eHarmony

Maximizing the Probability of Love

15.071x – The Analytics Edge

About eHarmony

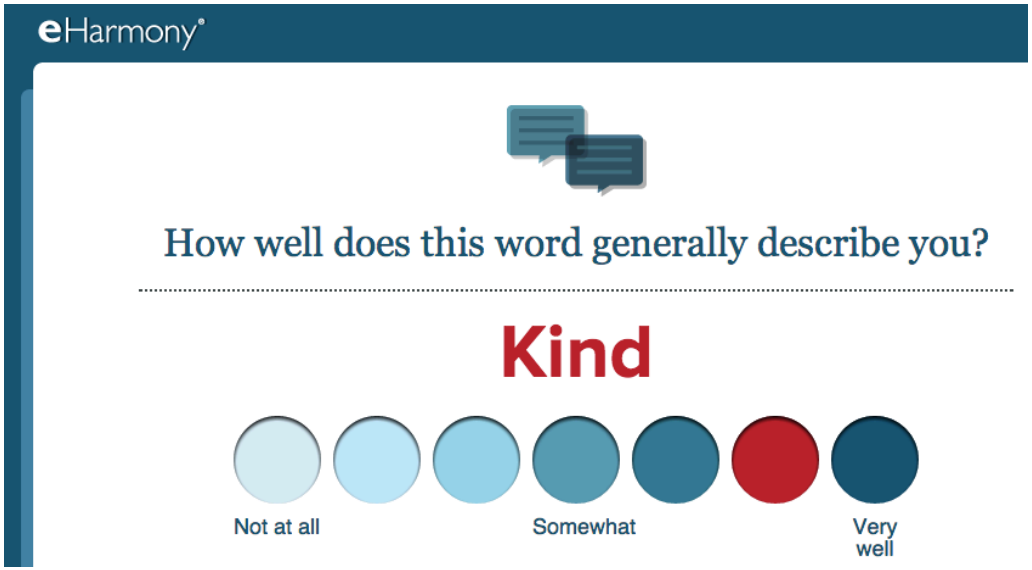
- Goal: take a scientific approach to love and marriage and offer it to the masses through an online dating website focused on long term relationships
- Successful at matchmaking
  - Nearly 4% of US marriages in 2012 are a result of eHarmony
- Successful business
  - Has generated over $1 billion in cumulative revenue

The eHarmony Difference

- Unlike other online dating websites, eHarmony does not have users browse others' profiles
- Instead, eHarmony computes a compatibility score between two people and uses optimization algorithms to determine their users' best matches

eHarmony's Compatibility Score

- Based on 29 different "dimensions of personality" including character, emotions, values, traits, etc.
- Assessed through a 436 question questionnaire
- Matches must meet >25/29 compatibility areas



Dr. Neil Clark Warren

- Clinical psychologist who counseled couples and began to see that many marriages ended in divorce because couples were not initially compatible

- Has written many relationship books: "Finding the Love of Your Life", "The Triumphant Marriage", "Learning to Live with the Love of Your Life and Loving It", "Finding Commitment", and others

Research → Business

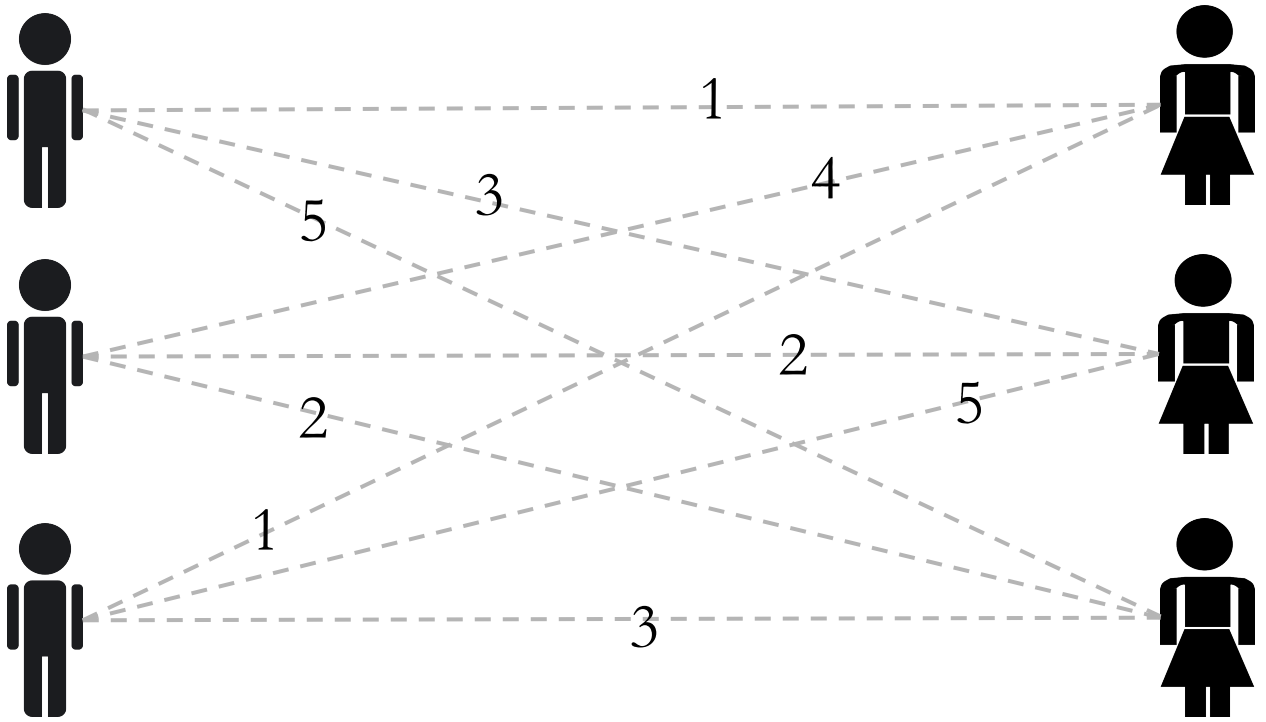
- In 1997, Warren began an extensive research project interviewing 5000+ couples across the US, which became the basis of eHarmony's compatibility profile
- www.eHarmony.com went live in 2000
- Interested users may fill out the compatibility quiz, but in order to see matches, members must pay a membership fee to eHarmony

eHarmony Stands Out From the Crowd

- eHarmony was not the first online dating website and faced serious competition
- Key difference from other dating websites: takes a quantitative optimization approach to matchmaking, rather than letting users browse

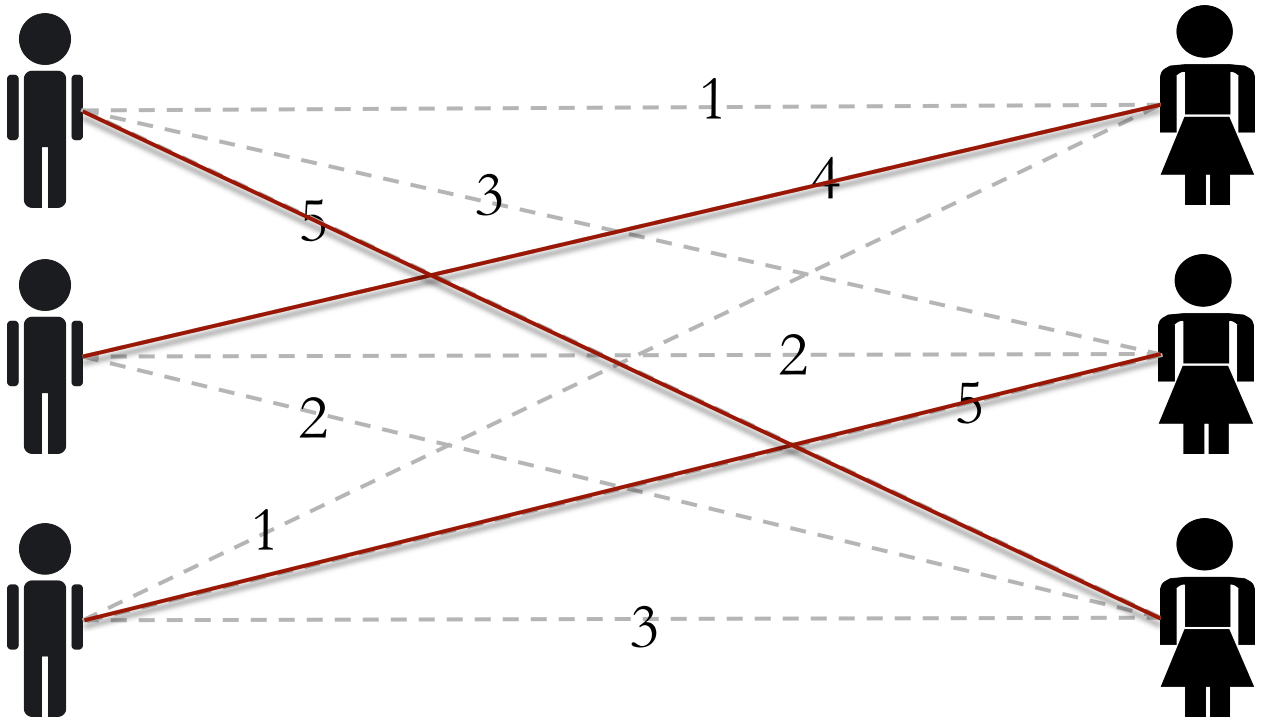
Integer Optimization Example

- Suppose we have three men and three women
- Compatibility scores between 1 and 5 for all pairs



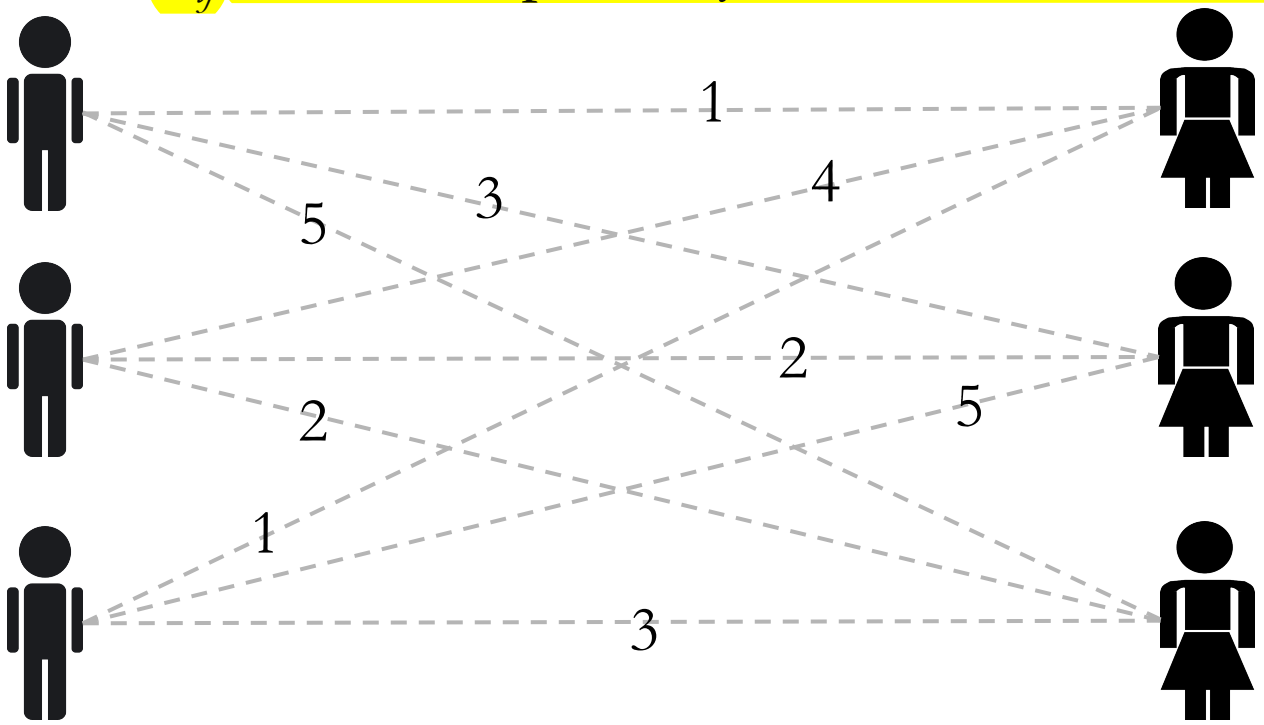
Integer Optimization Example

- How should we match pairs together to maximize compatibility?



Data and Decision Variables

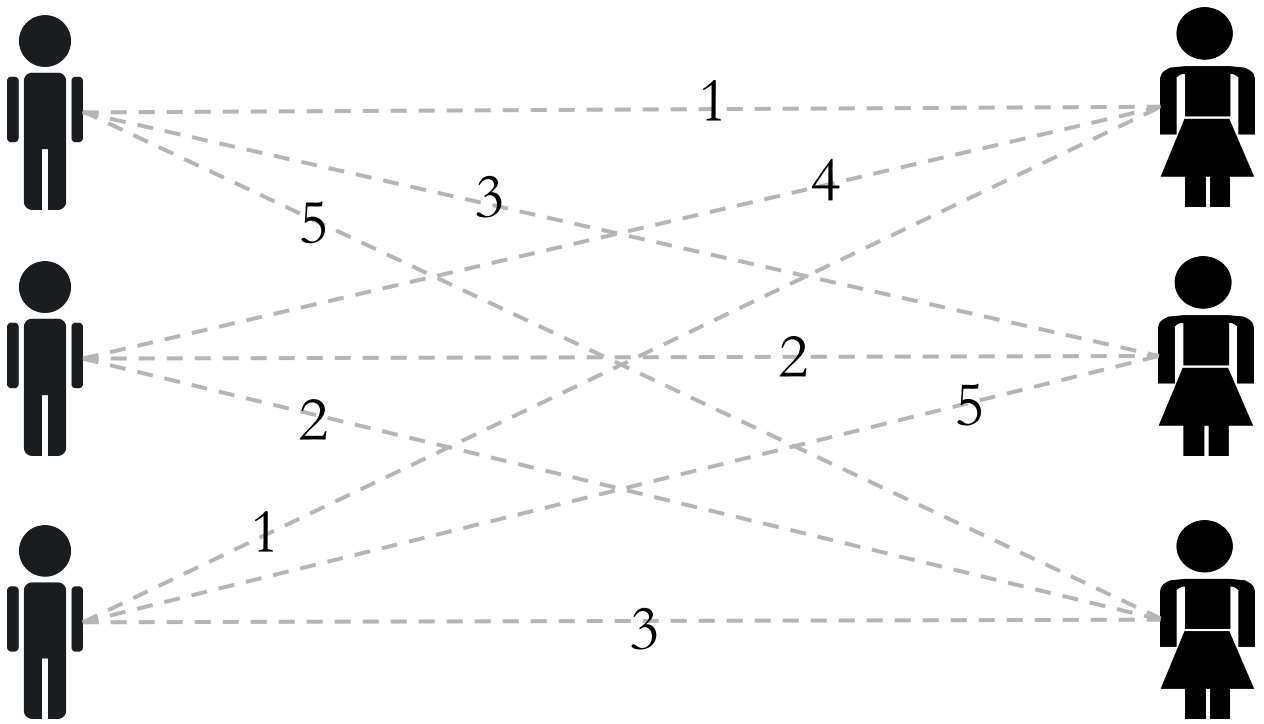
- Decision variables: Let x_{ij} be a binary variable taking value 1 if we match user i and user j together and value 0 otherwise
- Data: Let w_{ij} be the compatibility score between user i and j



Objective Function

- Maximize compatibility between matches:

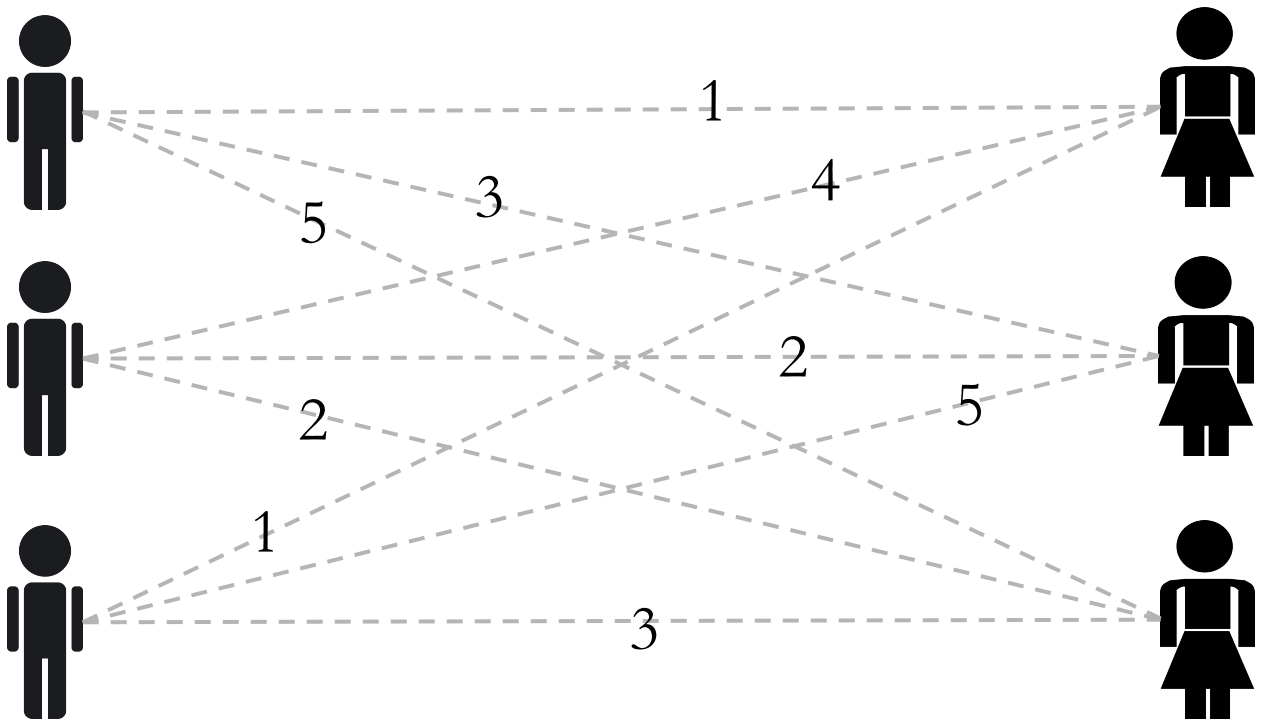
$$\max \quad w_{11}x_{11} + w_{12}x_{12} + w_{13}x_{13} + w_{21}x_{21} + \ldots + w_{33}x_{33}$$



Constraints

- Match each man to exactly one woman:

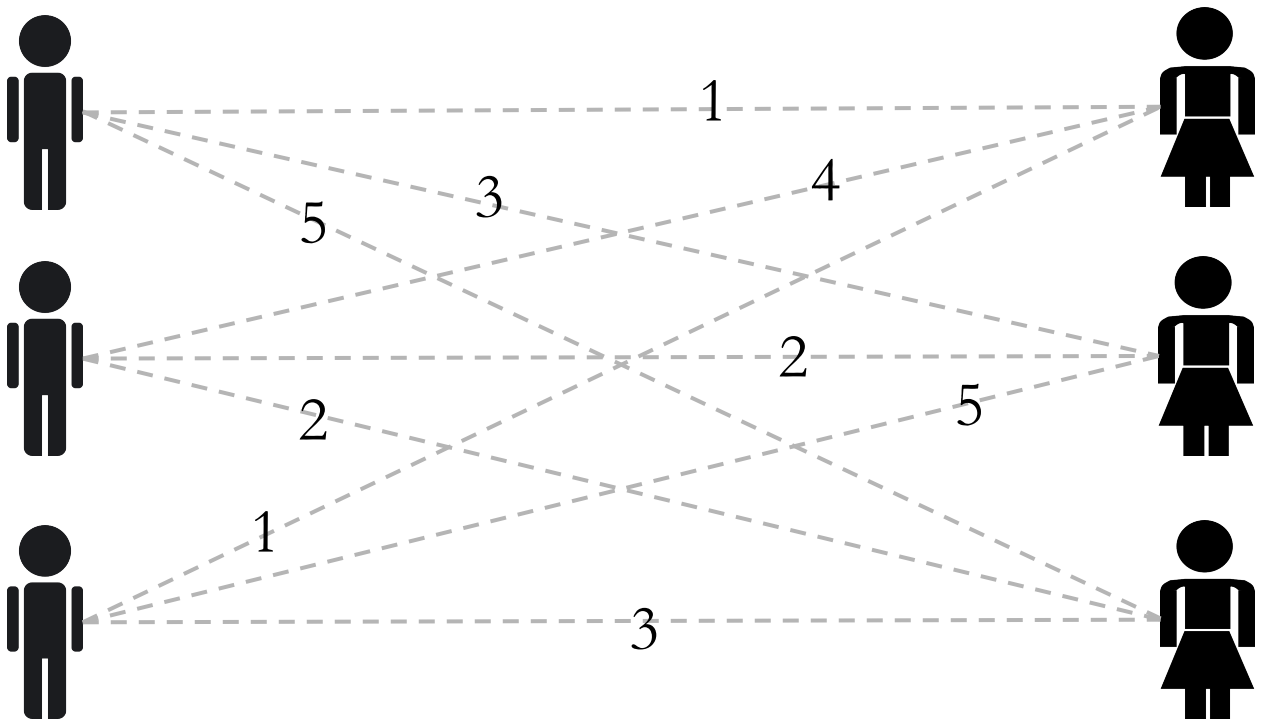
$$x_{11} + x_{12} + x_{13} = 1$$



Constraints

- Similarly, match each woman to exactly one man:

$$x_{11} + x_{21} + x_{31} = 1$$



Full Optimization Problem

$$\max \quad w_{11}x_{11} + w_{12}x_{12} + w_{13}x_{13} + w_{21}x_{21} + \ldots + w_{33}x_{33}$$

subject to:

$$x_{11} + x_{12} + x_{13} = 1$$
$$x_{21} + x_{22} + x_{23} = 1$$
$$x_{31} + x_{32} + x_{33} = 1$$

Match every man with exactly one woman

$$x_{11} + x_{21} + x_{31} = 1$$
$$x_{12} + x_{22} + x_{32} = 1$$
$$x_{13} + x_{23} + x_{33} = 1$$

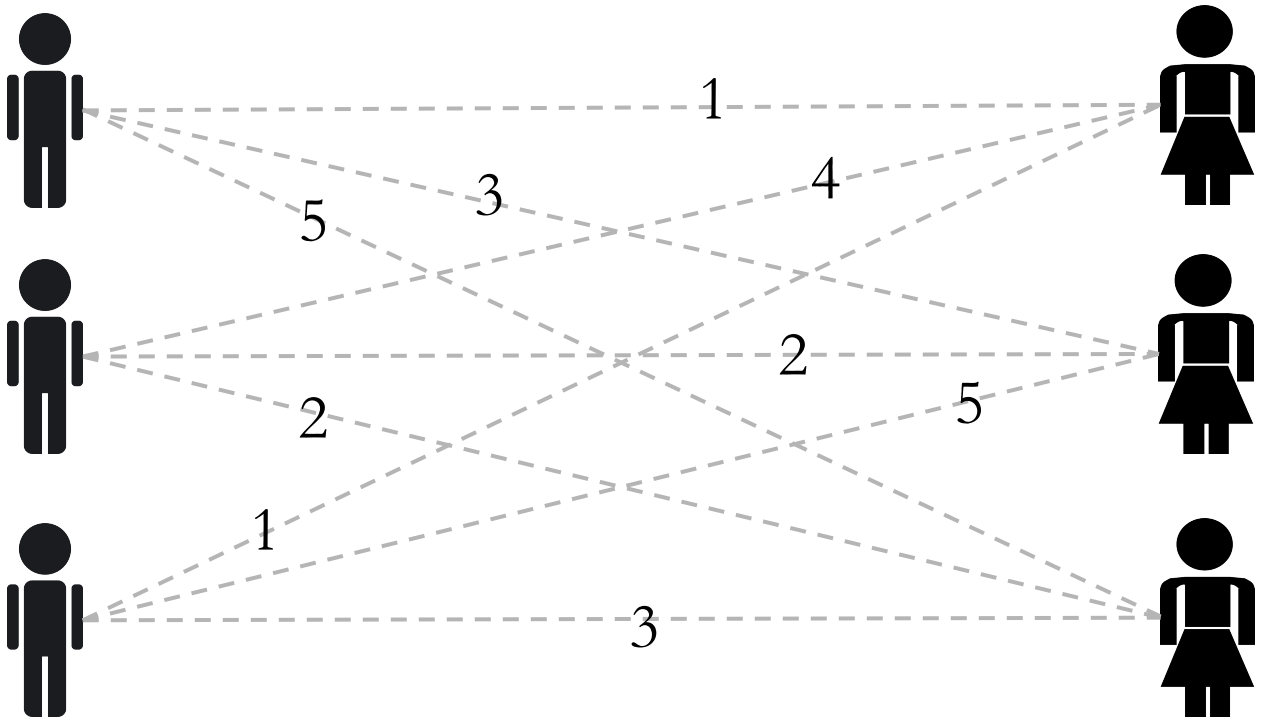
Match every woman with exactly one man

$x_{11}, x_{21}, x_{31}, x_{12}, x_{22}, x_{32}, x_{13}, x_{23}, x_{33}$ are binary

Extend to Multiple Matches

- Show woman 1 her top two male matches:

$$x_{11} + x_{21} + x_{31} = 2$$



Compatibility Scores

- In the optimization problem, we assumed the compatibility scores were data that we could input directly into the optimization model
- But where do these scores come from?
- "Opposites attract, then they attack"

  – Neil Clark Warren
- eHarmony's compatibility match score is based on similarity between users' answers to the questionnaire

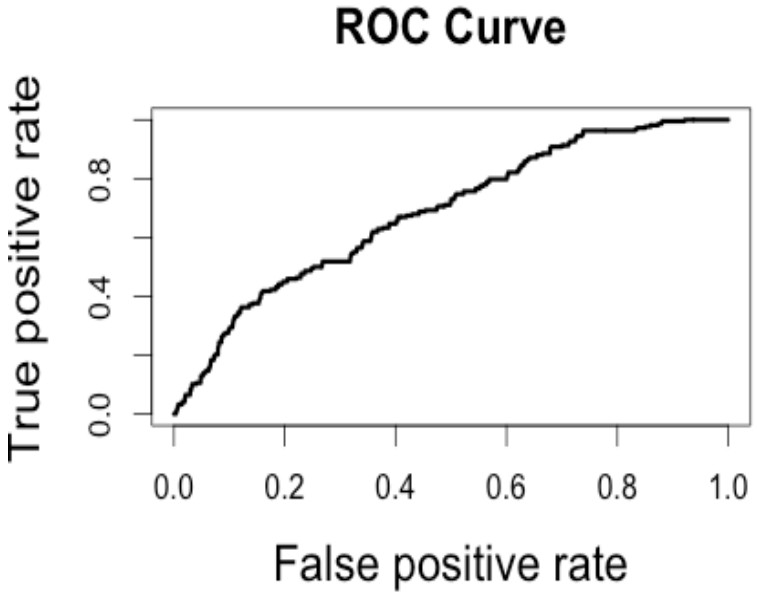
Predictive Model

- Public data set from eHarmony containing features for ~275,000 users and binary compatibility results from an interaction suggested by eHarmony
- Feature names and exact values are masked to protect users' privacy
- Try logistic regression on pairs of users' differences to predict compatibility

Reduce the Size of the Problem

- Filtered the data to include only users in the Boston area who had compatibility scores listed in the dataset
- Computed absolute difference in features for these 1475 pairs
- Trained a logistic regression model on these differences

Predicting Compatibility is Hard!



- Model AUC = 0.685

- If we use a low threshold we will predict more false positives but also get more true positives

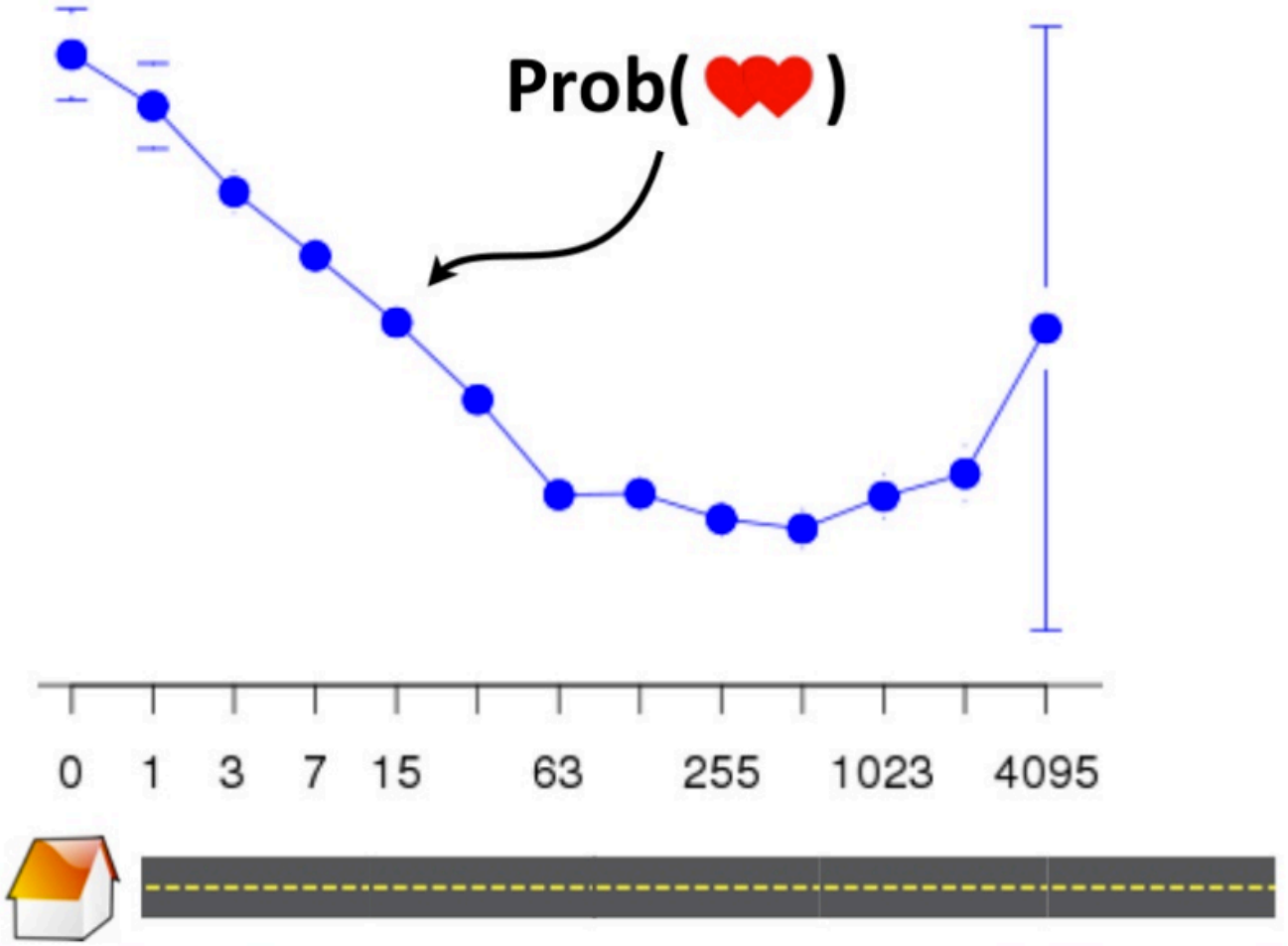
- Classification matrix for threshold = 0.2:

Act\Pred	0	1
0	1030	227
1	126	92

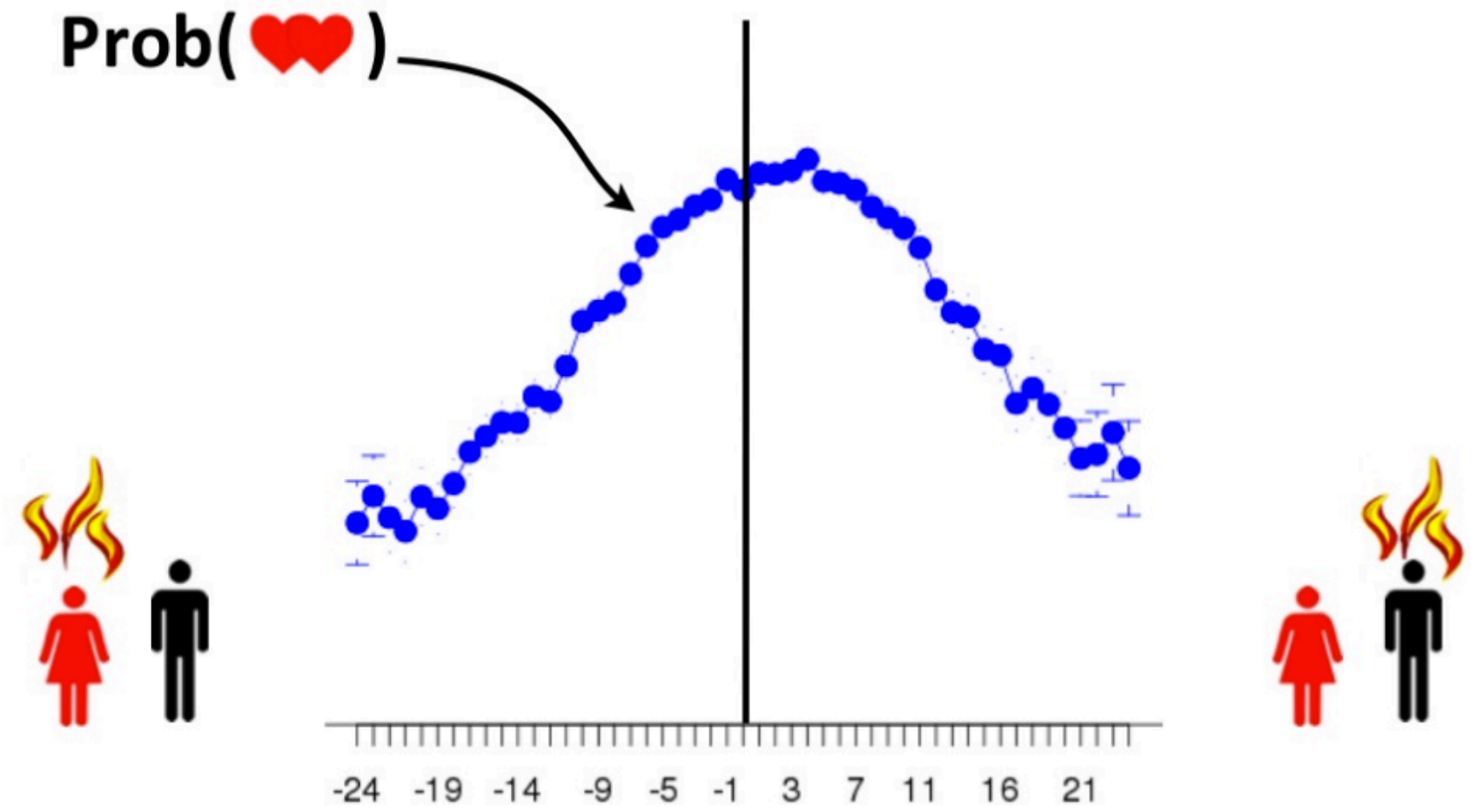
Other Potential Techniques

- Trees
  - Especially useful for predicting compatibility if there are nonlinear relationships between variables
- Clustering
  - User segmentation
- Text Analytics
  - Analyze the text of users' profiles
- And much more…

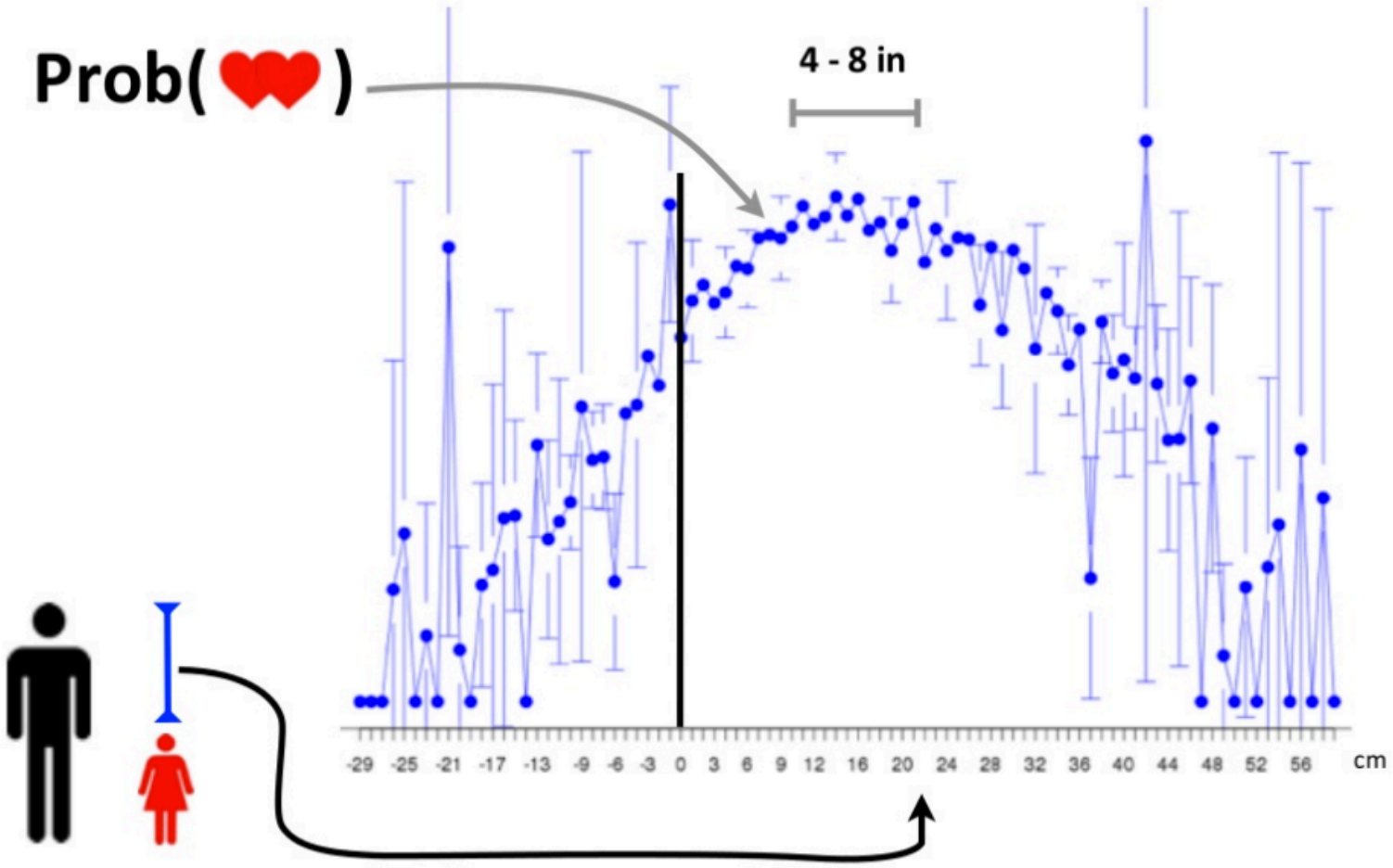
Feature Importance: Distance



Feature Importance: Attractiveness



Feature Importance: Height Difference



How Successful is eHarmony?

- By 2004, eHarmony had made over $100 million in sales.
- In 2005, 90 eHarmony members married every day
- In 2007, 236 eHarmony members married every day
- In 2009, 542 eHarmony members married every day

eHarmony Maintains its Edge

- 14% of the US online dating market.
- The only competitor with a larger portion is Match.com with 24%.
- Nearly 4% of US marriages in 2012 are a result of eHarmony.

- eHarmony has successfully leveraged the power of analytics to create a successful and thriving business.