MCS Subsystem Definition
Ver. 2

Steve Ellingson*

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Contents

*Bradley Dept. of Electrical & Computer Engineering, 302 Whittemore Hall, Virginia Polytechnic Institute & State University, Blacksburg VA 24061 USA. E-mail: ellingson@vt.edu

1 Scope of Work

MCS stands for "monitoring and control system". With the current allocation of ONR FY07 funds plus the currently-planned allocation of FY08 funds, Virginia Tech will develop MCS for the first LWA station ("LWA-1") to a sufficient level to facilitate LWA-1 "initial operational capability" (IOC). Here are some caveats:

1. Although this work is specific to LWA-1, the development will be such that that replication of the MCS design (including hardware and software) for subsequent LWA stations will be straightforward.
2. Selected capabilities that might not be necessary or desired for subsequent stations – e.g., specific capabilities intended to support the design or integration of other subsystems, and support for "outrigger" antennas for use in station commissioning experiments – will be accommodated, with the extent of the accommodation being at the discretion of Virginia Tech.
3. The development will be such that the integration of the station MCS with a future multistation "LWA-wide" MCS will be straightforward. However, the specification or development of the "LWA-wide" MCS is outside the scope of this work.
4. All MCS hardware that is installed in LWA-1 will purchased by the LWA Project Office (informally, this has been referred to as the "pile of parts" cost). Materials and supplies which are used to develop MCS – but not intended for installation in the station – will be purchased by Virginia Tech. However, some of what is purchased by Virginia Tech for MCS development may, at Virginia Tech's discretion, be provided to the Project Office for installation in LWA-1.

This statement of work is intended as elaboration for project management purposes only. Existing official documents take precedence all matters pertaining to administration and contracts.

2 MCS Functions

The following is a brief summary of the functions that MCS performs.

1. **Monitoring** of the station "state", the progress of commanded activities, and status information provided by integrated subsystems.
2. **Logging.** MCS will maintain a record of activity, including commands received; the beginning, ending, and changes in the status of observations; key changes in system or subsystem state (e.g., error conditions reported, actions taken); and so on.
3. **Control.** MCS converts commands from users into commands issued to station subsystems. Users do not interact directly with LWA subsystems. "Control" also includes the commanding of LWA subsystems to perform certain tasks which might occur independently of explicit user commands; e.g., diagnostics which are performed periodically, or which are automatically initiated when certain conditions are detected.
4. **Data Recording.** In lieu of a station-level data aggregation and communication (DAC) subsystem (not funded by the project office), MCS will provide a rudimentary data recording capability. See Section 3 for elaboration.
5. **User Interface**, including remote operation. See Section 4 for elaboration.
6. **Application Software**, including diagnostic and operational aids. See Section 5 for elaboration.

Data reduction is outside the scope of this work, except for certain limited capabilities which are intrinsic to monitoring and diagnostic features identified elsewhere in this document. The data product delivered to users is essentially the data which is produced by the digital processing (DP) subsystem, plus metadata captured by (or generated by) MCS.

3 Data Recording

According to the station architecture document [1], LWA stations are to have a data aggregation and communication (DAC) subsystem that is responsible for the routing of data from digital processing, and further says "The DAC includes separate output to facilitate local recording of output directly to disk. For example, this would allow continued operation of the station should data path to the LWA central processing facility be interrupted, or not yet implemented." However, DAC is currently an "orphan" – i.e., no institution is working on it, and no ONR FY07 and 08 funds are available for its development. In its place, University of New Mexico agreed to provide a network interface allowing off-site network communication, and Virginia Tech agreed to implement a rudimentary local data recording capability as part of the LWA-1 MCS.

The MCS interim data recording capability will accept output from DP via 10 Gb/s ethernet connections. Each connection nominally operates at less than 100 MB/s (800 Mb/s), although transfer rates up to 200 MB/s (1600 Mb/s) should be possible. The maximum duration of sustained recording depends on the transfer rate as well as the amount of disk drive storage. Also, the fraction of drive space that is available for sustained transfer diminishes with increasing transfer rate.[1] An educated guess is that at least 500 GB will be available per ethernet input, assuming 100 MB/s transfer per ethernet input. At 200 MB/s, the available storage for sustained transfer is difficult to predict but is likely to be significantly less.

It is important to note that MCS-DR will only *record* data from DP; it will not necessarily *reformat* the data, nor will it necessarily reorder data packets from DP should they arrive out of order. Thus, the data available to users will be in the same form and the same order received from DP by MCS-DR, at least in the initial realization of the system.

There will ultimately be four ways in which data can be recovered from the data recording computers. (1) Through an LTO-type tape drive which is part of MCS, (2) Through an internal station network directly into a user-provided PC, (3) Through an MCS-provided USB port directly to a user-provided external hard drive, and (4) Through the external internet connection to a remote computer. Option (3) will be implemented first, and is intended primarily as a stopgap measure. Option (4) may be restricted based on availability of the connection and priorities for its use.

It should be noted that it will probably not be possible to offload data – using any of the four techniques described above – while an observation is underway. It may be possible to "array" the data recording PCs so that some can be offloading while others are recording.

It is anticipated that the total amount of storage provided by data recording PCs will be limited to a few terabytes. Thus, a protocol will be established to automatically delete data from previous observations in order to make room for upcoming observations. The time required to offload data could result in significant "down time" for certain observing modes, and will need to be considered when planning observations.

4 User Interface

1. The primary physical interface with users will be via a network connection. Users which are on-site may access MCS using personally-owned computers connected to an internal ethernet connection. Users which are off-site may access MCS through the external internet connection. In this sense, there will be not normally be a distinction between users which are physically present at the station, and users which are accessing MCS via an external internet connection.

[1] This is because transfer to hard drives tends to be most efficient when the drive is empty of data, and tends to degrade as more data is placed on the drive.

For security and safety reasons, certain functions may be restricted for users which are not physically present.

2. The primary logical interface with users will be via selected standard internet protocols. Command line operation via the secure shell (ssh) protocol will be provided for both monitoring and control. To use this facility, users will login to a Linux-based operating system using personal accounts set up for them by the MCS system administrator.[2] An http-based monitoring-only capability will also be available to permit monitoring via a web browser. Other protocols and capabilities will be provided at the discretion of Virginia Tech.
3. Some application software will be provided. See Section 5 for specific information.
4. Dedicated computer(s) to serve as a station "console" or "status display" are not within the scope of this work, but software suitable to implement those functions on computers provided by the LWA Project Office will be provided. This will be essentially the same software described in items 2 and 3. It is recommended that at least one computer be permanently installed in the station as a local user console, and that this computer also have a second wall-mounted large-screen monitor that continuously displays the output of the default monitoring application.
5. Users will be able to obtain any information which is monitored or logged by MCS.
6. Users will be able to issue commands. The specific commands which can be issued will depend on the user, as identified by that user's login. Not all users will be allowed to use all commands.
7. A group of commands will be provided for the definition and scheduling of observations. See Section 6 for additional information.

5 Application Software

Some application software will be provided. This software will not be required to operate the station, and is intended only as a convenience to users. Specifically, this software will (1) provide a graphical user interface (GUI) alternative to the basic/default command line method of operation, and (2) provide an example for others who wish to develop more elaborate application software.

The applications will communicate with MCS using only the standard methods described in Section 4, item 2. The applications will be developed primarily in Python, and will use an open-source GUI toolkit. In some cases ANSI C will also be used. An effort will be made to develop this software in such a way that all common operating systems and distributions are supported either explicitly or through a straightforward porting mechanism (e.g., recompilation). However, the software will be developed using Ubuntu Linux, and the applications will be tested and validated only for this OS/distribution.

The following is a list of application software that will be provided as part of the LWA-1 IOC MCS. These applications will be available in both command line and GUI versions, except as indicated.

1. Monitoring application. Provides selected subsets of all possible data. Possible subsets could be: A summary status display (i.e., something suitable for a wall-mounted monitor); Data summarizing the status of a specific observation; a table of measured total power for each antenna (useful as a diagnostic); and so on. Command line application provides same information, but in numerical form only and without continuous updating.
2. Scheduling application. Provides a graphical interface for defining and scheduling an observation. For additional information on observing, see Section 6. Not available as a command line application. An "off-line" version of this application will also be provided as an aid in planning observations.

[2] The system administrator will be a Virginia Tech designee until IOC. This responsibility should at that time be formally transferred to an LWA Project Office representative.

3. Frequency-domain analyzer (max-hold, median, mean). By antenna, or by beam. Variable spectral resolution and integration time. The command line version will provide the same information, but in numerical form only and without continuous updating.

4. Time-domain analyzer. By antenna, or by beam. Variable bandwidth and integration time. The command line version provides same information, but in numerical form only and without continuous updating.

5. Time-frequency analyzer (i.e., spectrograms). By antenna, or by beam. Variable temporal and spectral resolution. The command line version provides same information, but in numerical form only and without continuous updating.

6. Sky map. Provides a low-resolution image of the sky in brightness temperature at the selected frequency, location, and time. Can be set to update in near-real-time. Provides also position (RA/Dec as well as current Az/El) of the Sun, Sag A, Cas A, Cyg A, and Tau A. Predicts antenna temperature. The command line application provides same information, but in numerical form only and without continuous updating.

7. Command line "help" application; essentially, "man" pages for all MCS commands.

6 User Observing Paradigm

The term "observation" may have multiple definitions in the context of an LWA station. In this section, we define an "observation" as the allocation of LWA station resources over a specified time period to a user, for the purpose of collecting science data. The sequence of events for an observation are as follows:

1. The user plans the observation. Parameters that must be determined include start and end times; configuration (choice of beamformer, TBN, or TBW, for example); pointing vs. time, center frequency, bandwidth, and integration time for specified beam(s); and so on. Users will not normally need to know site specifics or details of the digital signal processing to plan an observation. For example, to define a beam pointing, the user will have to provide RA/Dec and center frequency, but not Az/El, per-antenna delays, or FIR coefficients.

2. The user defines the observation using the on-line or off-line application software described in Section 5, item 2. If the off-line application is used, the process must be completed using the on-line application.

3. MCS determines if the observation is allowed. For example, if the observation is part of an approved proposal, MCS compares the observation request to information from the approved proposal. MCS also determines if the observation is possible; i.e., within the capabilities of the station, taking into account current status such as subsystem failures. The observation is then either accepted or rejected.

4. MCS conducts the observation. The observation can be monitored in near-real-time as described in Section 4.

5. Data acquired from the digital processing (DP) subsystem will be recorded as explained in Section 3. Metadata associated with the observation will also be recorded. Primary source of metadata will be MCS log entries pertaining to the observation (indicating progress of the observation and error conditions (if any) encountered) and station "state" information that may be needed to analyze or interpret the data at a later time; for example, details of station configuration, array geometry, maintenance conditions, and so on.

6. At some point after the observation is completed, the user is responsible for offloading data and metadata; see Section 3.

"Fire and forget" operation will be supported; that is, users will not be required to be logged in order for commands (including observation commands) to begin or complete execution.

7 Document History

- Version 2 (Feb 23, 2009):
  - Indicating explicitly that MCS-DR only records data from DP, and does not reformat it.
  - More specific comments on MCS-DR transfer rates and storage, based on project-level decisions to use 10 Gb/s ethernet.

References

[1] S. Ellingson, "Long Wavelength Array Station Architecture Ver. 1.0," Long Wavelength Array Memo Series No. 119, November 19, 2007. [online] http://www.phys.unm.edu/∼lwa/memos.