Real-Time E-VLBI
with the SFXC
Software Correlator

Mark Kettenis kettenis@jive.nl
Aard Keimpema keimpema@jive.nl
JIVE
SFXC

- SFXC = S? FX Correlator
  - Where S? used to mean “Super”
- Uses MPI to distribute/parallelize computation
- Descendant of the correlator used for to track descent of Huygens probe on Titan
- VEX driven
- Pulsar binning/gating
- High spectral resolution
- Accepts Mark4, VLBA, Mark5B and VDIF data
- Data product compatible with the Mark 4 correlator at JIVE
  - But higher data quality
New Features

• Multiple phase centers
  ▫ Use high time/spectral resolution internally to prevent smearing
  ▫ Apply phase shift for each center
  ▫ Average down to desired time/spectral resolution

• WOLA
  ▫ Windowing functions: Rectangular, Hann, Hamming, Cosine
    Adding other functions is trivial

• Space Science features
  ▫ Improved delay tracking for high spectral resolution
  ▫ Near-field model (Dmitry Duev)
  ▫ Possibility to include Doppler-shift in model

• Operational tools
  ▫ weight display, fringe display, clock search tool

Correlation shifting from Mark 4 correlator to SFXC
  ▫ More than half of the June 2011 EVN session correlated on SFXC
Direct Mark5 Diskpack Access

Simple software to:
- Isolate correlator software from StreamStor SDK
- Do automatic bank switching

Maximum throughput 1.2 Gbit/s (on Mark5A)
Direct Mark5 Diskpack Access

1. sfxc sends VSN + byte offset to mk5read

2. mk5read selects bank

3. kk5read sends data to sfxc
e-VLBI with SFXC

- Continue to use Mark5s for data input
- Replace *mk5read* with *mk5udp*

- Strip Packet Sequence Number and forward data

If network connection breaks, correlation will stop!
e-VLBI with SFXC

No packets received? Send fake frame every second

- Wait 2s before sending first fake frame
- Send frame with timestamp 1s in the past
- Supports generation of Mark4, Mark5B and VDIF frames
  - Mark4 & Mark5B: use fill pattern to mark data as invalid
  - VDIF: use validity bit in VDIF header

Initial testing done with Mark5 simulator (Bob Eldering, EXPReS)
- Add VDIF support (single-thread, single-channel for now)
Simulation setup

MPI

mark5_simul

mk5udp

sfxc
(input node)

sfxc
(corr. node)

mark5_simul

mk5udp

sfxc
(input node)

sfxc
(corr. node)

sfxc
(corr. node)

sfxc
(corr. node)

run_evlbi_job.py
First e-VLBI fringes

6-stations @512 Mbit/s
Elliptical Robin

How to get 1024 Mbit/s over a 2×1Gbit/s links?
and leave room for some other MERLIN stations

Use modified Ethernet bonding driver
5 packets on 1st interface, 1 packet on 2nd
By Paul Boven

Packets will arrive out of order
mk5udp doesn’t reorder
SFXC discards out-of-order data

Replace mk5udp with jive5ab
jive5ab properly reorders packets
and supports channel dropping
Hardware Upgrade

- Added 16 new nodes
  - Now 32 nodes, 256 cores
- Equipped 4 nodes with 10Gbit/s Ethernet
  - Directly connected to e-VLBI network
- Integrated Mark5A+/Mark5B/Mark5C’s with the cluster
  - All on 10Gbit/s Ethernet
  - Total of 24 playback units

Should allow real-time correlation of 9 stations @1024 Mbit/s
Need to improve software to fix Mark5 bottleneck
Speed Up Dechannellisation

- Current code uses JIT compilation
  - Fast, but not fast enough

- Use SSE instructions
  - CPUs in Mark5s @JIVE only support SSE2
  - Speedup of a factor 2
  - Hand written assembly code
    - Can be automatically generated?
  - I/O bottleneck remains
    - Parallelisation needed

- Use VDIF with single-channel frames
  - No dechannellisation necessary
  - Parallel I/O becomes trivial
VDIF/VTP support

- SFXC accepts single-channel VDIF frames
- mk5udp accepts the proposed VTP packets
  - Currently just strips the VTP header
- jive5ab VTP support is under development (Harro Verkouter)
  - On-the-fly conversion of Mark4 and Mark5B data to VDIF
  - Single-channel VDIF frames

Key to truly distributing correlation over multiple clusters!
Global Correlation

Distribute subbands over correlation centers

Onsala → Poznan
Irbene → Dwingeloo
Mopra → Perth
NEXPreS WP7 Update

“Computing in a shared infrastructure”

Create an automated, distributed correlator using the global, shared infrastructure of the EVN and its associated global partners

- Web-based Workflow Manager
  - Development well underway (Poznan)
- Automatic schedule generation
  - Prototype ready (Onsala)
  - Now working on acting upon triggers
- SFXC deployed at JIVE, Poznan, Ventspils
Questions?

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Additional Information at http://nexpres.eu