# HTCondor in Production

## Seamlessly automating maintenance, OS and HTCondor updates, all integrated with HTCondor's scheduling

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Physikalisches Institut
UNIVERSITÄT BONN

# Physics Institute at University of Bonn

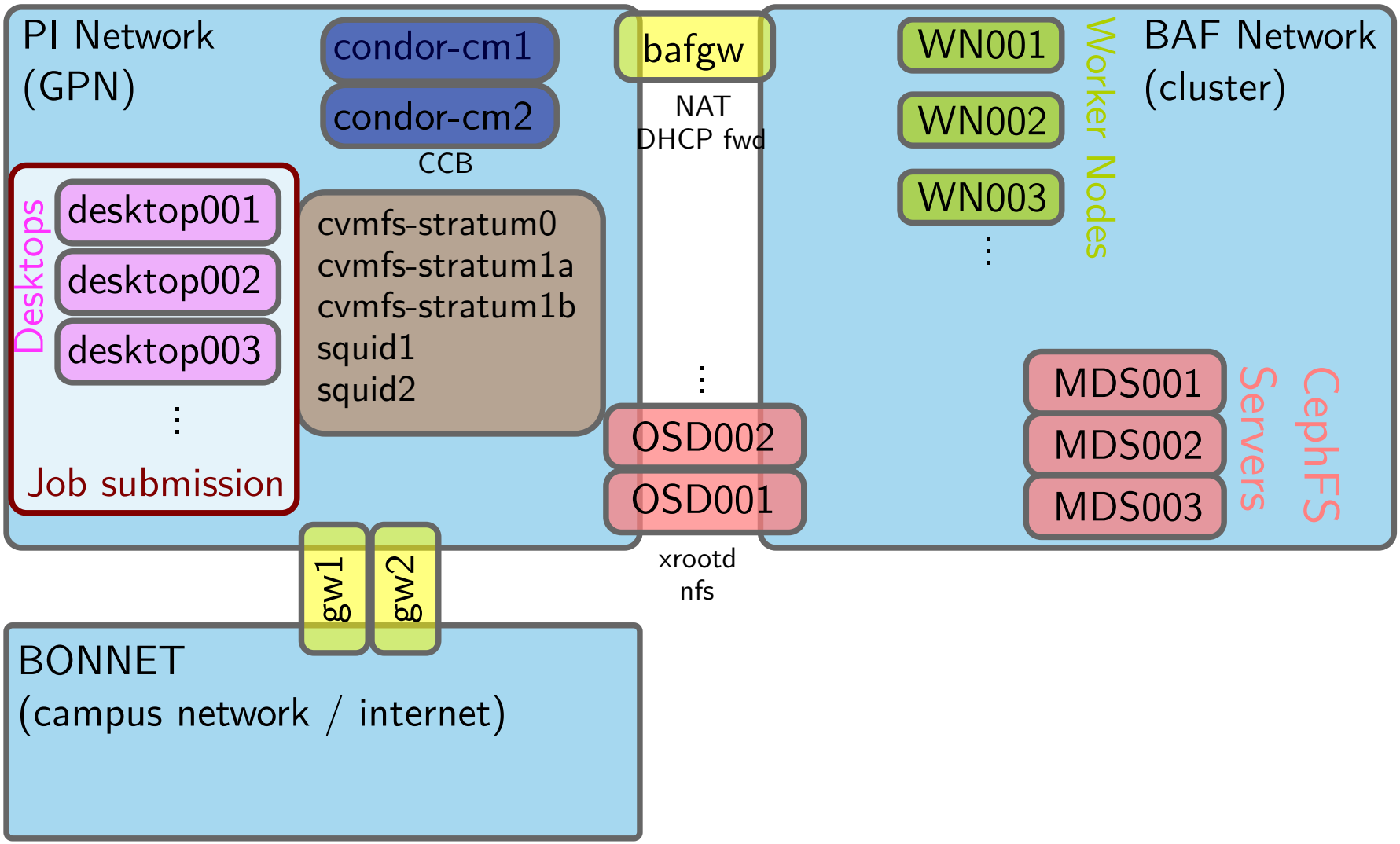
- 240 members
- Biggest particle accelerator run by a German university ('ELSA', 164.4 m circumference) with two experiments ($\approx$ 50 people)
- Groups from:
  - Particle physics: ATLAS, Belle II
  - Hadron physics
  - detector development
  - photonics
  - theory groups

**One cluster with growing hardware diversity & slowly growing resources for all users.**

## Provided by us — we are...

2 'full time' people, but cluster operations is only a small fraction
+ various part-time helping hands
$\Rightarrow$**High degree of automation needed!**

# Services surrounding the cluster



# Key points of our setup

- No login / submission nodes ('use your desktop')
- Condor central managers in desktop network
- Desktops running Ubuntu 18.04 LTS --→ Debian 10
- Cluster nodes running CentOS 7.8 --→ CentOS 8
- Full containerization (all user jobs run in containers)
- Containerization decouples OS upgrades from user jobs
- Cluster file system (CephFS) directly accessible from Desktop machines via NFS.
- Cluster worker nodes interconnected with InfiniBand (56 $^{\text{Gbit}}/_{\text{s}}$), second data centre with Ethernet (1 $^{\text{Gbit}}/_{\text{s}}$ per node, 10 $^{\text{Gbit}}/_{\text{s}}$ total)
- All desktops, worker nodes, condor central managers fully puppetized, for HTCondor: HEP-Puppet/htcondor
  Module allows to set up queue super-users, block users from submission, set up HTCondor for Singularity, set up a health check,...

# HTCondor Automation

## `STARTD_CRON` jobs on execute nodes

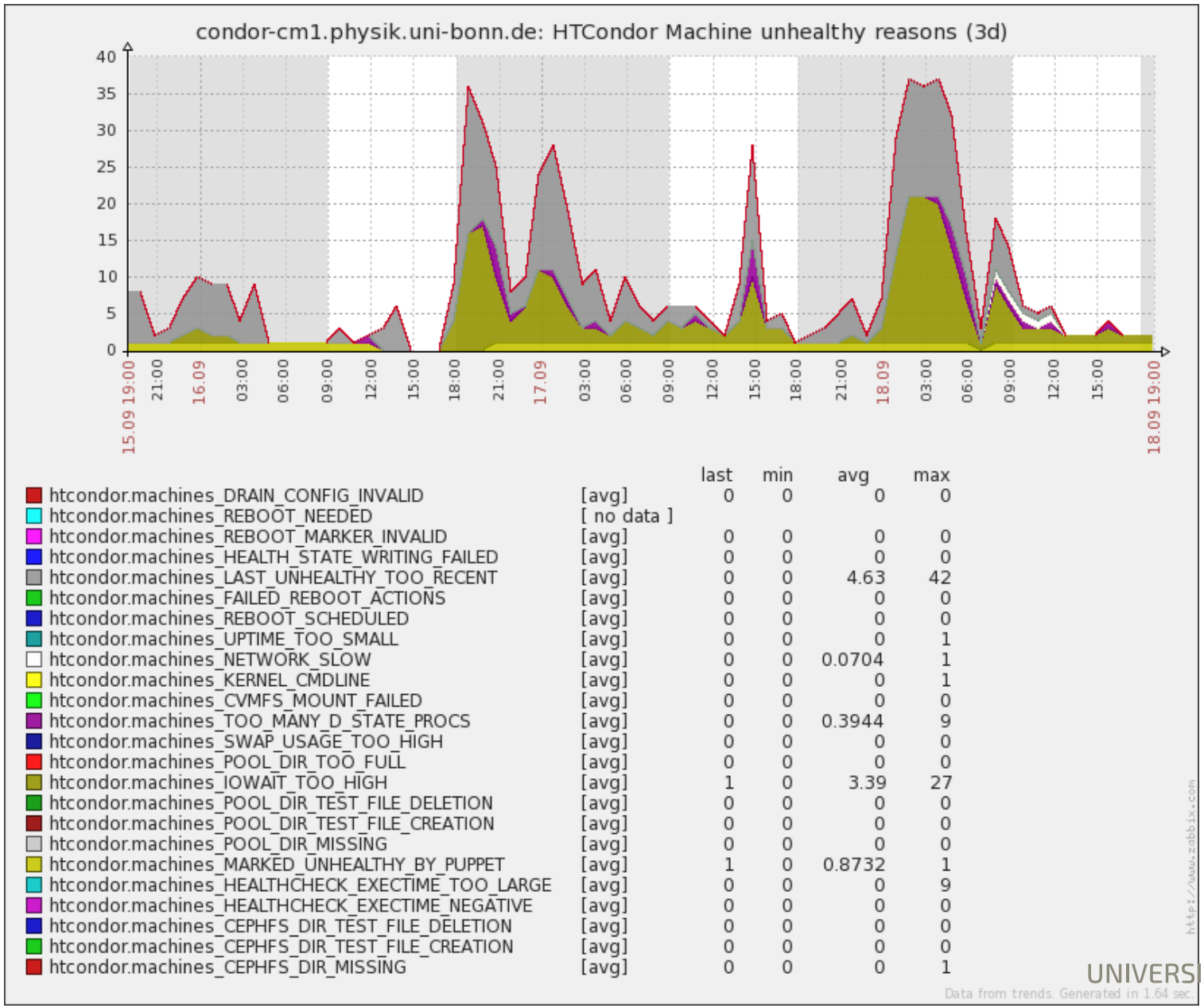
- node health check, covered in detail in this talk
  *runs every minute*
- script extracting job and machine information (*every 5 min*):
  - `condor_who` to determine the latest job end time
    *(we ask users to specify maximum runtime, more later)*
  - `condor_status` to find out applied drain settings
    *(more later)*

## If you have not used `STARTD_CRON` yet...

Output of `STARTD_CRON` becomes part of slot classads by default.

- Allows to adjust the `START` expression based on node health.
- Allows to use information in matchmaking with d-slots.

# Node health checking

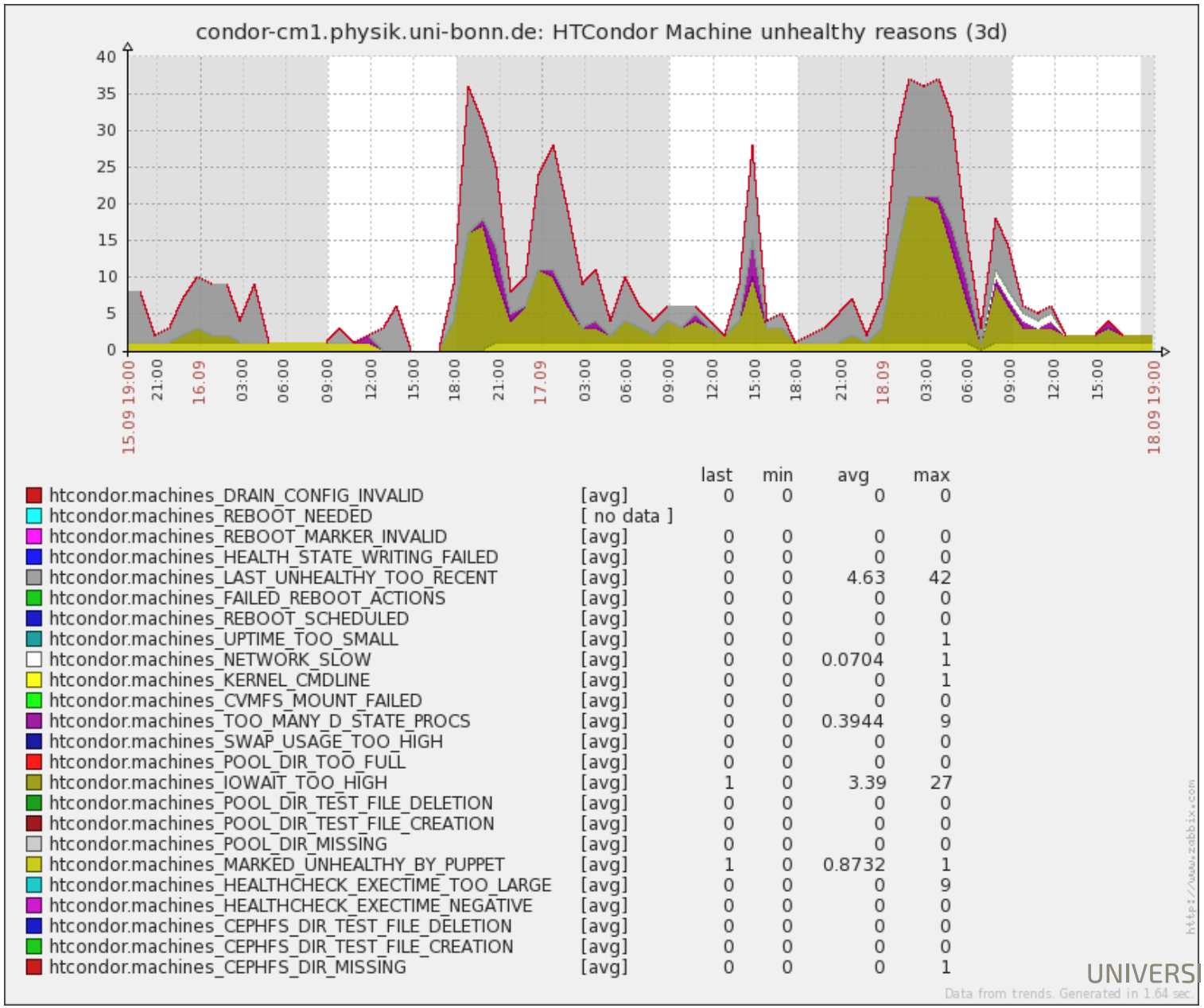



| | | last | min | avg | max |
|---|---|---|---|---|---|
| htcondor.machines_DRAIN_CONFIG_INVALID | [avg] | 0 | 0 | 0 | 0 |
| htcondor.machines_REBOOT_NEEDED | [ no data ] | | | | |
| htcondor.machines_REBOOT_MARKER_INVALID | [avg] | 0 | 0 | 0 | 0 |
| htcondor.machines_HEALTH_STATE_WRITING_FAILED | [avg] | 0 | 0 | 0 | 0 |
| htcondor.machines_LAST_UNHEALTHY_TOO_RECENT | [avg] | 0 | 0 | 4.63 | 42 |
| htcondor.machines_FAILED_REBOOT_ACTIONS | [avg] | 0 | 0 | 0 | 0 |
| htcondor.machines_REBOOT_SCHEDULED | [avg] | 0 | 0 | 0 | 0 |
| htcondor.machines_UPTIME_TOO_SMALL | [avg] | 0 | 0 | 0 | 1 |
| htcondor.machines_NETWORK_SLOW | [avg] | 0 | 0 | 0.0704 | 1 |
| htcondor.machines_KERNEL_CMDLINE | [avg] | 0 | 0 | 0 | 1 |
| htcondor.machines_CVMFS_MOUNT_FAILED | [avg] | 0 | 0 | 0 | 0 |
| htcondor.machines_TOO_MANY_D_STATE_PROCS | [avg] | 0 | 0 | 0.3944 | 9 |
| htcondor.machines_SWAP_USAGE_TOO_HIGH | [avg] | 0 | 0 | 0 | 0 |
| htcondor.machines_POOL_DIR_TOO_FULL | [avg] | 0 | 0 | 0 | 0 |
| htcondor.machines_IOWAIT_TOO_HIGH | [avg] | 1 | 0 | 3.39 | 27 |
| htcondor.machines_POOL_DIR_TEST_FILE_DELETION | [avg] | 0 | 0 | 0 | 0 |
| htcondor.machines_POOL_DIR_TEST_FILE_CREATION | [avg] | 0 | 0 | 0 | 0 |
| htcondor.machines_POOL_DIR_MISSING | [avg] | 0 | 0 | 0 | 0 |
| htcondor.machines_MARKED_UNHEALTHY_BY_PUPPET | [avg] | 1 | 0 | 0.8732 | 1 |
| htcondor.machines_HEALTHCHECK_EXECTIME_TOO_LARGE | [avg] | 0 | 0 | 0 | 9 |
| htcondor.machines_HEALTHCHECK_EXECTIME_NEGATIVE | [avg] | 0 | 0 | 0 | 0 |
| htcondor.machines_CEPHFS_DIR_TEST_FILE_DELETION | [avg] | 0 | 0 | 0 | 0 |
| htcondor.machines_CEPHFS_DIR_TEST_FILE_CREATION | [avg] | 0 | 0 | 0 | 0 |
| htcondor.machines_CEPHFS_DIR_MISSING | [avg] | 0 | 0 | 0 | 1 |

# Node health checking: Reasons for ‘unhealthiness’

- last ‘UNHEALTHY’ too recent (debouncing, $\leq 10\,\text{min}$)
  - writing of status files failed or syntax bad (drain configuration, reboot marker, health state)
  - failed reboot actions (more later!)
  - reboot scheduled (i.e. `shutdown` command with timeout)
  - minimum uptime ($\leq 20\,\text{min}$)
  - slow network interface ($\leq 100\,\text{Mbit/s}$)
  - bad kernel command line (should contain ‘`console=`’)
  - unhealthy CVMFS mounts
- swap usage is too high ($> 80\,\%$, HTCondor does not monitor swap)
- iowait too high ($> 15\,\%$)
- number of processes in D state too large ($> \frac{\#\text{logical cores}}{2}$)
  - read / write of execute directory or $> 80\,\%$ used (don’t limit disk use yet)
  - administrative ‘UNHEALTHY’ marker
  - read / write of cluster file system, check if mount healthy
  - execution time of health check ($> 10\,\text{s}$)

# Node health checking

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# Node reboot handling

Two kinds of reboot reasons:
Reasons triggering staggered draining, reasons that don't drain

## Draining reboot reasons

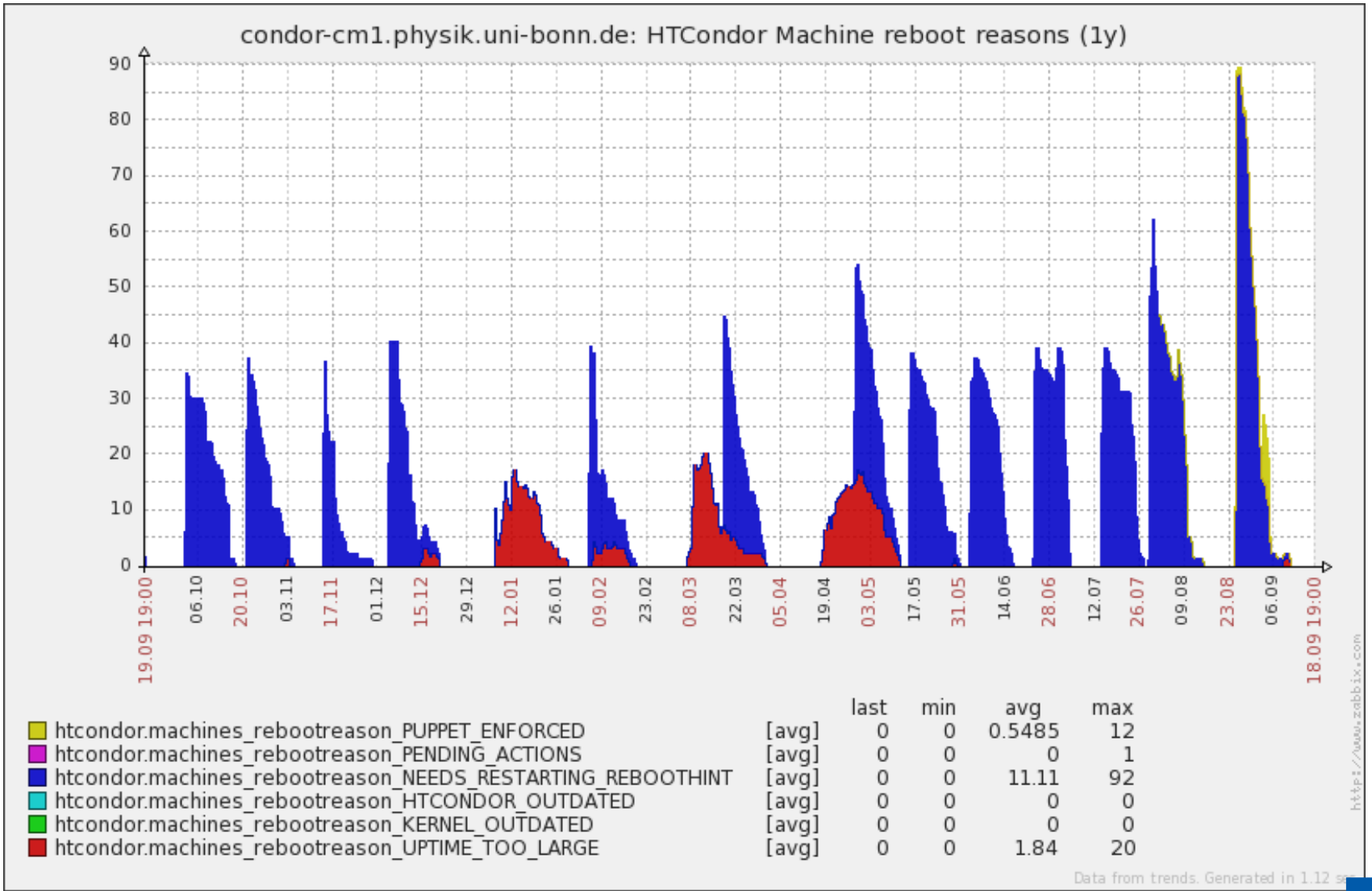
- Reboot for updates via `needs-restarting -r`
- Other possibilities: Kernel version too old, uptime $> 30\,\mathrm{d}$
- Start of drain smeared out over $10\,\mathrm{d}$
- If drain starts, node marked for **immediate draining**

## Non-draining reboot reasons

- Admin-enforced (Puppet)
- Pending actions to execute on reboot

- 'HTCondor version too old' can either be draining or non-draining

# Node reboot handling



# Node reboot handling in practice

- Hourly cronjob checks number of:
  `condor_starter` , jobs ( `condor_who` ), `condor_startd`
- No jobs and starters are found, but `condor_startd` running:
  1. Run `condor_off -peaceful`
  2. Wait up to two minutes until `condor_startd` is gone
- When 'all' are gone, check if `condor.service` is still active (might have failed!) and if it is not, alert admins
- If all is well, execute any executables from `/etc/wn-reboot-actions`
  *Admins can use that to hook into the reboot process!*
- Output is summarized into a mail sent to the admin mailing list, 30 min before the actual reboot / shutdown.
- Special reboot actions possible:
  `reboot`, `shutdown`, `notification`

# Draining: How a node becomes empty

## Several techniques to drain a node...

- **immediate draining**
  accept only jobs shorter than the latest allowed finish time of all running jobs
  ⇒ *like 'peaceful', but more efficient*
- **timed draining**
  don't accept jobs which may run longer than until a given point in time
  ⇒ *planned maintenance periods*
- **unhealthiness**
  don't accept any jobs anymore
  ⇒ *really like 'peaceful', used for hardware or software issues*

⇒ After the draining, the 'reboot' code runs!

# Draining: How to implement in HTCondor

- Users set `+MaxRuntimeHours` in their jobs (added to `SIGNIFICANT_ATTRIBUTES`)

```
START = ($(START)) && (MY.BackfillableMaxRuntimeHours >=
↪  ifThenElse(isUndefined(TARGET.MaxRuntimeHours), 168,
↪  TARGET.MaxRuntimeHours) )
```

⇒ Define `BackfillableMaxRuntimeHours` (variables are read in by `STARTD_CRON` jobs):

```
BackfillableMaxRuntimeHours_IMMEDIATE_DRAIN =
↪  ifThenElse((MY.IMMEDIATE_DRAIN =?= True) &&
↪  isInteger(MY.MaxLatestJobEndTime),
↪  Max({(MY.MaxLatestJobEndTime-time())/60/60-1, 0}),168)
BackfillableMaxRuntimeHours_TIMED_DRAIN =
↪  ifThenElse((MY.TIMED_DRAIN =?= True) &&
↪  isInteger(MY.DRAIN_TARGET_TIME),
↪  Max({(MY.DRAIN_TARGET_TIME-time())/60/60-1, 0}),168)
```

# Draining: How to implement in HTCondor

- Users set `+MaxRuntimeHours` in their jobs (added to `SIGNIFICANT_ATTRIBUTES`)

```
START = ($(START)) && (MY.BackfillableMaxRuntimeHours >=
↪  ifThenElse(isUndefined(TARGET.MaxRuntimeHours), 168,
↪  TARGET.MaxRuntimeHours) )
```

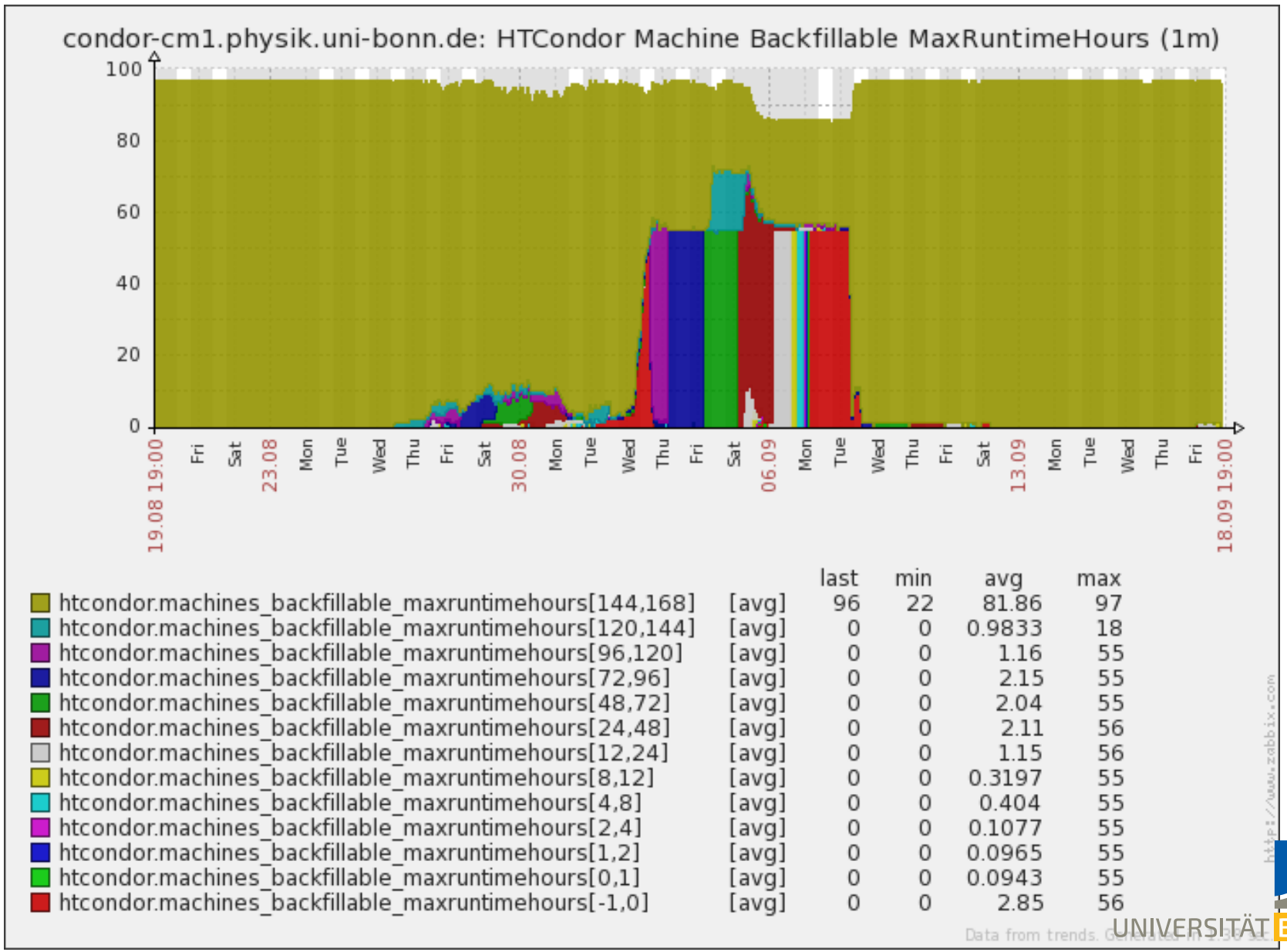
Finally, merge both:

```
BackfillableMaxRuntimeHours =
↪  Min({BackfillableMaxRuntimeHours_IMMEDIATE_DRAIN,
↪  BackfillableMaxRuntimeHours_TIMED_DRAIN})
```

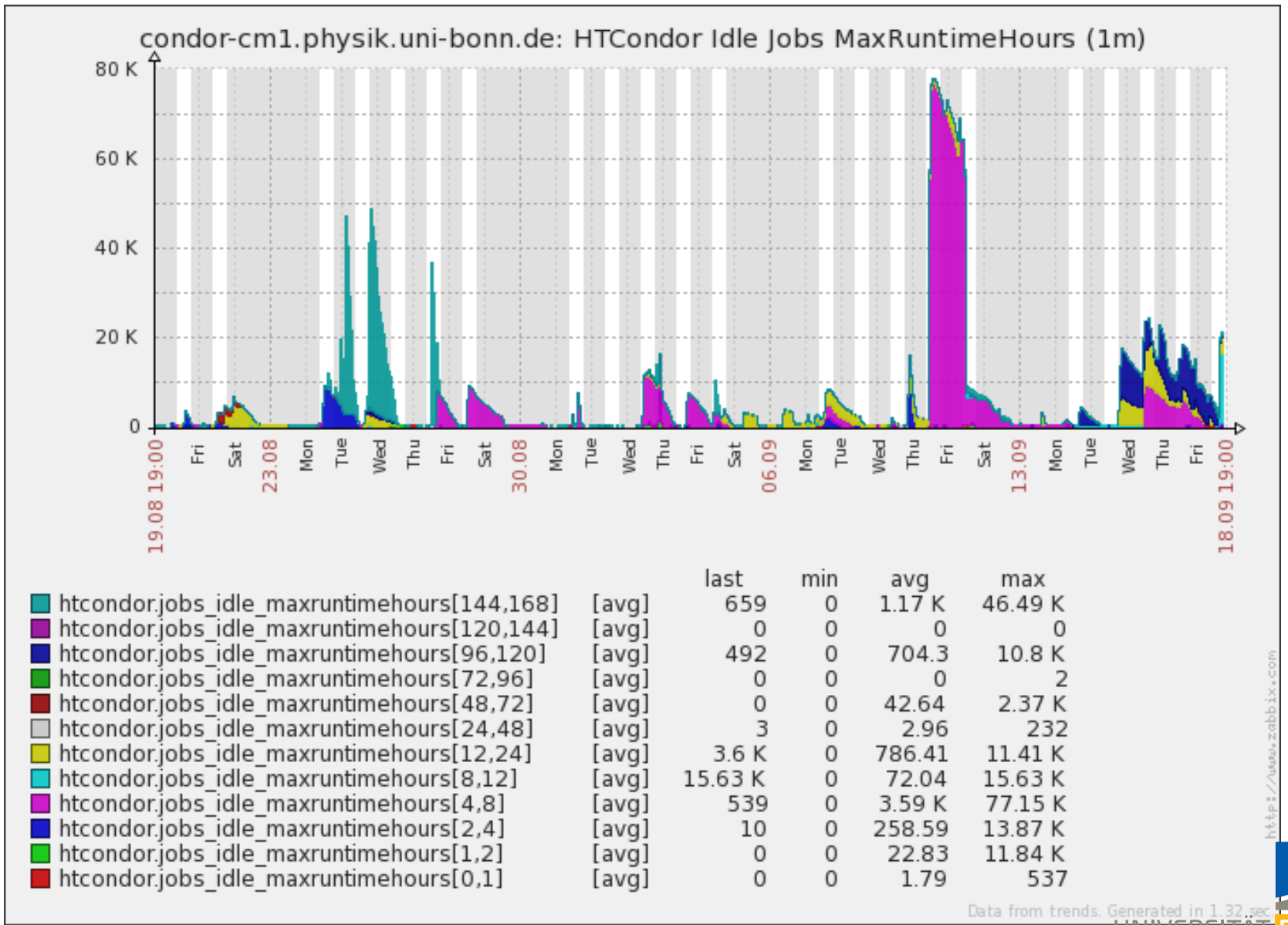
# Feedback to users and admins

- Self-regulating: Users specify correct `+MaxRuntimeHours`, get more resources
- Jobs exceeding `+MaxRuntimeHours` are removed
- Enforced limits on `+MaxRuntimeHours`:
  - Maximum `+MaxRuntimeHours` for interactive jobs: 24 h
  - Maximum `+MaxRuntimeHours` for batch jobs: 168 h
- `SUBMIT_REQUIREMENT` on `schedd` creates good error messages, enforces setting of these attributes
- Mails sent out before machines are rebooted (possibility to interfere), contain output from reboot actions
- All attributes of machines are exported and visible to users
- All attributes and their distributions monitored by Zabbix
- Addtional 'human-readable' attributes (e.g. `NODE_REBOOT_REASONS`, `NODE_HEALTH`, `DRAIN_REASONS`, ...)

# Monitoring BackfillableMaxRuntimeHours



# Monitoring `MaxRuntimeHours` of user jobs



# Admin feedback via the MOTD

```
Welcome to CentOS Linux release 8.2.2004 (Core) (GNU/Linux 4.18.0-193.14.2.el8_2.x86_64
↪  x86_64)
--------------------------------------------------------------------------------
This host is:
 * a bare-metal (physical) machine
 * using master: puppet-baf.physik.uni-bonn.de
 * in hostgroup: Linux/Server/BAF/WN eth Ceph no IB
 * in environment: production
 * in location: Nußallee 12
 * in room: 0.004
 * in rack: 14
 * in bay: 17
 * commissioned on: 2020-09-16 (brand new!)
 * in condor health state:
   MARKED_UNHEALTHY_BY_PUPPET:TEST_NODE
 * last marked unhealthy: 0d 0h 0m 5s ago
   (at Fri Sep 18 00:30:00 CEST 2020)
 * in timed drain
   backfillable MaxRuntimeHours: 26
   drain target time is in: 1d 3h 38m 5s
   (Sat Sep 19 04:08:10 CEST 2020)
 * marked for draining due to the following reason(s):
   COOLING_PROBLEMS
 * running 1 job(s)
 * running the latest finishing job for up to 0d 7h 55m 1s
   (Fri Sep 18 08:25:06 CEST 2020)
Time:  00:30:05 up 1 day,  3:58,  1 user,  load average: 0.08, 0.04, 0.00
--------------------------------------------------------------------------------
```

# Other news...

## Singularity interactive jobs & `condor_ssh_to_job`...

now work with 8.8.10!✓
Many thanks to Greg for persisting through a long chain of issues!
Some quirks remain with X11, see:
https://htcondor-wiki.cs.wisc.edu/index.cgi/wiki?p=SingularityCondor
**Already in production for our GPU machine.**

## Functional MPI jobs with Singularity containers...

without HTCondor being installed in the containers, using
https://github.com/htcondor/htchirp
(can now run as replacement for `condor_chirp`, thanks to Jason!)

# Other news...

## Ongoing work: JupyterHub with CCB

Adapt JupyterHub batchspawner to leverage `condor_ssh_to_job` for port forwarding.
Allows to run Jupyter notebooks via HTCondor CCB (i.e. 'firewalled' / NATted execute nodes).
**Working proof-of-concept exists (will upstream later)!**

## Added a new data centre

Nodes located in a different building, jobs steered via new attribute `+CephFS_IO` due to different bandwidth to cluster FS
**HTCondor allowed this without fragmentation / partitioning of the cluster!**

# Conclusions

- Huge flexibility of ClassAd language allowed us to:
  - backfill draining nodes easily and get more cycles out
  - add a second data centre with different capabilites to the existing cluster
  - expose all node states transparently to our monitoring and users
- Knobs like the `STARTD_CRON` allow easy automation
- We and our users don't have to take manual care of:
  - security updates / reboots
  - draining for maintenance periods
- With a distributed cluster, we can essentially (almost) always avoid a full downtime
- Users don't even notice maintenance / downtime (only parts of resources affected)

Thank you

for your attention!

# Usecase examples

## Memory upgrade of nodes

- Set drain target time to start of intervention (or immediate)
- Set reboot action to `shutdown`
- Inject a script running `dmidecode -t memory`

## Broken hard disk

- Mark node as `UNHEALTHY`
- Enforce 'reboot' with Puppet
- Set reboot action to `shutdown` or `notification`

## Intervention on cooling system

- Set a drain target time for the start of intervention (or `UNHEALTHY` if reduction is sufficient)
- Set reboot action to `shutdown`

# Example for a mail upon node reboot (1)

```
Dear BAF admins,

a reboot action was scheduled for wn000.baf.physik.uni-bonn.de in 30 minutes
for the following reason(s):
"PENDING_ACTIONS:1"

For your information, the machine has not yet been reboot-draining
(plan was to start at Wed May  8 01:02:20 CEST 2052), but it was empty and we made use of
↪  the chance.

In case you want to cancel this and prevent a future
reboot, login to wn000.baf.physik.uni-bonn.de within the next 30 minutes,
and execute:
 shutdown -c
 condor_on
Quickly set the inactivate-flag on profile::wn_reboot_check
for this host to true, and execute Puppet.

Here's a summary of the 1/1 executed reboot actions:
1. Executed /etc/wn-reboot-actions/10-hello-world.sh, it had the following content:
   ------------------------------------------------------------------------------
     #!/bin/bash
     echo "Hello world!"
   ------------------------------------------------------------------------------
   It exited with exit code 0 and the following output:
   ------------------------------------------------------------------------------
     Hello world!
   ------------------------------------------------------------------------------
All reboot actions executed successfully.

All the best,
the WN reboot automation script
```

# Example for a mail upon node reboot (2)

```
Dear BAF admins,

a reboot action was scheduled for wn014.baf.physik.uni-bonn.de in 30 minutes
for the following reason(s):
"NEEDS_RESTARTING_REBOOTHINT"

For your information, the machine has been reboot-draining since Thu Aug 27 00:20:02 CEST
↪  2020
(which is 337199 s ago, i.e. 3d_21h_39m_59s).

In case you want to cancel this and prevent a future
reboot, login to wn014.baf.physik.uni-bonn.de within the next 30 minutes,
and execute:
 shutdown -c
 condor_on
Quickly set the inactivate-flag on profile::wn_reboot_check
for this host to true, and execute Puppet.

No reboot actions have been specified.

All the best,
the WN reboot automation script
```