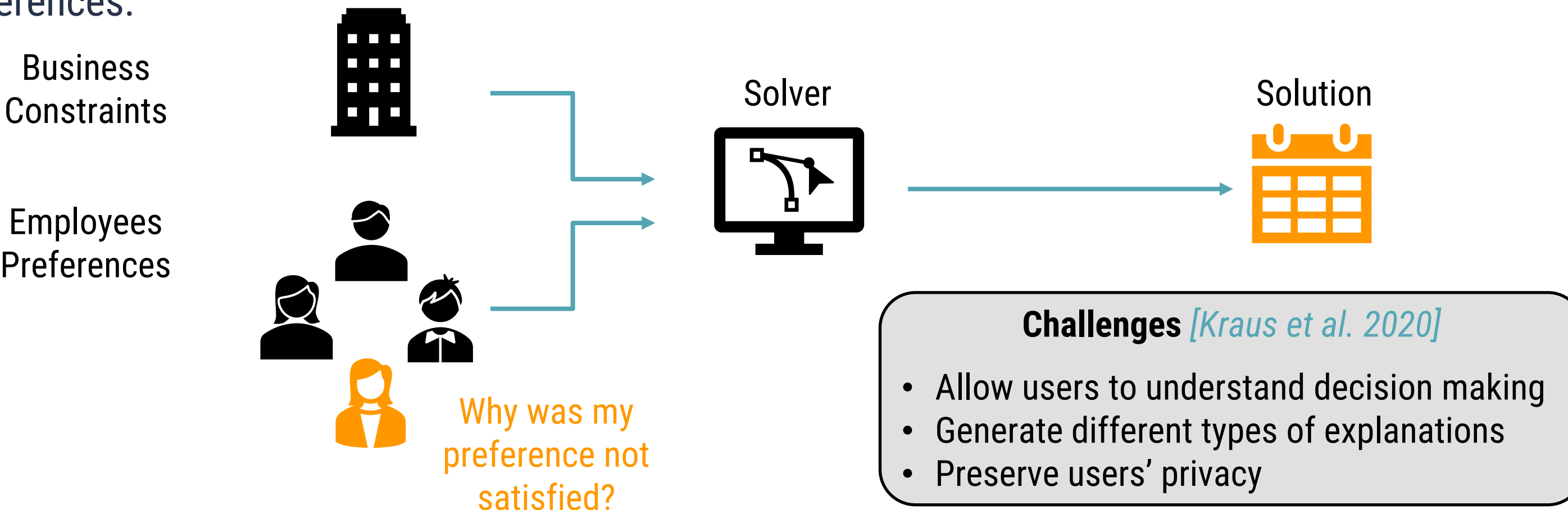


Motivation

Scheduling is the task of **assigning a set of scarce resources distributed over time to a set of agents**, who typically have **preferences** about the assignments. Due to the **constrained** nature of these problems, **satisfying all agents' preferences is often infeasible**.

Providing **explanations** has been shown to increase **satisfaction** and **trust** in solutions. We present the EXPRES framework, which explains **why a given preference was unsatisfied in a given optimal schedule**.

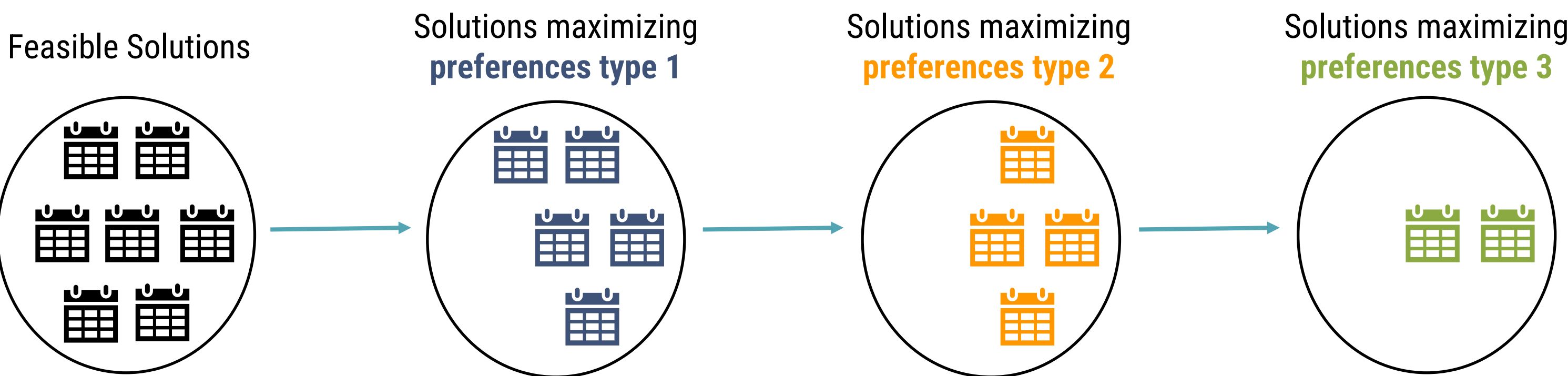
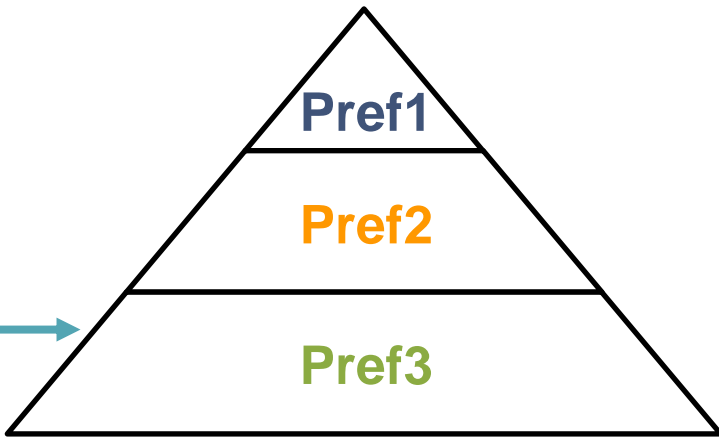
J.P.Morgan use case: return to office after COVID-19 restrictions required scheduling of employees to a limited number of desks over a fixed time period while considering their preferences.



Problem Setup: Preference-driven Scheduling

A **PRES** problem is a tuple $PRES = \langle R, Ag, T, C, P, O \rangle$ where:

- R : a set of resource types
- Ag : a set of agents
- T : a set of time slots
- C : the set of all constraints
- P : the set of all agents' preferences
- O : a totally ordered set of preference types



EXPRES: Explaining PRES Solutions

A **EXPRES** problem is a tuple $EXPRES = \langle PRES, S, u \rangle$ where:

- $PRES = \langle R, Ag, T, C, P, O \rangle$
- S : a set of assignments that optimally solve PRES
- u : an unsatisfied preference

Solution to an EXPRES problem is an explanation which is a **set of reasons** why preference u was unsatisfied. A **reason** is preference u from assignment S was unsatisfied due to preference p being satisfied.

Well Defined Reasons

- Provide exactly **one reason** for each of the **Involved assignments**
- Only reasons where the given assignment is affected by the preference are selected
- Only more/equally important preferences are used to justify less/equally important unsatisfied preferences

Edith: "Why my **preferred** day on Thursday was not satisfied?"

	Mon	Tue	Wed	Thu	Fri
Edith					
George				1	
Han					
Bob				2	
Charlie				3	
Daphne					
Alice				4	
Fei				5	

One reason for each of the involved assignments (1,2,3,4,5)

Clustered Explanation

- 1, 2, 3 – George's, Bob's and Charlie's minimum number of days
- 4 – Alice's meeting
- 5 – Fei's working group

Clustered Anonymized Explanation

- 1, 2, 3 – 3 employees' minimum number of days
- 4 – One employee's meeting
- 5 – One employee's working group

User Studies Results

Hypothesis 1: The EXPRES framework produces solutions faster than humans

	avg	Scenario 1 std dev	EXPRES	avg	Scenario 2 std dev	EXPRES
time (s)	195.9	80.8	≪ 1	186.3	96.2	0.8
difficulty	2.4	1.4	–	2.7	1.1	–

Results of User Study 1. Time is in seconds, difficulty is on 5-point Likert (1= Very easy, 5= Very difficult)

Hypothesis 2: Humans find EXPRES solutions at least as satisfying as the human-generated ones

		E1	E2	E3	tot.E	H4	H5	H6	tot.H
s1	# selections	22	19	14	55	17	5	7	29
	rank score	47	36	24	107	37	10	14	61
s2	# selections	23	17	11	51	14	8	11	33
	rank score	55	28	17	100	34	12	22	68

Results of User Study 2. The rank score is $3x_1 + 2x_2 + x_3$ (x_i is n. of times an explanation has been ranked as i)