DE LA RECHERCHE À L'INDUSTRIE

Depth oblivious hierarchical fairshare priority factor

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Slurm at CEA
Depth oblivious hierarchical fairshare priority factor

Overview of Slurm hierarchical fairshare

- Implemented inside the priority/multifactor plugin
  - Accounts are organized in a tree hierarchy
  - Shares (absolute value) are granted to each account
    - Slurm computes normalized shares ***S*** (0 <= ***S*** <= 1)
      - Percentage of machine allocated for each account
  - CPU usage is accounted to each account as jobs run (with optional decay factor)
    - Normalized to ***U*** the percentage of machine consumed by each account
  - The hierarchical nature of the shares is reflected in the effective usage ***Ue***

$$U_e = U + \left(\left(U_e^{parent} - U \right) * S / S^{siblings} \right)$$

  - The fairshare priority factor is then given by

$$F = 2^{(-U_e/S)}$$

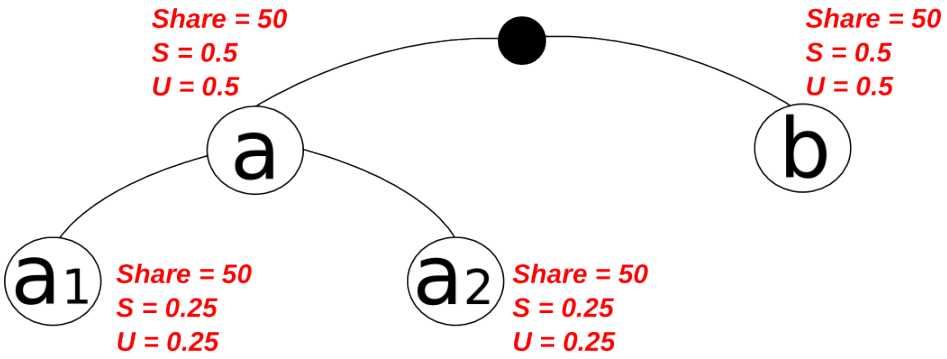
Drawbacks of Slurm hierarchical usage accounting

- Priority range depends on the account level in the tree
  - ***Ue*** increases but ***S*** stays the same

$$U_e = U + \underbrace{\left(\left(U_e^{parent} - U\right) * S / S^{siblings}\right)}_{positive\ \ term}$$

$$F = 2^{(-U_e/S)}$$

  - Low priorities overall
  - Unfair when the tree is not balanced




```
$ squeue -o "%i %a  %Q"
JOBID ACCOUNT PRIORITY
5       b       49645
6       a1      34999
7       a2      34999
```

If all users try to use as much resources as possible, actual usage will not converge towards allocated shares

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New feature in slurm 2.5 : ticket based algorithm

- ***F*** is computed slightly differently and it's no longer directly the priority factor

$$F = \frac{S}{U_e} \qquad U_e = max(U, 0.01 * S)$$

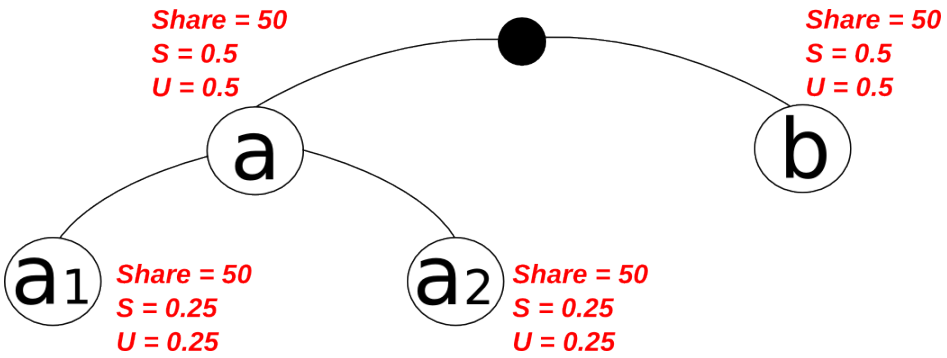
- Hierarchically distributes a pre-defined amount of tickets based on ***F***
  - Tickets are split at each level among active accounts
  - Each active account gets a share of its parent tickets
  - This share depends on the machine shares and usage of each account relative to his siblings

$$T = T^{parent} * \frac{S * F}{\left(\sum^{siblings} (S * F)\right)}$$

  - In the end, the account with the most tickets gets a priority factor of 1
  - Other accounts get a lower priority proportionally to their number of tickets

Ticket based mode

- Does not address our use cases at CEA
  - Priorities fluctuate depending on the queue state (troubling for users)
  - Unfair depending on the distribution of active accounts
  - Hierarchical factor is too « strict »
    - Small accounts can use their parents' shares too easily
  - Difficult to balance with other priority factors



If all leaf accounts are active
b gets twice as much resources as a

```
$ squeue -o "%i %a  %Q"
JOBID ACCOUNT PRIORITY
6     a1      100000
5     b       99999
```

```
$ squeue -o "%i %a  %Q"
JOBID ACCOUNT PRIORITY
5     b       100000
6     a1      50000
7     a2      50000
```

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Our motivation

- Improve handling of deep and/or unbalanced trees but stay closer to the original algorithm

- Objectives
  - Fair priority factors for unbalanced trees
  - Able to use the entire range of priority factors if needed
  - « Softer » impact of the hierarchical factor
    - A small sub-account should not get all the shares from the parent account too easily
    - Rather a limited boost in case of underconsumption of the parent
    - Respectively a limited penalty in case of overconsumption
  - Changes in priorities should happen over time
    - More understandable for users

New « depth oblivious » formula

- Basics
  - Define the consumption ratio $R = U/S$
  - Introduce an effective consumption ratio R_e and define $F = 2^{(-R_e)}$

- Main idea
  - If R_e^{parent} is close to 1, R_e should be close to R

    = > Priorities are mainly based on our own consumption ratio if our ancestors are on target

  - As R_e^{parent} gets further away from 1 R_e is pulled towards R_e^{parent} unless it's further away in the same direction

    => An account which has consumed more than its shares recovers some of its lost priority if the parent account has consumed less than its shares

New « depth oblivious » formula

- Local ratio

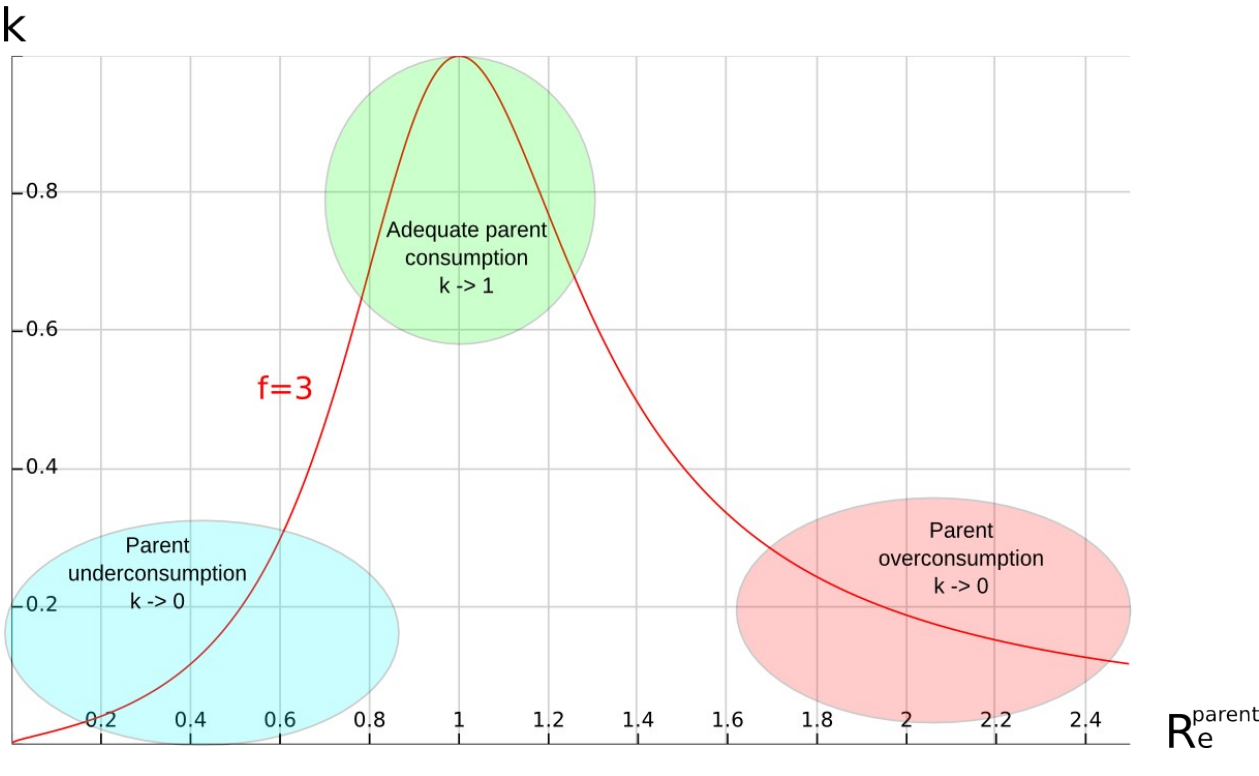
$$R_l = \frac{R}{R^{parent}}$$

- Effective ratio

$$R_e = R_e^{parent} * (R_l)^k$$

- Idea behind k

R_e tends towards R_e^{parent} when k decreases



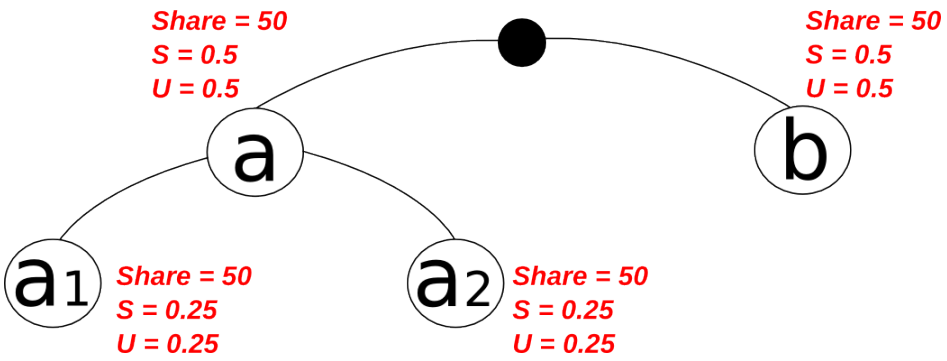
- Formula for k

$$k = \frac{1}{(1 + (f * \ln(R_e^{parent}))^2)} \quad if \ \ln(R_e^{parent}) * \ln(Rl) \leq 0$$

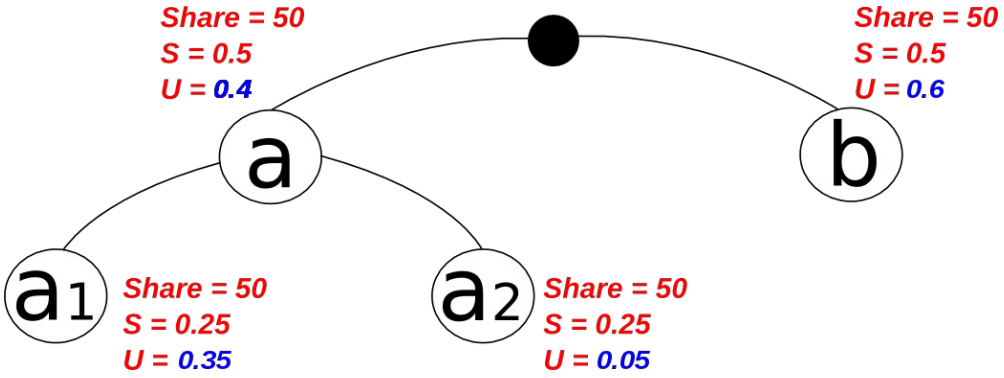
$$k = 1 \quad otherwise$$

This means we are further away than our parent from adequate consumption, in the same direction, so we should not be pulled back

Examples




```
$ squeue -o "%i %a  %Q"
JOBID ACCOUNT PRIORITY
5       a1       49654
6       b        49654
7       a2       49654
```




```
$ squeue -o "%i %a  %Q"
JOBID  ACCOUNT PRIORITY
7       a2       86939
6       a1       48298
5       b        43166
```

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Current status

- Small patch : approximately 100 lines of code

- Running on our clusters at TGCC and CCRT
  - Real usage is now closer to shares
  - Partners can subdivide their shares if needed
    - Fairer scheduling when the tree is not balanced
  - Good feedback from our users

- Will be contributed upstream if the community is interested
  - Could replace the current non ticket-based algorithm or live alongside it
  - For now, enabled by setting PriorityFlags=DEPTH_OBLIVIOUS

Thank you for your attention

Questions ?

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