Social Network Analysis

Course Outline

- Graph Theory and Social Networks
- Visualizing Social Networks
- **Network Dynamics**
- Information Networks and the World Wide Web
- Game Theory
- Applications of SNA in various domains

The Small-World Phenomenon

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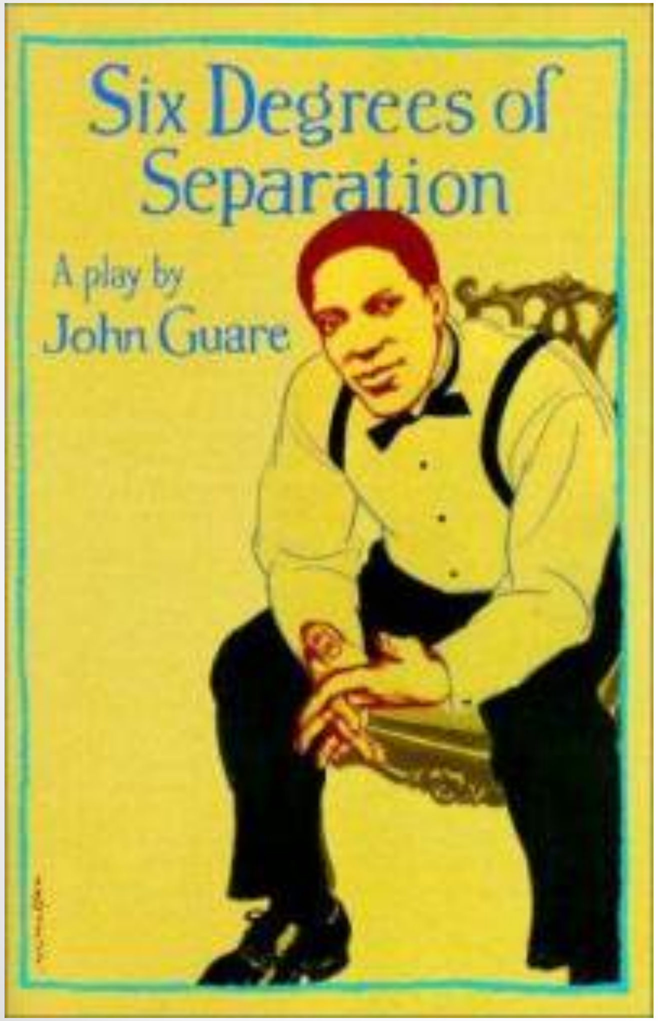
Six Degrees of Separation



"Everybody on this planet is separated by only six other people. Six degrees of separation. Between us and everybody else on this planet. The president of the United States. A gondolier in Venice.... It's not just the big names. It's anyone. A native in a rain forest. A Tierra del Fuegan. An Eskimo. I am bound to everyone on this planet by a trail of six people. It's a profound thought. How every person is a new door, opening up into other worlds."

WWW: 19 DEGREES OF SEPARATION

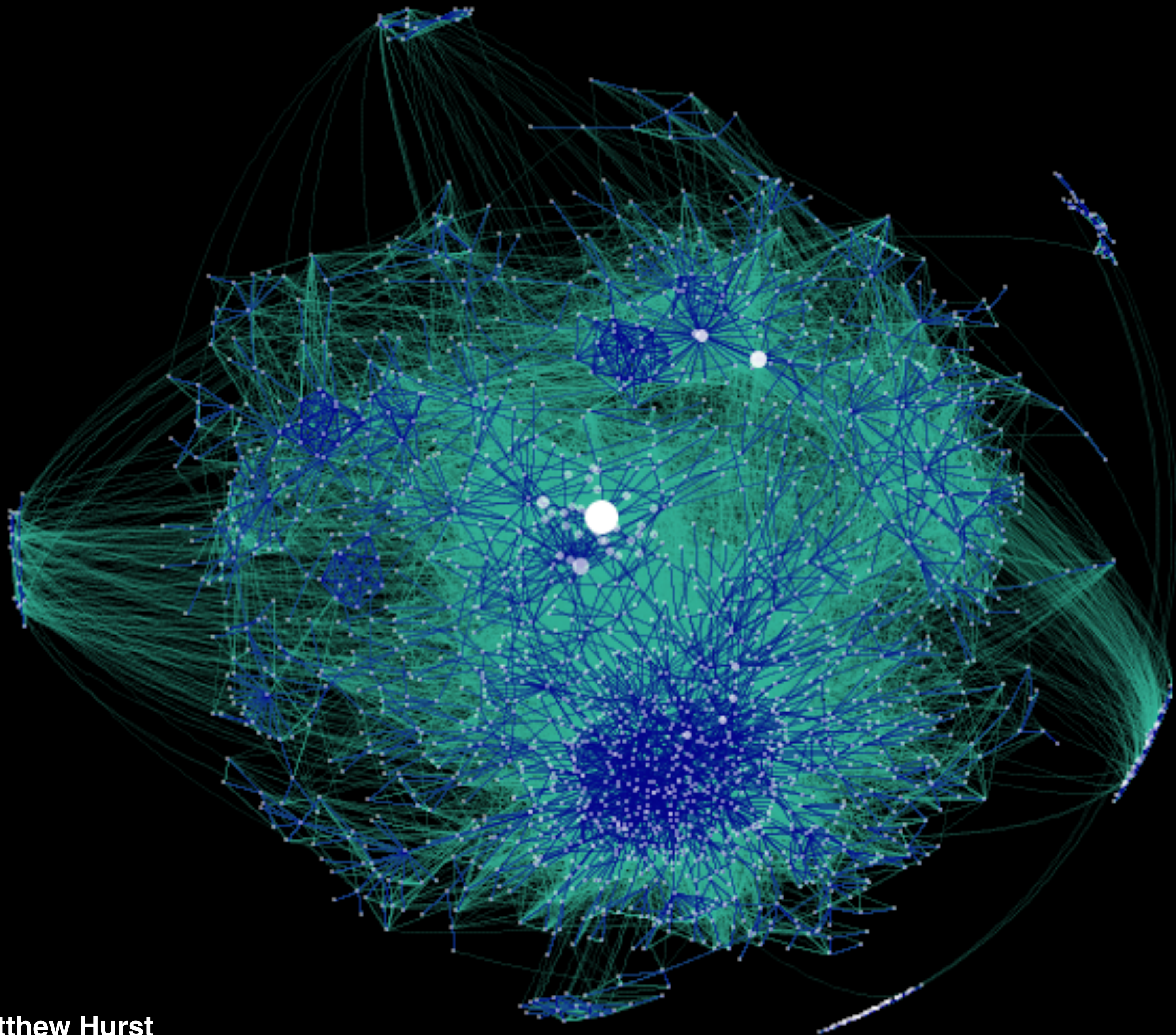


Image by **Matthew Hurst**
Blogosphere

Six Degrees of Separation

- The fact that social networks are so rich in short paths is known as the *small-world phenomenon*, or the "six degrees of separation," and it has long been the subject of both anecdotal and scientific fascination.

- The first significant empirical study of the small-world phenomenon was undertaken by the social psychologist Stanley Milgram

- ..who asked randomly chosen "starter" individuals to each try forwarding a letter to a designated "target" person living in the town of Sharon, MA, a suburb of Boston.

Six Degrees of Separation

- He provided the target's name, address, occupation, and some personal information, but stipulated that the participants could not mail the letter directly to the target;
- rather, each participant could only advance the letter by forwarding it to a single acquaintance that he or she knew on a first-name basis, with the goal of reaching the target as rapidly as possible.
- Roughly a third of the letters eventually arrived at the target, in a median of six steps,
- and this has since served as basic experimental evidence for the existence of short paths in the global friendship network, linking all (or almost all) of us together in society.

Six Degrees of Separation

- Milgram's experiment really demonstrated two striking facts about large social networks:
  - first, that short paths are there in abundance; and
  - second, that people, acting without any sort of global "map" of the network, are effective at collectively finding these short paths.
- It is easy to imagine a social network where the first of these is true but the second isn't:
  - For example, a large social-networking site where everyone was known only by 9-digit pseudonyms would be like this.
  - "Forward this letter to user number 482285204, using only people you know on a first-name basis,"

Six Degrees of Separation

- The real global friendship network contains enough clues about how people fit together in larger structures – both geographic and social – to allow the process of search to focus in on distant targets.

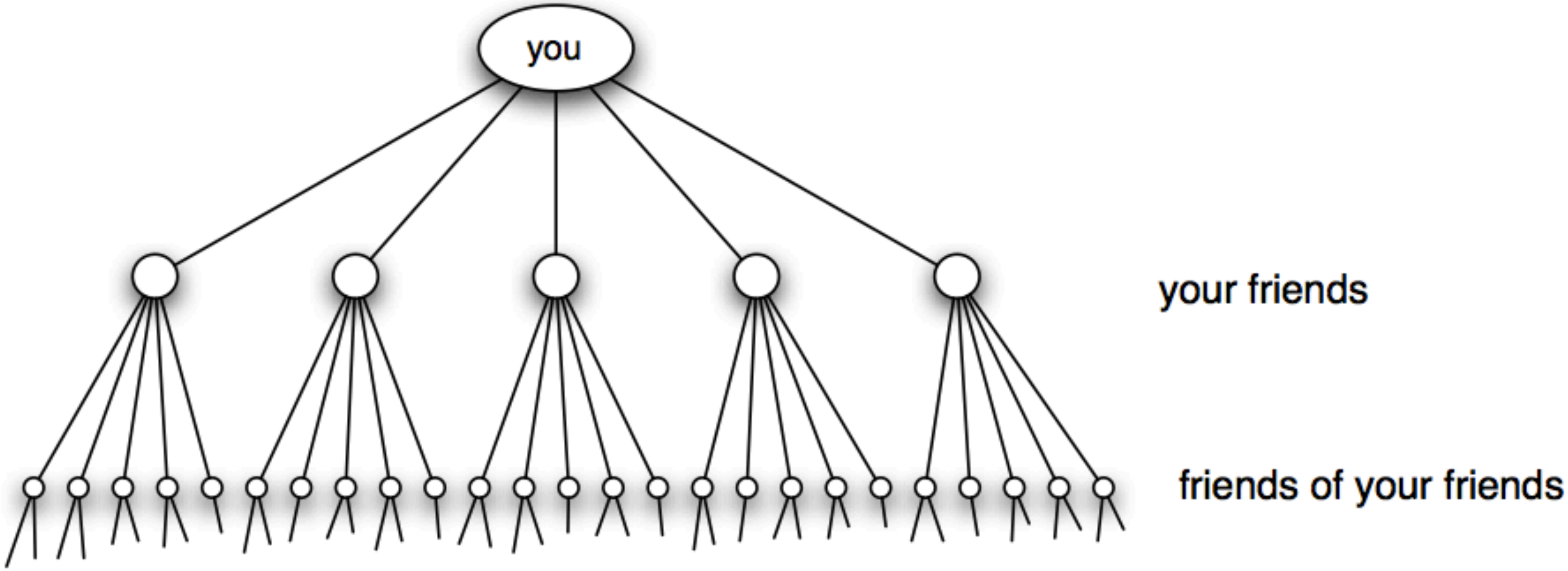
- Kilworth and Bernard [5] did a followup on the Milgram experiment, to study the strategies that people employ for choosing how to forward a message toward a target,

- They found a mixture of primarily geographic and occupational features being used, with different features being favoured depending on the characteristics of the target in relation to the sender.

- We can develop models for both of these principles – existence of short paths, and the fact that they can be found.

Existence of Short Paths

- Should we be surprised by the fact that the paths between seemingly arbitrary pairs of people are so short?

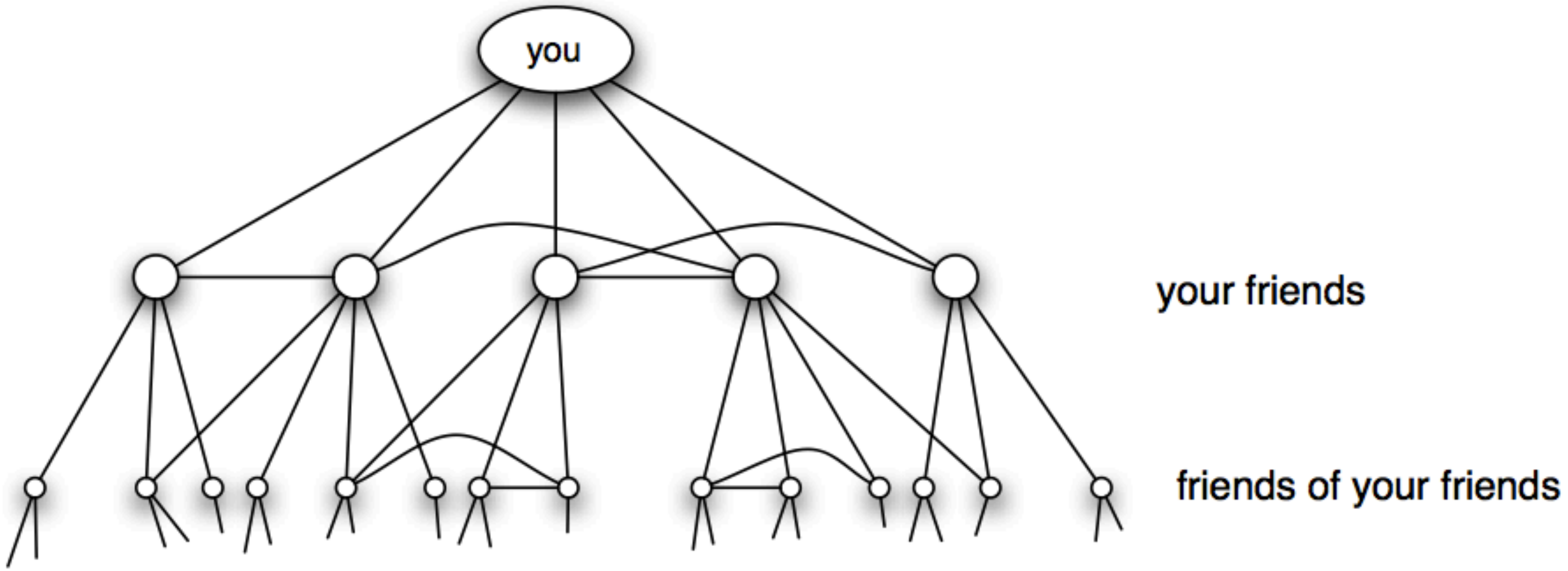


- Pure exponential growth produces a small world
- 100 @ 1; 10,000 @ 2; 1,000,000 @ 3; ....

Existence of Short Paths

- Is this how it is in the real world?

- Social networks abound in triangles — sets of three people who mutually know each other — and in particular, many of your 100 friends will know each other.



- So, the effect of triadic closure in social networks works to limit the number of people you can reach by following short paths.

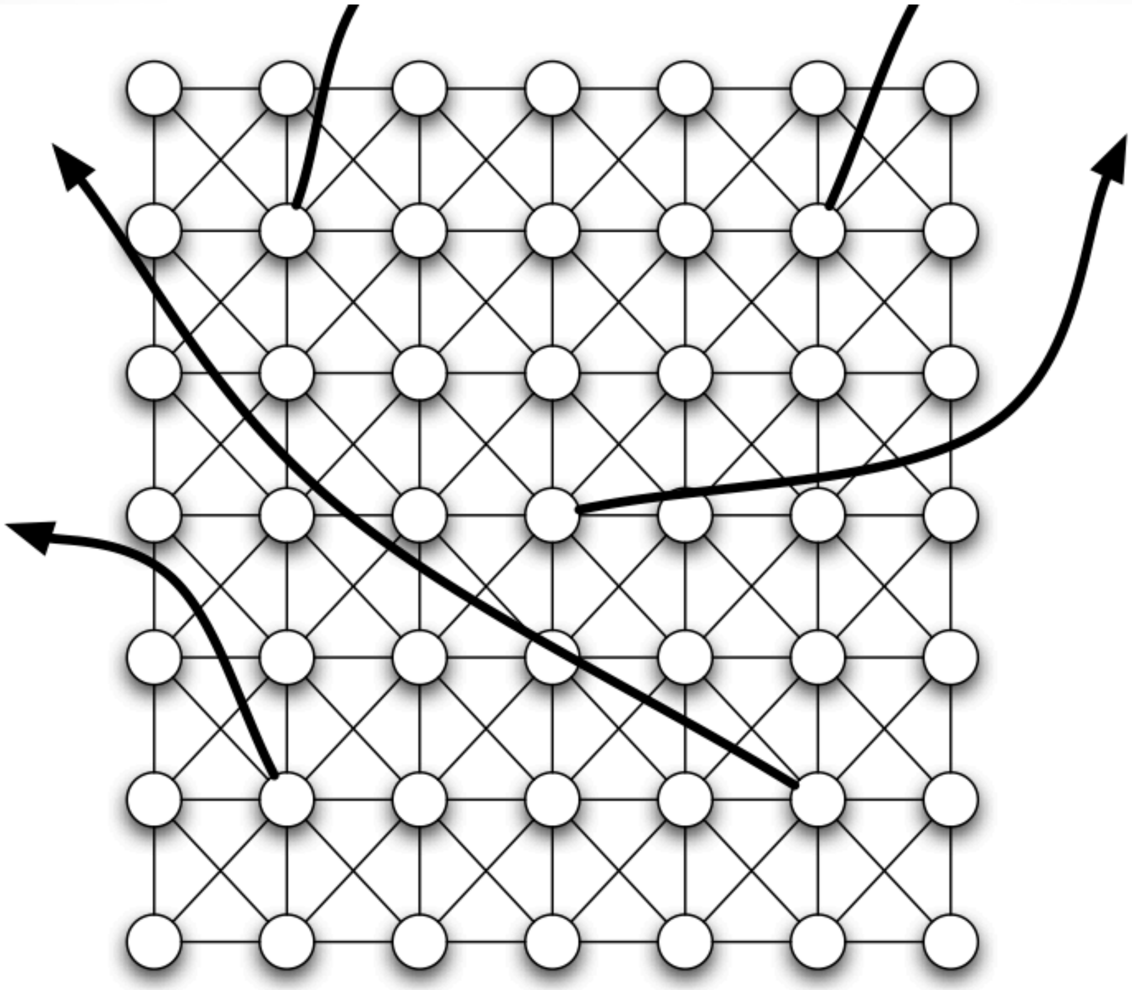
Triangles & Short Paths

- Perhaps, this is what makes the small-world phenomenon surprising to many people:
  - from the local perspective of any one individual the social network appears to be highly clustered,
  - not the kind of massively branching structure that would lead to short paths.

- Can we make up a simple model that exhibits both of the features we've been discussing: many closed triads, but also very short paths?

- Watts and Strogatz made this proposal concrete in a very simple model that generates random networks with the desired properties [6].

Watts – Strogatz Model



Watts-Strogatz Model

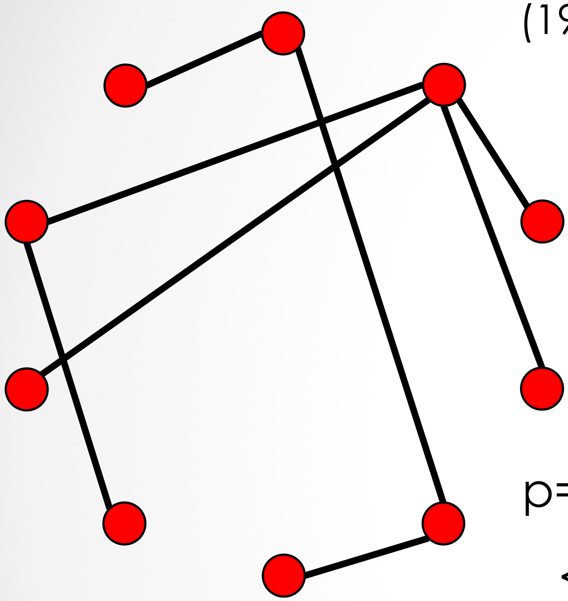
- Watts and Strogatz observe first that the network has many triangles:
    - any two neighbouring nodes (or nearby nodes) will have many common friends

- They also find that there are — with high probability — very short paths connecting every pair of nodes in the network.

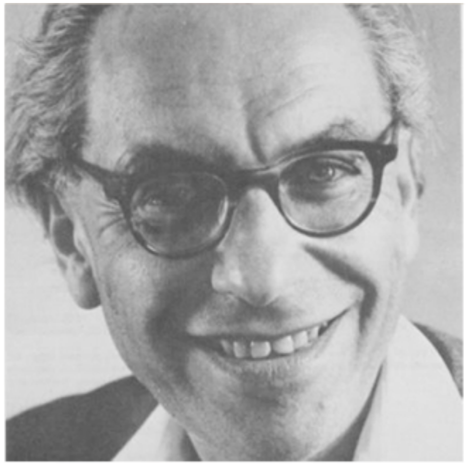
- Suppose we start tracing paths outward from a starting node v, using only the k random links out of each node.

- In fact a surprisingly small amount of randomness is needed to achieve the same qualitative effect.

Random Graphs



Paul Erdős
(1913-1996)



Alfréd Rényi
(1921-1970)

p=1/6 N=10

<k> ~ 1.5

Erdös-Rényi model (1960)
Connect with probability p

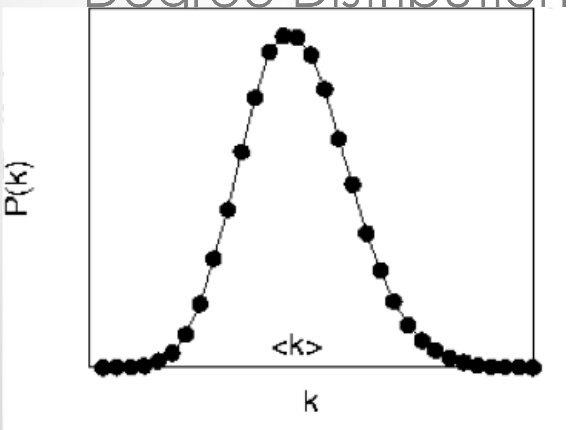
A random graph is a graph of N nodes where each pair of nodes is connected by probability p.

G(N,p) model: Given N nodes, each pair of nodes has an edge between them with probability p.

ERIWSIBA models

Erdös-Rényi

- Random graphs
- Has small diameter
- Low clustering coefficient
- Degree Distribution



Watts–Strogatz

- Regular graphs
- Random links
- Explains "small world" along with high clustering coefficient

Barabási–Albert

- Preferential Attachment
- Rich-get-richer (Copying model)
- Explains Power Law degree distributions

References

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2. Stanley Milgram. The small-world problem. Psychology Today, 2:60–67, 1967.
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4. Jon Kleinberg. Navigation in a small world. Nature, 406:845, 2000.
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6. Duncan J. Watts and Steven H. Strogatz. Collective dynamics of ‘small-world’ networks. Nature, 393:440–442, 1998.