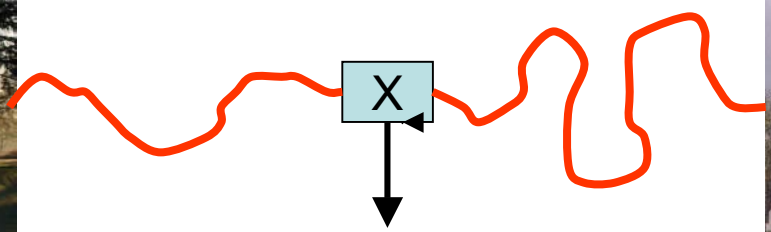
THE UNIVERSITY of MANCHESTER

EUROPEAN vlbi NETWORK

The Resilience of e-VLBI Data to Packet Loss

Ralph Spencer[1], Steve Parsley[2],
Richard Hughes-Jones[1]

1: University of Manchester
2: JIVE

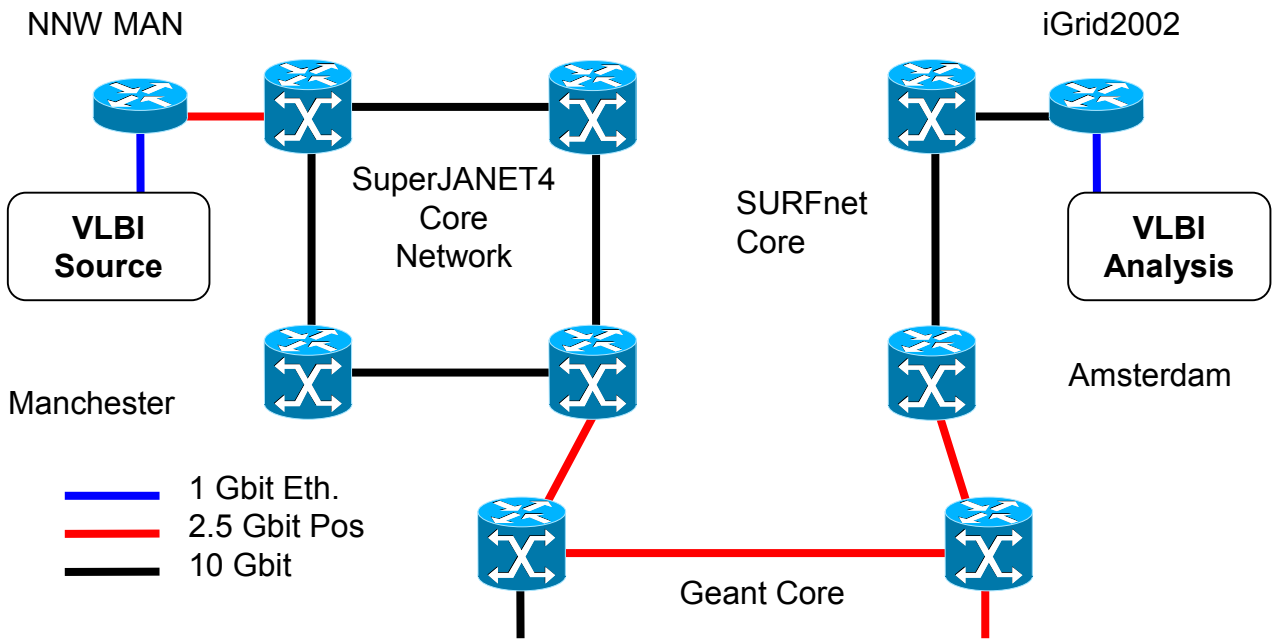


Abstract

- Demonstrations of internet VLBI data transfer were made at *i*GRID2002 (Sept 2002, Amsterdam) and at the EU's FP6 Launch (Nov 2002, Brussels)
- Sustainable data rates of > 500 Mpbs using UDP were achieved on 1 Gbps Ethernet connections to the SuperJanet, Surfnet and Geant production networks with some packet loss (see ref. [1])
- The MkIV VLBI correlator is designed for data on magnetic tape and is tolerant of dropouts etc.
- This paper shows that internet packet loss is not expected to result in loss of data frames when used with the JIVE MkIV correlator unless losses are very high, though decorrelation will lead to a decrease in signal:noise

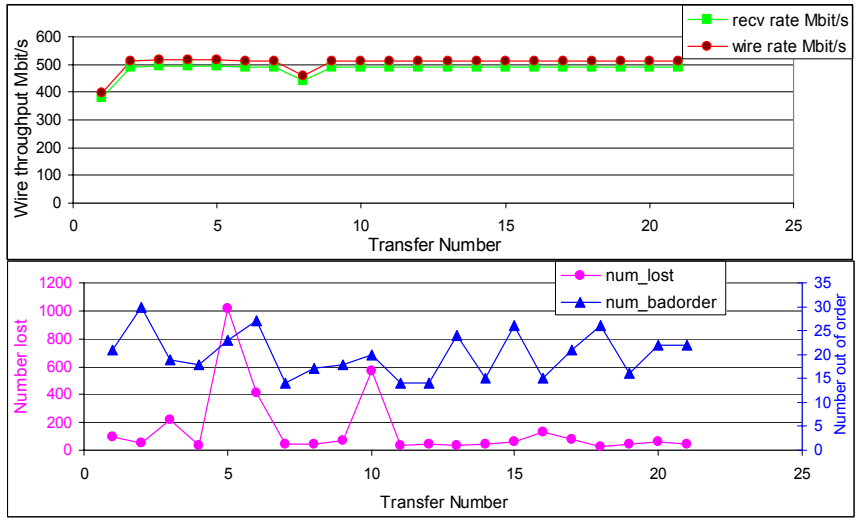
[1] Hughes-Jones, R., Parsley, S. & Spencer, R. E., 2002, Fut. Gen. New. Comp. Systems, 2003, in press

The Network Topology for *vlbi*GRID demo at iGRID 2002, SARA, Amsterdam

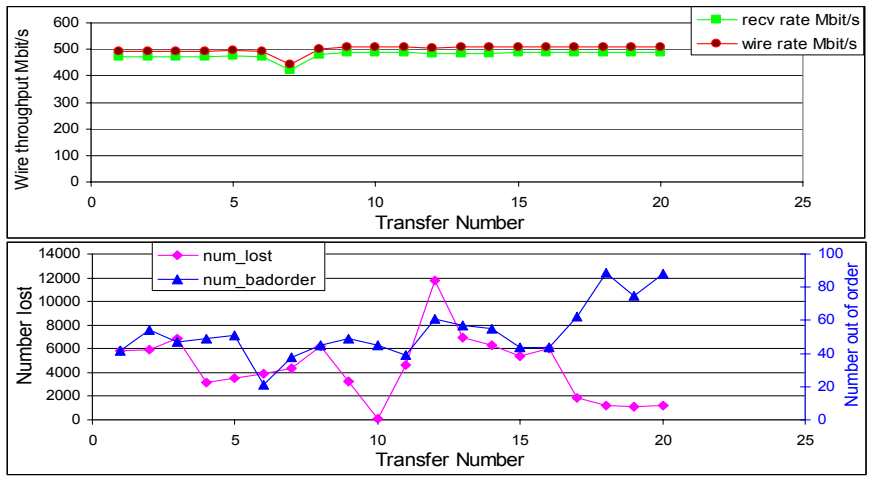


Data Rates and Packet Loss

a)

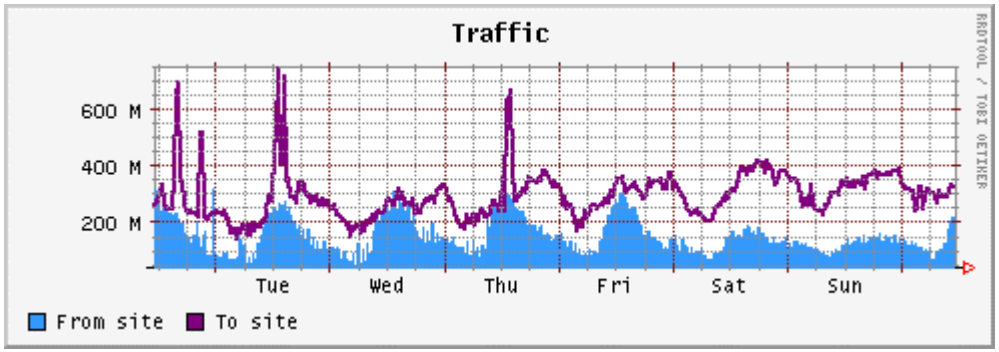


b)



Graphs of user and ‘wire’ transfer rates, packet loss and number of packets out of order during a) setting up and b) the iGRID exhibition

Effect of tests on Manchester Node

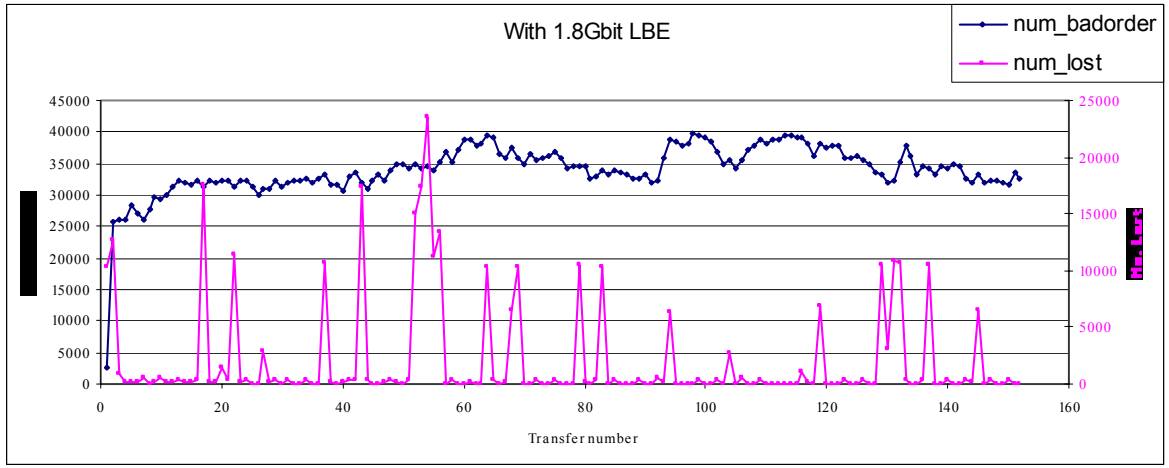


Plot of the traffic levels from the SuperJANET4 access router at Manchester for the Net North West MAN during the iGrid2002 meeting.

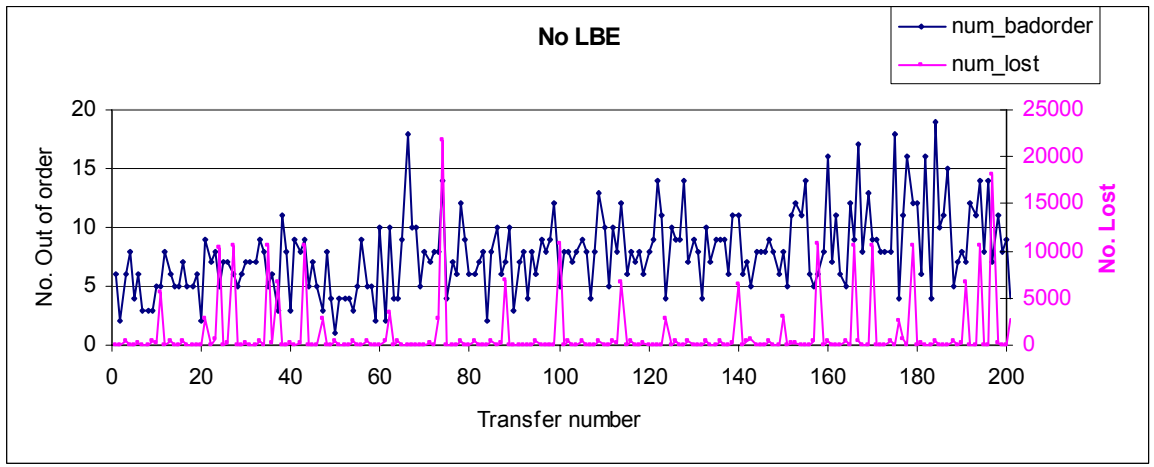
NB above out of university term – academic use reached >600 Mbps in Jan 2003 so our 500 Mpbs tests suppressed traffic!

ER 2002 – FP6 Launch: Packet Loss

With 1.8 Gbps
Less than best efforts traffic



Without LBE traffic



Packet Loss and UDP *vs* FTP

- Typical packet loss per file using UDP was ~100 during quiet times on the internet, rising to ~ 5000 during heavy use in *i*GRID2002, ~10000 in ER2002 (but with large numbers out of order), out of 1.24 M packets. NB across production network including campus access links.
- Subsequent tests show that packet loss depends strongly on traffic levels and can be severe if traffic high – *how does this effect data quality in VLBI??*
- High fidelity transfer can be achieved by using FTP in TCP/IP rather than simply streaming UDP packets.
- The loss of a single packet in TCP/IP results in the assumption of traffic congestion and a reduction of transmission rate of a factor of 2, followed by a long recovery time
- The net result is a much lower overall data transfer rate for FTP e.g. at 10's Mbps
- There is a compromise to be made between data rate and data fidelity

MKIV VLBI Data Rejection

- MkIV Station Unit checks parity of each 9-bit (8 plus parity) MkIV VLBI byte. If more than 10% of the bytes per frame are wrong then the frame is rejected
- If lost packets are replaced by random data then on average 50% will have wrong parity
- 1452 8-bit bytes in a packet
- 2500x9 bit bytes in a VLBI data frame and 32 tracks
- This gives 2500x9x4/1452=61.98 packets per frame (mistake in ref [1])
- On average then 0.2x62=12.4 packets need to be lost per frame before a frame is rejected

Statistics

Suppose average packet loss per frame is $a=L/N_f$ where L is the number of packets lost per file and N_f is the number of frames in a file. The probability of n packets being lost in a frame is then given by the Poisson distribution:

$$P_n = \frac{a^n e^{-a}}{n!}$$

A frame is rejected if more than12 packets are lost so the number of frames rejected per file is:

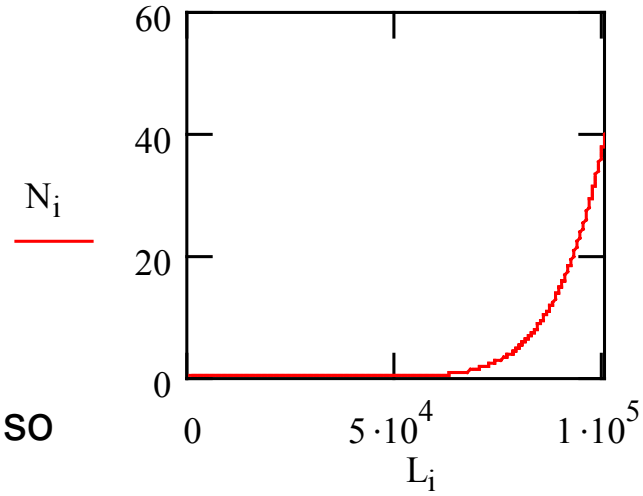
$$N = N_f\left(1 - \sum_{n=0}^{n=12} P_n\right)$$

The loss in signal to noise on a single baseline is

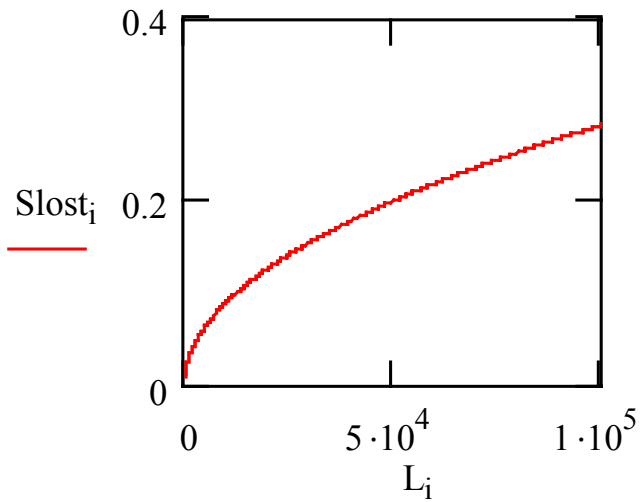
$$Slost = \sqrt{\frac{L}{N_p}}$$

where N_p is the number of packets per file.

Number of frames lost vs packet loss per file



Loss in signal vs packet loss

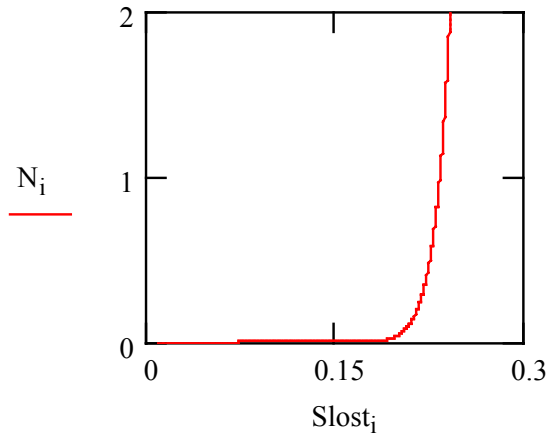


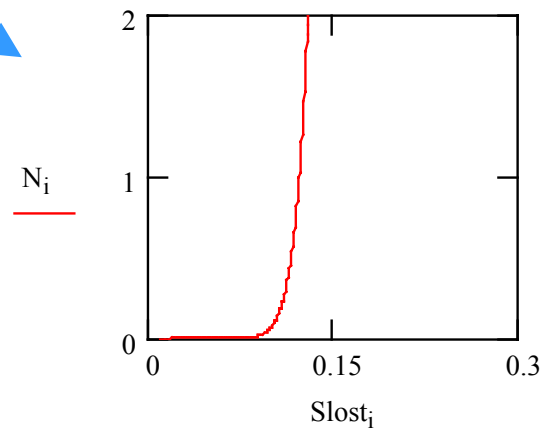
Results

- 1 frame rejected per file on average if 5×10^4 packets lost, out of the 1.24 M, with ~20% loss of signal:noise
- If lost packets not replaced by random data, then a frame is rejected if >6 packets are lost. We then get 1 frame lost per file for 2×10^4 packets lost, with 12% loss of signal:noise

- Increasing frame size or decreasing packet size reduces frame rejection for a given packet loss

Lost frames vs S/N





Discussion

- Synchronisation process in the MkIV station unit will not reject frames until packet loss is high (> 20000 packets per file), though signal to noise is lost due to bad data.
- This assume that packets can be ordered correctly in the ring buffer and that the VLBI byte boundaries are preserved thus maintaining time order – otherwise parity errors will result in rejected frames
- A Poisson process has been assumed, though in practice packet loss may appear in bursts. Frames could then be rejected even though the average packet loss rate is low.
- **Isn't theory wonderful - what happens in reality?**

Conclusion and further work

- Use of MkIV technology results in a high resilience of VLBI data to packet loss
- Other techniques which rely on the intrinsic high data fidelity of disk based systems may have problems in the face of packet loss – and not be able to achieve high data rates
- This work was theoretical – we obviously need to test performance using the correlator, and to try to optimise packet and file sizes etc.
- There may be other protocols which may reach a more favourable compromise between data rates and packet loss