Mathematics in Education and Industry

50 years at the forefront of Mathematics Education

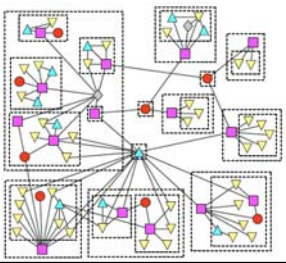
Interesting applications of Decision Maths

WHAT DOES THE LONDON UNDERGROUND REALLY LOOK LIKE?

Decision Maths?

- It's a graph
- It uses the same ideas that were explored by Euler in the Konigsberg bridges problem by ignoring the actual geography
- Euler's Konigsberg proof is often considered the starting point for *topology* which ignores features such as distances and angles and considers only how things are connected.

SOCIAL NETWORKS



The six degrees

- In 1967, Stanley Milgram at Harvard University conducted one of the most famous and elegant studies into the structure of social networks.
- He sent packages to 196 people in Nebraska, with a request that they forward them to a named intended recipient, a stock broker living near to Boston.

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The six degrees

- Milgram found that on average just six journeys were needed before the packages found their way to the right person.

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Bacon

- The Bacon Number is the smallest number of movies that link an actor with Kevin Bacon.
- An actor who has been in a movie with Kevin Bacon has a Bacon Number of 1
- If your Bacon Number is not 1 but you've been in a movie with someone who has been in a movie with Kevin then your Bacon Number is 2

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Erdos

- Mathematicians have their own version of this game!

MR Erdos Number = 5

Richard Lissaman	coauthored with	Charudatta R. Hajarnavis	MR1621728 (99e:16016)
Charudatta R. Hajarnavis	coauthored with	Kenneth Alexander Brown	MR0647437 (84a:16025)
Kenneth Alexander Brown	coauthored with	John W. Lawrence	MR0574921 (82k:20013)
John W. Lawrence	coauthored with	Denis A. Higgs	MR0575375 (81g:46100)
Denis A. Higgs	coauthored with	Paul Erdös[1]	MR0764321 (85m:04002)

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Social Networks

- Get your facebook analytics report at http://www.wolframalpha.com/facebook/

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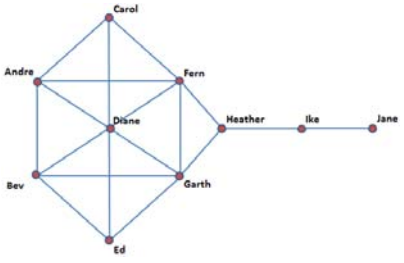
Network Centrality:
Who is the most central person in this network?

a) Diane

b) Heather

c) Garth/Fern



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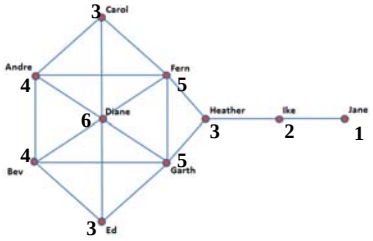
Degree Centrality

This ranks centrality by the degree of the node



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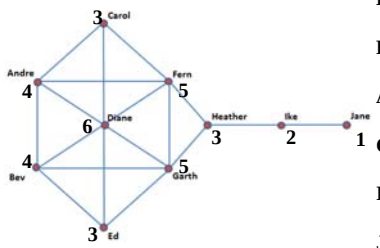
Degree Centrality

This simply ranks centrality by the degree of the node



Diane (6)

Fern/Gareth (5)

Andre/Bev (4)

Carol/Ed/Heather (3)

Ike (2)

Jane (1)

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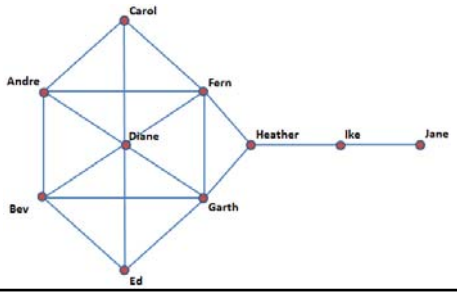
Closeness Centrality

For each person calculate the average length of the shortest path to all the other people in the network



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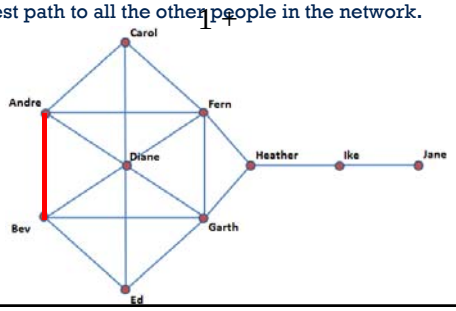
Closeness Centrality

For each person calculate the average length of the shortest path to all the other people in the network.

1 +



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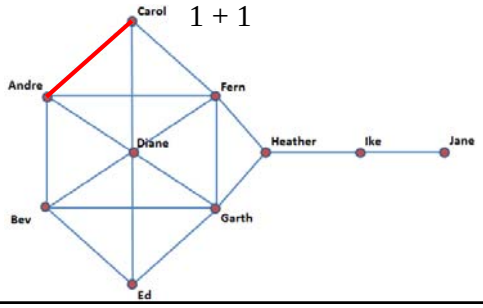
Closeness Centrality

1 + 1



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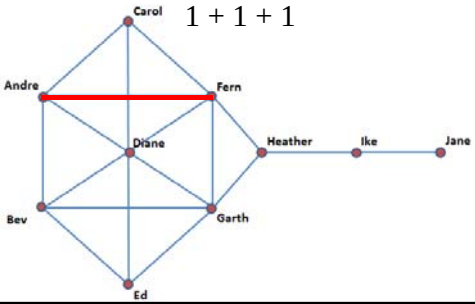
Closeness Centrality

1 + 1 + 1



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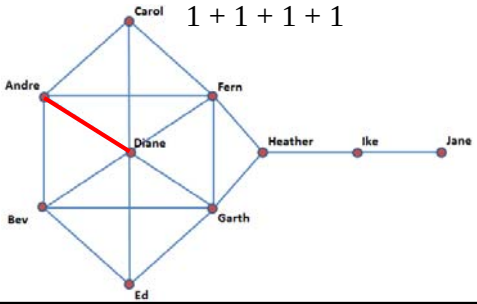
Closeness Centrality

1 + 1 + 1 + 1



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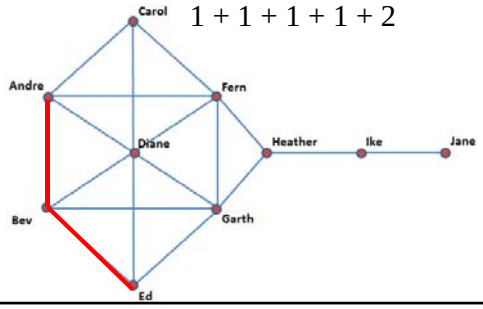
Closeness Centrality



1 + 1 + 1 + 1 + 2

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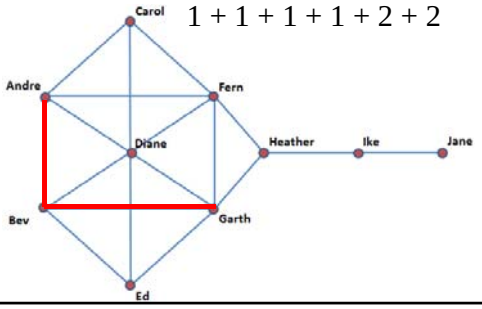
Closeness Centrality



1 + 1 + 1 + 1 + 2 + 2

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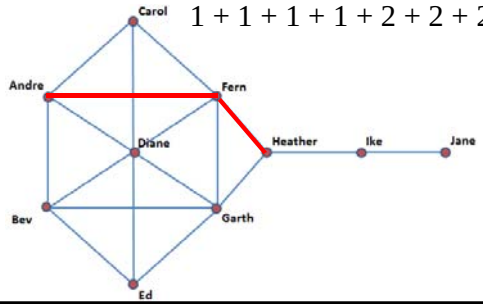
Closeness Centrality



1 + 1 + 1 + 1 + 2 + 2 + 2

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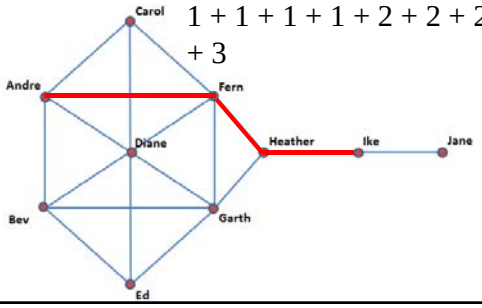
Closeness Centrality



1 + 1 + 1 + 1 + 2 + 2 + 2 + 3

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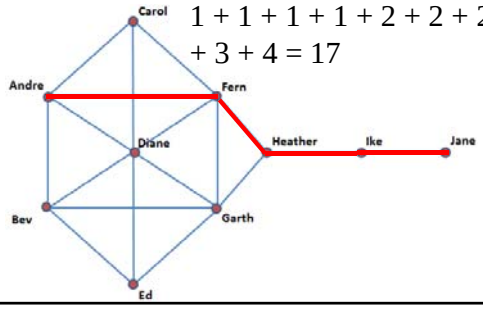
Closeness Centrality



1 + 1 + 1 + 1 + 2 + 2 + 2 + 3 + 4 = 17

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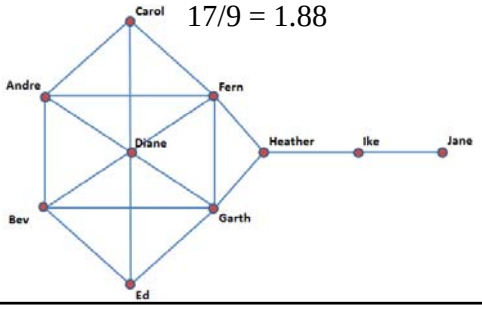
Closeness Centrality



17/9 = 1.88

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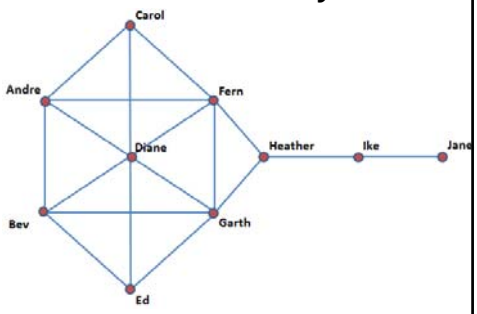
Closeness Centrality

A – 1.88
B – 1.88
C – 2.0
D – 1.67
E – 2.0
F – 1.56
G – 1.56
H – 1.67
I – 2.33
J – 3.22



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Closeness centrality

- Closeness centrality measures the average social distance from each individual to every other individual in the network.
- High closeness centrality individuals tend to be important influencers within their local network community. .

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Between-ness Centrality

- Take all the shortest paths in the network (Floyd's algorithm will give this)
- For each node, count how many of the shortest paths it's on.

Floyd's Algorithm Output - Distances

	a	b	c	d	e	f	g	h	i	j
a	0	1	1	1	2	1	2	2	3	4
b	1	0	2	1	1	2	1	2	3	4
c	1	2	0	1	2	1	2	2	3	4
d	1	1	1	0	1	1	1	2	3	4
e	2	1	2	1	0	2	1	2	3	4
f	1	2	1	1	2	0	1	1	2	3
g	2	1	2	1	1	1	0	1	2	3
h	2	2	2	2	1	1	0	1	2	3
i	3	3	3	3	2	2	1	0	1	4
j	4	4	4	4	3	3	2	1	0	4

Floyd's Algorithm Output - Routes

	a	b	c	d	e	f	g	h	i	j
a	1	1	1	1	2	1	2	6	8	9
b	2	2	1	2	2	1	2	7	8	9
c	3	1	3	3	4	3	4	6	8	9
d	4	4	4	4	4	4	4	6	8	9
e	2	5	4	5	5	4	5	7	8	9
f	6	1	6	6	4	6	6	6	8	9
g	2	7	4	7	7	7	7	7	8	9
h	6	7	6	6	7	8	8	8	8	9
i	6	7	6	6	7	8	8	9	9	9
j	6	7	6	6	7	8	8	9	10	10

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A	B				
A	C				
A	D				
A	B	E			
A	F				
A	B	G			
A	F	H			
A	F	H	I		
A	F	H	I	J	
B	A	C			
B	D				
B	E				
B	A	F			
B	G				
B	G	H			
B	G	H	I		
B	G	H	I	J	
C	D				
C	D	E			
C	F				
C	D	G			
C	F	H			

C	F	H	I	
C	F	H	I	J
D	E			
D	F			
D	G			
D	F	H		
D	F	H	I	
D	F	H	I	J
E	D	F		
E	G			
E	G	H		
E	G	H	I	
E	G	H	I	J
F	G			
F	H			
F	H	I		
F	H	I	J	
H	I			
H	I	J		
I	J			

List of all shortest paths

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A	B				
A	C				
A	D				
A	B	E			
A	F				
A	B	G			
A	F	H			
A	F	H	I		
A	F	H	I	J	
B	A	C			
B	D				
B	E				
B	A	F			
B	G				
B	G	H			
B	G	H	I		
B	G	H	I	J	
C	D				
C	D	E			
C	F				
C	D	G			
C	F	H			

C	F	H	I	
C	F	H	I	J
D	E			
D	F			
D	G			
D	F	H		
D	F	H	I	
D	F	H	I	J
E	D	F		
E	G			
E	G	H		
E	G	H	I	
E	G	H	I	J
F	G			
F	H			
F	H	I		
F	H	I	J	
H	I			
H	I	J		
I	J			

A – 2

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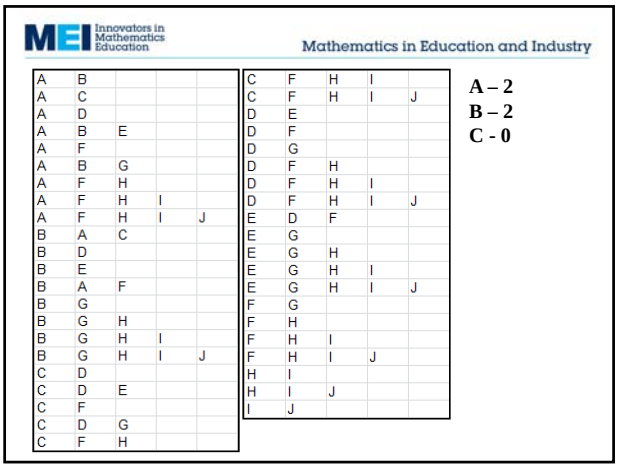
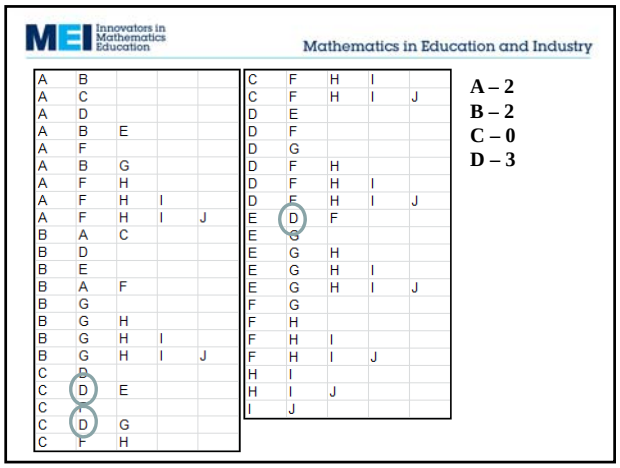
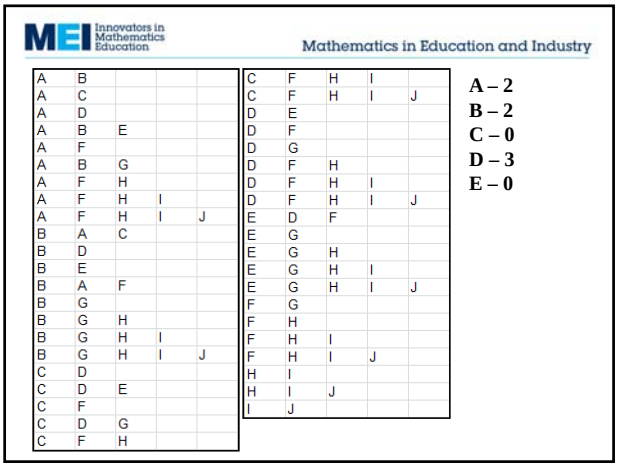
A	B				
A	C				
A	D				
A	B	E			
A	F				
A	B	G			
A	F	H			
A	F	H	I		
A	F	H	I	J	
B	A	C			
B	D				
B	E				
B	A	F			
B	G				
B	G	H			
B	G	H	I		
B	G	H	I	J	
C	D				
C	D	E			
C	F				
C	D	G			
C	F	H			

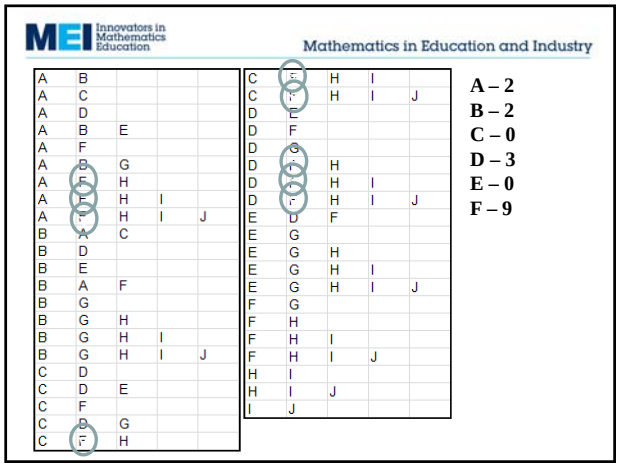
C	F	H	I	
C	F	H	I	J
D	E			
D	F			
D	G			
D	F	H		
D	F	H	I	
D	F	H	I	J
E	D	F		
E	G			
E	G	H		
E	G	H	I	
E	G	H	I	J
F	G			
F	H			
F	H	I		
F	H	I	J	
H	I			
H	I	J		
I	J			

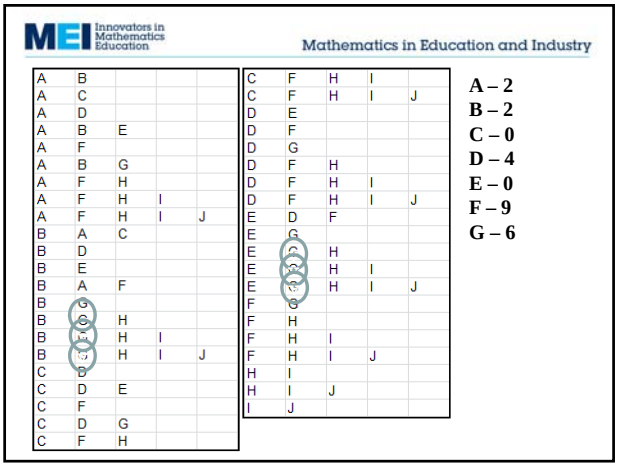
A – 2
B – 2

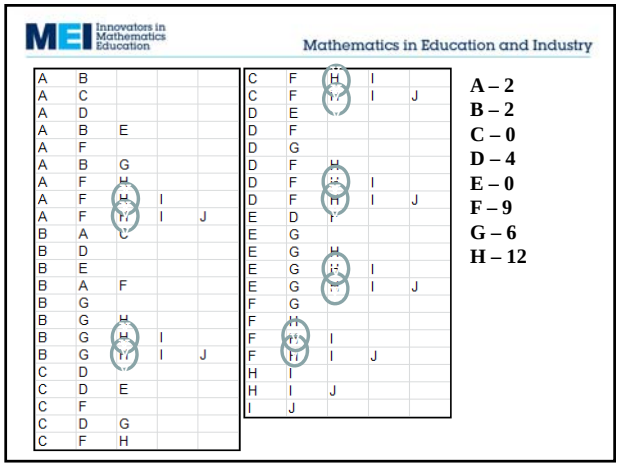

Innovators in Mathematics Education
Mathematics in Education and Industry
A – 2
B – 2
C - 0


Innovators in Mathematics Education
Mathematics in Education and Industry
A – 2
B – 2
C – 0
D – 3


Innovators in Mathematics Education
Mathematics in Education and Industry
A – 2
B – 2
C – 0
D – 3
E – 0


Innovators in Mathematics Education
Mathematics in Education and Industry
A – 2
B – 2
C – 0
D – 3
E – 0
F – 9


Innovators in Mathematics Education
Mathematics in Education and Industry
A – 2
B – 2
C – 0
D – 4
E – 0
F – 9
G – 6


Innovators in Mathematics Education
Mathematics in Education and Industry
A – 2
B – 2
C – 0
D – 4
E – 0
F – 9
G – 6
H – 12

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A	B				
A	C				
A	D				
A	B	E			
A	F				
A	B	G			
A	F	H			
A	F	H	I		
A	F	H	I		J
B	A	C			
B	D				
B	E				
B	A	F			
B	G				
B	G	H			
B	G	H	I		
B	G	H	I		J
C	D				
C	D	E			
C	F				
C	D	G			
C	F	H			

C	F	H	I		
C	F	H	I		J
D	E				
D	F				
D	G				
D	F	H			
D	F	H	I		
D	F	H	I		J
E	D	F			
E	G				
E	G	H			
E	G	H	I		
E	G	H	I		J
F	G				
F	H				
F	H	I			
F	H	I		J	
H	I				
H	I	J			
I	J				

A – 2
B – 2
C – 0
D – 3
E – 0
F – 9
G – 6
H – 12
I – 7

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A	B				
A	C				
A	D				
A	B	E			
A	F				
A	B	G			
A	F	H			
A	F	H	I		
A	F	H	I		J
B	A	C			
B	D				
B	E				
B	A	F			
B	G				
B	G	H			
B	G	H	I		
B	G	H	I		J
C	D				
C	D	E			
C	F				
C	D	G			
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C	F	H	I		
C	F	H	I		J
D	E				
D	F				
D	G				
D	F	H			
D	F	H	I		
D	F	H	I		J
E	D	F			
E	G				
E	G	H			
E	G	H	I		
E	G	H	I		J
F	G				
F	H				
F	H	I			
F	H	I		J	
H	I				
H	I	J			
I	J				

A – 2
B – 2
C – 0
D – 3
E – 0
F – 9
G – 6
H – 12
I – 7
J – 0

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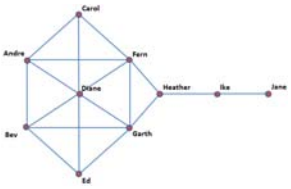
A – 0.833
B – 0.833
C – 0
D – 2
E – 0
F – 7.5
G – 7.5
H – 12
I – 7
J – 0



Heather

Fern/Gareth

Ike

Diane

Andre/Bev

Carol/Ed/Jane

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Degree Centrality	Closeness Centrality	Between-ness Centrality
Diane	Heather	Fern/Gareth
Fern/Gareth	Fern/Gareth	Diane/Heather
Andre/Bev	Ike	Andre/Bev
Heather/Carol/ Ed	Diane	Carol/Ed
Ike	Andre/Bev	Ike
Jane	Carol/Ed/Jane	Jane

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Betweenness centrality

- These are individuals who are necessary conduits for information that must traverse parts of the network. These are usually different individuals from those with high closeness.
- High betweenness individuals often do not have the shortest average path to everyone else, but they do have the greatest number of shortest paths that necessarily have to go through them.

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UNUSUAL APPLICATIONS OF DIJKSTRA'S ALGORITHM (OR HOW TO CATCH A BADDIE

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Edsgar Dijkstra

"Computer Science is no more about computers than astronomy is about telescopes."

http://www.cs.utexas.edu/~EWD/

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Applications of Dijkstra's Algorithm

- Traffic Information Systems
- Mapping (Google Maps)
- Routing Systems
- Social Networks

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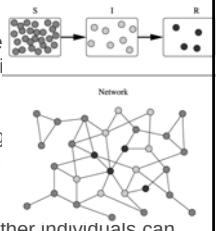
Applications of Dijkstra's Algorithm



- Epidemiologists use networks to mode infectious diseases and design preventi strategies.
- Vertices represent individuals, and edg contacts. It is useful to calculate how a is connected to others.
- Knowing the shortest path lengths to other individuals can be a relevant indicator of the potential of a particular individual to infect others.

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Now, about those baddies

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A* Pursuit Algorithm

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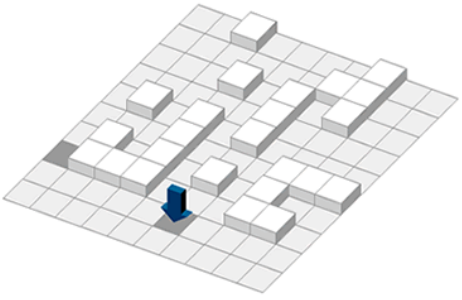
The algorithm in action!



FIND YOUR PERFECT PARTNER

Game theory and dating

If you are choosing a long term partner you have to weigh two opposing factors.

- *If you pick someone too early*, you are making a decision without checking out your options. You might get lucky, but it's a big risk.
- *If you wait too long*, you leave yourself with only a few candidates to pick from. Again, this is a risky strategy.

The game boils down to selecting an optimal stopping time between playing the field and holding out too long. What does the maths say?

Game theory and dating

- One approach is to select the first relationship, but what's the chance that the first person is the best?
- It is equally likely for the first person to be the best, the second best, or the worst. This means by pure luck you have a 1/3 chance of finding true love if you always pick the first person. You also have a 1/3 chance if you always pick the last person, or always pick the second.
- Can you do better than pure luck?

Game theory and dating

DATING RULES

- You only date one person at a time.
- A relationship either ends with you "rejecting" or "selecting" the other person.
- If you "reject" someone, the person is gone forever. Sorry, old flames cannot be rekindled.
- You plan on dating some fixed number of people (N) during your lifetime.
- As you date people, you can only tell if the second person was better than the first person, but you cannot judge whether the second person is your true love. After all, there are people you have not dated yet.

Game theory and dating

- Consider the following strategy: *get to know–but always reject–the first person*. Then, select the next person you think is better than the first person (till you run out of people)
- How often does this strategy find the best overall person?

Game theory and dating

There are 6 possible dating orders

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1 2 **3** Lose

1 3 **2** Lose

2 **1** 3 **Win**

2 3 **1 Win**

3 **1** 2 **Win**

3 **2** 1 Lose

the strategy wins in three cases.

It turns out it wins 50 percent of the time!

Mathematics in Education and Industry

Game theory

- is the study of mathematical models of conflict and cooperation between intelligent rational decision-makers.
- the idea of **GAME THEORY** is to decide whether or not there is a strategy you can play that gives you a good chance of success.
- It's origins are in the 18th Century, but it was famously driven forward by mathematicians John von Neumann and John Nash in the 1940s and 1950s.

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SHOULD YOU ASK THE AUDIENCE?

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Golden Balls

TV show from Feb 2008 to Feb 2009 where a jackpot is to be shared between 2 contestants who secretly choose to "split" or "steal".

Rules

1. If both players "split", the jackpot is split equally between them.
2. If 1 player "splits" and the other "steals", the stealer gets the whole jackpot and the splitter leaves with nothing.
3. If both players "steal", they both leave with nothing.

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Golden Balls

Player B

Player A	Split	Steal
Split	(50,50)	(0,100)
Steal	(100,0)	(0,0)

While cooperation is collectively rational, defection is individually rational.

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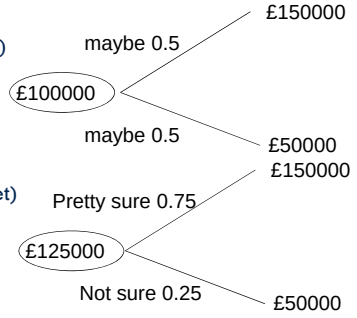
Should you ask the audience?

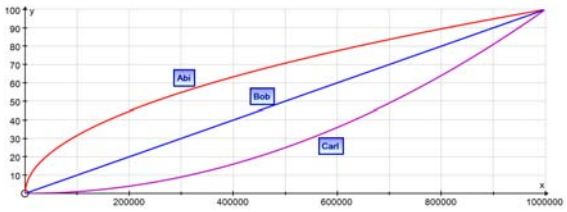
- £1000 (safety net)
- £2000
- £5000
- £10000
- £20000
- £50000 (safety net)
- £75000
- 250000
- £500000
- £1000000



Mathematics in Education and Industry

Utility

- Abi owes £10000 on her credit card
- Bob would like £50000 to pay off his mortgage
- Carl owns 2 houses and a Porsche



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WHY AM I ALWAYS IN THE SLOWEST QUEUE?

Mathematics in Education and Industry

Why am I always in the slowest queue?

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