Multi-level Optimization Problems for Kidney Exchange

Doctoral defense

Danny Blom

15 december 2023

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

Kidney transplantation

End-stage renal disease (ESRD):

- Undergoing dialysis
- Kidney transplantation (preferred treatment)

Waiting list	Transplants		Registered	Removals
	deceased donors	living donors		
9,939	2,970	1,232	5,466	1,660

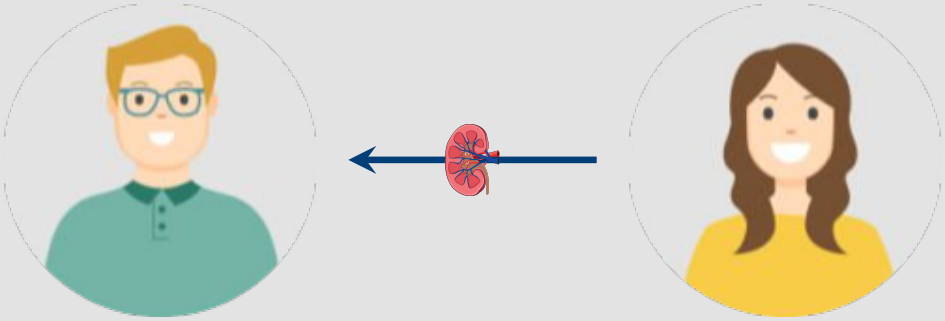
Data from Eurotransplant Statistics Report Library (2022)

Kidney Exchange

Henk

Ingrid

Kidney Exchange



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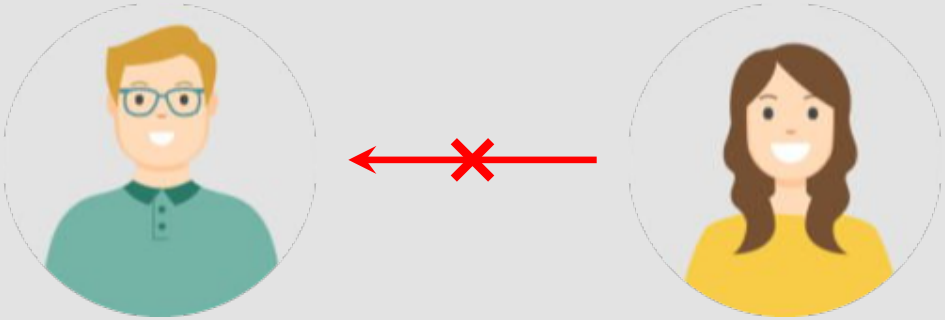

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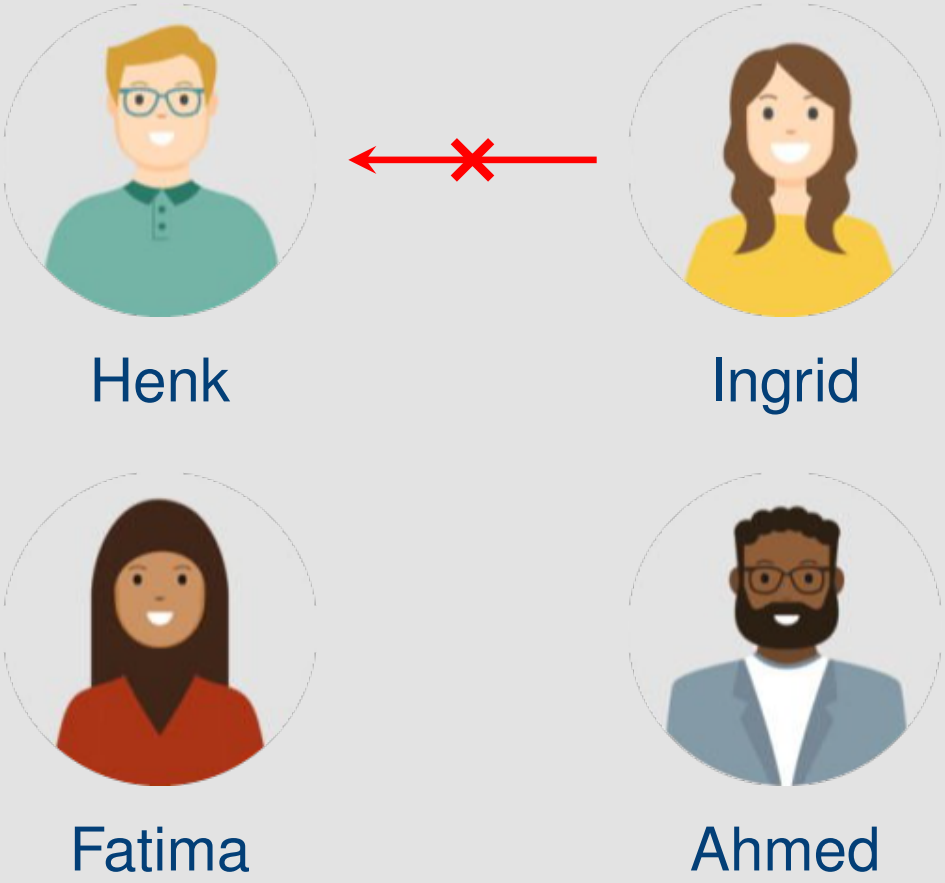

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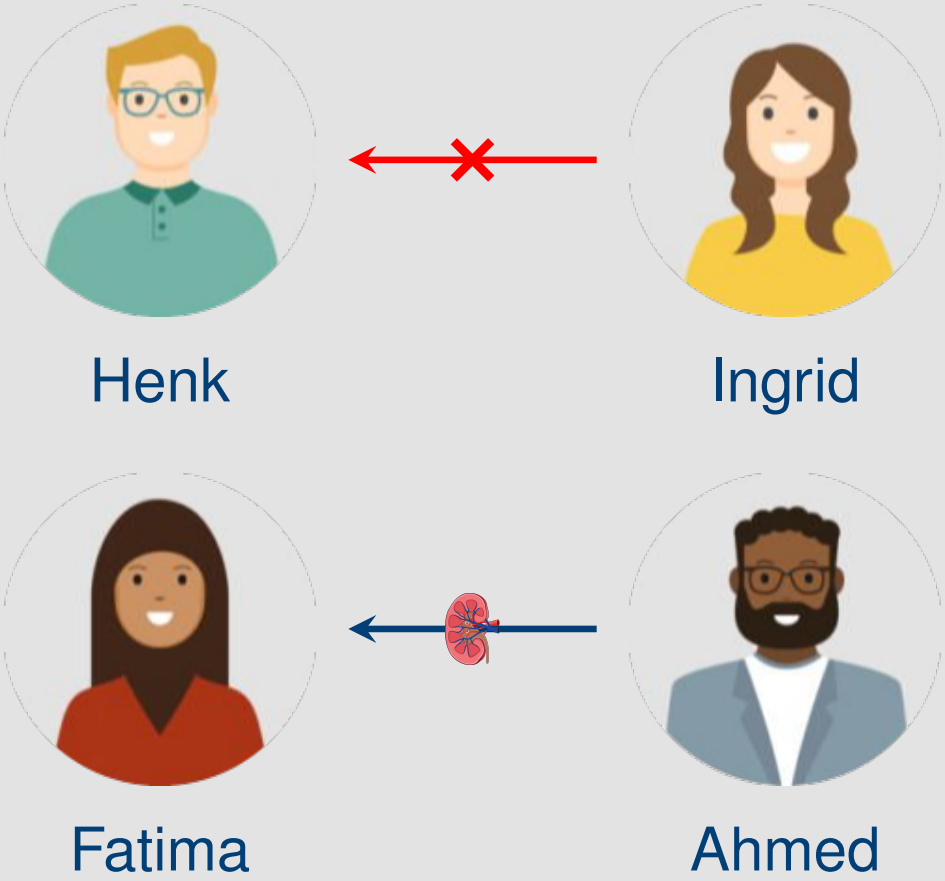

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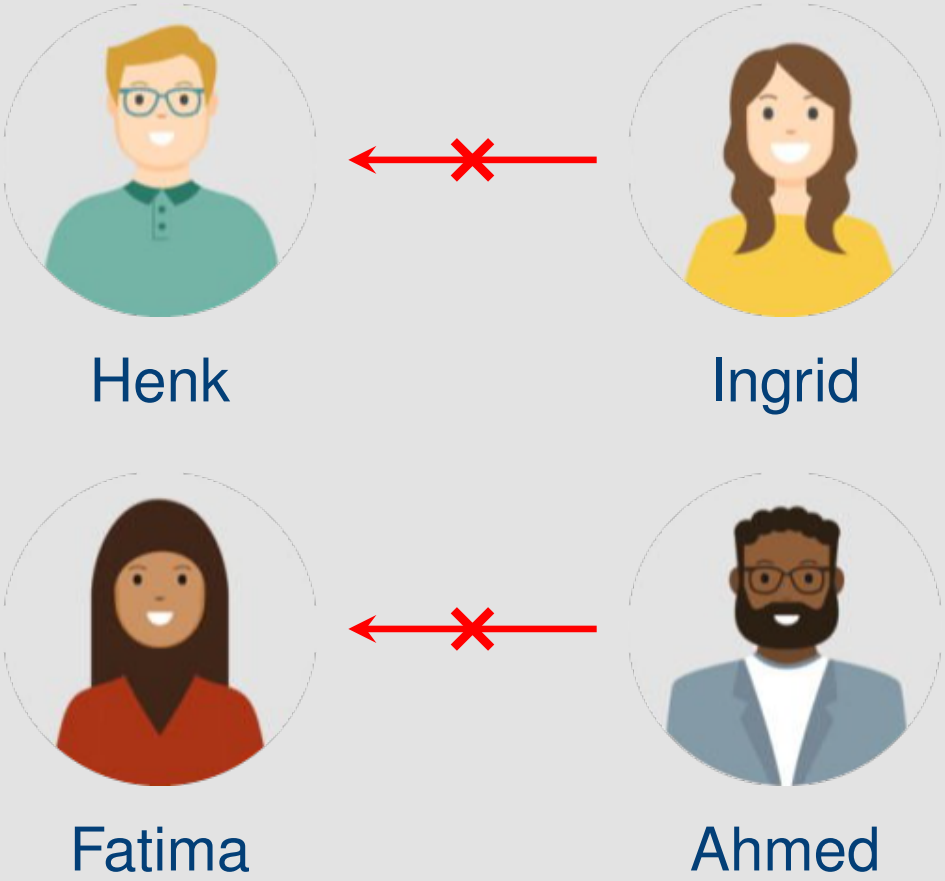

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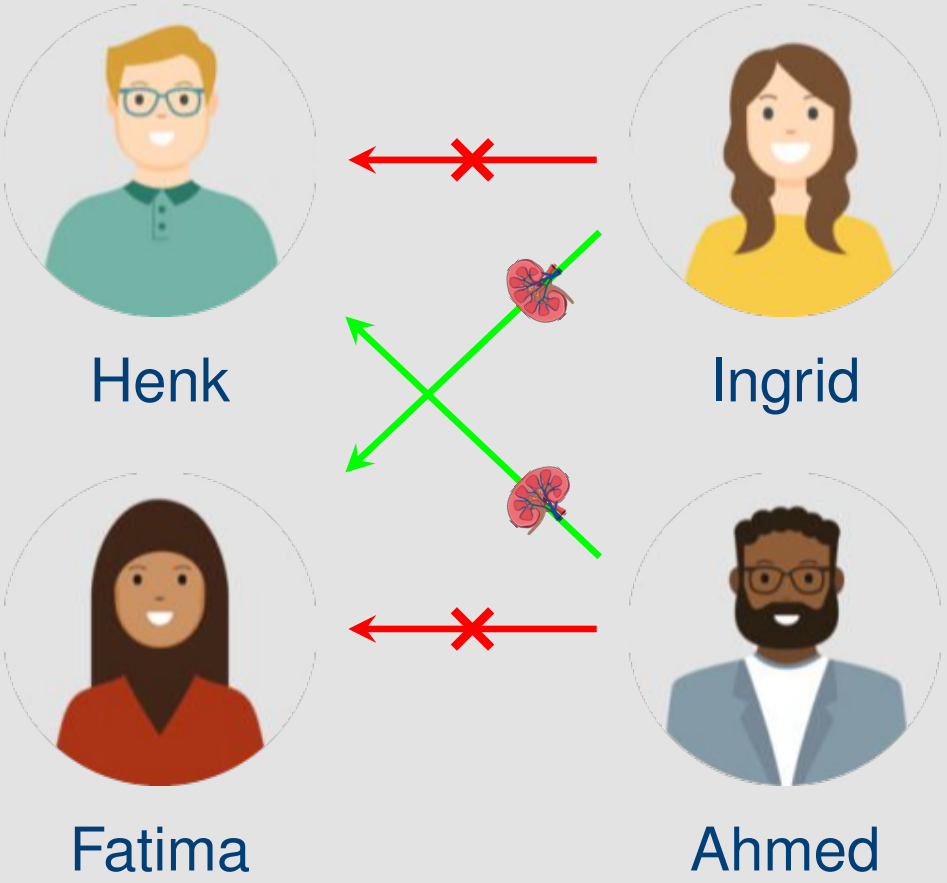

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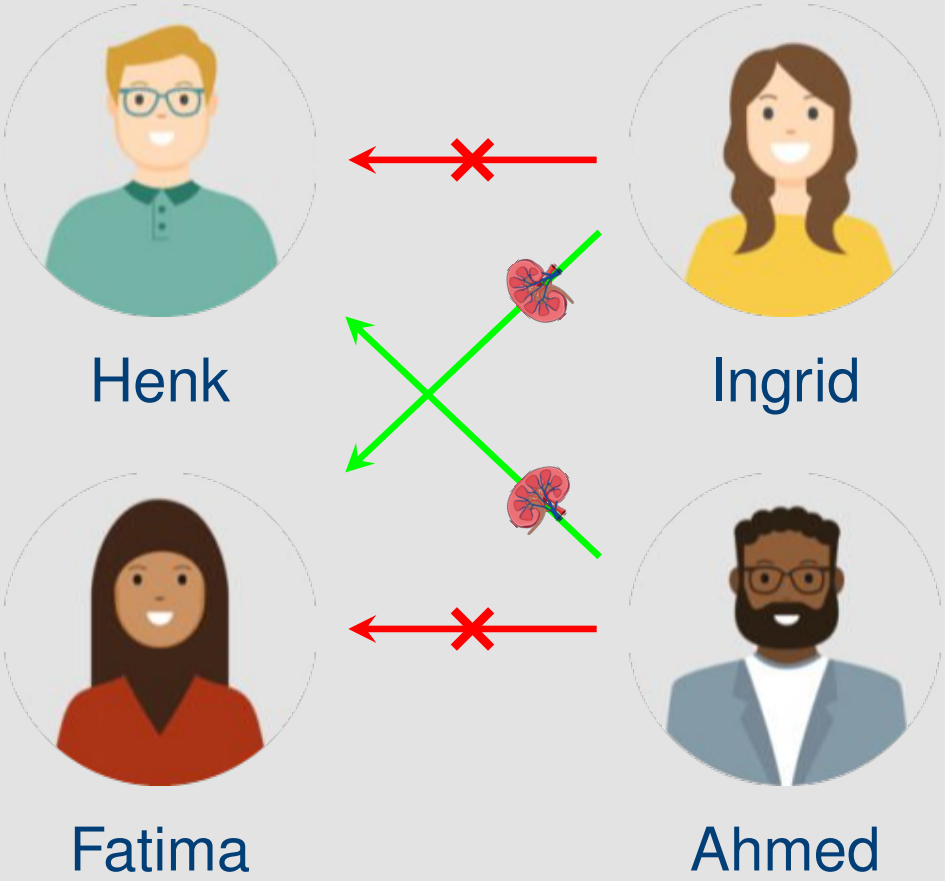

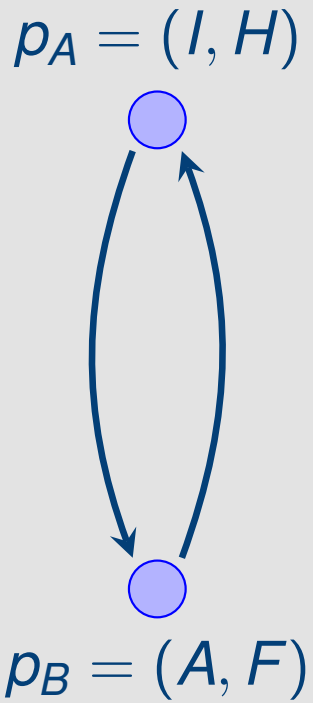

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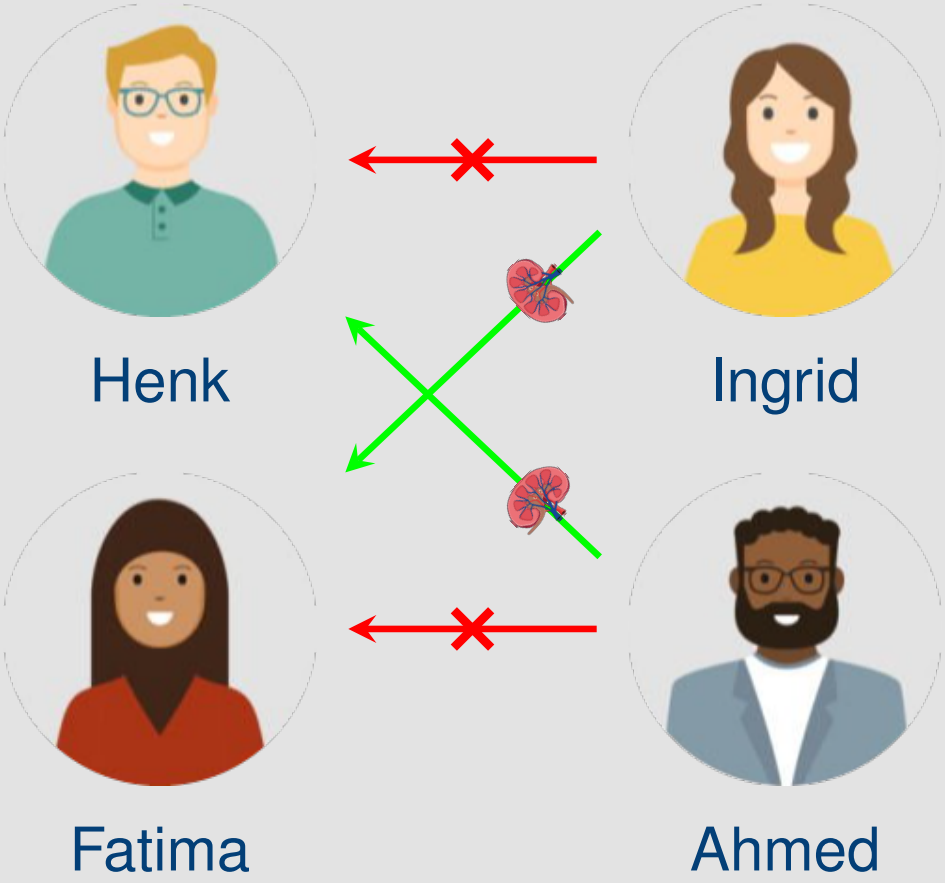
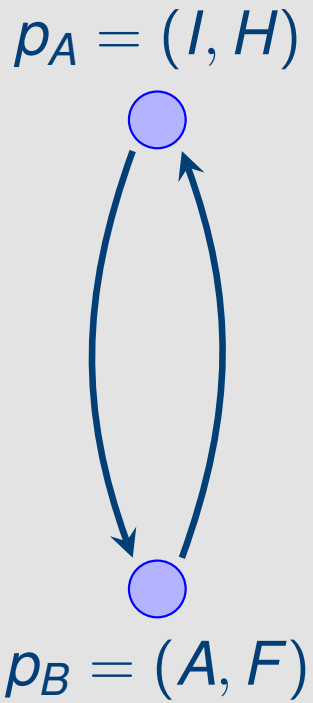
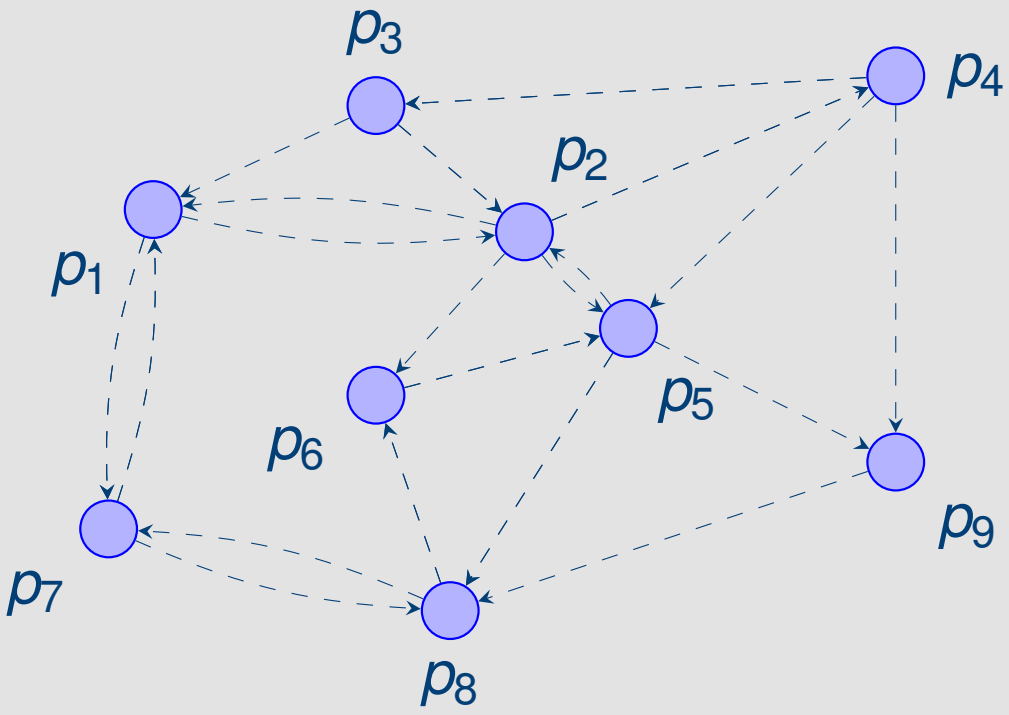




Can be generalized to multiple pairs!

Kidney Exchange Programs (KEPs)

- Each donor can donate at most one kidney!
- Donor donates kidney $\Rightarrow$ Patient receives kidney
- Restricted number of pairs in an exchange



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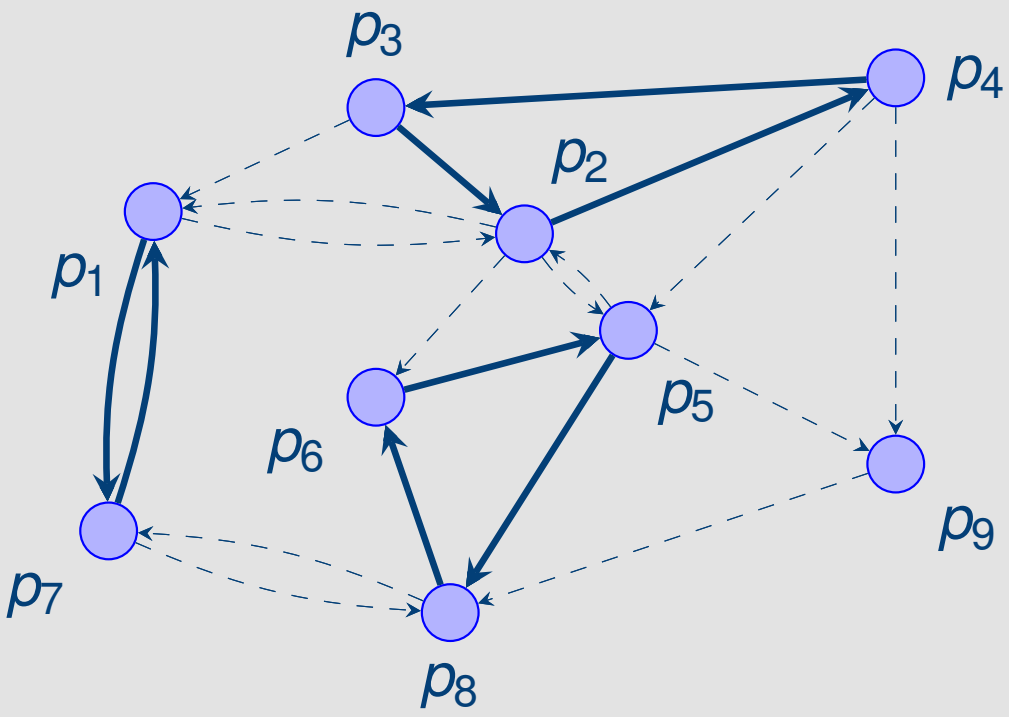

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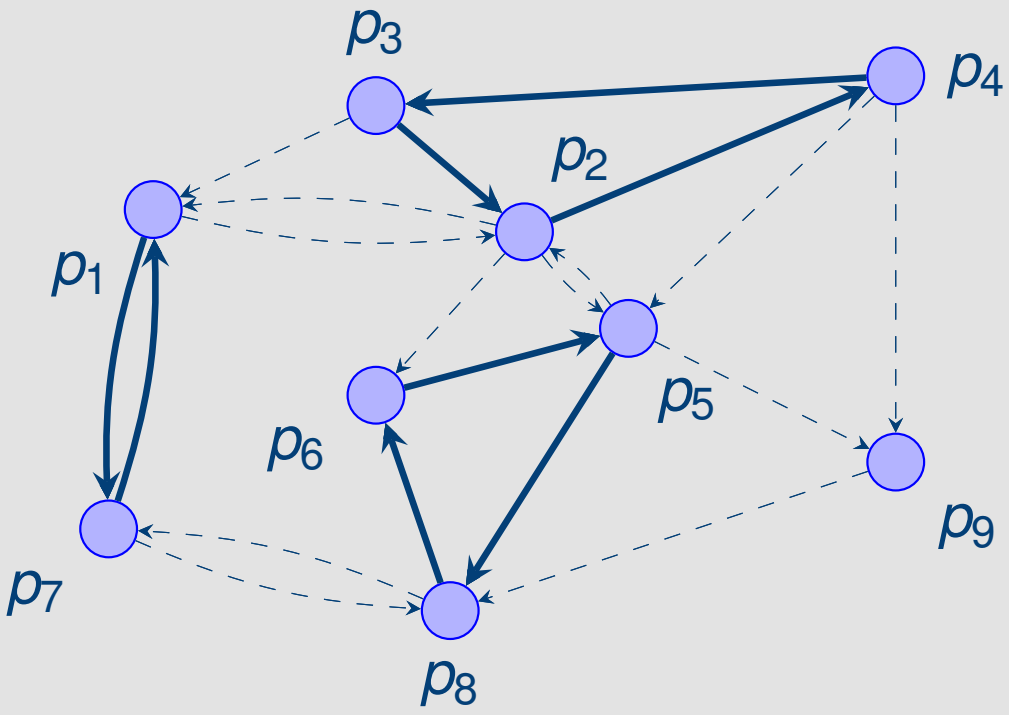

Note: there is no exchange option for pair p_9!

Part 1: Collaborations in Kidney Exchange

Reality: many pairs remain unmatched in a single iteration

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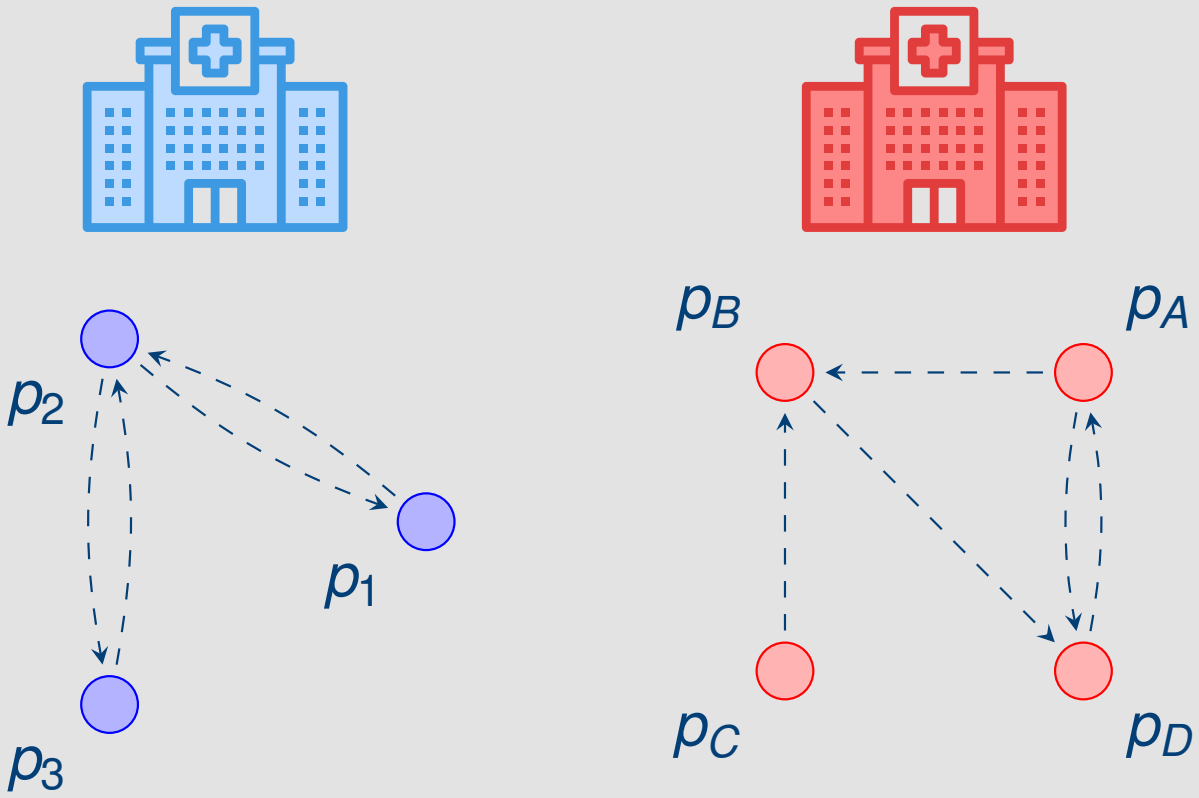
Idea: merge pools of multiple programs!



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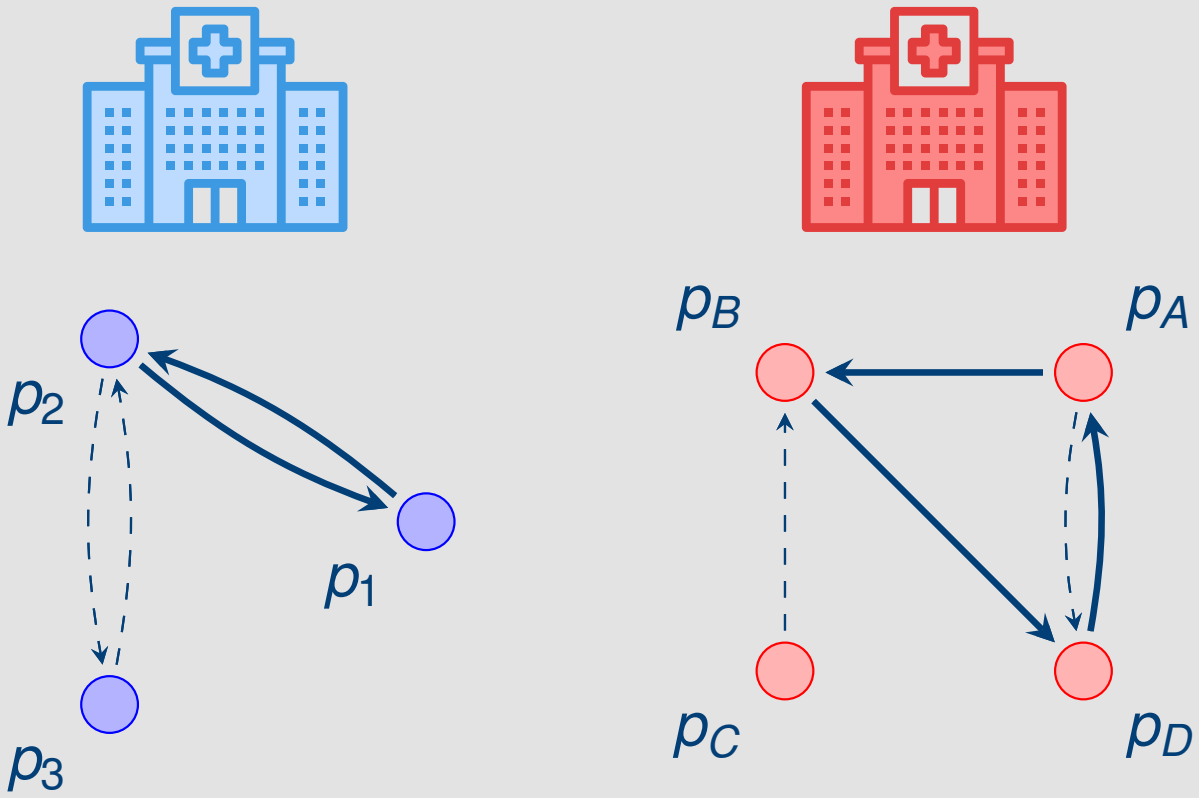

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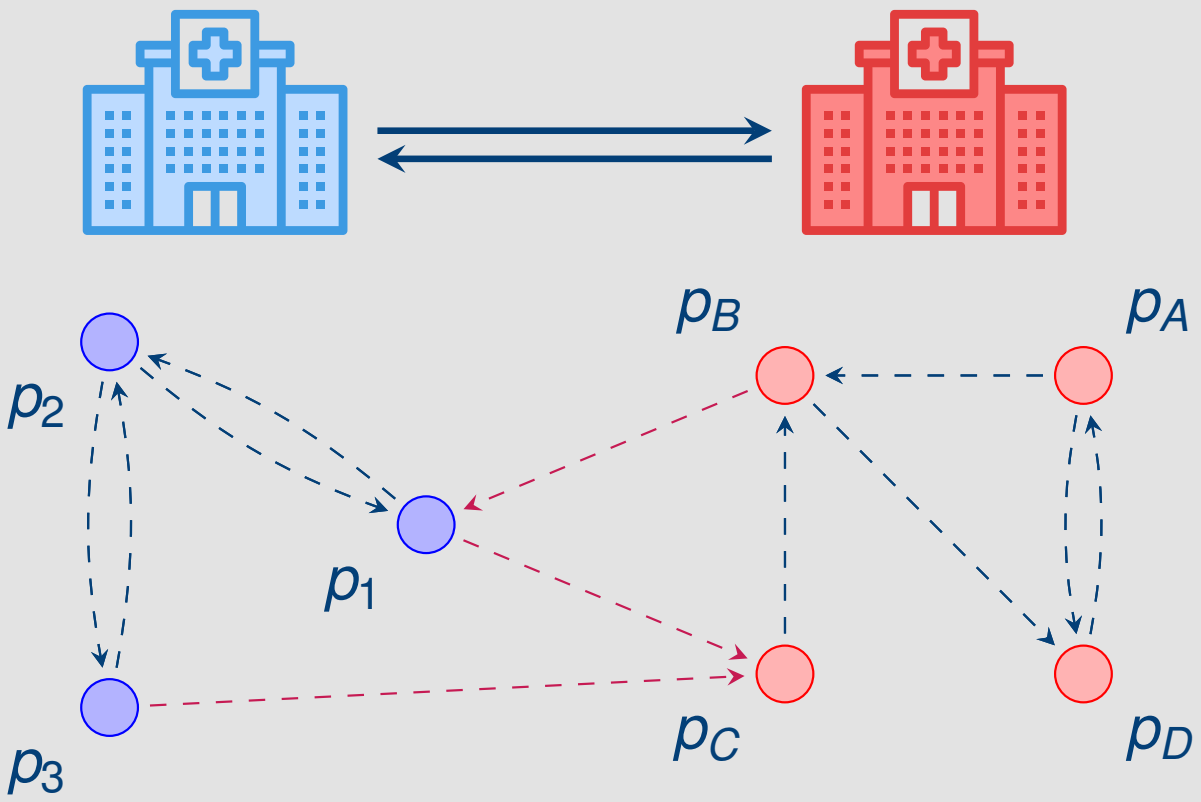

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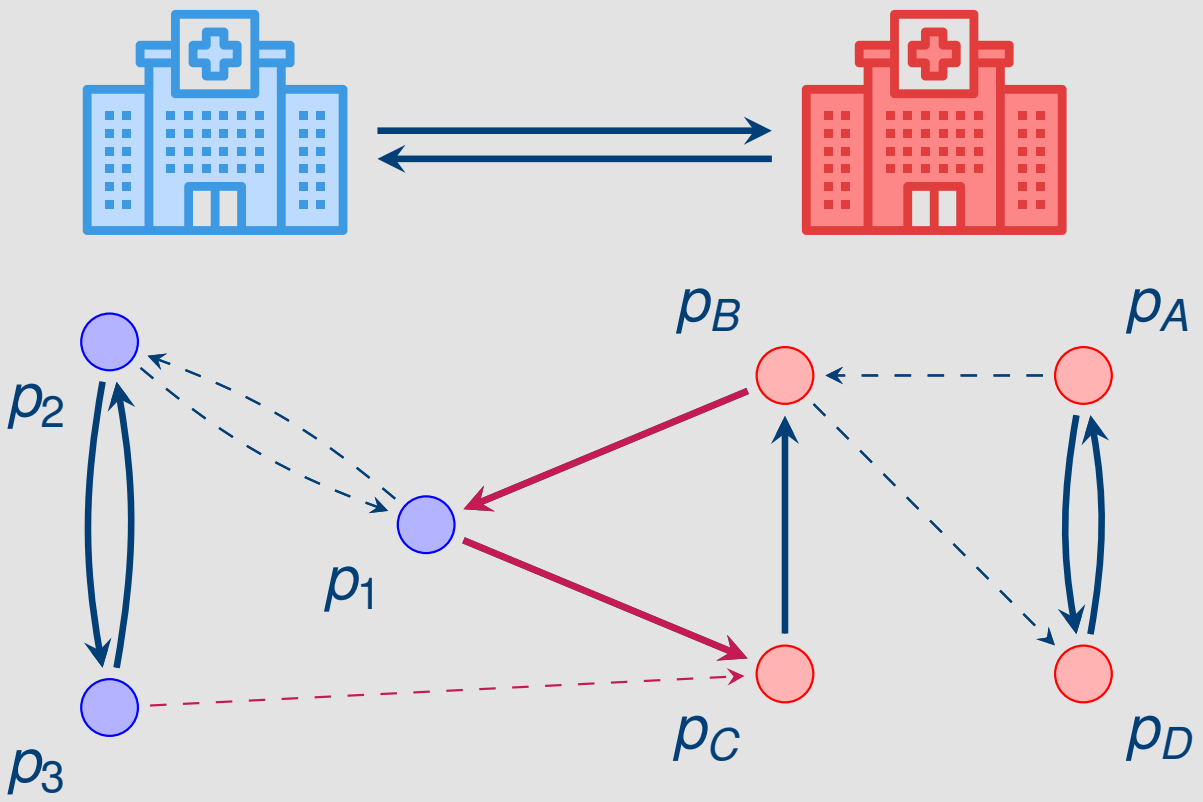
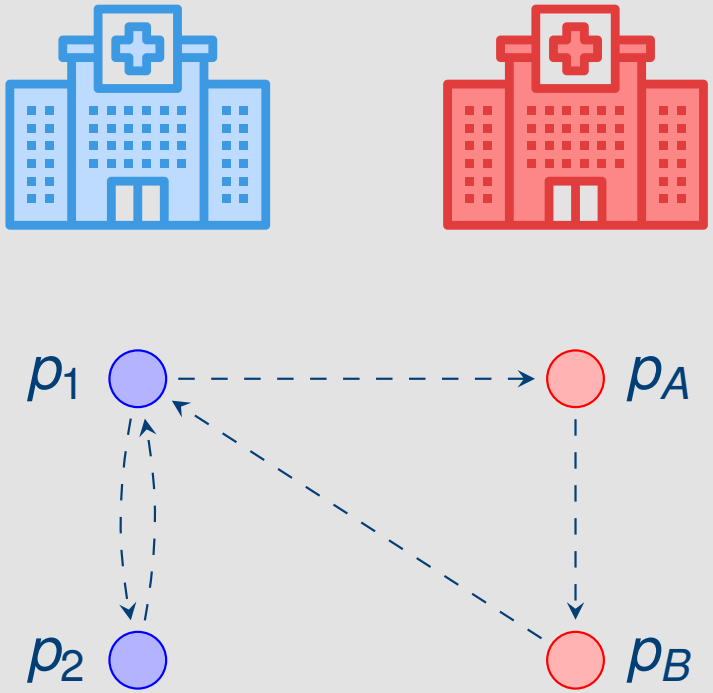


Issues with Collaboration

However, not everyone benefits equally from collaboration

- Conflict of interest: personal welfare versus social welfare
- Strategic choices (internal exchanges, withholding pairs)



Part 1: Main Results

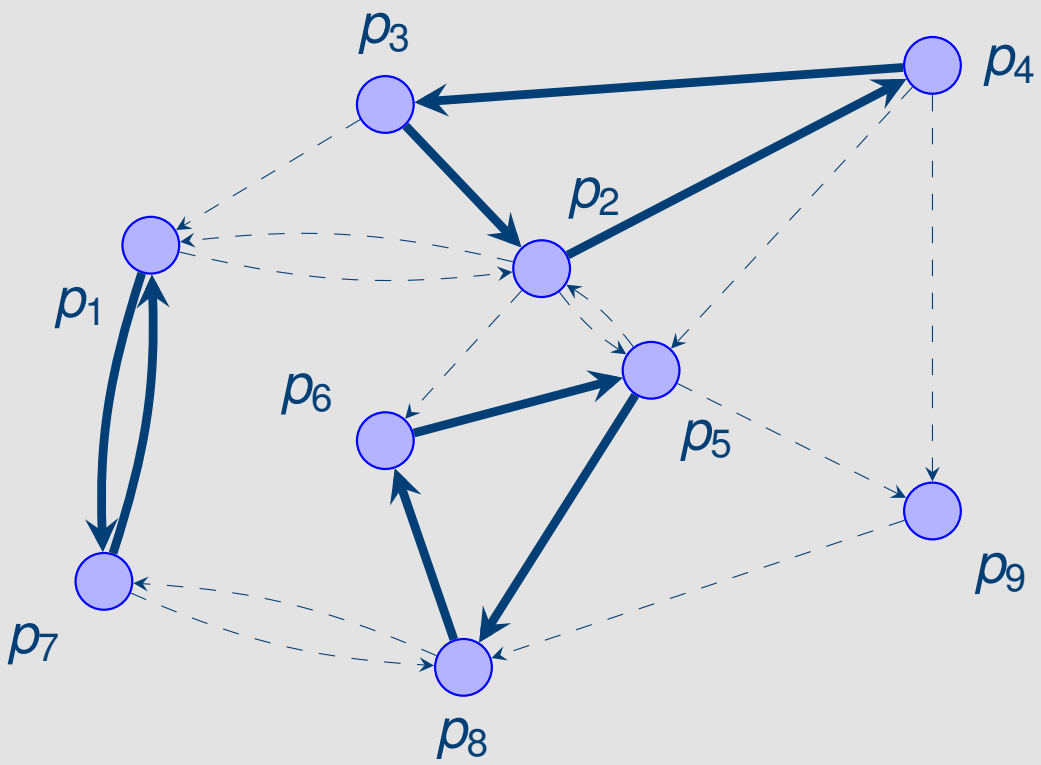
Chapter 2: computing an “optimal withholding strategy” is (theoretically) difficult

Chapter 3: new mechanism for KEP collaborations

- Reporting all pairs often better than greedy withholding
- Outcomes very close to those obtained by merging pools

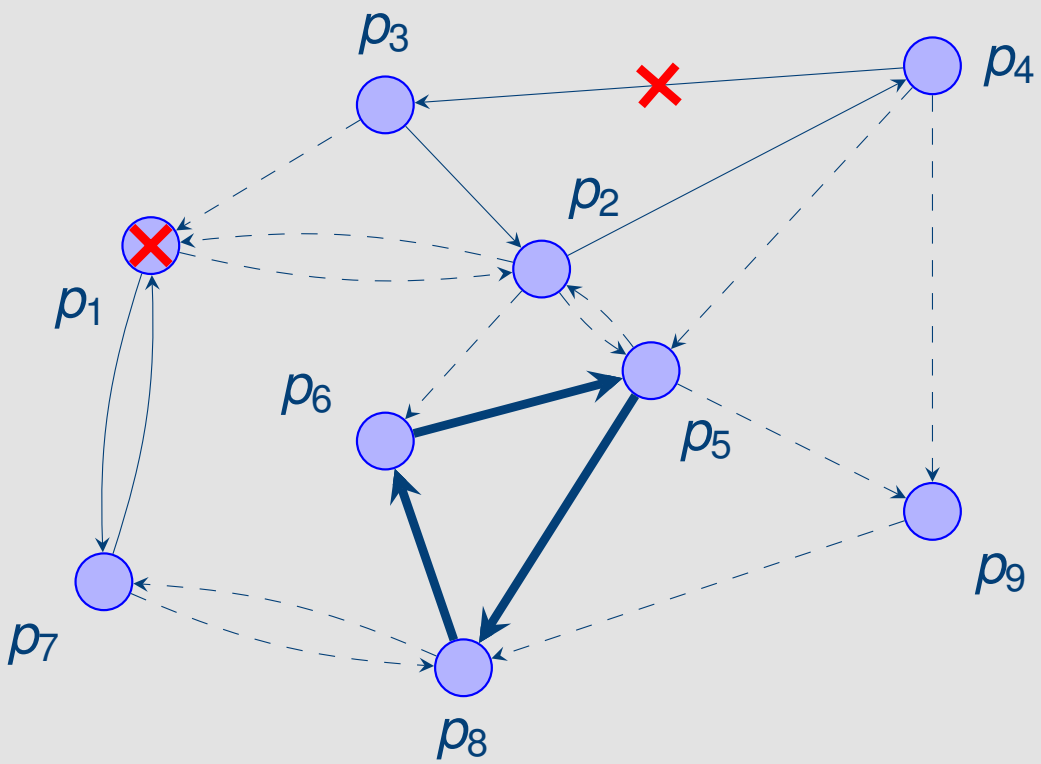
Part 2: Uncertainty in Kidney Exchange

Stage 1: proposal for a set of exchanges



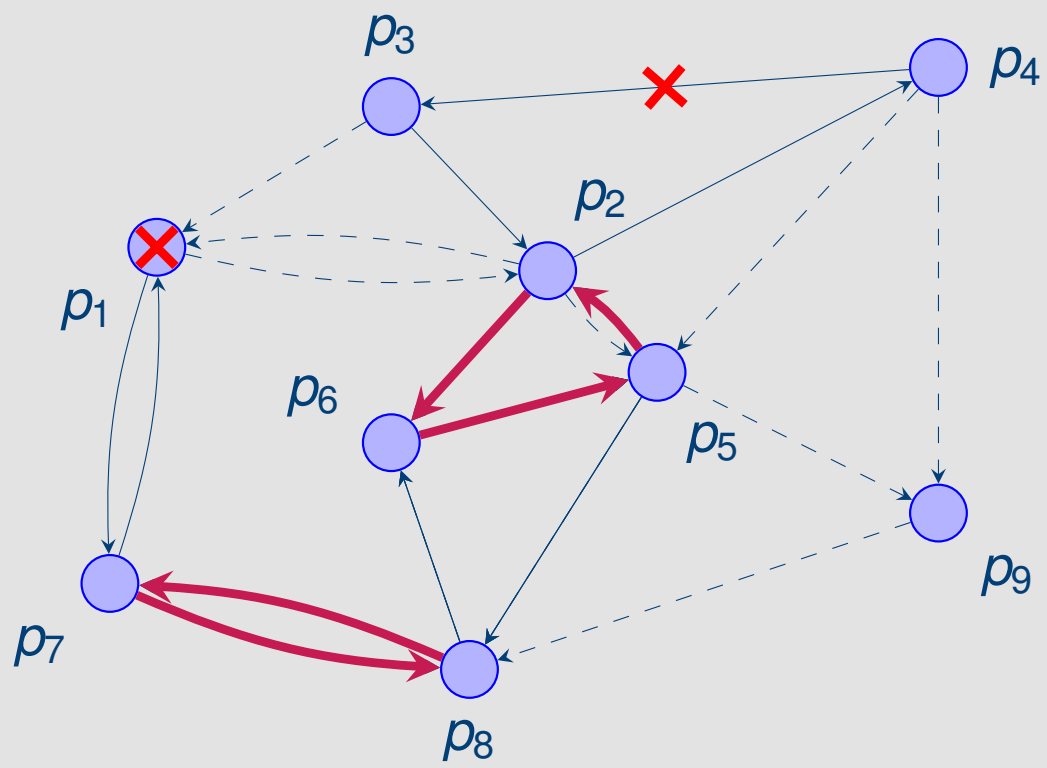
Part 2: Uncertainty in Kidney Exchange

Uncertainty: unexpected incompatibilities, pairs leaving prematurely



Part 2: Uncertainty in Kidney Exchange

Stage 2: reconsider exchanges (*recourse*)



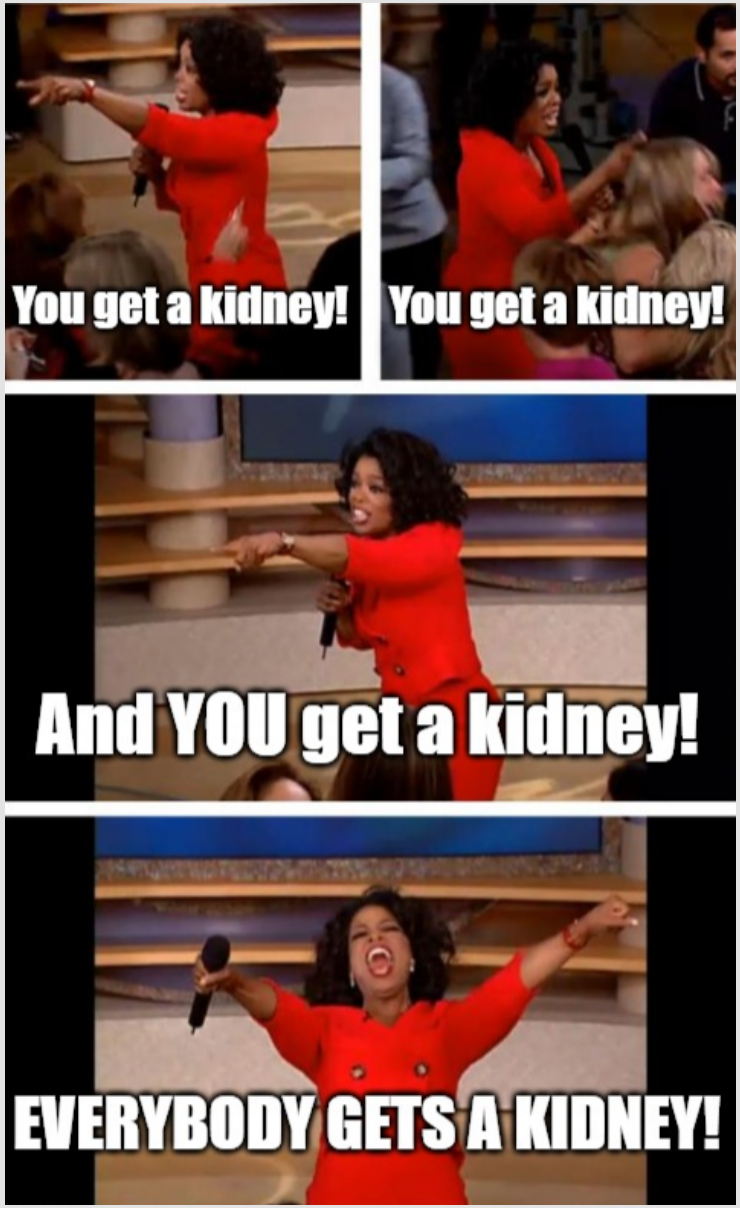
- Take into account stage 1 decision when reoptimizing
- Minimizing disappointment for stage 1 exchange patients

Part 2: Main Results

Optimization involves computing the worst-case failure scenario?

- New algorithm for this subproblem (Chapter 4)
- *Downward monotone interdiction games* (Chapter 5)

Conclusion


You get a kidney!
You get a kidney!
And YOU get a kidney!
EVERYBODY GETS A KIDNEY!

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