NEXPReS and the EVN
Towards 4 Gbps operational VLBI

Arpad Szomoru, JIVE
Outline

- Overview of NEXPReS
  - Rationale, structure
  - Several talks on specific aspects later on during workshop
- Status of Work Packages 7 and 5
- Towards 4Gbps VLBI operations
E-VLBI after EXPReS

- Works great!
  - Stable, robust connectivity
  - Big telescopes, long baselines at full 1024 Mbps in real time
  - Enabling new science, increasing demand

- But, limitations remain…
  - Some (important) telescopes will not (ever?) be able to join
    - KVAZAR, Urumqi, global baselines with VLBA…
  - No such thing as a perfect system/hardware, failures do occur
  - Re-correlation with different parameters currently impossible
  - Higher bandwidth/data rates becoming available, crucial for science
    - Need to accommodate 2, 4, 10? Gbps per telescope
    - 4 Gbps dBBCs being rolled out in EVN
    - 100 Gbps technology on its way
Novel EXplorations Pushing Robust e-VLBI Services

Correlate in real time what you can
Correlate later what you need
NEXPReS: EXPReS follow-up

- Project has started July 1, 2010

- 15 partners (cf. 19 in EXPReS)
  - Good mix from astronomy-networking-HPC communities
  - High level of partner-contributed effort

- Main objective: introduce transparent caching
  - Bring increased sensitivity, flexibility and robustness of real-time VLBI to all EVN experiments
  - Deploy a high-speed, flexible caching system
    - allow transparent re-transmissions and/or re-correlation
  - Remove distinction between VLBI and e-VLBI operations
  - Continue collaboration with NRENs
  - Explore common technology questions with LOFAR, SKA
  - Prepare the EVN for higher bandwidths to come

- Continuity for e-VLBI operations
NEXPReS structure

2 Service Activities
focus on new operational astronomical features:
Higher bandwidth, dynamically cached transport, increasing flexibility of observations

2 Joint Research Activities aiming at innovating future operations
Distributed correlation in astronomy domain
Transparent buffering

2 user community networks continue from EXPReS
Astronomy use and policy
Network providers/telescope operators

2 special Networking Activities
Management & Outreach
Essential for success
Activities

• WP6: High bandwidth on demand (presentation Boven)
  • Permanent, static links are very convenient, but under-used, and limited to 1Gbps
  • Integrate e-VLBI with existing BoD techniques
  • Investigate on-demand access for large archives
  • Establish international multi-Gbps on-demand services
  • Keen interest in networking community, not all NRENs in agreement

• WP8: FlexBuff (presentation Salminen)
  • Develop buffering solutions capable of multi-Gbps simultaneous I/O streaming
  • Investigate use of LTAs, allocation of resources
WP 7: Computing in a shared infrastructure

- Partners: PSNC, OSO, VENT, JIVE
- and Curtin through CSIRO for global correlation

- Create an automated, distributed correlator using the global, shared infrastructure of the EVN and its global partners in order to
  - Make use of otherwise unused telescope time
  - Surveys
  - Astrometric monitoring programmes
  - Targets of Opportunity

- Realizing that resources are scarce (staff time, disk pool, correlator time)

Data from 2008 NME C band 10 stations
WP 7: principles

- e-VLBI: no impact on disk resources
- Software correlation: no impact on hardware correlator reduced need for correlator operators
- Workflow Manager: limit impact on telescope operators
- Distributed computing: pool resources for larger observations
- Innovative observation strategies: triggers that automatically interrupt background observations

- Strong dependence on SFXC capabilities

Data from 2008 NME C band 10 stations
WP 7: SFXC

- Developed at JIVE
  - First used for Huygens descent on Titan
- Multiple phase centers
- Pulsar gating/binning
- Phasing up of EVN
- Windowing functions: Rectangular, Hann, Hamming, Cosine
- Space Science features:
  - Improved delay tracking for high spectral resolution
  - Near-field model (Dmitry Duev)
- Operational tools
  - weight display, fringe display, clock search tool
- All disk-based VLBI now correlated on SFXC
  - e-VLBI to follow shortly
WP 7: software modules (OSO)

- Station module
  - Runs on FS PC, interface between FS and WfM
  - Receives schedules, drudges
  - Start-stop operations

- Decider module
  - Receives VOEvent, compares with trigger definitions
  - Makes decision whether to observe or not, and when
  - Send observation parameters to

- Schedule writer
  - Produces standard VEX file
  - Submits it to WfM
WP 7: Work flow Manager (PSNC)

- Simplifies and enhances work of various actors: PIs, administrators, operators
- Dedicated widgets, called portlets, to create, submit and monitor e-VLBI observation
- Liferay portal
- Authentication and authorization
- Roles, permissions for groups, communities
- Communication between users (alerts, chat, shared documents)
WP 5: Cloud Correlation

- Partners: AALTO, TUM, MPG, JIVE

- Extend the benefits of real-time e-VLBI to all EVN observations

- Transforming the VLBI operational chain
  - scheduling
  - setting up of observations and actual observing
  - buffering, transferring and correlation of the data

- Prepare the EVN for the much higher data rates that are becoming available, both recorded and real-time

- Accommodate bandwidth-on-demand techniques (topic of WP6) in a transparent and efficient way

- Implement monitoring, authorization and remote control (presentations Neidhardt and Ettl)

Data from 2008 NME C band 10 stations
WP 5: Progress at JIVE

• Further increase of functionality of Jive5AB Mark5 (and more) control code (presentation Verkouter)
  • Recently: implementation of full Mark5 command set
• New monitoring and alarm system at JIVE
•Buffering control and administration of multiple copies
  • All based on completely re-designed database structure

• First steps towards automated fringe tests
  • Without disruption of science observations
  • Or human intervention
• First full implementation of disk-less recording – transmitting – correlation

Data from 2008 NME C band 10 stations
Continuous Automated Intelligent Monitoring system

- Based on Zabbix
  - Used for monitoring hardware health of Mark5s, cluster nodes, switches, etc
- Monitors “quality” of fringes of selected calibrators, weights
- Generates warnings via email (or sms)
CAIM: fringe and weight monitoring
Towards 4Gbps

- Several deliverables depend on availability and roll-out of 4Gbps-capable equipment
  - Mark5C recorders
  - DBBCs (digital baseband converters)
  - Fila10G boards
  - VDIF support
  - Firm- and software for all of the above

- Towards end of 2011: no indication any of this was happening
  - Mark5C: only 2Gbps
  - DBBC: had only been tested in 1 and 2Gbps mode
  - Only 1 DBBC operational within EVN
  - Fila10G: only Mark5B format, no VDIF support, untested
  - No plans, or available staff, to write additional firmware for Fila10G
  - Production of DBBC and Fila10G delayed

- Things were looking bleak…
Actions

- Several telecons with EVN TOG officers, designer of DBBC, Haystack engineers
  - Re-affirmation of commitment to work towards higher bandwidth
  - Attempt to speed up development, fix timeline
  - Detached JIVE engineer to Haystack January 2012

- December 2011: discussions with EC officer on deliverable 5.2
  - Demonstrate progress of WP5 through live demo
  - 3 EVN stations (On, Yb, Ef), 4Gbps recording, simultaneous real-time 1Gbps correlation
  - Before end of second period (July 1st 2012)
  - Unfortunately tests had to be done during gaps in block schedule

- Imposed a clear timeline, for all parties involved
- Focus for the effort of several deliverables in WP5
4Gbps recording/1Gbps (or more) real time

- DBBCs in PFB 4Gbps mode: untested
- Yb DBBC sent back to MPG for troubleshooting, no Mark5C at Yb
- On DBBC: clock jumps
- Fila10G cards
  - Only 3 available (4?) available in all of Europe
  - Of which one was sent to Chile...
  - Only ever tested at 2 Gbps
- Mark5C recording at 4 Gbps
  - Never tested in EVN(?)
- Yebes 10G connection not lit yet

What could possibly go wrong!!!
Lots of activity

- Countless telecons
- Mark5C shipped from JIVE to Yb
- Fila10G from Chile to Germany in hand luggage (stuck in customs)
- Fila10G for Mh on loan to Yb
- Modules for switches, cables
- Powerful 1U servers with multiple 10G interfaces purchased, shipped to stations, installed (HarroBoxes)
- Software for “chunking” written
- Modifications to SFXC correlator
- *much* testing, bug fixing, new insights
- Excellent way to get many techniques and tools developed in NEXPReS to actually work and work together
- Fantastic support from networks
4 Gbps demo
4 Gbps demo: local networking setup
4 Gbps demo: results (June 20)

- Some initial problems
  - Flooding
  - Mark5C configuration
  - Scan length recording issue
  - Some packet loss at Ef
- But, technically everything just worked!!!
- All equipment keeping up
- Networks stable and performing flawlessly

- But….. No fringes

- DBBC configuration, Fila10G time synchronization?
- Completely new equipment, need to learn
- Anyway, EC officer and review panel were well pleased
4 Gbps: the future

- New attempt soon(ish)
- Maybe demo during final review of project (what could possibly etc etc)
- Common LO settings need figuring out
- Idem wrt globals at 2Gbps

- Need all stations to start using DBBC for production, slow process
- Will need more disk packs…

- Even core 4Gbps network of just 5 EVN stations at would probably be very much in demand