DCS/CSCI 2350:
Social & Economic Networks

Matching

Mohammad T. Irfan

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Two-sided matching

Handout for stable marriage
(on Canvas)

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60 Lives, 30 Kidneys, All Linked

By KEVIN SACK FEB. 18, 2012

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RIVERSIDE, Calif. — Rick Ruzzamenti admits to being a tad impulsive. He traded his Catholicism for Buddhism in a revelatory flash. He married a Vietnamese woman he had only just met. And then a year ago, he decided in an instant to donate his left kidney to a stranger.

In February 2011, the desk clerk at Mr. Ruzzamenti's yoga studio told him she had recently donated a kidney to an ailing friend she had bumped into at Target. Mr. Ruzzamenti, 44, had never even donated blood, but the story so captivated him that two days later he called Riverside Community Hospital to ask how he might do the same thing.

Halfway across the country, in Joliet, Ill., Donald C. Terry Jr. needed a kidney in the worst way. Since receiving a diagnosis of diabetes-related renal disease in his mid-40s, he had endured the burning and bloating and dismal tedium of dialysis for nearly a year. With nobody in his family willing or able to give him a kidney, his doctors warned that it might take five years to crawl up the waiting list for an organ from a deceased donor.

FROM START TO FINISH A donation by a Good Samaritan, Rick Ruzzamenti, upper left, set in motion a 60-person chain of transplants that ended with a kidney for Donald C. Terry Jr., bottom right.

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A Record Chain of Kidney Transplants
FEB. 18, 2012

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Alvin Roth
Nobel Prize 2012

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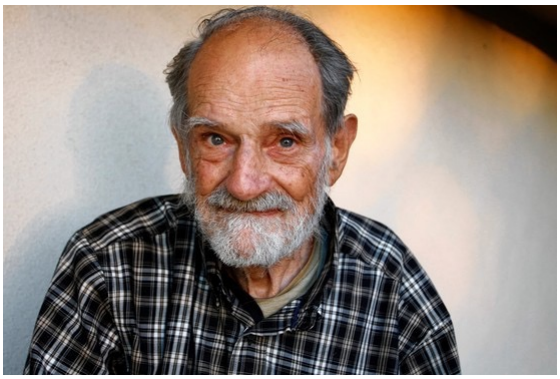

Lloyd Shapley
Nobel Prize 2012

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Stable matching

Given n men and n women, where each man ranks all women and each woman ranks all men, find a stable matching.

Stable matching: There exists no unmatched pair (X, Y) that prefer each other over their matched partners.

- Such (X, Y) pair if exists is called a "blocking pair"

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Perfect matching

Each person is matched to another

Necessary condition: # men = # women

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Is there always a perfect matching that's stable?

- Yes, Gale-Shapley algorithm (1962)
- *Deferred acceptance algorithm*

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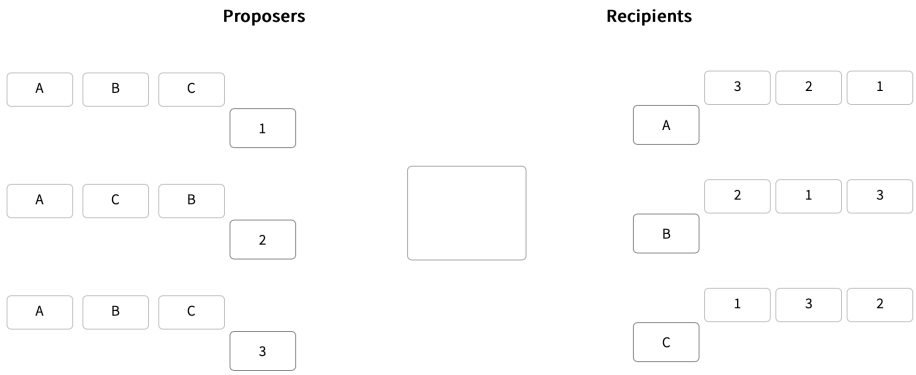
Demo

https://gale-shapley.com



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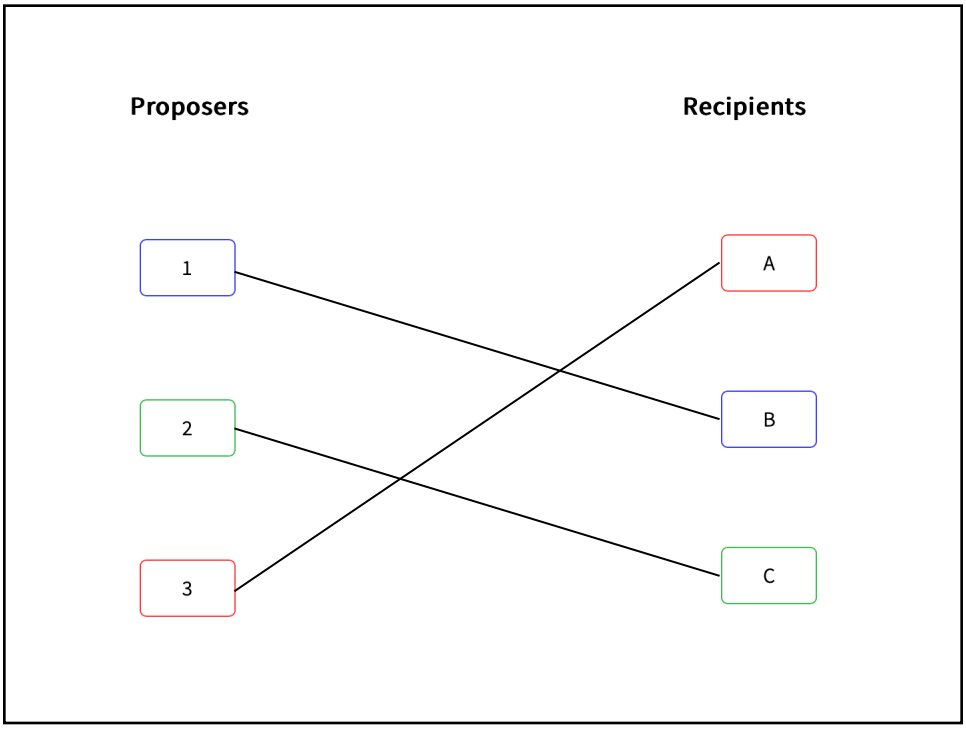

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Gale-Shapley algorithm: Men-proposing version

```
assign each person to be free ;
while some man m is free do
begin
    w := first woman on m's list to whom m has not yet proposed ;
    if w is free then
        assign m and w to be engaged {to each other}
    else
        if w prefers m to her fiancé m' then
            assign m and w to be engaged and m' to be free
        else
            w rejects m {and m remains free}
end ;
output the stable matching consisting of the n engaged pairs
```

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Gale-Shapley algorithm

- Thm 1.2.1. The algorithm terminates with a stable matching.
- Thm 1.2.2. Men-proposing version is men-optimal [ordering of men doesn't matter]
- Thm 1.2.3. Men proposing version is the worst for women [each woman gets the worst man subject to the matching being stable]

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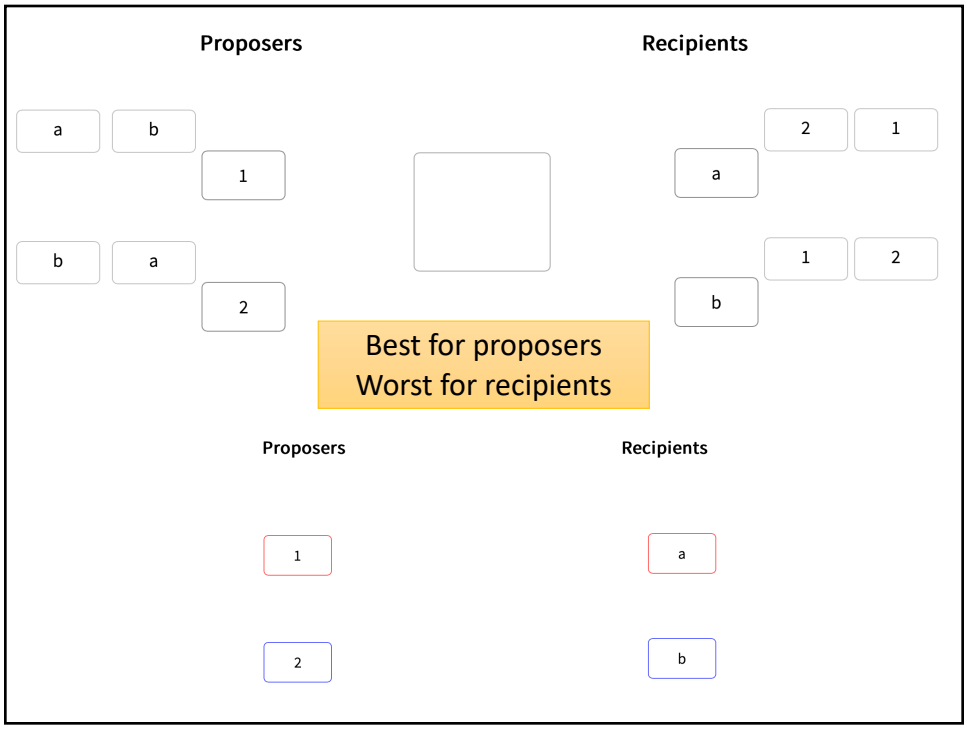
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Best for proposers
Worst for recipients
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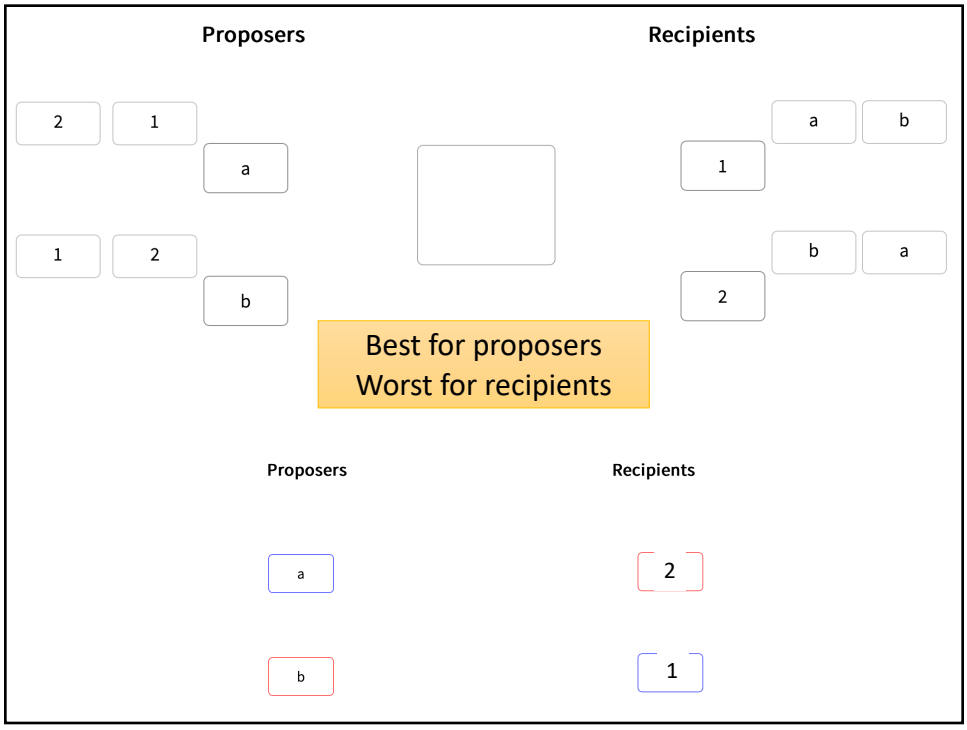
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Best for proposers
Worst for recipients
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Recipients
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Applications

beyond kidney exchange

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Residency matching

Hospitals interview candidates and rank them

Candidates rank hospitals that interviewed them

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N.Y. / REGION

How Game Theory Helped Improve New York City's High School Application Process

By TRACY TULLIS DEC. 5, 2014

Tuesday was the deadline for eighth graders in New York City to submit applications to secure a spot at one of 426 public high schools. After months of school tours and tests, auditions and interviews, 75,000 students have entrusted their choices to a computer program that will arrange their school assignments for the coming year. The weeks of research and deliberation will be reduced to a fraction of a second of mathematical calculation: In just a couple of hours, all the sorting for the Class of 2019 will be finished.

To middle-school students and their parents, the high-school admissions process is a grueling and universally loathed rite of passage. But as awful as it can be, it used to be much worse. In the late 1990s, for instance, tens of thousands of children were shunted off to schools that had nothing going for them, it seemed, beyond empty desks. The process was so byzantine it appeared nothing short of a Nobel Prize-worthy algorithm could fix it.

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NYC high school matching

- Around 80K 8-th graders are matched to around 500 high schools
- Each student ranks at most 12 schools
- Schools rank applicants
  - 'But schools continue to tell parents and students — "with a wink" — that they may be penalized if they don't list their school first.' (https://www.dnainfo.com/new-york/20161115/kensington/nyc-high-school-admissions-ranking)
- Match by DOE

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Content delivery networks (CDN)

Algorithmic Nuggets in Content Delivery

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The authors take full responsibility for this article's technical content. Comments can be posted through CCR Online.

ABSTRACT

This paper "peeks under the covers" at the subsystems that provide the basic functionality of a leading content delivery network. Based on our experiences in building one of the largest distributed systems in the world, we illustrate how sophisticated algorithmic research has been adapted to balance the load between and within server clusters, manage the caches on servers, select paths through an overlay routing network, and elect leaders in various contexts. In each instance, we first explain the theory underlying the algorithms, then introduce practical considerations not captured by the theoretical models, and finally describe what is implemented in practice. Through these examples, we highlight the role of algorithmic research in the design of complex networked systems. The paper also illustrates the close synergy that exists between research and industry where research ideas cross over into products and product requirements drive future research.

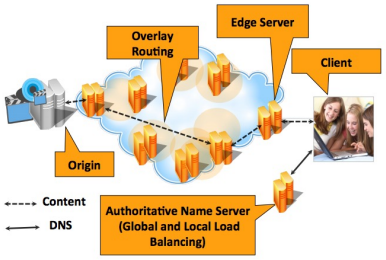

Figure 1: A CDN serves content in response to a client's request.

1. INTRODUCTION

The top-three objectives for the designers and operators of a content delivery network (CDN) are high reliability, fast and consistent performance, and low operating cost.

CDN's authoritative name server. The authoritative name

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