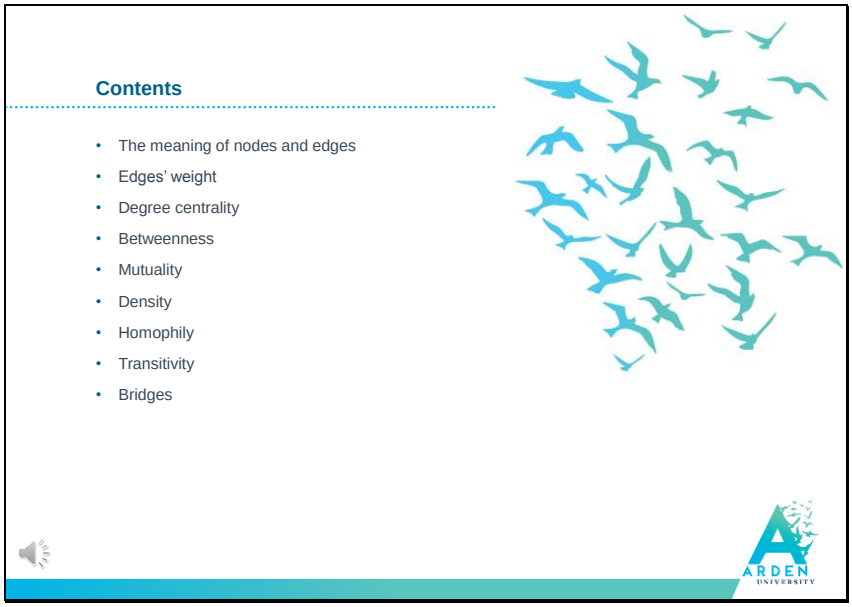
Slide 1


A network is a data structure. It is no more than just a collection of nodes and another collection of edges, connecting some of these nodes.
However, many business and social questions can use network analysis to describe and even predict many variables.
This is because many of those questions require modeling the data as a set of entities (e.g., people, computers, companies, films) and the relationships between them (e.g., friendships, organizational relations, mergers, references etc.).

Slide 2




In this presentation, we will discuss the main concepts of network analysis.

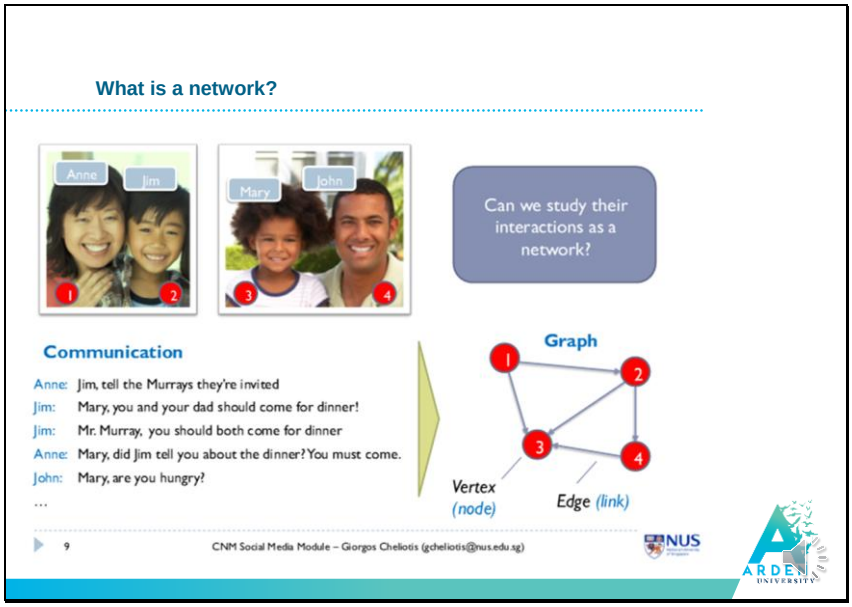
Slide 3


The book "*Networked: The new social operating system" by* Rainie and Wellman begins with a story about the Jhonson-Lenz couple:

In December 2007, Trudy Jhonson-Lenz had an accident. She slipped, fell and knocked her head.
On her hospital bedside, Peter used his mobile phone to snap a few digital pictures of her injuries and emailed the pictures along with a description of the accident to some friends. Friends forwarded it to their friends, some whom Peter and Trudy have never even personally met.
In 36 hours, 150 emails were sent and more text messages arrived at Peter's mobile.
People used blogs, forums, online delivery services and text messages to help the couple with logistics, food, social work services, house safety, support, money, nutrition, household chores and more.
Their situation was too complicated for a couple to deal with, but not too complicated for an entire network.
This support network originated from these two people, each having some relationships (through work, family, interest-based communities etc), each of them having their own relationships and so it goes: a complex network was created virtually around one specific cause.

As the couple later reflected on the power of social networks: "We are truly wealthy in our network" (Rainie, L. and Wellman, 2012).

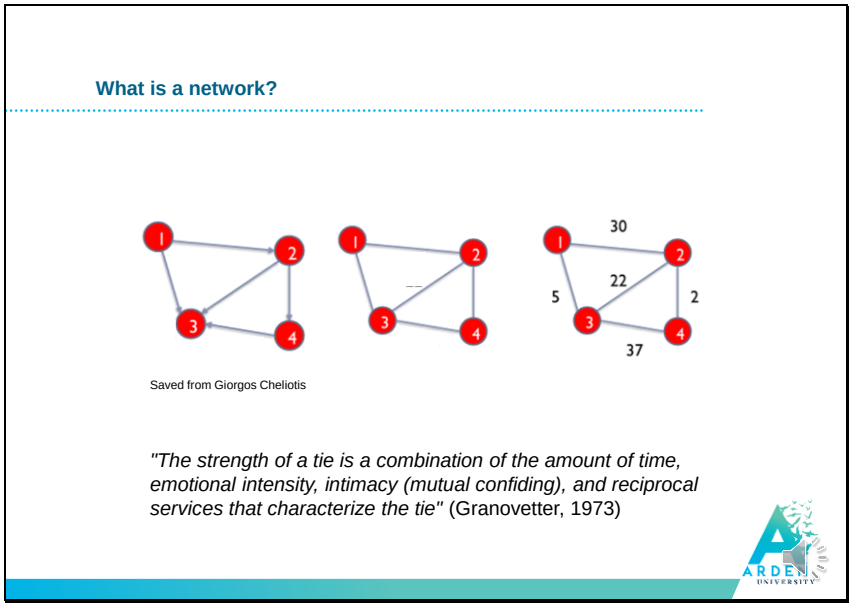
Slide 4




For an example, let's try to model a conversation as a network.
Each person of the four people in the slide is represented as a node (or vertex) in the graph on the right side of the slide (Anne will be denoted as 1, Jim as 2, Mary as 3 and John as 4).
Each (spoken or written) interaction between two people is denoted as an edge stretched between the person speaking (who is the source of the edge) and the person spoken to (who is the target of the edge).
This is an example of a social network. Can you imagine now how the network of the Jhonson-Lenz story has evolved?

We could use the same structuring to model other, non-social situations, such as hyperlinks between websites, contagious diseases, or acquisition of companies.

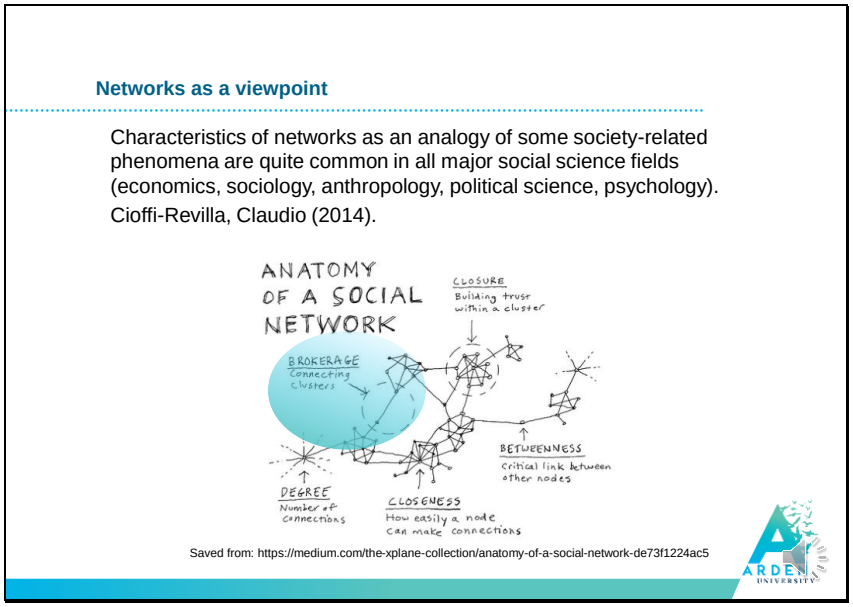
Slide 5




Let's consider the edges of the network.
The conversation graph we just used is shown here on the left. This is an example of a directed network: as you can see, each edge is pointed to some direction.
We use directed networks where there is significance to the direction of a relationship. For example: 'speaking' is a directional relation, since if X speaks to Y, it does not necessarily mean that Y speaks to X.
However, if the edge designates two people sharing a room, there is no meaning of saying that X shares a room with Y but Y does not share the room with X.
Thus, 'Sharing a room' is an un-directional relation as can be seen in the middle network on the slide. Another example is Facebook friendships. Two people can only be friends if both sides agree, thus designating an un-directional relation (edge in the network graph).

Both the left and middle networks are un-weighted networks.
However, the network on the right side has a weight (or any other property) assigned to each edge.
What is transferred in the network? Information? Trends, gossip, recommendations, diseases, emotions?
Weights could designate the intensity of an interaction: e.g., a number of items exchanged between two nodes, the frequency of interactions between them, individual perception of the strength of the relationship etc.

Slide 6

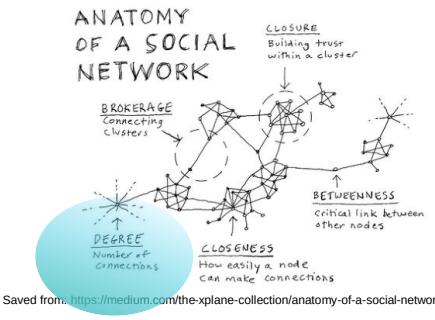



Why are networks so important?
Networks can explain dating, employment, innovation and more.
Since so many phenomenon can be modelled as networks, tools for analyzing networks are so often used.
As an example, you can see in the image here, how we can spot the brokers (connecting between clusters).
Brokers can designate, for example, relations or people which are very important since they are the only ones maintaining a connection between two departments/organisations/political parties.

Slide 7

## Networks as a viewpoint

Characteristics of networks as an analogy of some society-related phenomena are quite common in all major social science fields (economics, sociology, anthropology, political science, psychology). Cioffi-Revilla, Claudio (2014).

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Or the degree of a node, which emphasizes the number of edges connecting to a node. The degree can be a very good measure of the importance of a node for example.

Slide 8

## Networks as a viewpoint

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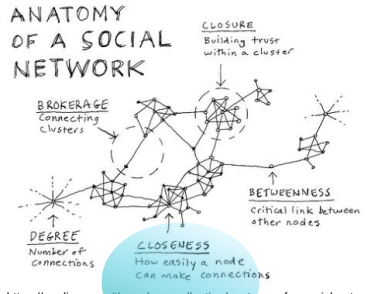


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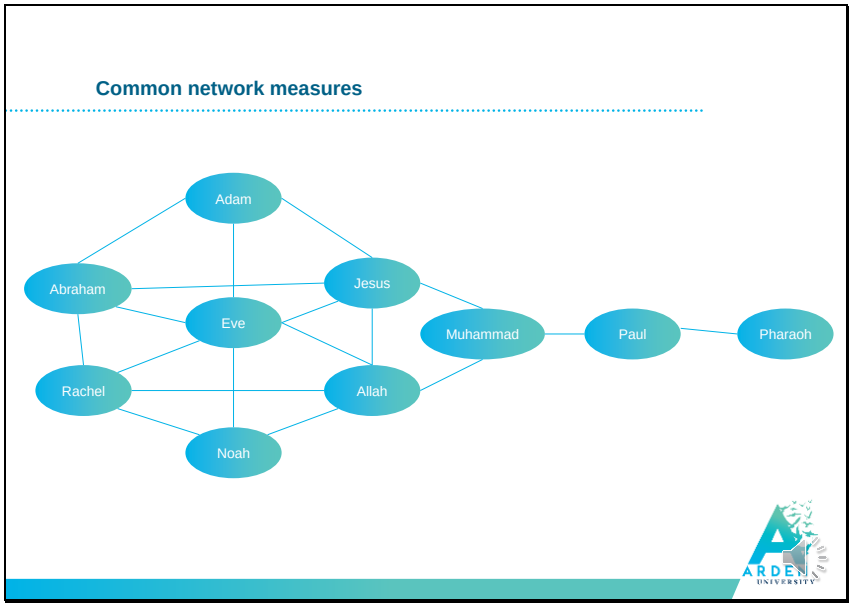
Or for example, closeness which emphasizes how easily a node can make connections with other nodes.

Slide 9

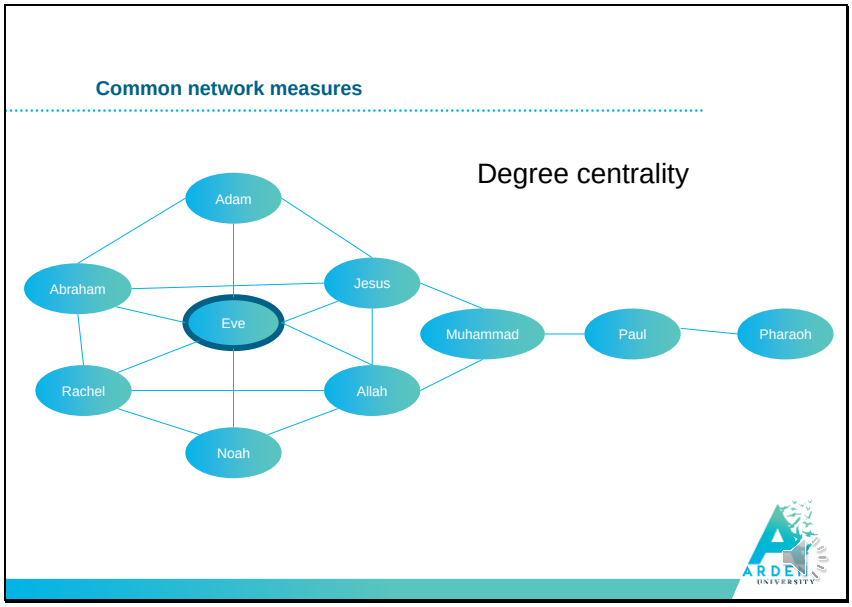

So we know how networks look like and how common they are.
Let’s have a quick look at some of the common quantitative measures we can extract from networks, and what we could use these for.

Slide 10



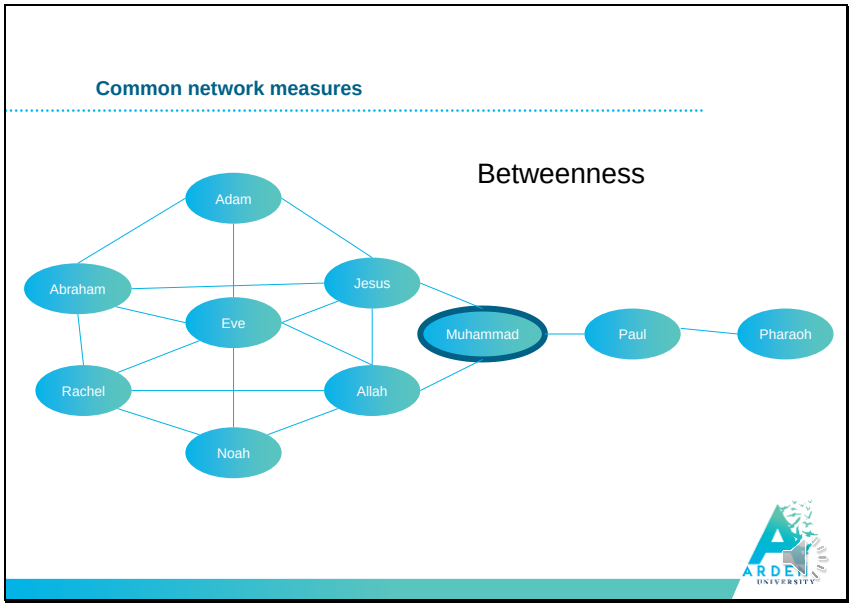

Say our HR department is after identifying key players in our organisation. For that, we have asked all employees to map their colleagues they are regularly collaborating with.
We then took these data and mapped it as a network, as shown in the figure here. What can we learn about our organisational structure?

Slide 11



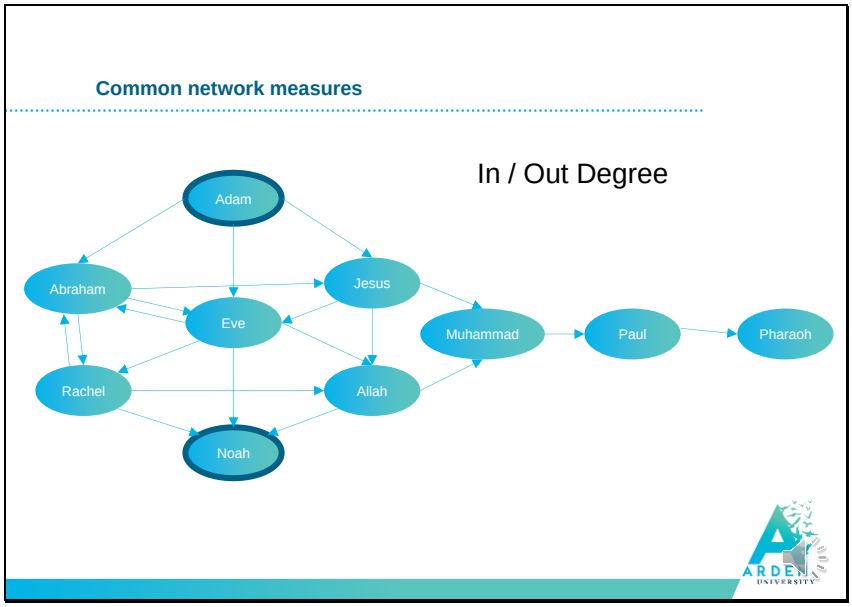

According to degree centrality, Eve is the most central employee, since she has the highest set of connections. Thus, we can identify Eve as very important to the information flow in our organisation.

Slide 12



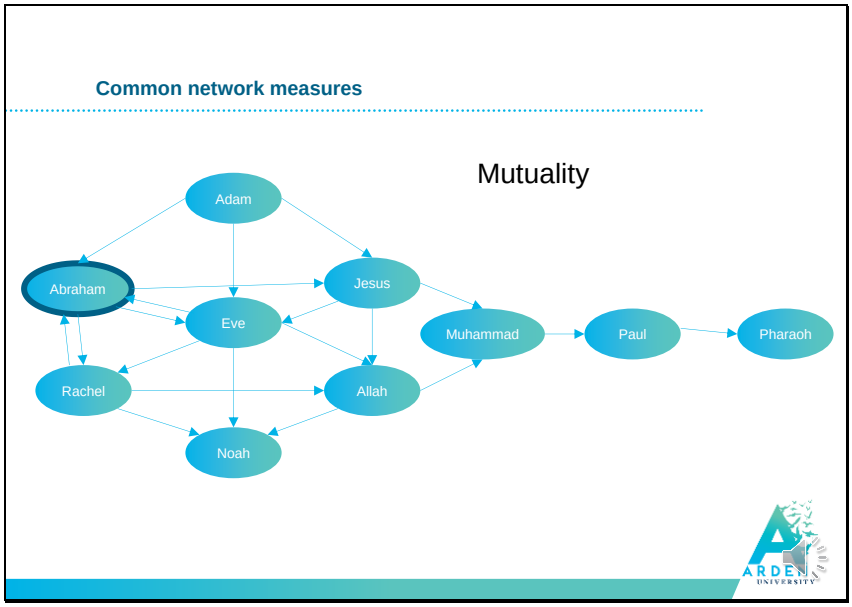

But if we look at the measure of Betweenness centrality, Muhammad is a more critical employee. Unlike Eve, if we take out Muhammad, we break the network to two unconnected components.
Betweenness centrality quantifies the number of times a node acts as a bridge along the shortest path between two other nodes, so if we look at the paths from Pharaoh and Paul to the rest of the network, we see Muhammad is a key figure, although he has a number of connections lower than Eve.

Slide 13



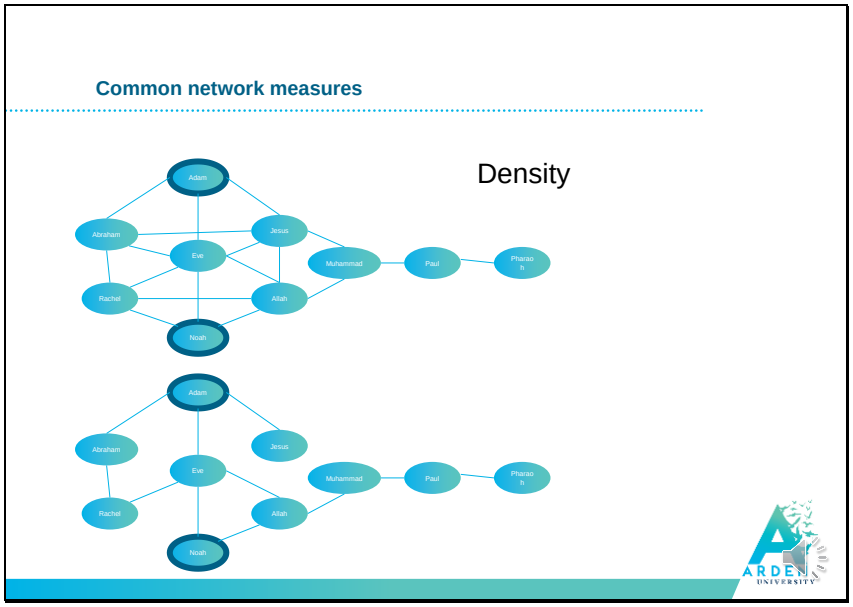

We may want to turn our network into a directed network, since we wish for an example to map for each connection who initiates the relationship.
If we compare Adam and Noah: both have the same degree centrality of 3, since they both have three relations.
However, the picture changes when we introduce the notion of In and Out degree: In-degree is the number of relations going into a node. Hence the node is their target.
Out-degree is the number of relations going out of a node. Hence the node is their source.
Now it is clear that Adam and Noah's position in the organization is completely different: while Adam is apparently a typical initiator (with an out-degree of 3), for some reason, no one has initiated a relationship with him (i.e., his in-degree is 0).
Noah, on the other hand, is kind of passive in terms of initiating collaboration, but his in-degree is 3, which means, people tend to want to collaborate with him.

Slide 14



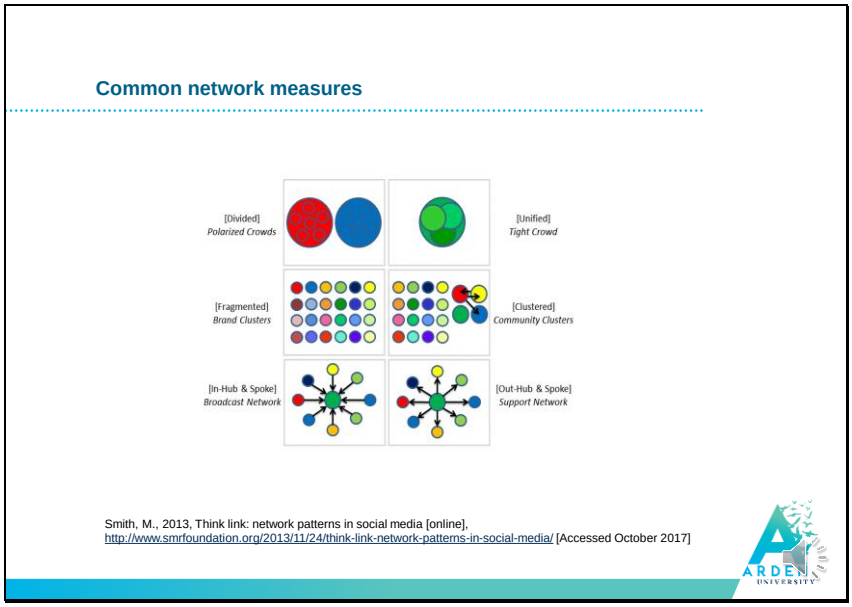

Abraham also has the out-degree of 3, but two of his connections are mutual. Mutuality helps estimate the level of reciprocation in the organisational environment.

Slide 15




The upper network is our known collaboration network.
Now we add another network, at the bottom of the slide, showing social connections between employees.
It is evident that the social network is much more sparse than the collaboration network. This means that many of the professional relations are not based on social ones, and that the social network of our organisation is much weaker than the professional one.

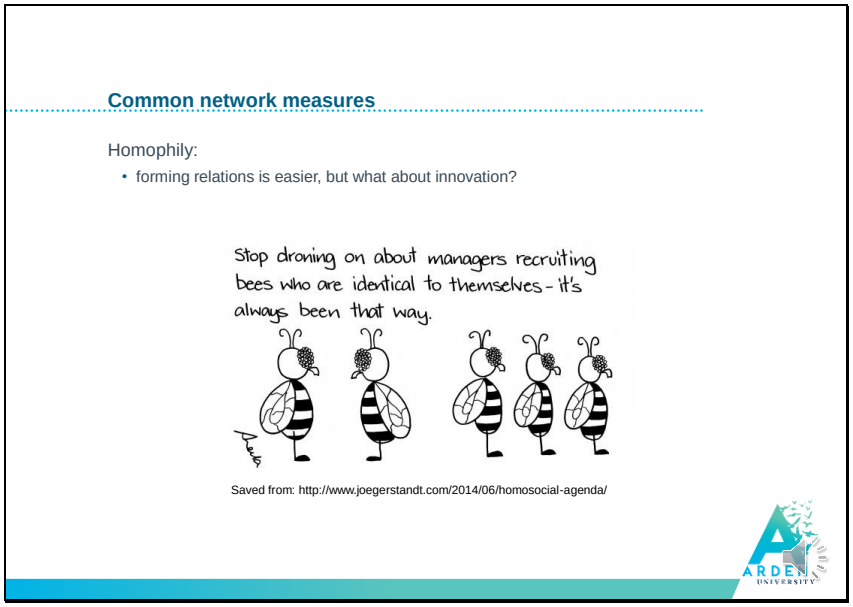
Slide 16




Social network researchers extract the measures we showed and others to understand the intimacy of connections, their strength and dynamics, the processes of information transmission in networks, who are the key players etc.
Mark Smith has shown six types of networks that can teach us about social structures and interactions:

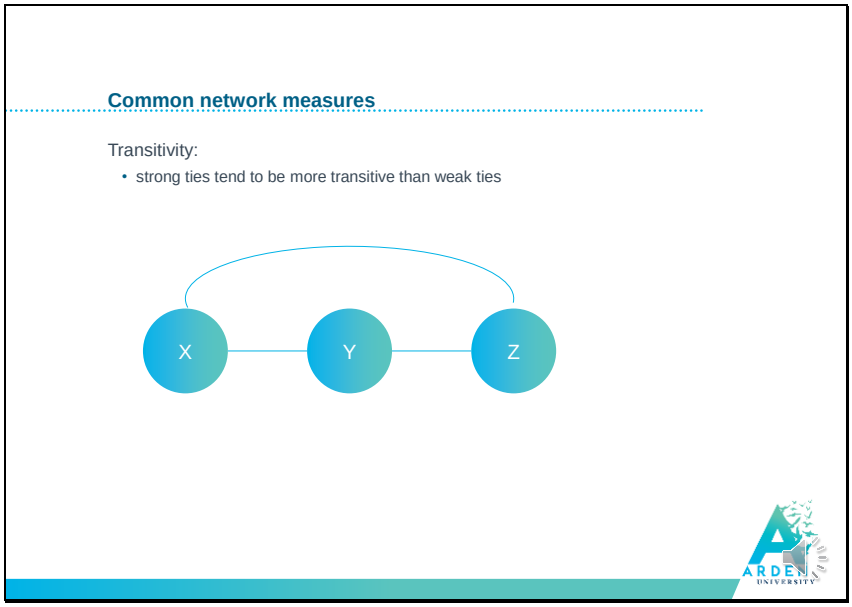
Divided networks are created when two groups discuss for example some controversial topic, and no one reaches out to the other group.
Clusters for example, can help us identify inherently grown "communities" within networks.
Broadcast networks are created when a prominent leader is widely followed by many others. This is how we spot political leaders or organisational experts.
And the reverse form is the support network, which resembles the story of the Jhonson-Lenz couple.

Slide 17



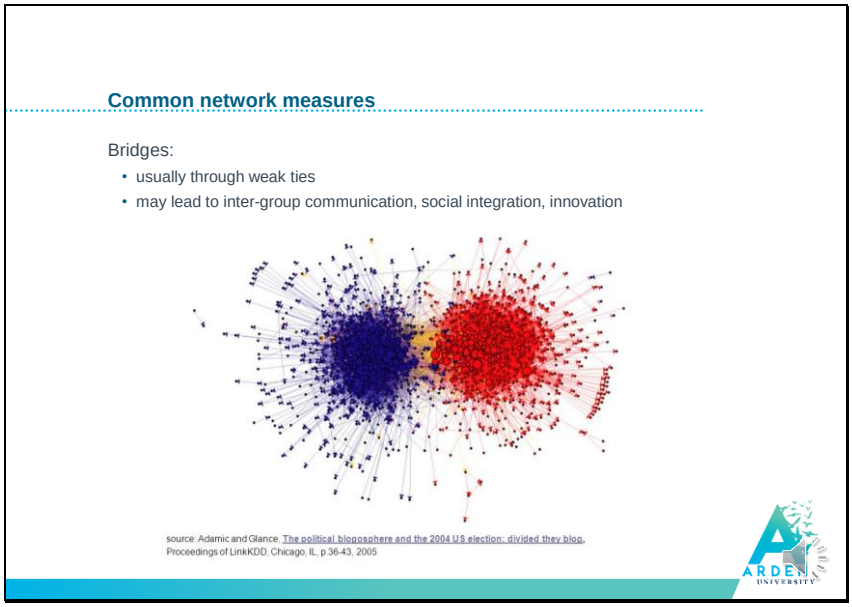

Other characteristics of networks that are commonly used:
Homophily is the tendency to relate to people with similar characters as we have. Often, homophily leads to the formations of clusters of 'similar people'.

Slide 18



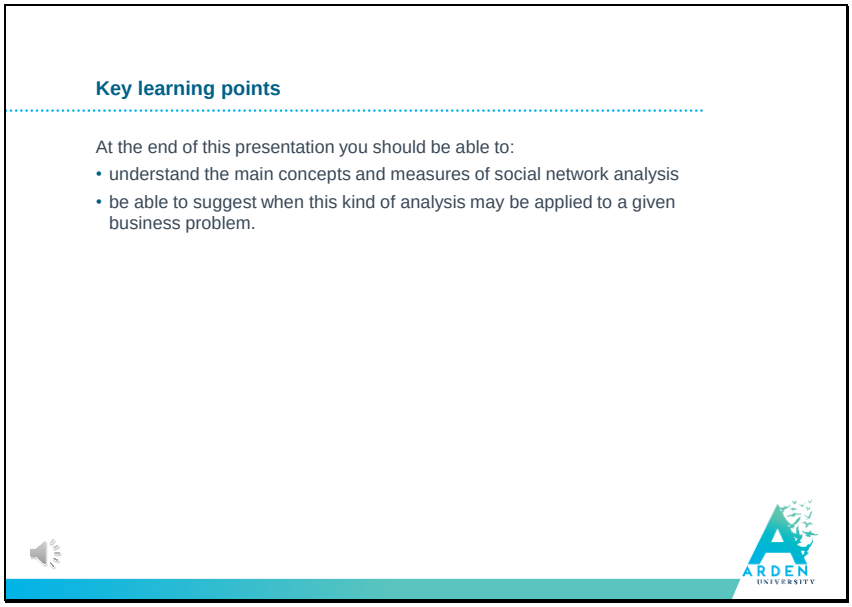

Transitivity is a property of a relation: if X is related to Y and Y is related to Z, then X and Z are also related.
For example, if the relation designates being family members, then if X and Y are family members, and so do Y and Z, it also means that X and Z are family members.

Slide 19




Finally, Bridges are those nodes that inter-connect between groups otherwise disconnected. For example, this analysis of the political blogosphere from 2005 shows much polarization between liberals (in blue) and conservatives (red) blogs, while having just a few bridges in between.

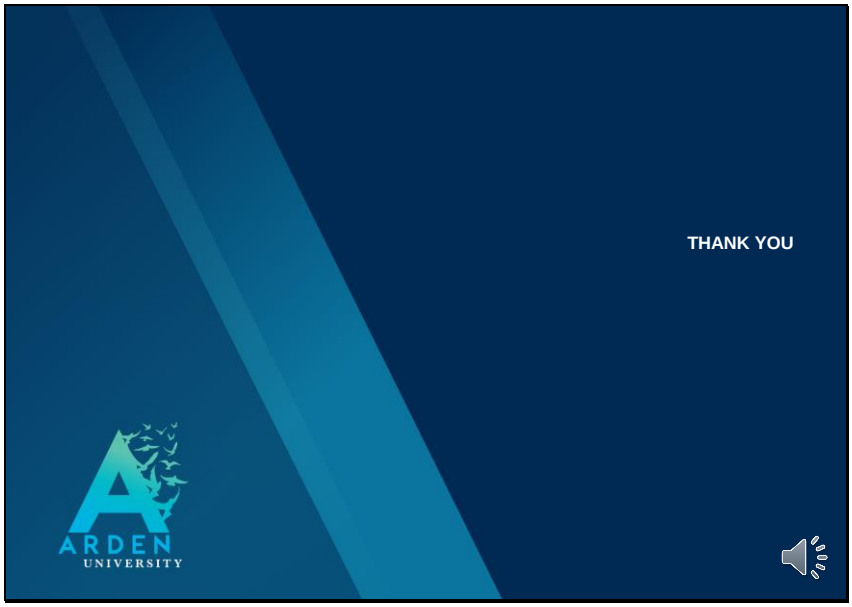
Slide 20




At the end of this presentation you should be able to:

- understand the main concepts and measures used in social network analysis
- be able to suggest when this kind of analysis may be applied to a given business problem.

Slide 21




Thank you for listening.