DiFX Software Correlator for Geodesy

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VLBI correlators can be realised either in hardware (MK II, MK III, MK IV, VLBA, ...) or software, running on general purpose computers (MK I). The development of truly digital VLBI data recording (Mark 5, K5...) and of inexpensive commodity computers have led to a renaissance of software correlators.

Advantages of Software Correlators

Upgrading the software is relatively easy

Flexible: no hard limits for No. of antennas, bandwidth, data rates, new requirements for processing

Compatibility for new recording formats = adding a new subroutine

Efficiency: correlator uses all resources (MK IV typically uses ~25% for geodetic correlation)

Scalability: buy more computers if more performance in needed

Floating point precision for all calculations; hardware correlators use integers

Development time is very short

A Software correlator is less complex than the software to control a VLBI hardware correlator

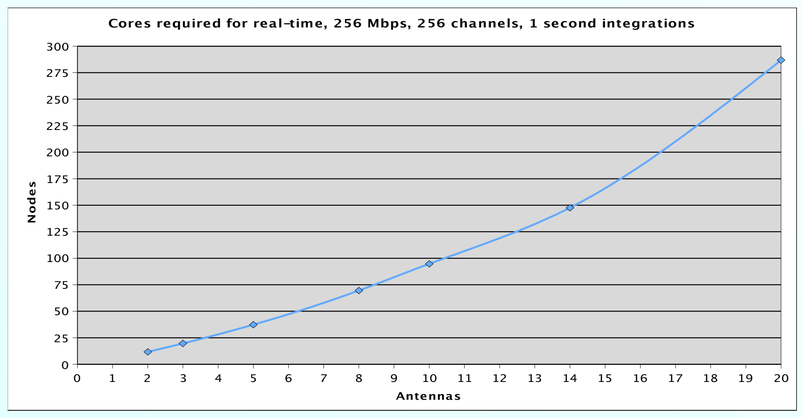
BUT:

need really digital data sources, like disks

power consumption is higher

real-time data sources like e-VLBI require spare capacity and buffers

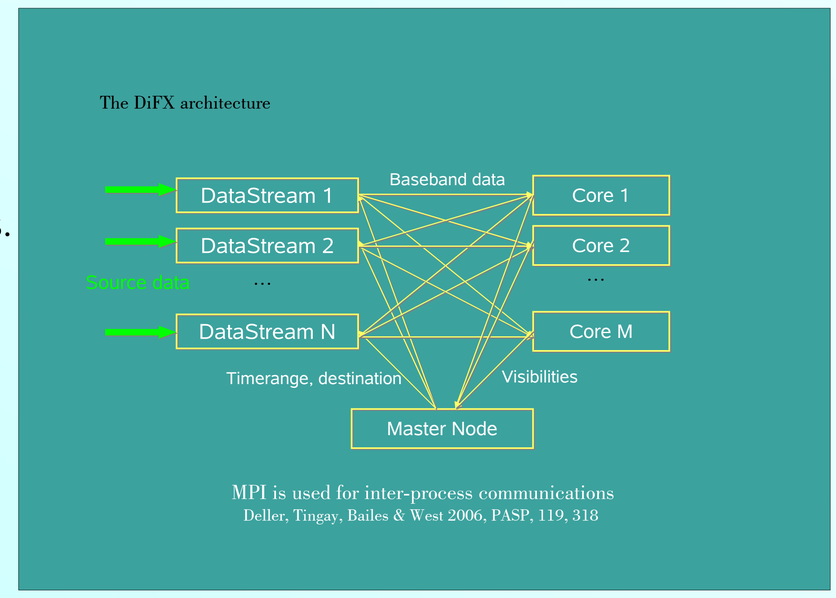
inefficient for really big arrays (may require a super-computer)



Performance of DiFX as a function of No of antennas. E.g 100 cores can correlate 10 stations at 256 Mbit/s, 500 cores more than 14 stations @ 1 Gbit/s (At present a modern computer cluster node has 8 cores in 2 processors)

The DiFX (Distributed FX) Software Correlator

- DiFX has been developed by Adam Deller (Swinburne) as part of his PhD thesis in 6 months.
- It has been adopted at a number of institutions: NRAO, LBA, MPIfR, Bologna.
- Test installations exist at Haystack, USNO, Metsähovi and others.
- Common software development by above partners



Developments at MPIfR with Geodetic Support

- Implement Phase-cal
- Verify DiFX for geodesy
  - Simple comparison of total phase and delay to the MK IV correlator. (Done: see below)
  - Correlation of an INT3 and comparison to the MK IV correlator. (ongoing)
  - Comparison of a geodetic multi-station 24 hour run.
  - Full documentation expected in Deller's thesis.
- Output to Haystack MK IV format with HOPS fringe-fitting and DBEDIT export

Simple comparison of DiFX and the MK IV correlator

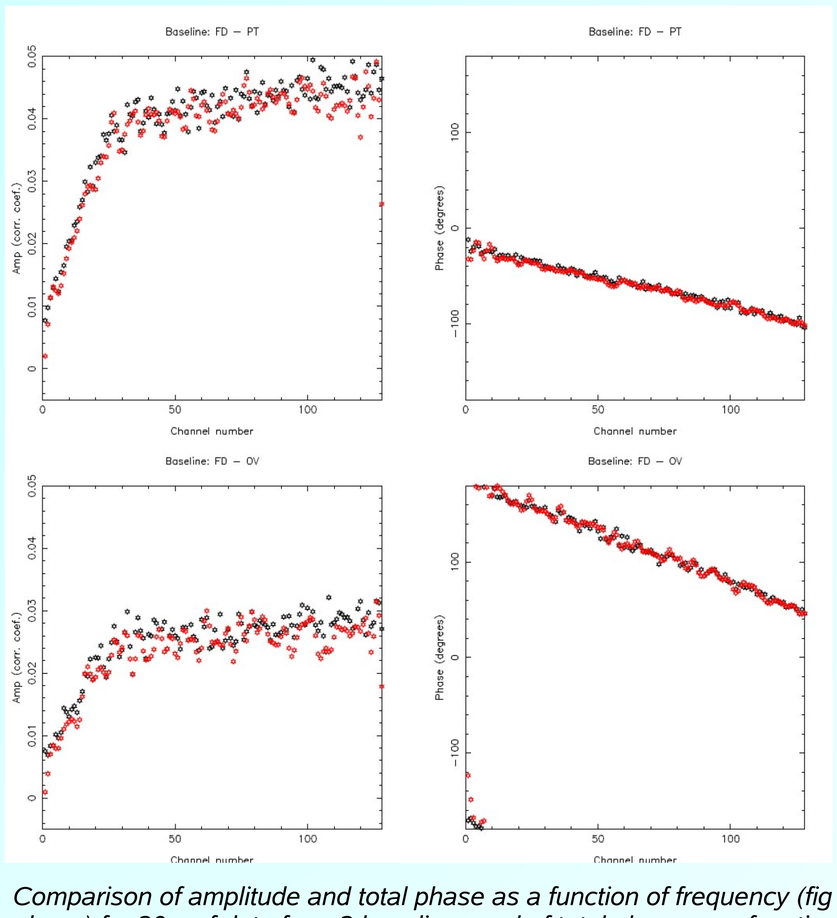
- The comparison was done with 30 s of data of 4 stations, 1 lower sideband
- The data was exported to AIPS, the comparison was done in MIRIAD
- The total phase as a function of frequency (delay) and the total phase over time were calculated (differences exist for the residual data due to different correlator models)
- The differences between the results of DiFX and the MK IV correlator were calculated
- **Results: the mean phase difference is well within 1σ of zero, and the r^2 values indicate that far less than 1% of the variation in the data can be explained by linear regression. Thus, no significant differences exist between the phase outputs as a function of time, between the MK IV and DiFX correlators.** (see tables below)

Comparison of phase differences as a function of frequency

Baseline	Mean of phase differences (°)	Standard deviation of phase differences (°)	r^2
FD - PT	−1.60	2.46	1×10^{-4}
FD - OV	0.56	4.22	4.5×10^{-3}
PT - KP	−0.74	2.56	1×10^{-6}
OV - KP	1.71	3.14	8×10^{-4}

Comparison of phase as a function of time

Baseline	Mean of phase differences (°)	Standard deviation of phase differences (°)	r^2
FD - PT	−0.234	1.700	4.7×10^{-2}
FD - OV	−0.663	1.676	1.03×10^{-1}
PT - KP	−0.188	1.620	1×10^{-3}
OV - KP	0.050	1.996	2.3×10^{-2}



Comparison of amplitude and total phase as a function of frequency (fig above) for 30 s of data from 2 baselines and of total phase as a function of time (fig. below) for hardware and software correlator. MK IV = red

Comparison of an INT3 dataset

The next step is the comparison on a 1 h 3 station INT3 (Wettzell, Ny Ålesund, Tsukuba)

Problems encountered so far:

- "Illegal VLBA format" of translated Tsukuba data. Fix soon (will use Japanese converter)
- Non-standard track assignments of Tsukuba data has to be implemented.
- Mark IV formatted Mark 5 data starting on integer second before scan starts. Problem only for geodetic data due to early start. Fixed
- Processing has to be done be with manual phase-cals. (phase-cal will be implemented towards the end of 2008)
- DiFX data export and fringe fitting via AIPS to data-base. Problems with importing to AIPS encountered due to "unusual" (=geodetic) frequency setup. Under investigation.
- Bonn and Leipzig analysis centres will be asked to perform CALC/SOLVE comparison.
- Results so far:
- INT3 processing with DiFX takes less than 10 minutes + no copying to 8-packs needed !!