Engineering Systems for Allocating Public Goods

One possibility: allocate randomly

Group Work:

1. Get to know the other members of your group! Share your name, your program, and something that you are excited about.
2. Identify (at least) one positive feature of random allocation, and (at least) one concern or shortcoming.
3. Brainstorm an alternative procedure. Does this procedure addresses one of your listed shortcomings for random allocation?
4. When you are ready to discuss, add your pro and con to the board.

How To Design A System?

In practice: copy what we see elsewhere, possibly with modifications.

An Engineering Approach

First, define requirements and/or an objective.

Then try to design an algorithm that satisfies these requirements or maximizes the objective.

Possible Goals

1. Efficient

2. Fair

3. Truthful

Questions:

How do we define efficiency?

- Give people fruit that they like?
- Minimize time and effort?

How do we define fairness?

- Equal priority?
- Give to the hungriest?

How do we know people's preferences and needs?

- Hopefully, they tell us!

Course Content (First Half)

Key Algorithms	Leading Applications
Unit 1: Foundations/Efficiency, Fairness, Truthfulness	
Serial Dictatorship	Board Game Swaps
First Preferences First	Dorm Room Allocation
Top Trading Cycles	
Unit 2: Respecting Priorities/Deferred Acceptance	
Deferred Acceptance	School Choice: New York, Boston, Chicago, New Orleans
	Residency Matching
Unit 3: Selecting for Diversity/Quotas and Reserves	
Minimum and Maximum Quotas	Visa Allocation
Minimum Guarantee Reserves	Medical Rationing
Over-and-Above Reserves	Affirmative Action
	Cadet Matching

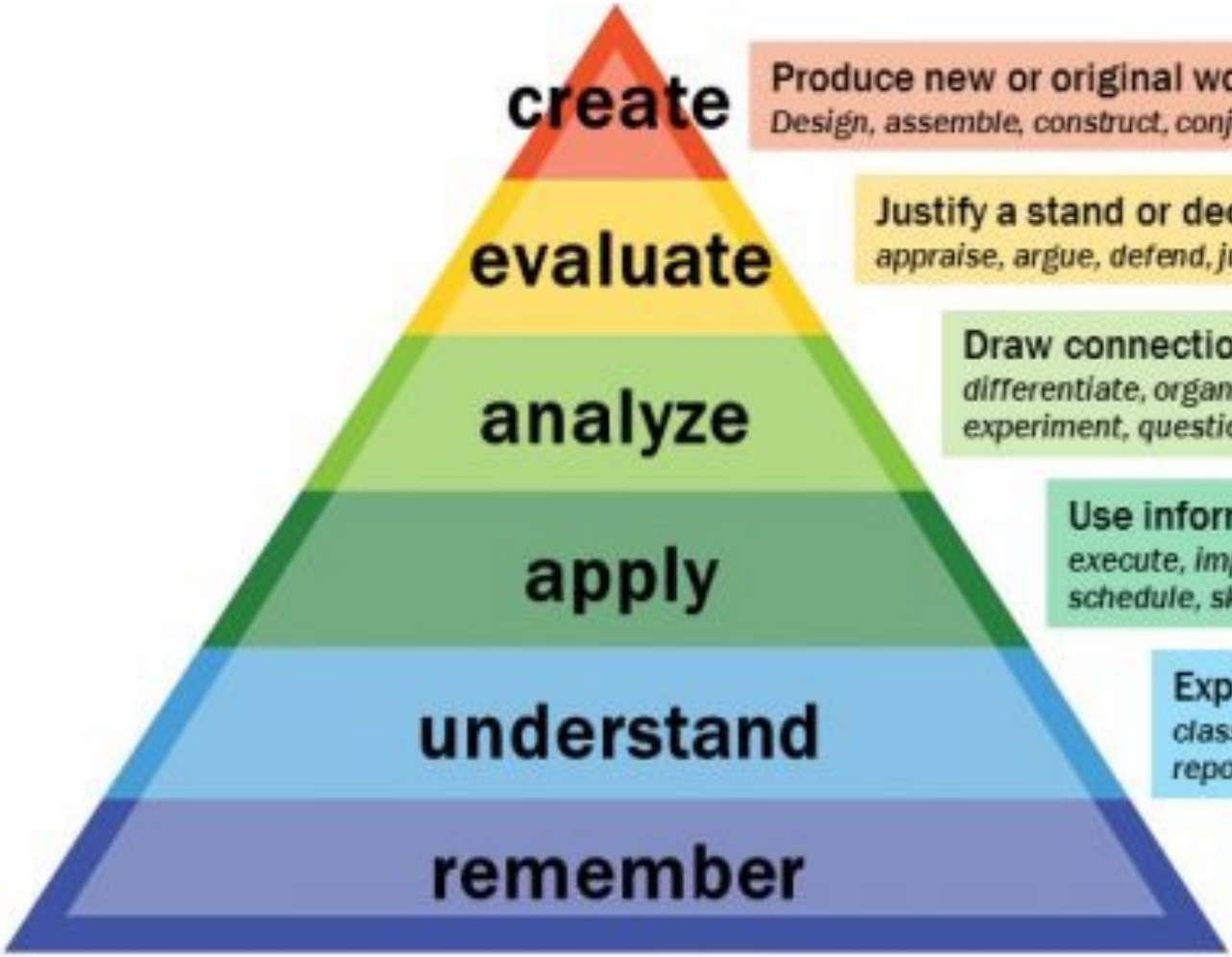
Course Content (Second Half)

	Key Algorithms	Leading Applications
Unit 4: Screening for Need/Auction Theory		
	First Price (Pay as Bid) Auction	Online Advertising
	Second Price (Uniform Price) Auction	Browser Choice Screens
	Ascending Auction	Fishing Quotas
Unit 5: Organ Allocation		
	Kidney Exchange Cycles and Chains	Living Donation
	Iran's Kidney Market	
	Waitlists with Deferral	Deceased Donation
Unit 6: Housing Allocation		
	Waitlists without Deferral	Public Housing
	Independent Lotteries	Inclusionary Zoning
	Common Lottery	Homeless Services
Unit 7: Frontiers/Beyond Unit Demand, Known		**Preferences**
		Food Banks
		Course Allocation
		Hiking and Hunting Permits
		License Plate Rationing

Course Goals: Learning

1. Key concepts and definitions (i.e. efficiency, fairness, truthfulness).
2. Algorithms that are (or could be) used.
3. Relationships between concepts and algorithms.
4. Assess existing solutions.
5. Apply knowledge to propose new solutions.

Bloom's Taxonomy



Produce new or original work
Design, assemble, construct, conjecture, develop, formulate, author, investigate

Justify a stand or decision
appraise, argue, defend, judge, select, support, value, critique, weigh

Draw connections among ideas
differentiate, organize, relate, compare, contrast, distinguish, examine, experiment, question, test

Use information in new situations
execute, implement, solve, use, demonstrate, interpret, operate, schedule, sketch

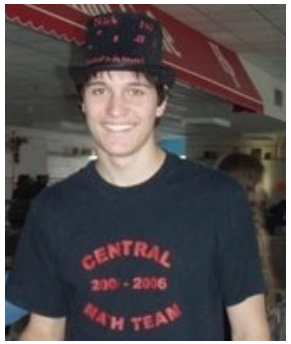
Explain ideas or concepts
classify, describe, discuss, explain, identify, locate, recognize, report, select, translate

Recall facts and basic concepts
define, duplicate, list, memorize, repeat, state

Course Goals: Relationships

I want to get to know you as a person!

About Me



CENTRAL HIGH SCHOOL

Professor, Industrial and Systems Engineering

BA, Math and Computer Science

Stanford

PhD, Operations Research

Hobbies:

- Board Games
- Ultimate Frisbee
- Camping
- World Travel

Columbia Business School
AT THE VERY CENTER OF BUSINESS™

Professor, Decisions Risk and Operations

Course Goals: Relationships

I want to get to know you as a person!

Come to office hours: Tuesdays 11:15-12:15 over Zoom.
E-mail me for other times (arnosti@umn.edu)

Use name tents (first few classes).

Course Goals: Fun

Ideal: Your favorite course at the University of Minnesota.
Plausible: Your favorite course this semester.
Realistic: Interesting, engaging, a little rough around the edges.

How you can help:

- Commit to spending time outside of class
- Share your thoughts with me (in person or anonymously)

This is my passion project!

Teaching Philosophies

- Lots of practice
- Rapid feedback
- Low stress

Grading

Homework: 50%

- Due before each class
- Drop lowest 4 scores

Exams: 24%

- Two midterms and a final

Blog Post: 16%

- Describe and analyze real-world allocation

Participation: 10%

- Class discussion, office hours

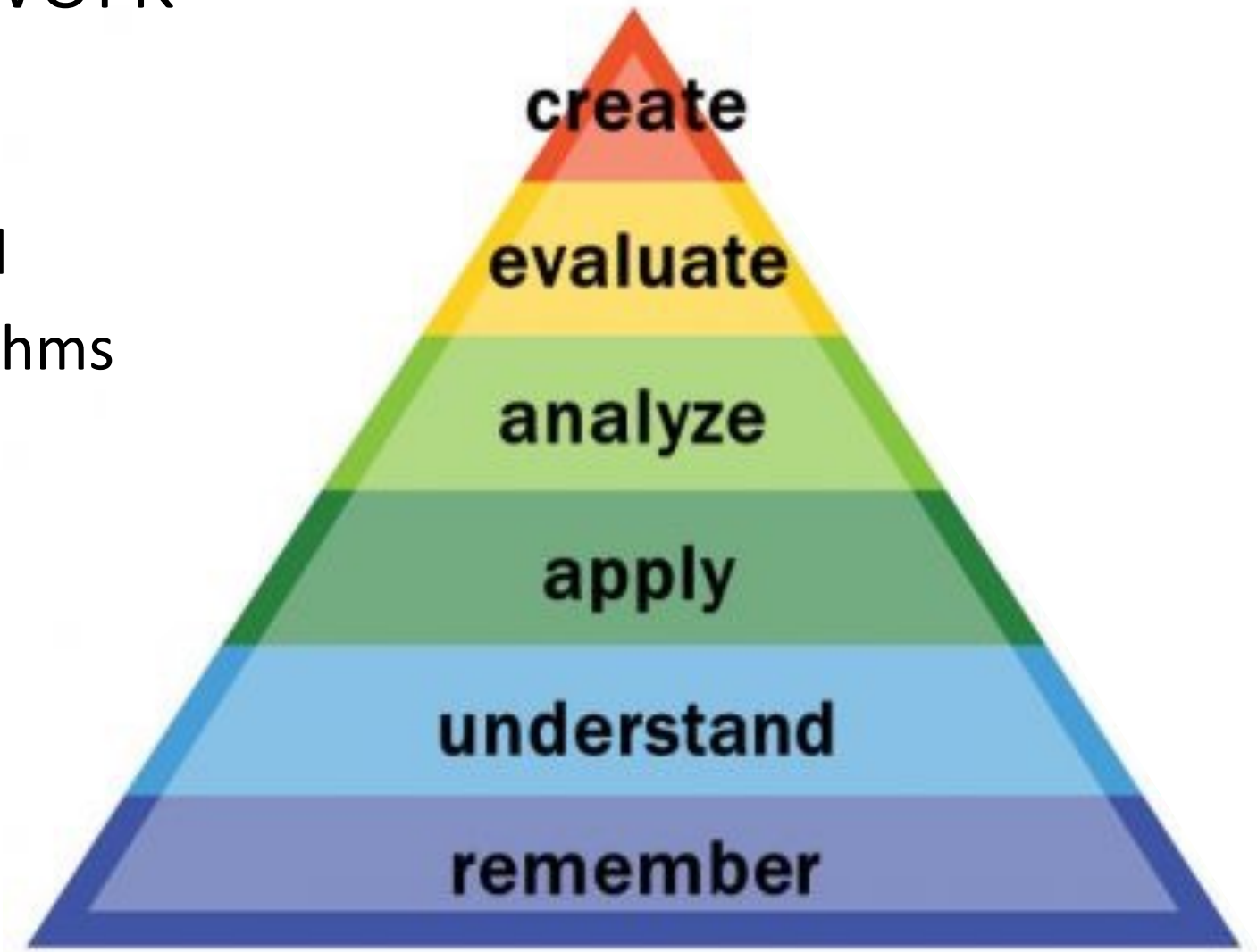
Two Types of Homework

Reflection + Critical Thinking

- Apply knowledge to real world
- Analyze definitions and algorithms
- May discuss with classmates

Concept Check

- Used as diagnostic
- Immediate feedback
- Individual – do not discuss!
- Open notes



Norms and Expectations

- Attend class (Illness excepted)
- Ask lots of questions! (Lots of new terms, reminders are good)
- Laptops and phones away

Break

Unit 1: Foundations

- Efficient
- Fair
- Truthful

Precise language and definitions are important!

Allocating Efficiently

Our Setting

We wish to allocate objects to a set of agents.
The objects are different, and the agents care about which they receive.

1

2

3

4

Key Assumptions:

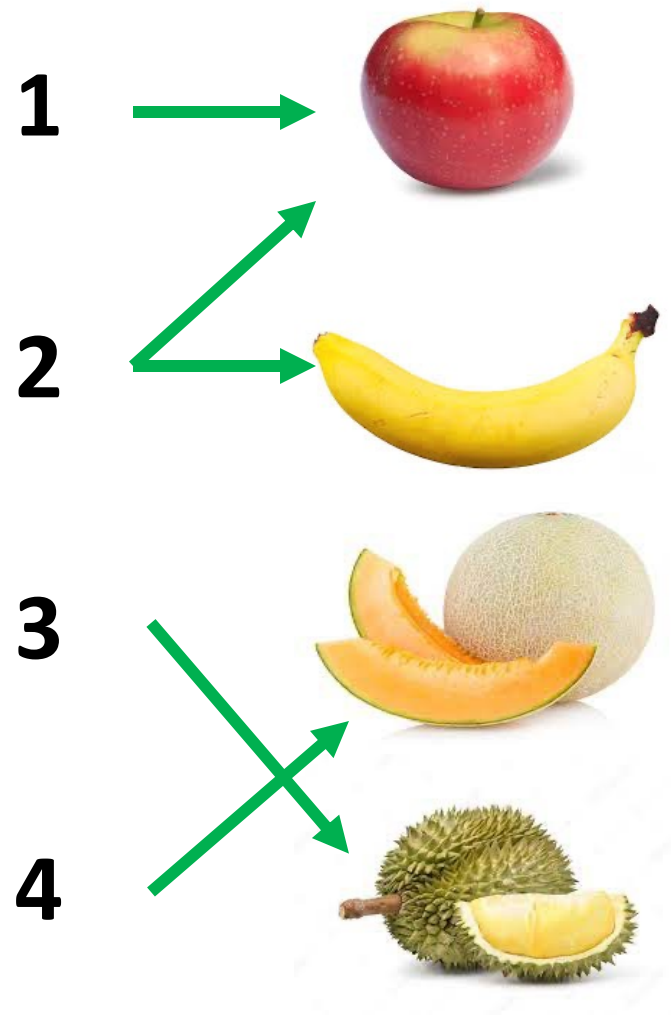
1. **Consequentialist:** agents care about outcome, not process.
2. **Unit Demand:** agents demand at most one item.
3. **No Externalities:** agents care only about their own allocation.
4. **Strict Preferences:** agents can rank all items (no ties).
5. **Known Preferences:** agents know their own ranking of items.
6. **No Money!**

Defining Efficiency

An **allocation** is a function from agents to objects (specifies what each agent gets).

An allocation is **feasible** if the number of agents assigned to each object is $\leq$ the number of copies of that object.

A feasible allocation is **Pareto Efficient** if there is no other feasible allocation that is at least as good for every agent, and strictly better for some agent (cannot help any agent without hurting another).



Informal: allocation is *inefficient* if people want to switch objects.

Preference Profile

Favorite

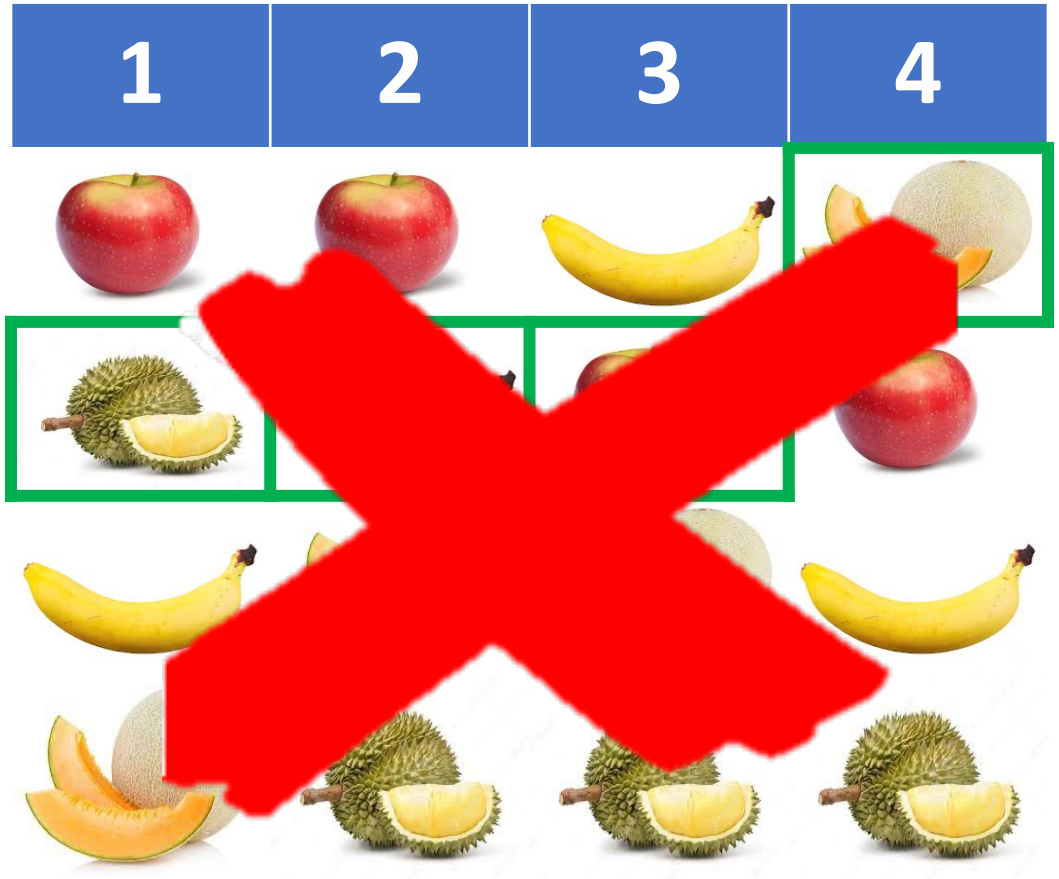
Least Favorite

1	2	3	4
			
			
			
			

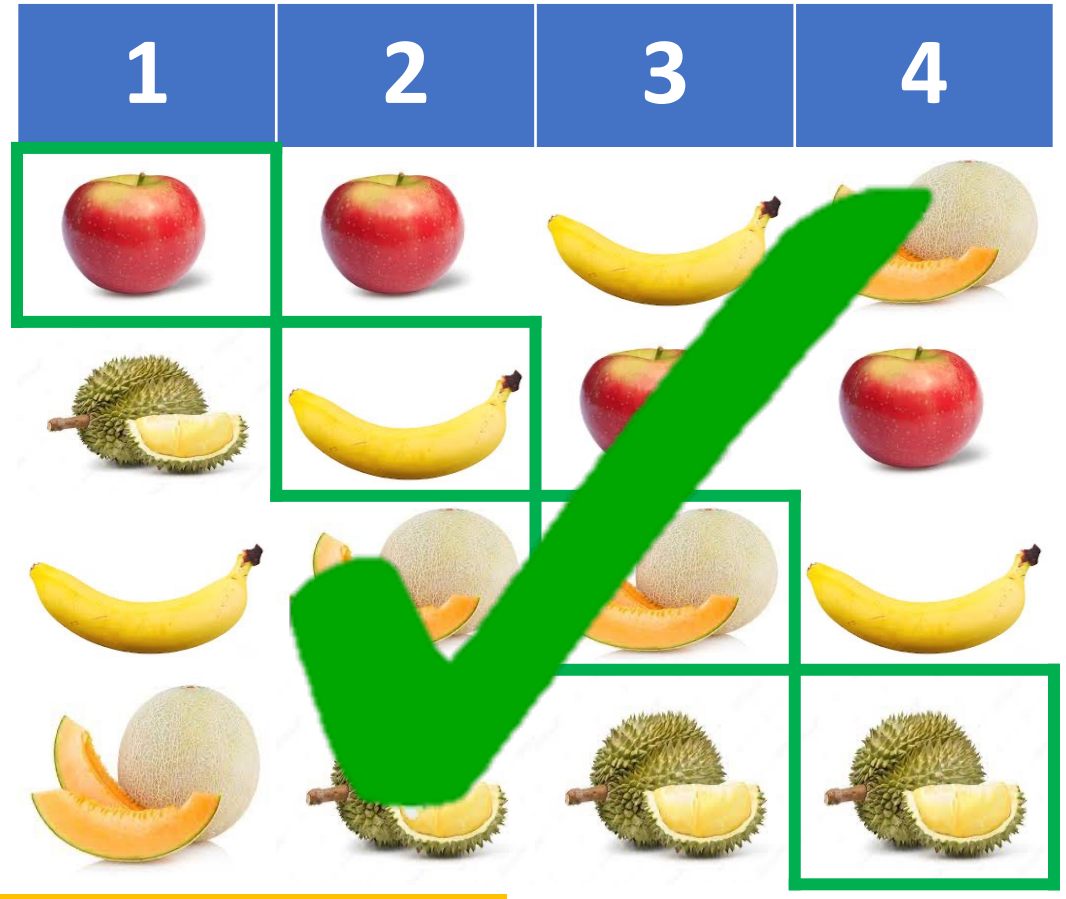
Group Work

1. Get to know the other members of your group! Share your name, your program, and something that you are excited about.

2. Is this allocation Pareto Efficient?



3. Is this allocation Pareto Efficient?



4. How many Pareto Efficient allocations can you find?

1	2	3	4
			
			
			
			

1	2	3	4
			
			
			
			

1	2	3	4
			
			
			
			

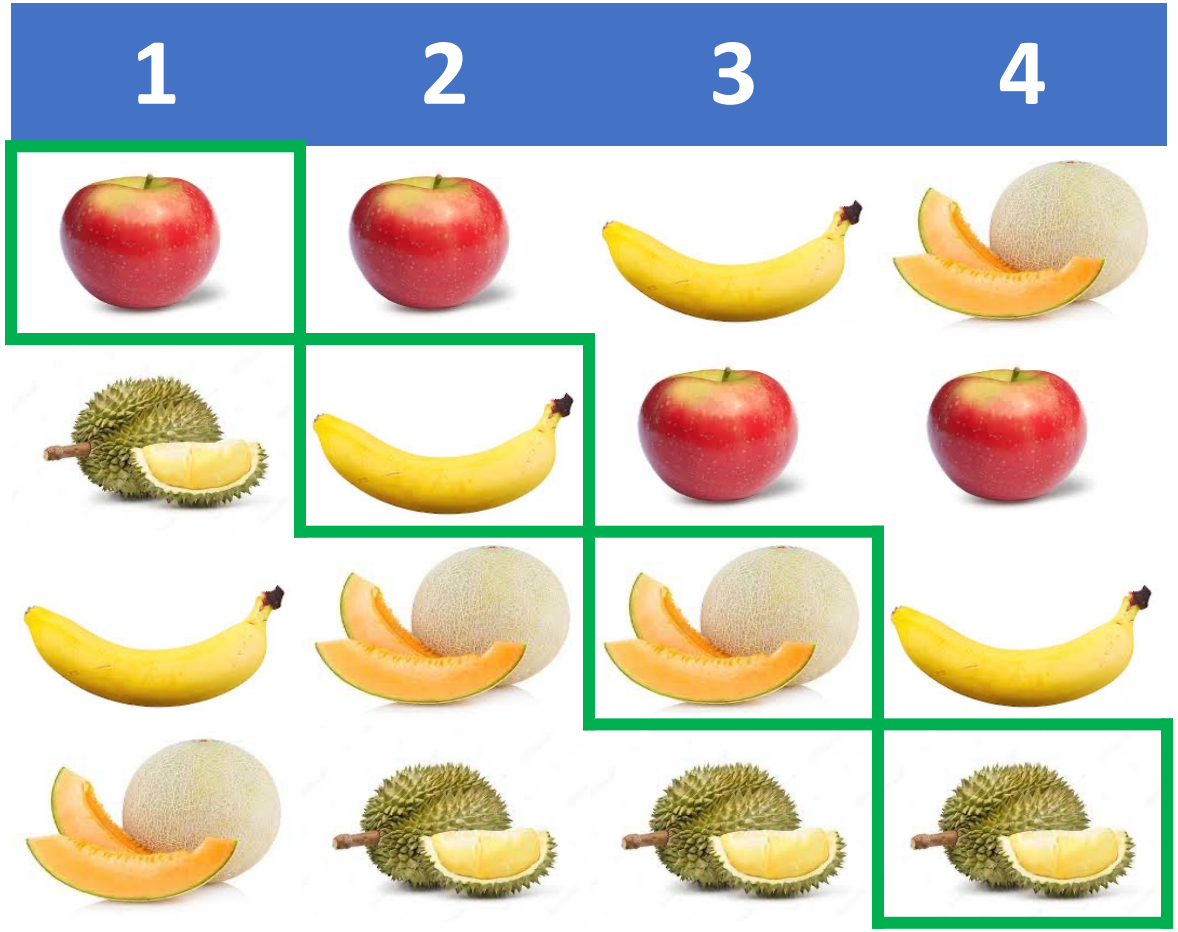
1	2	3	4
			
			
			
			

1	2	3	4
			
			
			
			

How To Find Pareto Efficient Allocations?

Serial Dictatorship

1. Place agents in some order.
2. One by one, have them choose favorite remaining option.



Group Work:

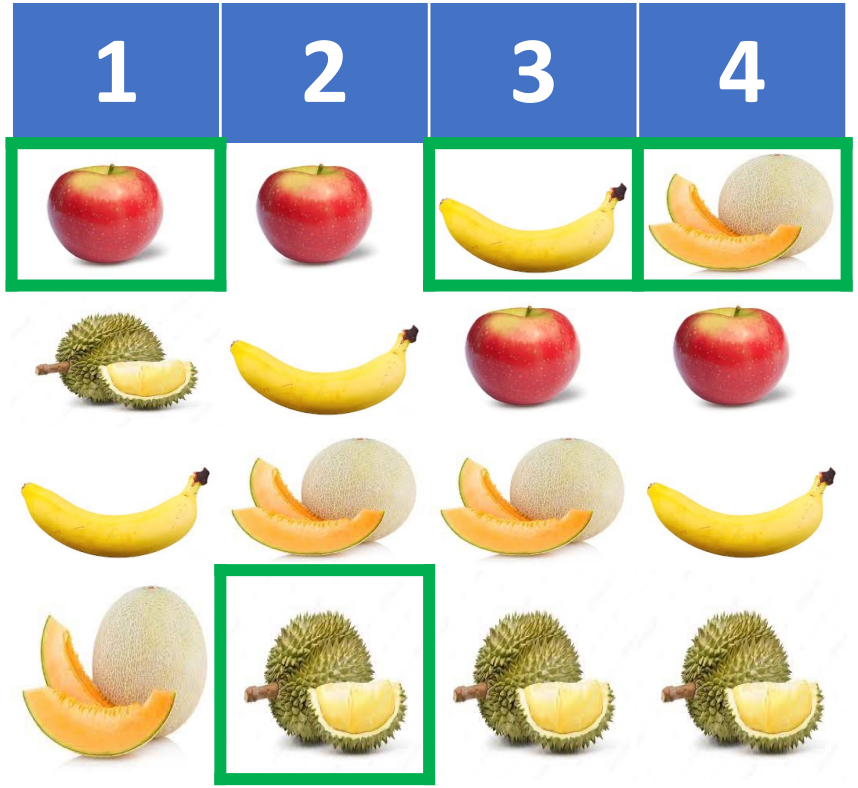
1. If the order is 1, 2, 3, 4, which allocation is selected by the Serial Dictatorship?
2. Is the allocation of the Serial Dictatorship always Pareto Efficient? ✓

“First Choices First” Algorithm

1. Give as many agents their first choice as possible.
2. Give as many of the remaining agents their second choice as possible.
3. Give as many of the remaining agents their third choice as possible.

⋮

To make this well-defined, must specify how to choose among agents: suppose 1 > 2 > 3 > 4.



Group Work:

1. Which allocation is selected by the First Choices First algorithm?
2. Is the allocation of the First Choices First algorithm always Pareto Efficient? ✓

Utilitarianism

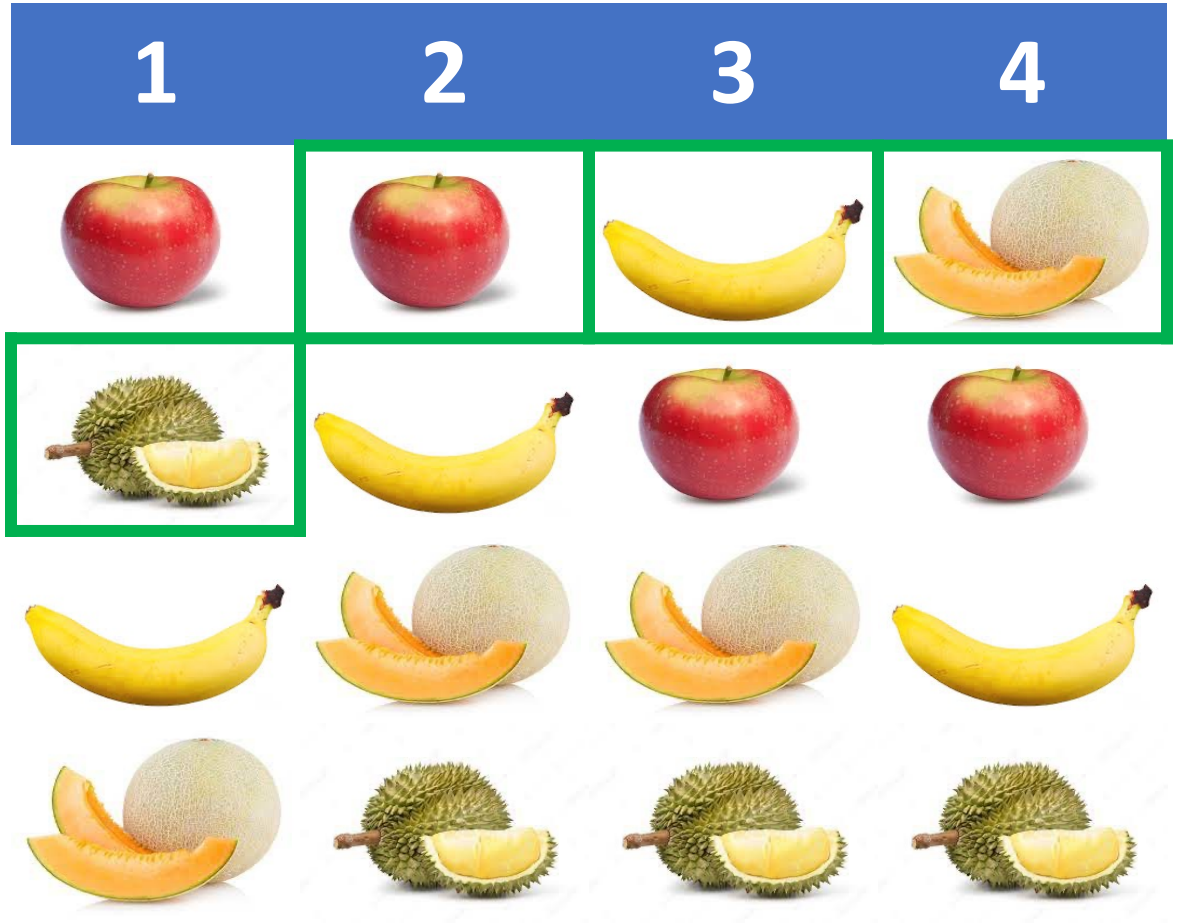
Goal: maximize “total happiness.”

How could we turn this into an algorithm?

Optimization

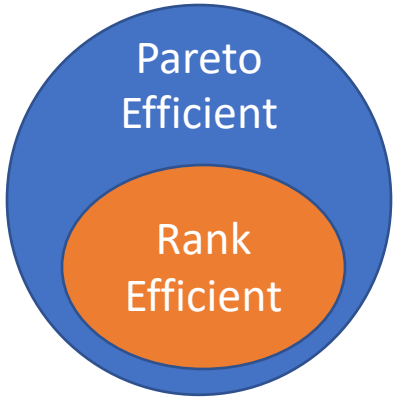
The **sum of ranks** of an allocation is calculated by adding the rank that each agent gives to his or her object.

A feasible allocation is **rank efficient** if no other feasible allocation has a lower sum of ranks.



Group Work:

1. In our example, which allocations are rank efficient?
2. In general, is every rank efficient allocation Pareto efficient?
3. In general, is every Pareto efficient allocation rank efficient?



Implementing Serial Dictatorship

Two Approaches:

1. **Dynamic** mechanism (ask people to choose one at a time).
2. **Direct** mechanism (ask people to tell you their preferences).

When is a dynamic mechanism better?

When is a direct mechanism better?

Dynamic vs Direct

✚Doesn’t require participants to provide as much information.

✚Reasonable if either number of people or number of prizes is small.

✚Only requires one round of back and forth, and thus may take less time.

✚Reasonable if not too many options for people to rank.

Dynamic vs Direct

- ✚Doesn't require participants to provide as much information.
- ✚Reasonable if either number of people or number of prizes is small.

- ✚Only requires one round of back and forth, and thus may take less time.
- ✚Reasonable if not too many options for people to rank.

Group Work: Would you recommend a direct or dynamic implementation?

CBS Offices: 20 faculty assigned to 20 offices.

IE 5541: 50 students assigned to 10 project teams.

Study Guide

Concepts

- Allocation (Assignment)
- Preference Profile
- Pareto Efficient (PE)
- Rank Efficient
- Dynamic Mechanism
- Direct (Revelation) Mechanism

Algorithms

- Serial Dictatorship
- First Choices First (Boston)

Facts

- Serial Dictatorship is PE
- First Choices First is PE.
- Neither is guaranteed to be Rank Efficient.

For Monday (Posted this afternoon)

1. Concept check

2. Reflection + Critical Thinking