UPPMAX file systems

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UPPMAX Data Management Seminar
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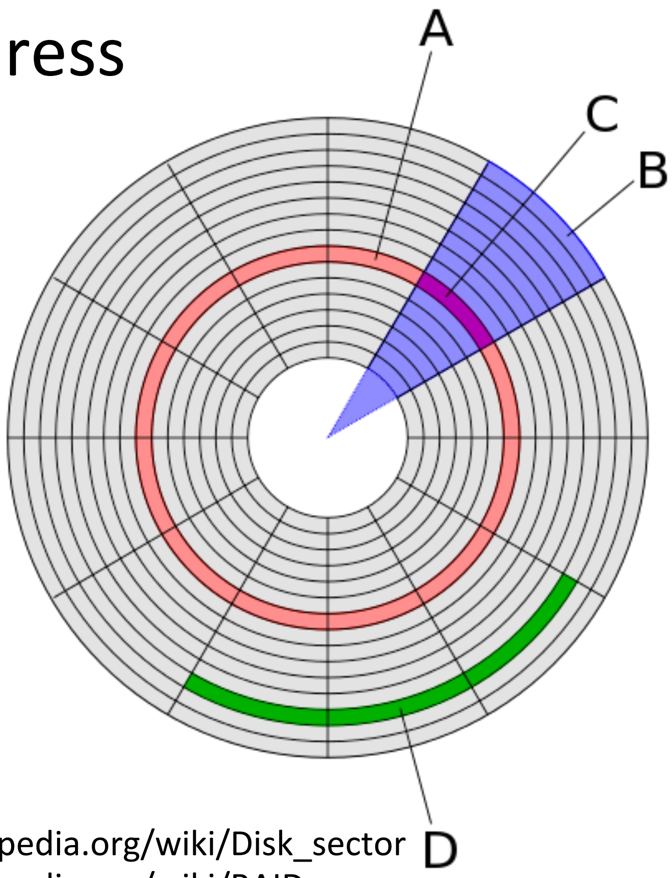
What we'll cover

- What is a computer 'disk' ?
- What is a 'file system' ?
- What is a 'file' ?
- What is high-performance storage ?
- What do the following mean at UPPMAX ?
  - backup storage
  - nobackup
  - private
  - glob
  - scratch
  - node-local
- When do I use what?

What is a computer 'disk' ?

- Storage organised into ***sectors***
  - all sectors of fixed, standard size
  - each has unique hardware address
- Can be virtualised (RAID)
  - many disks appear as one
  - redundancy ('hot-swap')
  - performance



https://en.wikipedia.org/wiki/Disk_sector
https://en.wikipedia.org/wiki/RAID

What is a 'file system' ?

- A method for organising a disk's sectors
  - ext3, HFS+, NTFS, FAT32, many others
  - some are organised to 'hide' the physical disk
- ***Blocks*** are (usually) larger than disk sectors
  - ... also equally-sized and uniquely addressable
- Some blocks are very special (*where is the OS?*)
- *Everything* is built out of blocks
  - In storage, a file can be no smaller than a block
  - Large files are split into separate blocks
  - Files are read by blocks

https://en.wikipedia.org/wiki/File_system `ls -li` shows inode numbers

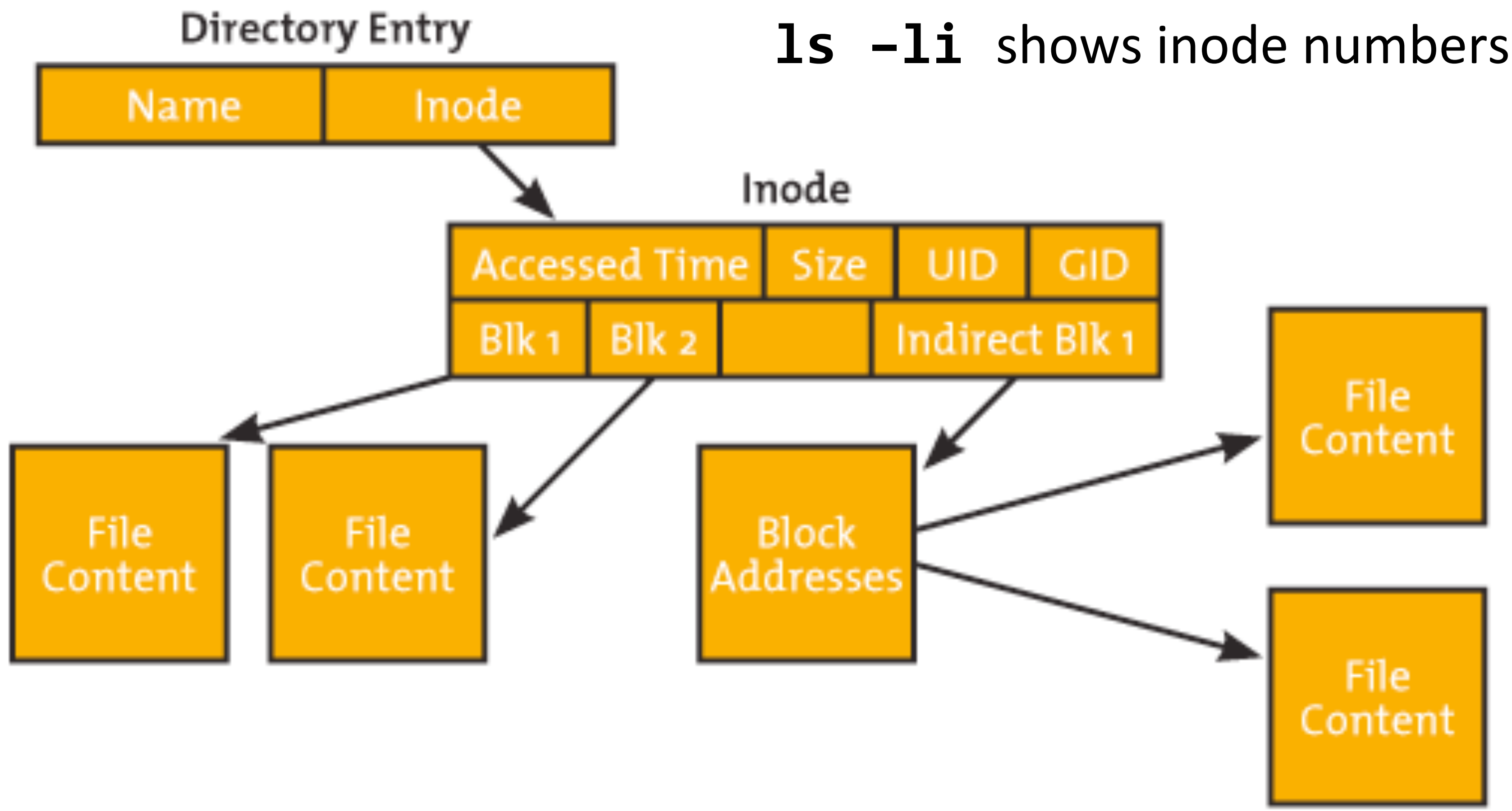
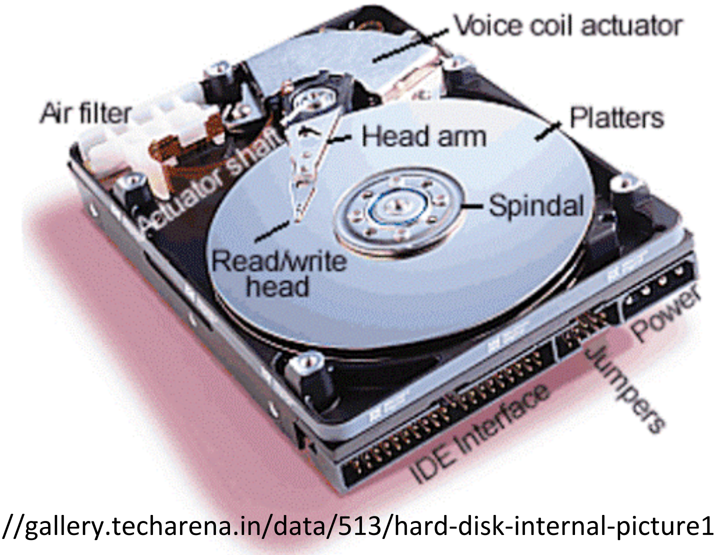


FIGURE 1 RELATIONSHIP BETWEEN THE DIRECTORY ENTRY, AN INODE, AND BLOCKS OF AN ALLOCATED FILE

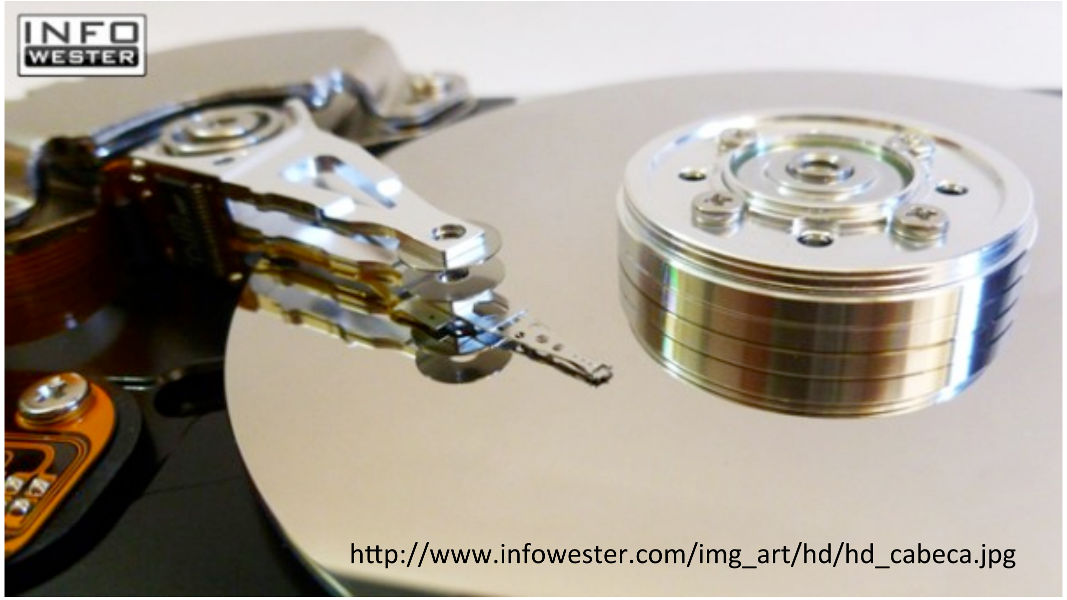
http://gemsres.com/story/aug05/117909/linux-carrier-fig1.gif

Consequences of file systems

- File contents are separate from file *metadata*
- A file cannot be located without its metadata
- Files need not be contiguous on disk
- Read/write speeds may be subject to substantial physical constraints



http://gallery.techarena.in/data/513/hard-disk-internal-picture1.jpg



http://www.infowester.com/img_art/hd/hd_cabeca.jpg

High-performance storage

- Accounts for physical constraints (RAID)
- Intensive file and metadata management
- One file may be spread across many disks
- ... often 2+ copies

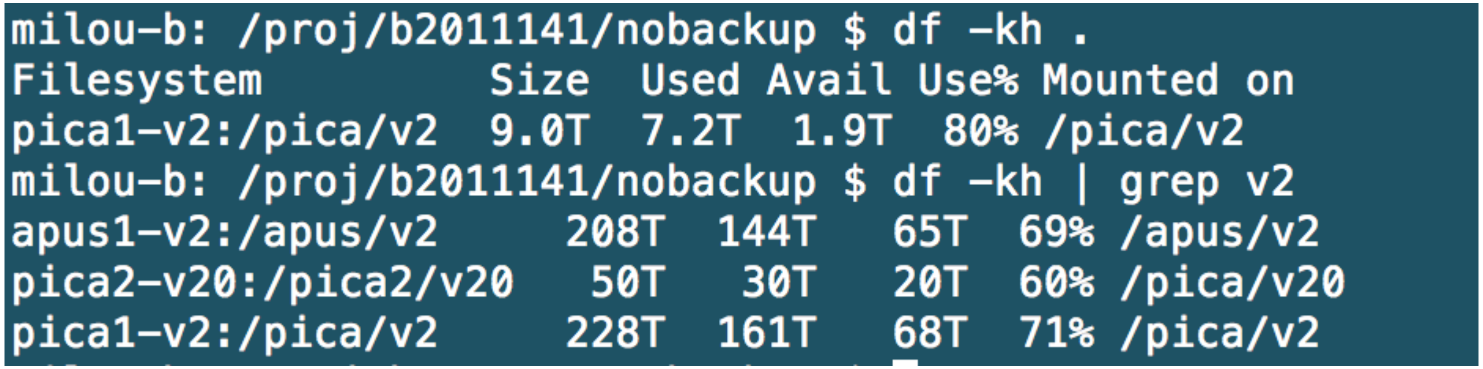
- Always tradeoffs

'Streaming' read/write speed
vs
Speed of random access

https://commons.wikimedia.org/wiki/File:HuaweiRH2288HV2.JPG

When high-performance storage, isn't

- Intensive management requires rapid decisions
- If many reads/writes, many decisions
- As storage fills, more time required per decision
  - Many users + full storage = perfect storm
- Random access requires more time per decision
- **Disks** >90% full likely to experience bottlenecks



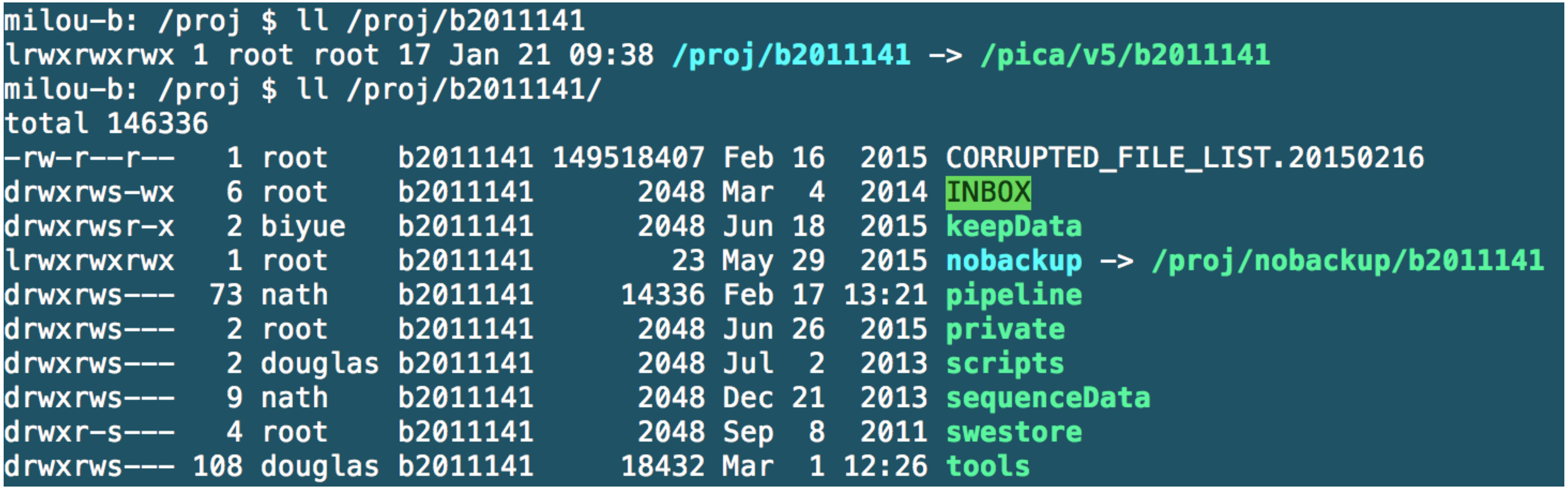
```
milou-b: /proj/b2011141/nobackup $ df -kh .
Filesystem         Size  Used Avail Use% Mounted on
pica1-v2:/pica/v2  9.0T  7.2T  1.9T  80% /pica/v2
milou-b: /proj/b2011141/nobackup $ df -kh | grep v2
apus1-v2:/apus/v2     208T  144T   65T  69% /apus/v2
pica2-v20:/pica2/v20   50T   30T   20T  60% /pica/v20
pica1-v2:/pica/v2     228T  161T   68T  71% /pica/v2
```

Good to know…

- Moving a file (`mv`) on the same disk requires a simple change to the metadata
- Copying (`cp`, `rsync`) or a move between disks requires copying file contents
- A hard link (`ln`) creates a copy of the metadata (new inode) but not the contents
- A symbolic link (`ln -s`) is a simple entry with an alternate name
  - not a copy of the metadata nor the contents

UPPMAX Backup Storage

- Files in `/proj/`*`project-name/`* that are not under `nobackup/` and `INBOX/`

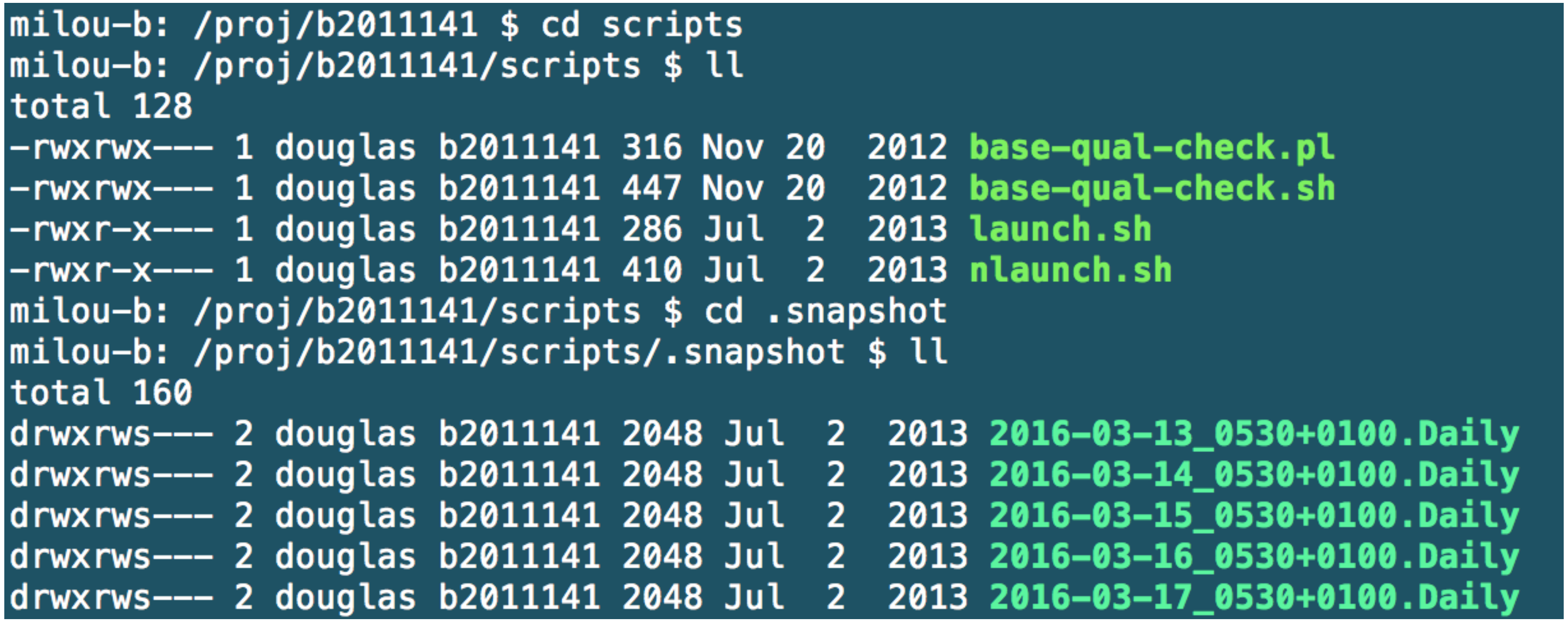


```
milou-b: /proj $ ll /proj/b2011141
lrwxrwxrwx 1 root root 17 Jan 21 09:38 /proj/b2011141 -> /pica/v5/b2011141
milou-b: /proj $ ll /proj/b2011141/
total 146336
-rw-r--r--    1 root    b2011141 149518407 Feb 16  2015 CORRUPTED_FILE_LIST.20150216
drwxrws-wx    6 root    b2011141      2048 Mar  4  2014 INBOX
drwxrwsr-x    2 biyue   b2011141      2048 Jun 18  2015 keepData
lrwxrwxrwx    1 root    b2011141        23 May 29  2015 nobackup -> /proj/nobackup/b2011141
drwxrws---   73 nath    b2011141     14336 Feb 17 13:21 pipeline
drwxrws---    2 root    b2011141      2048 Jun 26  2015 private
drwxrws---    2 douglas b2011141      2048 Jul  2  2013 scripts
drwxrws---    9 nath    b2011141      2048 Dec 21  2013 sequenceData
drwxr-s---    4 root    b2011141      2048 Sep  8  2011 swestore
drwxrws---  108 douglas b2011141     18432 Mar  1 12:26 tools
```

- Files in your home directory

Snapshots

- Each directory in backup storage has a hidden `.snapshot/` folder containing dated backup copies



```
milou-b: /proj/b2011141 $ cd scripts
milou-b: /proj/b2011141/scripts $ ll
total 128
-rwxrwx--- 1 douglas b2011141 316 Nov 20  2012 base-qual-check.pl
-rwxrwx--- 1 douglas b2011141 447 Nov 20  2012 base-qual-check.sh
-rwxr-x--- 1 douglas b2011141 286 Jul  2  2013 launch.sh
-rwxr-x--- 1 douglas b2011141 410 Jul  2  2013 nlaunch.sh
milou-b: /proj/b2011141/scripts $ cd .snapshot
milou-b: /proj/b2011141/scripts/.snapshot $ ll
total 160
drwxrws--- 2 douglas b2011141 2048 Jul  2  2013 2016-03-13_0530+0100.Daily
drwxrws--- 2 douglas b2011141 2048 Jul  2  2013 2016-03-14_0530+0100.Daily
drwxrws--- 2 douglas b2011141 2048 Jul  2  2013 2016-03-15_0530+0100.Daily
drwxrws--- 2 douglas b2011141 2048 Jul  2  2013 2016-03-16_0530+0100.Daily
drwxrws--- 2 douglas b2011141 2048 Jul  2  2013 2016-03-17_0530+0100.Daily
```

Backup storage is expensive

- Snapshots reduce available storage
- Additional computation by the storage system

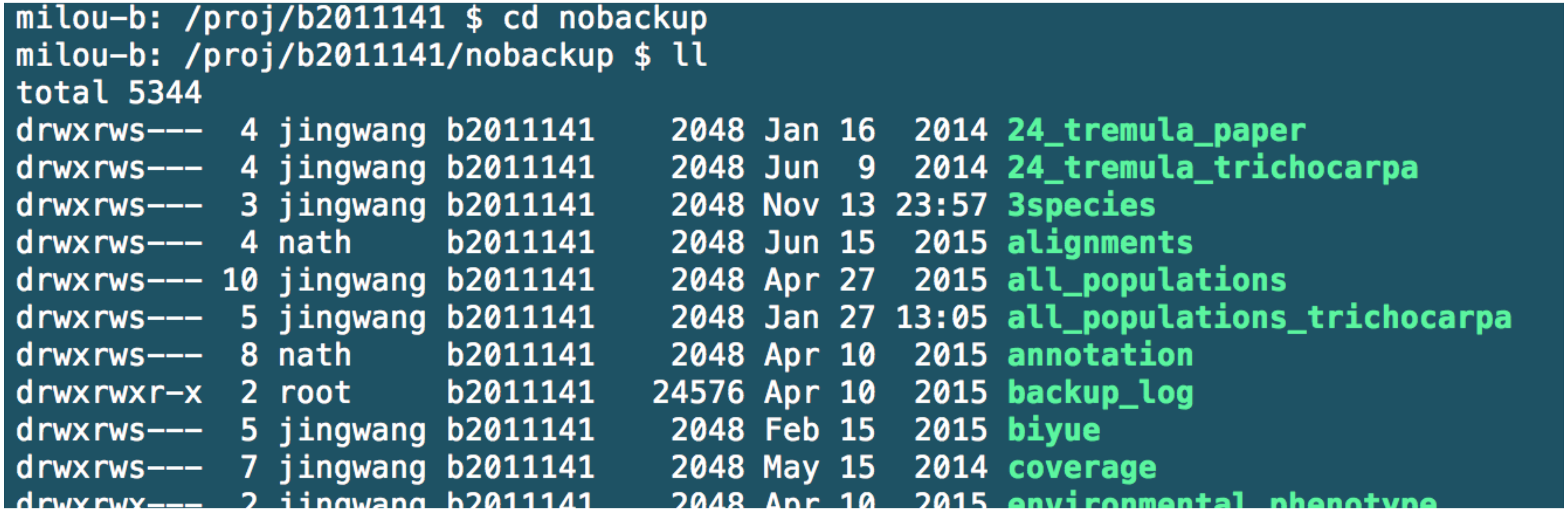
- Within projects, only the most valuable files
  - raw data
  - scripts
  - tools
  - final results

- If it can be regenerated, it doesn't go here!
- Still not a comprehensive backup solution

  What if a tsunami flooded Ånsgströmlaboratoriet?...

UPPMAX Nobackup Storage

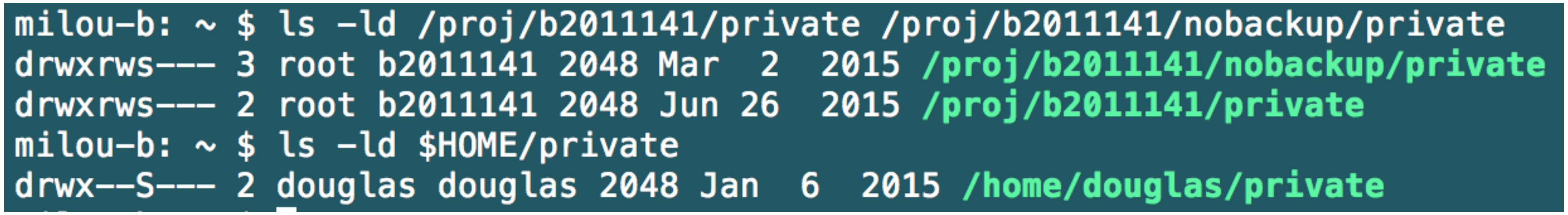
- /proj/*project-name*/nobackup/
- Not backed up
- Contains everything else
  - anything that can be replaced or regenerated
- May be on a different disk ('disk volume')



```
milou-b: /proj/b2011141 $ cd nobackup
milou-b: /proj/b2011141/nobackup $ ll
total 5344
drwxrws---  4 jingwang b2011141    2048 Jan 16  2014 24_tremula_paper
drwxrws---  4 jingwang b2011141    2048 Jun  9  2014 24_tremula_trichocarpa
drwxrws---  3 jingwang b2011141    2048 Nov 13 23:57 3species
drwxrws---  4 nath     b2011141    2048 Jun 15  2015 alignments
drwxrws--- 10 jingwang b2011141    2048 Apr 27  2015 all_populations
drwxrws---  5 jingwang b2011141    2048 Jan 27 13:05 all_populations_trichocarpa
drwxrws---  8 nath     b2011141    2048 Apr 10  2015 annotation
drwxrwxr-x  2 root     b2011141   24576 Apr 10  2015 backup_log
drwxrws---  5 jingwang b2011141    2048 Feb 15  2015 biyue
drwxrws---  7 jingwang b2011141    2048 May 15  2014 coverage
drwxrwx---  2 jingwang b2011141    2048 Apr 10  2015 environmental_phenotype
```

UPPMAX `private/`

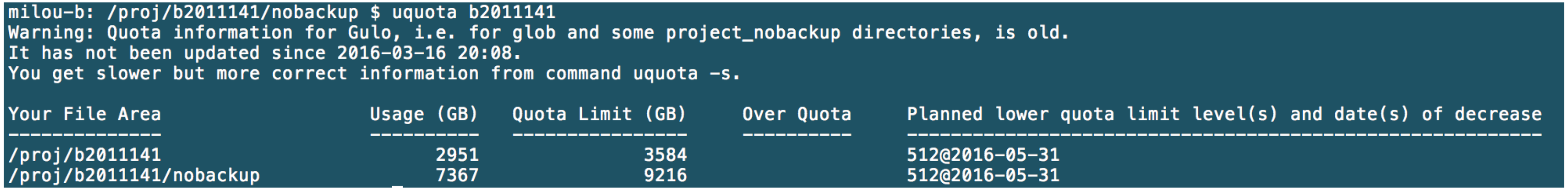
- Contents only accessible to project members
  - `/proj/`*`project-name`*`/private/`
  - `/proj/`*`project-name`*`/nobackup/private/`
- Contents only accessible to you
  - `$HOME/private/`



```
milou-b: ~ $ ls -ld /proj/b2011141/private /proj/b2011141/nobackup/private
drwxrws--- 3 root b2011141 2048 Mar  2  2015 /proj/b2011141/nobackup/private
drwxrws--- 2 root b2011141 2048 Jun 26  2015 /proj/b2011141/private
milou-b: ~ $ ls -ld $HOME/private
drwx--S--- 2 douglas douglas 2048 Jan  6  2015 /home/douglas/private
```

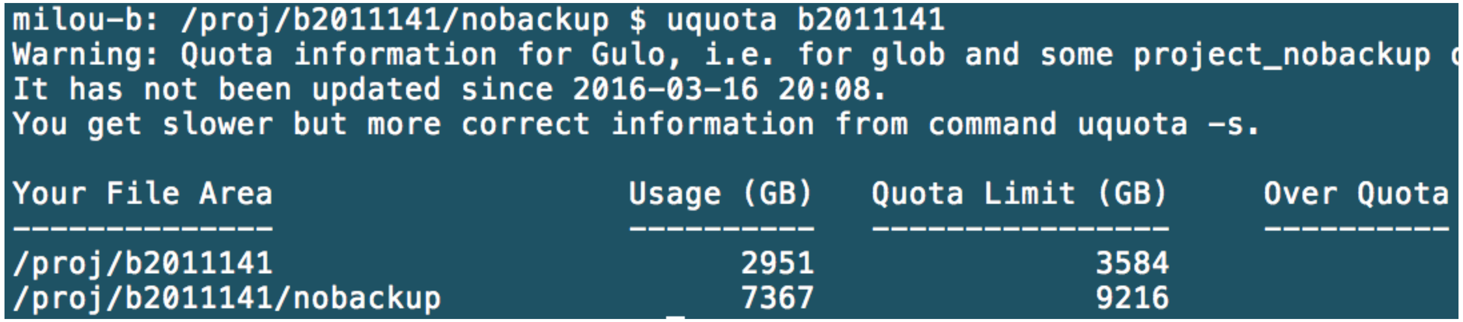
UPPMAX Quotas

- `uquota [ `*`project-number`*` ]`
- **Hard quota: cannot be exceeded!!!!!**
- True for both *projects* and *home directories*
- Quota increases are **temporary**



```
milou-b: /proj/b2011141/nobackup $ uquota b2011141
Warning: Quota information for Gulo, i.e. for glob and some project_nobackup directories, is old.
It has not been updated since 2016-03-16 20:08.
You get slower but more correct information from command uquota -s.

Your File Area                   Usage (GB)   Quota Limit (GB)     Over Quota     Planned lower quota limit level(s) and date(s) of decrease
--------------                   ----------   ----------------     ----------     ----------------------------------------------------------
/proj/b2011141                         2951               3584                    512@2016-05-31
/proj/b2011141/nobackup                7367               9216                    512@2016-05-31
```



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--------------                   ----------   ----------------     ----------
/proj/b2011141                         2951               3584
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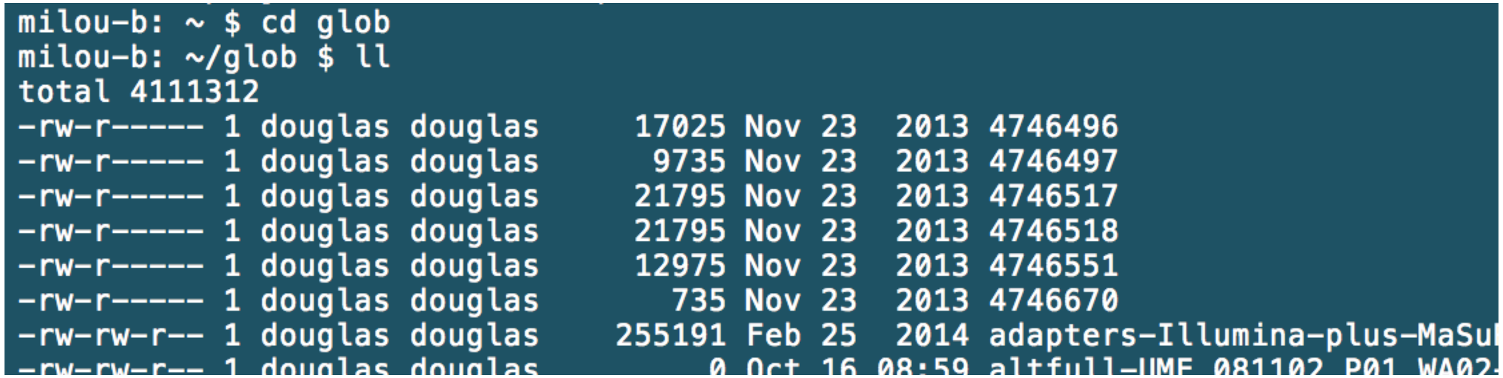
```

UPPMAX glob

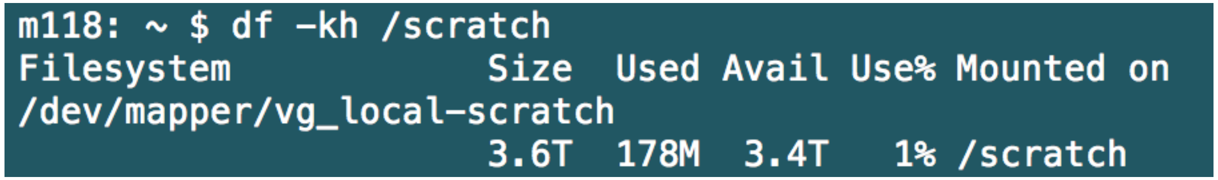
- `$HOME/glob/`
- Nobackup for your home directory
- Quota, but not a hard quota
  - ideal for large, short-lived files of unknown size
- Currently located on `/gulo` disk
  - (usually) higher performance than `/pica`
  - limited remaining lifetime (less than a year)



```
milou-b: ~ $ cd glob
milou-b: ~/glob $ ll
total 4111312
-rw-r----- 1 douglas douglas     17025 Nov 23  2013 4746496
-rw-r----- 1 douglas douglas      9735 Nov 23  2013 4746497
-rw-r----- 1 douglas douglas     21795 Nov 23  2013 4746517
-rw-r----- 1 douglas douglas     21795 Nov 23  2013 4746518
-rw-r----- 1 douglas douglas     12975 Nov 23  2013 4746551
-rw-r----- 1 douglas douglas       735 Nov 23  2013 4746670
-rw-rw-r-- 1 douglas douglas    255191 Feb 25  2014 adapters-Illumina-plus-MaSu
-rw-rw-r-- 1 douglas douglas         0 Oct 16 08:59 altfull-UME_081102_P01_WA02-
```

UPPMAX Scratch Storage

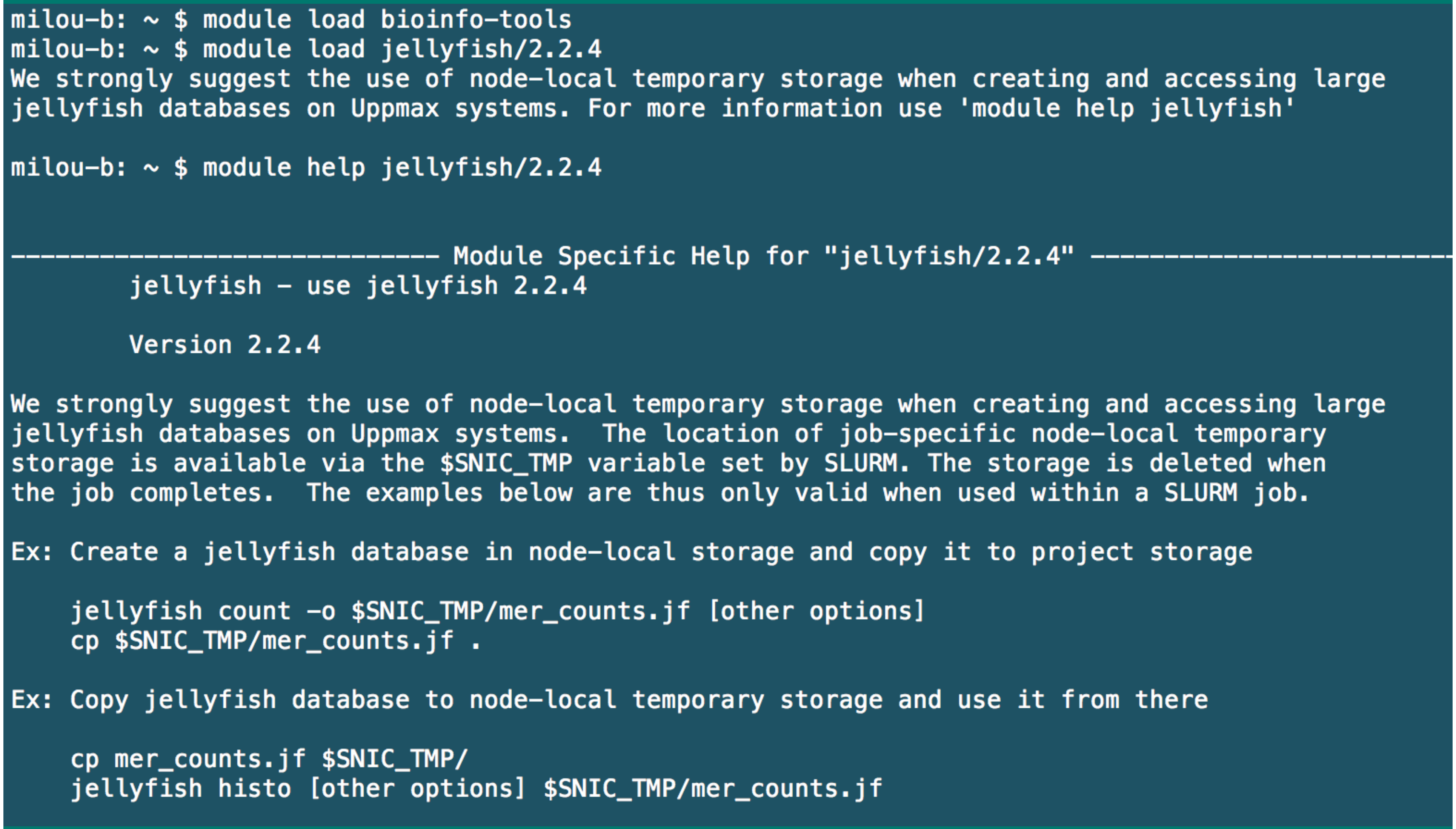
- A disk located on the node itself ('**node-local**')
- `$SNIC_TMP` is always set to its location
  - `/scratch` on a login node
  - `/scratch/`*`job-number`* within a SLURM job
- Explicitly short-lived and nobackup
  - deleted at end of job
- 'Small' size shared with other users
  - about 3 TB on milou compute nodes



```
m118: ~ $ df -kh /scratch
Filesystem            Size  Used Avail Use% Mounted on
/dev/mapper/vg_local-scratch
                      3.6T  178M  3.4T   1% /scratch
```

Using scratch might really help

- UPPMAX high-performance disks are not optimised for random access (RA)
- RA occurs during database creation and usage
  - k-mer counts, custom blast databases, ...
  - some jobs will run 10x faster or more
- For a single job, it might not matter
- For multiple jobs it is really worth considering
  - especially if many jobs could run at the same time
- Do some tests!



```
milou-b: ~ $ module load bioinfo-tools
milou-b: ~ $ module load jellyfish/2.2.4
We strongly suggest the use of node-local temporary storage when creating and accessing large
jellyfish databases on Uppmax systems. For more information use 'module help jellyfish'

milou-b: ~ $ module help jellyfish/2.2.4


----------------------------- Module Specific Help for "jellyfish/2.2.4" -------------------------
        jellyfish - use jellyfish 2.2.4

        Version 2.2.4

We strongly suggest the use of node-local temporary storage when creating and accessing large
jellyfish databases on Uppmax systems.  The location of job-specific node-local temporary
storage is available via the $SNIC_TMP variable set by SLURM. The storage is deleted when
the job completes.  The examples below are thus only valid when used within a SLURM job.

Ex: Create a jellyfish database in node-local storage and copy it to project storage

    jellyfish count -o $SNIC_TMP/mer_counts.jf [other options]
    cp $SNIC_TMP/mer_counts.jf .

Ex: Copy jellyfish database to node-local temporary storage and use it from there

    cp mer_counts.jf $SNIC_TMP/
    jellyfish histo [other options] $SNIC_TMP/mer_counts.jf
```

UPPMAX storage, by task

- Read large permanent files (FastQ)
  - project backed-up storage
- Read/write of large created files (BAM, ...)
  - glob, project nobackup
- Database creation and use?
  - under 3TB? yes: scratch   no: project nobackup
- Ensured privacy?
  - private storage in project or home directory
- Uncertain, or have specific questions? Ask!