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CIP- OSN
Online Social Networks as Graphs

Dr. Thanassis Tiropanis - tt2@ecs

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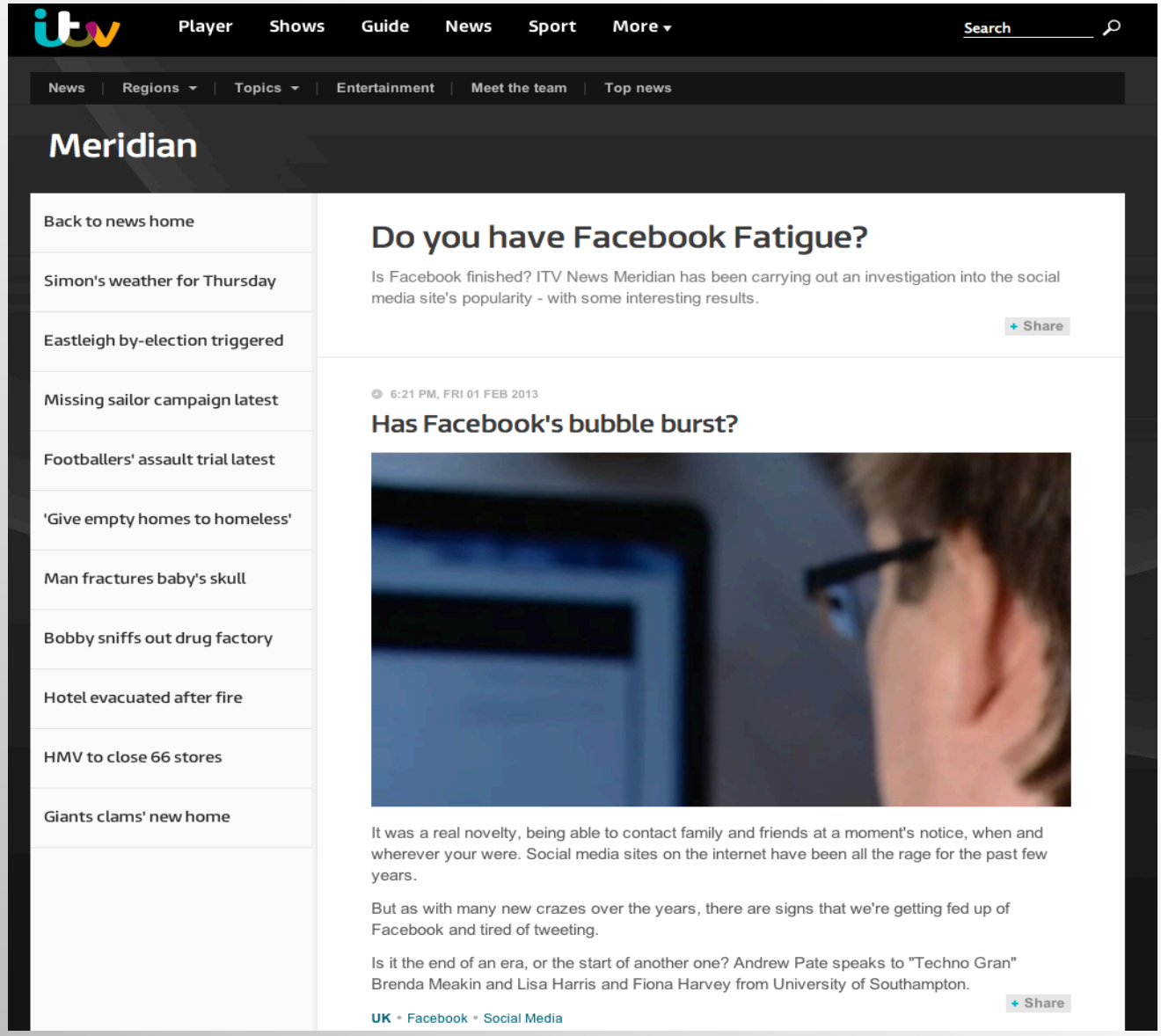

http://vimeo.com/58729247

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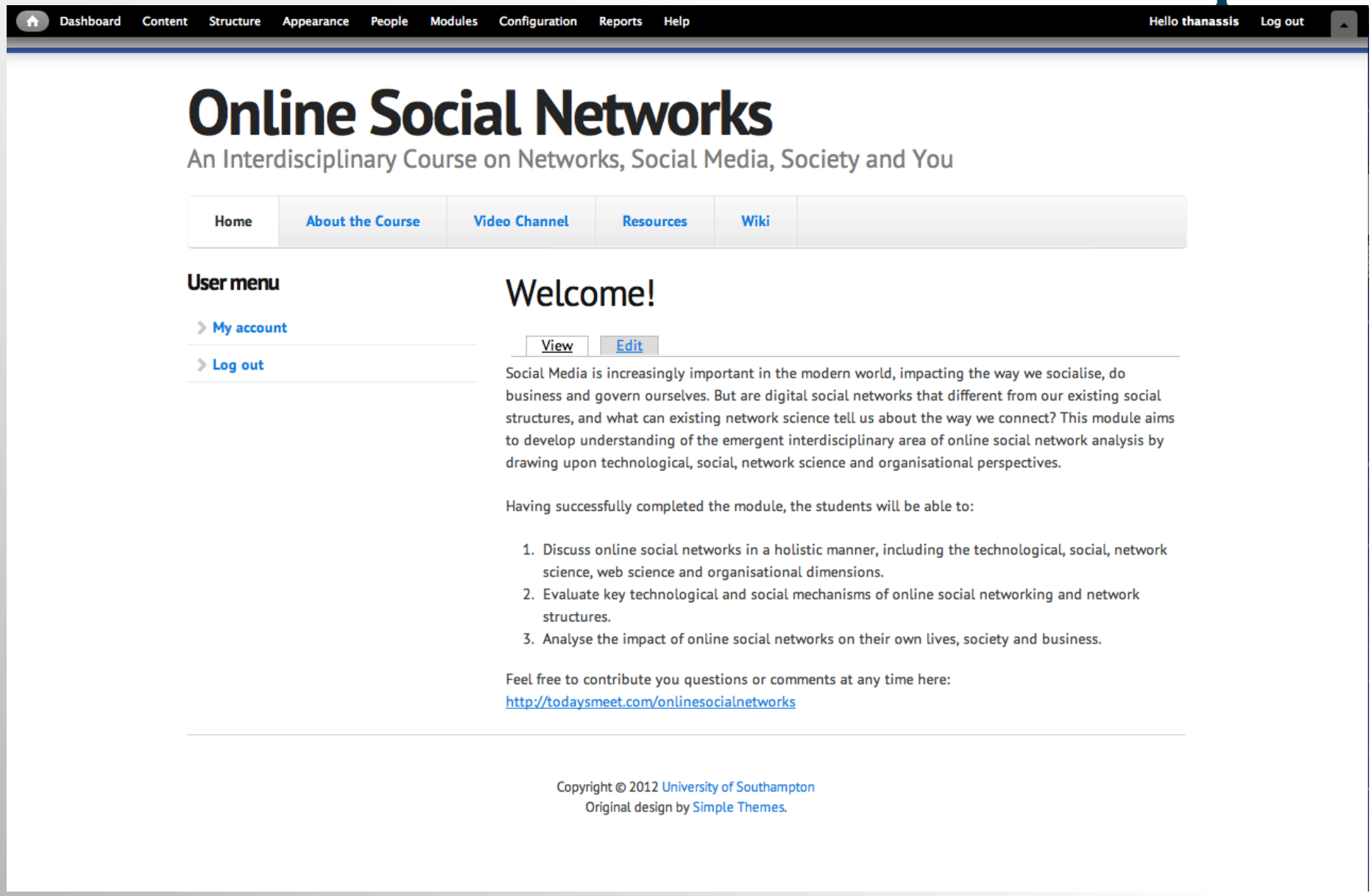

http://socialnetworks.soton.ac.uk

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The narrative

Web Evolution and
Online Social Networks

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Web Evolution – Stage 1

- The Web of Documents
  - Web 1.0; Read-only Web
- The Web experienced as a technological artefact
  - A network where the nodes are documents and the edges are links nn documents
  - Search engines enabled users to discover documents
  - E-commerce services

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Web Evolution – Stage 2

- The Web of People
  - Web 2.0; Read-write Web
- The Web experienced as an artefact that includes people publishing and communicating on a large scale
  - A network where the nodes are people, documents, software and the edges are links between them
  - Recommender engines (and search engines) enabled people to discover people, documents and services

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Web Evolution – Stage 3

- The Web of Data and Social Networks
  - Web 3.0; The Social Semantic Web
- The Web experienced as an artefact that includes people and documents and data linked together in social networks
  - A network where the nodes are people, datasets, documents, services and the edges are links between them
  - Enhanced discovery powered by online social networks
  - The Web is increasingly becoming the reflection of human activity and innovative applications take advantage of online social networks and data

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The narrative

Graphs representing social networks

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Discussion

- How many of you have joined one or more online social networks?
- Have you used any tools/apps to show you your network?
- Do you find those tools/apps useful? Why?

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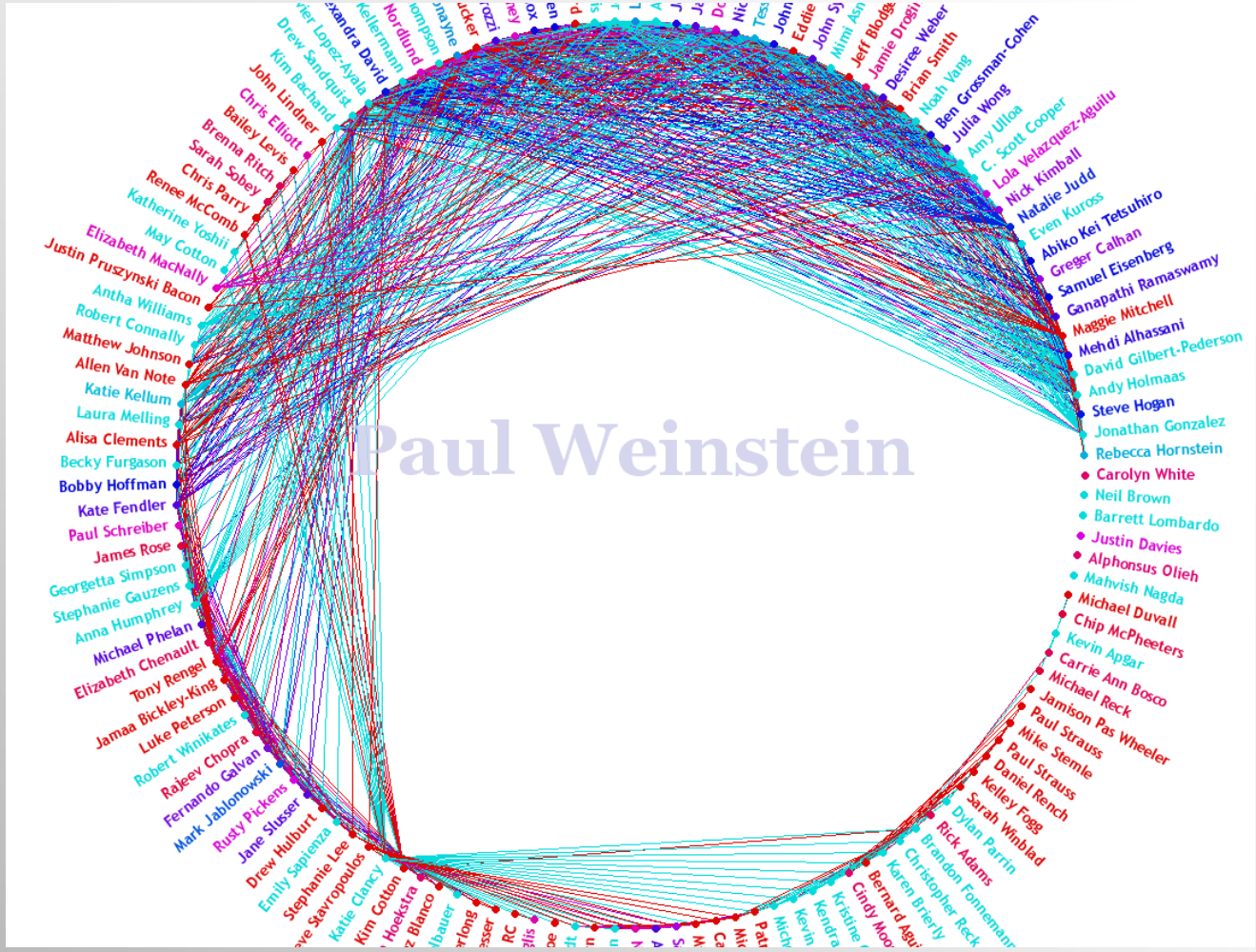
A Facebook Network



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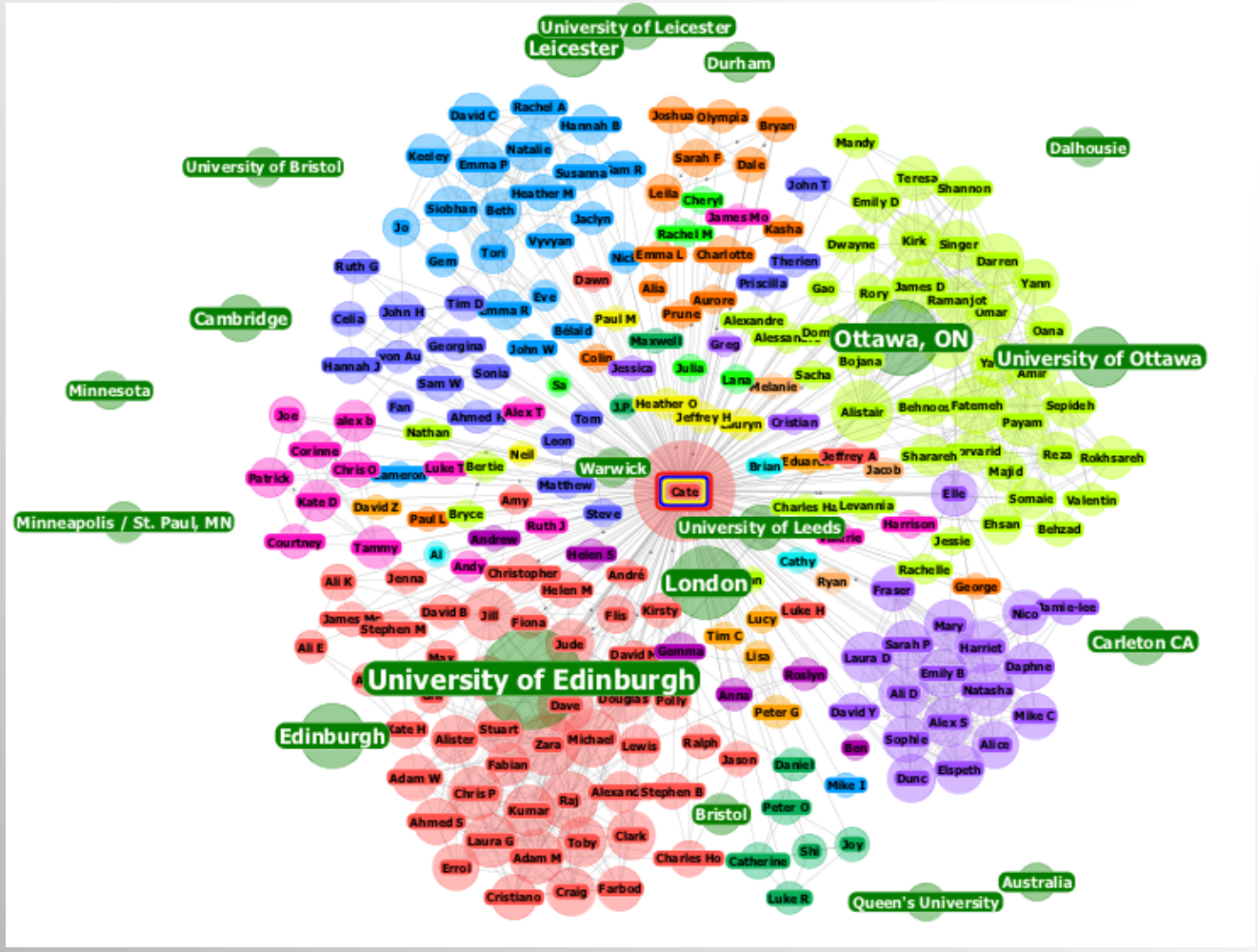
A Facebook Network



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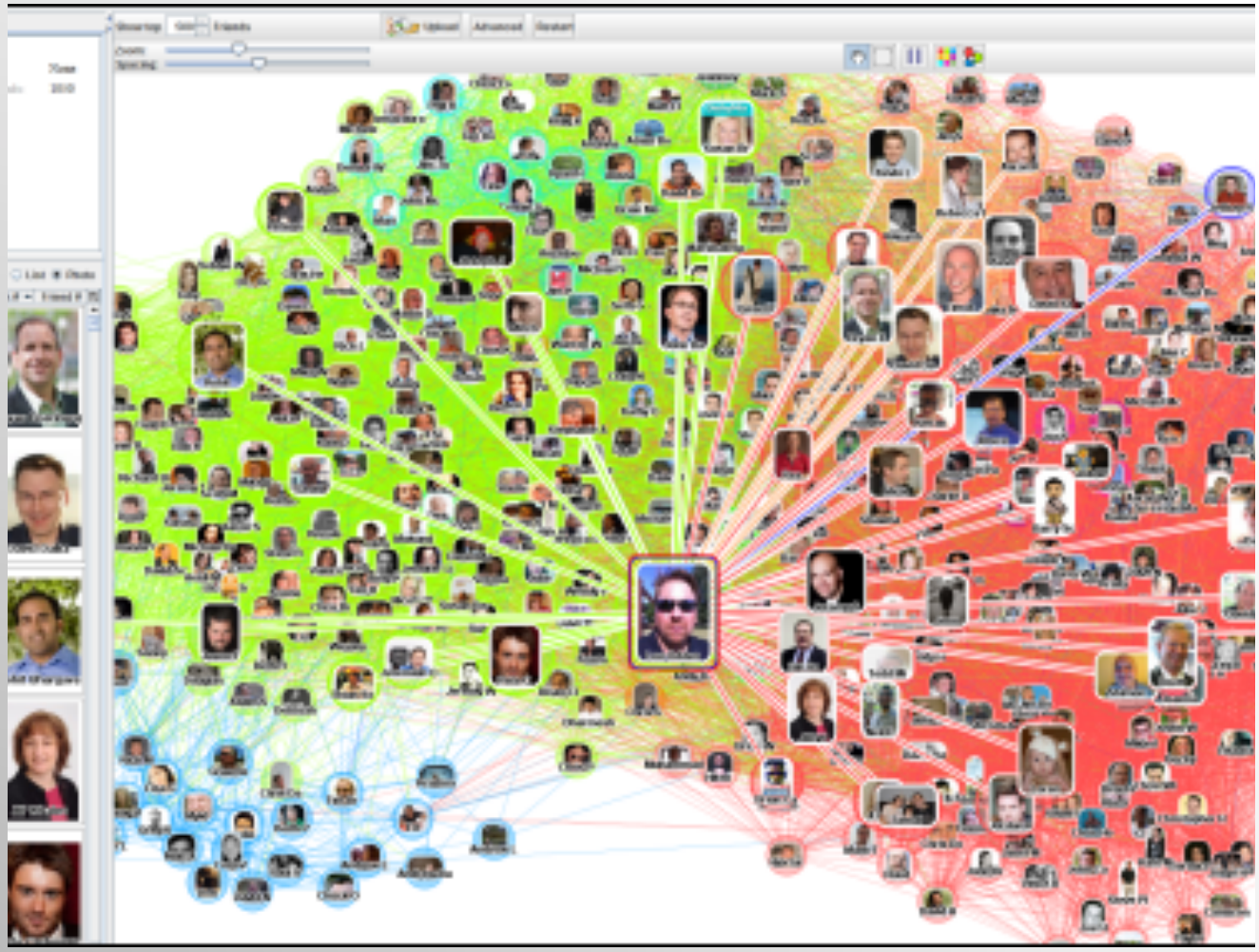
A Facebook Network



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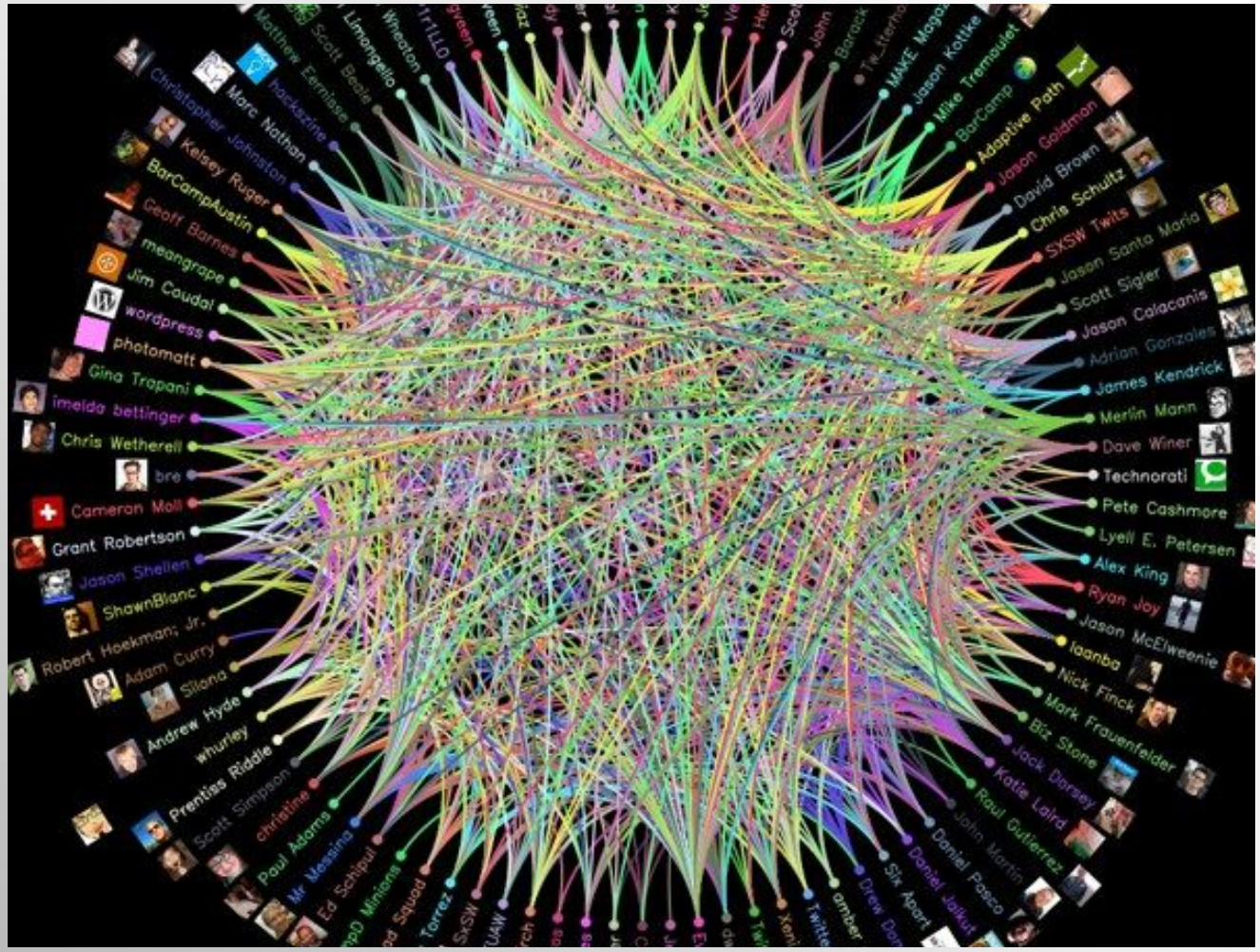
A Twitter Network



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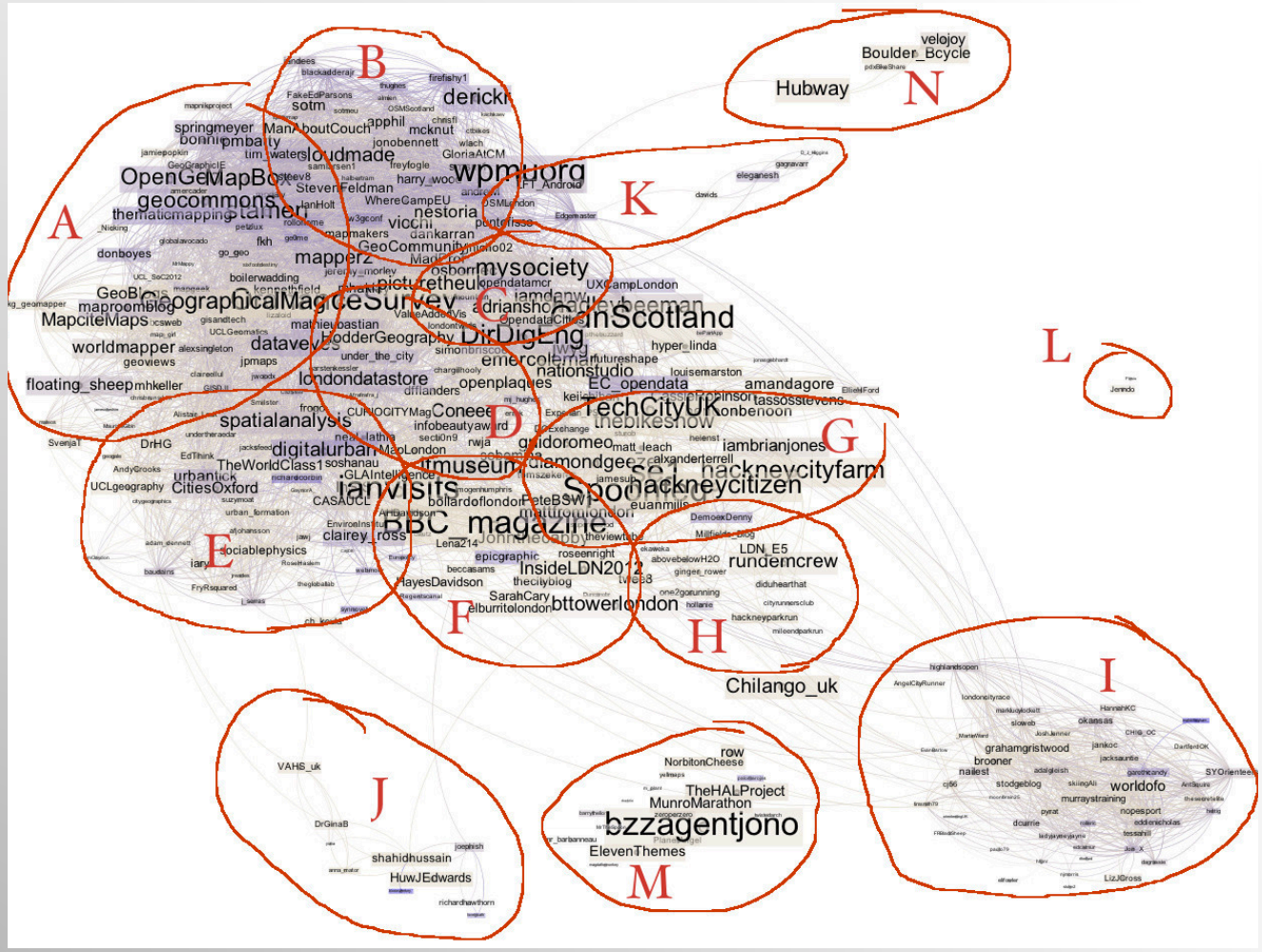
A Twitter Network



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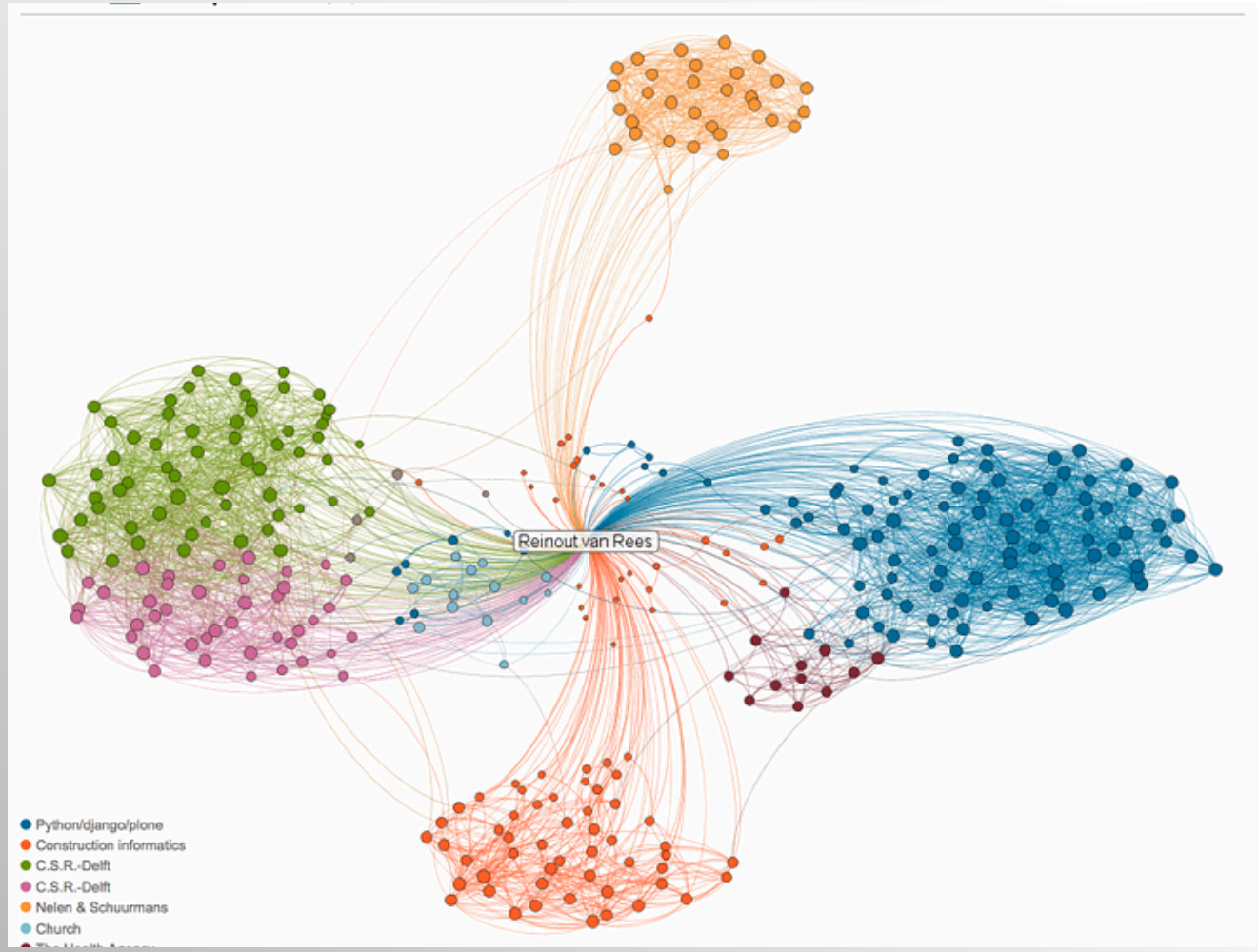
A LinkedIn Network



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Discussion

- What do those illustrations of my network tell me about my connections?
- What do they tell me about myself?
- Are the different ways to visualise my network to gain further insights?

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Real World Networks/Graphs

- Collaboration Graphs
- Who-Talks-to-Whom Graphs
- Information Linkage Graphs
- Technological Networks
- Networks in the Natural World

Easley and Kleinberg (2010)

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The narrative

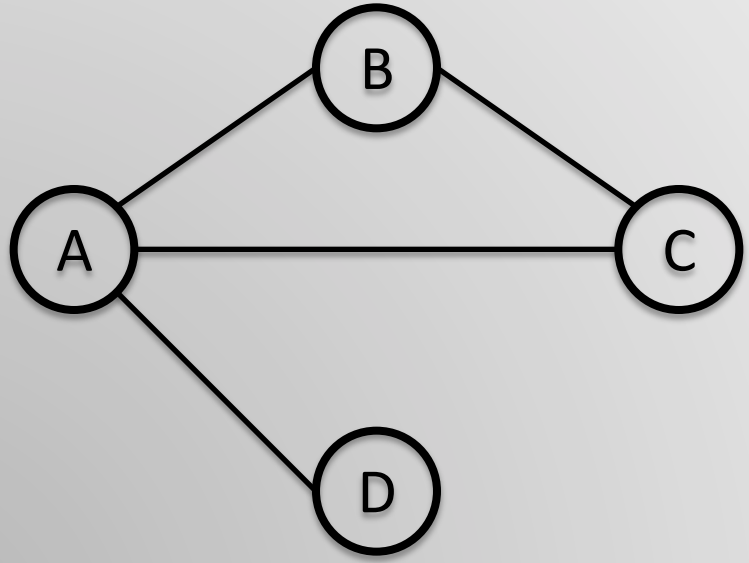
Graphs on an abstract level

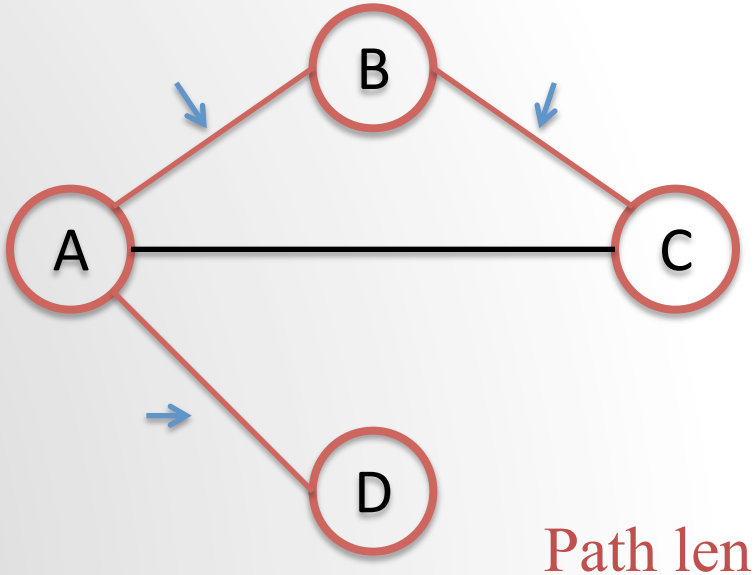
Graphs

- Representing relationships among items
  - Nodes (vertices)
  - Edges
    - Symmetric (undirected)
    - Asymmetric (directed)
  - Paths
  - Connected graph (a path for every pair of nodes)
  - Components (connected graph component)

Graphs, Edges, Paths

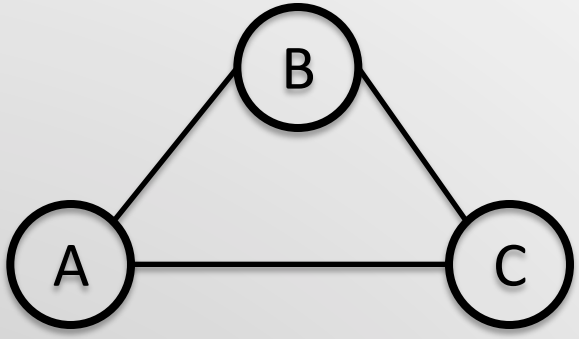
Directed graph

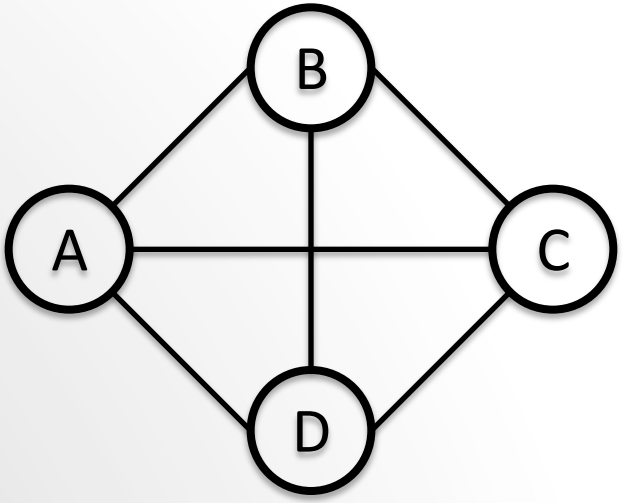


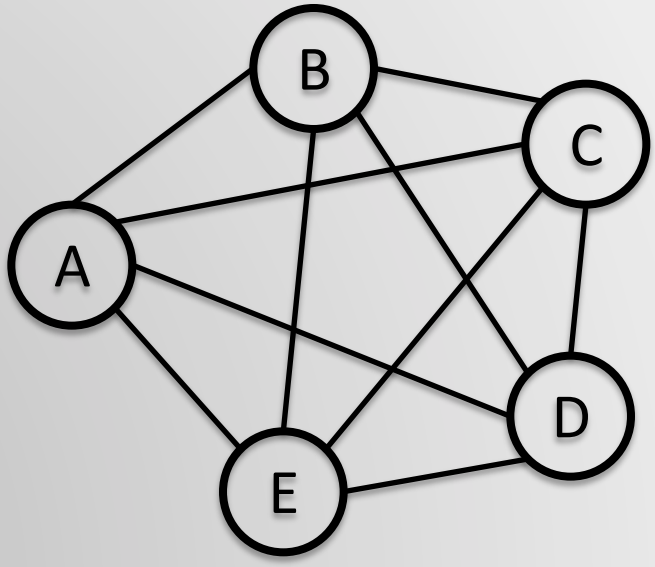


Path length: 3

Complete Graphs







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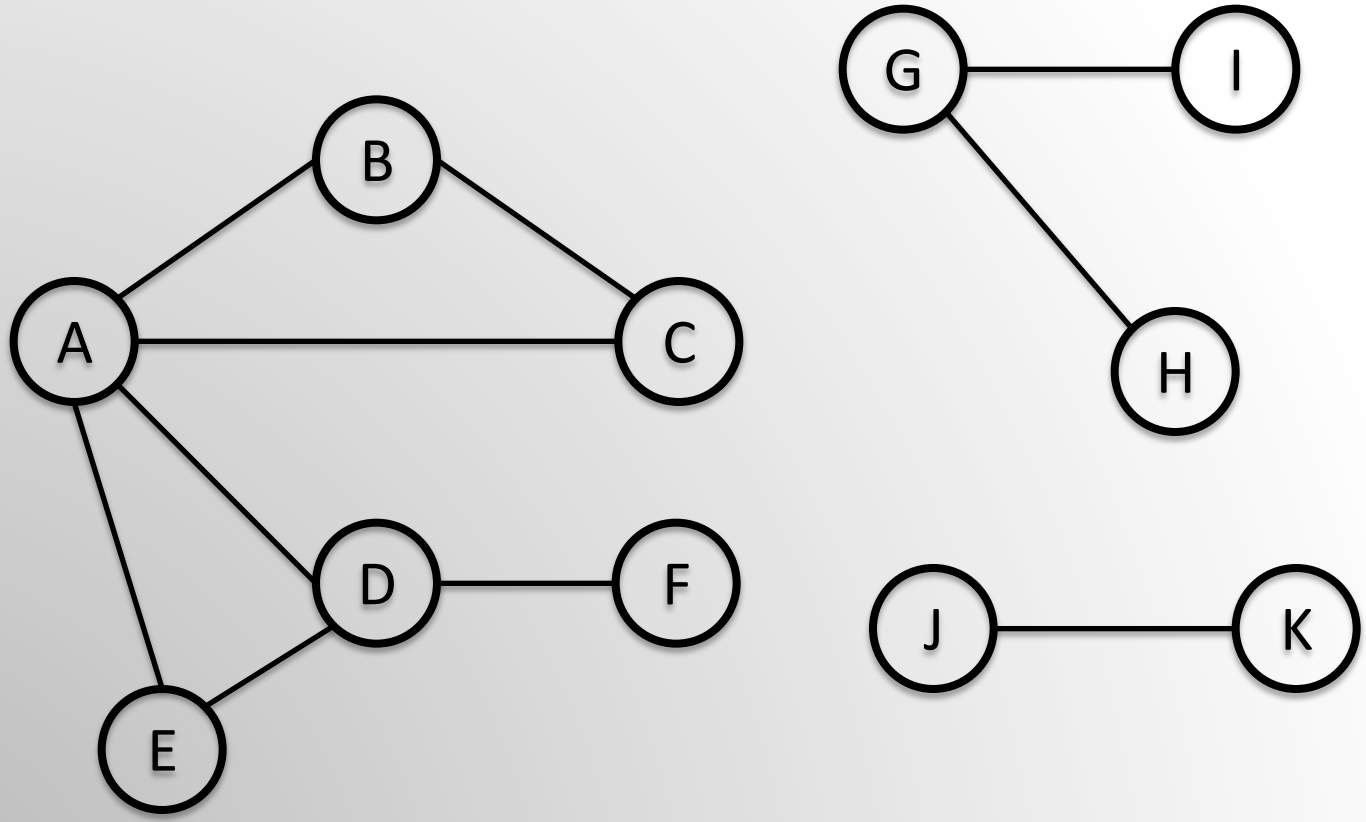
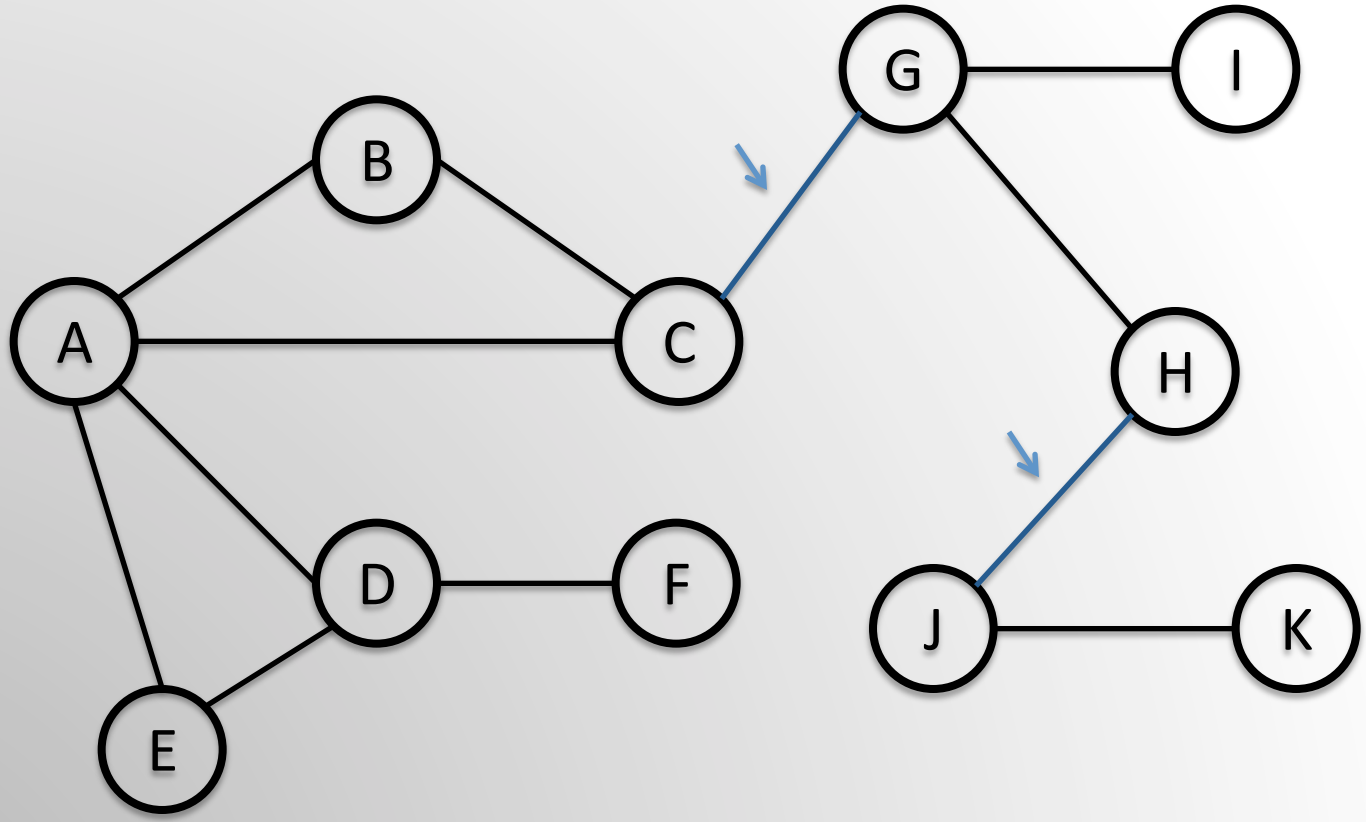
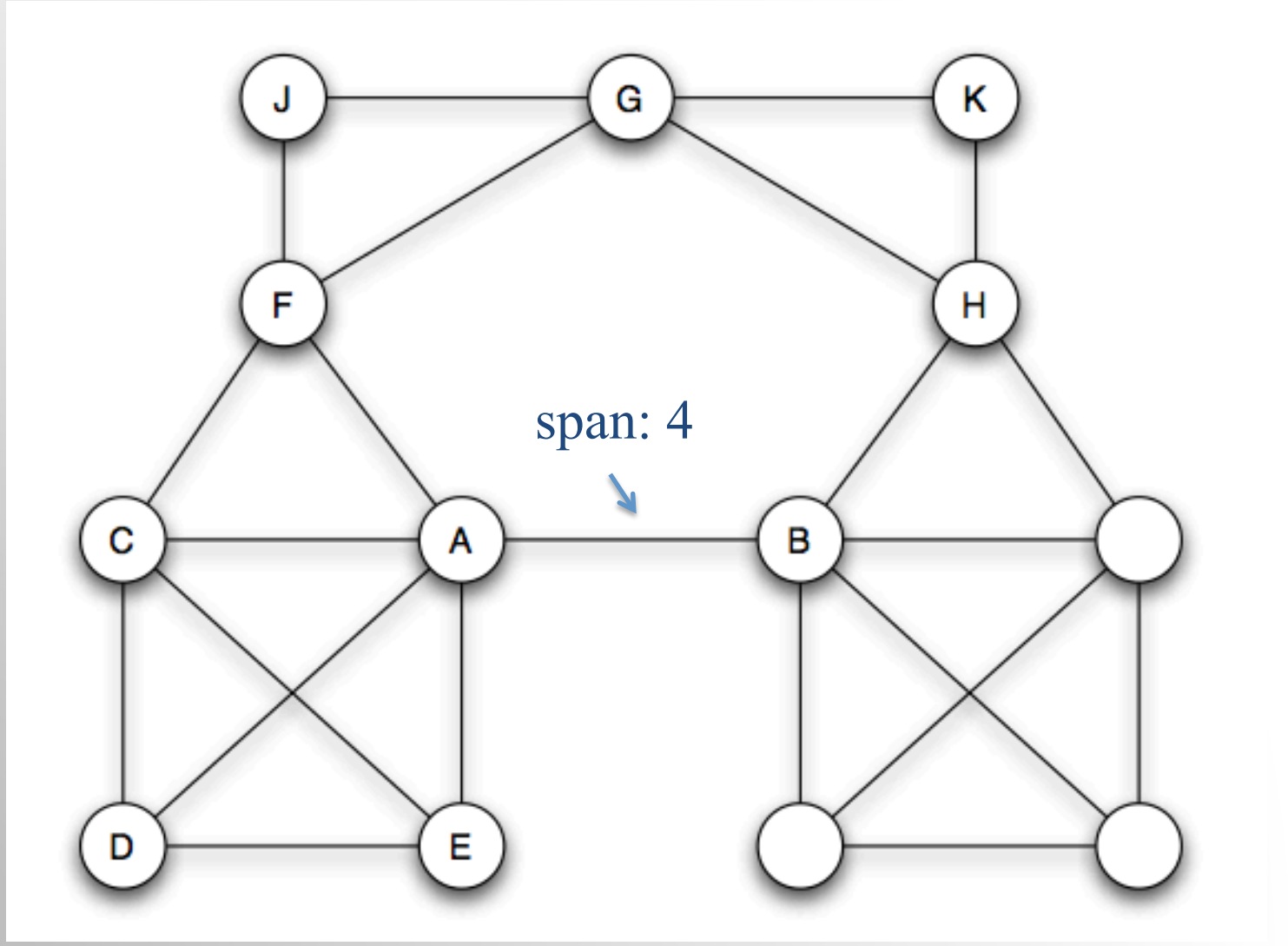
Components



Bridges



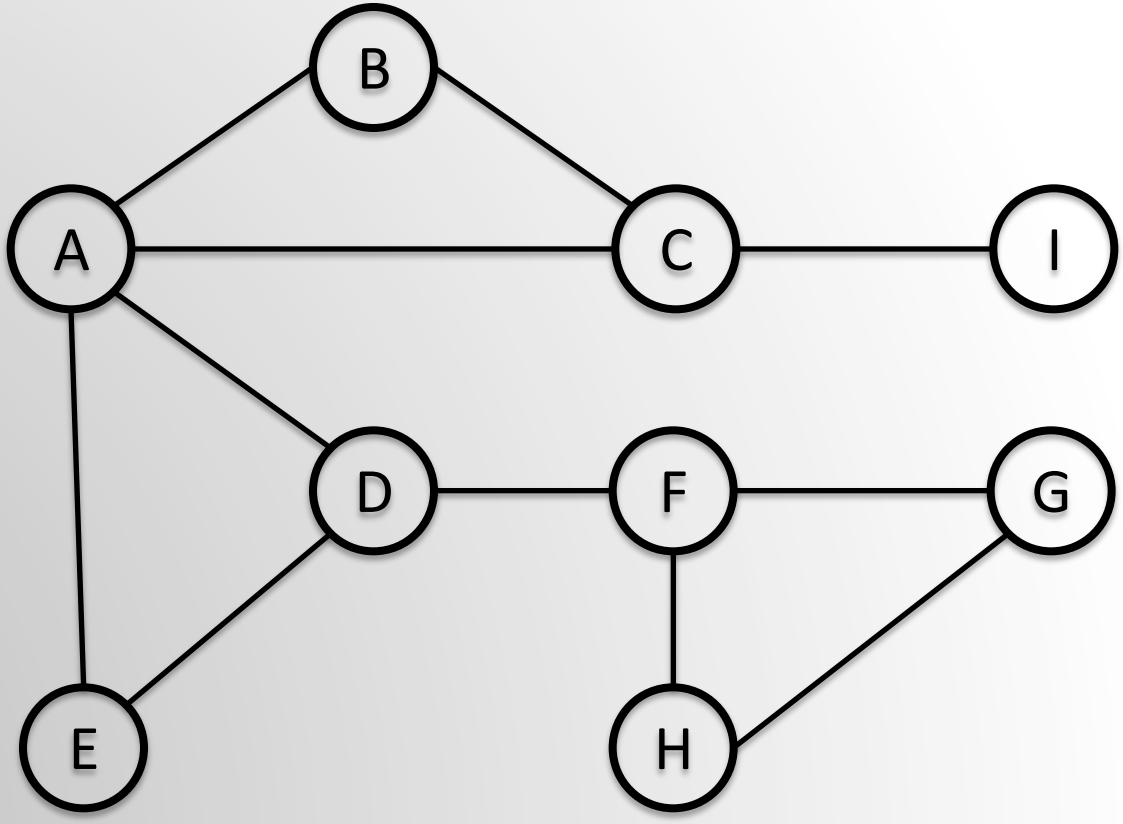
Local Bridges



SOURCE: http://www.cs.cornell.edu/home/kleinber/networks-book

Path Length

- How long is the shortest path from A to G?
- What is the distance between A and any other node?



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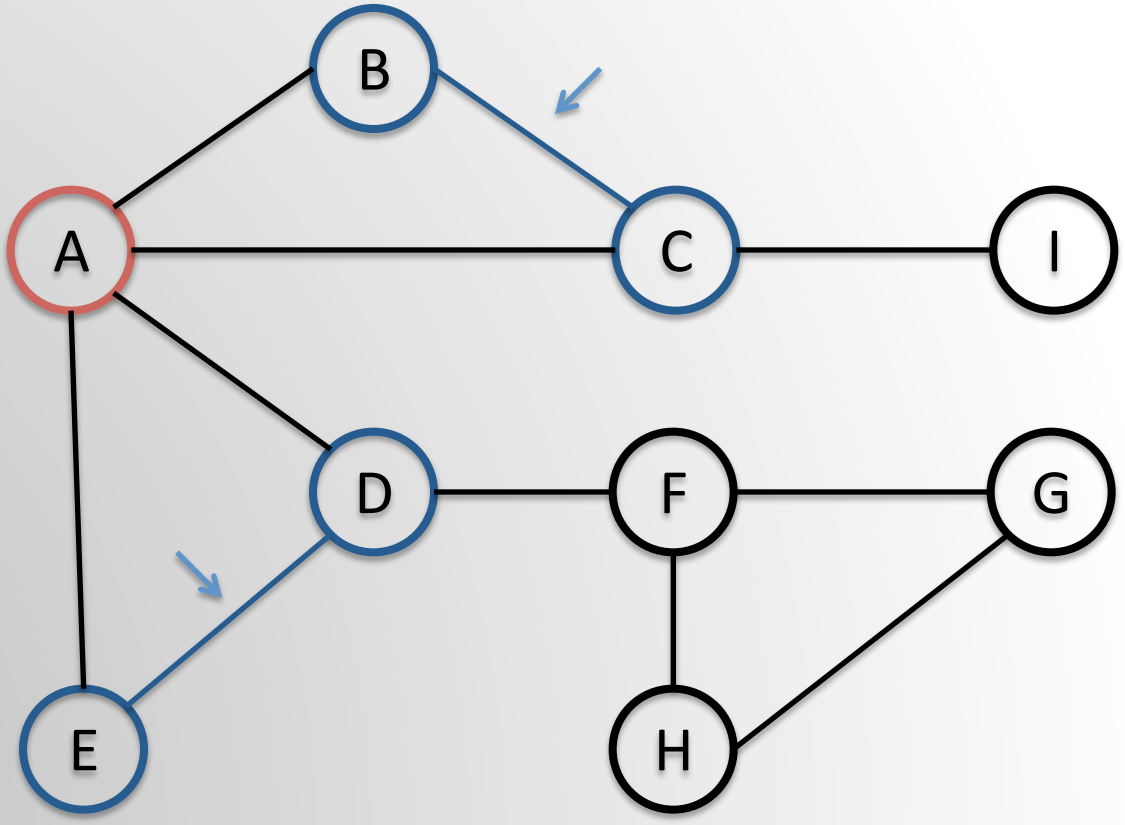
Clustering and Graph Partitioning

- Can you observe clusters on this graph?
- How many?

SOURCE: YAHOO RESEARCH

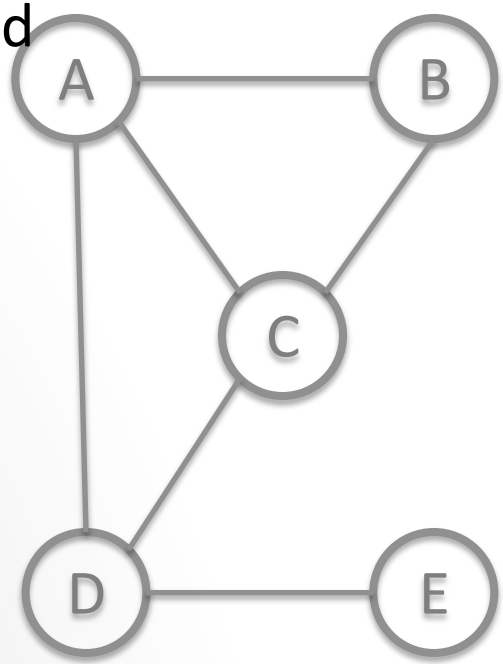
Local Clustering Coefficient

- The probability that two randomly selected friends of a node are friends with each other (for undirected graphs)
- What is the clustering coefficient of node A?

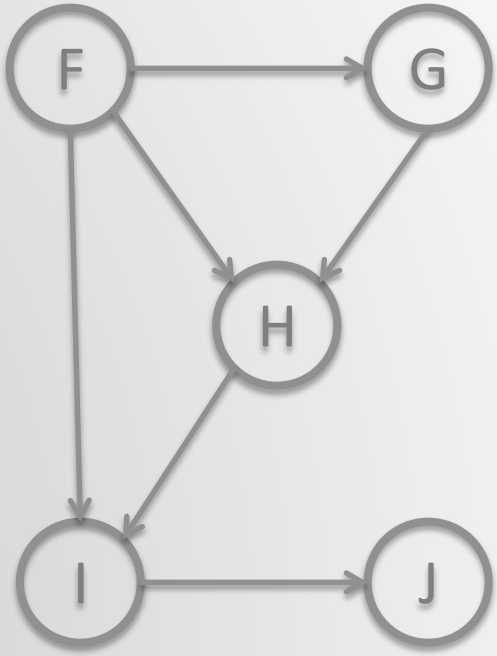


Degree of a node

- The number of nodes to which a node is connected
  - *Degree of Node C: 3*
  - *Degree of Node E: 1*
- In directed graphs we distinguish between outdegree and indegree
  - *Outegree of Node H: 1*
  - *Indegree of Node H: 2*



What can a high degree of a node in a graph representing a social network mean?



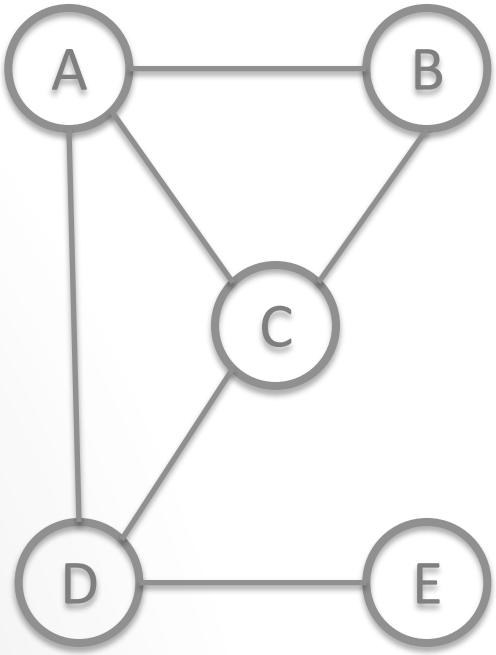
Closeness of two nodes

- The mean distance from a node to all the other nodes
  - *Distance between nodes is the shortest path between them.*

Which node is closer to the other nodes in this network?

Edge Betweenness

- Let's take any two nodes of a graph and find the shortest path between them (if there is one)
  - There can be more than one shortest paths
- For each edge in the path we allocate one unit of 'traffic'; this traffic is divided equally to *flow* along all possible shortest paths with every other node
- When this is completed for all pairs of nodes, we will have a measure of the 'traffic' that each edge carries
- This measure is the betweenness of an edge



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Discussion

- What do the different types of centrality mean in graphs representing social networks such as Facebook, Twitter or collaboration networks?
  - Degree centrality
  - Closeness centrality
  - (Edge) betweenness centrality

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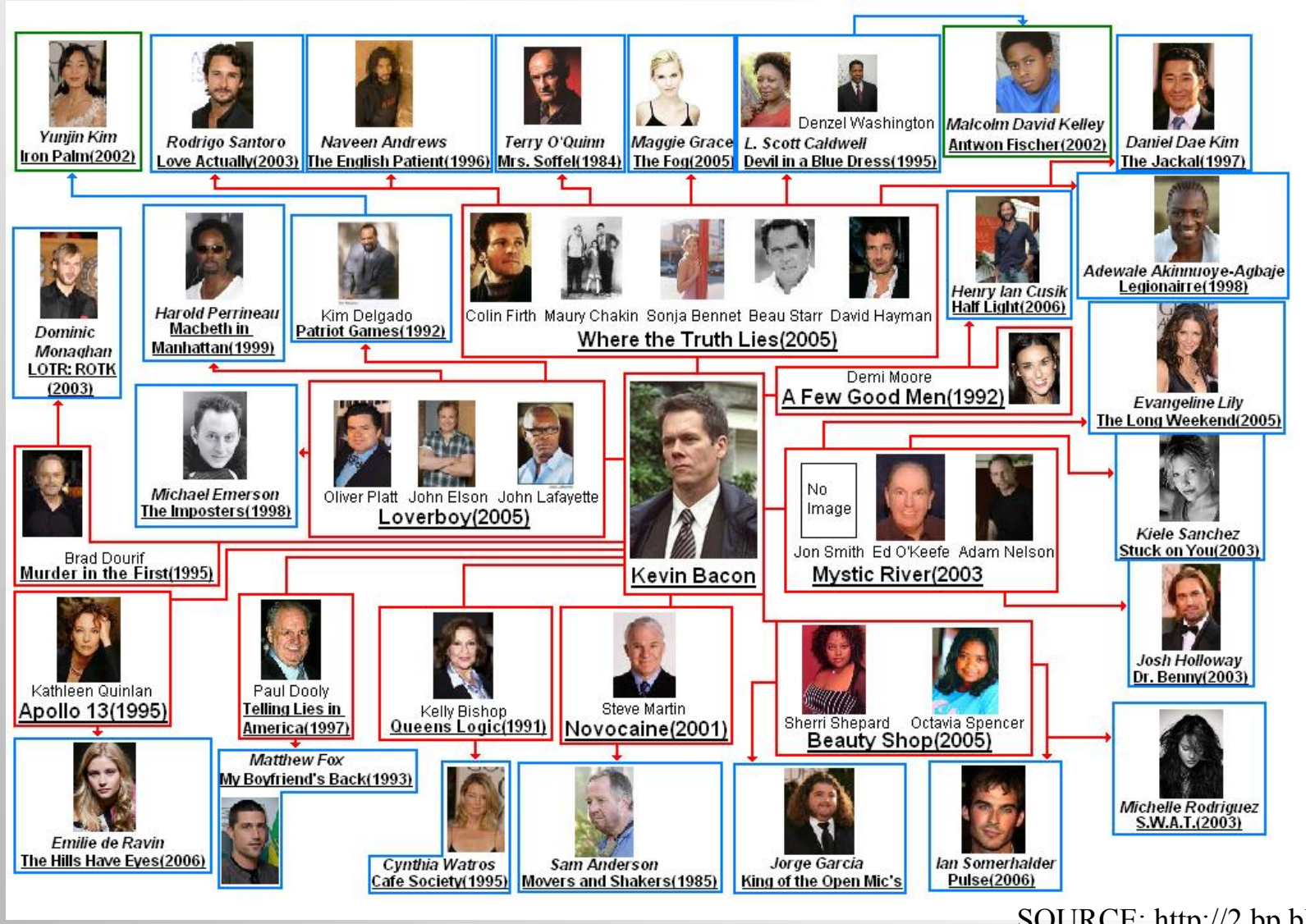
Kevin Bacon Distance



SOURCE: http://2.bp.blogspot.com

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Kevin Bacon Distance

http://oracleofbacon.org/

The Oracle of Bacon

Welcome
Credits
How it Works
Contact Us
Other stuff »

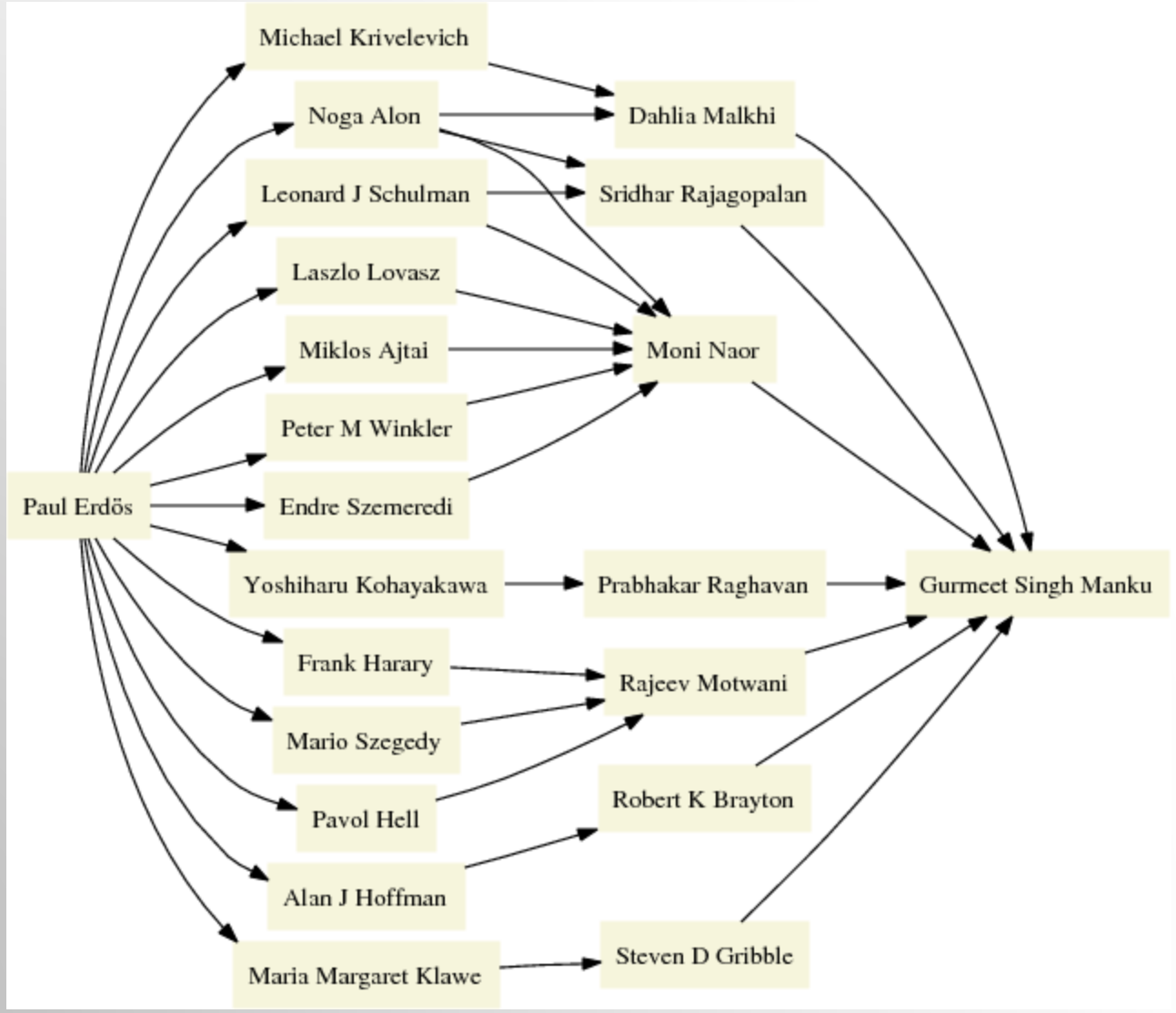
Richard Stilgoe has a Kevin Bacon number of infinity.

Richard Stilgoe cannot be linked to Kevin Bacon using only feature films. Do you want to include documentaries or TV shows?

About 12% of all actors cannot be linked to the rest of the movie universe, either because they have appeared only in video games or straight-to-video releases that the Oracle doesn't count, or because they have not appeared in any films with actors from the Hollywood mainstream.

Kevin Bacon to Richard Stilgoe [Find link] [More options >>]

Erdős Distance



SOURCE: http://gurmeet.net/Images/erdos.gif

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Erdős distance

http://www.oakland.edu/enp/

Oakland University

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The Erdös Number Project

- The Erdös Number Project
- Information about the Erdös Number Project
- The Erdös Number Project Data Files
- Facts about Erdös Numbers and the Collaboration Graph
- Some Famous People with Finite Erdös Numbers
- Computing Your Erdös Number
- Research on Collaboration in Research
- Information about Paul Erdös (1913–1996)
- Publications of Paul Erdös
- Items of Interest Related to Erdös Numbers

The Erdös Number Project

This is the website for the Erdös Number Project, which studies research collaboration among mathematicians.

This site is maintained by **Jerry Grossman** at **Oakland University**, with the collaboration of **Patrick Ion** (**ion@ams.org**) at **Mathematical Reviews** and **Rodrigo De Castro** (**rdcastro@matematicas.unal.edu.co**) at the **Universidad Nacional de Colombia, Bogota**. Please address all comments, additions, and corrections to Jerry at **grossman@oakland.edu**.

Erdös numbers have been a part of the **folklore of mathematicians** throughout the world for many years. For an introduction to our project, a description of what Erdös numbers are, what they can be used for, who cares, and so on, choose the "What's It All About?" link below. To find out who **Paul Erdös** is, look at this **biography** at the MacTutor History of

WHA

SPECIAL NOTES:

We have finished updating the lists of Erdös coauthors.

There are about 1100 new people with Erdös number 2, compared to three years ago.

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The narrative

How do real online social networks develop over time?
Small-world networks

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Discussion

- Do all your social friends have more or less the same number of connections (degree centrality)?
  - If so, what is the average number of friends for each of person?
- Do some have more connections than others?
  - If so, what percentage?

Small World Phenomenon

- We can think about the world as a big graph where nodes are people and edges represent acquaintance, collaboration, communication, etc.
- We can devise mechanisms to measure path length between nodes (people)
  - E.g. how short is the average path between any two nodes
- A number of experiments indicate that the world can appear very small this way
  - E.g. Milgram's six degrees of separation

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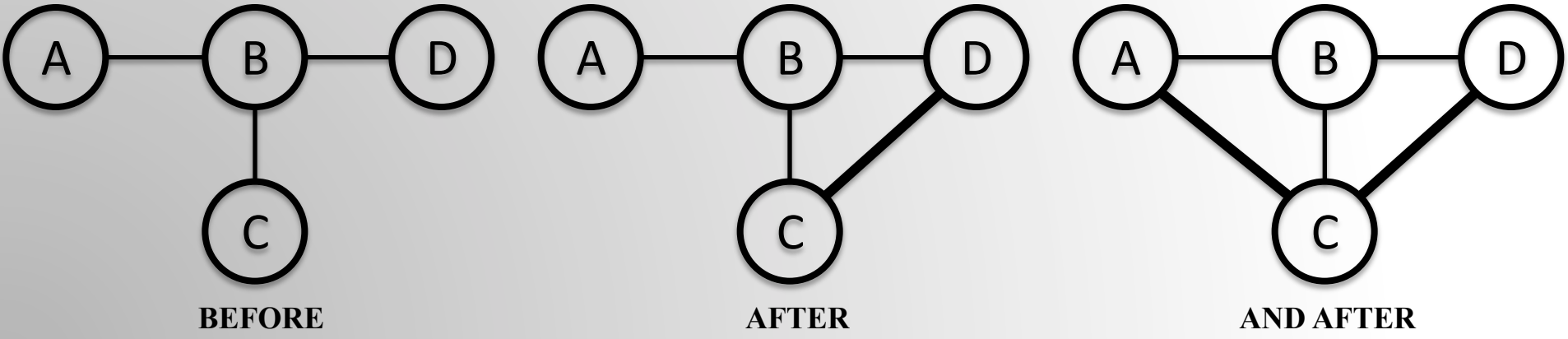
Characteristics of small-world networks

- They tend to contain clusters of densely inter-connected nodes
- The mean shortest path between any two nodes can be short
- They tend to grow denser
  - Triadic closure

Triadic Closure

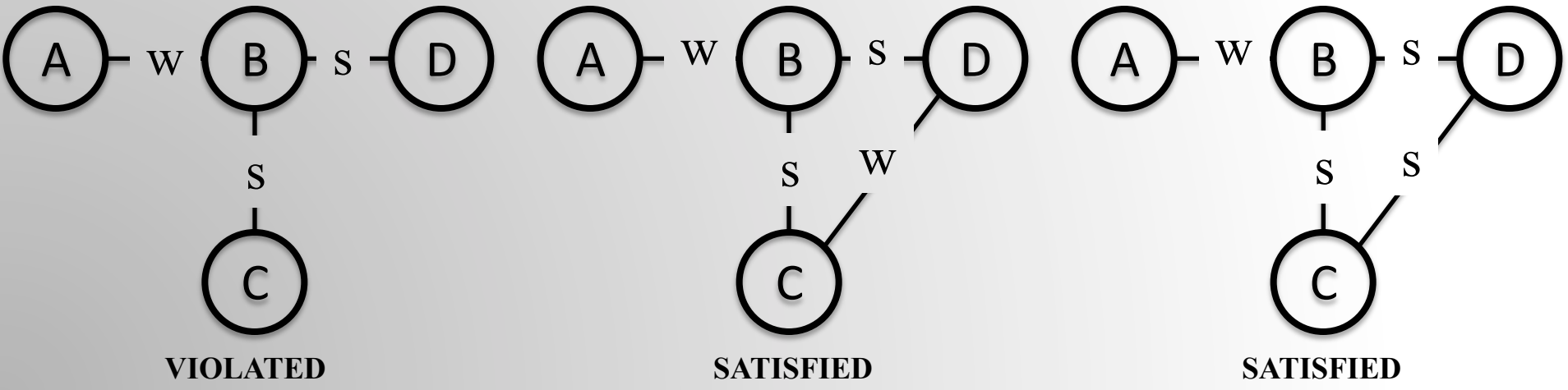
- Is the world getting even smaller?
  - Are the paths connecting individuals getting shorter?
- Triadic closure
  - *If two people in a social network have a friend in common, then there is an increased likelihood that they will become friends themselves at some point in the future (Rapoport, 1953)*



Strong Triadic Closure

- "If a node A has edges to nodes B and C, then the B-C edge is especially likely to form if A's edges to B and C are both strong ties"
- A node A violates the strong triadic closure property it has strong ties to two other nodes between which there is no edge at all (strong or weak)
- Strong triadic closure is satisfied if it is not violated

(Easley and Kleinberg 2010)



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Discussion

- Which types of social networks do you consider to present small-world network properties?

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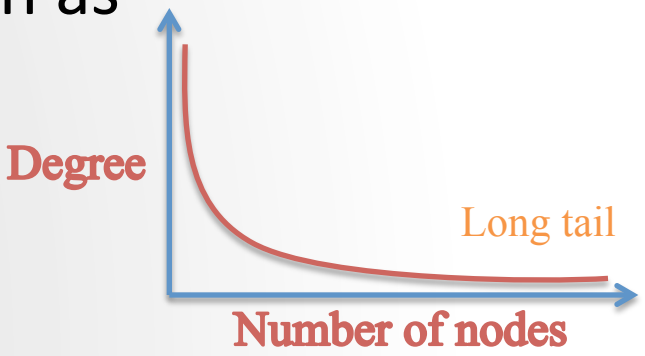
The narrative

How do real online social networks develop over time?

Scale-free networks

Scale-free networks

- There are networks in which the degree distribution among nodes is a ‘power-law’ distribution; a smaller number of nodes have the most links
- Examples:
  - The WWW, Social networks such as Twitter



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Characteristics of scale-free networks

- Preferential attachment
- Emergence of new nodes
- Upper limits on the degree of a node

- *E.g. on the Web*
  - *Websites with many links get even more*
  - *New websites keep emerging every moment*
  - *There appears to be a limit on the number of links from a website*

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Discussion

- Which types of social networks do you consider to present scale-free network properties?
- Consider a number of networks in the discussion

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Facebook

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Twitter

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Studying online social networks

- On generated models
- On samples
- On the whole network, online

- Quantitative and Qualitative research

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Lessons learned

- Familiarity with how networks can be represented as graphs, the local clustering co-efficient metric, the different types of centrality (degree, closeness, betweenness) and what those types of centrality can indicate for graphs representing social networks.
- Familiarity with the triadic closure and the strong triadic closure property and what its presence can signify in an online social network.

- Wang, X. F., & Guanrong Chen Circuits and Systems Magazine, I. (n.d.). Complex networks: small-world, scale-free and beyond. *Circuits and Systems Magazine, IEEE*, *3*(1). http://www.ee.cityu.edu.hk/~gchen/pdf/CW-CASM03-overview.pdf
- Easley, D. and Kleinberg, J. Networks Crowds and Markets. Cambridge University Press, 2010. http://www.cs.cornell.edu/home/kleinber/networks-book
- Hein, O., Schwind, M., & König, W. (2006). Scale-free networks. *Wirtschaftsinformatik*, *48*(4), 267–275. http://eaton.math.rpi.edu/csums/papers/ScaleFree/Scale-Free%20Networks.pdf