Express Production Real-time e-VLBI Service

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Report on integration of E-Vlbi System

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1. Status before

The following figure presents the status of the e-Vlbi System before integration at Jive.

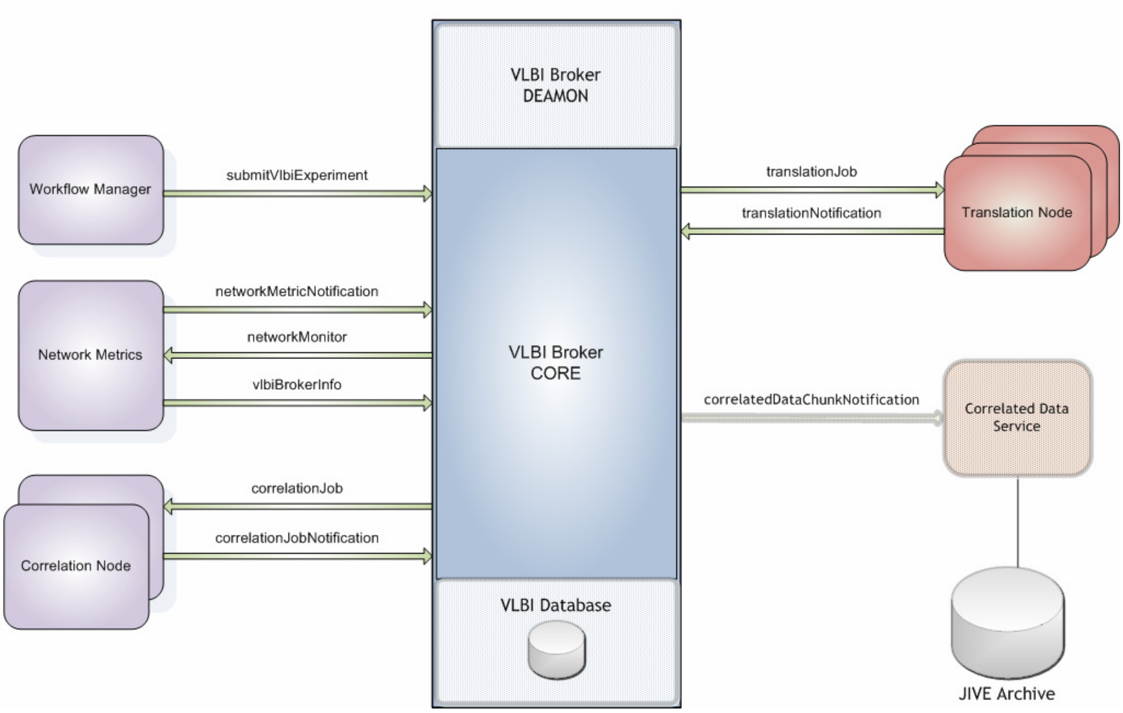


Figure 1 e-Vlbi System - status before integration

- *Vlbi Broke*r module – single threaded module core implemented. The broker core and persistence layer is missing. The module is not integrated with other system components. *Vlbi Broker Demon* is responsible for triggering all events depending on the system state i.e. starting new experiments, updating statuses or sending notifications. *Vlbi Database* – internal storage for VLBI experiments
- *Correlated Data Service* (CDS) - service responsible for storing correlated data in the Jive Archive. The CDS service is not implemented.
- *Translation Node* (TN) – responsible for handling data from radio telescopes and preparing data for correlation. There can be many TNs involved in VLBI experiment. However it is required that each radio telescope has one Translation Node assigned. The TN module is informed about new experiment by VLBI Broker. The TN core has been implemented but not integrated with Vlbi Broker.
- *Correlation Node* (CN) – responsible for managing and executing correlation jobs on the cluster/grid. The module core has been implemented. The integration with Vlbi Broker is required.

2. e-Vlbi system testbed

The e-Vlbi System working environment has been prepared where all system components have been deployed. The actual system testbed description can be found at:

http://www.jive.nl/dokuwiki/doku.php/expres:fabric:evlbisystem:internal:testbed.[1]

1. Vlbi Broker – deployed at Jive (huygens.jive.nl)
2. Translation Node – deployed at Jive (huygens.jive.nl)
3. Correlation Node –three correlation nodes have been deployed:
    - expres.reef.man.poznan.pl (Psnc)
    - clusia.man.poznan.pl (Psnc)
    - adam.astron.nl (Jive)

3. e –Vlbi system components

The first objective was to integrate all system components with Vlbi Broker. First, old communication schema has been analysed. Since Vlbi Broker is a central module, which communicates with other components it was decided that common communication interface for all modules should be introduced.

The following figure presents interactions between system modules.

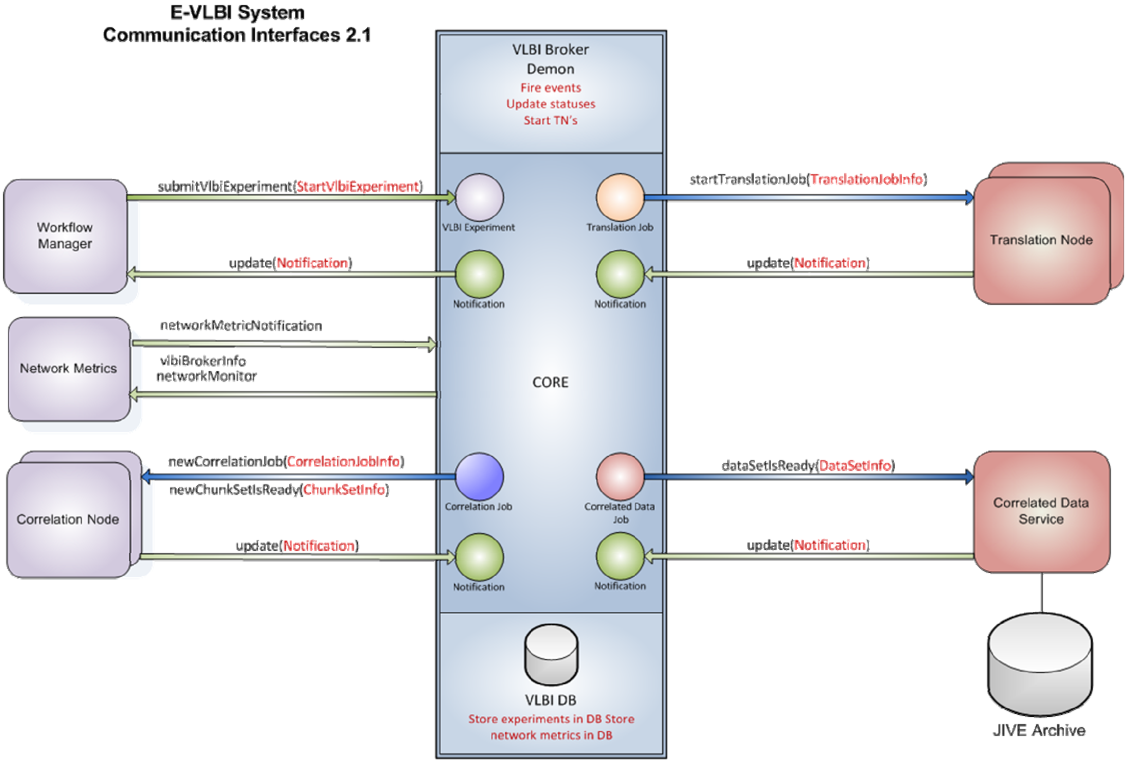


Figure 2 e-Vlbi system components

Changes in the new communication interface:

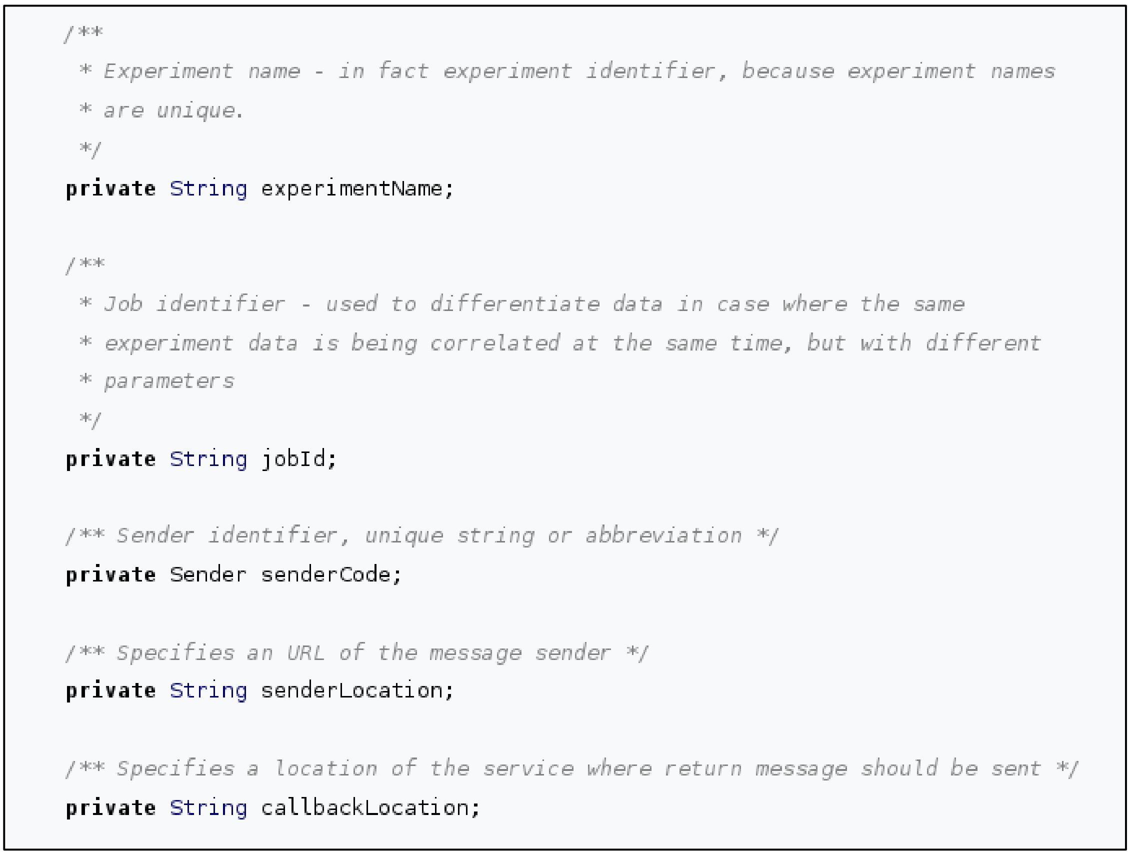
- unused fields removed
- added missing items

[1] Wiki account is required to view this page

- the communication schema has been unified. Each message consists of MessageHeader and ChunkInfo
- all modules are using common Notification interface to exchange information

3.1. MessageHeader structure

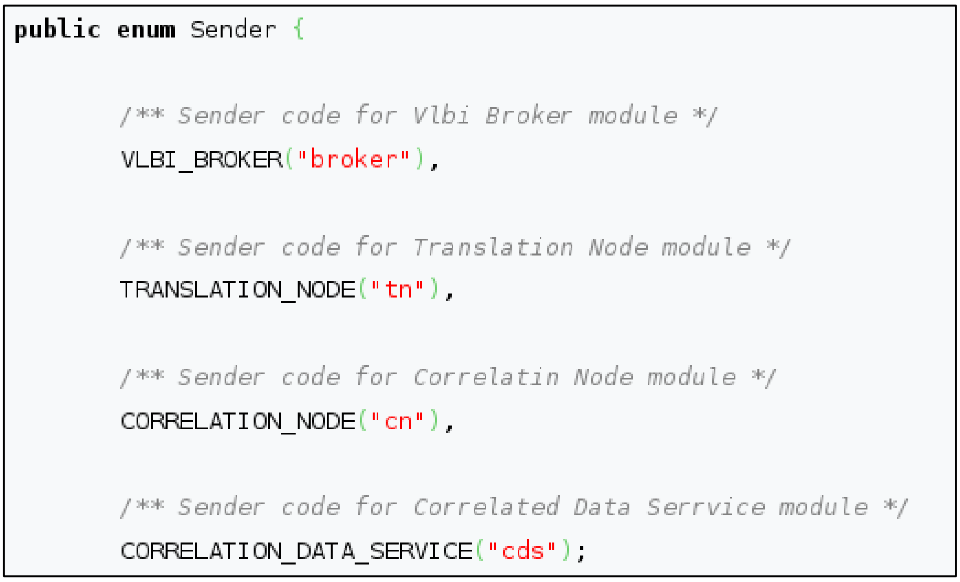
Each message send between system components has a structure called *Message Header* which contains general information about message sender.



```
/**
 * Experiment name - in fact experiment identifier, because experiment names
 * are unique.
 */
private String experimentName;

/**
 * Job identifier - used to differentiate data in case where the same
 * experiment data is being correlated at the same time, but with different
 * parameters
 */
private String jobId;

/** Sender identifier, unique string or abbreviation */
private Sender senderCode;

/** Specifies an URL of the message sender */
private String senderLocation;

/** Specifies a location of the service where return message should be sent */
private String callbackLocation;
```

Figure 3 Message Header

We have introduced a *jobId* which is used to distinguish the same experiments correlated with different parameters. The *callbackLocation* property is used by the message receiver for sending a reply message. The *senderCode* determines the message sender. The list of valid message senders is presented in the figure below.

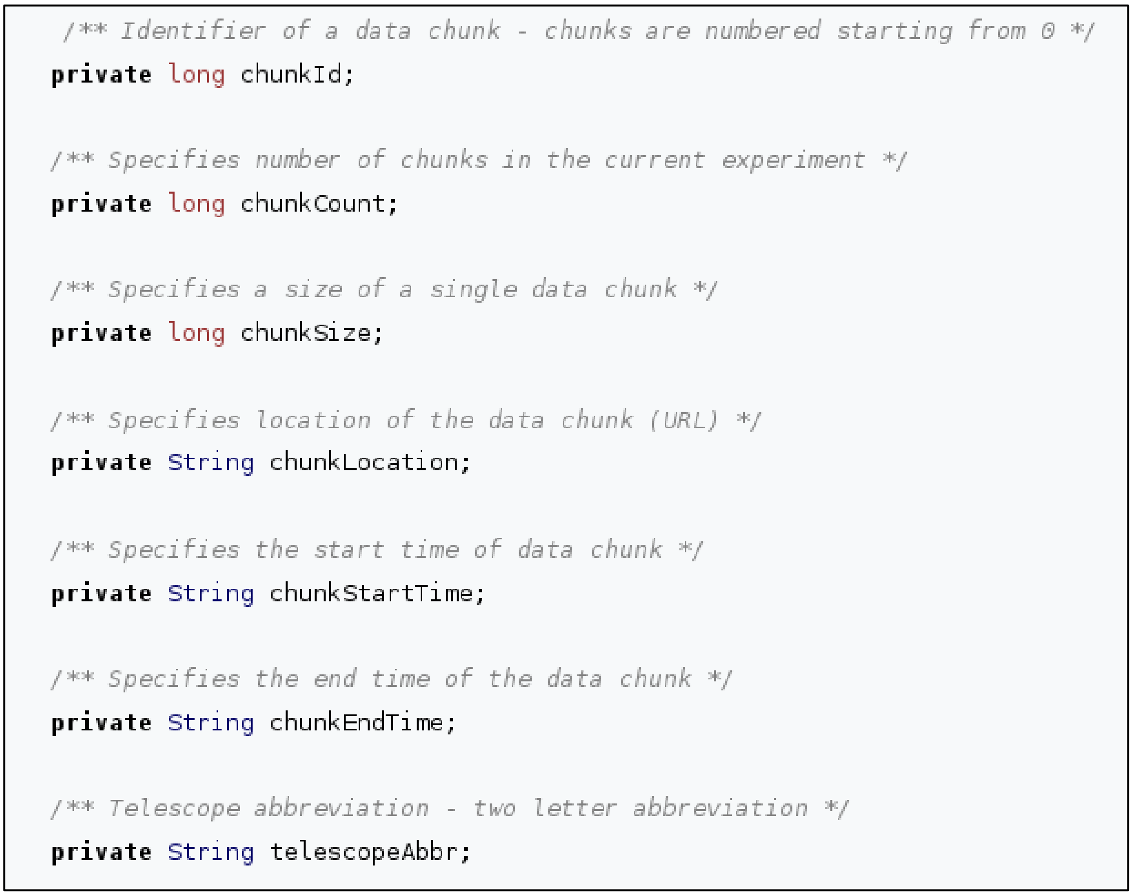


```
public enum Sender {

        /** Sender code for Vlbi Broker module */
        VLBI_BROKER("broker"),

        /** Sender code for Translation Node module */
        TRANSLATION_NODE("tn"),

        /** Sender code for Correlatin Node module */
        CORRELATION_NODE("cn"),

        /** Sender code for Correlated Data Serrvice module */
        CORRELATION_DATA_SERVICE("cds");
```

Figure 4 List of valid message senders

3.2. ChunkInfo structure

Each message send between system components has a structure called *Chunk Info* which contains general information about a data chunk from a given radio telescope. The chunk info structure is also used to inform Vlbi Broker and Correlation Data Service about a location of a correlated data. The detailed description of the Chunk Info structure is presented in the figure below.

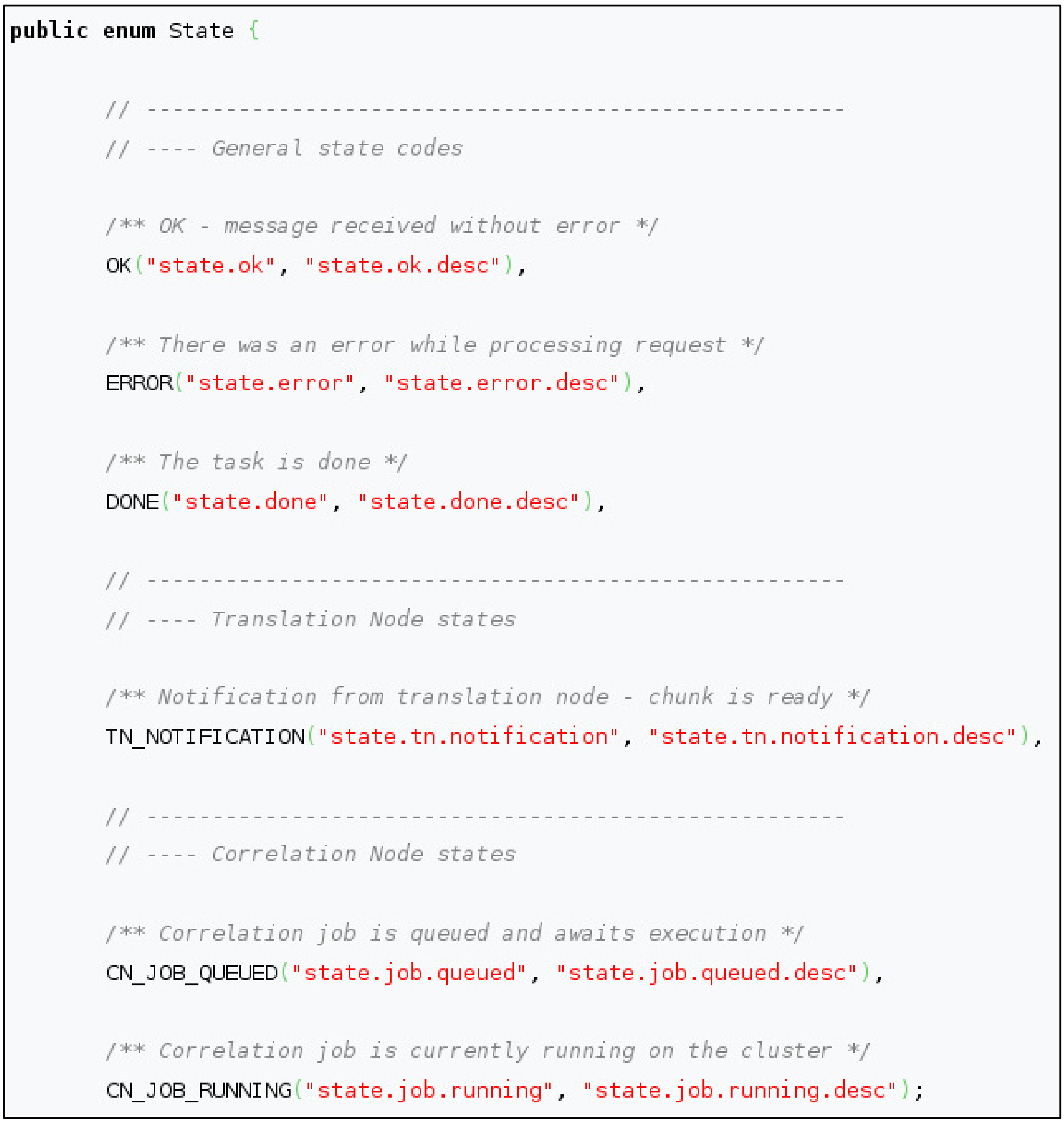


```
 /** Identifier of a data chunk - chunks are numbered starting from 0 */
private long chunkId;

/** Specifies number of chunks in the current experiment */
private long chunkCount;

/** Specifies a size of a single data chunk */
private long chunkSize;

/** Specifies location of the data chunk (URL) */
private String chunkLocation;

/** Specifies the start time of data chunk */
private String chunkStartTime;

/** Specifies the end time of the data chunk */
private String chunkEndTime;

/** Telescope abbreviation - two letter abbreviation */
private String telescopeAbbr;
```

Figure 5 Chunk Info structure

3.3. Notification service

The *Notification* service is used by system modules to notify other components about errors or changes i.e. new data chunk is ready, a chunk set has been correlated. The notification message consists of message header, chunk info structure (if this is relevant), state and message.



```
public enum State {

       // -----------------------------------------------------
       // ---- General state codes

       /** OK - message received without error */
       OK("state.ok", "state.ok.desc"),

       /** There was an error while processing request */
       ERROR("state.error", "state.error.desc"),

       /** The task is done */
       DONE("state.done", "state.done.desc"),

       // -----------------------------------------------------
       // ---- Translation Node states

       /** Notification from translation node - chunk is ready */
       TN_NOTIFICATION("state.tn.notification", "state.tn.notification.desc"),

       // -----------------------------------------------------
       // ---- Correlation Node states

       /** Correlation job is queued and awaits execution */
       CN_JOB_QUEUED("state.job.queued", "state.job.queued.desc"),

       /** Correlation job is currently running on the cluster */
       CN_JOB_RUNNING("state.job.running", "state.job.running.desc");
```

Figure 6 Notification type

4. Problems

During work on the e-Vlbi system we have faced several problems. The detailed, up to date list of issues can be found at EXPReS wiki at : http://www.jive.nl/dokuwiki/doku.php/expres:fabric:evlbisystem:internal:sfxcissues .

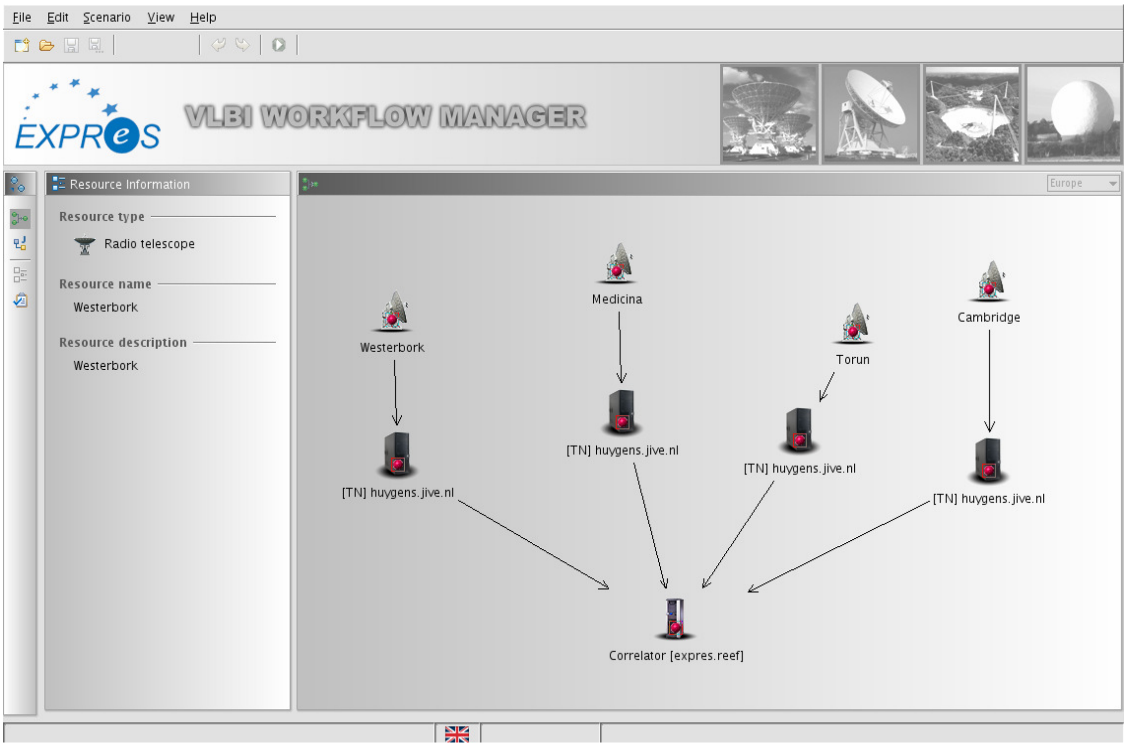
5. e-Vlbi system – test results

All system components have been deployed within the system testbed. We have managed to conduct several experiments using distributed software correlation:

1. self correlation
2. distributed correlation with one software correlator and four radio telescopes: Torun, Medicina, Westerbork and Cambridge.
3. distributed correlation with two software correlators and four radio telescopes: Torun, Medicina, Westerbork and Cambridge.

5.1. Sample experiment description

This section describes briefly the process of conducting sample Vlbi experiment. First the experiment workflow has to be constructed based on the specified vex file using Workflow Manager Application (see Figure 7)



Resource Information

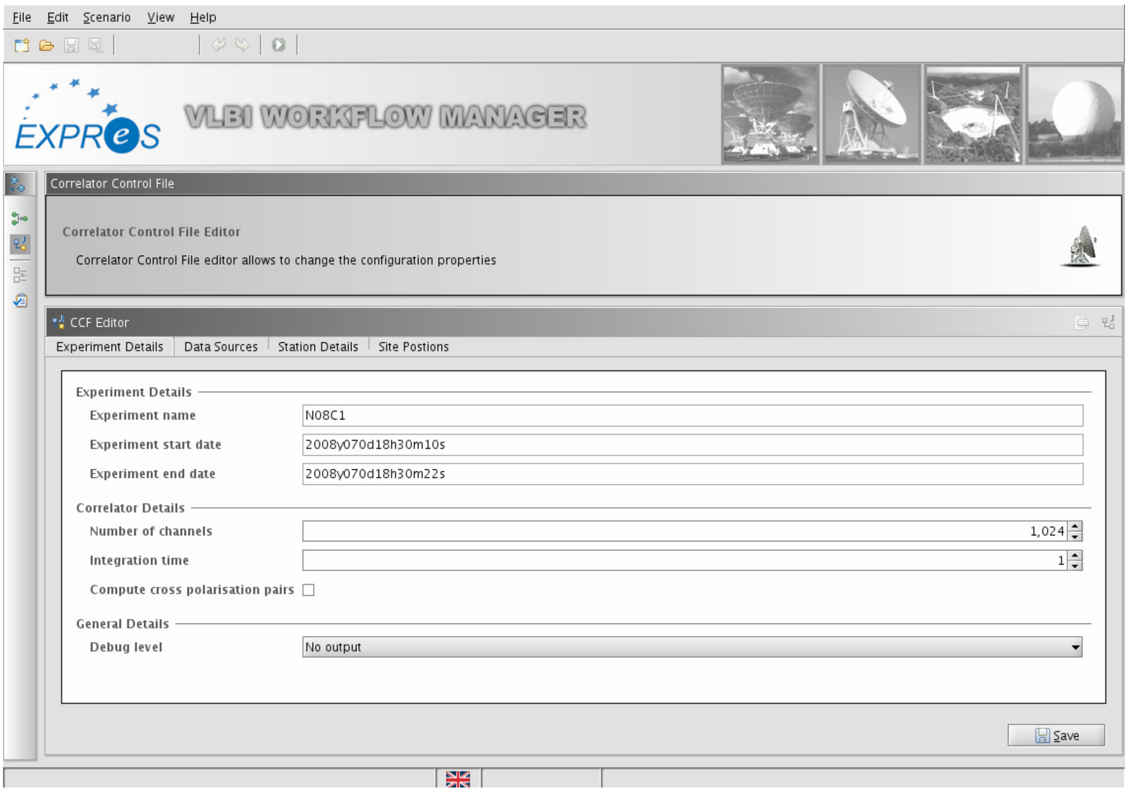
Resource type
Radio telescope

Resource name
Westerbork

Resource description
Westerbork

Figure 7 Sample Vlbi experiment

The experiment parameters has to be set up using CCF editor:



Correlator Control File Editor

Correlator Control File editor allows to change the configuration properties

Experiment Details

Experiment name: N08C1

Experiment start date: 2008y070d18h30m10s

Experiment end date: 2008y070d18h30m22s

Correlator Details

Number of channels: 1,024

Integration time: 1

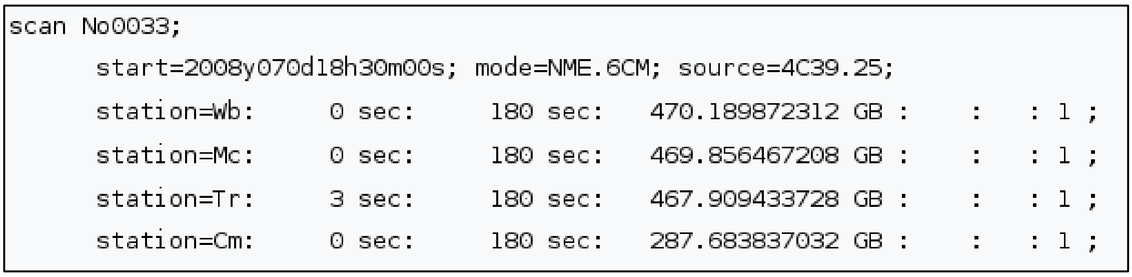
Compute cross polarisation pairs ☐

General Details

Debug level: No output

Figure 8 CCF editor

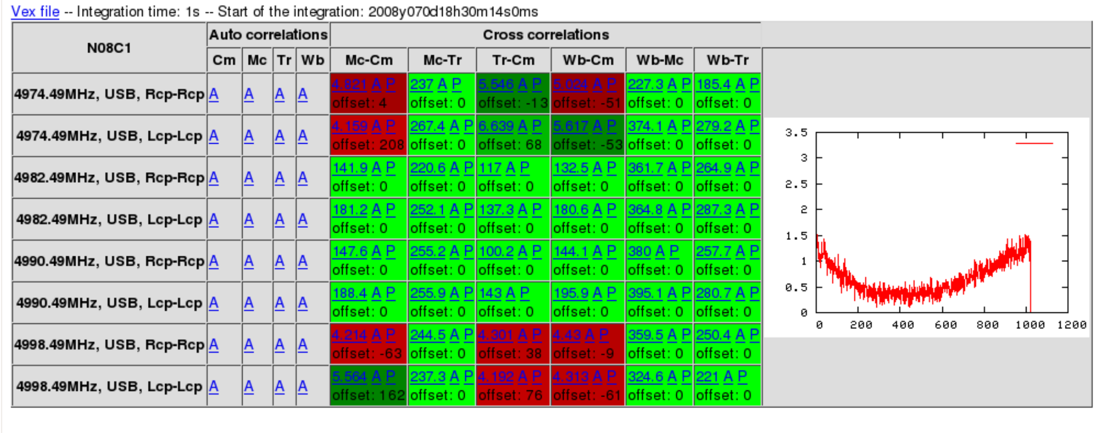
The figure below contains scan details. There are four antennas: Westerbork, Medicina, Torun and Cambrigde.



```
scan No0033;
      start=2008y070d18h30m00s; mode=NME.6CM; source=4C39.25;
      station=Wb:     0 sec:     180 sec:   470.189872312 GB :    :   : 1 ;
      station=Mc:     0 sec:     180 sec:   469.856467208 GB :    :   : 1 ;
      station=Tr:     3 sec:     180 sec:   467.909433728 GB :    :   : 1 ;
      station=Cm:     0 sec:     180 sec:   287.683837032 GB :    :   : 1 ;
```

Figure 9 Scan details

Finally, when distributed correlation has been finished we can see the fringe tests - integration start: 2008y070d18h30m14s0ms.



Vex file -- Integration time: 1s -- Start of the integration: 2008y070d18h30m14s0ms

N08C1	Auto correlations				Cross correlations					
	Cm	Mc	Tr	Wb	Mc-Cm	Mc-Tr	Tr-Cm	Wb-Cm	Wb-Mc	Wb-Tr
4974.49MHz, USB, Rcp-Rcp	A	A	A	A	4.821 A P offset: 4	237 A P offset: 0	5.546 A P offset: -13	5.024 A P offset: -51	227.3 A P offset: 0	185.4 A P offset: 0
4974.49MHz, USB, Lcp-Lcp	A	A	A	A	4.159 A P offset: 208	267.4 A P offset: 0	6.639 A P offset: 68	5.617 A P offset: -53	374.1 A P offset: 0	279.2 A P offset: 0
4982.49MHz, USB, Rcp-Rcp	A	A	A	A	141.9 A P offset: 0	220.6 A P offset: 0	117 A P offset: 0	132.5 A P offset: 0	361.7 A P offset: 0	264.9 A P offset: 0
4982.49MHz, USB, Lcp-Lcp	A	A	A	A	181.2 A P offset: 0	252.1 A P offset: 0	137.3 A P offset: 0	180.6 A P offset: 0	364.8 A P offset: 0	287.3 A P offset: 0
4990.49MHz, USB, Rcp-Rcp	A	A	A	A	147.6 A P offset: 0	255.2 A P offset: 0	100.2 A P offset: 0	144.1 A P offset: 0	380 A P offset: 0	257.7 A P offset: 0
4990.49MHz, USB, Lcp-Lcp	A	A	A	A	188.4 A P offset: 0	255.9 A P offset: 0	143 A P offset: 0	195.9 A P offset: 0	395.1 A P offset: 0	280.7 A P offset: 0
4998.49MHz, USB, Rcp-Rcp	A	A	A	A	4.214 A P offset: -63	244.5 A P offset: 0	4.301 A P offset: 38	4.43 A P offset: -9	359.5 A P offset: 0	250.4 A P offset: 0
4998.49MHz, USB, Lcp-Lcp	A	A	A	A	5.564 A P offset: 162	237.3 A P offset: 0	4.192 A P offset: 76	4.313 A P offset: -61	324.6 A P offset: 0	221 A P offset: 0

Figure 10 Sample result