

Argus Radio Telescope Architecture

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Introduction: Traditional Telescopes

Radio telescopes commonly consist of a single large parabolic dish. Physical constraints limit either the amount of visible sky or the size of the radio telescope.

At 100-by-110 meters, the Robert C. Byrd Green Bank Telescope (GBT) is likely about as large as a fully steerable radio telescope will ever be. Cost was \$74.5M.

Larger radio telescopes such as the 305 meter dish at Arecibo gain their larger size at the expense of mobility. Less sky is visible.

Introduction: Telescope Arrays

To increase resolution, Very Long Baseline Interferometry (VLBI) techniques are used to combine signals from smaller telescopes.

Examples:

- The Very Large Array (VLA) in NM.
- The Allen Telescope Array (ATA) in CA.
- Argus (not to be confused with the SETI League's *Project Argus*).

Introduction: What is Argus?

Argus is a radically new radio telescope design.

- Conceived by Dr. Robert Dixon of the Ohio State University Radio Observatory beginning in the 1980's.
- Replaces large antennas of high directivity with an array of numerous smaller omni-directional antennas.
- Uses computers to form virtual telescopes to look at multiple locations or even the entire sky.
- Well suited for viewing transient radio astronomy and SETI applications.
- Presents unique design challenges in terms of computing and networking.

Introduction: Argus Advantages

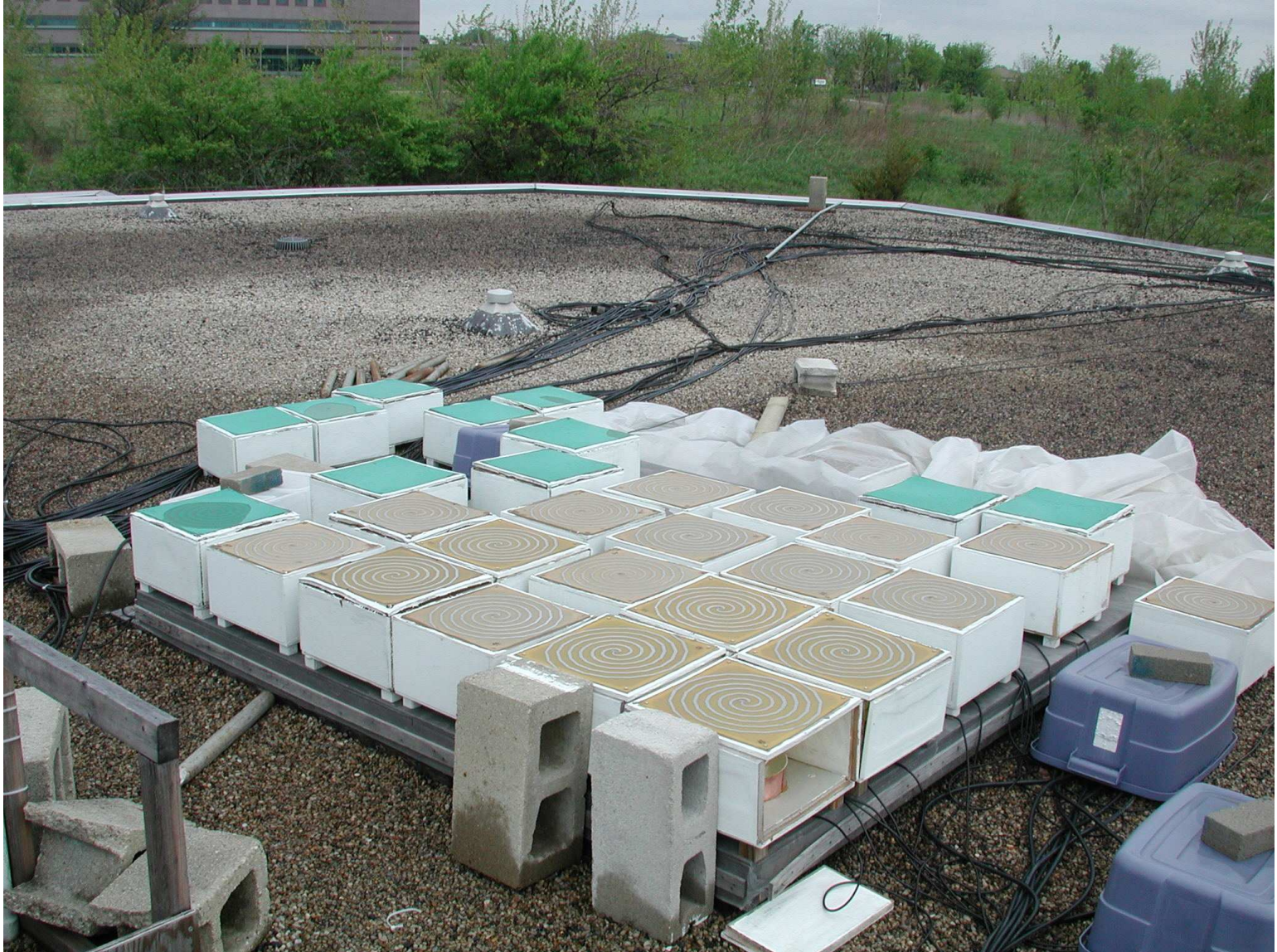
- Argus size is not constrained by physical construction limitations.
- Argus permits the creation of multiple virtual radio telescopes, which can observe the entire sky, or multiple small portions of it. Compare this to the GBT, which has single beam width of $12' / f(\text{GHz})$. At 1420MHz, this is 8.5'.
- Argus should be able to use VLBI techniques to increase resolution.
- Cost??

Introduction: Argus Disadvantages

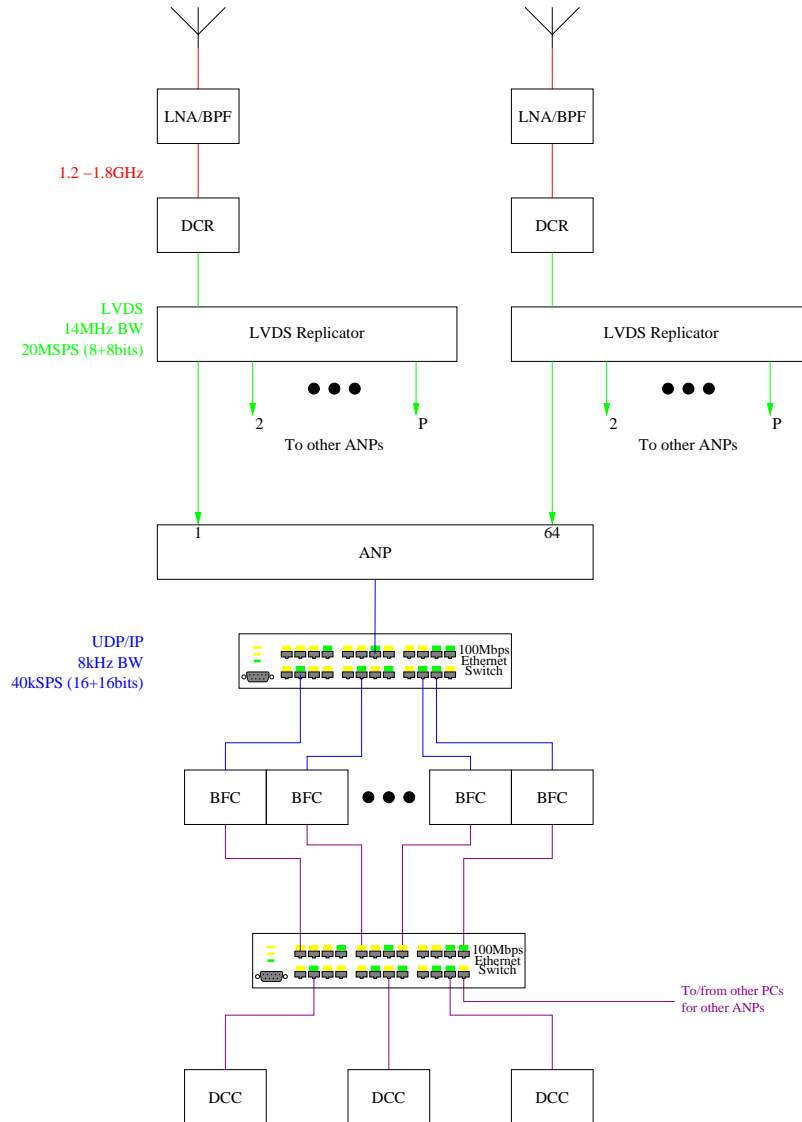
- The current implementation with 32 elements has a minimum beam width of approximately 6 deg.
- Current antenna elements still have a low effective aperture ($\approx 0.006m^2$ at $1420MHz$).
- Construction of smaller arrays is very costly and labor intensive.

The effective aperture costs on the order of $\$200K/m^2$ for Argus vs. $\$10K/m^2$ for the 100m telescope at Green Bank. Argus is 20 times as expensive.

What does Argus look like?



Argus 2002 Architecture



Networks

The Argus architecture implies the existence of several separate networks, including:

- At least one high speed network for raw data. (Data Network)
- At least one network for computed products. (Display/Command Network)
- A possible separate control network for controlling the ANPs.

Networks - Data Network

- Handles the raw data sent from the ANP for processing.
- Data is broadcast using 4+KB UDP packets at rates of up to 80Mbps on a 100baseTX network.
- Data samples are grouped into acquisitions, which include a status packet and multiple data packets.
- All packets begin with a identification header.
- All packets are required to process the acquisition, but some loss of acquisitions can be tolerated.

Networks - Data Network Problems

Some issues exist which are addressable today with code changes, but others will likely require more powerful equipment. They include:

- Multiple writes for the ID header and data make the data subject to acquisition corruption due to UDP reordering.
- Packets are currently subject to issues related to fragmentation and reassembly.
- Scaling beyond a single ANP may introduce synchronization issues between multiple ANPs.
- In the future, scaling limitations will likely exist due to network and computer limitations.

Networks - Display Network

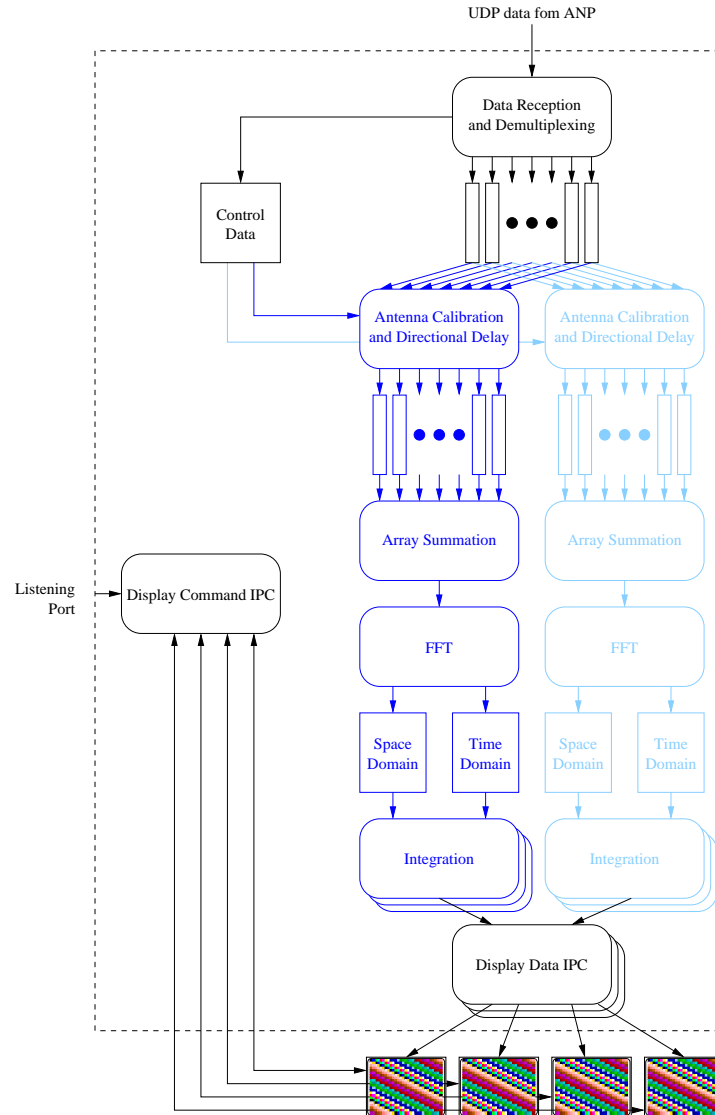
- Transports data reduced as the result of processing.
- Uses a proprietary command protocol modeled after FTP and HTTP.
- Uses multiple separate data channels for the transfer of display data.
- May involve connections via an insecure WAN.
- Makes provisions for strong authentication of commands which may impact other users.

Argus Authentication Protocol

Argus uses an authentication protocol which relies on the MD5 digest combined with a form challenge/response to avoid playback.

- The tuple of *username*, $MD5(\textit{passphrase})$ is stored via secure means.
- When authorization is required, a status code is returned by the server which includes a challenge.
- The client responds with $MD5(\textit{challenge}, \textit{now}(), MD5(\textit{passphrase}))$
- The server validates the response using the stored MD5 hash of the user's pass-phrase and a small time window.

Argus Beam Forming



Links

- <http://www.naapo.org> - The North American AstroPhysical Observatory, containing information about Argus.
- <http://www.nrao.edu> - The National Radio Astronomy Observatory, with information about the GBT and VLA.
- <http://www.naic.edu> - The National Astronomy and Ionosphere Center, with information about the Arecibo Radio Telescope.
- <http://www.seti.org> - The SETI Institute, with information about the Allen Telescope Array and Project Argus.