MA/CS-109: It's a Small World After All!

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Understanding emergent behaviors

- Stacking up simple functionalities results in complex artifacts …


… whose behaviors and properties we need to understand and make statements about!

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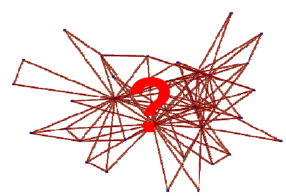
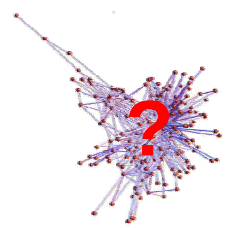




… whose behaviors and properties we need to understand and make statements about!

Let's take an example

- How does the Internet "graph" or a social network "graph" grow over time?
  - What will it look like in 10 years?
- Important to find out to answer questions like
  - Are there vulnerabilities? What are the weakest links? How to slow down virus propagation?
  - How to design marketing/political campaigns?
  - Who is the most influential blogger out there?

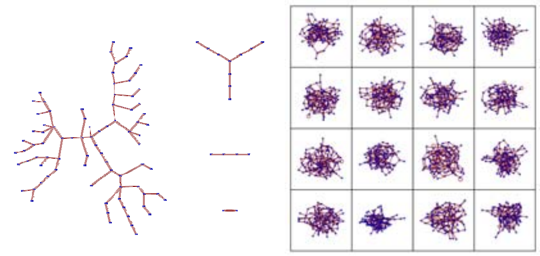
Let's take an example

- How does the Internet "graph" or a social network "graph" grow over time?
  - What will it look like in 10 years?
- I have no idea, but I can make a wild guess
  - I can "imagine" a model of how such networks may form…

Attempt #1: Edges at Random

1. Pick the size of the graph you want – i.e., the number of nodes ***n*** you want
2. Pick the average number of neighbors (degree) for a node ***d***
3. For every pair of nodes in the graph – roll the dice and with probability ~ ***d/n*** establish an edge between the pair of nodes

What do we get? [demo]



"ER" Model due to Erdos-Renyi (circa 1959)

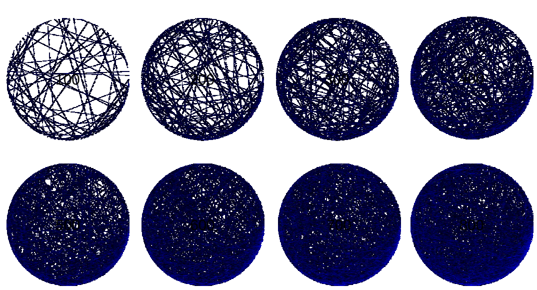
Observations for ER Graphs

- Graph disconnected when ***d*** < 1 and very "quickly" gets connected when ***d*** > 1
- Not a natural way to explain how (Internet or social) networks develop because it is not an "evolutionary" graph
- Need a "growth" model…

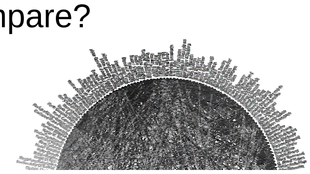
Attempt #2: Radom Attachment

1. In the beginning, the network had a single node
2. Then, came a new node which decided to link up to the network. To do so:
   - The new node selected one of the existing nodes in the network uniformly at random
   - The new node establishes a link to that node
3. Go to 2 until graph of desired size is reached

What do we get? [Demo]



How does it compare?



Which one is my "real" Facebook graph?