Networks

Big data: networks

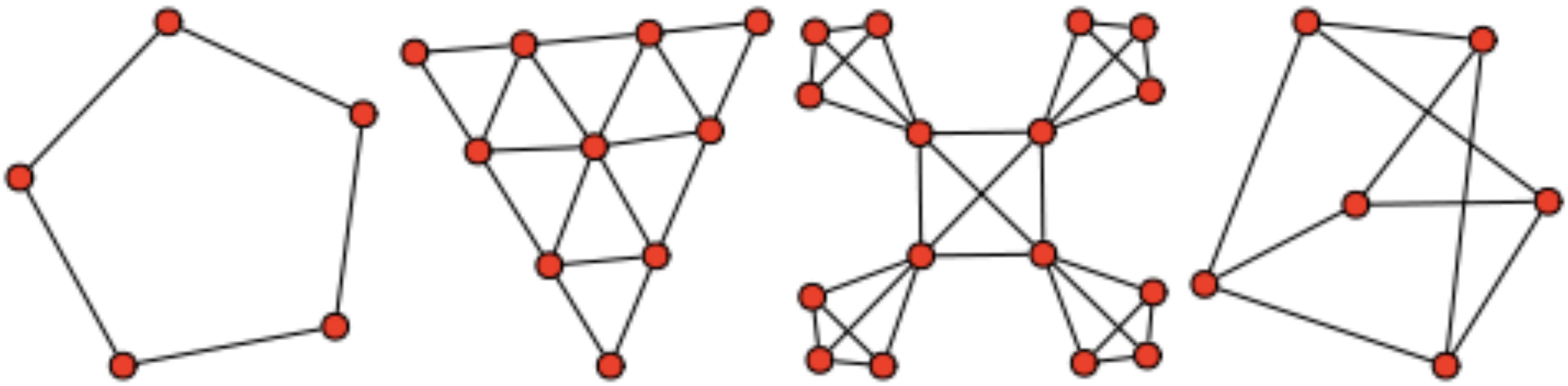
- Graphical models provide a language for networks
  - 0/1 connections between people/sites/variables.
  - Think of graphs like a binary version of correlation: it's either 0 or 1

- Graph Structure:
  - Summaries: nodes, edges, direction.
  - Measuring connectivity and betweenness.

- Constructing graphs: the A Priori algorithm

Graph structure

- A graph has nodes:
  - people, websites, YouTube videos, products, songs…
- It also has edges: links between the nodes
  - Can be directed or undirected.

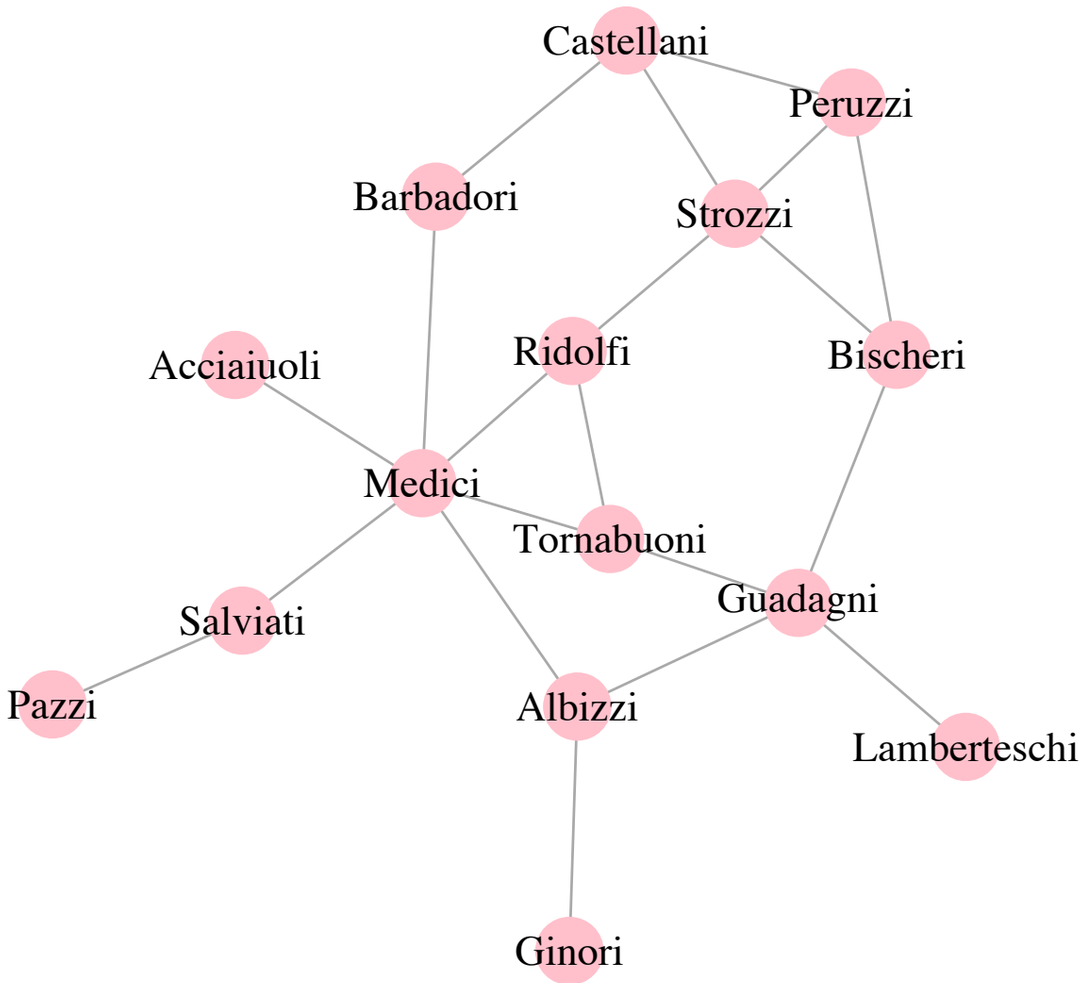


Graph structure: summary

- Suppose we start with the graph structure given.
- Goal: summarize its important properties
- Each node can be described in terms of various connectivity metrics. Here are two:
  - *Degree*: How many other nodes are you connected to?
  - *Betweenness*: How many node-to-node paths go through you?

Graph structure: degree

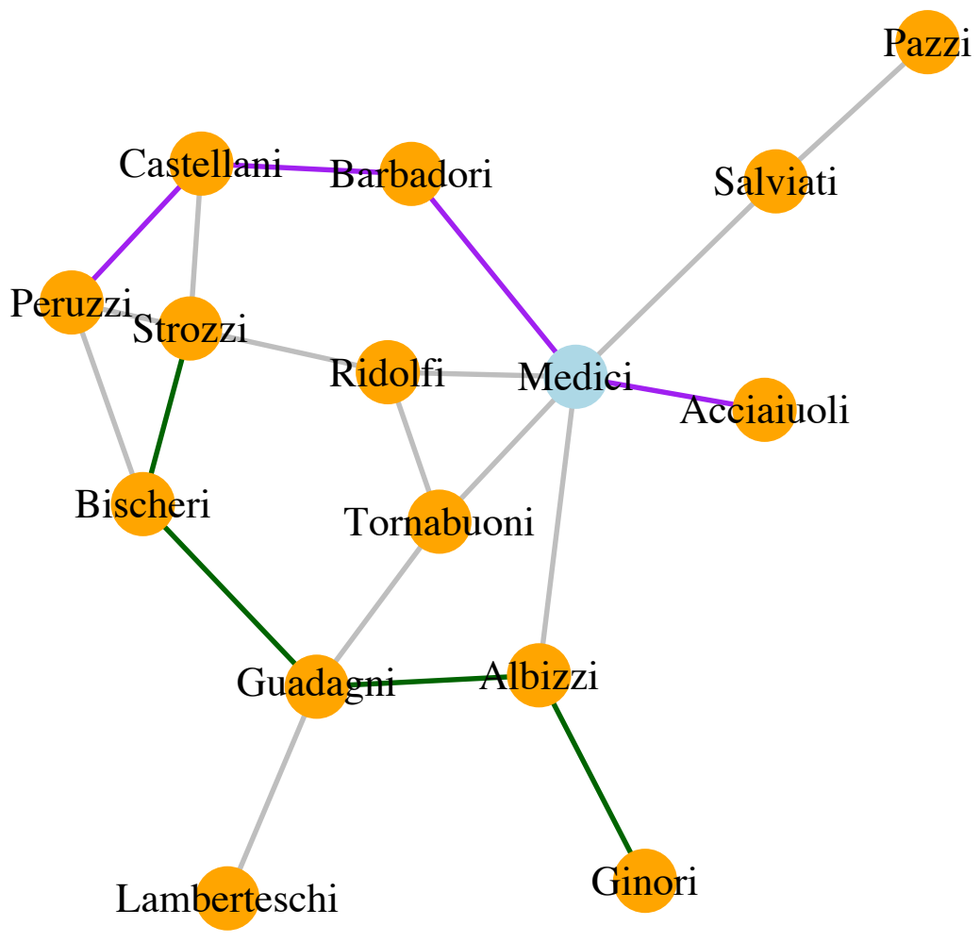
- An example of a graph showing connections by marriage between prominent families in Renaissance Florence



- degree(Medici) = 6
- degree(Strozzi) = 5
- degree(Ginori) = 1
- etc

Graph structure: betweenness

- Every pair of nodes has at least one shortest path between them.
- Betweenness: how many of these shorts paths pass through a given node?
- Acciaiuoli to Peruzzi: blue
- Ginori to Strozzi: green



Graph structure: betweenness

- Betweenness measures how much “influence” a node has over connections between other nodes (“deep connectivity”)

- Formally, we define the betweenness of a vertex v as:

$$B(v) = \sum_{s \neq v \neq t} \frac{\sigma_{st}(v)}{\sigma_{st}}$$

Number of shortest paths from s to t that contain v

Total number of unique shortest paths from s to t

Betweenness in organizational theory

- Scholars of organizational behavior use the term “structural hole” to mean a low-level node in an organization chart with a high betweenness.

- Can act like bottlenecks in the flow of information.

- But good if you’re the employee!

Structural Holes and Good Ideas[1]

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This article outlines the mechanism by which brokerage provides social capital. Opinion and behavior are more homogeneous within than between groups, so people connected across groups are more familiar with alternative ways of thinking and behaving. Brokerage across the structural holes between groups provides a vision of options otherwise unseen, which is the mechanism by which brokerage becomes social capital. I review evidence consistent with the hypothesis, then look at the networks around managers in a large American electronics company. The organization is rife with structural holes, and brokerage has its expected correlates. Compensation, positive performance evaluations, promotions, and good ideas are disproportionately in the hands of people whose networks span structural holes. The between-group brokers are more likely to express ideas, less likely to have ideas dismissed, and more likely to have ideas evaluated as valuable. I close with implications for creativity and structural change.

Graph structure: getting started in R

- **`igraph`** is a graph toolbox with front-ends for both R and Python. Good documentation: see ?igraph

- Typical input = reading graphs from an edge list

```
0   1
0   2
1   0
2   1
```