Commensal Systems at LWA-SV
Ver. 2

J. Dowell*   G. B. Taylor†

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*University of New Mexico. E-mail: jdowell@unm.edu
†University of New Mexico. E-mail: gbtaylor@unm.edu

1 Introduction

The purpose of this document is to expand upon the commensal system capabilities described in the LWA-SV Station Architecture memo (LWA memo 214 [2]) and provide reference for future commensal systems at the station.

The Advanced Digital Processor subsystem (ADP; [1, 2]) is the digital backend for LWA-SV. ADP supports two styles of commensal systems, one that needs access to the raw F-Engine data and one that needs access to the final beamformed (DRX) and transient buffer–narrowband (TBN) data products (Table 1). The F-Engine data currently consists of 12, 3.3 MHz sub-bands. Each sub-band contains dual polarization complex spectra from all 256 antennas in the array. The sub-bands are organized into two tunings, each containing six sub-bands. These two tunings correspond to the two DRX tunings for beamformed data. Within each of the tunings the sub-bands are contiguous in frequency but the two tunings are not necessarily contiguous.

Name	Description	Bandwidth	Data Rate	Address	Port(s)
F-Engine – Complex Spectra					
Sub-band 1	256 stands, dual pol.	2x 3.3 MHz	25 Gb/s	239.168.40.11	4015/4016
Sub-band 2	256 stands, dual pol.	2x 3.3 MHz	25 Gb/s	239.168.40.12	4015/4016
Sub-band 3	256 stands, dual pol.	2x 3.3 MHz	25 Gb/s	239.168.40.13	4015/4016
Sub-band 4	256 stands, dual pol.	2x 3.3 MHz	25 Gb/s	239.168.40.14	4015/4016
Sub-band 5	256 stands, dual pol.	2x 3.3 MHz	25 Gb/s	239.168.40.15	4015/4016
Sub-band 6	256 stands, dual pol.	2x 3.3 MHz	25 Gb/s	239.168.40.16	4015/4016
Beamformed – Complex Voltages					
Beam 1	2 tunings, dual pol.	19.6 MHz	600 Mb/s	239.168.40.41	10000
Beam 2	2 tunings, dual pol.	19.6 MHz	600 Mb/s	239.168.40.42	10000
Transient Buffer – Complex Voltages					
TBN	256 stands, dual pol.	100 kHz	800 Mb/s	239.168.40.44	10000

Table 1: Available commensal data sources at LWA-SV.

Both of these modes are supported through IP multicast[1], a method of sending one data packet from a source to multiple receivers with a single transmission. In particular, ADP uses UDP for the transport layer on top of IP multicast, which is referred to as UDP multicast in LWA documentation. Since the multicast client subscriptions are handled by the switches at the station, additional commensal systems are largely transparent to the station. In principle, all that is needed to add a new commensal system is to configure it to subscribe to the correct multicast address and the switches will take care of sending the data.

2 Network Topology

Commensal systems need access to the ADP data network. The topology of the network is shown in Figure 1. Briefly, this network consists of ADP (both the 16 ROACH2 boards and the seven GPU servers), two Arista DCS-7060CX-32S switches[2], and a Dell PowerConnect 8024F switch[3]. All of this network, with the exception of the second DCS-7060CX-32S switch, is located inside the LWA-SV shelter. The second DCS-7060CX-32S is located in the server room of the UNM Sevilleta Education and Research Facility (SERF) building located on the refuge approximately 500 m north

[1] See RFC 112 – `https://tools.ietf.org/html/rfc1112`, RFC 4604 – `https://tools.ietf.org/html/rfc4604`, and RFC 5771 – `https://tools.ietf.org/html/rfc5771`.

[2] `https://www.arista.com/assets/data/pdf/Datasheets/7060X_7260X_DS.pdf`

[3] `https://www.dell.com/downloads/global/products/pwcnt/en/switch-powerconnect-8024f-spec.pdf`

of LWA-SV. The shelter is connected to the SERF building through a ∼600 m run of multi-strand single mode fiber cable. See A for details of the fiber path.

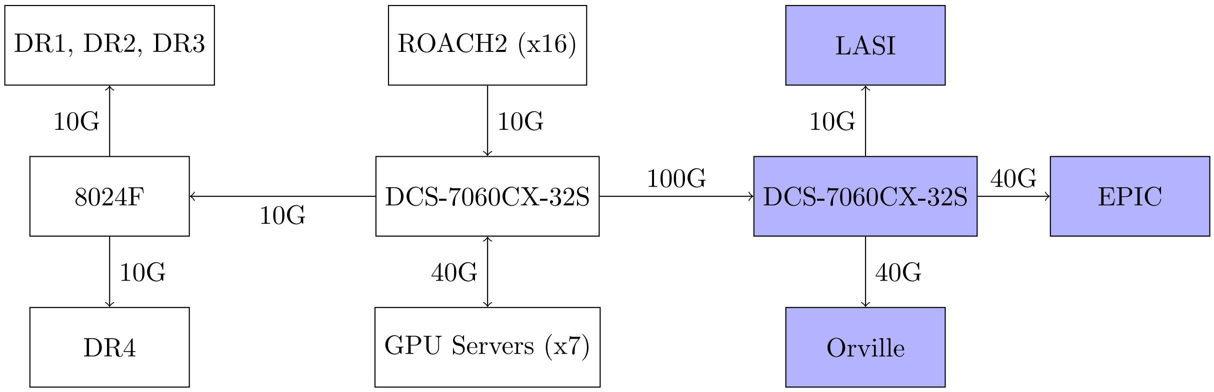

Figure 1: Network topology of the ADP data network. The arrows indicate the predominate direction of data flow and are labeled by the link speed. Blocks that are blue are located in the server room of the UNM SERF building.

As of November 17, 2022 there are currently seven machines connected to this network: the four data recorder machines inside the LWA-SV shelter and three commensal systems located in the SERF building. The commensal machines are the LWA All-Sky Imager (LASI; [3]), the Orville system (which runs on the same machine as Wilbur; [5, 4]), and the E-Parallel Imaging Correlator machine (EPIC; [6]). All three are connected to the DCS-7060CX-32S switch in the SERF building. The LASI and Orville machines receive a combination of DRX and TBN data from ADP and the maximum expected data transit of the 10G link to the SERF building is ≈1.4 Gb/s (800 MB/s for TBN at a sample rate of 100 kHz; 600 MB/s for DRX at a sample rate of 19.6 MHz). The EPIC machine receives raw F-Engine data from the ROACH2 boards and has a maximum expected data rate of 25 Gb/s (12.5 GB/s per 3.3 MHz sub-band).

3 Capacity for Future Expansion

As mentioned in LWA Memo 214 [2] the ability to add additional commensal systems is dependent on the available data switch bandwidth, number of free ports on the data switch, and the added power and heat loads. With the current hardware in place it is possible to have:

- Additional machines in the shelter that use either the DRX or TBN data products. The 8024F switch has ≈15 SFP+ ports free. The largest constraint on installing machines here is the heat load and it is not likely that additional machines would be allowed.
- Additional machines in the server room that use either the DRX or TBN data products. The DCS-7060CX-32S switch has ≈29 QSFP ports free. The largest constraints on installing machines here is the available rack space and free IP addresses on the publicly routable network. LWA currently has a single rack in this room and it may be able to hold an additional one or two 4U machines. Similarly, the number of publicly routable addresses available to LWA is two.
- An additional machine in the shelter that uses the raw F-Engine data. There are a few 40G ports free on the DCS-7060CX-32S switch in the shelter but the additional heat load would likely rule this location out.

It is currently possible to support additional machines that utilize the raw F-Engine data in the server room with the current 100G link. This link should allow for three sub-band pairs to be sent to the SERF building. This could be further expanded by using a spare working fiber pair to establish another 100G link and then combining the two 100G links into a link aggregation group (LAG[4]) to increase the bandwidth available. A LAG with two links should allow for all of the F-Engine data to be transmitted to the server room.

[4] `https://en.wikipedia.org/wiki/Link_aggregation`

4 Document History

- Version 2 (Dec 14, 2022): Updated for new switches in the shelter and SERF building.
- Version 1 (Sep 1, 2020): First version.

References

[1] M. Cranmer et al., "Bifrost: a Python/C++ Framework for High-Throughput Stream Processing in Astronomy", 2017, JAI, 650007.

[2] J. Dowell & G. B. Taylor, "LWA-SV Station Architecture", Ver. 1, Long Wavelength Array Memo 215, Aug 28, 2020. [online] `http://www.phys.unm.edu/~lwa/memos/index.html`.

[3] K. Obenberger, et al., "Monitoring the Sky with the Prototype All-Sky Imager on the LWA1", 2015, JAI, 4, 450004.

[4] J. Dowell, S. Vargehese, & G. B. Taylor "The Orville Wideband Imager," Ver. 1, Long Wavelength Array Memo 215, Aug 28, 2020. [online] `http://www.phys.unm.edu/~lwa/memos/index.html`.

[5] J. Dowell & G. B. Taylor, "The Wilbur Single Dispersed Pulse Search System," Ver. 1, Long Wavelength Array Memo 216, Aug 28, 2020. [online] `http://www.phys.unm.edu/~lwa/memos/index.html`.

[6] J. Kent et al., "A Real-Time, All-Sky, High Time Resolution, Direct Imager for the Long Wavelength Array", 2019, MNRAS, 486, 5052

A Fiber Connection from LWA-SV to the UNM SERF Building

The fiber connections from the LWA-SV shelter to the SERF building server room are shown in Figure 2. All of the fiber shown here is single mode fiber and it is lit using LR type transceivers. Although the path has the potential to have five pairs in use between the shelter and the SERF building, several of the fibers where damaged during installation, particularly for the ∼600 m run between the two outdoor termination boxes. This damage was due to trying to pull fiber cable with the FC connectors already installed. The current state of the fiber as of November 17, 2022 is:

- All five pairs are operable from the shelter to the termination box nearest it. Two pairs are currently in use.
- Four of the six pairs are operable between the two termination boxes. Two pairs are currently in use.
- Four of the six pairs are operable between the SERF telecom room and the termination box nearest it. Two pairs are currently in use.
- All three pairs from the telecom room to the server room are operable. One pair are currently in use.

It should be noted that it is likely possible to return part of the broken fibers to a working condition by re-connectorizing them. This, however, requires FC fiber pigtails, a fiber cutter, a splicing machine, and expertise to perform the work.

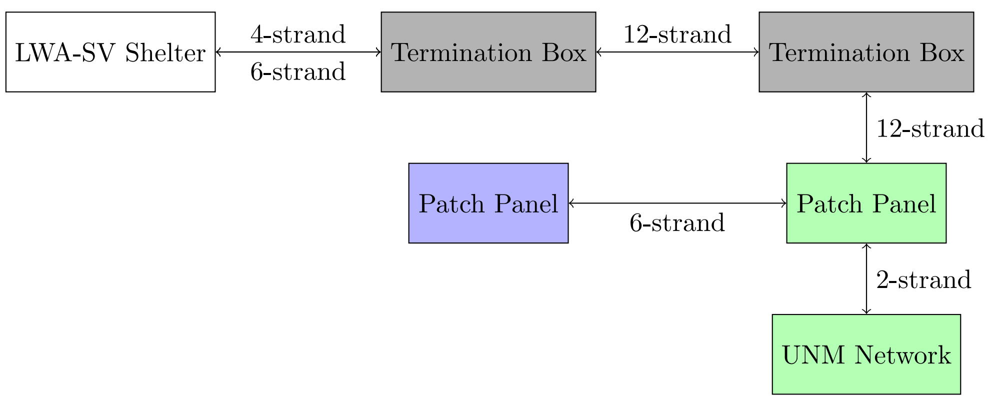

Figure 2: Fiber connections from LWA-SV to the server room of the SERF building. The boxes are color coded by location: white is in the LWA-SV shelter, gray is outdoors, green is the telecom room in the SERF building, and blue is the server room in the SERF building. The links are labeled by the total number of fibers installed.