



Centrality Measures

Measures of the “importance” of a node in a network

The Oracle of Bacon

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Kevin Bacon to Charles Chaplin Find link More options >

```

    graph TD
      KB[Kevin Bacon] --> RT[Revs & Ties (2017)]
      RT --> MM[Margo Martindale]
      MM --> TF[The Firm (1993)]
      TF --> JD[John Dahl (I)]
      JD --> PP[Picture People No. 3: Hobbes of the Stars (1941)]
      PP --> CC[Charles Chaplin]
  
```

The screenshot shows a web browser window with the title "The Oracle of Bacon". The main content area displays a vertical chain of nodes connected by arrows, representing a path from Kevin Bacon to Charles Chaplin. The nodes are: Kevin Bacon (green box), Revs & Ties (2017) (blue box), Margo Martindale (green box), The Firm (1993) (blue box), John Dahl (I) (green box), Picture People No. 3: Hobbes of the Stars (1941) (blue box), and Charles Chaplin (green box). Below the path is a search bar with "Kevin Bacon" in the input field and "to Charles Chaplin" in the dropdown menu. There are buttons for "Find link" and "More options >". The browser's address bar shows a URL starting with "http://www.theoracleofbacon.org". The Windows taskbar at the bottom shows several open applications, including "The Oracle of Bacon".

Analisi di reti sociali - Aprile 2011

Hollywood Revolves Around

Click on a name to see that person's table.

[Steiger, Rod](#) (2.678695)

[Lee, Christopher \(I\)](#) (2.684104)

[Hopper, Dennis](#) (2.698471)

[Sutherland, Donald \(I\)](#) (2.701850)

[Keitel, Harvey](#) (2.705573)

[Pleasence, Donald](#) (2.707490)

[von Sydow, Max](#) (2.708420)

[Caine, Michael \(I\)](#) (2.720621)

[Sheen, Martin](#) (2.721361)

[Quinn, Anthony](#) (2.722720)

[Heston, Charlton](#) (2.722904)

[Hackman, Gene](#) (2.725215)

[Connery, Sean](#) (2.730801)

[Stanton, Harry Dean](#) (2.737575)

[Welles, Orson](#) (2.744593)

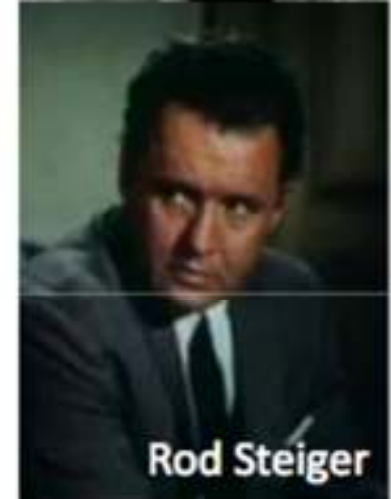
[Mitchum, Robert](#) (2.745206)

[Gould, Elliott](#) (2.746082)

[Plummer, Christopher \(I\)](#) (2.746427)

[Coburn, James](#) (2.746822)

[Borgnine, Ernest](#) (2.747229)



Rod Steiger



Most Connected Actors in Hollywood

(measured in the late 90's)

Mel Blanc 759
Tom Byron 679
Marc Wallice 535
Ron Jeremy 500
Peter North 491
TT Boy 449
Tom London 436
Randy West 425
Mike Horner 418
Joey Silvera 410



XXX



DEGREE CENTRALITY

K = number of links

$$k_i = \sum_{j=1}^n A_{ij}$$

Where $A_{ij} = 1$ if nodes i and j are connected and 0 otherwise

BETWEENNESS CENTRALITY

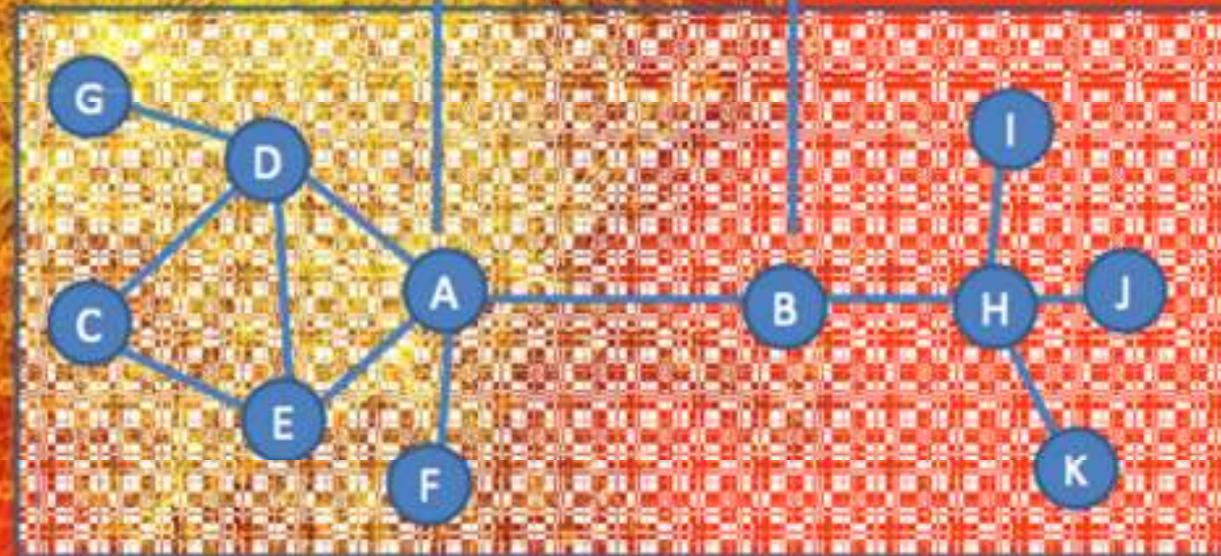
BC= number of shortest Paths that go through a node.

$$BC(G)=0$$

$$BC(D)=9+7/2=12.5$$

$$BC(A)=5*5+4=29$$

$$BC(B)=4*6=24$$



N=11

A set of measures of centrality based on
betweenness

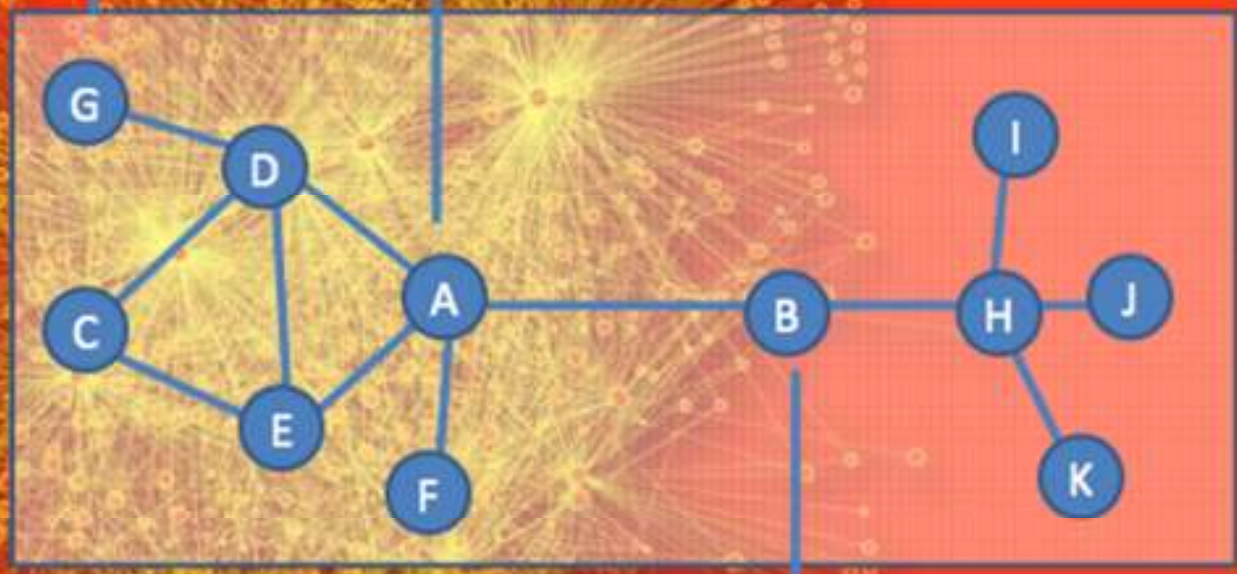
LC Freeman - Sociometry, 1977 - jstor.org

$$C(G) = \frac{1}{10}(1 + 2 \cdot 3 + 2 \cdot 3 + 4 + 3 \cdot 5)$$
$$C(G) = 3.2$$

$$C(A) = \frac{1}{10}(4 + 2 \cdot 3 + 3 \cdot 3)$$
$$C(A) = 1.9$$

CLOSENESS CENTRALITY

C = Average Distance to neighbors



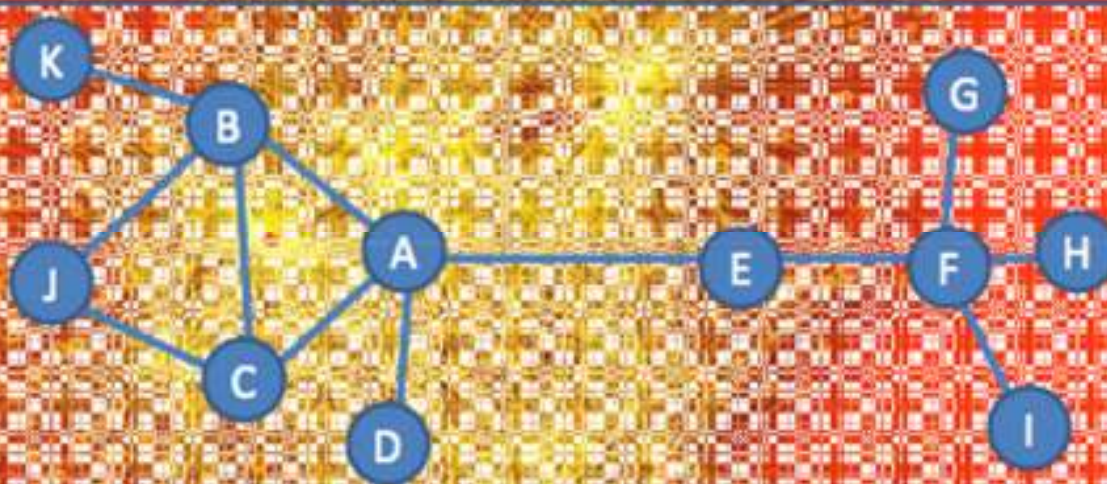
$$C(B) = \frac{1}{10}(2 + 2 \cdot 6 + 2 \cdot 3)$$
$$C(B) = 2$$

N=11

PAGE RANK

PR=Probability that a random walker with interspersed Jumps would visit that node.

PR=Each page votes for its neighbors.



$$PR(A) = PR(B)/4 + PR(C)/3 + PR(D) + PR(E)/2$$

A random surfer eventually stops clicking

$$PR(X) = (1-d)/N + d(\sum PR(y)/k(y))$$

PAGE RANK

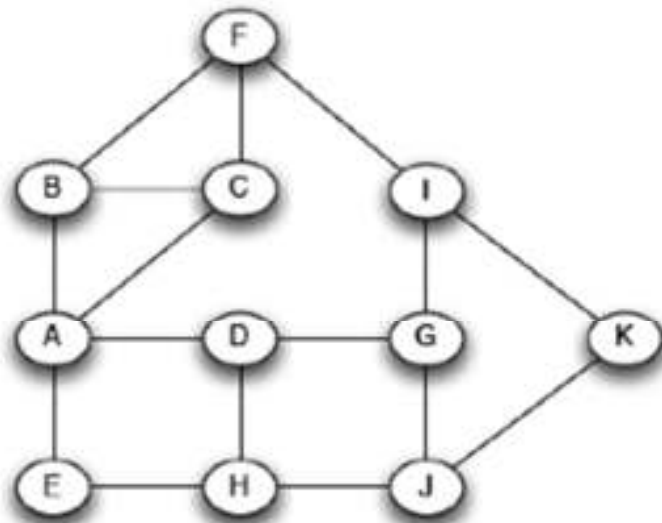
PR=Probability that a random Walker would visit that node.
PR=Each page votes for its neighbors.

$$\mathbf{R} = \begin{bmatrix} PR(p_1) \\ PR(p_2) \\ \vdots \\ PR(p_N) \end{bmatrix}$$

$$\mathbf{R} = \begin{bmatrix} (1-d)/N \\ (1-d)/N \\ \vdots \\ (1-d)/N \end{bmatrix} + d \begin{bmatrix} \ell(p_1, p_1) & \ell(p_1, p_2) & \dots & \ell(p_1, p_N) \\ \ell(p_2, p_1) & \ddots & & \vdots \\ \vdots & & \ell(p_i, p_j) & \\ \ell(p_N, p_1) & \dots & & \ell(p_N, p_N) \end{bmatrix} \mathbf{R}$$

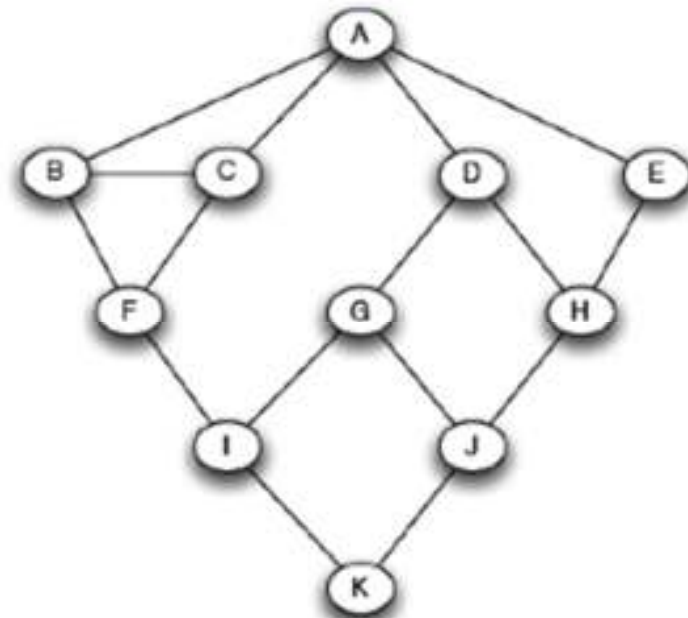
$$\sum_{i=1}^N \ell(p_i, p_j) = 1,$$

How to compute betweenness?



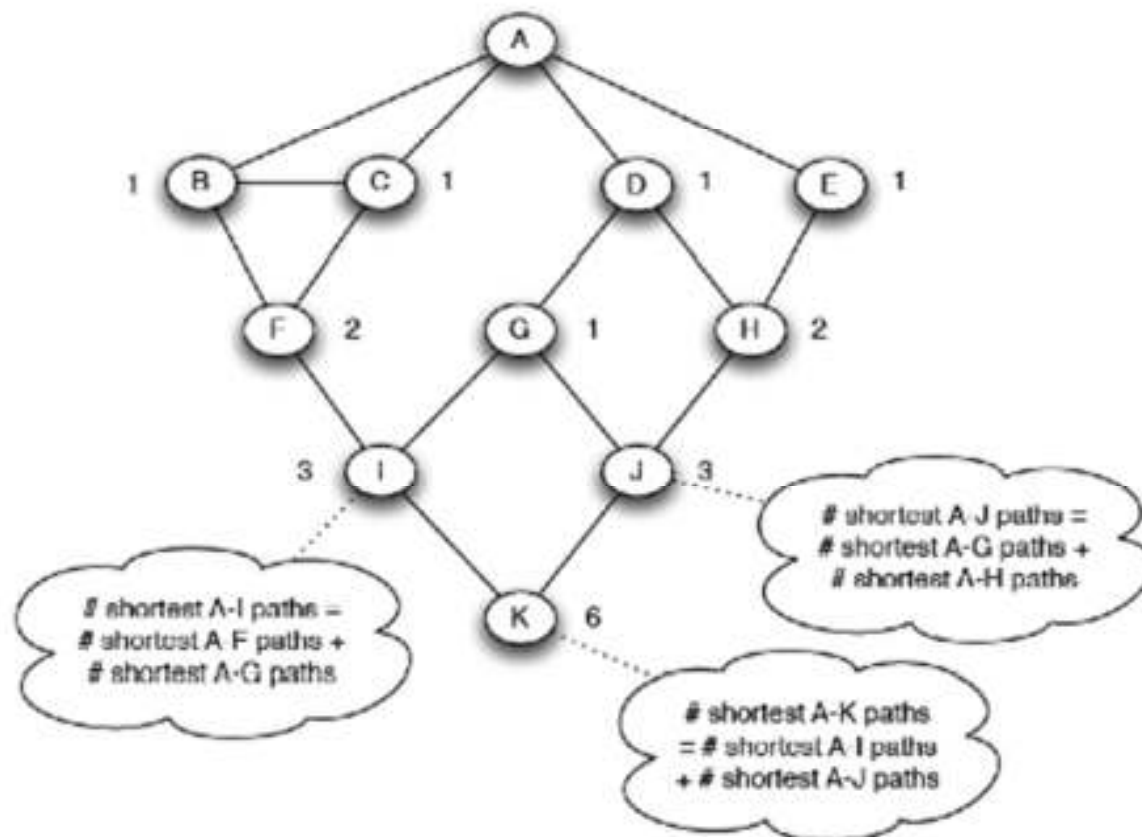
- Want to compute betweenness of paths starting at node A

- Breath first search starting from A:



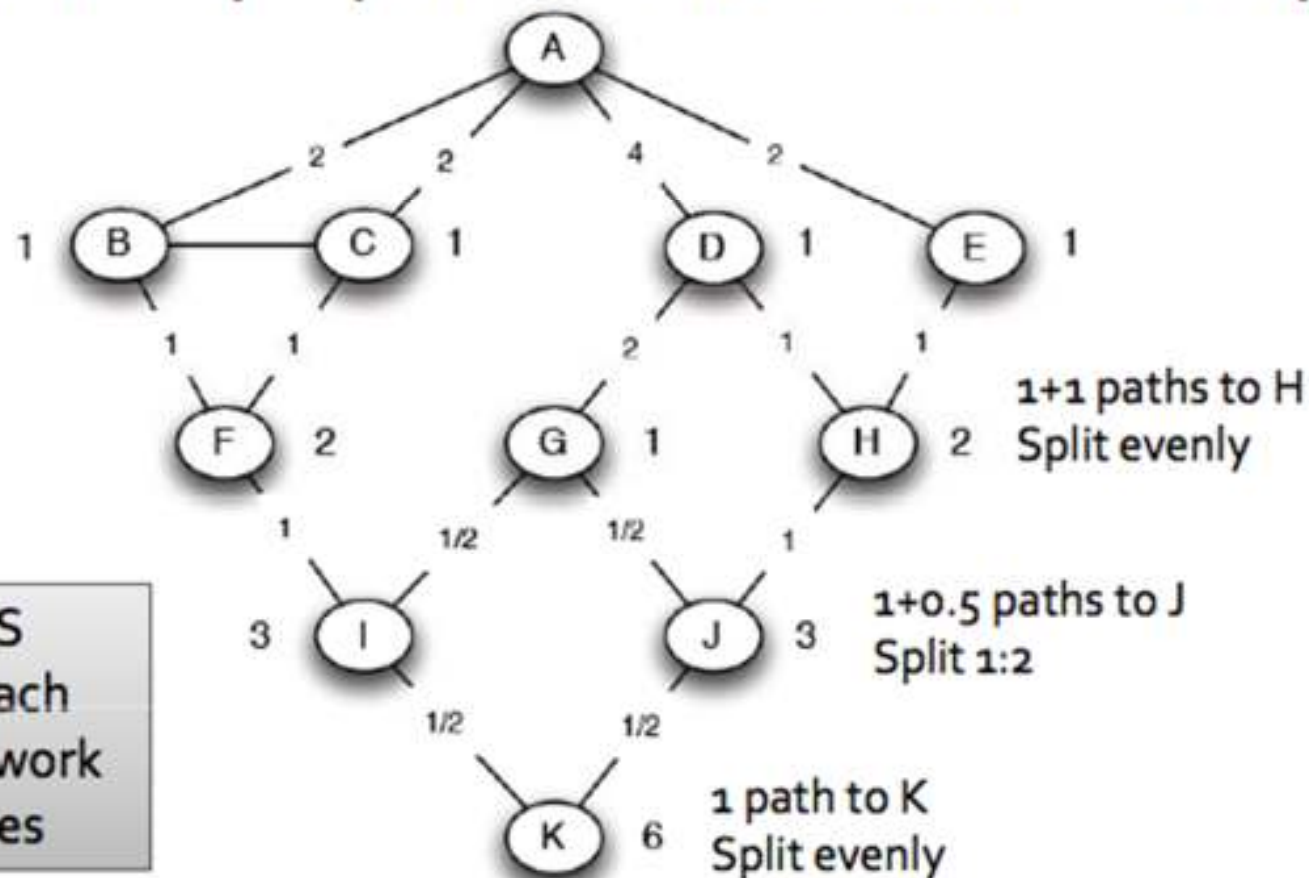
How to compute betweenness (2)

- Count the number of shortest paths from A to all other nodes of the network:



How to compute betweenness (3)

- Compute betweenness by working up the tree: If there are multiple paths count them fractionally



- Repeat the BFS procedure for each node of the network
- Add edge scores