APPLIED MECHANISM DESIGN FOR SOCIAL GOOD

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Lecture #17 – 3/29/2018

CMSC828M
Tuesdays & Thursdays
9:30am – 10:45am

COMPUTER SCIENCE
UNIVERSITY OF MARYLAND

THIS CLASS:

COMBINATORIAL ASSIGNMENT PROBLEMS & COURSE MATCH

PART I: JOHN DICKERSON
PART II: JANIT ANJARIA

Thanks to: John Kubiatowicz (JK)

RECALL: DRF

Proportional demands (a.k.a. Leontief preferences)

$$u(x_1, \ldots, x_m) = \min \left\{ \frac{x_1}{w_1}, \ldots, \frac{x_m}{w_m} \right\}$$

Dominant resource: resource the agent has the biggest share of out of all resources available:

- 16 CPUs, 10 GB available, user allocated 4 CPUs, 8 GB
- Dominant resource is GB, because 4/16 CPU < 8/10 GPU

Dominant share: fraction of dominant resource allocated

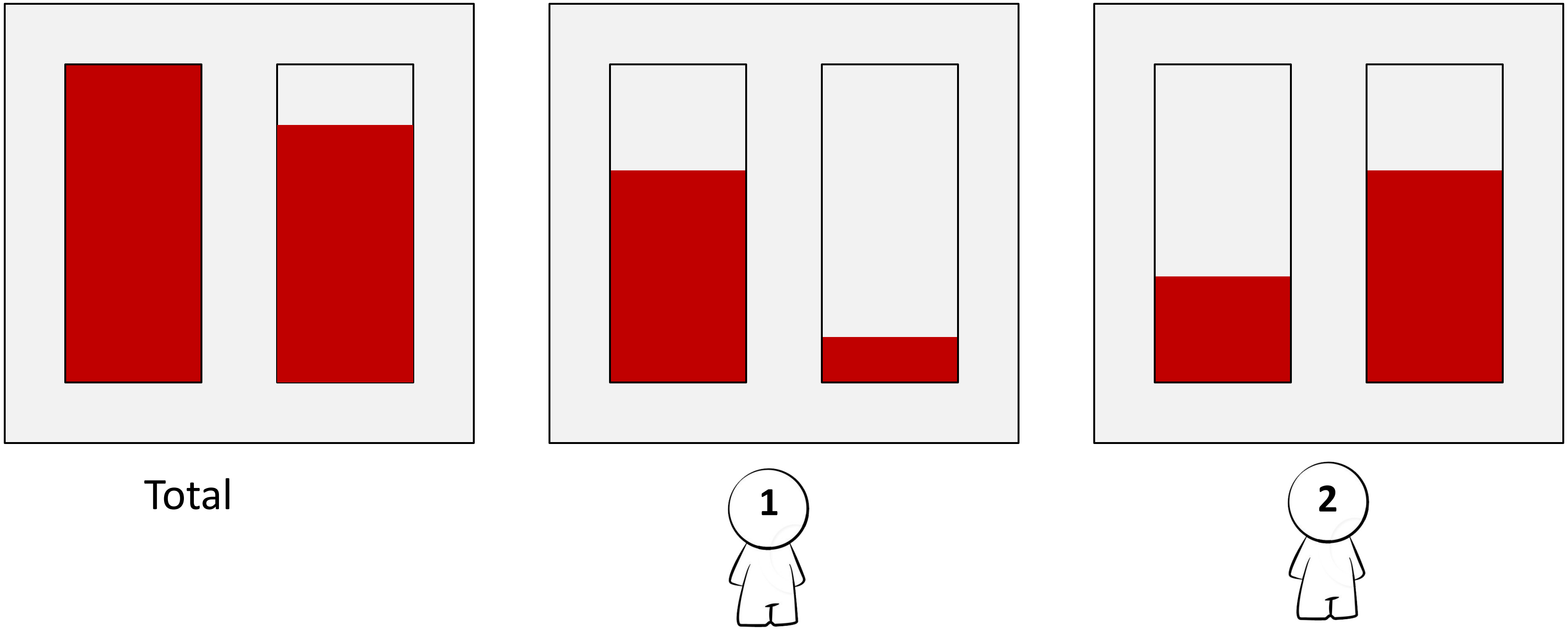
- Above, dominant share is 8/10 = 80%

DRF: application of max-min fairness to dominant shares

- Equalize the dominant share amongst agents

STATIC DRF MECHANISM

Dominant Resource Fairness = equalize largest shares
(a.k.a. dominant shares)



ALTERNATIVE: MAKE A MARKET

Competitive Equilibrium from Equal Incomes (CEEI):

- **Agents report their preferences over sets of items**
- **Give agents an equal budget of funny money**
- **Computer finds prices that clear the market**
  - That is, prices such that when each agent chooses its most favored set that it can afford, the market clears
- **Assign all resources to agents based on their demands and these computed prices**

CEEI EXAMPLE: DIVISIBLE RESOURCES

Supply: {1 cake, 1 doughnut}

Two agents, both with $1 (funny money), capacity of 1

- ***A*: cake = 1/2, doughnut = 1**
- ***B*: cake = 1/4, doughnut = 1**

Market clearing prices: cake = $2/5, doughnut = $8/5

- *A* wants to max $1/2c + 1d$
  s.t. $c + d \leq 1$
  $p_c c + p_p d <= 1$
  → Max: ½ cake, ½ doughnut

??????????

- *B* wants to max $1/4c + 1d$
  s.t. $c + d \leq 1$
  $p_c c + p_p d <= 1$
  → Max: ½ cake, ½ doughnut (and many others – clearinghouse chooses!)

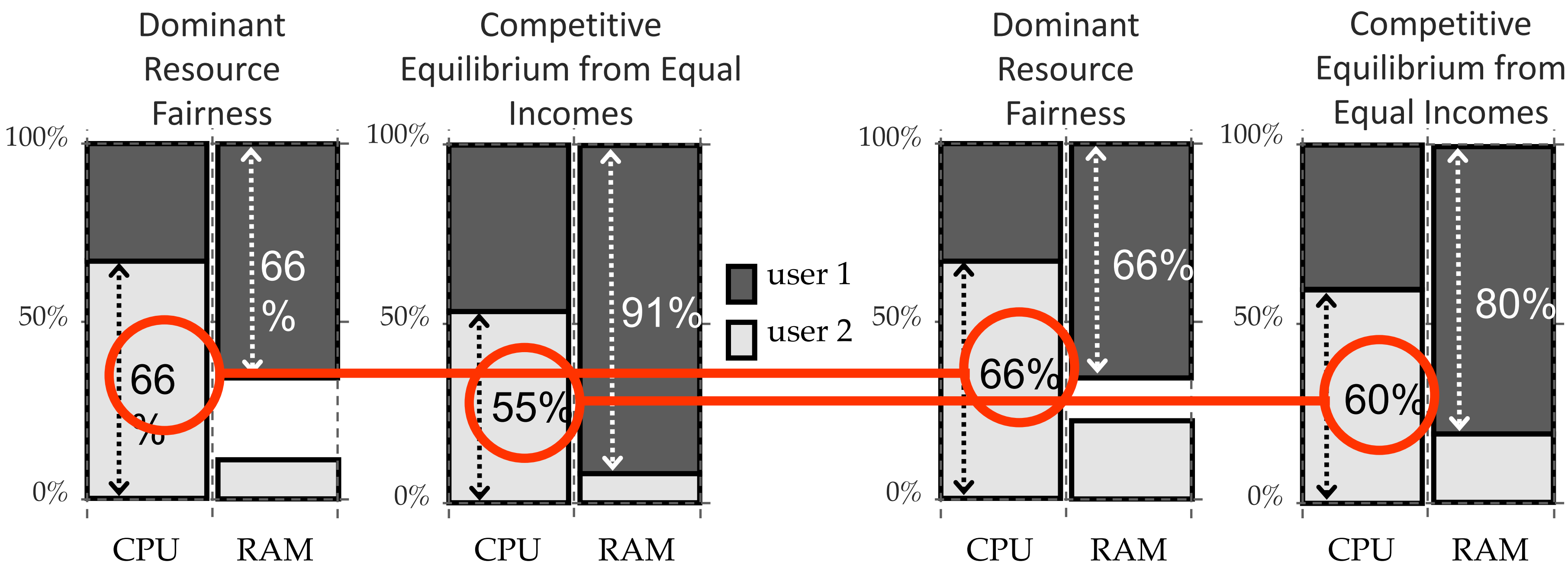
CEEI PROPERTIES

- **Envy-free** ????????
  - Yes! Given the prices, you bought the best bundle you could afford
  - If you envy somebody else's bundle, you could've purchased it!
- **Pareto-efficient** ????????
  - Yes! Market is cleared → taking a Pareto step involves taking a resource from one agent and giving it to somebody new … but this lowers their utility by above
- **Strategy proof** ????????
  - No! Intuition: CEEI clears the market → can game the system by requesting more underutilized resources

DRF VS CEEI

A1: <1 CPU, 4 GB> A2: <3 CPU, 1 GB>

- DRF more fair, CEEI better utilization



A1: <1 CPU, 4 GB> A2: <3 CPU, 2 GB>

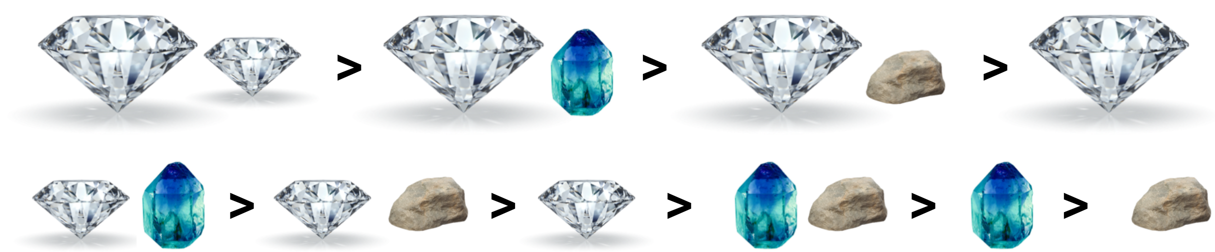
- A2 increased her share of both CPU and memory

CEEI FOR INDIVISIBLE ITEMS?

Two agents

Capacity: 2

Both agents will share the same preference profile:



Market clearing prices ????????

- Don't exist! For any price, for any item, either both agents demand that item or both do not.
- Small changes in price can cause big changes in demand

APPROXIMATE-CEEI

Can we tiebreak somehow?

Idea: give agents slightly different, but roughly equal budgets

- For each agent, draw budget from [1, 1 + *B*)
- 0 < *B* < min(1/m, 1/(k-1)) – k is capacity of agent
- Note: if *B* = 0, this is just CEEI

Still "feels fair" – random winners and losers in the budget draw, and the playing ground is still roughly equal.

A-CEEI FOR INDIVISIBLE ITEMS

Two agents

Capacity: 2

Agent 1's budget: $1.2

Agent 2's budget: $1

= $1.10

= $0.80

= $0.20

= $0.10

????????????

Agent 1: 

Agent 2: 

A-CEEI: PROPERTIES

Always exists if *B* > 0 (need unequal budgets)

The market approximately clears:

- There exist prices that clear the market to within an error of at most √k*m/2

??????????????

- Error does not depend on the number of participants → error goes to zero as a fraction of the underlying endowment

Approximately strategy proof

- **“Strategy-proof in the large"**

Bounded envy free

Very difficult to compute!

NEXT UP:
COURSE MATCH

PRESENTER: JANIT ANJARIA

Wharton
UNIVERSITY of PENNSYLVANIA

NEXT CLASS:
INCENTIVE AUCTIONS & SPECTRUM REPACKING