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First experiences with the InfiniBand (TM) Interconnect

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- Infiniband: What is this ? Key features of a new technology
- Test equipment at the IWR: Hardware used for measurements
- Performance tests and scalability
- High-Throughput-Computing (HTC): RFIO over InfiniBand
- Summary and Outlook

All numbers are preliminary

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Motivation:

The problem(s):

- computing power has increased much faster than the interconnects
- increasing need of applications for high bandwidth **within** computer centers
- parallel computing applications need low latency
- scalability to thousands of computing nodes

The solution (?): InfiniBand (TM)

- merged best of Next Generation I/O (NGIO) and Future I/O (FIO) projects
- specifications released in autumn 2000 by InfiniBand Trade Association (IBTA)

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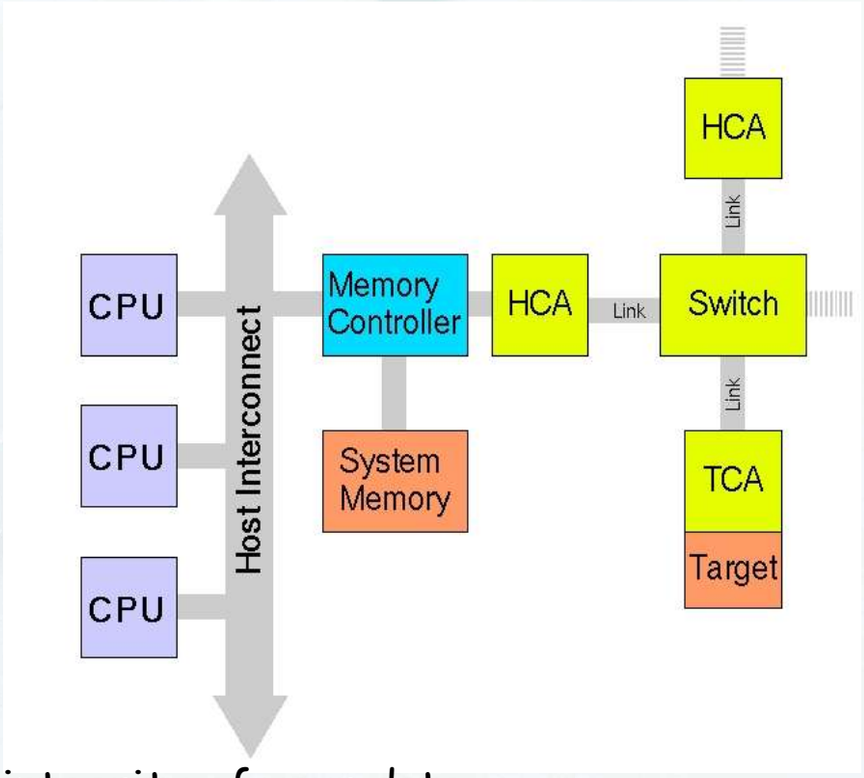
What is InfiniBand ?

A fast interconnect technology with open specifications

Key-features:

- low latency channel oriented switched fabric
- runs over copper or fibre cables
- speed: 2.5, 10 or 30 GBit/s (1x,4x,12x)
- (un)reliable and (un)connected data transfers
- RDMA capable
- redundant connections possible
- only one fabric for HTC and HPC applications



Notes:

- **reliable connections**: hardware takes care of the integrity of your data
- **RDMA**: one machine can directly put data into a registered memory of another node without going through the processor
- TeraScale System/Virginia (No. 3 of top 500 list) uses InfiniBand (TM)

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Available software

- **low level drivers** available for different architectures and operating systems

  (IA32, IA64, X86_64, PowerPC OS: Linux and Windows)

Available high level protocols:

- IPoIB : creates virtual ethernet devices, transparent for all applications
- SRP : using block storage devices over InfiniBand(TM) fabric
- MPI : several implementations, commercial and free, including MPI2
- DAFS, DAPL, SDP and more ....

See also http://infiniband.sourceforge.net

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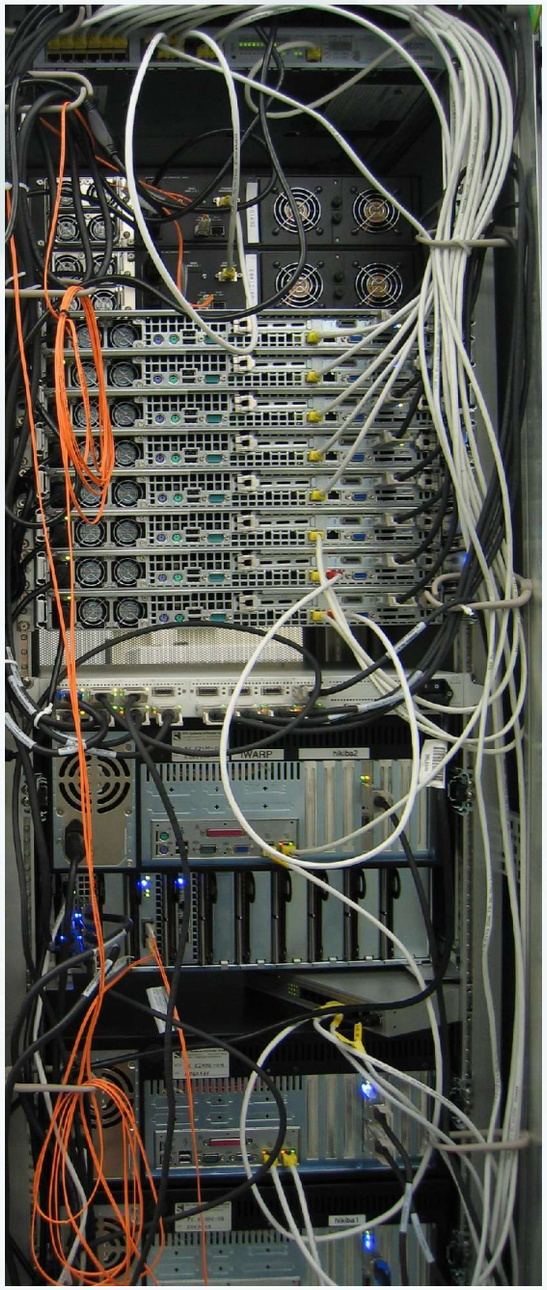
Hardware setup at the IWR:



iWarp Cluster: evaluation of a production environment:

- 8 worker nodes: 2.4GHz Dual Xeon 2GB RAM, GE on board
- 1 interactive node: 2.4GHz Dual Xeon, 1GB RAM, GE on board
- Interconnect: 4x InfiniBand, 16Port 'fat tree' 4x InfiniBand switch

Test equipment:

for software developement and hardware evaluation

- 3 2.4GHz Dual Xeon, GE on board
- 4x Infiniband between nodes
- InfinIO7000 Chassis, FC and GE card to 4x InfiniBand backplane
- 2 IDE Raid boxes with 7x120GB disks each
- 2GB/s FC connection between RAID and InfiniBand Fabric

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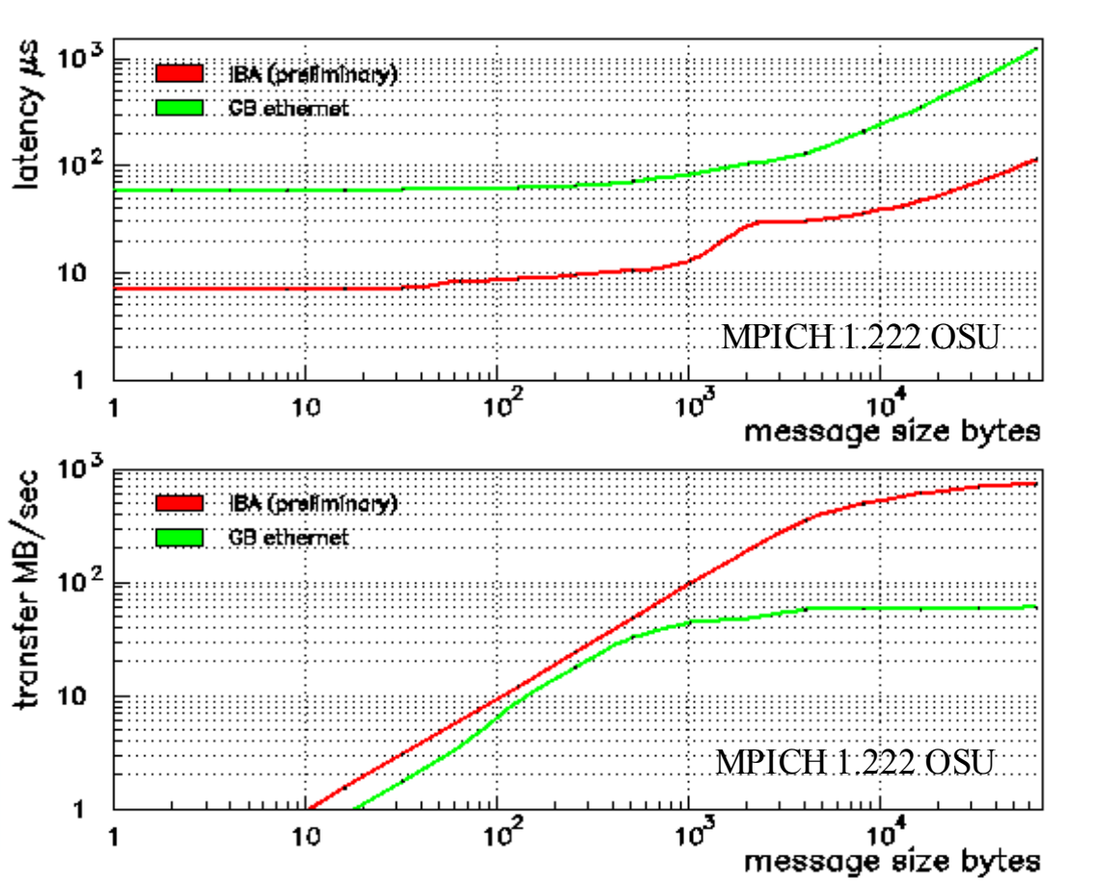
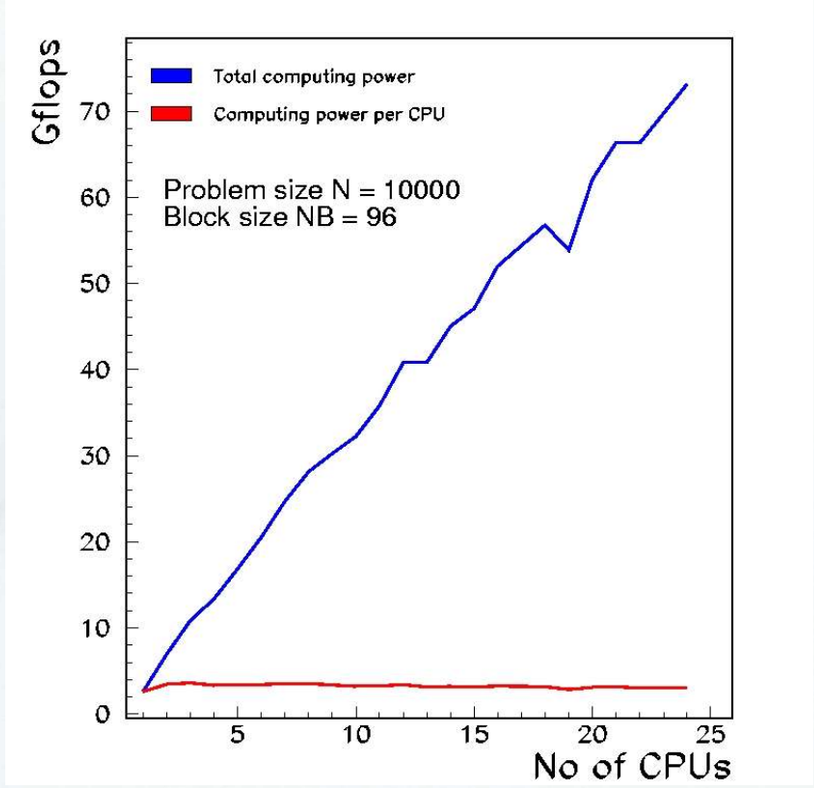
MPI performance and scalability





- 1byte latency: ~7µs
- peak bandwidth 780MB/s

- good scalability (up to our 24 CPU's)
- peak performance ~ 70GFlops

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Status of iWARP cluster:

- available for tests of MPI application
- several test accounts to different persons to test real life applications.
- up and running since late summer, without major problems

Work in progress:

- optimisation of file I/O using the two IDE Raids systems, connected via SRP to fabric
- test of different file systems on the raid systems (cluster file systems, RAID0 ...)
- tests with real world MPI applications (Lattice QCD, climate predictions and others)
- job forwarding queue from cross-grid test bed, first tests are in progress
- software developement targeting at High Throughput Computing (HTC) applications

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High Throughput Computing (HTC) application: RFIO over InfiniBand

About RFIO:

- efficient protocol for large data transfers
- under developement at CERN since 1990
- now part of the CASTOR software suite
- interfaces to RFIO exist in ROOT, CERNLIB, PARROT etc

Basic idea: implementation of an alternative fast streaming protocol (rfcp)

- profit from high transfer rates well above GE capabilities
- keep CPU usage at a low level

Solution (?): combine RDMA and reliable connection (RC) features of InfiniBand(TM)

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High Throughput Computing (HTC): RFIO over InfiniBand(TM)

Status of the project:

- code is in early beta developement state
- in contact with CERN group A. Horvath/A. v. Praag
- first results look promising
- still some work to be done (performance, multithreading ...)

Preliminary results :

- tests done on Dual-Xeon nodes
- GE via cross-cable (no switch!)
- 100 single measurements for each measurement point
- transfer time and consumption measured using `time`
- using cached files

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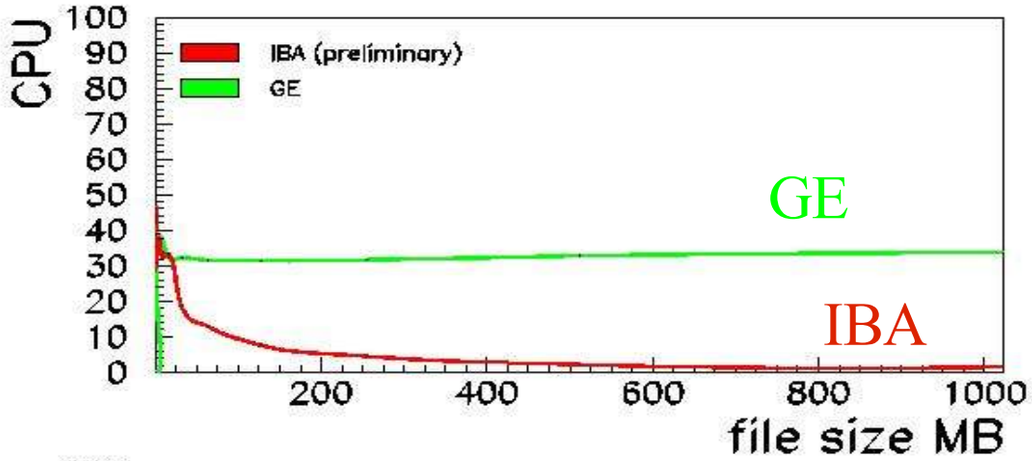
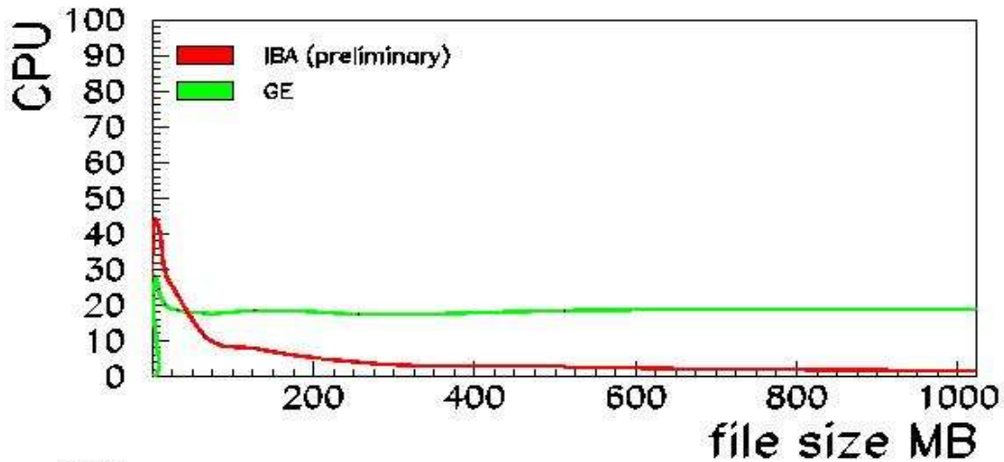
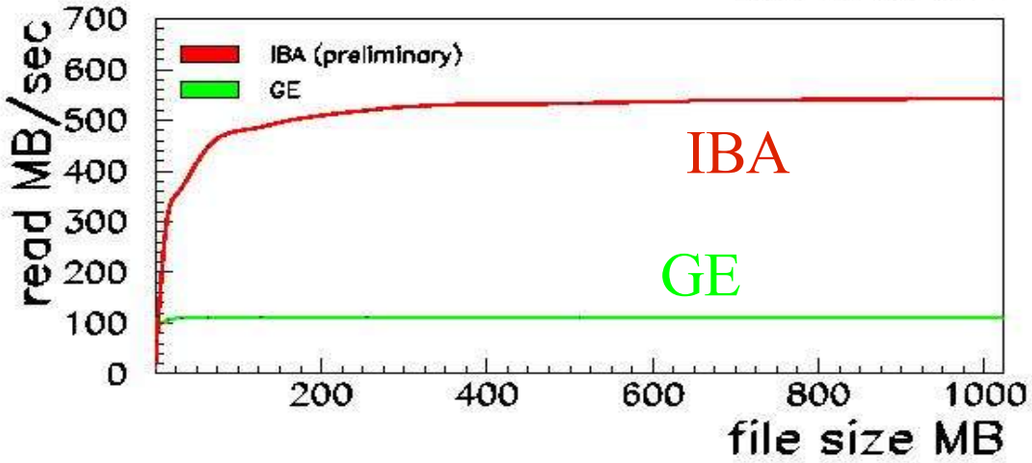
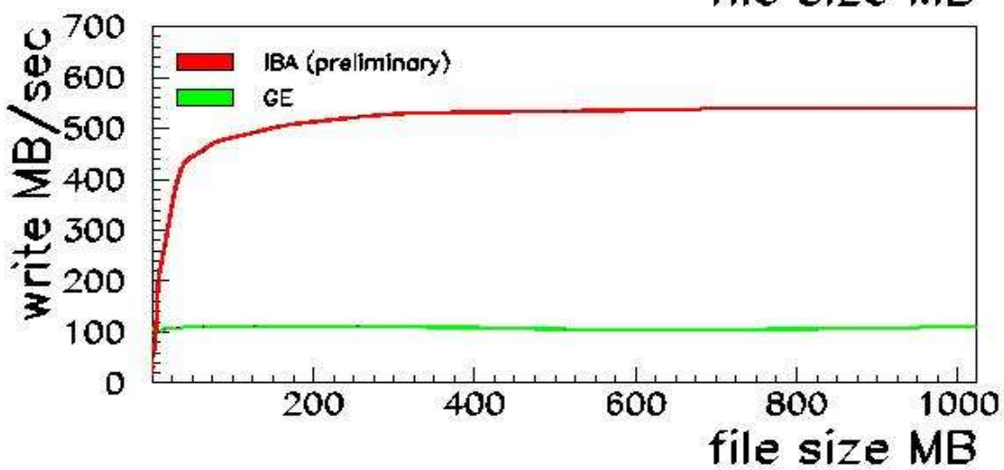
network+protocol performance comparison: read/write garbage to /dev/null









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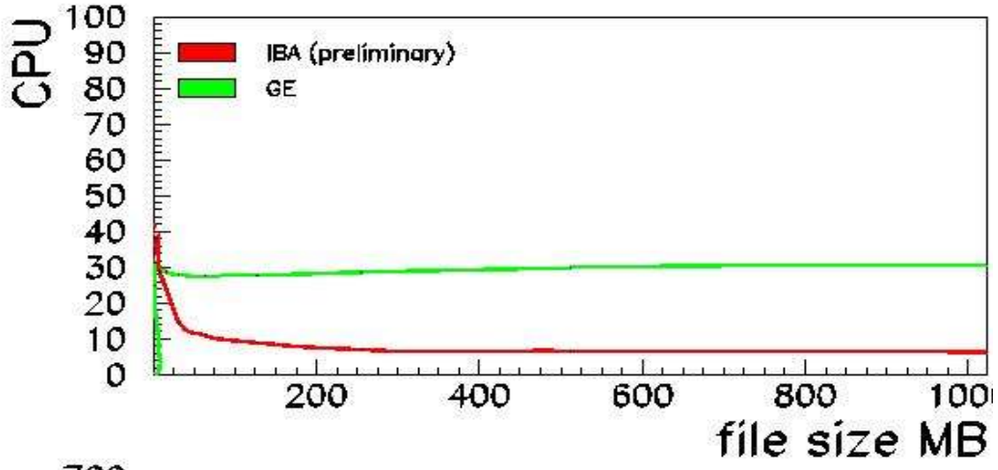
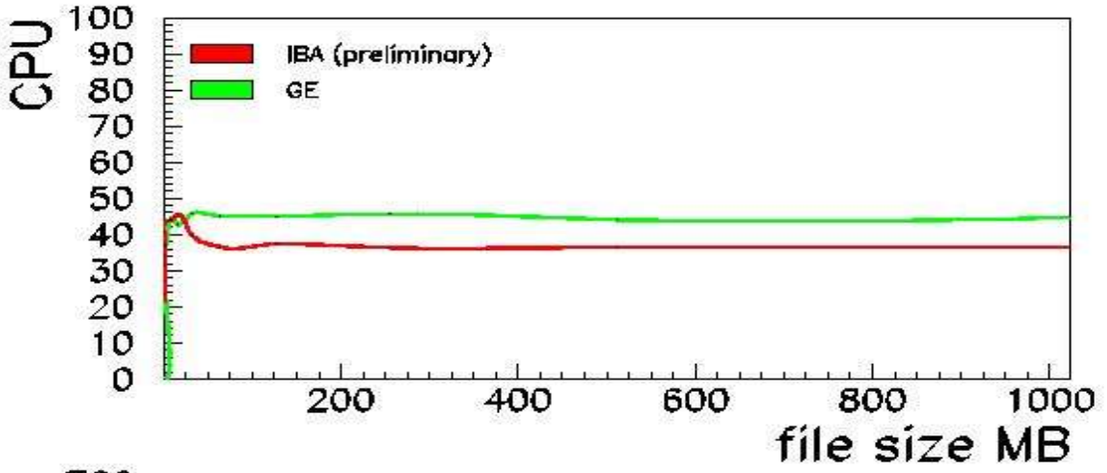
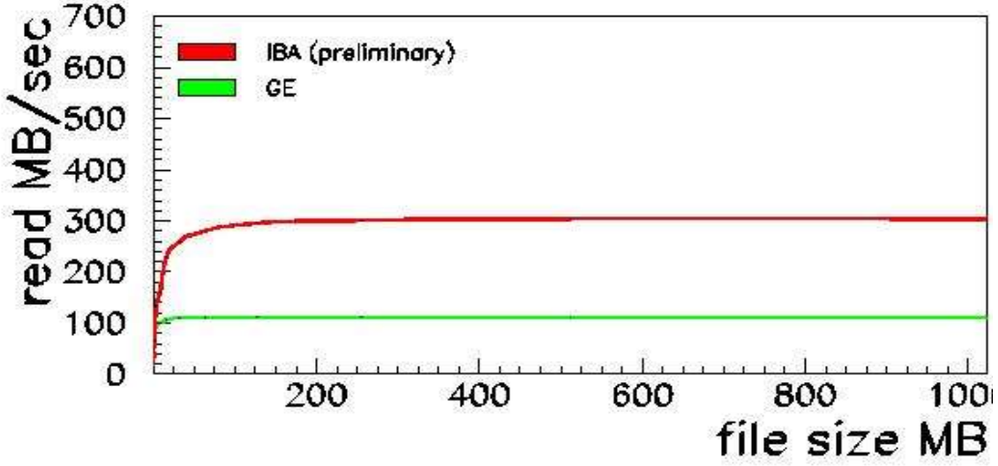
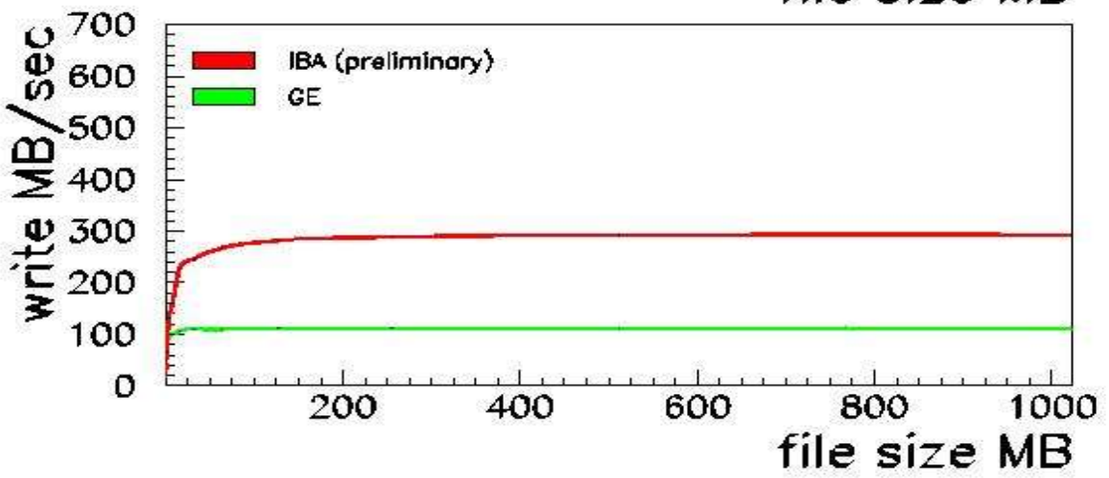
performance comparison: reading/writing cached file to /dev/null









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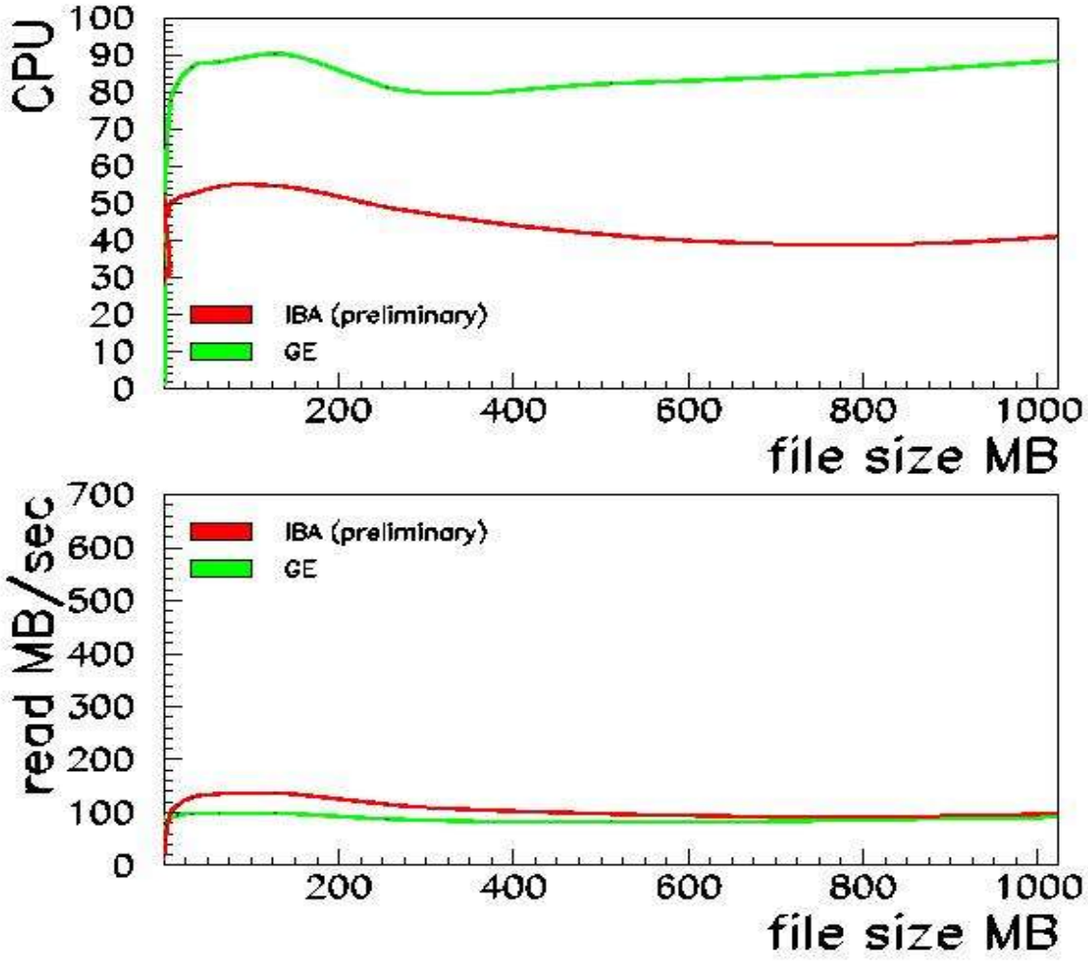
True rfcp file transfers to IDE-Raid system: comparison GE and IBA



- bonnie++ write performance: ~130MB/s
- Raid performance reached with IBA
- CPU usage with IBA only half of GE
- drop of transfer rate for large file sizes

  (needs to be investigated)

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Summary of preliminary results on dual XEON

- RDMA write raw performace : ~780MB/s
- rfcp remote garbage to /dev/null : ~540MB/s (~110 MB/s for GE)
- rfcp remote cached file to /dev/null : ~300MB/s (~110 MB/s for GE)
- rfcp remote cached file to local file : ~100MB/s (limited by Raid write)

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RFIO: Conclusion and more tests

- with InfiniBand (TM), the network is not a bottle neck any longer
- transfer speed limited by XEON server architecture and I/O devices

- 64-Bit architectures: works for Itanium, earlier version was tested on Opteron
- first tests made on Itanium2 give up to 450MB/s at < 10% CPU

  (credits: A. Horvath, A. v. Praag, CERN)

- some known problems still to be solved
- close collaboration with people at CERN and Karlsruhe (Jos van Wezel)

Work is in progress !

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THE END: Summary and Outlook

- InfiniBand is a nice open standard for interconnecting computer clusters
- it offers perspectives for HPC as well as HTC computing
- 4x is available and working, 12x (30Gb/s) hardware has been announced

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