

CS 744: DRF

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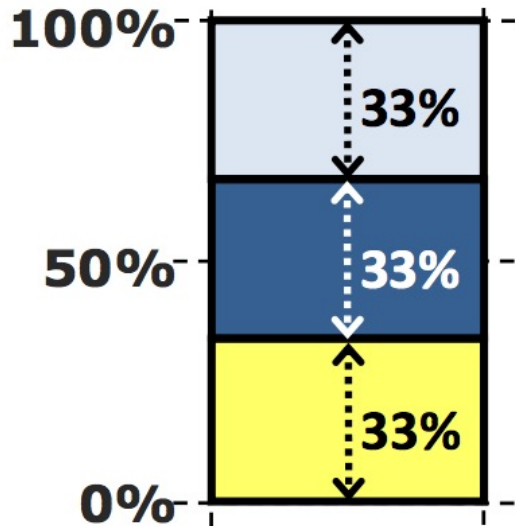
Fall 2021

ADMINISTRIVIA

- Assignment 2 out!
- Course Project
 - Project list by Oct 1
 - Form groups and submit project bids by Oct 8
 - Assigned project by Oct 14
 - Introductions due Oct 25

SETTING: FAIR SHARING

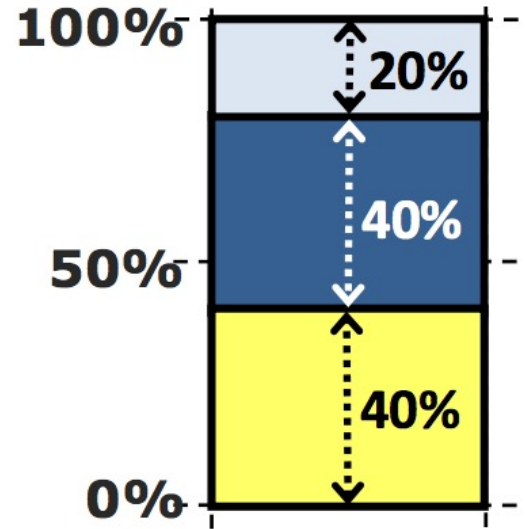
Equal Share



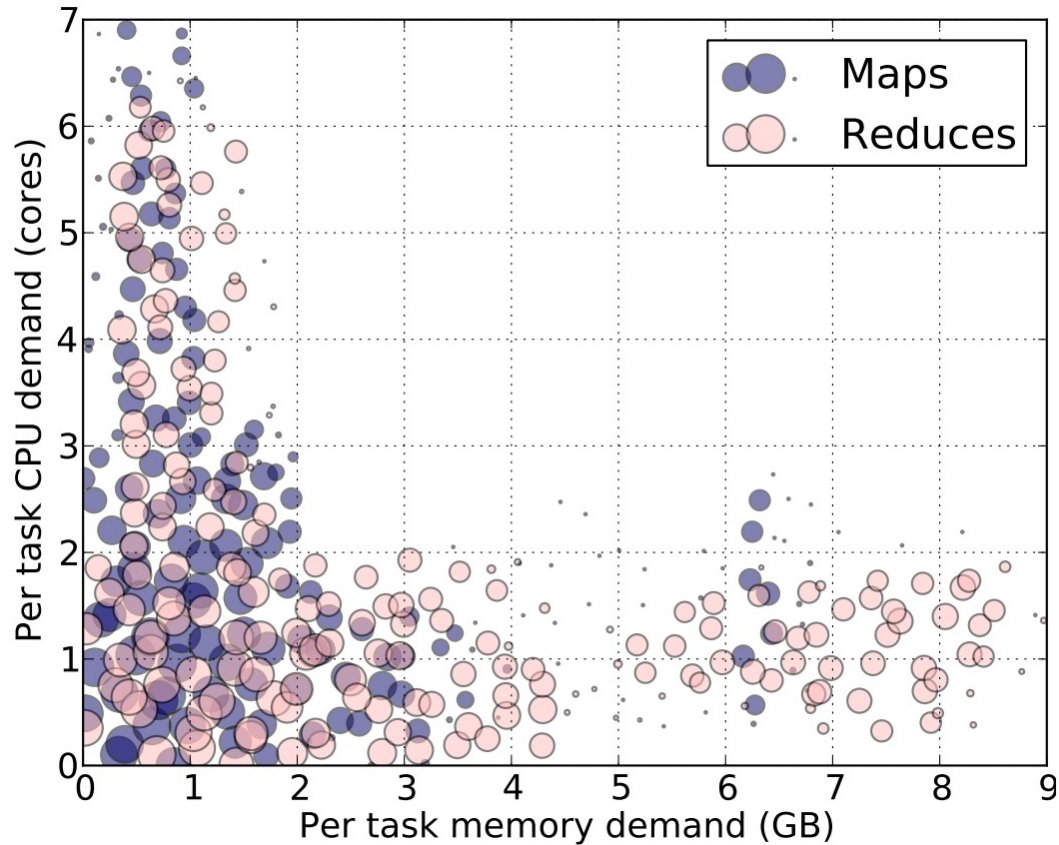
Max-Min Share

Maximize the allocation for most poorly treated users

Maximize the minimum



MOTIVATION: MULTI RESOURCES



DRF: MODEL

Users have a **demand vector**

$\langle 2, 3, 1 \rangle$ means user's task needs 2 R1, 3 R2, 1 R3

Resources given in multiples of demand vector

i.e., users might get $\langle 4, 6, 2 \rangle$

PROPERTIES

Sharing Incentive

Strategy Proof

Pareto Efficiency

Envy free

PROPERTIES

Sharing Incentive

User is no worse off than a cluster with
 $1/n$ resources

Strategy Proof

User should not benefit by
lying about demands

Pareto Efficiency

Not possible to increase
one user without
decreasing another

Envy free

User should not desire the
allocation of another user

DRF: APPROACH

Dominant Resource

Resource user has the **biggest** share of

Total: <10 CPU, 4 GB>

User 1: <1 CPU, 1 GB>

Dominant resource is **memory**

Dominant Share

Fraction of the dominant resource user is allocated

E.g., for User 1 this is **25% or 1/4**

DRF: APPROACH

Equalize the dominant share of users

Total: <9 CPU, 18 GB>

User1: <1 CPU, 4 GB>
dom res: mem

User2: <3 CPU, 1 GB>
dom res: CPU

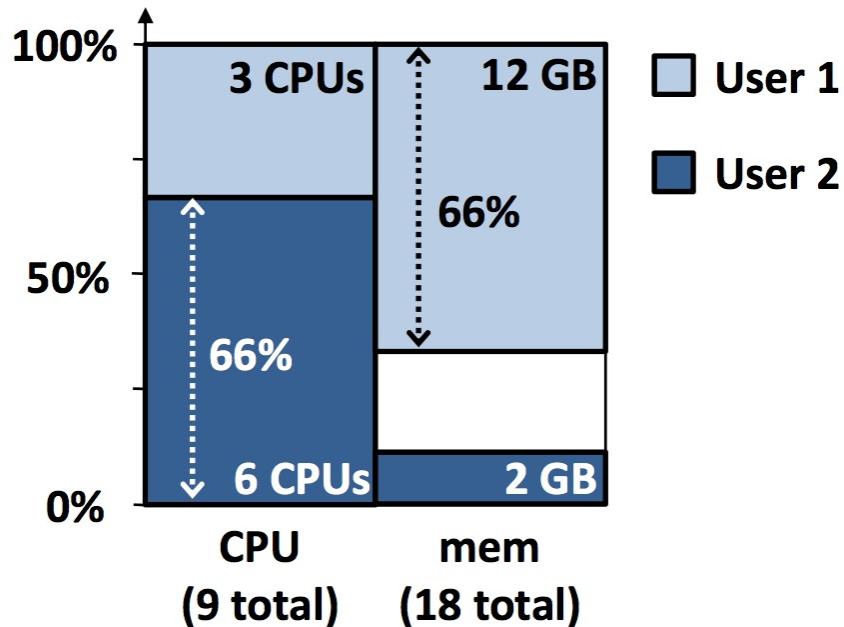
User	Allocation	Dominant Share
User1	<0 CPU, 0 GB>	0
User2	<0 CPU, 0 GB>	0

DRF: APPROACH

Total: <9 CPU, 18 GB>

User1: <1 CPU, 4 GB> per task
<3 CPU, 12 GB> for 3 tasks
dom res: mem
dom share: $12/18 = 2/3$

User2: <3 CPU, 1 GB>
<6 CPU, 2 GB> for 2 tasks
dom res: CPU
dom share: $6/9 = 2/3$



DRF ALGORITHM

Whenever there are available resources:

Schedule a task to the user with **smallest dominant share**

COMPARISON: ASSET FAIRNESS

Asset Fairness: Equalize each user's sum of resource shares

Consider total of 70 CPUs, 70 GB RAM

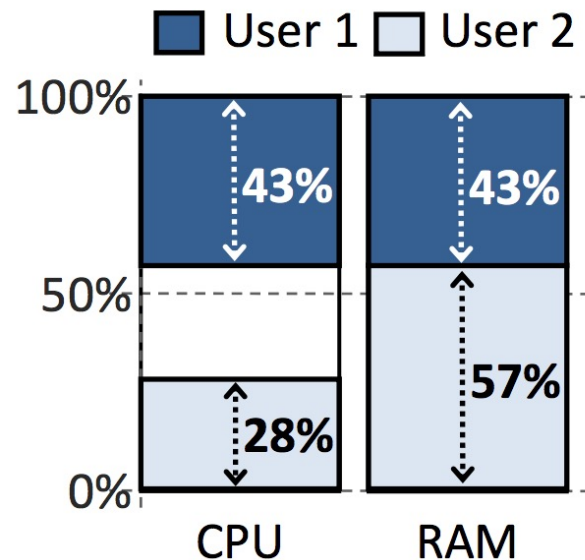
U1 needs <2 CPU, 2 GB RAM> per task

U2 needs <1 CPU, 2 GB RAM> per task

Asset Fair Allocation:

U1: 15 tasks: 30 CPU, 30 GB (Sum = 60)

U2: 20 tasks: 20 CPU, 40 GB (Sum = 60)



COMPARISON: ASSET FAIRNESS

Asset Fairness: Equalize each user's sum of resource shares

Violates Sharing Incentive

Consider total of 70 CPUs, 70 GB RAM

U1 needs <2 CPU, 2 GB RAM> per task

U2 needs <1 CPU, 2 GB RAM> per task

Sharing incentive?

Half of the cluster is 35 CPU, 35 GB RAM

U1:

U2:

COMPARISON: CEEI

CEEI: Competitive Equilibrium from Equal Incomes

- Each user receives initially $1/n$ of every resource,
- Subsequently, each user can trade resources with other users in a perfectly competitive market
- Computed by maximizing **product of utilities** across users

COMPARISON: CEEI

Total: <9 CPU, 18 GB>

User1: <1 CPU, 4 GB>

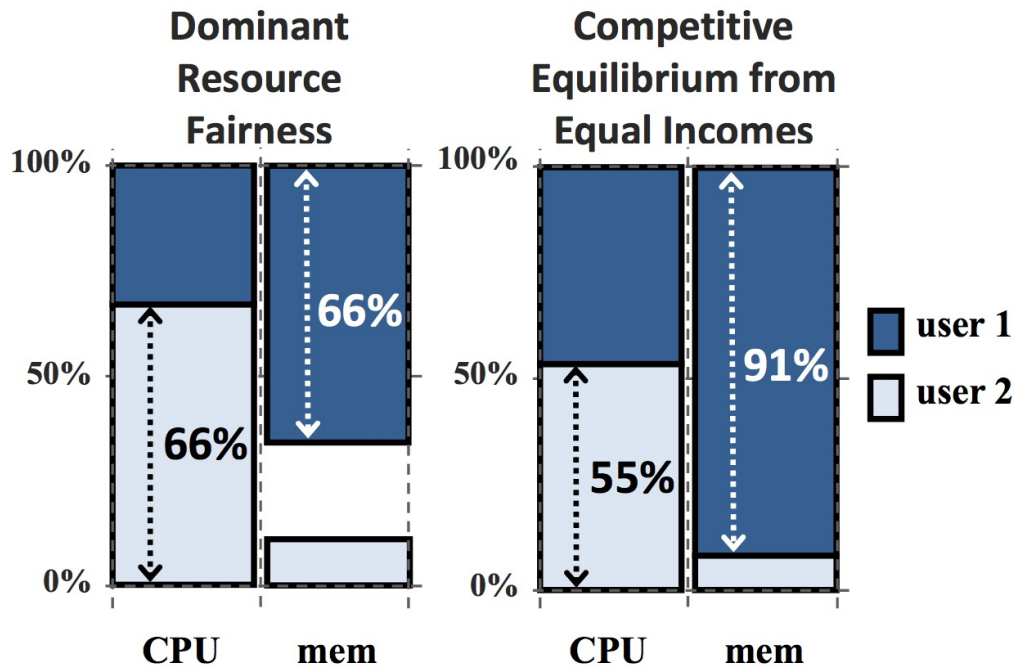
User2: <3 CPU, 1 GB>

$$\max (x \cdot y)$$

subject to

$$x + 3y \leq 9$$

$$4x + y \leq 18$$



CEEI: STRATEGY PROOFNESS

Total: <9 CPU, 18 GB>

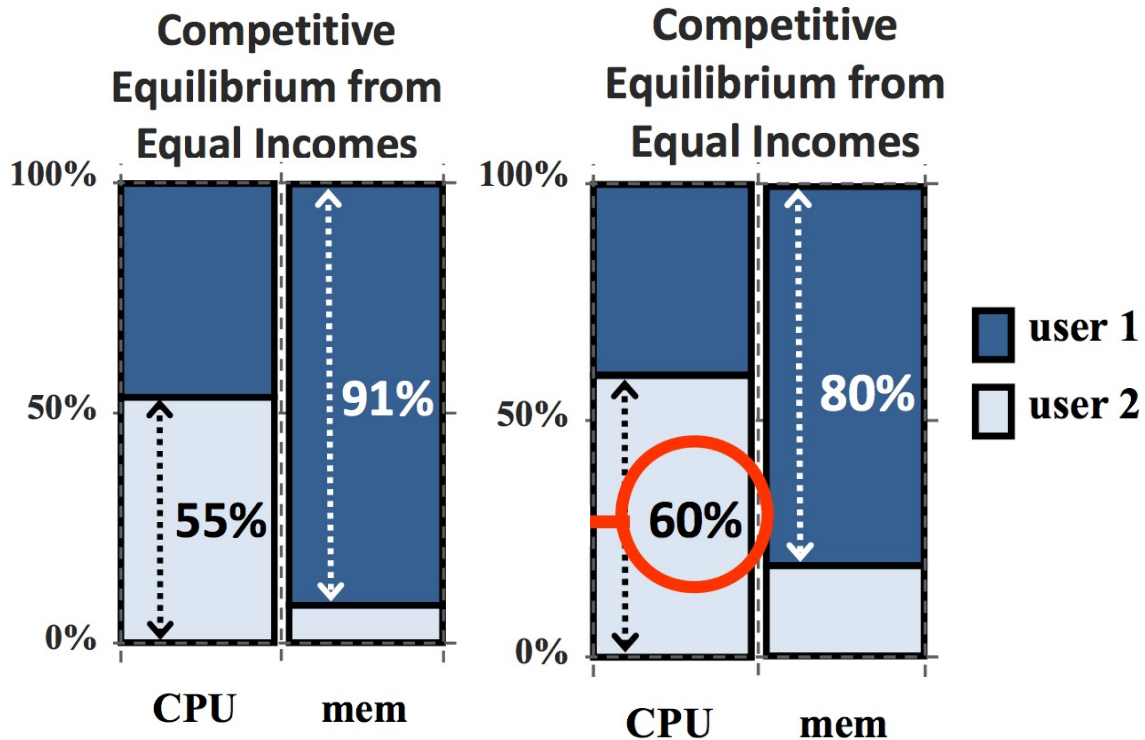
User2 Before:

CEEI: 55% CPU, 9% mem

Total: <9 CPU, 18 GB>

User1: <1 CPU, 4 GB>

User2: <3 CPU, 2 GB>



COMPARISON

Property	Allocation Policy		
	Asset	CEEI	DRF
Sharing Incentive		✓	✓
Strategy-proofness	✓		✓
Envy-freeness	✓	✓	✓
Pareto efficiency	✓	✓	✓
Single Resource Fairness	✓	✓	✓
Bottleneck Fairness		✓	✓
Population Monotonicity	✓		✓
Resource Monotonicity			

Table 2: Properties of Asset Fairness, CEEI and DRF.

SUMMARY

DRF: Dominant Resource Fairness

Allocation policy for scheduling

Provides multi-resource fairness

Ensures sharing incentive, strategy proofness

DISCUSSION

<https://forms.gle/wdN8bwqxEwjPEcAq7>

Consider a system with 40 units of CPU, 20 units of memory and 160 units of disk. Consider three users with the following requirements

Alice (4 CPU, 1 memory, 1 disk)

Bob (1 CPU, 4 memory and 4 disk)

Carol (1 CPU, 2 memory and 16 disk)

List the dominant resource as defined in DRF for Alice, Bob and Carol

What would be the final task allocation in the given cluster for Alice, Bob and Carol ?

What could be one workload / cluster scenario where DRF implemented on Mesos will NOT be optimal?

NEXT STEPS

Next Week: Machine Learning

Assignment 2 out!