

A Software Correlator for the VLBA for the VLBA Sensitivity Upgrade Project

Walter Bricken

NRAO

April 18, 2007

The VLBA

- Since 1993
- 330 MHz to 86 GHz
- 0.1 mas resolution at highest frequency
- Ten 25m antennas on US soil
- Max baseline 8600 km



VLBA Sensitivity Upgrade Project

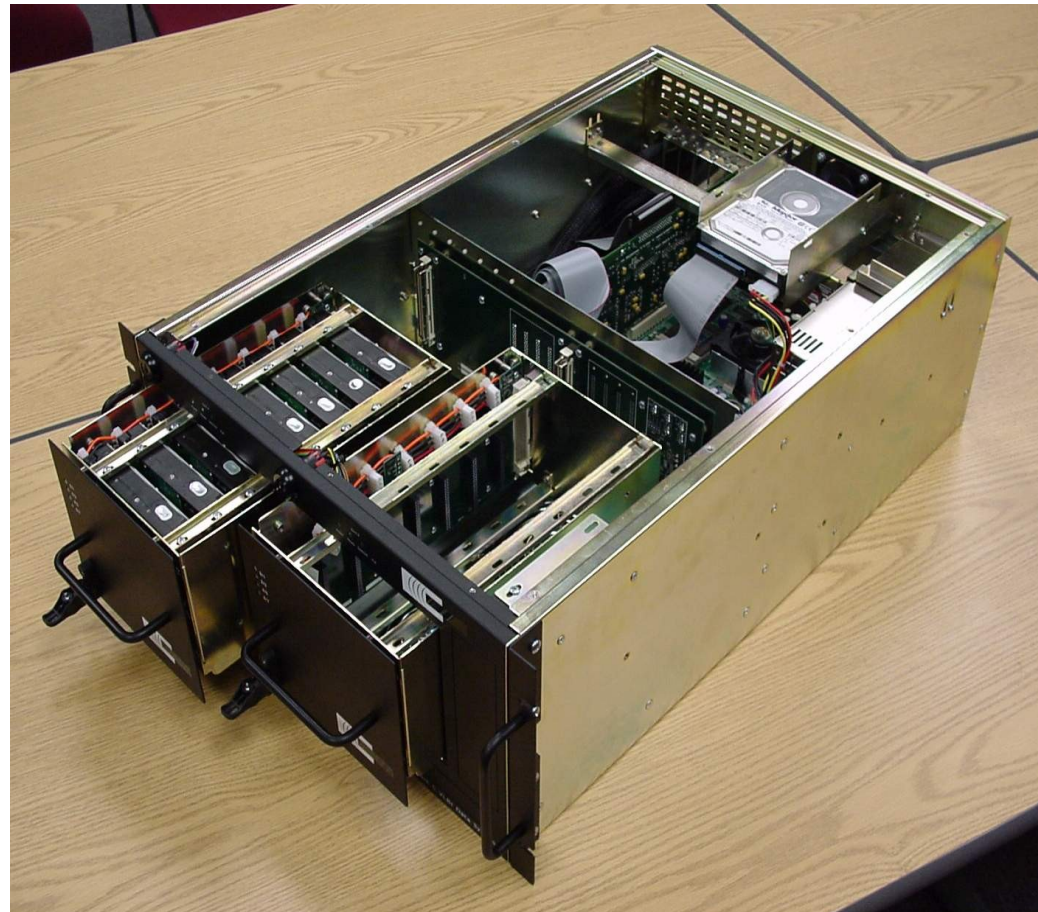
- First major hardware upgrade since construction
- Upgrade peak record rate to 4 Gbit/sec
 - Maximum now 512 Mbps
- Replace baseband converters, sampler, and formatter with digital back end (DBE) in collaboration with Haystack
- Upgrade data recorders
- Replace correlator
- Not fully funded at the moment, but there is strong internal support for this project

Correlator upgrade options

- Share WIDAR correlator with EVLA
 - Large BW hardware correlator for free
 - Needs software support, will be operationally difficult, not available for several years
- “mini-WIDAR”
 - Becoming possible
 - Not available for several years
- Software correlator
 - Perhaps expensive, but might fit the bill...

Haystack Mark5

- Disk-based VLBI recorder
- Up to 1 Gbit/sec continuous
- 8 ATA hard-discs per module. Up to 6TB
- ~150 Mark5 units worldwide
- 4Gbit/sec version coming



Software correlators

- Why?
 - Flexibility – t_{int} , Δf , n_{Ant}
 - Upgradability
 - Compatibility – accept data from many formats
 - Special processing – e.g. Pulsar, radar
 - Rapid development
- Is the price is right?

Walter's law, *“If you can record it, you can software correlate it”*

Since for fewer than ~20 stations, the CPU cost to correlate is a factor of several cheaper than the storage cost for 1 month supply

DiFX

(*Distributed FX*)

- Product of Adam Deller, Swinburne Univ.
- Based on MPI, written in C++
- Designed for medium to large scale cluster of PCs on a fast network
- Available for free, subject to some agreements
- Limited tests show good agreement with VLBA correlator

DiFX architecture

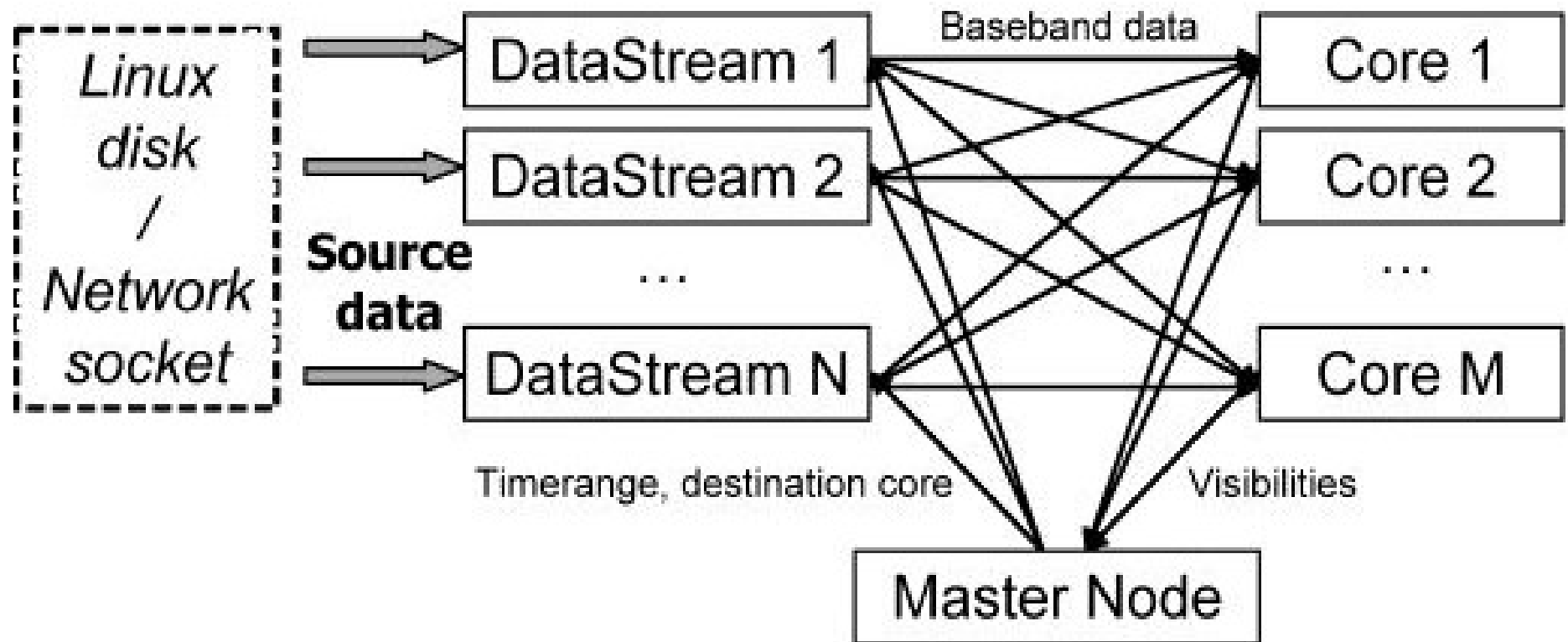


Diagram by Adam Deller

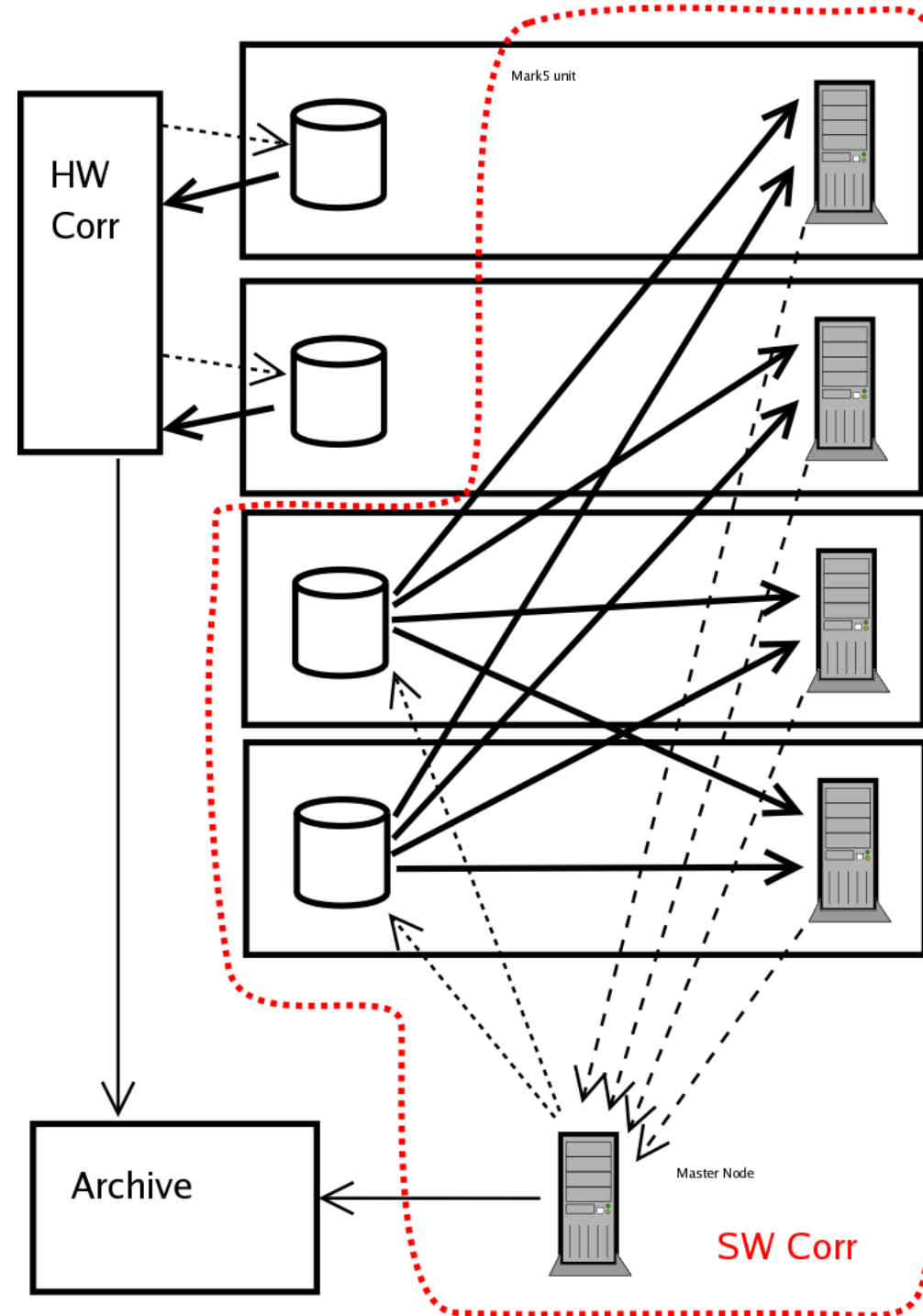
DiFX shortcomings

- Output format is non-standard
 - Fix: Write converter to generate FITS
- Data weights not generated
 - To be implemented
- Multiple subarrays not natively supported
 - Can be run as separate parallel jobs
- Does not support direct correlation off Mark5 media
 - Software project to do this about to begin

Prototype hardware plan

- Build on existing Mk5 infrastructure
- Share Mk5 units between two corrs.
- Upgrade Mk5 CPUs to aggregate ~135 GFlops
- Upgrade network
- Speed $\sim$ 1/2 VLBA corr

Coexisting correlators



10 stations at 1 Gbit/sec

- Requires about 2 TFlop computer cluster
 - 50% efficiency assumed
- Would require about 200 quad-core Intel CPUs
 - Cost : ~\$500,000 today
- Alternatives:
 - Cell processor
 - ~40 GFlops/CPU FFT performance
 - ~32 CPUs needed – substantially cheaper!
 - GPUs, FPGA accelerators, ...
- 1 Gbit/sec is not the goal, 4Gbit/sec is!

Optimistic Time-line

- Project Start : Feb 23, 2007
- First fringes goal : Apr 1, 2007
 - Achieved Apr 15
- First correlation off Mark5A : Jul 1, 2007
- Operations training : Sep 1, 2007
- Routine correlation : Nov 1, 2007
- Replacement of VLBA correlator : ???