

# An Introduction to BeeGFS

Solid, fast, flexible – and easy!



[www.beegfs.com](http://www.beegfs.com)

# An Introduction to BeeGFS

- Introduction
- BeeGFS Architecture
- BeeOND – BeeGFS on Demand
- Buddy Mirroring
- Tools & API
- BeeGFS News
- BeeGFS in use
- Conclusion

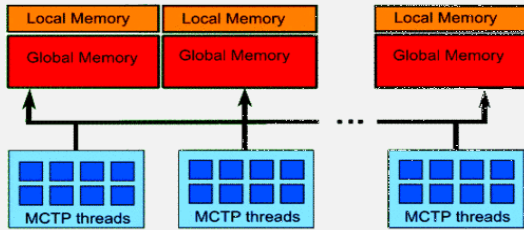


# Fraunhofer

- BeeGFS was originally developed at the Fraunhofer Center for HPC
- The Fraunhofer Gesellschaft (FhG)
  - **Largest organization for applied research in Europe**
    - Special base funding by German government
  - Institutes, research units and offices around the globe
  - Staff: ~24000 employees



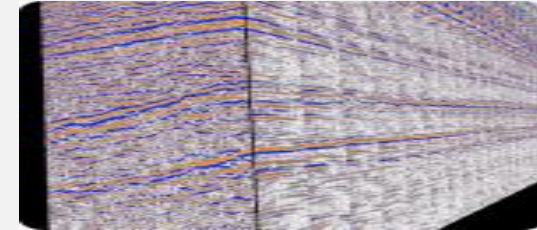
# The Fraunhofer Center for HPC



**Parallel  
Programming  
models & tools**



**Photo realistic real  
time ray tracing**



**Interactive seismic  
imaging**



**Parallel File System**



**Big Data**



**Smart Energy /  
Green by IT**

# thinkparQ

- A Fraunhofer spin-off
- Founded in 2014 specifically for BeeGFS
- Based in Kaiserslautern (right next to Fraunhofer HPC Center)
- **Consulting, professional services & support for BeeGFS**
- Cooperative development together with Fraunhofer (Fraunhofer will continue to maintain a core BeeGFS HPC team)
- First point of contact for BeeGFS



© BIC

# BeeGFS Architecture



# History

- Development started in 2005
- Why?
  - Evaluated existing solutions, not happy with what we found:
    - Very complex and limited flexibility
    - Required dedicated staff for continuous maintenance
    - Expensive
    - Scalability and performance problems for metadata access, shared file writes, single-stream I/O, ...
  - We're a HPC center, so a lot of knowledge and users in-house

# What is BeeGFS?



**BeeGFS is...**

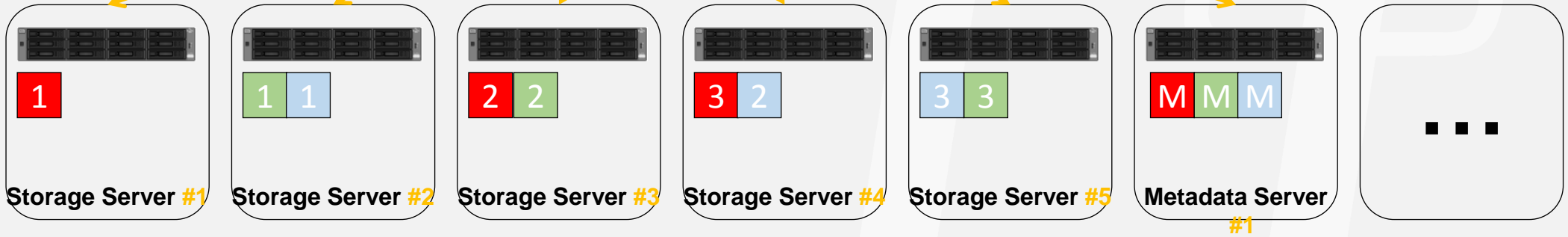
...a *hardware-independent* parallel file system  
(aka Software-defined Storage)

...designed for *performance-critical environments*





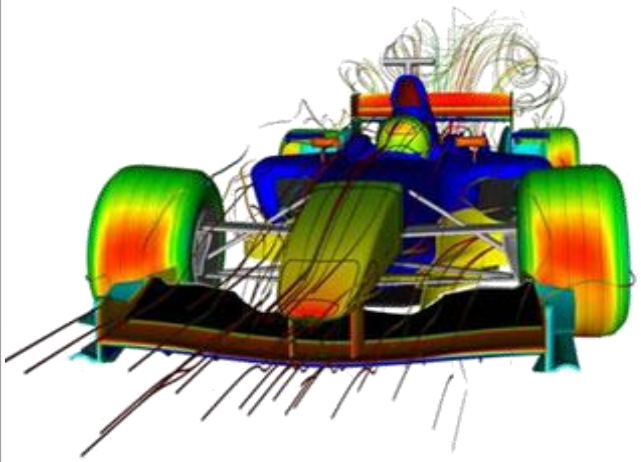
/mnt/beegfs/dir1

→ Simply grow **capacity**  
and **performance** to the  
level that you need





# Key Aspects



**Maximum  
Performance &  
Scalability**

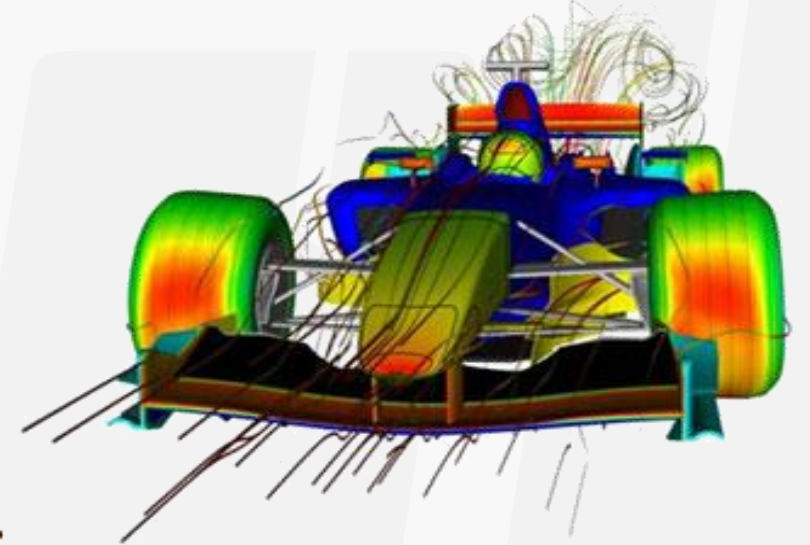
**High  
Flexibility**

**Robust &  
Easy to use**

# Key Aspects

## • Performance & Scalability

- Initially optimized for performance-critical workloads
- Efficiently multi-threaded and light-weight design
  - *"Not even breaking a sweat: BeeGFS at 10GB/s on single node all-flash unit over 100Gbit network"*
    - ScalableInformatics
- Supports RDMA/RoCE and TCP (Infiniband, Omni-Path, 100/40/10/1GbE, ...)
- Distributed file contents & distributed metadata
  - Aggregated IOPS and throughput of multiple servers
  - Scales to millions of metadata operations *per second*
- High single stream performance
  - 9GB/s single-stream throughput with Mellanox EDR (Few file streams completely saturate a 100Gbit link.)



# Key Aspects

## ✓ Performance & Scalability

### • **Flexibility**


- Multiple BeeGFS services (any combination) can run together on the same machine: Converged system
- Flexible striping per-file / per-directory
- Add servers at runtime
- On-the-fly creation of file system instances (BeeOND)
- Installation & updates without even rebooting
- NFS & Samba re-export possible
  
- Runs on different Architectures, e.g.
  - ...




**Converged  
Computation &  
Storage**



# Flexibility: CPU Architectures




OpenPOWER

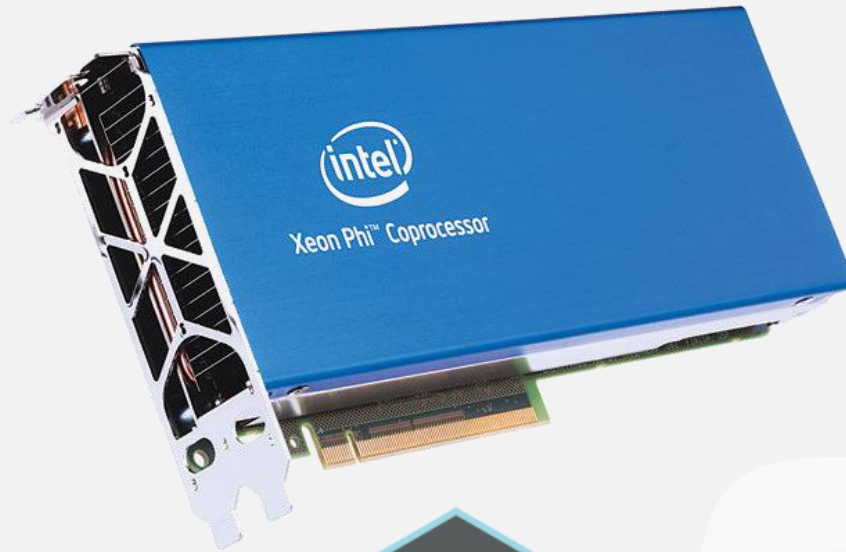


BeeGFS®

BeeGFS is a proud new Member of the OpenPower Ecosystem thanks to Support from IBM



thinkpar



# Key Aspects

✓ Performance & Scalability

✓ Flexibility

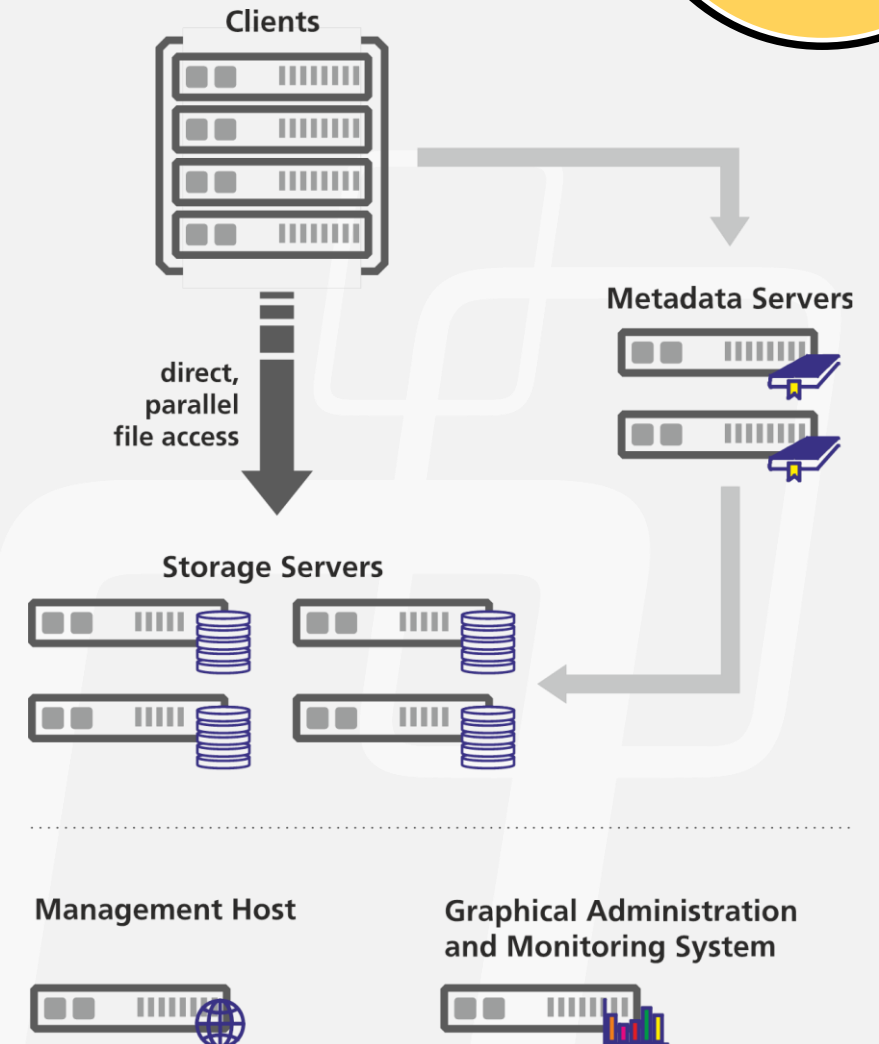
• **Robust & Easy to use**

- Very intensive suite of release stress tests, in-house production use before public release
  - The move from a 256 nodes system to a 1000 nodes system did not result in a single hitch, similar for the move to a 2000 nodes system.
- Applications access BeeGFS as a normal (very fast) file system mountpoint
- Servers run on top of standard local filesystems (ext4, xfs, zfs, ...)
- No kernel patches
  - Updates of system packages, kernel and BeeGFS are trivially simple
- Packages for Redhat, SuSE, Debian and derivatives
- No special hardware requirements
- Graphical monitoring tool

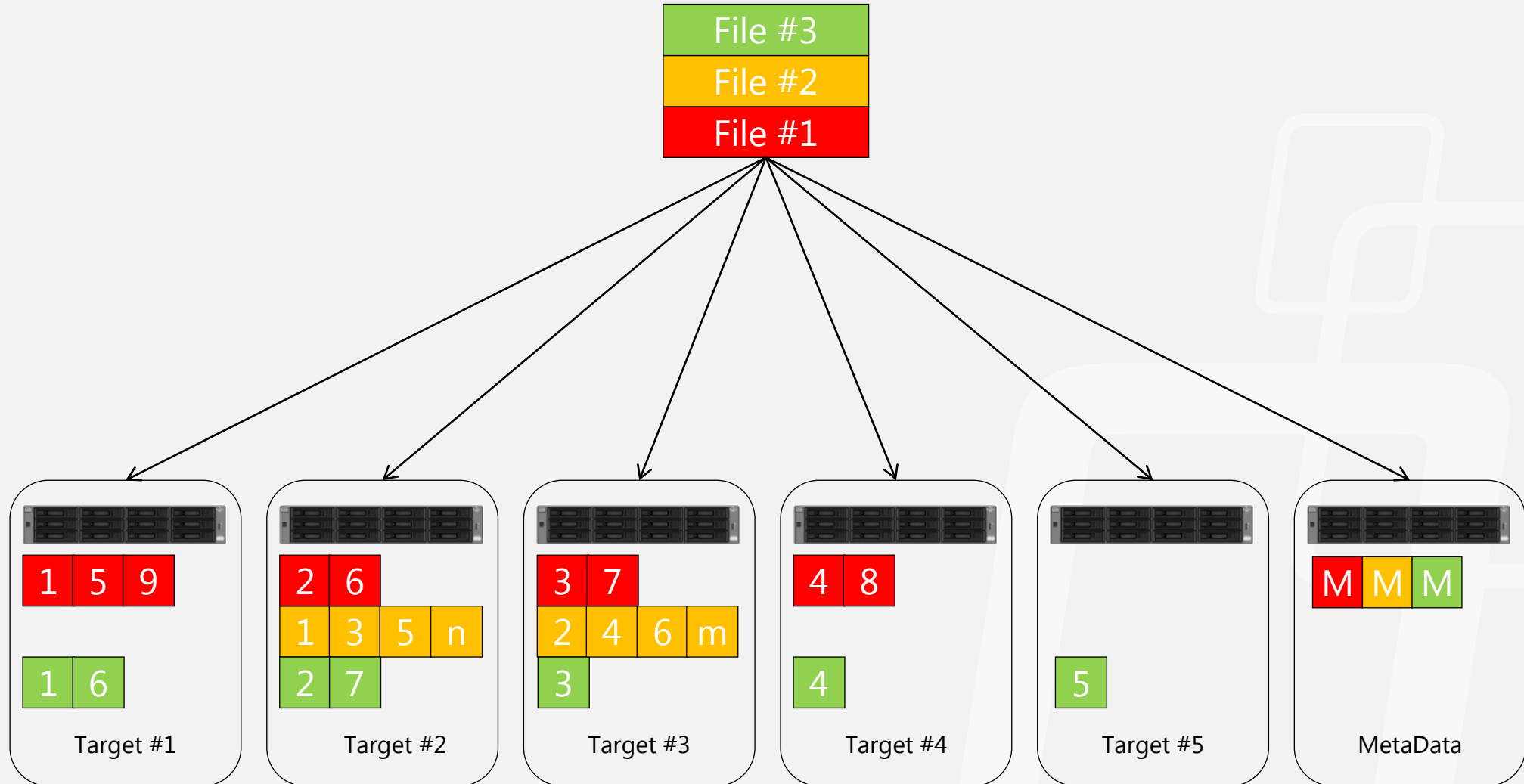


# BeeGFS Architecture

- Client
  - Native Linux module to mount the file system
- Storage Service
  - Store the (distributed) file contents
- Metadata Service
  - Maintain striping information for files
  - Not involved in data access between file open/close
- Management Service
  - Service registry and watch dog
- Graphical Administration and Monitoring System
  - GUI to perform administrative tasks and monitor system information
    - Can be used for “Windows-style installation”



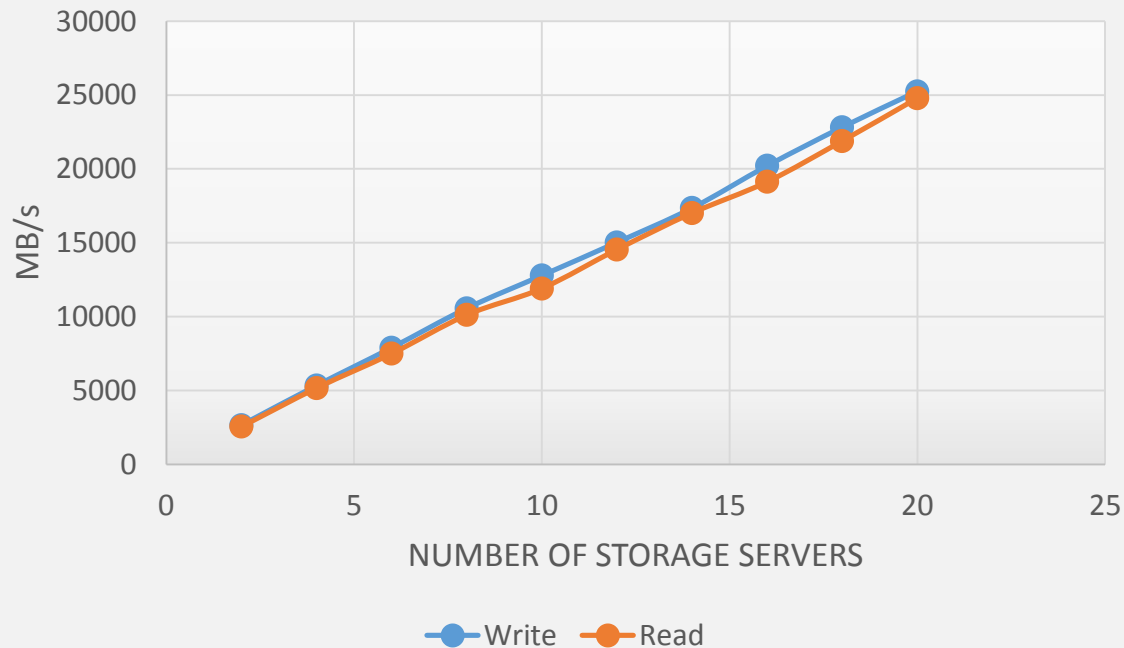
# BeeGFS Striping



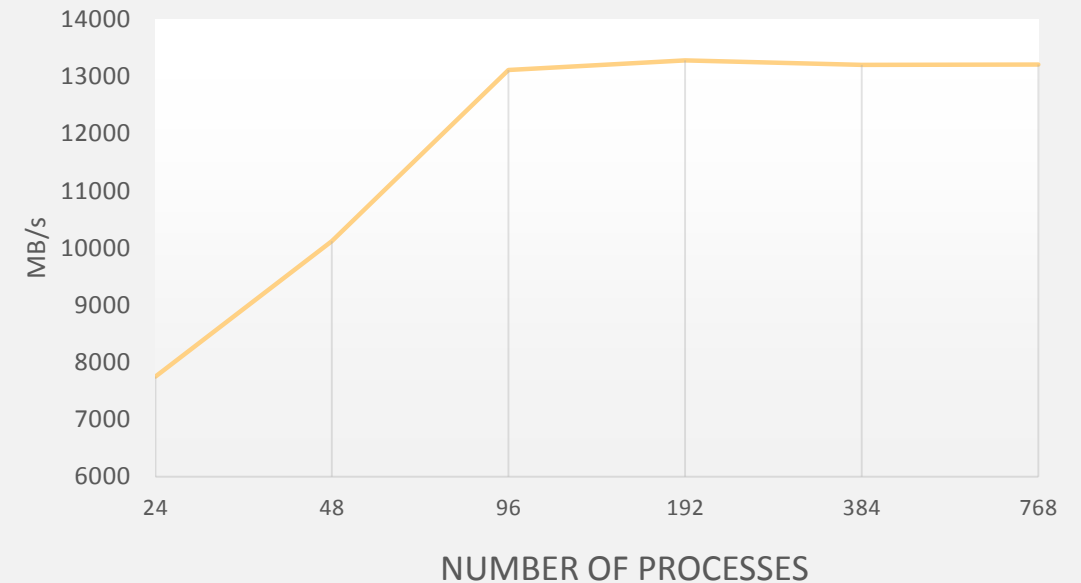
# Throughput Scalability



Sequential read/write  
up to 20 servers, 160 application processes



Strided unaligned shared file writes,  
20 servers, up to 768 application processes



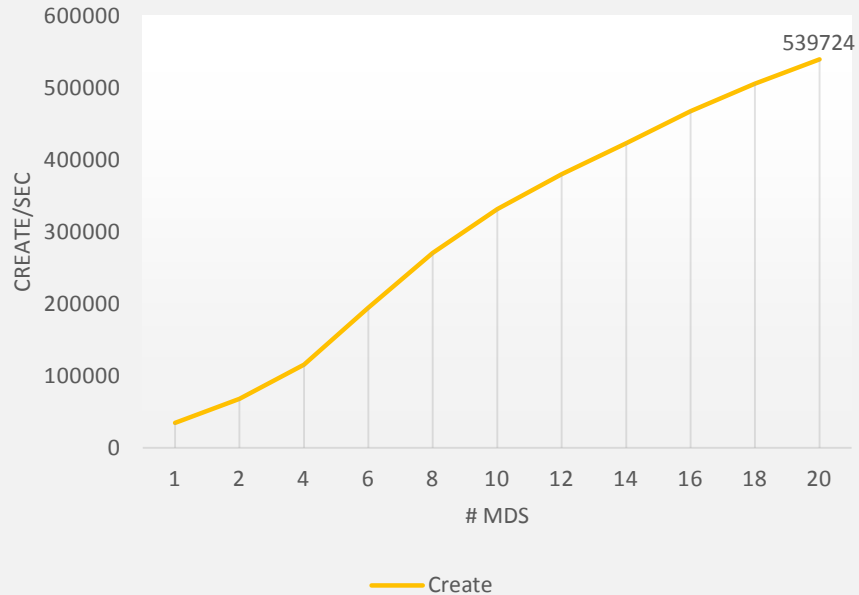
**Note: Absolute numbers in these cases depend on per-server hardware performance, of course.**



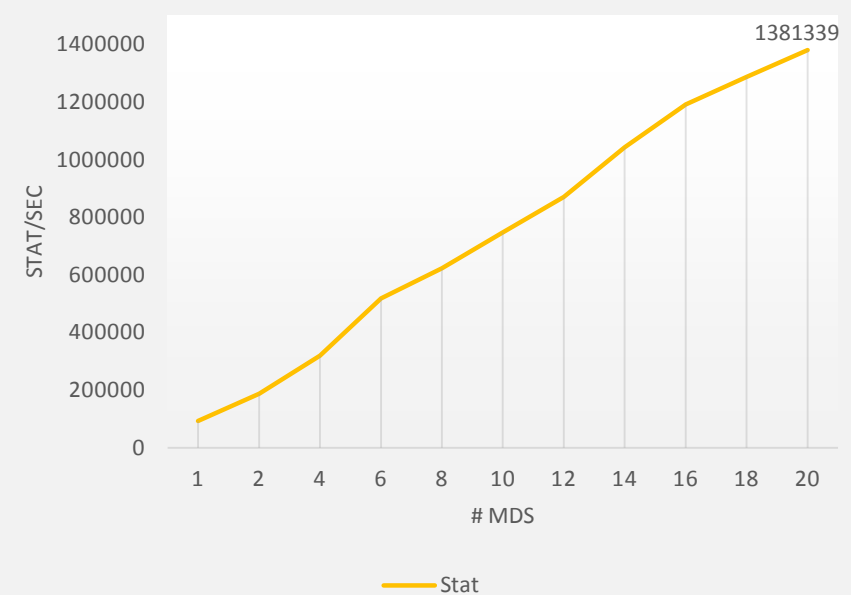
# Metadata Scalability



File creation scalability with increasing number of metadata servers



File stat (attribute query) scalability with increasing number of metadata servers



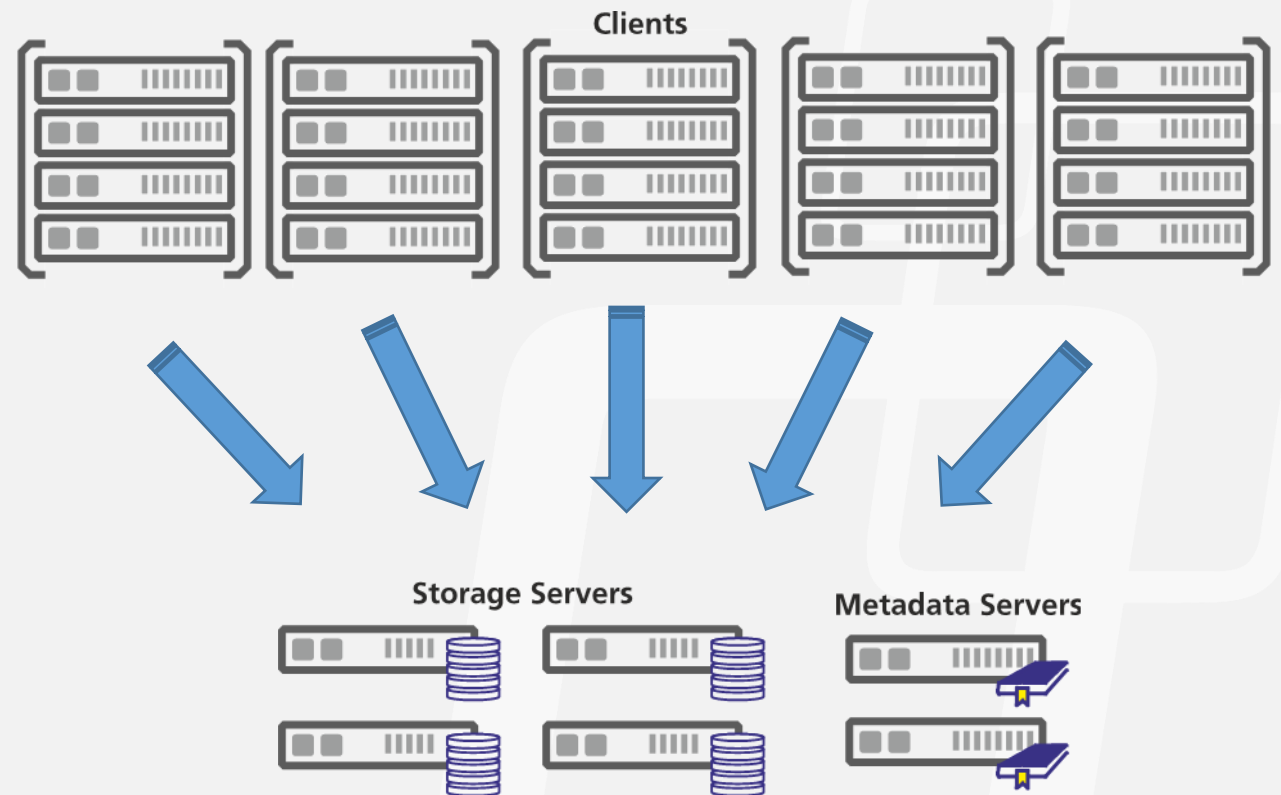
**Note: Absolute numbers in these cases depend on per-server hardware performance, of course.**

# **BeeOND – BeeGFS on Demand**



# Cluster File Systems

- Usually: One big file system for the whole cluster
- Despite parallelism:
  - Potential bottlenecks:
    - Network
    - Hard drives



# Flexibility

- Any machine can run any BeeGFS service
- Multiple BeeGFS instances at the same time



# BeeOND

- Per-job on-demand storage



# The easiest way to set up a parallel FS

- Package part of BeeGFS repository

```
root@seislab-compute@node02 ~->yum search beeond
Loaded plugins: auto-update-debuginfo, dellsysid, security
===== N/S Matched: beeond =====
beeond.i686 : BeeOND
beeond.x86_64 : BeeOND
beeond-thirdparty-gpl.i686 : BeeOND Thirdparty GPL
beeond-thirdparty-gpl.x86_64 : BeeOND Thirdparty GPL

Name and summary matches only, use "search all" for everything.
```

See  
`beeond -help`  
or  
[wiki.beegfs.com/BeeOND](http://wiki.beegfs.com/BeeOND)  
for more information

- Startup with a single command line

```
# beeond start -n nodefile -d /data/beeond -c /mnt/beeond
```

- **nodefile**: contains all hostnames to run BeeOND on (one host per line)
- **/data/beeond**: path, where BeeOND will save its raw data on each node
- **/mnt/beeond**: mountpoint of the filesystem on each node

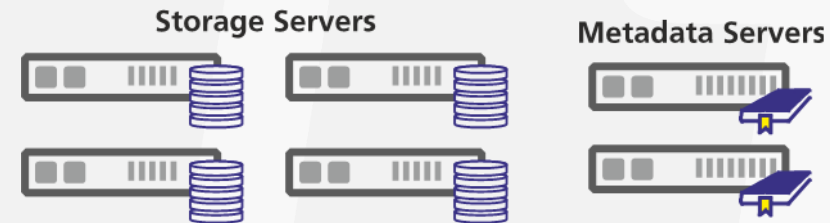
# BeeOND – BeeGFS on Demand

- BeeGFS instance is started when job starts
- Provides temporary storage during job runtime
- Is shut down after compute job is finished
- Stage in/out process

## Per-Job on-Demand Storage

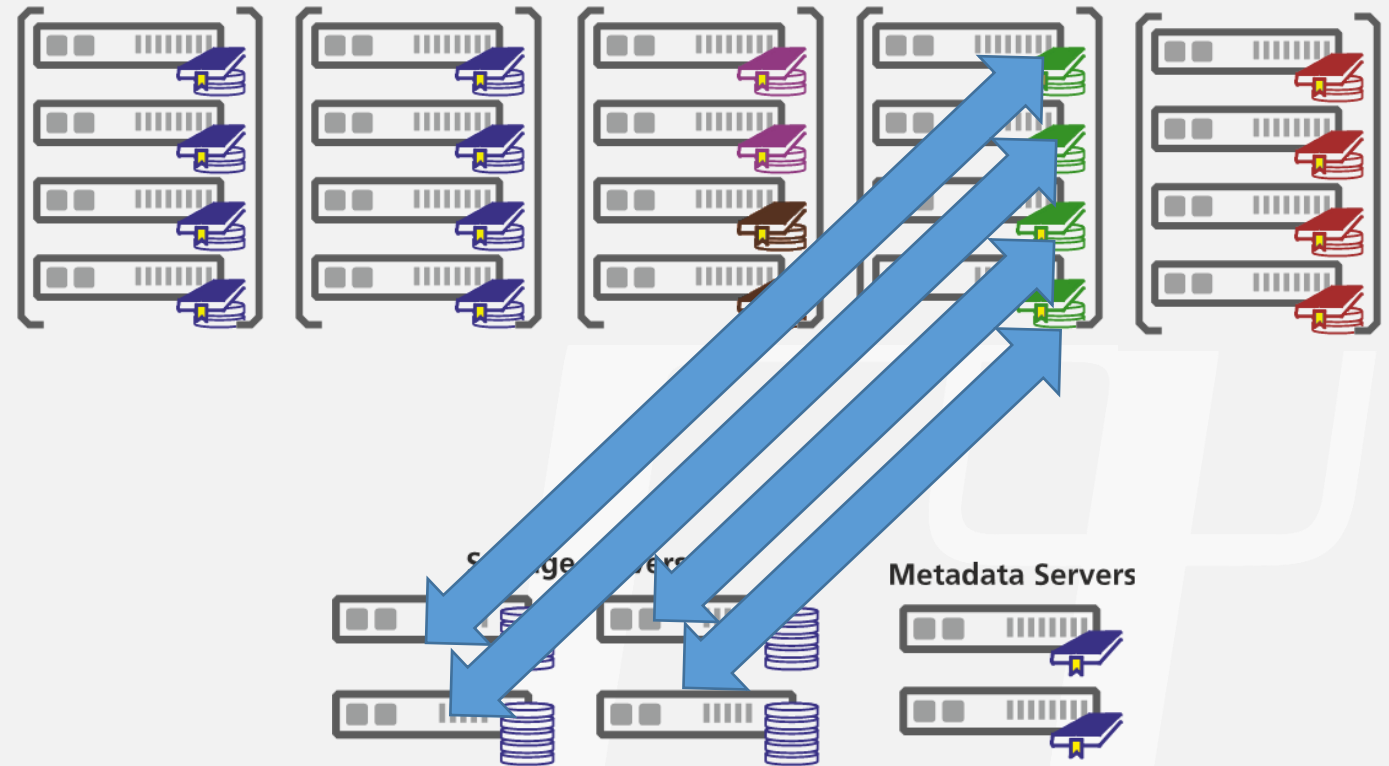


## Global Persistent Storage



# Stage-in / stage-out

- Parallel copy from and to global store
- Optional
  - Depending on IO-pattern of job





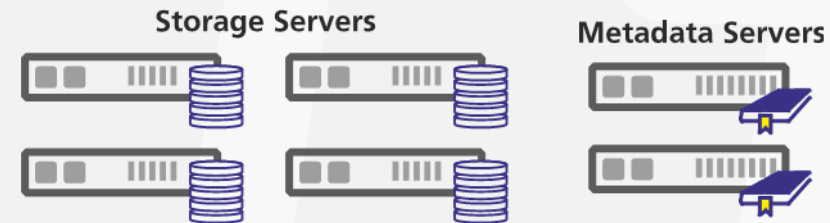
# Move storage closer to computation

- Scales with job size
- Closer to the computation
  - Less network traffic
- Reduces traffic on global storage servers
- Speeds up "dirty" IO patterns

Per-Job on-Demand Storage



Global Persistent Storage



# Features

- Selectable number of storage + metadata servers
  - Diskless nodes can be client-only
- Multiple instances at the same time
- Access to all BeeGFS tuning parameters
- Use tmpfs
- Works with any kind of global storage layer (NFS, ...)

# Use-cases

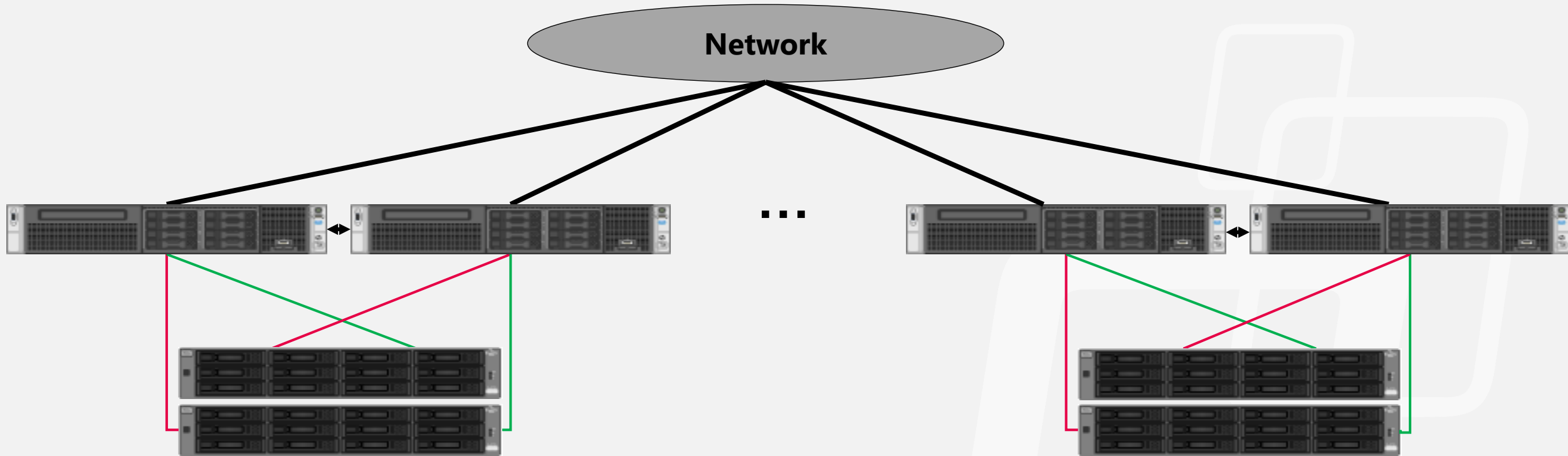


- Read input once
  - Produce lots of temporary data
  - Write output all at once
- 
- Read input x-times
  - No temporary data
  - Write output in random pattern
- 
- Read and modify small chunks of data in-place
- 
- Some software can even be simplified when used with BeeOND:
    - Take advantage of one shared "temp" filesystem instead of one temp folder per node

# Buddy Mirroring



# High Availability - Shared Storage



# High Availability - Shared Storage



- No additional storage capacity needed

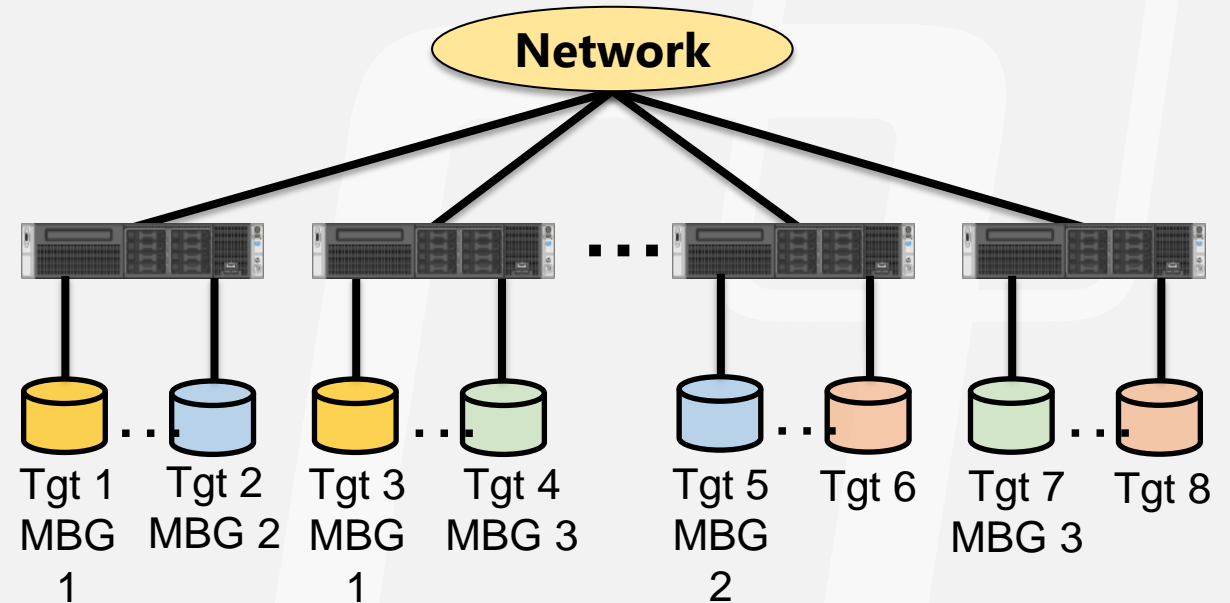


- Expensive storage components needed
- 3rd party software components needed
- Complex to set up and maintain
- Failover Risk
- No increased data safety

# Built-in Data Mirroring



- Based on „mirror buddy groups“ of storage targets
  - Primary/secondary target in a buddy group internally replicate chunks
  - But: Targets can still also store non-mirrored chunks
  - Write operations are forwarded for high throughput
  - Read possible from both targets
- Internal failover mechanisms
  - In case primary is unreachable or fails, an automatic switch is performed
  - Self-healing (differential rebuild) when buddy comes back
- Flexible: Can be enabled globally or on a per-directory basis



# High Availability – Built-in Replication



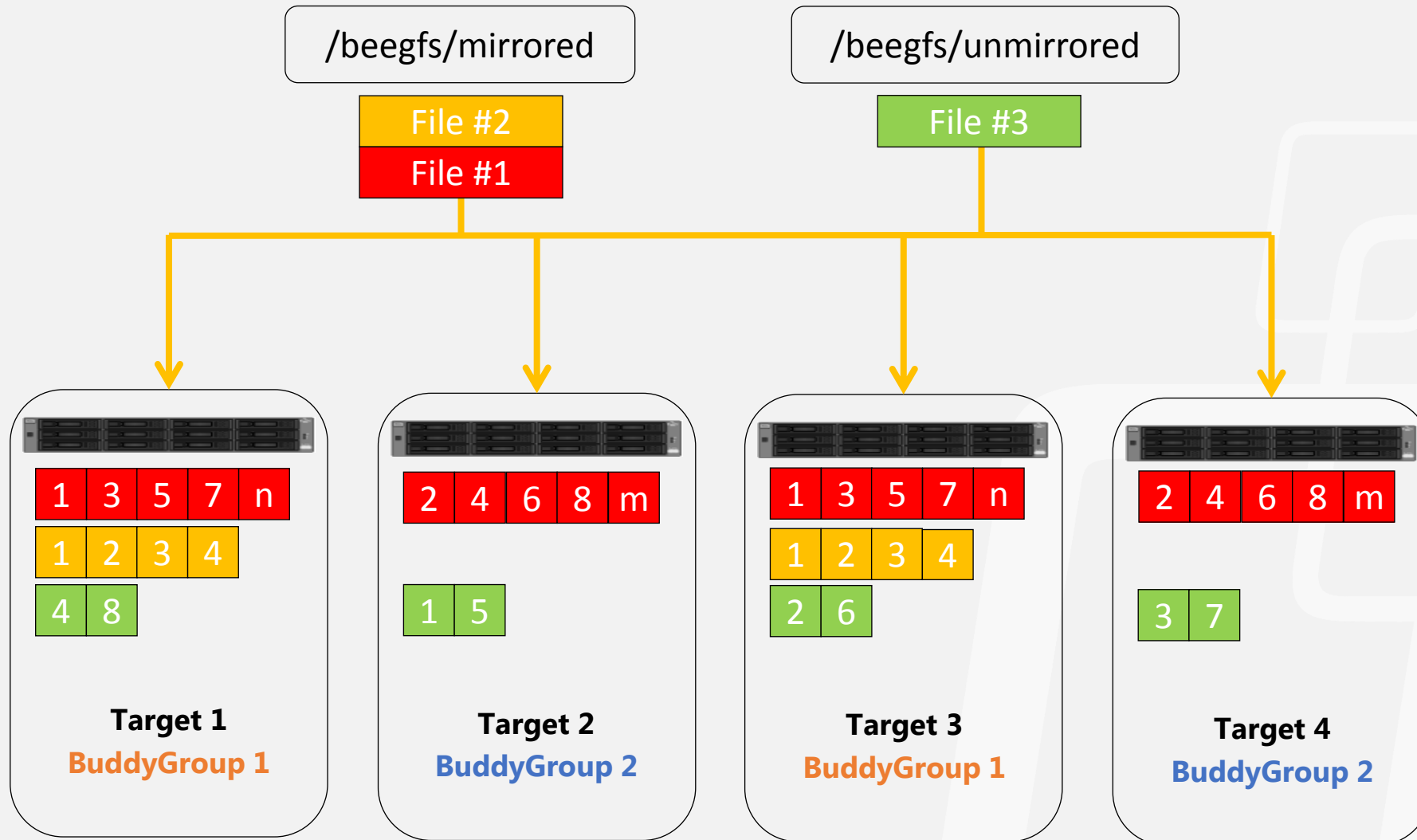
- Flexible (replication configurable per-directory)
- Easy to scale/extend
- No 3rd party tools for monitoring and failover functionality
- Any storage backend can be used
- Additional data safety



- Overhead in storage capacity
- Write penalty for replicated data



# Buddy Mirroring per Directory



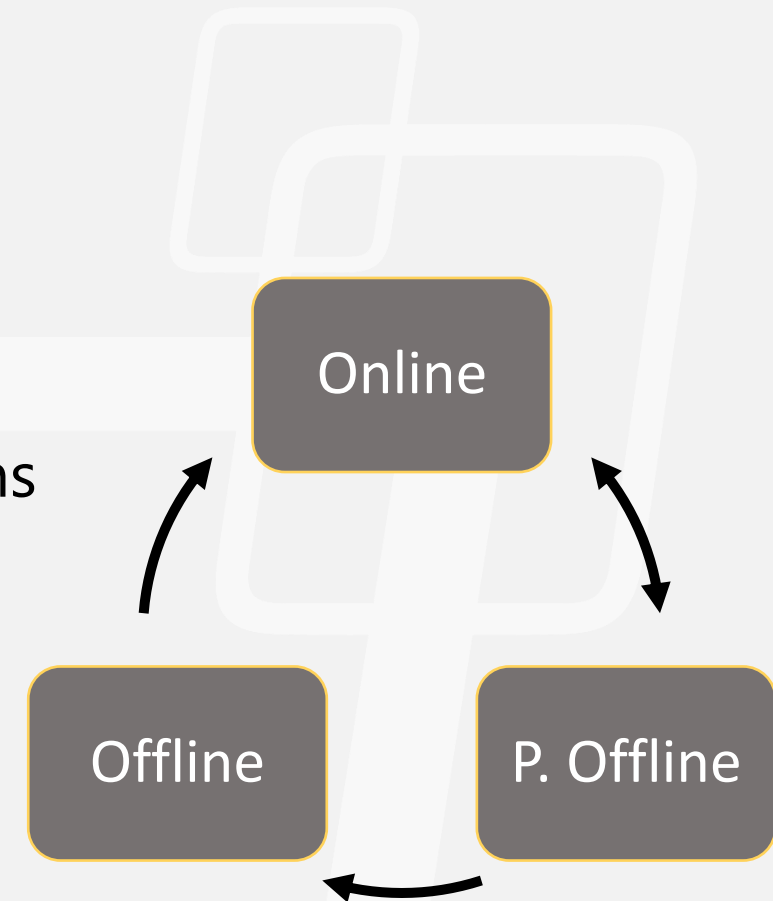
# Target States

- Introduced in BeeGFS 2015.03
- Two different states for targets
  - Consistency state
  - Reachability state
- Internally used for several optimizations
- Important for HA
- Display with beegfs-ctl

```
mohrbach@seislab-master1:~$ beegfs-ctl --listtargets --state
TargetID      Reachability  Consistency  NodeID
=====
1             Online       Good        65055
2             Online       Good        48360
3             Online       Good        45532
4             Online       Good        38454
5             Online       Good        34731
6             Online       Good        37553
7             Online       Good        14879
8             Online       Good        62821
9             Online       Good         8360
10            Online       Good        17740
11            Online       Good        37553
12            Online       Good        14879
13            Online       Good        62821
14            Online       Good         8360
15            Online       Good        17740
16            Online       Good        37553
17            Online       Good        14879
18            Online       Good        62821
19            Online       Good         8360
```

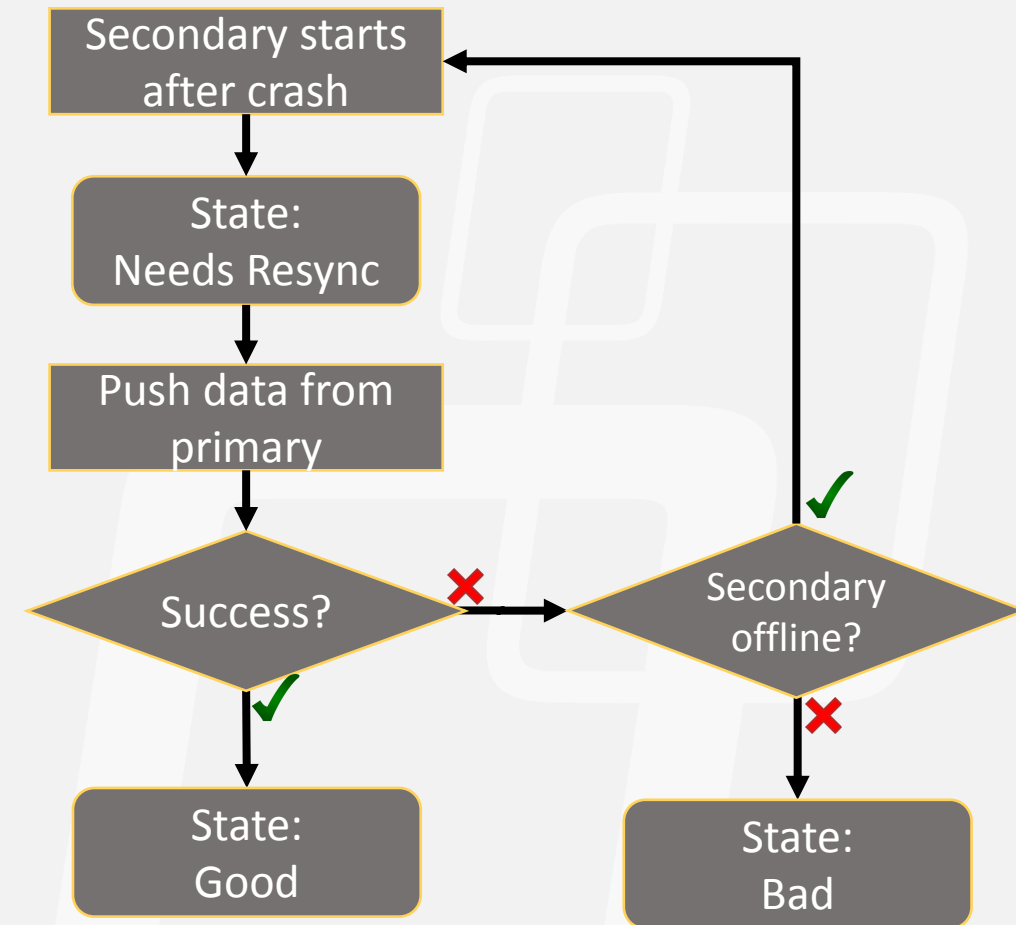
# Reachability State

- Online
  - The target is reachable and fully usable by clients
- Probably Offline
  - The target might be offline
  - Mirrored files on this target may not be accessed
  - Non-mirrored files can be attempted (but may fail)
  - intermediate state avoid races and split-brain situations
- Offline
  - If target is part of a buddy group, try a switchover



# Consistency State

- Good
  - Target may be used without limitations
- Needs Resync / Resyncing
  - Target needs a resync (or resync in progress)
  - Only valid for secondary targets
  - Clients may still access non-mirrored files
- Bad
  - A resync failed
  - Needs manual intervention



# Resync

- Completely transparent & automatic in case a node comes back after a failure
- Pushes all chunks modified since last successful communication from the Primary to the Secondary
  - Optionally (e.g. for rebuild of completely lost storage target): All files
- Can also be triggered manually
- Statistics through `beegfs-ctl`

# Tools & API



# GUI for Windows-style Installation



The screenshot shows the BeeGFS administration interface. The main window is titled "BeeGFS admon @ localhost:8000 (on fslab-s01)". It features a sidebar menu with options like "Menu", "Metadata nodes", "Storage nodes", "Client statistics", "User statistics", "Management", "FS Operations", "Installation", "Configuration", "Install", "Uninstall", and "Installation Log File". The main content area is titled "Installation => Configuration" and has tabs for "Define roles", "Create basic configuration", and "Configure Infiniband".

Under "Define roles", there is a "Step 1 : Define roles." section with instructions: "Please define the management host and the names of the hosts that shall act as metadata servers, storage servers and clients. For each category provide one hostname per line. The default value for the management daemon is the same host, which runs the admon daemon." Below this, it says "Right-Click into the boxes to modify the lists." and "Management daemon: fslab-s01".

There are three lists of hostnames:

- Metadata servers: fslab-s01, fslab-s02, fslab-s03, fslab-s04
- Storage servers: fslab-s01, fslab-s02, fslab-s03, fslab-s04
- Clients: fslab-c11, fslab-c12, fslab-c13, fslab-c14, fslab-c15, fslab-c16, fslab-c17, fslab-c18

Buttons for "Save", "Reload from server", and "Next" are visible at the bottom of this section.

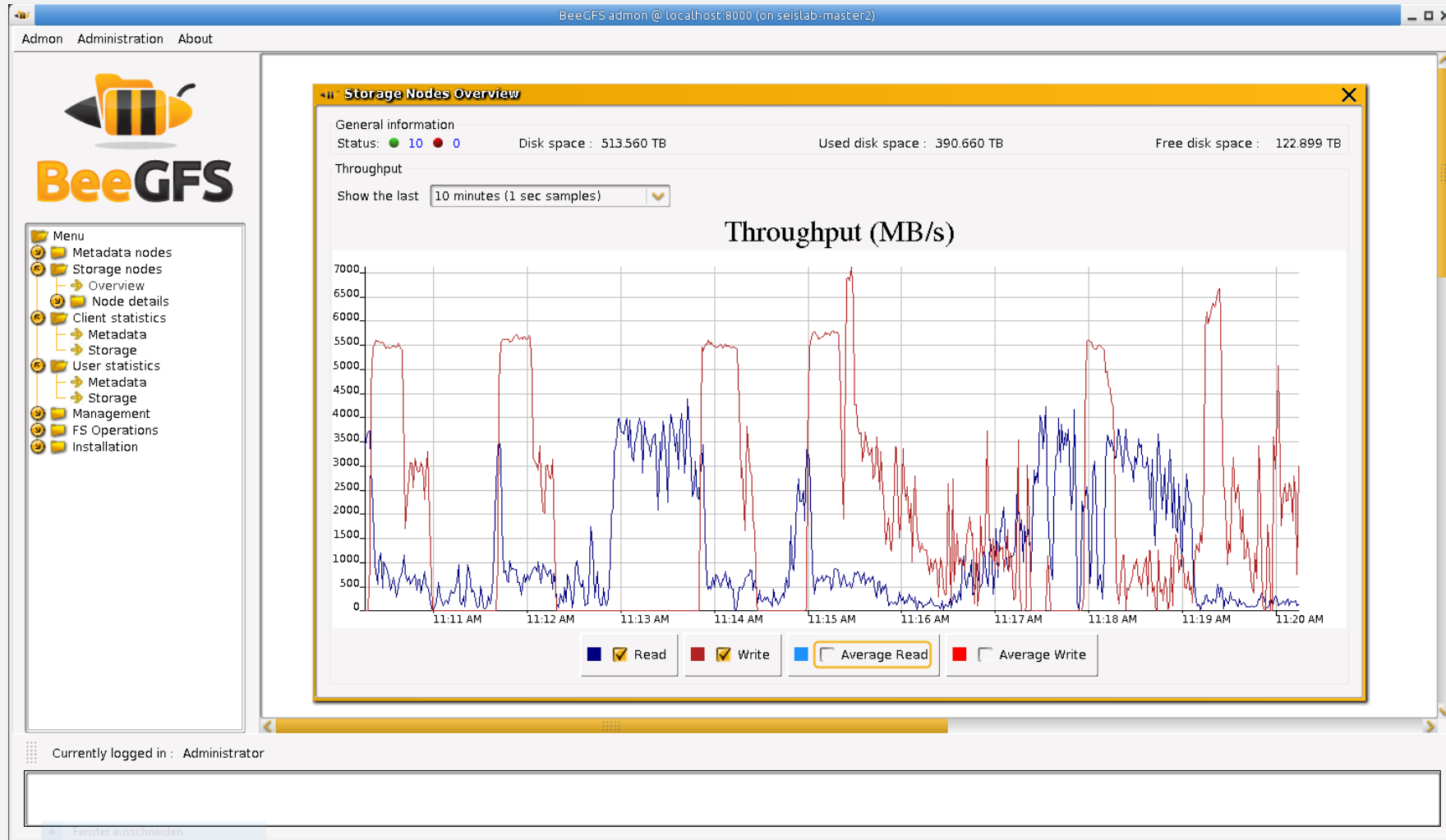
An "Install BeeGFS" dialog box is open in the foreground, showing a summary table of the configuration:

Type	Host	Architecture	Distribution
management	fslab-s01	x86_64bit	Scientific Linux release 6.8 (Carbon)
metadata	fslab-s01	x86_64bit	Scientific Linux release 6.8 (Carbon)
metadata	fslab-s02	x86_64bit	Scientific Linux release 6.8 (Carbon)
metadata	fslab-s03	x86_64bit	Scientific Linux release 6.8 (Carbon)
metadata	fslab-s04	x86_64bit	Scientific Linux release 6.8 (Carbon)
storage	fslab-s01	x86_64bit	Scientific Linux release 6.8 (Carbon)
storage	fslab-s02	x86_64bit	Scientific Linux release 6.8 (Carbon)
storage	fslab-s03	x86_64bit	Scientific Linux release 6.8 (Carbon)
storage	fslab-s04	x86_64bit	Scientific Linux release 6.8 (Carbon)
client	fslab-c11	x86_64bit	Scientific Linux release 6.8 (Carbon)
client	fslab-c12	x86_64bit	Scientific Linux release 6.8 (Carbon)
client	fslab-c13	x86_64bit	Scientific Linux release 6.8 (Carbon)
client	fslab-c14	x86_64bit	Scientific Linux release 6.8 (Carbon)
client	fslab-c15	x86_64bit	Scientific Linux release 6.8 (Carbon)
client	fslab-c16	x86_64bit	Scientific Linux release 6.8 (Carbon)
client	fslab-c17	x86_64bit	Scientific Linux release 6.8 (Carbon)
client	fslab-c18	x86_64bit	Scientific Linux release 6.8 (Carbon)

The dialog box also contains the text: "Based on the information provided in the previous steps, an automatic installation of BeeGFS is performed now. Please check the data gathered about your nodes before you continue." and buttons for "Reload" and "Install".

At the bottom of the main window, it says "Currently logged in : Administrator".

# Live Throughput Overview





# Live per-Client and per-User Statistics



The screenshot displays the BeeGFS administration interface. On the left is a navigation menu with categories like Metadata nodes, Storage nodes, Client statistics, User statistics, Management, FS Operations, and Installation. The main area shows the 'Client stats metadata' window, which includes settings for interval and number of clients, and a table of client statistics. A terminal window in the foreground shows the output of the 'module avail' command, listing available modules and providing contact information for Seislab.

**Client stats metadata**

Settings: Interval in sec: 3, Number of clients: 20, Filter: Use Hostname [checked]

client IP	sum	mkdir	create	rmdir	open	stat	unlnk	lookLI	statLI	revalLI	openLI	createLI
sum	47067	44		11	1738	3629	10240		12089	12142		1
seislab-master3...	30997			11		20	10240		10240	10265		1
192.168.72.252	15776	44			1737	3518		1782	1747			
node92.ib.cluster	134				1	37		61	34			
node91.ib.cluster	26					9		1	16			
node79.ib.cluster	26					9		1	16			
node78.ib.cluster	26					9		1	16			
node74.ib.cluster	26					9		1	16			
node66.ib.cluster	26					9		1	16			
node65.ib.cluster	26					9		1	16			
192.168.72.253	4											

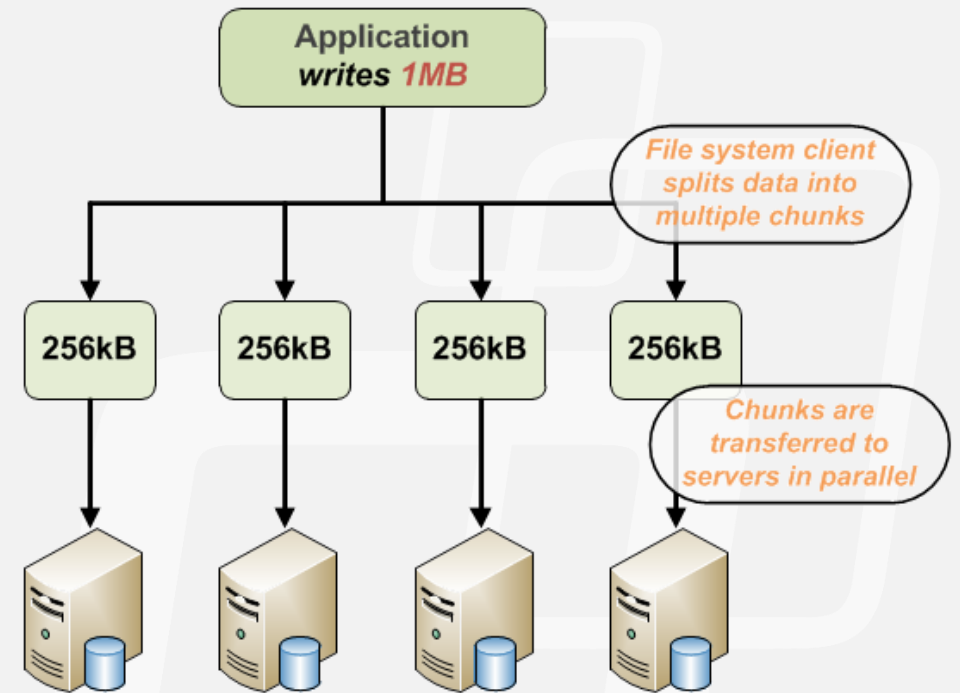
```
breuner@seislab-master3:~/scratch/breuner/bonnie$ module avail
module avail - show available modules
module add <module> - adds a module to your environment for this session
module initadd <module> - configure module to be loaded at every login

-----
An overview on available nodes follows.
-----
Nodes in state Free : 36
Nodes in state Job-Exclusive : 52
Nodes in state Offline : 0
-----
* seislab wiki: http://wiki.itwm.fhg.de/itwm/Seislab_User_Manual *
* seislab mailinglist: seislab@itwm.fraunhofer.de *
* seislab support: seislab-support@itwm.fraunhofer.de *
-----

breuner@seislab-master3:~$ cd /scratch/breuner/bonnie
breuner@seislab-master3:~/scratch/breuner/bonnie$ ~/prog/bonnie++-1.96/bonnie++ -s0 -n 10:0:0:10 -r0
Create files in sequential order...done.
Stat files in sequential order...done.
Delete files in sequential order...
```

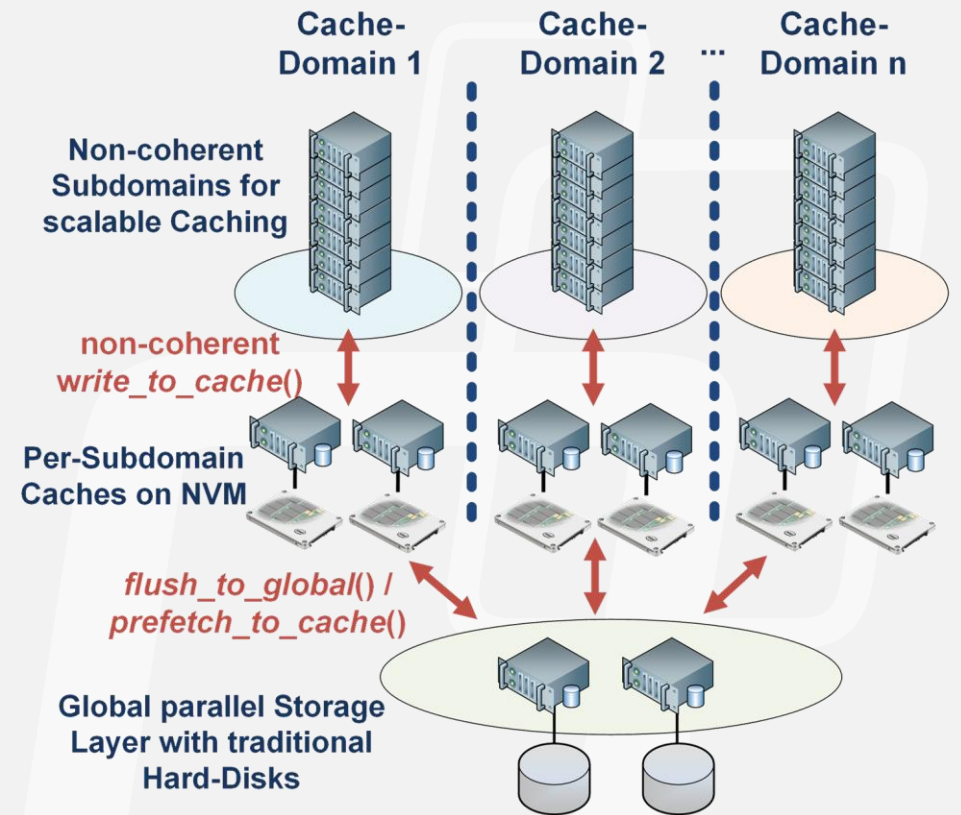
# Striping API

- Include file beegfs.h
- Creates new files with stripe-settings
  - Block size
  - Number of strip targets
  - Stripe pattern
- Gets the striping information of a file
- Checks a given path if the file-system is a BeeGFS



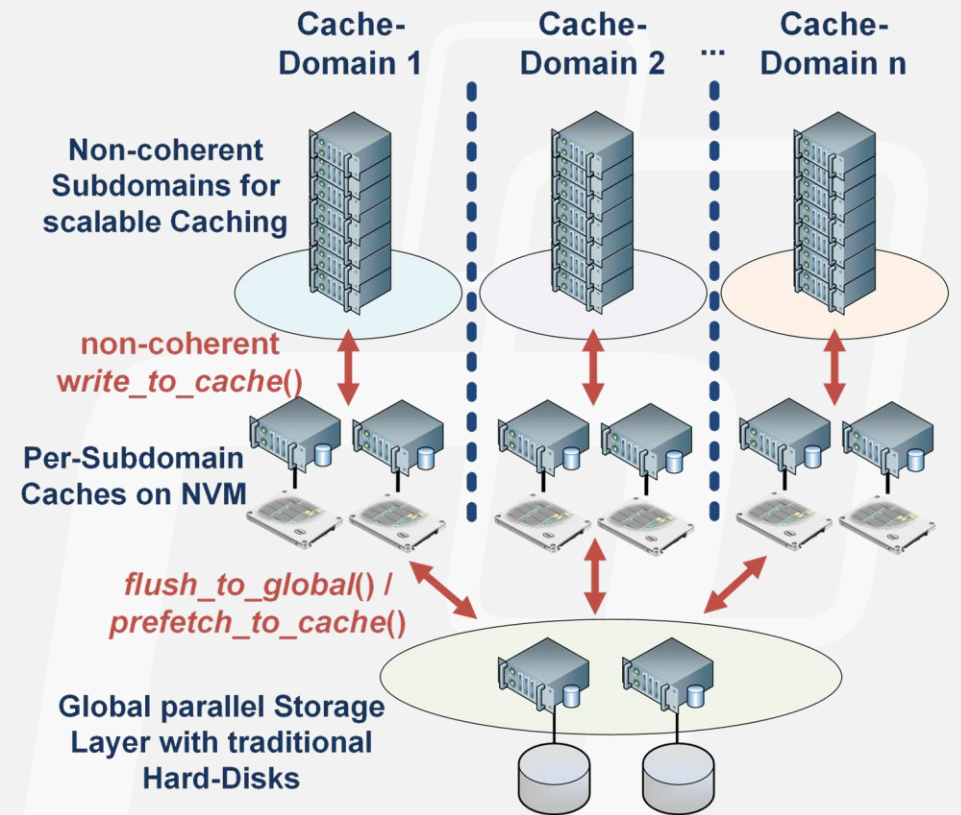
# Cache API

- Two storage layers
  - Globally visible layer for capacity on traditional HDDs
    - Avoid accessing this layer as much as possible for maximum scalability
  - Partitioned cache layer for work-in-progress data
    - HDD or High-throughput solution with SSD or NVMe
    - Cache layer is accessed through new BeeGFS Cache API
    - Use especially for temporary files and data that is not written in large chunks



# Cache API

- Include file deeper/deeper\_cache.h
- Open()
  - Additional options which are executed during the close() → discard or flush on close
- Close()
- Prefetch()
  - Copy a file/directory from global FS to cache FS
- Flush()
  - Copy a file/directory from cache FS to global FS



# BeeGFS News



# What's new in the recent Major Releases?

- BeeOND (BeeGFS On Demand)
- **Enterprise Edition** (Codename: Trinity)
  - Quota Enforcement
  - Access Control Lists (ACLs)
  - Built-in data mirroring and metadata mirroring
- Per-User Statistics in Admon GUI
- New setup tools (/opt/beegfs/sbin/beegfs-setup...)
- BeeGFS C API

# License Model



## ■ BeeGFS is free to use for end users: [www.beegfs.com/download](http://www.beegfs.com/download)

- Ready-to-use binary packages
- Complete source code also available (but: BeeGFS is intentionally not a community project)

## ■ System integrators/partners for turn-key solutions

- System setup and tuning
- First point of contact (1st- and 2nd-level support)
- Partners make back2back contract with ThinkParQ for 3rd-level support



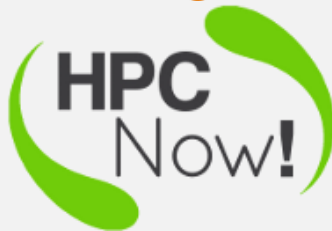
*BeeGFS allows us to easily deliver peta-scale turn-key storage solutions*  
- transtec

## ■ Professional 3rd-level support contract

- Pricing based on number of servers and timeframe (e.g. 3 or 5 years)
- Access to enterprise edition features
- Special customer website area: [www.beegfs.com/customerlogin](http://www.beegfs.com/customerlogin)

→ *Support contracts are also the financial basis for development of great new features*

# Global Turn-Key Solution Partners



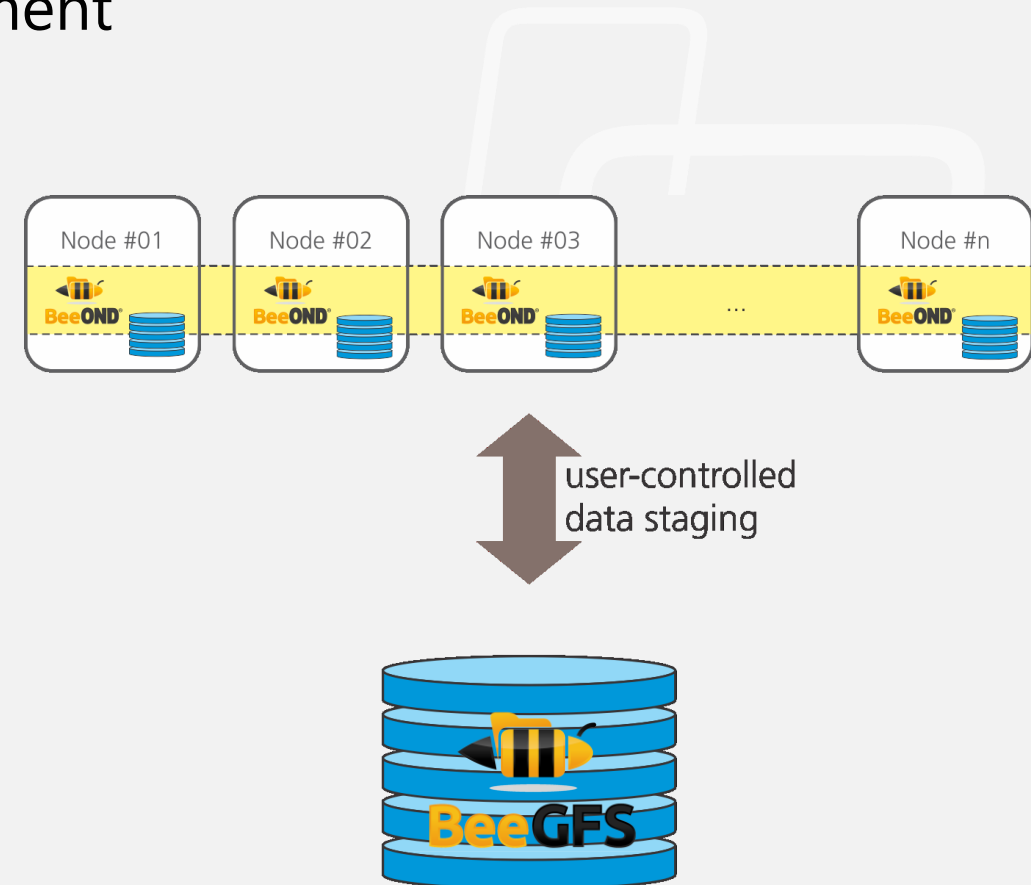


**BeeGFS in use**



# BeeOND - Use in Fraunhofer Seislab

- Fraunhofer Seislab
  - In-house cluster of Fraunhofer HPC Department
  - 100 compute nodes with 1 TB of SSDs each
  - Global BeeGFS storage on spinning disks
- Create BeeOND on SSDs on job startup
  - Integrated into Torque startup
- Stage-in input data, work on BeeOND, stage-out results



# Customer Examples

900 Clients  
12 Servers



Heidelberg Institute for  
Theoretical Studies

10 Servers  
100 Clients  
Several PB



Automotive



2000 Clients  
9 Servers



Stanford  
University



Basic Research



Seismic Data  
Analytics



BNP PARIBAS



Deep learning,  
Radio astronomy, ...

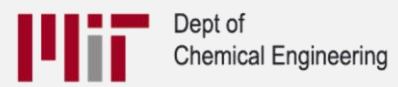
30 Servers  
100 Clients  
Several PB



Life Science



Finance



# Why do people go with BeeGFS?



***"We are extremely happy with our 3.1PB BeeGFS on 30 servers – it runs rock-solid."***

***- Bioinformatics Aarhus, Denmark***

***"After many unplanned downtimes with our previous parallel FS, we moved to BeeGFS more than 2 years ago. Since then we had no unplanned downtimes anymore."***

***- University of Halle, Germany***



**FRED HUTCH**  
CURES START HERE™

***"We're now at one year of uptime without a single hitch of the BeeGFS."***

***- Fred Hutchinson Medical Institute, USA***

***"We've seen BeeGFS performing very well and also saw its easy and robustness – which we did not see in many other parallel file systems."***

***- ClusterVision***

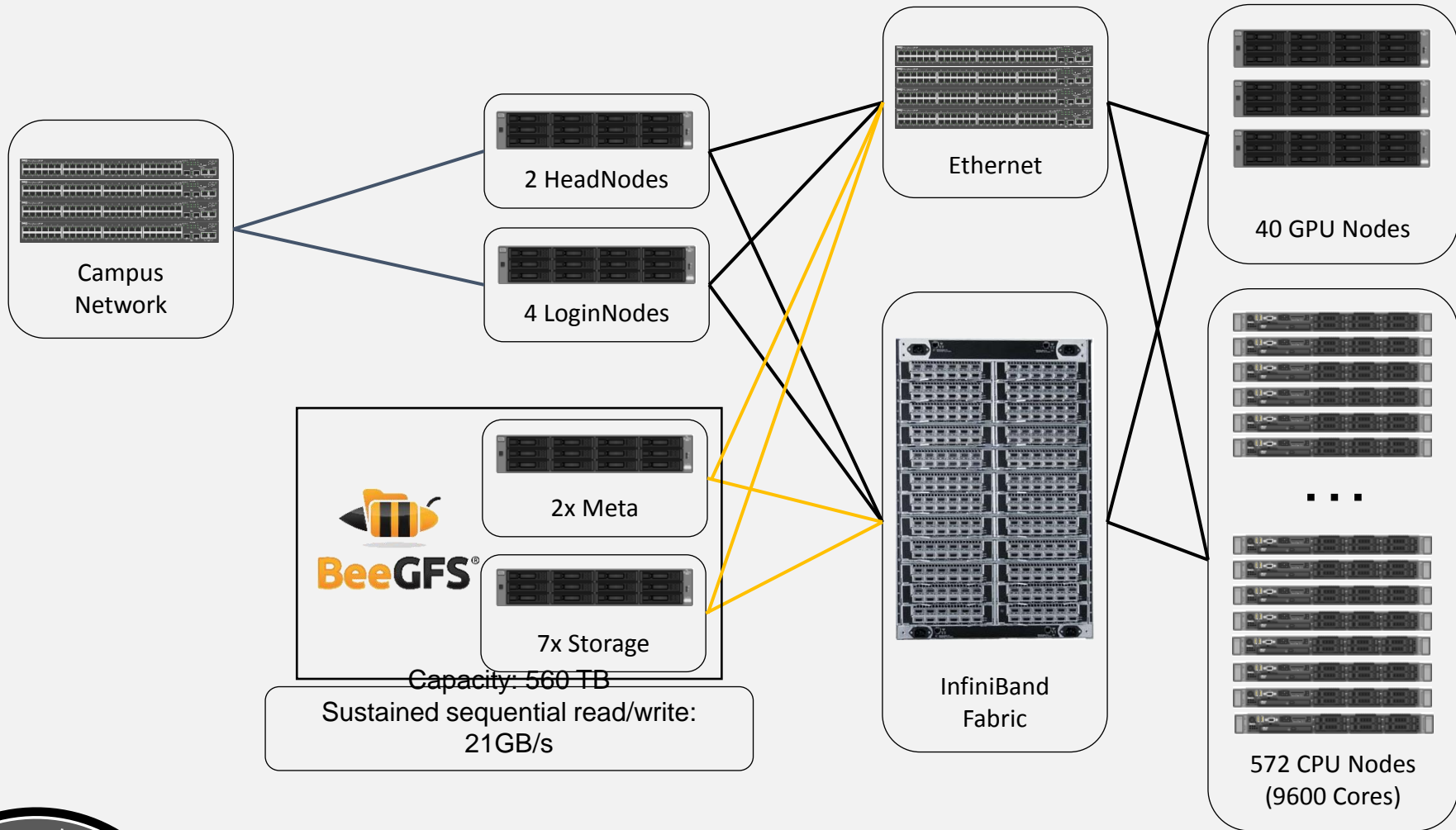


**clustervision**

**Currently about 250 supported installations spread all around the globe.  
(By the way: all of them are happy)**

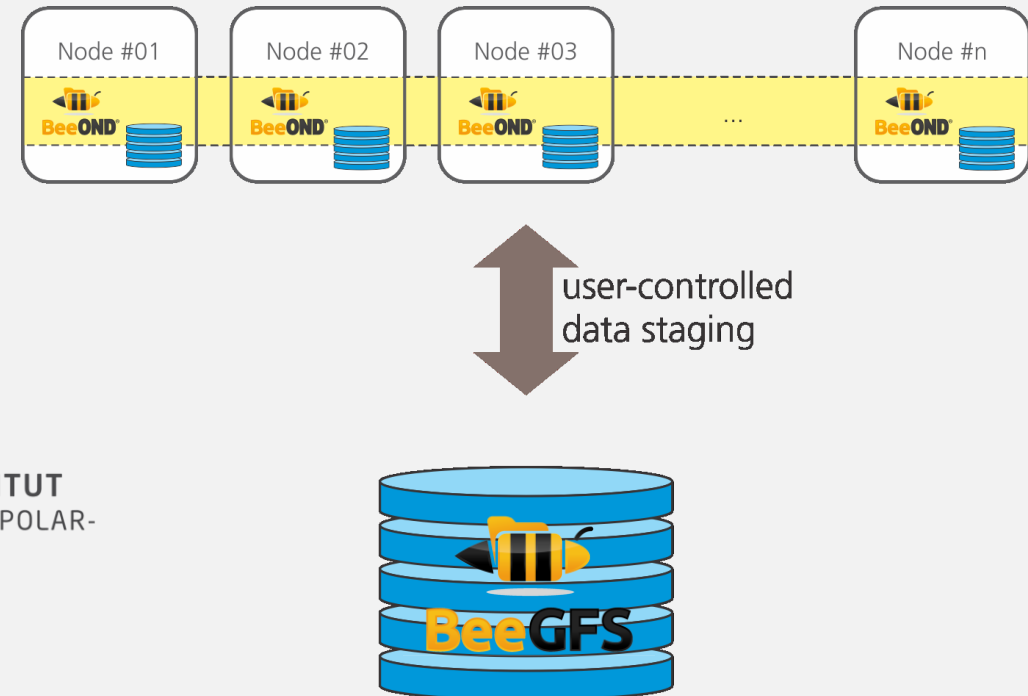
Plus 1000's of unsupported installations  
(free download, open-source)

# OcULUS – A Typical HPC Installation



# BeeOND - Use at Alfred-Wegener-Institute

- Cray CS-series Cluster
  - Global BeeGFS storage on spinning disks (*4 servers, 16GB/s*)
  - 300 compute nodes with a 500MB/s SSD each
  - 150GB/s aggregate BeeOND speed "for free"*
- Create BeeOND on SSDs on job startup
  - Integrated into Slurm prolog/epilog script
- Stage-in input data, work on BeeOND, stage-out results



# A workload-optimized solution (1/3)



## ■ Customer Situation

- 2 Mio EUR proprietary solution
- served home directories and HPC work storage
- HPC compute jobs were all single core (life science) working on the same data
- Compute nodes uplinked with 1GbE
- 30 to 40 single core compute jobs saturated the storage, making it completely unresponsive



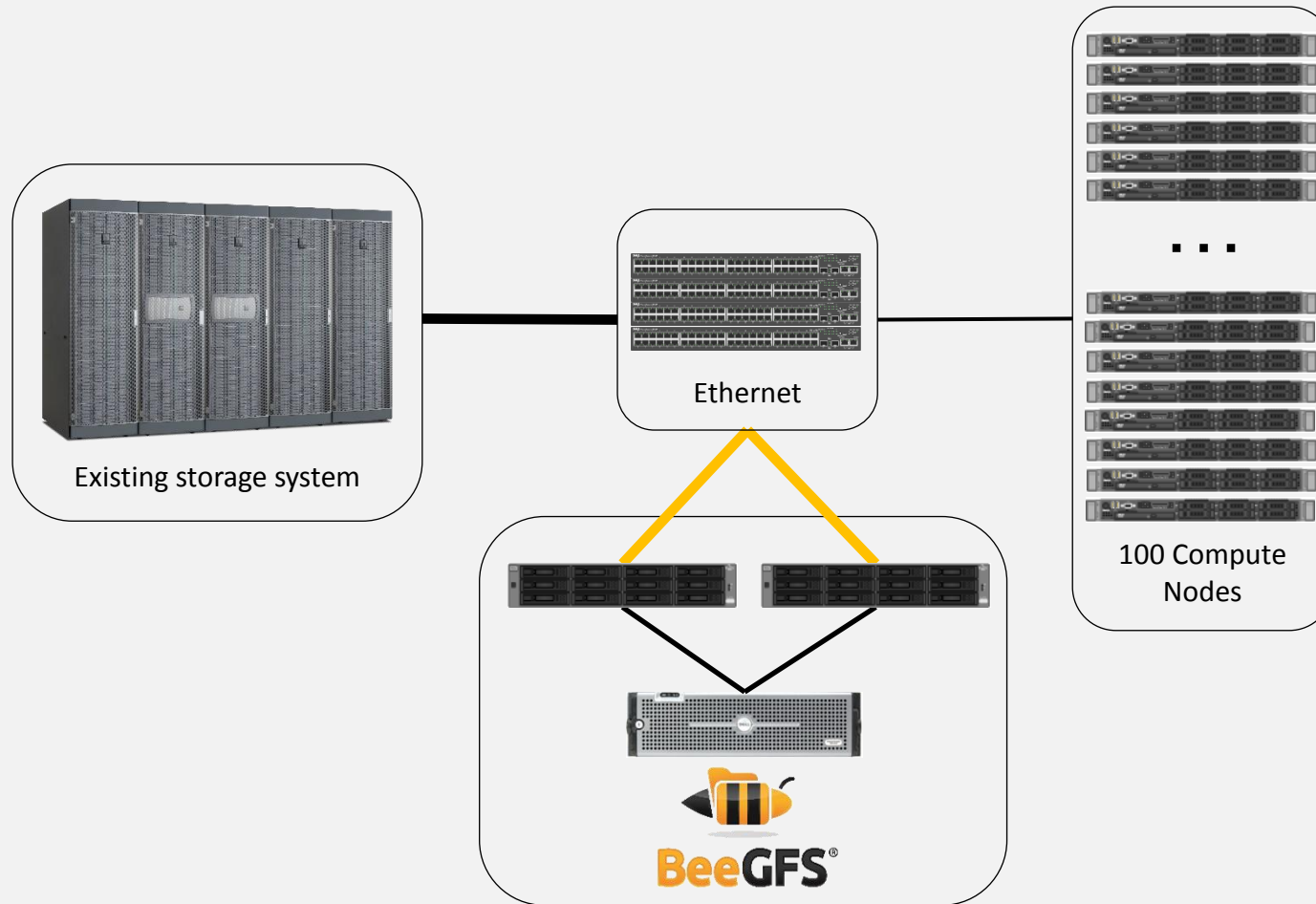
## ■ Customer's Expectation

- Build a dedicated storage just for the HPC cluster
- Use fast 10k or 15k disk drives – or even SSDs
- Create a system serving 100k+ random IOPS





# A workload-optimized solution (2/3)



# A workload-optimized solution (3/3)

## ■ Findings through workload analysis

- About 0.5 TB of cache should be sufficient
- Disk performance becomes irrelevant then
- BeeGFS can make use of 40GbE very well

## ■ Solution

- 2 storage servers – together 1 TByte RAM
- 40GbE uplinks for the storage servers
- 60 disk drives for persistent storage
- Tested with 600 single core compute jobs and no drop in performance

# Another workload-optimized solution (1/2)

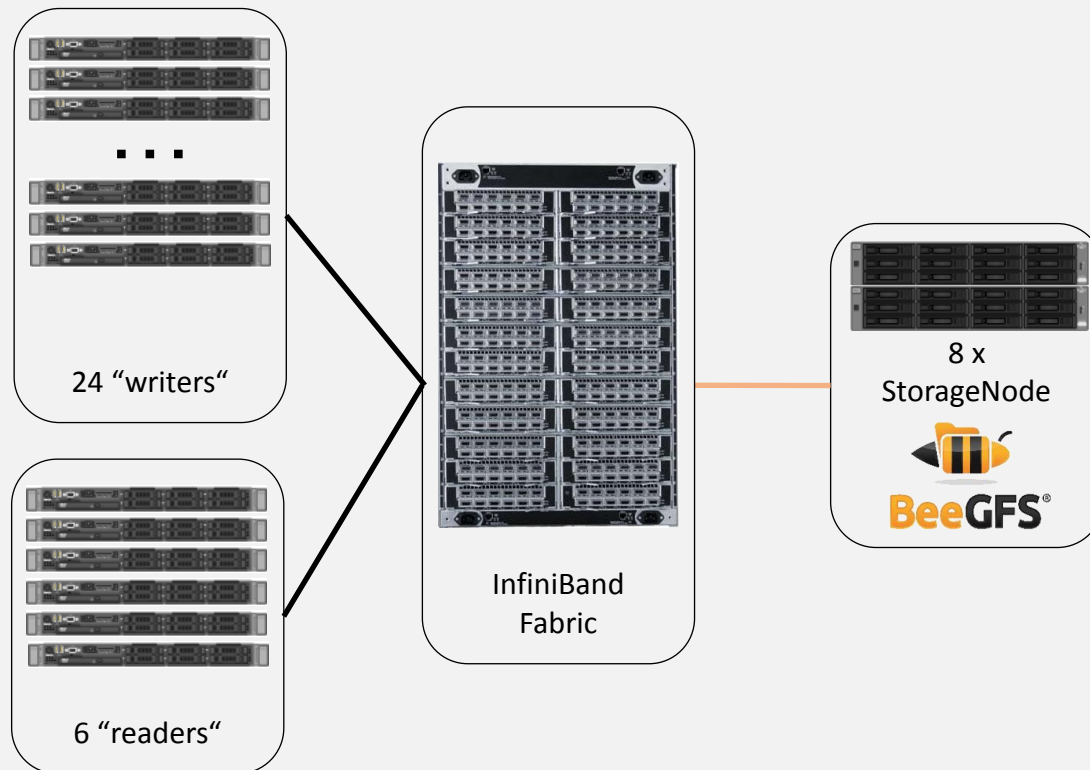
## ■ Situation

- 16 to 32 clients write sequential data, each client a unique data set
- 2 to 8 clients read through (some of) these datasets
- No “writer” needs to access data of any other writer, “readers” have to see everything
- Reads are executed when no writes are done
- **Required sequential writes of 30+ GB/s**

## ■ Customer Expectations

- **Based on previous systems the customer expected to need 800 to 1000 disks in several fibre channel based systems**
- FDR InfiniBand to get enough throughput for the „readers”

# Another workload-optimized solution (2/2)



## ■ Solution

- 8 storage nodes, each with FDR Infiniband
- 60 disks per server, **480 drives total**
- 3 RAID controllers per server, RAID6 8+2

## ■ Performance

- **40 GB/s sustained** writes
- Each reader gets 4+ GB/s
- 1.5 PByte usable capacity

# A hyper-converged solution

- Four compute nodes for seismic data interpretation
- 12x 3.5" drives per compute node
- BeeGFS running on compute nodes, no separate/dedicated storage servers



# Bees up in the Clouds



**Already available...**  
**(Thanks to funding and technical support from Amazon)**

The screenshot shows the AWS Marketplace interface. At the top, there's a search bar with 'beegfs' entered and a 'GO' button. Below the search bar, there are two search results for 'BeeGFS - Support Included' and 'BeeGFS - Free (Community Support)'. The first result is priced at \$350.00/mo + \$0.08 to \$1.326/hr. The second result is free. Both results include a description of BeeGFS as a parallel file system and a link to the Amazon Machine Image (AMI).

**Upcoming...**  
**(Thanks to funding and technical support from Microsoft)**



# To infinity and beyond...



**BeeGFS is participating in exascale projects to stay on the bleeding edge...**

The DEEP-ER logo is displayed in a rounded rectangular box. It consists of the text "DEEP-ER" in a bold, blue, italicized sans-serif font, preceded by three vertical blue bars of varying heights.

The ExaNeSt logo is displayed in a rounded rectangular box. It features a green hexagonal grid pattern on the left, followed by the text "ExaNeSt" in a black, sans-serif font.

A rounded rectangular box containing three black dots, representing an ellipsis, indicating further projects.

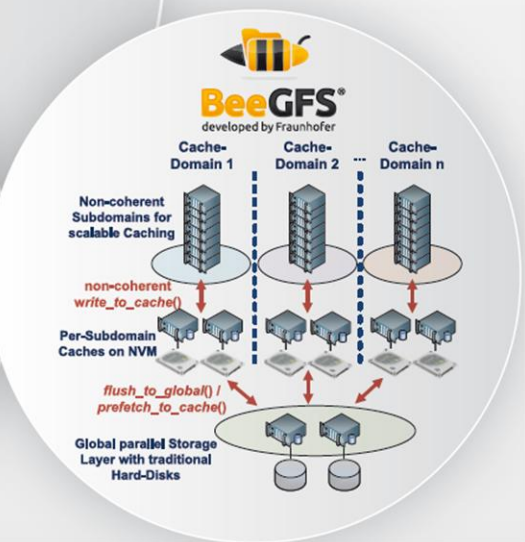
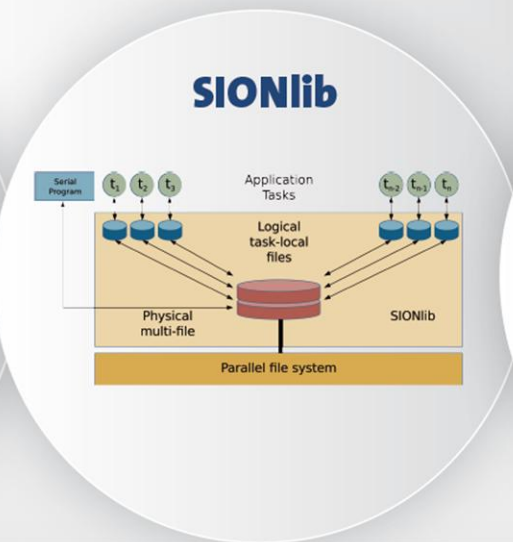
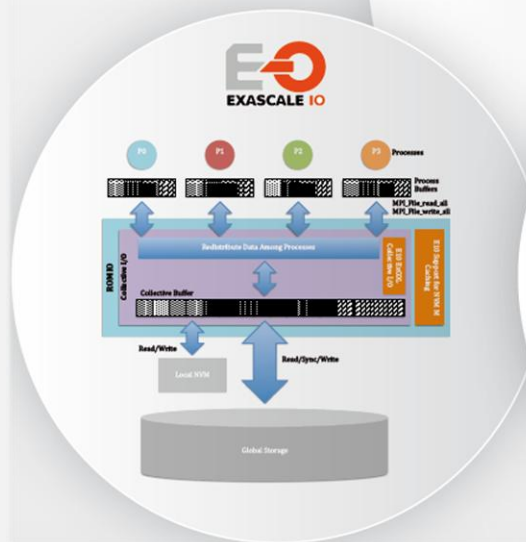
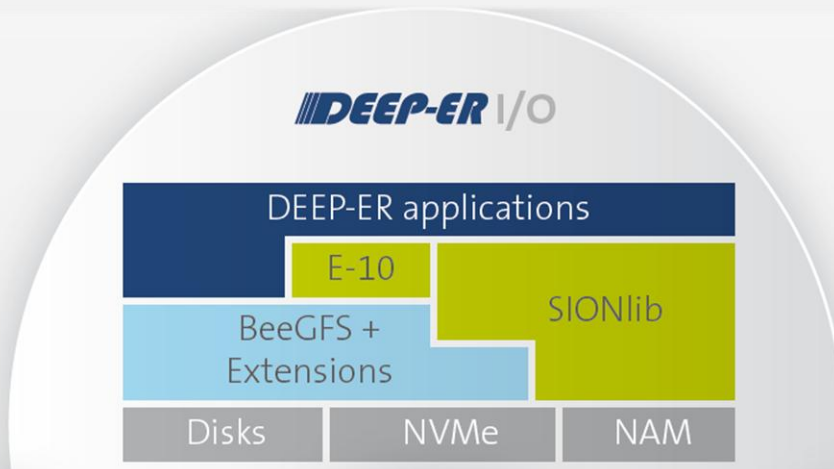
# The DEEP-ER European Exascale Project (FP7)



- DEEP-ER extends cluster/booster concept of DEEP project with focus on application resiliency/recovery and scalable I/O



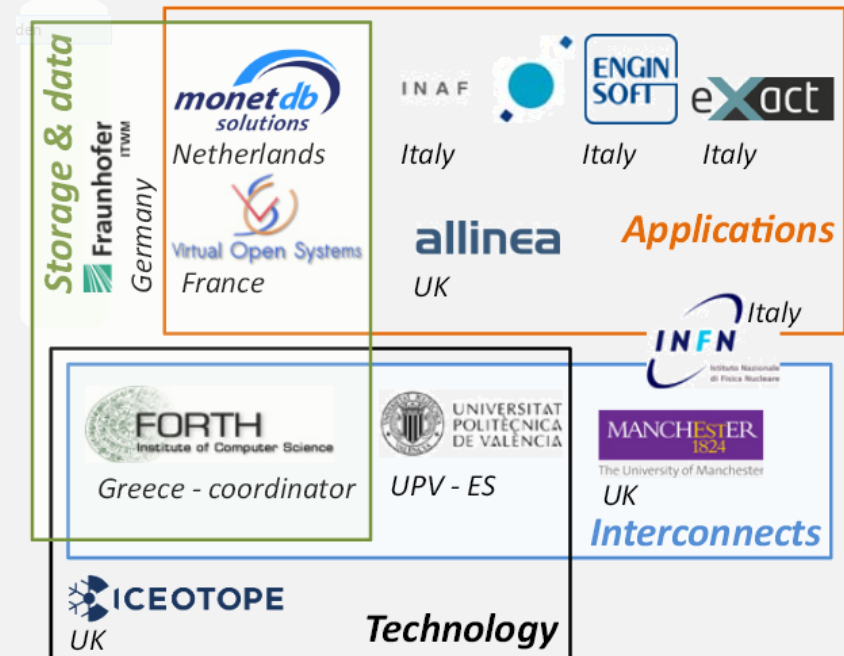
This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement n°610476.





# ExaNeSt (Horizon2020)

- **Exascale Network & Storage**  
EU Project
- Based on **ARM servers**  
with new UNIMEM  
architecture/interconnect for  
dynamic memory sharing

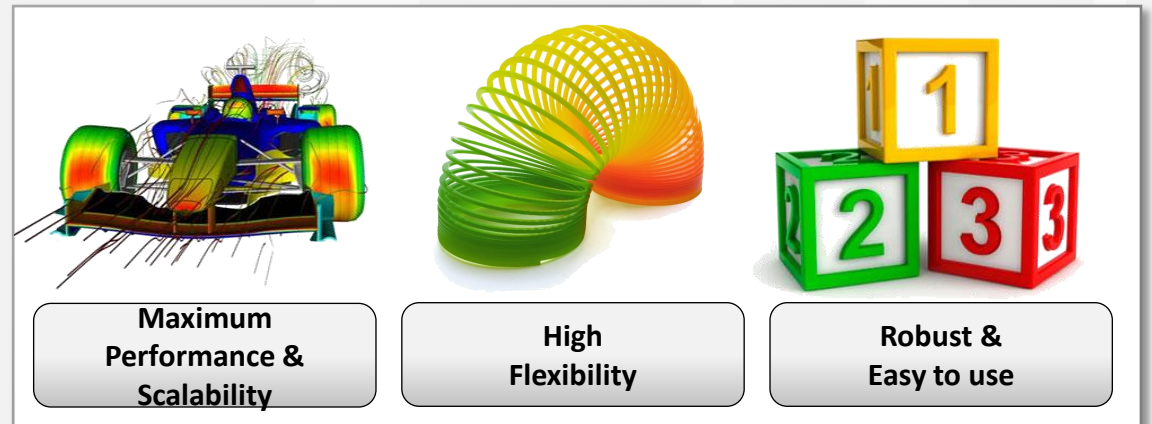


# Conclusion



# Conclusion

- Easy to use and robust parallel file system
- Excellent performance based on highly scalable architecture
- Maximum flexibility with some unique features for special workloads
- Turn-key solutions available, backed by excellent professional support from development team



# Questions? / Keep in touch



- **Web**  
[www.beegfs.com](http://www.beegfs.com)  
[www.thinkparq.com](http://www.thinkparq.com)
- **Mail**  
[sales@thinkparq.com](mailto:sales@thinkparq.com)  
[support@beegfs.com](mailto:support@beegfs.com)
- **Twitter**  
[www.twitter.com/BeeGFS](http://www.twitter.com/BeeGFS)
- **Newsletter**  
[www.beegfs.com/news](http://www.beegfs.com/news)