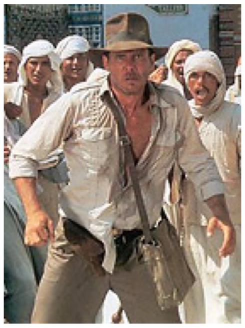
Midterm Project -- Knapsack Problem



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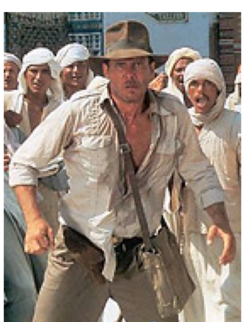
Knapsack Problem

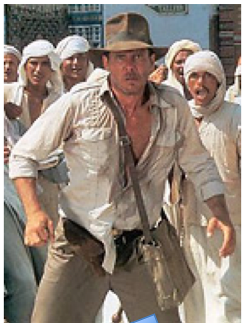


Statchel can only hold C lbs. of treasure

There are n items in the treasure chest.

Each item i: value v_i and a weight w_i

Knapsack Problem



Statchel can only hold C lbs. of treasure

There are n items in the treasure chest.

Each item i: value v_i and a weight w_i

Which items should Indiana put in his satchel to maximize value?

Knapsack Instance

v_i	10	10	12	2	
	1	2	3	4	C=7
w_i	2	3	4	1	

Knapsack Instance

	1	2	3	4
v_i	10	10	12	2
w_i	2	3	4	1

C=7

In the Project:

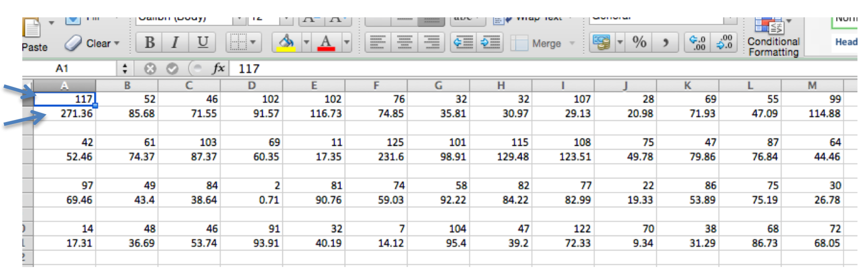
- C in U[100,150]
- Only find out C once you choose which items to put in the knapsack
- If you go over C, then you get nothing for that instance

Knapsack Instance

In the Project:

- 500 Knapsack Instances
- C in U[100,150]
- Only find out C once you choose which items to put in the knapsack
- If you go over C, then you get nothing for that instance

Here is how I'll give you the knapsack instances



A	B	C	D	E	F	G	H	I	J	K	L	M
117	52	46	102	102	76	32	32	107	28	69	55	99
271.36	85.68	71.55	91.57	116.73	74.85	35.81	30.97	29.13	20.98	71.93	47.09	114.88
42	61	103	69	11	125	101	115	108	75	47	87	64
52.46	74.37	87.37	60.35	17.35	231.6	98.91	129.48	123.51	49.78	79.86	76.84	44.46
97	49	84	2	81	74	58	82	77	22	86	75	30
69.46	43.4	38.64	0.71	90.76	59.03	92.22	84.22	82.99	19.33	53.89	75.19	26.78
14	48	46	91	32	7	104	47	122	70	38	68	72
17.31	36.69	53.74	93.91	40.19	14.12	95.4	39.2	72.33	9.34	31.29	86.73	68.05

How to Submit

	A	B	C	D	E	F	G	H	I	J	K	L	M	
Space consump.	117	52	46	102	102	76	32	32	107	28	69	55	99	Instance 1
rewards	271.36	85.68	71.55	91.57	116.73	74.85	35.81	30.97	29.13	20.98	71.93	47.09	114.88	
	42	61	103	69	11	125	101	115	108	75	47	87	64	Instance 2
	52.46	74.37	87.37	60.35	17.35	231.6	98.91	129.48	123.51	49.78	79.86	76.84	44.46	
	97	49	84	2	81	74	58	82	77	22	86	75	30	Instance 3
	69.46	43.4	38.64	0.71	90.76	59.03	92.22	84.22	82.99	19.33	53.89	75.19	26.78	
	14	48	46	91	32	7	104	47	122	70	38	68	72	
	17.31	36.69	53.74	93.91	40.19	14.12	95.4	39.2	72.33	9.34	31.29	86.73	68.05	

Turn in your Answer as “Name.csv”

	A	B	C	D	E	F
	30	63	98	83	102	
	18.12	35.2	53.81	40.26	34.58	
decision	1	1	0	0	0	
	119	17	1	104	59	
	37.35	27.87	1.24	120.29	32.19	
	1	0	0	0	0	

Conservative Approach

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- Assume the size of the knapsack is 100 for all instances
  - This way you will never go over

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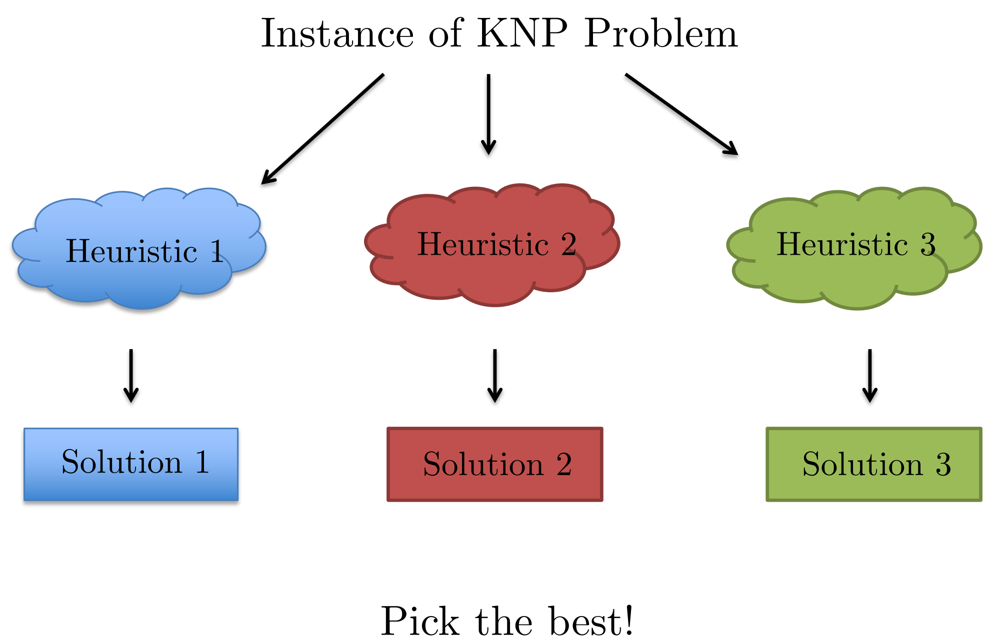
- Assume the size of the knapsack is 100 for all instances
  - This way you will never go over

- Find best way to pack knapsack.
  - Develop a few heuristics.
  - For each instance of the knapsack problem, pass the instance to each heuristic and then pick the best.

Conservative Approach



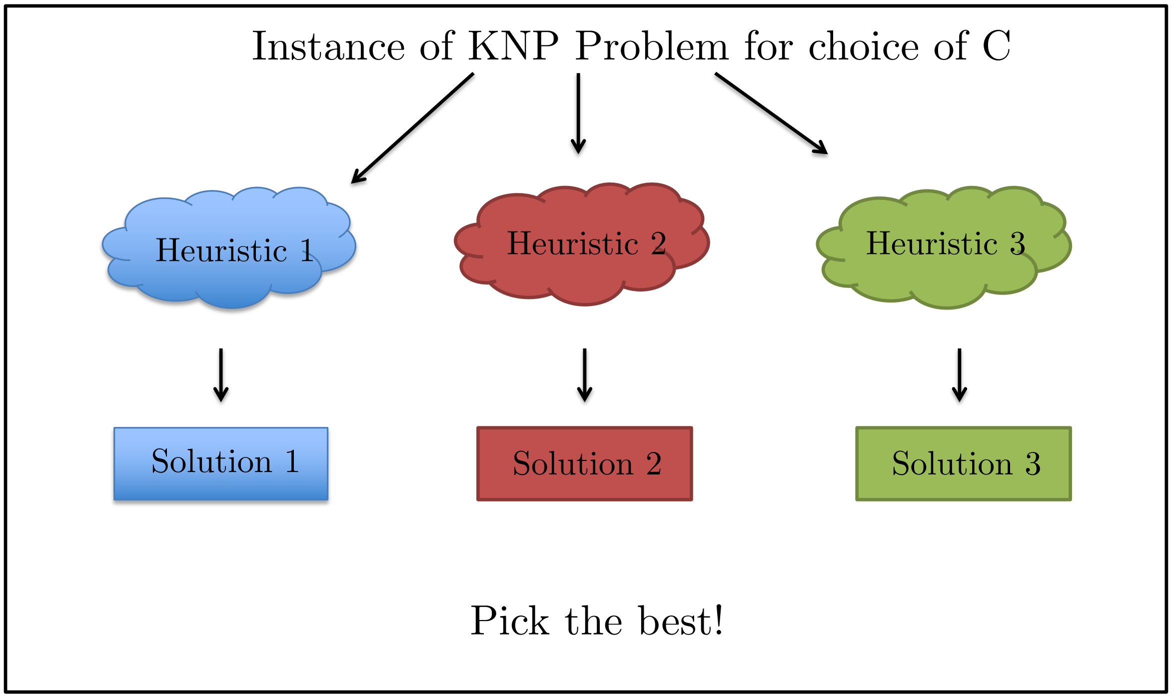
Improving Solution

- If I assume all knapsacks have size 100, I might be leaving points on the table.

- Use Monte Carlo to find a good mix of knapsack sizes.
  - Start by assuming all knapsacks are the same size.

Conservative Approach

Monte Carlo Simulation



Grading

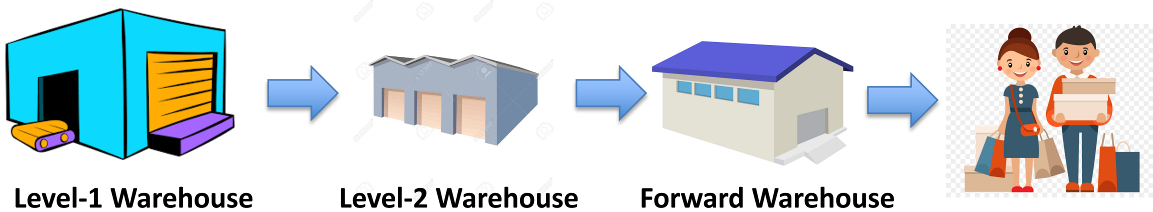
- 20 points total
  - 4 points towards how good your solution is
    - Top Three Place (among all groups across sessions) – 4 points
    - Rest of top 33% - 3 points
    - Middle 33% - 2 points
    - Bottom 33% - 1 point
  - 16 points towards the fact your code actually runs.
    - Your code needs to pass the auto-grader and provides a non-negative value.

Actual use cases of Knapsack Problems

- Logistics Problem in Cainiao (Alibaba) or Amazon:
  - **3-tier shipping logistics:** Level-1 Warehouse, Level-2 Warehouse, Forward Warehouse
  - **Level-1 Warehouse:** The largest warehouse which are far from customers (5 – 10 in China)
  - **Level-2 Warehouse:** Smaller warehouse closer to customers (1-5 per province in China)
  - **Forward Warehouse:** Smallest warehouse closest to customers (1-2 per major tier-1 and tier-2 cities in China)

- Question: Which items should we put in the forward warehouses?
  - Each item has a value: the value equals to the improvement in shipping speed in terms of putting it in the forward warehouse than other warehouses.
  - Each item has a cost: the cost equals to the shipping costs of the item from level-1 or level-2 warehouses to the forward warehouse and the storage costs.

- This is exactly a Knapsack problem!



Actual use cases of Knapsack Problems

- Creating cheat-sheet for Exams

- Each solution or knowledge point:
  - **Has a value:** the points of the solution/knowledge point in the exam * the probability that you will not know it if it is not on the cheat sheet
  - **Has a cost:** The space it takes to write down this solution or knowledge point