntenna to move antennas between subarrays
- **rtd** – start up Real Time Displays
- **pdbi** – project database interface, used to schedule observations
- **schedPlot** – graph source and phasecal LST availability
- **quality** – assess data quality (can also be run from PDBI)
## Observing project scheduling tool

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Who Ya Gonna Call?

(after you have tried to solve the problem yourself or talked to the babysitter)

help@mmarray.org – Goes to real-time systems (RTS) and hardware groups

rts@mmarray.org – If you know it is a computer or software problem

hardware@mmarray.org – If you know it is a hardware problem