1. Introduction to Network Analysis

Introduction to Social Network Analysis in R

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1. Introduction to Network Analysis

2. Basics of Networks

Basic Network Elements

WA: Let's explore our network!

Closer inspection

Introduction to Social Network Analysis(SNA) in R

1. Introduction to R as we will use R language for SNA for the rest of the lecture series
2. Introduction to basic concepts in SNA
3. Visualization of networks.
4. Metrics - Individual nodes.
5. Metrics - Whole network.
6. (Time permitting) Network models, algorithms and Inference.
7. SNA in Education, Surveys and Data Manipulation.
8. Ongoing Research Project with Keio University.

1. Introduction to Network Analysis

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Network Analysis

- Map and understand complex structures & systems
- Relational methods
- Connections, structures & positions

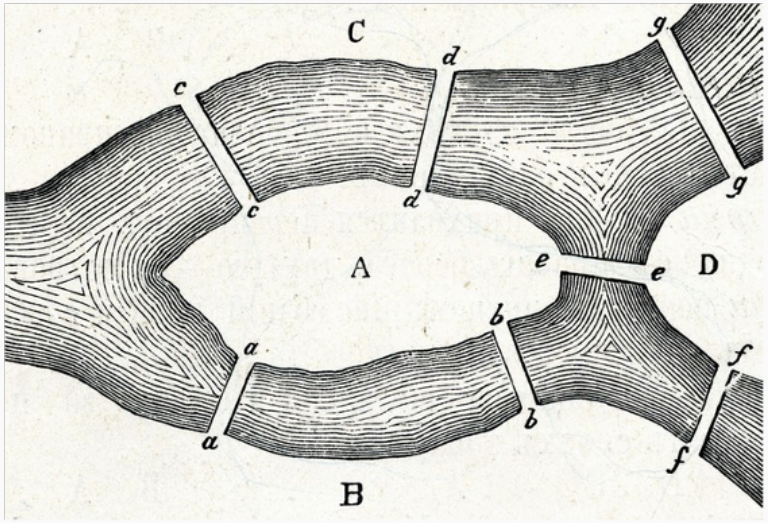
Data with ***Entities*** and their ***relations***

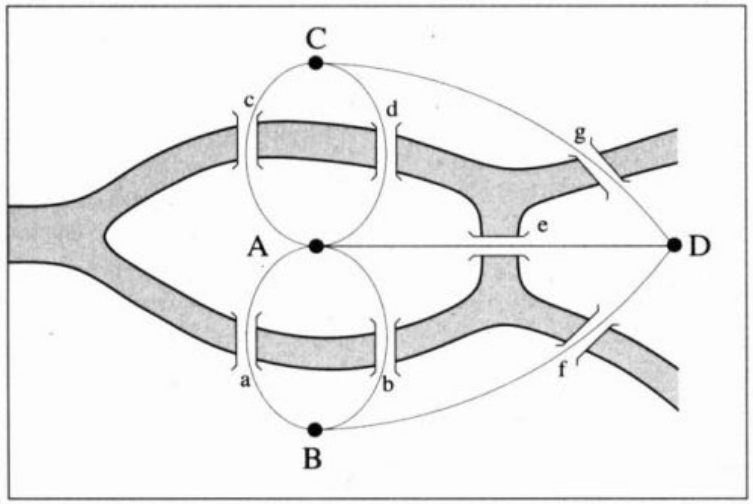
Origins

- Network Analysis rooted in graph theory in 1735
  - Euler
  - Bridges of Königsberg problem
- Social Network Analysis rooted in Social Dynamic Analysis
  - Jacob L. Moreno, a psychiatrist (1889 - 1974)
  - dynamics of social interactions within groups of people
- Modern-day Network Science rooted in the beginnings of the Internet
  - Facebook

Network science has a long history (almost 300 years! (1735))

Beginnings in Graph Theory begins with solution to the "Bridges of Königsberg" question in 1735.





Question: Can one walk across all seven bridges and never cross the same one twice?

Euler diagram: land areas by letters(vertices), bridges between land represented as edges.

Simple observation: if there is a path crossing all bridges, but never the same bridge twice, then nodes with odd number of links must be either the starting or the end point of this path

The birth of social network analysis

Moreno in 1930's, in his 1934 book "Who Shall Survive", describes the First Social Network depicting friendship patterns between the boys (triangles) and girls (circles) in a class of schoolchildren in the 1930s.

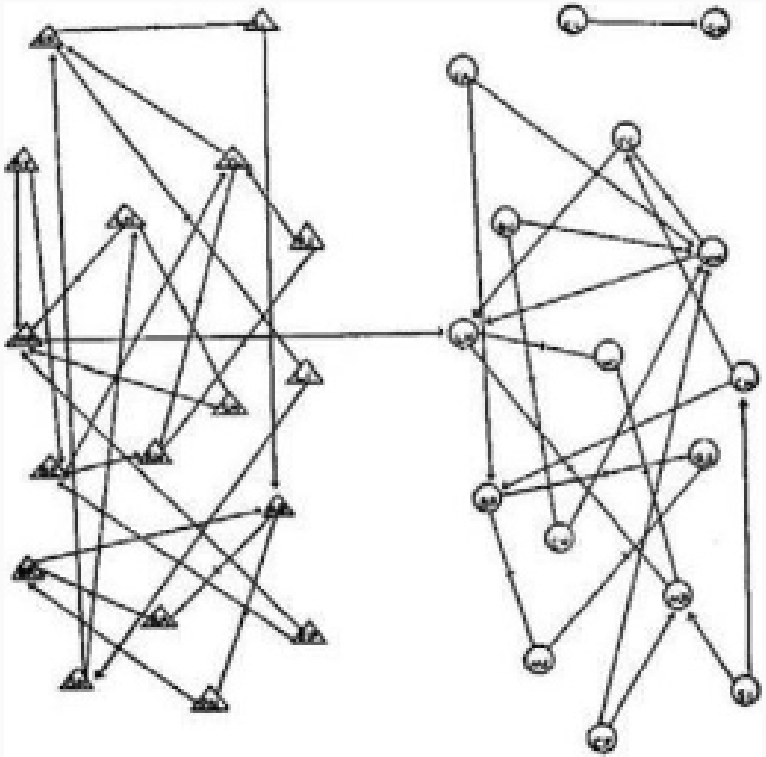


Diagram was hand-drawn and is called a Sociogram - a new model for human interactions

In Contrast: Modern Social Networks

Modern Social Networks

- Many possible definitions of an edge!
  - friends (sociology)
  - professional relationships (mobility, influence)
  - romantic relationships (psychology, sociology)
  - exchange of goods or money (economics)
  - communication (internet, neuroscience)
  - virus and diseases (biology, health)
- Applications
  - Power grid networks
  - Transportation (air, subway, road systems)
  - Migration networks
  - Textual networks
  - Citation networks
  - Recommendation networks
- can be used to understand a wide array social and economic dynamics

To summarise

- Network science has a long history (1735!)
- Inherently interdisciplinary! (biology, physics, mathematics, sociology, statistics, economics, psychology. . .)
- Modern Network Analysis provides a framework to extract information from a relational system.
- Tools borrow from
  - Graph Theory for mathematical framework
  - Computer Science for software algorithms for large networks
  - Statistics for framework for modeling
  - Computational Statistics for analysis, prediction, inference

2. Basics of Networks

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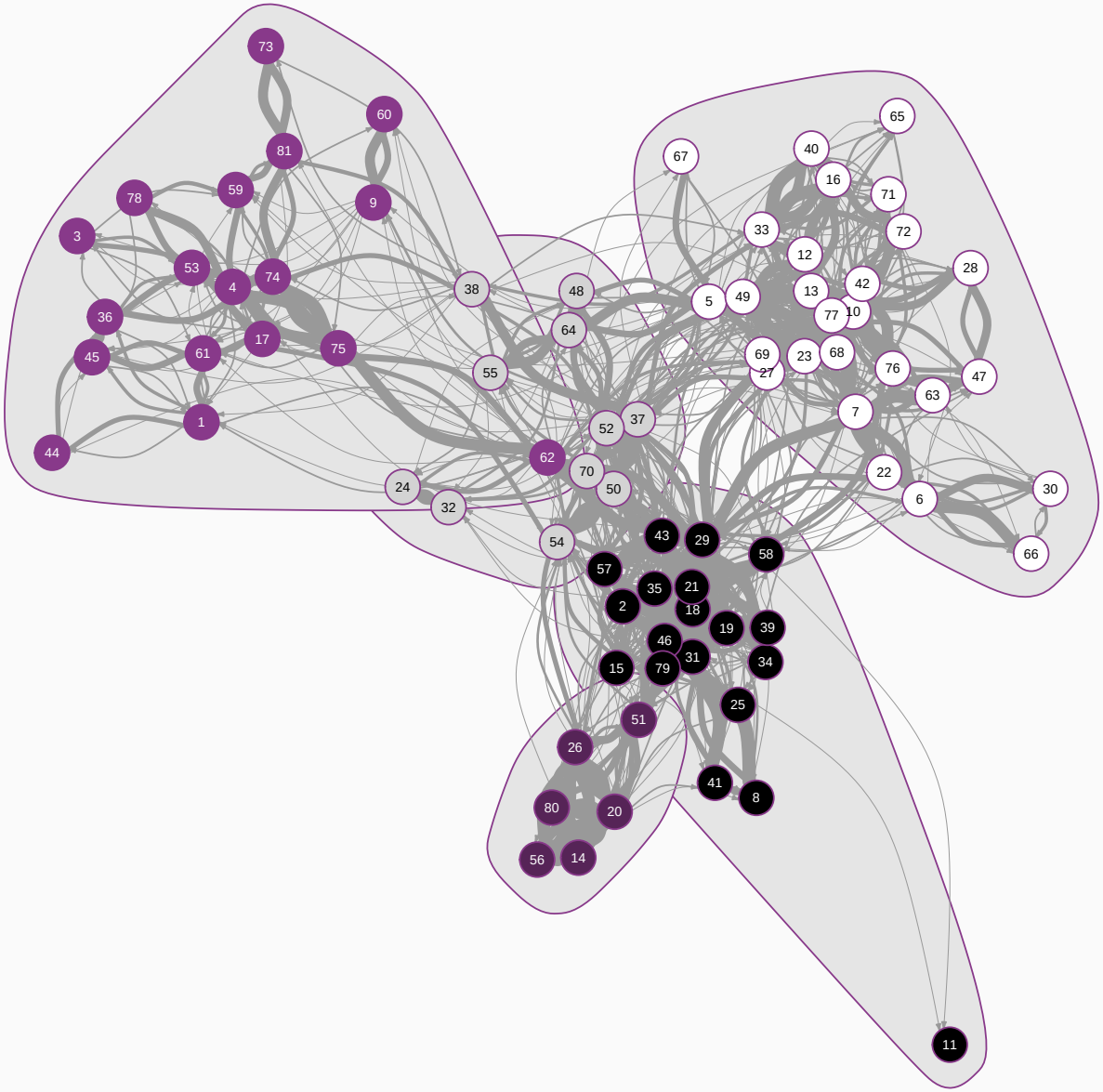
UKFaculty network



The personal friendship network of a faculty from four UK universities.

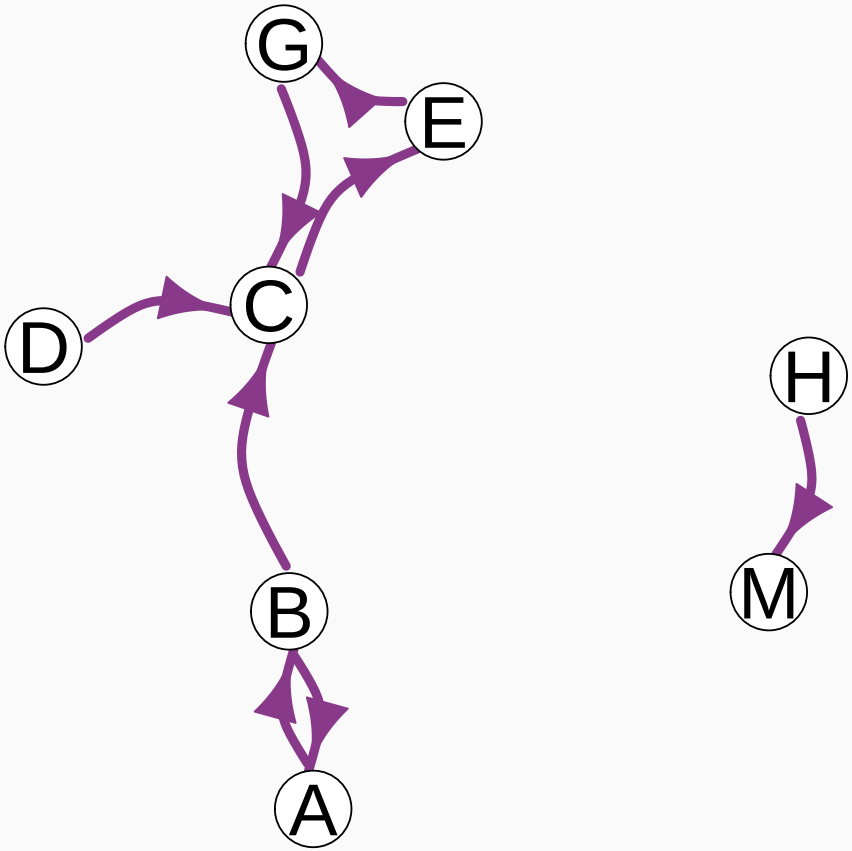
Basic Network Elements

Basic Network Elements

- Vertices (nodes, actors)
- Edges (links, ties)

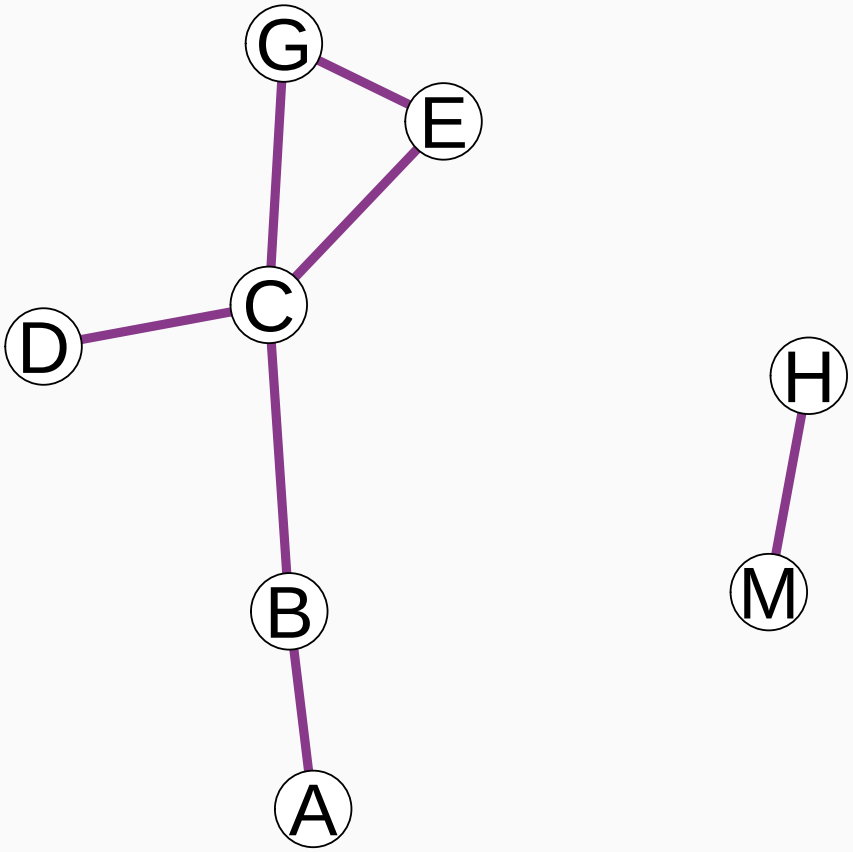
Basic Network Elements: Direction

- Directed



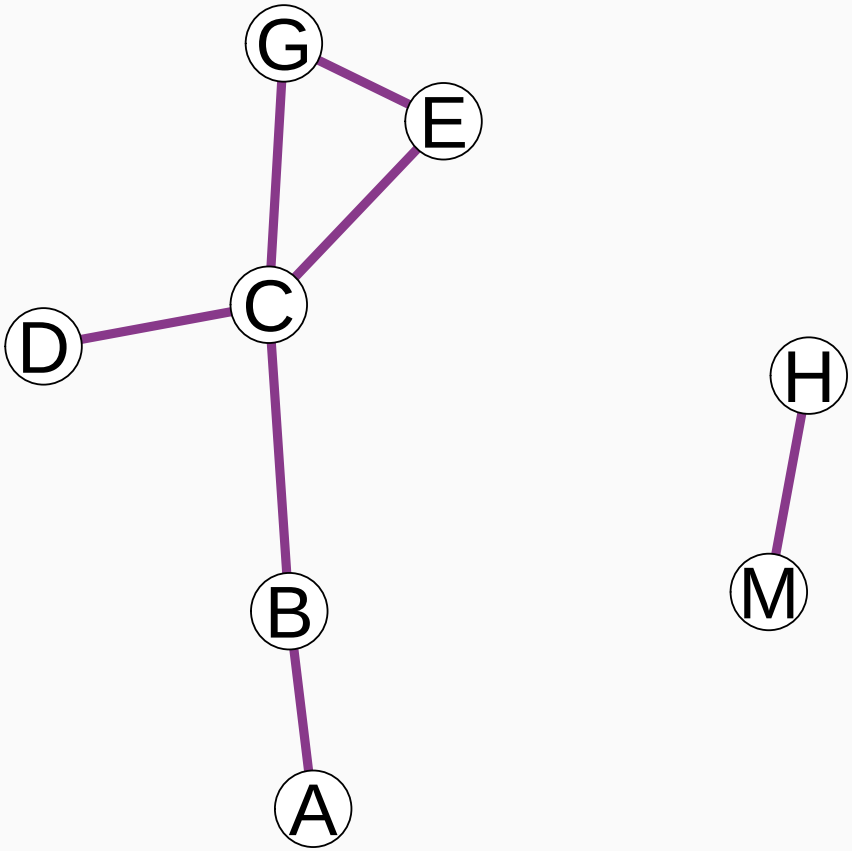
Basic Network Elements: Direction

- Undirected



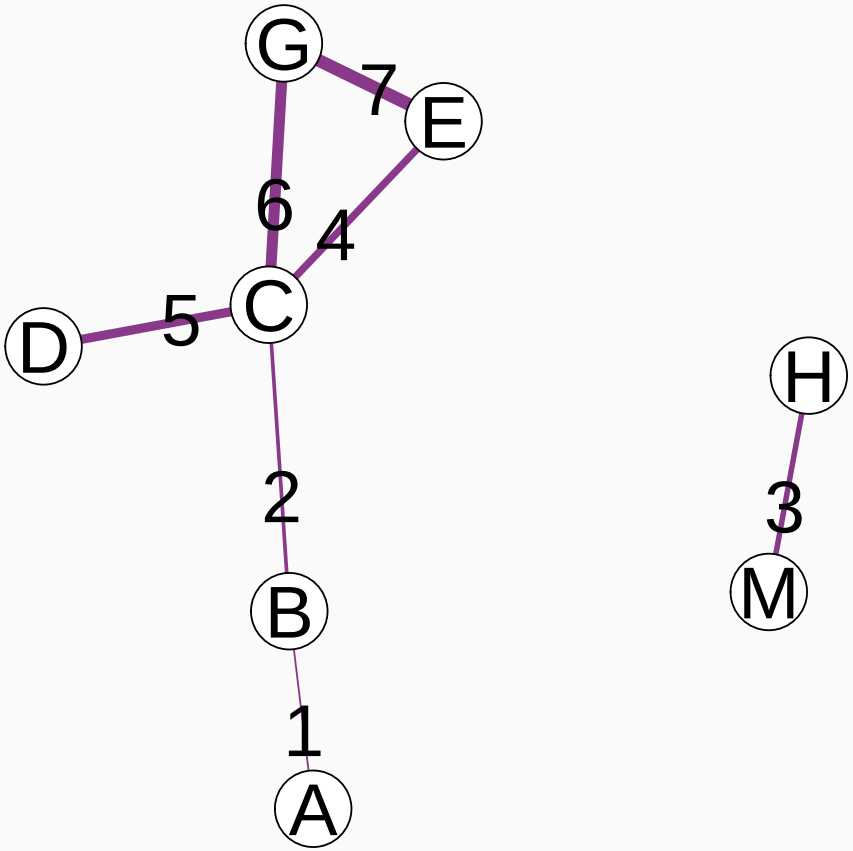
Basic Network Elements: Weights

- Unweighted



Basic Network Elements: Weights

- Weighted



WA: Let's explore our network!

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Before we start

Make sure you have installed the following packages:

```
# for network analysis
install.packages("igraph")

# for accessing the data
install.packages("igraphdata")
```

Work Along to explore the UKFaculty dataset

`2_WA_IntroSNA.Rmd`

Your turn!

- Explore the karate network
- How many nodes does the network have?
- Is the network directed or undirected?
- What vertex and edge attributes does the network have?
- Does the graph have multiple edges per pair of nodes or any loops?

Solutions

```
data(karate)
karate
```

```
## This graph was created by an old(er) igraph version.
##   Call upgrade_graph() on it to use with the current igraph version
##   For now we convert it on the fly...
```

```
## IGRAPH 4b458a1 UNW- 34 78 -- Zachary's karate club network
## + attr: name (g/c), Citation (g/c), Author (g/c), Faction (v/n), name
## | (v/c), label (v/c), color (v/n), weight (e/n)
## + edges from 4b458a1 (vertex names):
##  [1] Mr Hi  --Actor 2  Mr Hi  --Actor 3  Mr Hi  --Actor 4  Mr Hi  --Actor 5
##  [5] Mr Hi  --Actor 6  Mr Hi  --Actor 7  Mr Hi  --Actor 8  Mr Hi  --Actor 9
##  [9] Mr Hi  --Actor 11 Mr Hi  --Actor 12 Mr Hi  --Actor 13 Mr Hi  --Actor 14
## [13] Mr Hi  --Actor 18 Mr Hi  --Actor 20 Mr Hi  --Actor 22 Mr Hi  --Actor 32
## [17] Actor 2--Actor 3  Actor 2--Actor 4  Actor 2--Actor 8  Actor 2--Actor 14
## [21] Actor 2--Actor 18 Actor 2--Actor 20 Actor 2--Actor 22 Actor 2--Actor 31
## [25] Actor 3--Actor 4  Actor 3--Actor 8  Actor 3--Actor 9  Actor 3--Actor 10
## + ... omitted several edges
```

```
is.simple(karate)
```

```
## [1] TRUE
```

Closer inspection

Closer inspection

Your turn! Take a closer look at the Karate network

Replace every [xxx] in the code to answer each question.

- How many factions does the karate network have?
- How many nodes belong to each faction?
- Which nodes nominated Mr Hi?
- Which nodes nominated John A?
- How many nodes nominated both Mr Hi and John A?
- Is there an edge between Mr Hi and John A?

Solutions

Factions

```
table(V(karate)$Faction)
```

```
##
##  1  2
## 16 18
```

Nodes that nominated Mr Hi

```
neighbors(karate, "Mr Hi", mode = "in")
```

```
## + 16/34 vertices, named, from 4b458a1:
##  [1] Actor 2  Actor 3  Actor 4  Actor 5  Actor 6  Actor
##  [9] Actor 11 Actor 12 Actor 13 Actor 14 Actor 18 Actor
```

Solutions

Nodes that nominated John A

```
neighbors(karate, "John A", mode = "in")
```

```
## + 17/34 vertices, named, from 4b458a1:
##  [1] Actor 9  Actor 10 Actor 14 Actor 15 Actor 16 Actor
##  [9] Actor 23 Actor 24 Actor 27 Actor 28 Actor 29 Actor
## [17] Actor 33
```

How many nodes nominated both Mr Hi and John A?

```
mh <- neighbors(karate, "Mr Hi", mode = "in")
ja <- neighbors(karate, "John A", mode = "in")
sum(mh %in% ja)
```

```
## [1] 4
```

Summary:

Today we looked at

1. Introduction and Origins of Network Analysis
2. Basic Elements of Networks
3. Explored the basic elements in `UKFaculty` and `karate` networks availabe in `igraphdata` package

Next session:

3. Visualization of networks
4. Metrics - Individual nodes