Grid Integration of Future Arrays of Broadband Radio Telescopes – moving towards e-VLBI

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Outline

- Introduction to the e-VLBI
- PSNC in EXPReS - FABRIC
- Grid – VLBI design & technology
- Summary

Introduction to the e-VLBI

VLBI is a technique, in which physically independent and widely separated radio telescopes observe the same region of sky simultaneously, in order to generate very high-resolution continuum and spectral-line images of cosmic radio sources

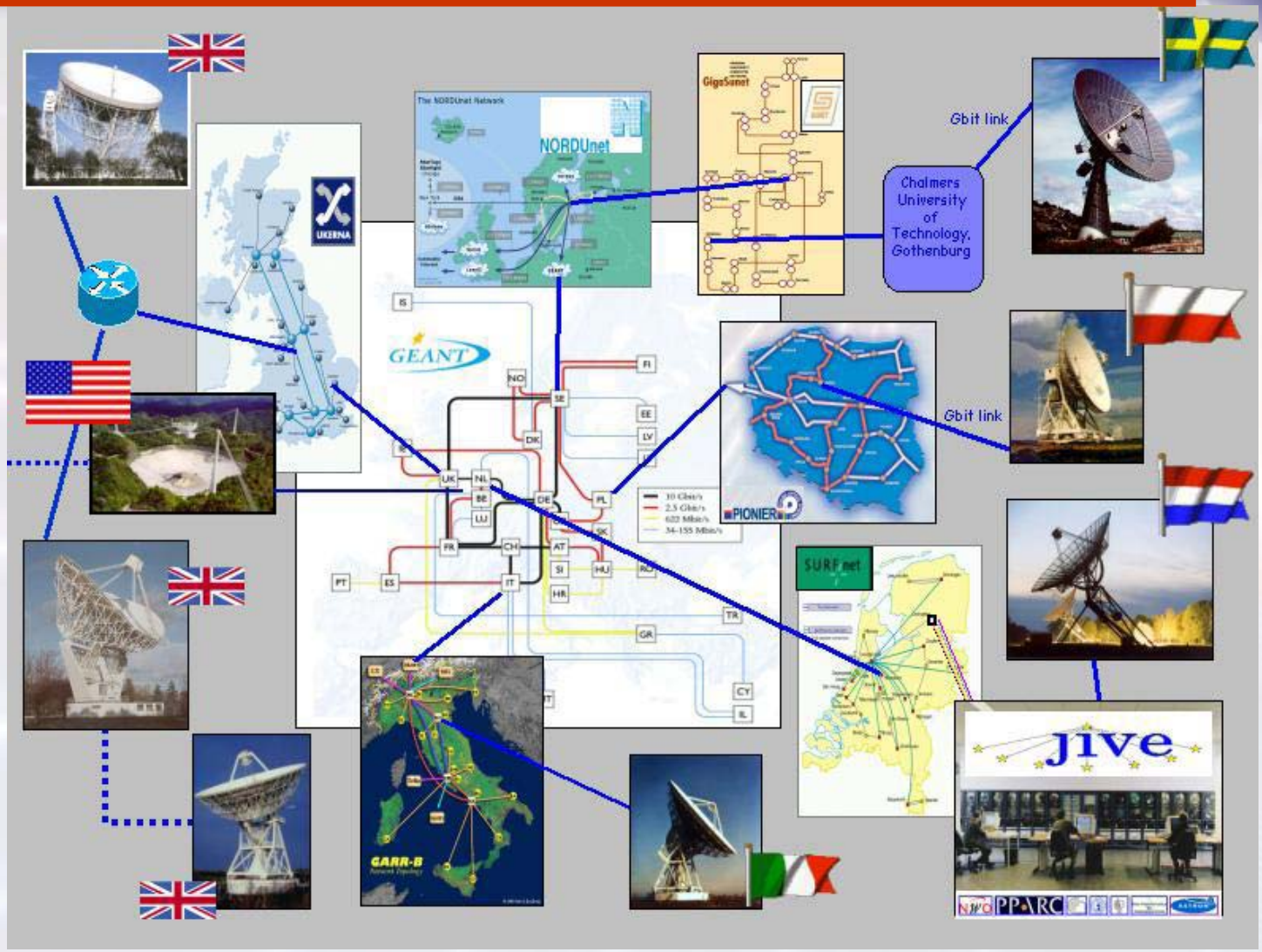
- **Telescopes are usually separated by thousands of kilometres**
- **Data from each telescope are digitally sampled and stored locally, using high-capacity magnetic tape systems and magnetic disk-array systems**
- **Data are sent and correlated at the central point (JIVE)**
- **The total flow of data into the central processor is approximately 10-100 Terabytes per single observation, after processing this is reduced to 10-100 Gbytes.**

Introduction to the e-VLBI (cont.)

EXPReS – the objective is to create a production-level "electronic" VLBI (e-VLBI) service, in which the radio telescopes are reliably connected to the central data processor at JIVE via a high-speed optical-fibre communication network:

- **Single radio telescope is producing a 2.5Gbps of data during e-VLBI observation**
- **Up to 16 radiotelescopes can take part in the e-VLBI**
- **Aggregate data flow of up to 40 Gbps into the central processor**
- **Generating high-resolution images of cosmic radio sources in real-time**

e-VLBI pilots



Current status of the e-VLBI Proof-of-Concept Telescope Network connections. Five telescopes are connected to their NREN, GEANT & ultimately JIVE at 1 Gbps (Jodrell Bank & Cambridge – UK; Westerbork –NL; Torun – PL; Onsala – SE). Arecibo (USA) is connected at 155 Mbps.

PSNC in EXPReS

- **EXPReS – a Real-time e-VLBI Radio Telescope**

  - JRA1: Future Arrays of Broadband Radio-Telescopes on Internet Computing (FABRIC)
    - Grid – VLBI collaboration
    - Grid Workflow management
    - Grid Routing

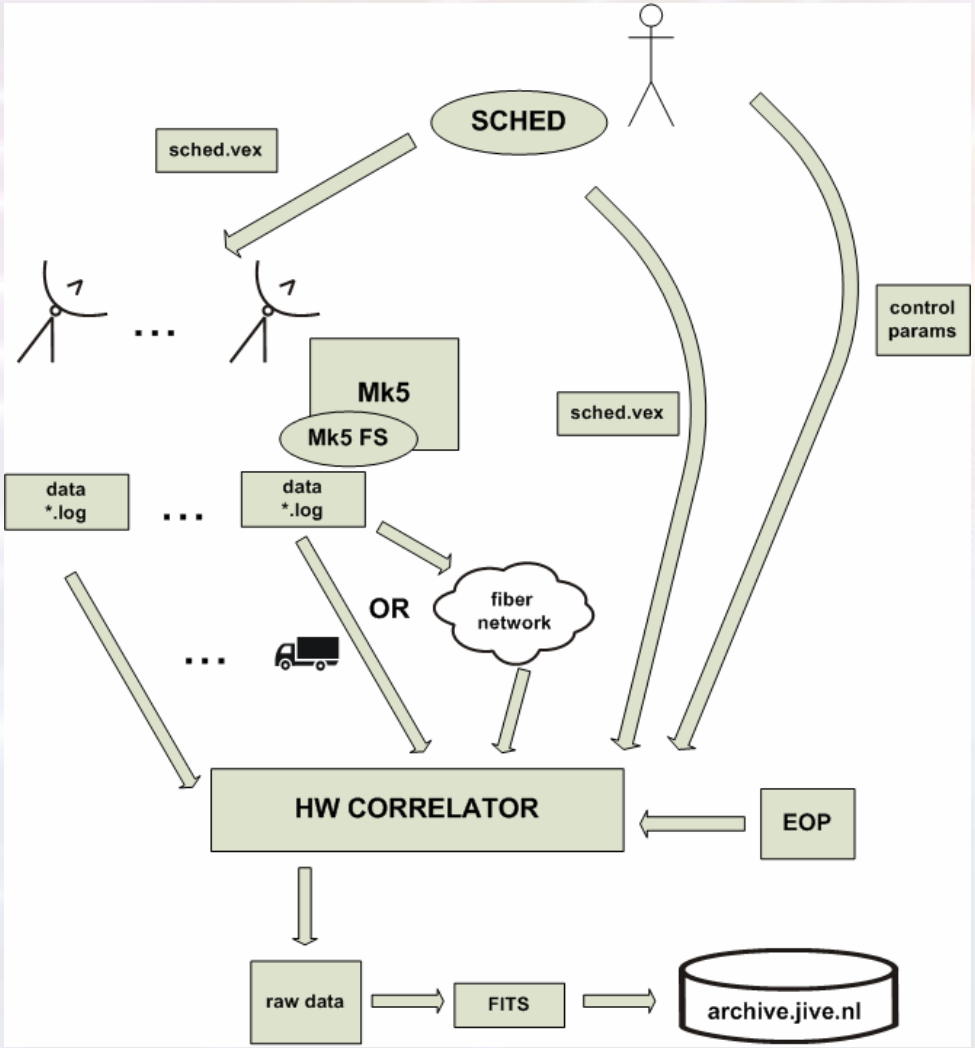
Creating solution for incorporating Grid resources for distributed correlation using existing infrastructure.

Ultimate objective

Real – time eVLBI correlation on distributed Grid resources:

- **4 radio telescopes**
- **experiment length (2 – 4 hrs)**
- **data rate 128 Mb/s per telescope**

Current state of VLBI operations



Design & hardware limitations

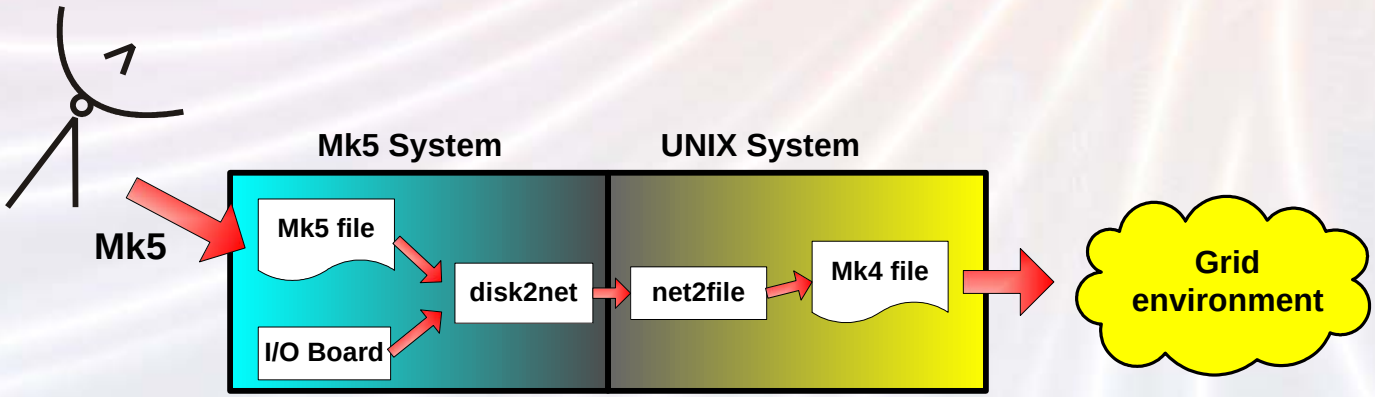
Hardware limitations:

- **Unable to do dynamic routing from the telescopes**
- **The data can only be streamed using Mk5 format**

(conversion to UNIX-friendly Mk4 at some point is needed)

Design & hardware limitations

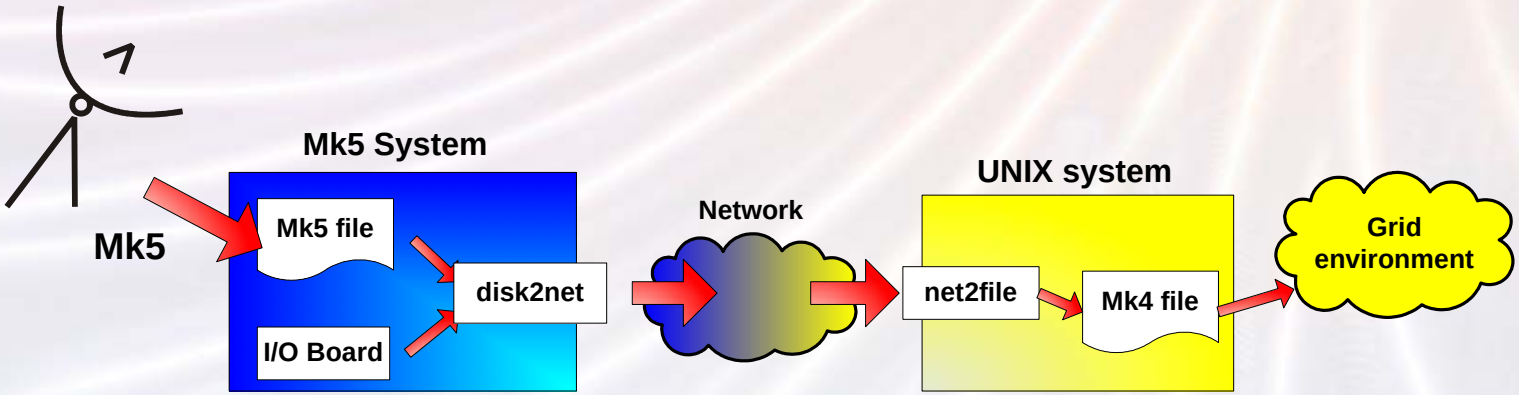
Hardware limitations (cont.):



On-site conversion

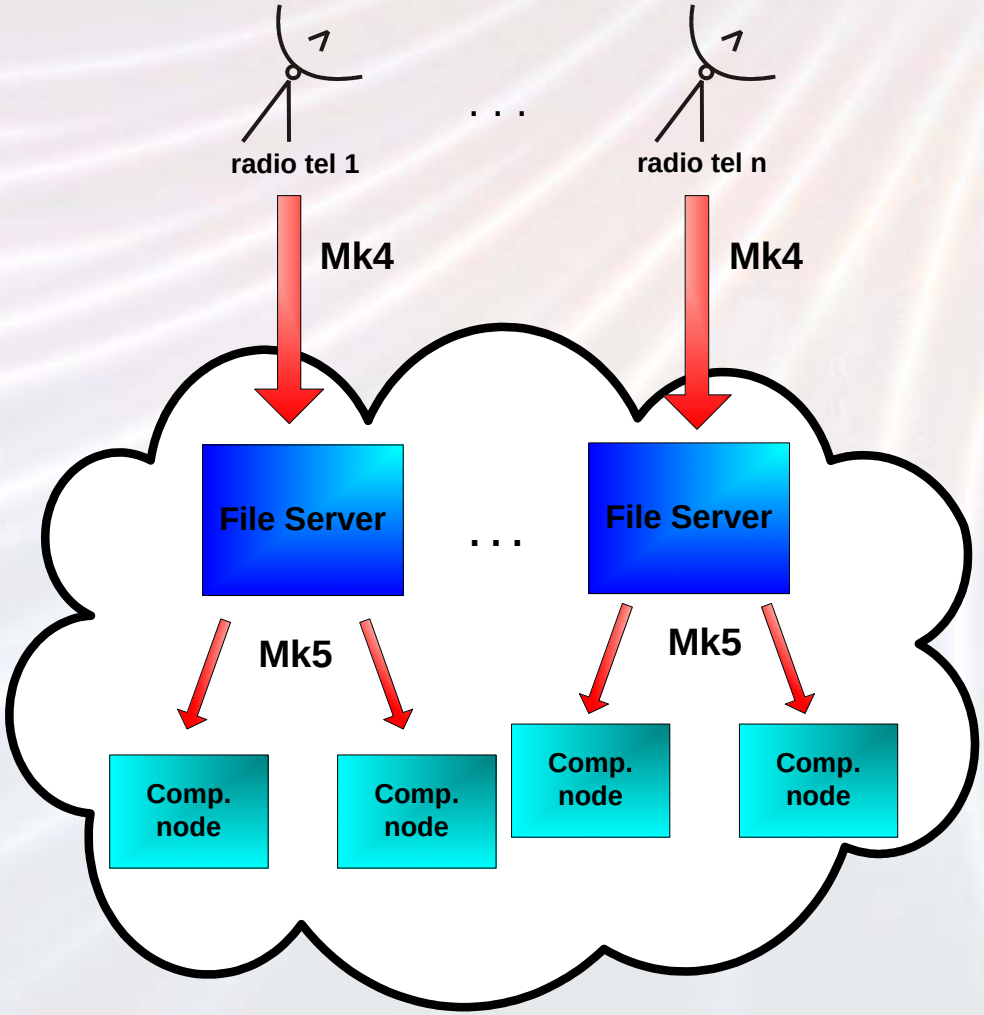
Design & hardware limitations

Hardware limitations (cont.):

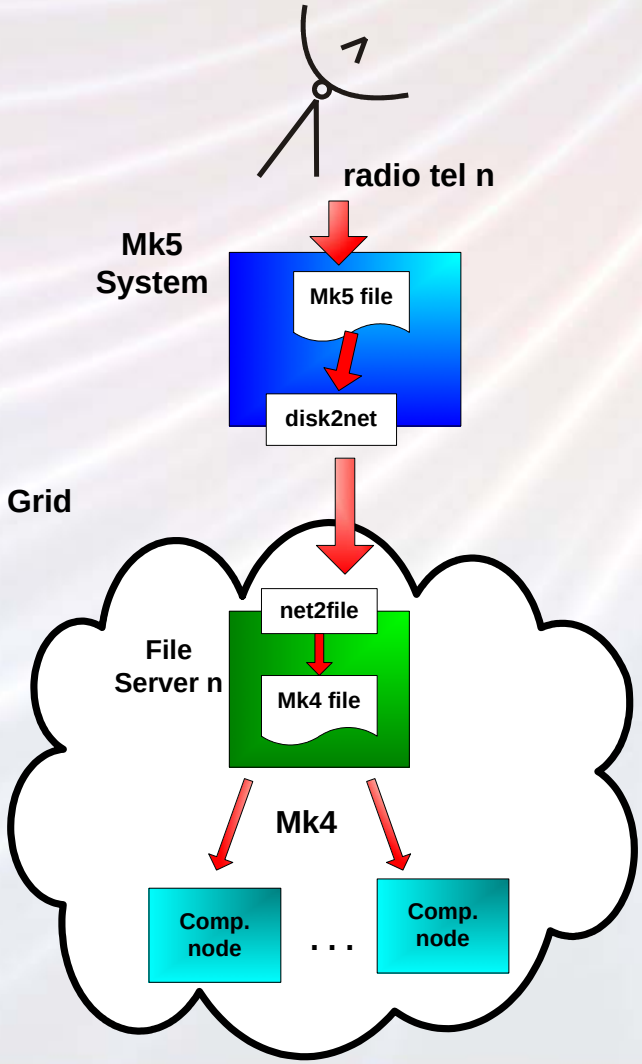


Remote conversion

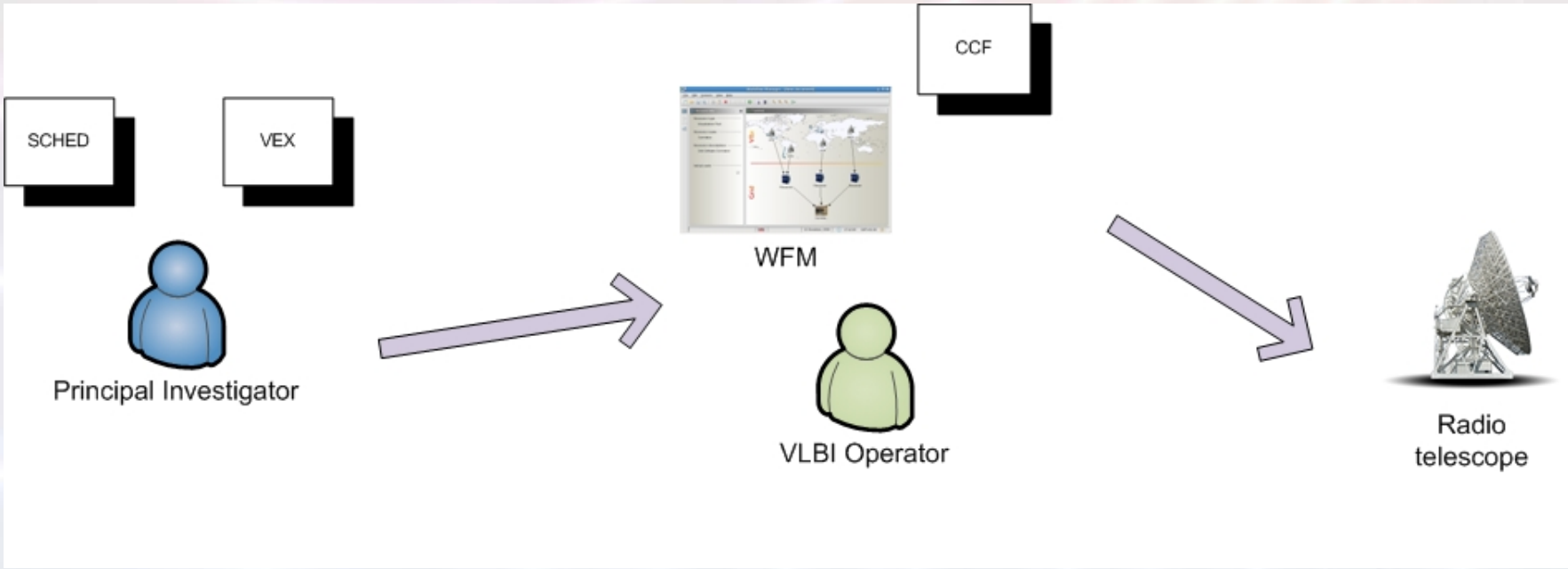
File servers



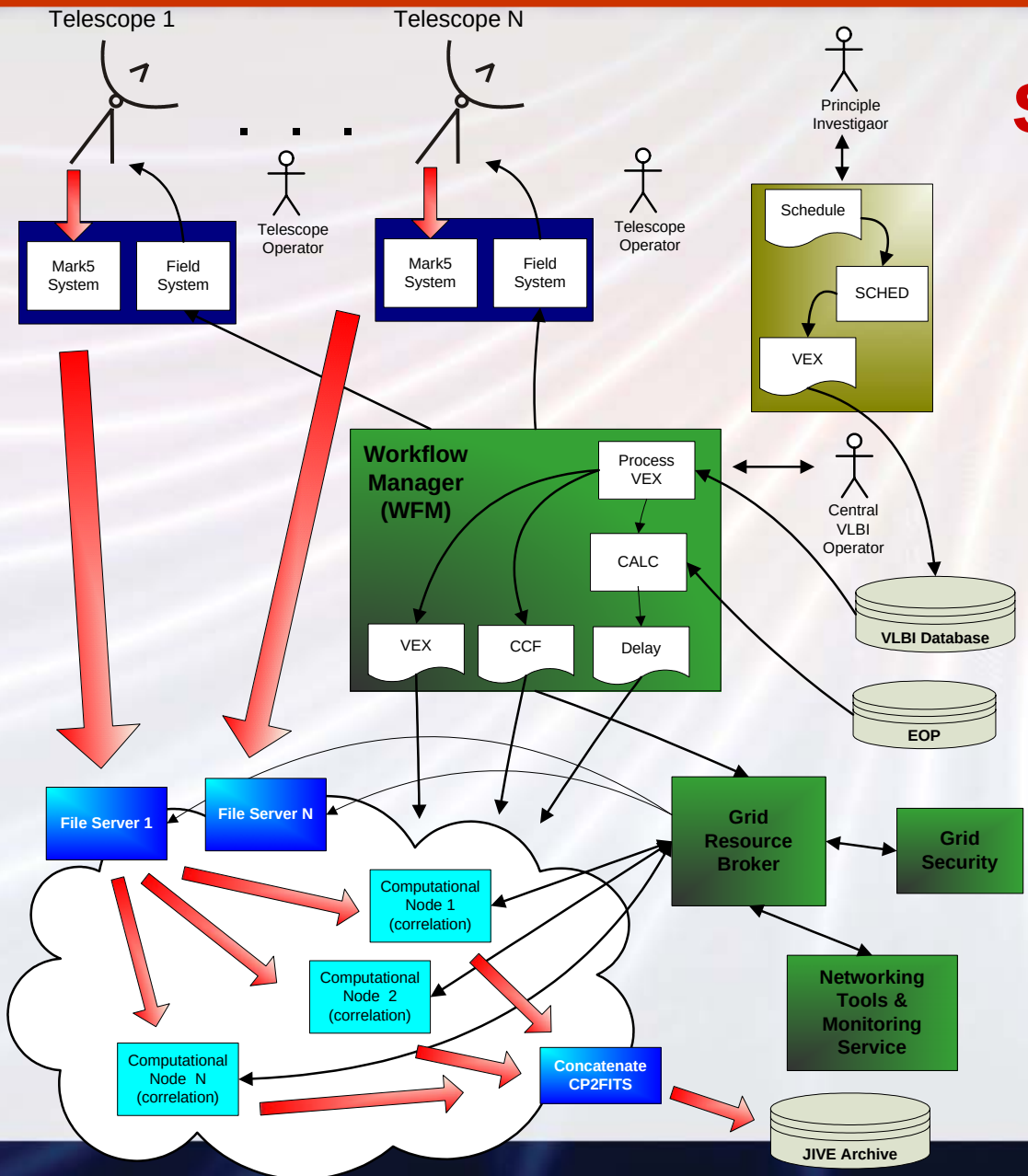
File servers (close-up)



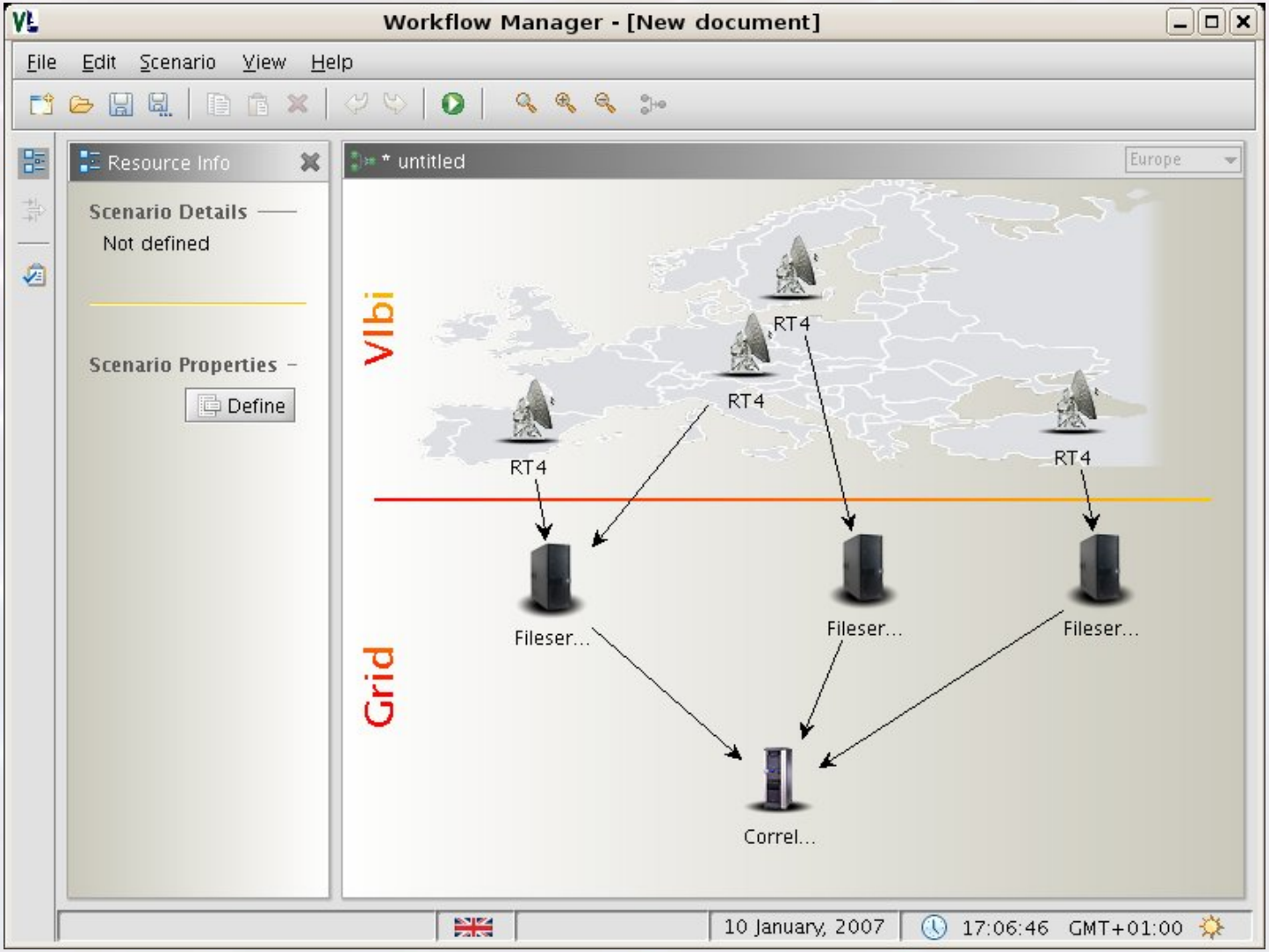
System design

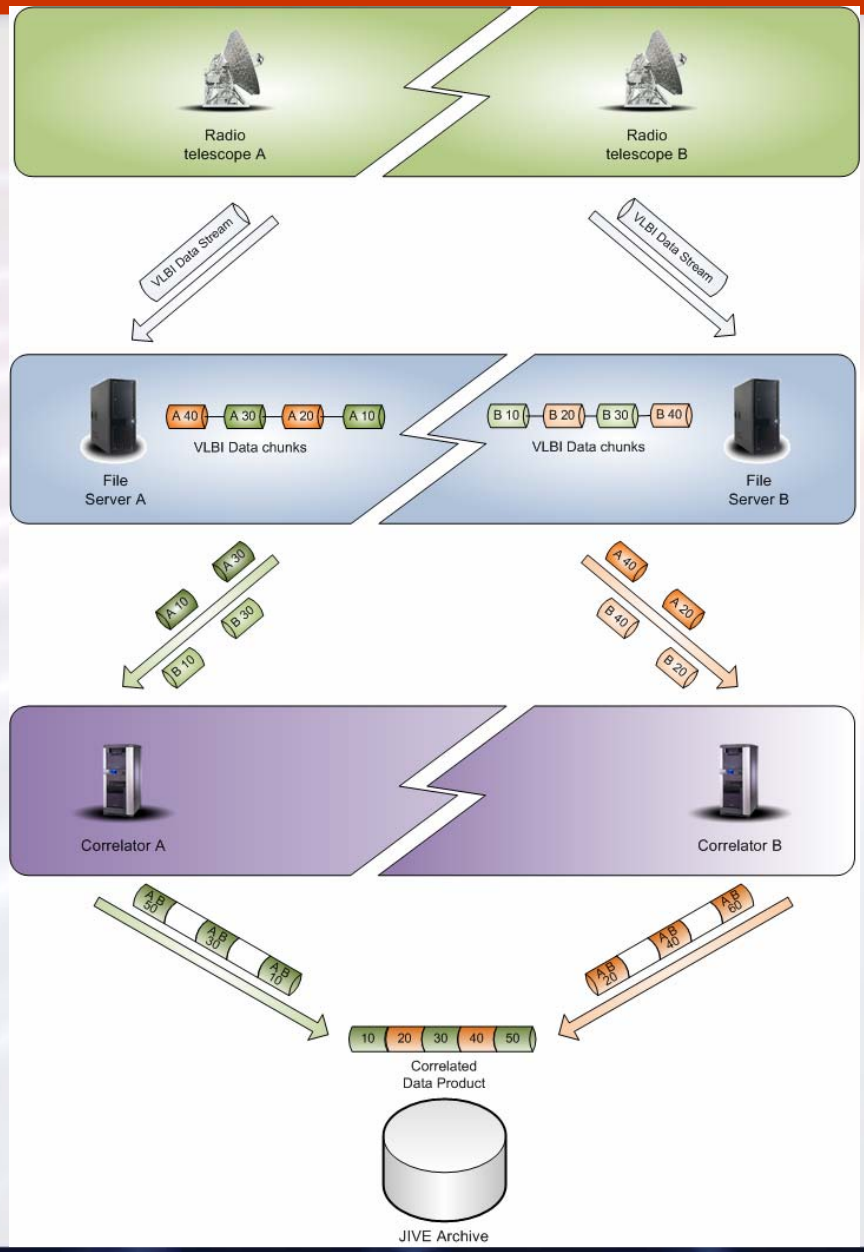


System design



Workflow Manager application




Radio telescope A
Radio telescope B
VLBI Data Stream
VLBI Data Stream
A 40
A 30
A 20
A 10
VLBI Data chunks
B 10
B 20
B 30
B 40
VLBI Data chunks
File Server A
File Server B
A 30
A 10
B 30
B 10
A 40
A 20
B 40
B 20
Correlator A
Correlator B
A B 50
A B 30
A B 10
A B 60
A B 40
A B 20
10
20
30
40
50
Correlated Data Product
JIVE Archive

Summary

e-VLBI

- Natural path for evolution of VLBI
- ”Unlimited” Grid resources vs dedicated hardware for data correlation
- User-friendly graphical interface to facilitate experiment set-up and monitoring
- The ultimate goal of real-time correlation

Thank you for your attention

http://www.expres-eu.org/

6th FP contract no 026642

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