Rebalancing the HTCondor fairshare

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INFN-T1, Current Status (HTC-CE/HTC)

- $(6+1)\times$ HTC-CE, $(1+1)\times$ CM, $1\times$ SN (Remote Submission from local UI)
- $(875+216)\times$ WN, ($\sim(55+15.5)$ Kcores, $\sim(430+215)$ KHS06)
- HTC 9.0.11 (latest Long Term Release version), HTC-CE, 5.1.3
- ~ 50 User groups: 26 Grid VOs, ~ 25 local user groups.
- Every user group yearly negotiates Computing Power **quotas**, which are then translated to percentual **shares** of the *expected* Total Computing Power of the centre.

Fairshare

- A fairshare policy is designed to provide active users with an average amount of CPU power proportional with their shares on the available resources while also preventing *starvation* and *underusage*.

Starvation: A job is never dispatched because there always are higher priority ones.

Underusage: Computing resources remain unused because constraints on job requirements never meet cachine capabilities.

Typical workload at INFN-T1

- Saturation: whenever a computing slot becomes available, there always is a pending job who could be started there.
- Heterogeneity: user groups have independent and almost unpredictable submission patterns and payload size (duration, memory and I/O needs). In particular
- Job size: mix of multicore (8-core) and singlecore, even from the same user.

Limits of Fairshare

There are situations where a particular group can work far from its expected average quota. These depends on several conditions. Two notable ones are:

1. Mcore availability vs Mcore demand

- demand for mcore slots can grow and drop quickly and frequently.
- Provisioning mcore resources takes time: no machine normally has 8 free slots, thus a draining policy is needed. This of course implies resources underusage during the draining time.

2. Different Node Computing Power

- Different Compute Node (aka WN) models have different power (in HS06).
- However the fairshare implementation does not consider specific core power.

Common strategies to provide Multicore resources

Use DEFRAG. HTCondor daemon configured to implement a draining policy

Cons: does not cope well with dynamic multicore demand.

Static provisioning. A set of nodes is dedicated to only accept multicore jobs

Cons: Risk of machine underusage or group overquota

Use both. Useful to model a fixed base load plus dynamic pattern.

Cons: better, but no static tuning fits all submission patterns.

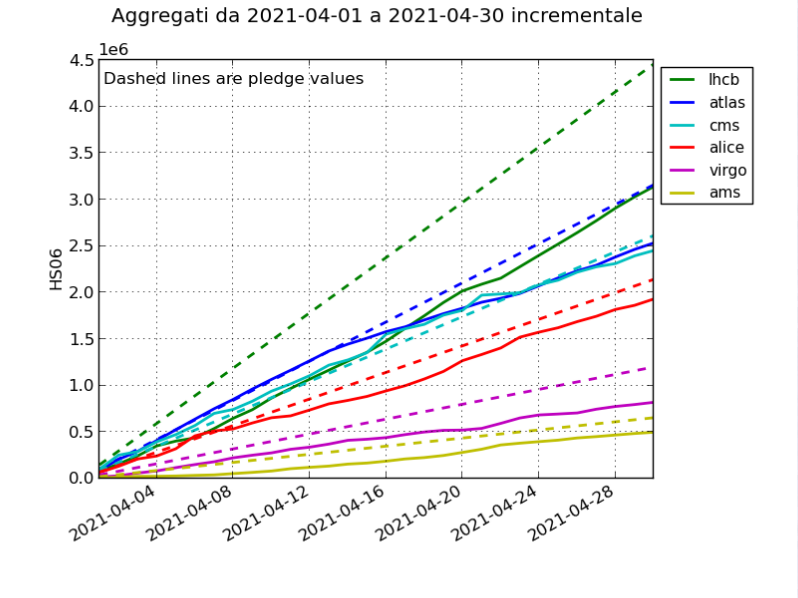
- All the above "classic methods", in order, were adopted at CNAF.
- A new strategy was defined, implemented and adopted starting from Jul. 2021. We compare results and explain the method.

Problems with classic methods

Note: in the following: multicore → mc , singlecore → sc.

1. Unused slots on mc shortage, or overpledge of a group over another one
2. un-even opportunities: sc jobs tend to start sooner than mc of the same group
3. mc of some groups last much longer than others (days vs hours)
4. fairshare makes no distinction on sc and mc and is unaware of different core power
5. whenever a mc job ends (and claim expired) one sc is likely to be the "next one" in queue and claim one of 8 just freed cores. Thus a new defrag time is needed.

Cumulative work vs pledges (classic methods vs new method)



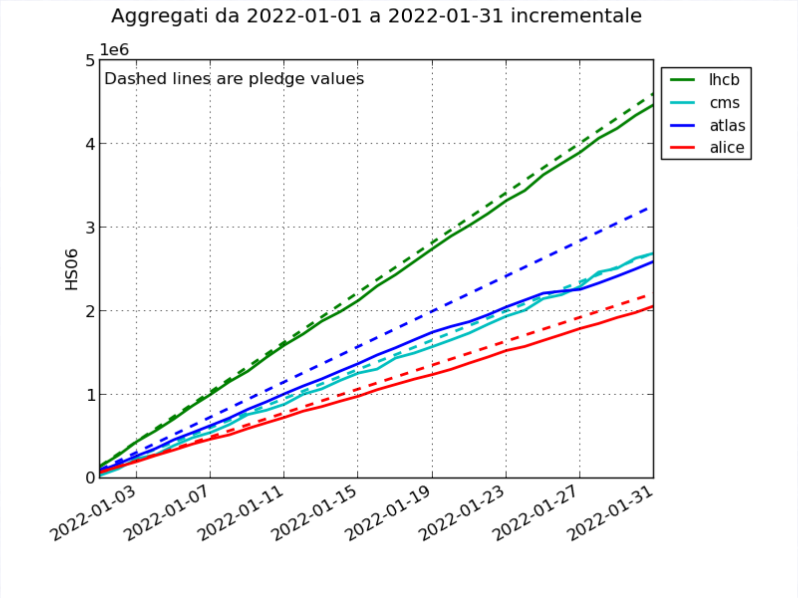


Figure 1. **Left: April 2021**. LHCb (sc only) under quota, ALICE (sc only as of April) almost ok. **Right: January 2022**. All groups reasonably near to target, except for ATLAS (discontinuous submission rate)

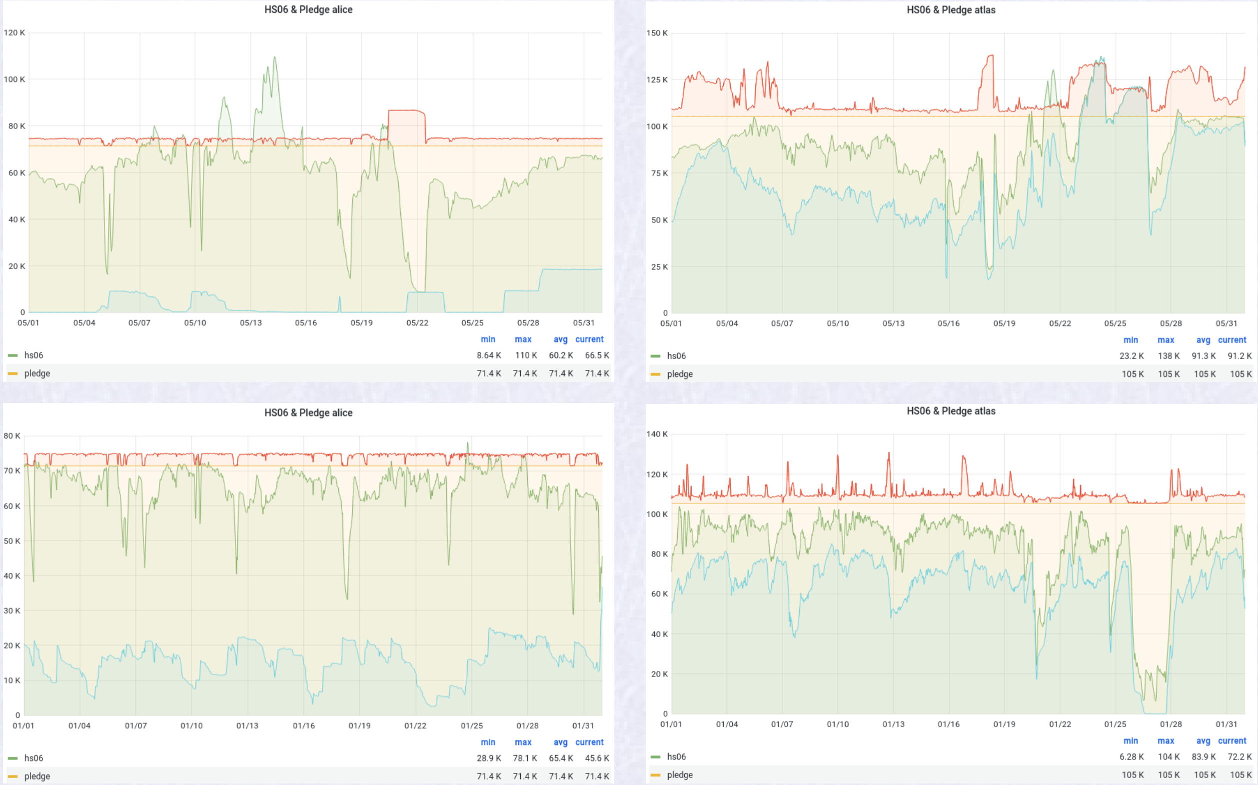


Figure 2. ALICE, ATLAS, 30 days, old vs new method

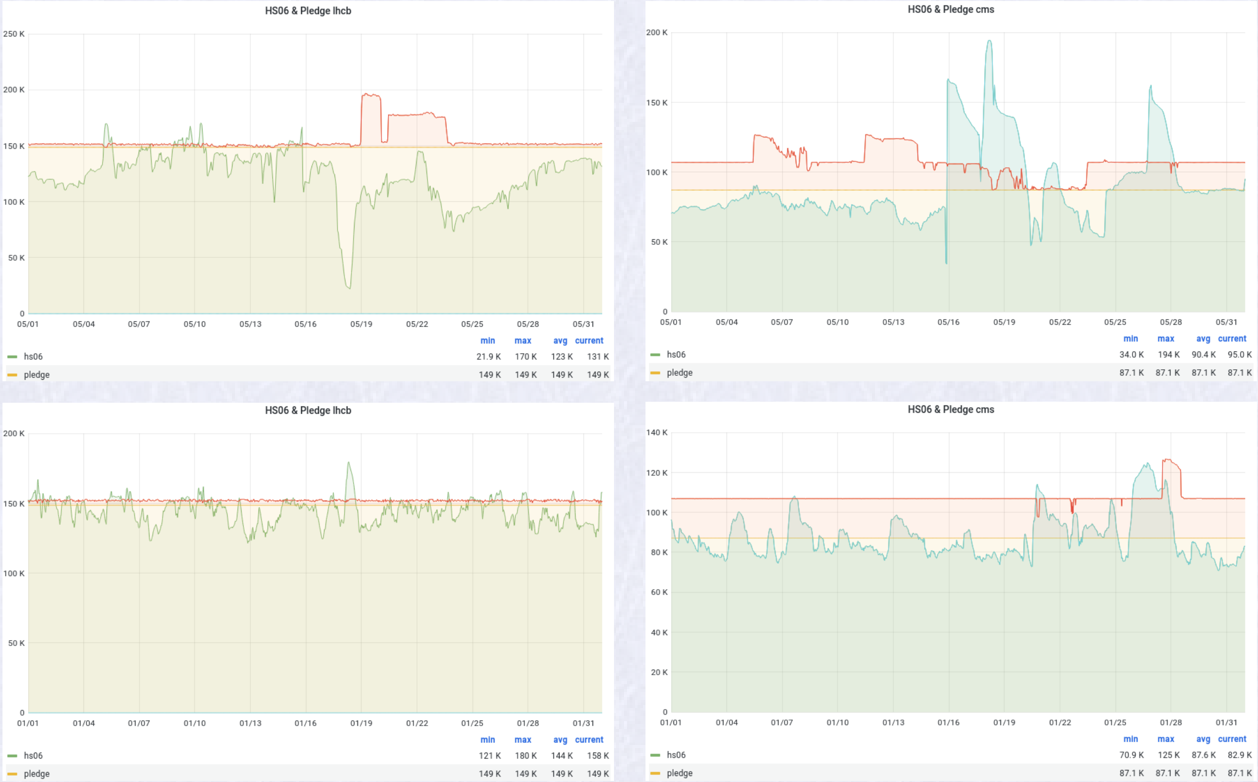
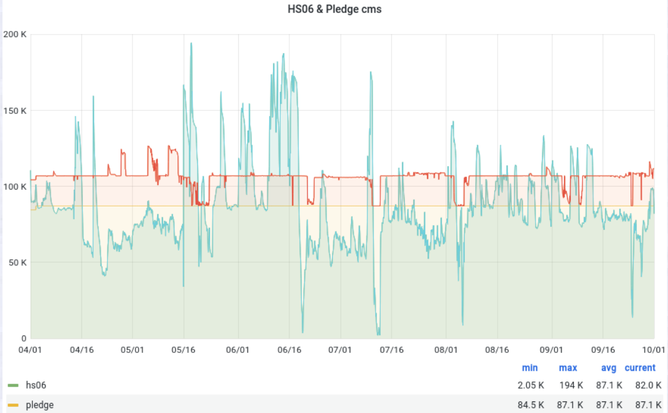
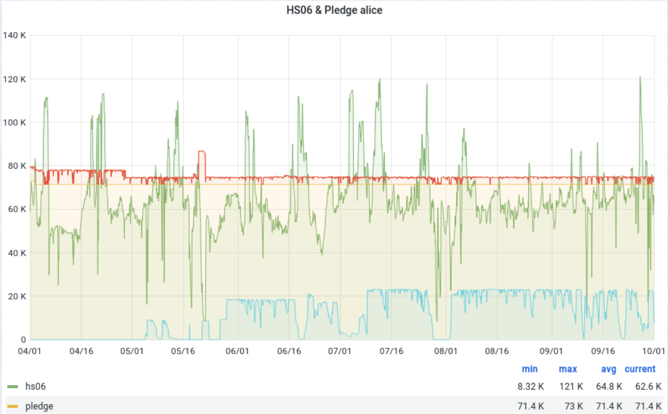
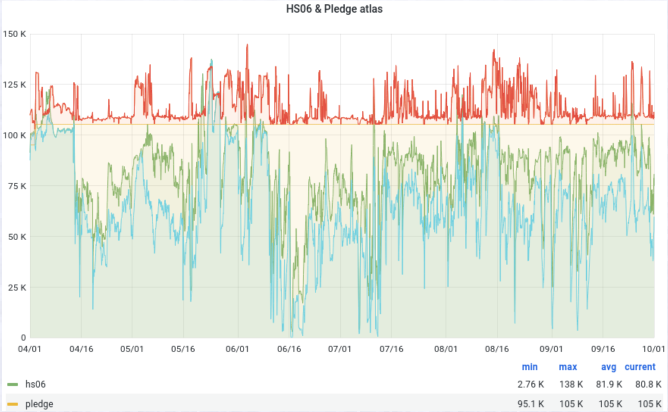


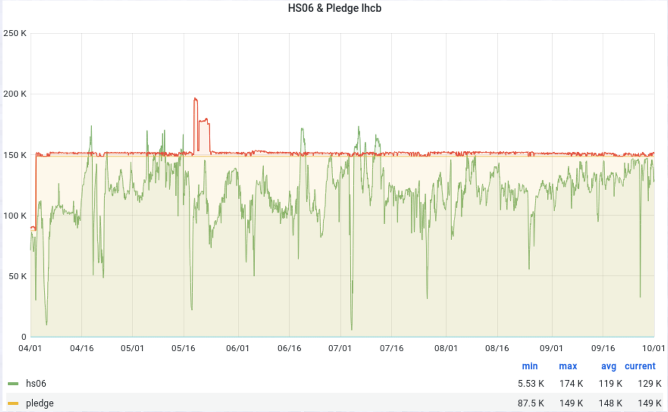
Figure 3. LHCb, CMS, 30 days, old vs new method

LHC VOs jobs, over 6 months (Apr. to Sep 2021)









Ideas for the new method

1. Add a grace time: when a mc job ends, only accept another mc for some time.
2. For each group g, having a target quota $\bar{q}_g$, consider the errors $\boxed{e_g(t) = q_g(t) - \bar{q}_g}$
3. Compute $\boxed{g_r = \mathrm{Arg\,max}\,\{e_g\}}$, $\boxed{g_p = \mathrm{Arg\,min}\,\{e_g\}}$ for groups with pending jobs.
4. Add constraints on a set of WN accept jobs from g_p and limit those from g_r.

Implementation

1. A `STARTD` cronjob defines a custom boolean classad attribute `MC_GRACE` defined as `True` if 8 Cpus are free for less than a few minutes (currently: 8 mins).
2. Computing e_g requires to centrally collect data for all running and pending jobs.
3. Another `STARTD` cronjob (`JOB_CTL`) to set a few more custom machine attributes

Collecting data (Warning: gory details ahead!)

Every 17 minutes we run:

```
condor_q -global -all -cons 'Member(JobStatus,{1,2}) && (JobUniverse != 7)' \
-af JobStatus  'split((RemoteHost ?: "u@PEND.t1"),"@.")[1]' \
'split(AcctGroup,".")[0]' 'time() - (JobStartDate ?: time())' \
'CpusProvisioned ?: min({RequestCpus ?: 1,8})' \
'((int(MATCH_t1_wn_hs06 ?: 400) + 0.0)/(MATCH_TotalSlotCpus ?: 40))'

# MATCH_t1_wn_hs06 = node power as machine classad attribute, inherited by the job
# MATCH_TotalSlotCpus = same as NUM_CPUS, inherited by the job
# NOTE: We already collect elsewhere these data for monitoring
```

The output is worked on and appended to an auxiliary shares_Error.log file:

# TO	VO	PLEDGE	DC	SC	MC	DHS	DPHS	PSC	PMC
1627101243	**cms**	87100	-542	0	4888	**-3321**	-29403	0	12784
1627101243	atlas	105300	-236	1608	4720	-489	-32021	4	2572
1627101243	**alice**	71400	1150	4170	1432	**12594**	-8785	242	410

Final result goes to a shared file:

condor_q -glob ... -af ... / AcctGroup_hs06.txt → sharectl.py → /shared/sharectl.txt

The sharectl file

Since CMS is under quota ($e_{\text{CMS}} < 0$) and ALICE is over quota, we reduce by 8 the maximum number of allowed ALICE cores per machine. We do this according to the number of pending CMS jobs. We set this target into the shared file, which looks like this:

```
~$ cat /shared/sharectl.txt
cn-609-05-06 alice 56 cms 8
cn-610-02-03 alice 56 cms 8
cn-608-06-06 alice 42 cms 8
...
```

The JOB_CTL cronjob. Run by STARTD every 13 mins. It sets the following attributes:

```
cn-609-05-06 ~]# condor_status -comp -af:ln t1_CurrentJobs t1_TargetGroups t1_Targetcores
t1_CurrentJobs = alice:64:lhcb:3:atlas:5
t1_TargetGroups = { "alice","cms" }
t1_Targetcores = { 56,8 } # { 0,0 } means no target
```

It checks for its hostname into `sharectl.txt` and set `t1_Target*` accordingly

Now to the START expression (just a little bit cumbersome)

```
cn-609-05-06 ~]# ccv StartJobs
True && (!t1_overheat) && (t1_mc_grace) && t1_sharectl

#Prevent singlecore when MC_GRACE is True
cn-610-05-06 ~]# ccv t1_mc_grace
( (TARGET.RequestCpus > 1) || ((TARGET.RequestCpus == 1) && !(MC_GRACE ?: False)) )

cn-610-05-06 ~]# ccv t1_sharectl
( (t1_Targetcores[0] =?= 0) || \
(( split(AcctGroup,".")[0] =?= t1_TargetGroups[1] && RequestCpus =?= t1_Targetcores[1] ) || \
( AcctGroup =?= t1_TargetGroups[0] && \
(t1_Targetcores[0] ?: 0) > int(split(t1_CurrentJobs ?: "none:0",":")[1]))))
```

```
cn-609-05-06 ~]# condor_status -comp -af:ln t1_CurrentJobs t1_TargetGroups t1_Targetcores
t1_CurrentJobs = alice:64:lhcb:3:atlas:5
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```

Observations

- This setup can be active on a subset ($\sim 50\%$ or more) of total computing power.
- The HTCondor `DEFRAG` daemon was stopped a few days after
- The `Errors` used to compute `sharectl.log` are in `HS06` units.
- The actual scheduling is driven by the HTCondor fairshare algorithm. This method is only intended to reduce imbalances experienced when using the classic methods.

Work in progress and future plans

- For every user group g, having a target quota $\bar{q}_g$, the control policy only consider the latest value for the error $\boxed{e_g(t) = q_g(t) - \bar{q}_g}$, i.e. current - target quota. We expect better results by averaging it with past values (More in general: PID controller or other classic control theory approaches).
- Since a rich dataset is made available from our monitoring system, we would like to attempt the training of a ML/DL model (e.g. reinforcement learning).