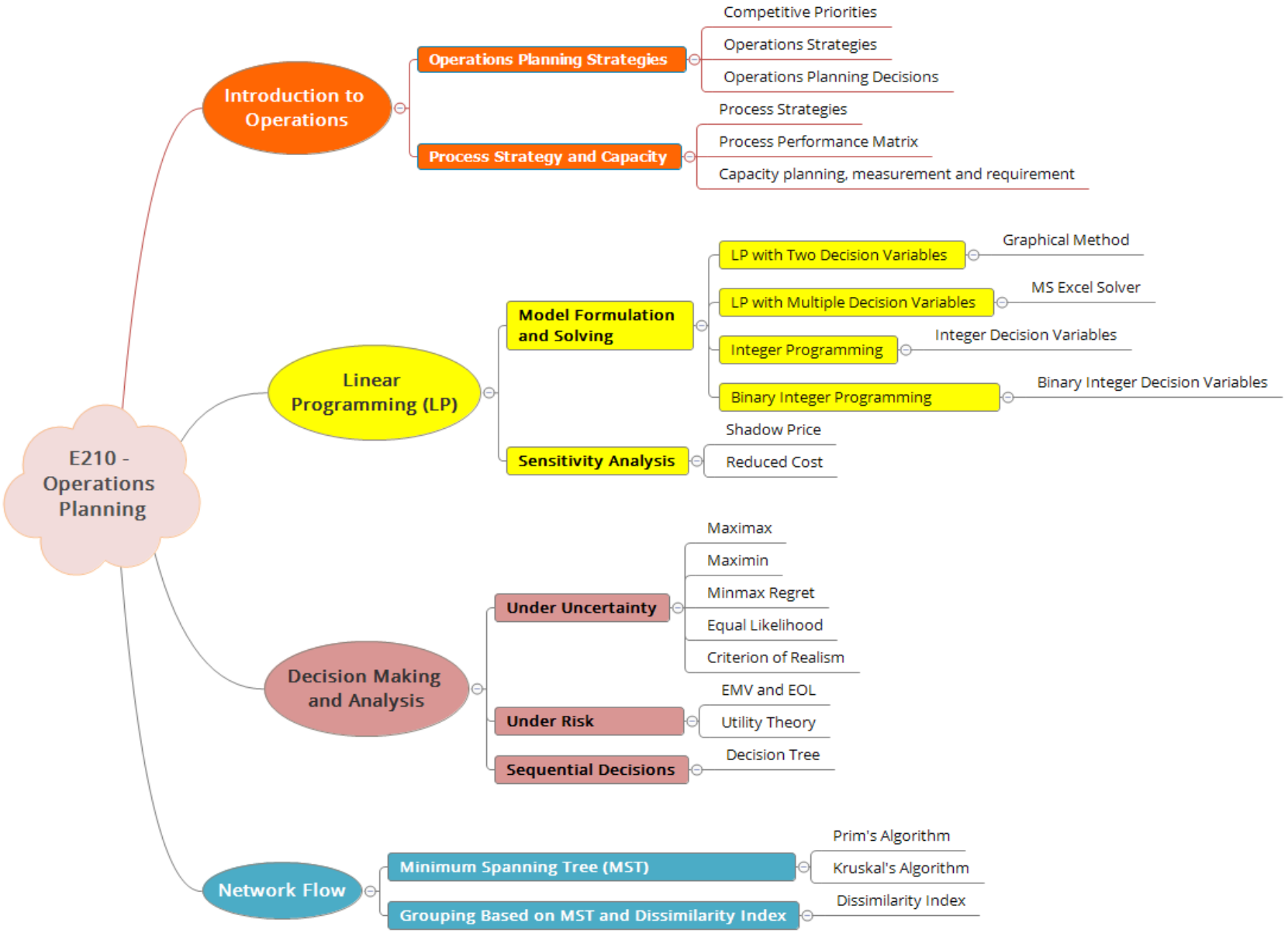
Problem 13

Team Bonding

E210 – Operations Planning

SCHOOL OF ENGINEERING

E210 Operations Planning Topic Tree



Purpose of Grouping

- An approach in which people or objects are grouped together based on similar attributes or traits.

- For people, attributes like age and interests can be used as grouping criteria. For objects, it can be functionalities, size, weight, etc. depending on the purpose

- The objective of grouping is to exploit the similarity between entities to be grouped. Applications include:

  - Placement of machines with similar processes or processing parts.
  - Image processing (e.g. segregation of specific colours)
  - Transmission tracing (e.g. transmission of disease, gene mutation)
  - Social network – formation of communities within larger groups
  - Marketing – consumer segregation and targeted marketing

How to Group?

- How to group people/objects into specific groups so that differences in attributes can be minimized?

1. Use a measure (such as dissimilarity index) to determine the degree of ‘likeness’ among the entities.

2. Construct a minimum spanning tree to connect the entities based on their dissimilarity index.

3. Group the entities of the minimum spanning tree. Examples of grouping criteria are minimization of total dissimilarity, number of groups, balanced number of people (objects) within groups or some other attributes.

Dissimilarity Index

- A measure of dissimilarity, d_{ij} between the entity *i* and *j* can be expressed as:

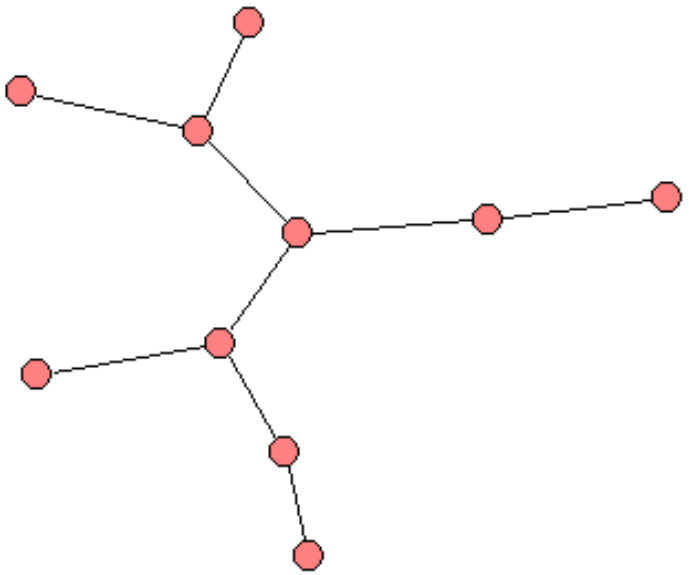
$$d_{ij} = 1 - \frac{n_{ij}}{n_{ij} + m_{ij}}$$

n_{ij} is the number of common attributes between entities *i* and *j*

m_{ij} is the number of attributes of either entity *i* or entity *j* only

- In network representation
  - Dissimilarity measure d_{ij} - **Arcs**
  - Entities (objects or people) - **Nodes**

Recall: Minimum Spanning Tree Model



- Spanning tree – a connected network with **no loops allowed**
- Minimum spanning tree – nodes are connected such that the length of the arcs is **minimized**
- If arcs are the dissimilarity measures, the minimum spanning tree provides a way to connect the entities such that the total dissimilarity is minimized.

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Team Bonding

Today's Problem – Objective and Grouping Criteria

- Objective
  - Determine the dissimilarity between each pair of staff by comparing their hobbies
  - Group staff to minimize the total dissimilarity index (so as to maximize their shared hobbies)
- Some possible criteria when forming groups:
  - Number of teams
  - Number of staff in each team
  - Gender distribution
  - Department distribution

Today's Problem – The Dissimilarity Matrix

	Hobby										
Staff	Arts	Collectibles	Food	Gardening	Movies	Pets	Photography	Reading	Shopping	Sports	Travelling
A			1			1		1			1
B		1				1	1		1		
C			1	1	1					1	
D	1								1	1	
E			1			1		1	1		
F			1		1			1			
G		1			1				1	1	
H			1			1					1
I	1			1				1		1	
J	1				1		1		1		1
K	1	1	1				1		1		
L			1	1						1	
M			1		1					1	
N		1						1	1		1
O				1			1	1			1
P	1			1	1		1		1		

Calculate Dissimilarity Index for each pair of staff

Staff	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
A	-	0.857	0.857	1.000	0.400	0.600	1.000	0.250	0.857	0.875	0.875	0.833	0.833	0.667	0.667	1.000
B	-	-	1.000	0.833	0.667	1.000	0.667	0.833	1.000	0.714	0.500	1.000	1.000	0.667	0.857	0.714
C	-	-	-	0.833	0.857	0.600	0.667	0.833	0.667	0.875	0.875	0.250	0.250	1.000	0.857	0.714
D	-	-	-	-	0.833	1.000	0.600	1.000	0.600	0.667	0.667	0.800	0.800	0.833	1.000	0.667
E	-	-	-	-	-	0.600	0.857	0.600	0.857	0.875	0.714	0.833	0.833	0.667	0.857	0.875
F	-	-	-	-	-	-	0.833	0.800	0.833	0.857	0.857	0.800	0.500	0.833	0.833	0.857
G	-	-	-	-	-	-	-	1.000	0.857	0.714	0.714	0.833	0.600	0.667	1.000	0.714
H	-	-	-	-	-	-	-	-	1.000	0.857	0.857	0.800	0.800	0.833	0.833	1.000
I	-	-	-	-	-	-	-	-	-	0.875	0.875	0.600	0.833	0.857	0.667	0.714
J	-	-	-	-	-	-	-	-	-	-	0.571	1.000	0.857	0.714	0.714	0.333
K	-	-	-	-	-	-	-	-	-	-	-	0.857	0.857	0.714	0.875	0.571
L	-	-	-	-	-	-	-	-	-	-	-	-	0.500	1.000	0.833	0.857
M	-	-	-	-	-	-	-	-	-	-	-	-	-	1.000	1.000	0.857
N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.667	0.875
O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.714
P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

The Dissimilarity Matrix (Calculation Example)

Construct a dissimilarity matrix first by calculating the dissimilarity index of each pair of staff *i* and *j*.

	Hobby										
Staff	Arts	Collectibles	Food	Gardening	Movies	Pets	Photography	Reading	Shopping	Sports	Travelling
A			1			1		1			1
B		1				1	1		1		
C			1	1	1					1	
D	1								1	1	
E			1			1		1	1		
F			1		1			1			

Example

Number of common hobbies between Brian and Esther = 2

Number of hobbies unique to Brian and Esther = 4

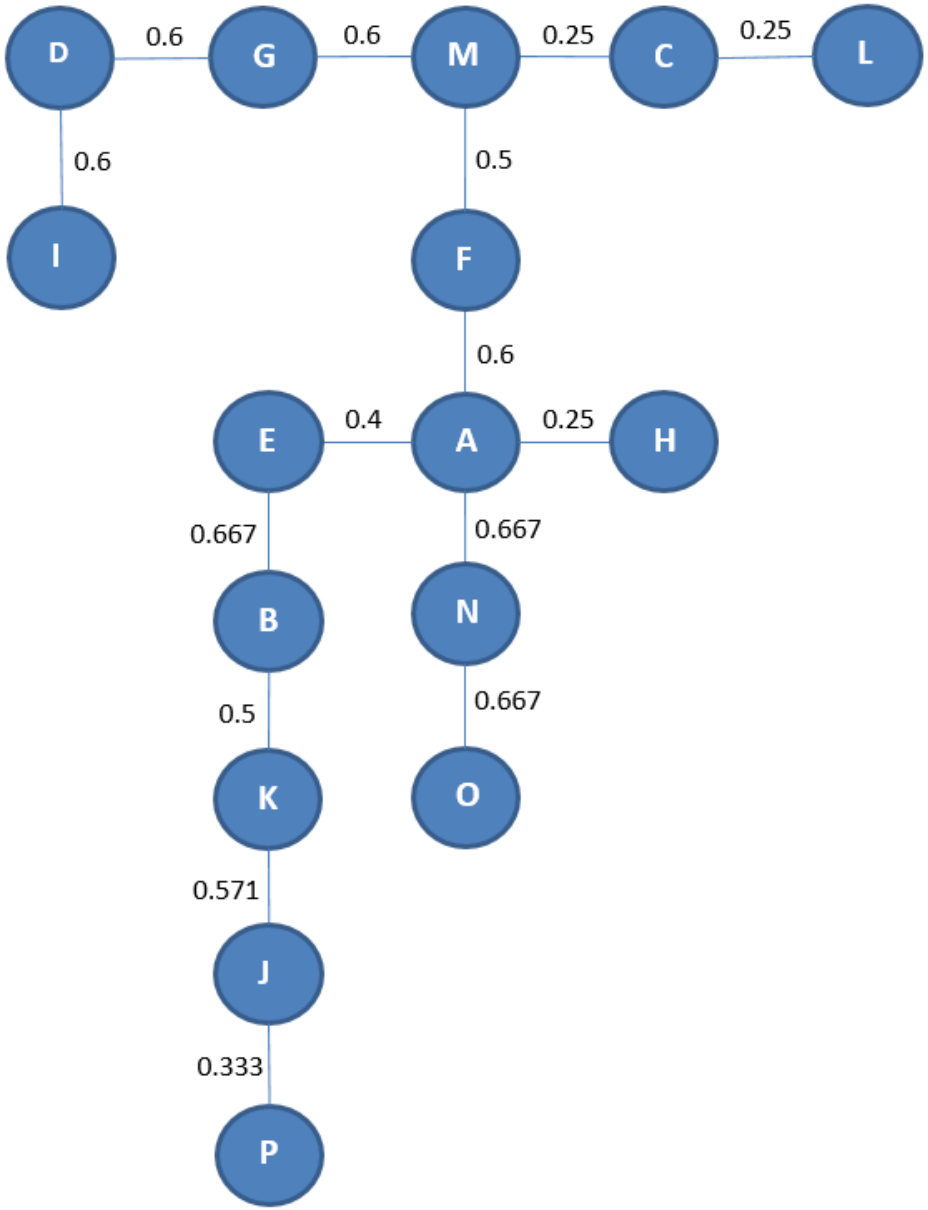
Dissimilarity Index between Brian and Esther:

= 1 – 2/(2+4)

= 0.667

Construct Minimum Spanning Tree (Prim's Algorithm)

- A minimum spanning tree based on Prim's Algorithm is shown on the right. (Start from node 1)
- Multiple optimal solutions exist due to non-unique arc values.
- Total Dissimilarity = 7.455



Question

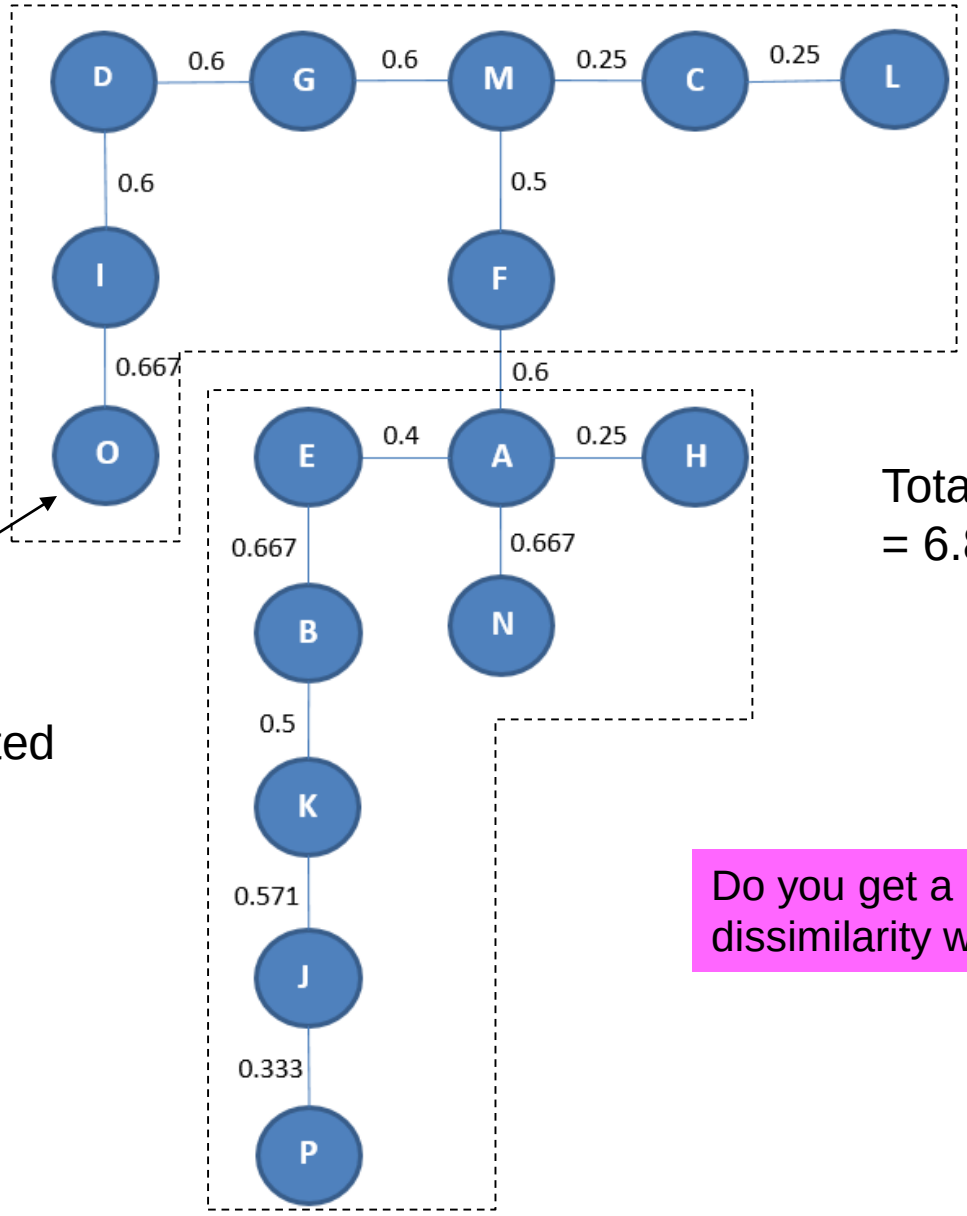
- Can you construct a Minimum Spanning Tree using Kruskal's algorithm?

- Will the optimal solution value (total dissimilarity) be the same for Kruskal's algorithm?

- Will the Minimum Spanning Tree be the same as the one constructed from Prim's algorithm? Why or why not?

Grouping Solutions

Grouping : 2 Teams of 8 Staff each

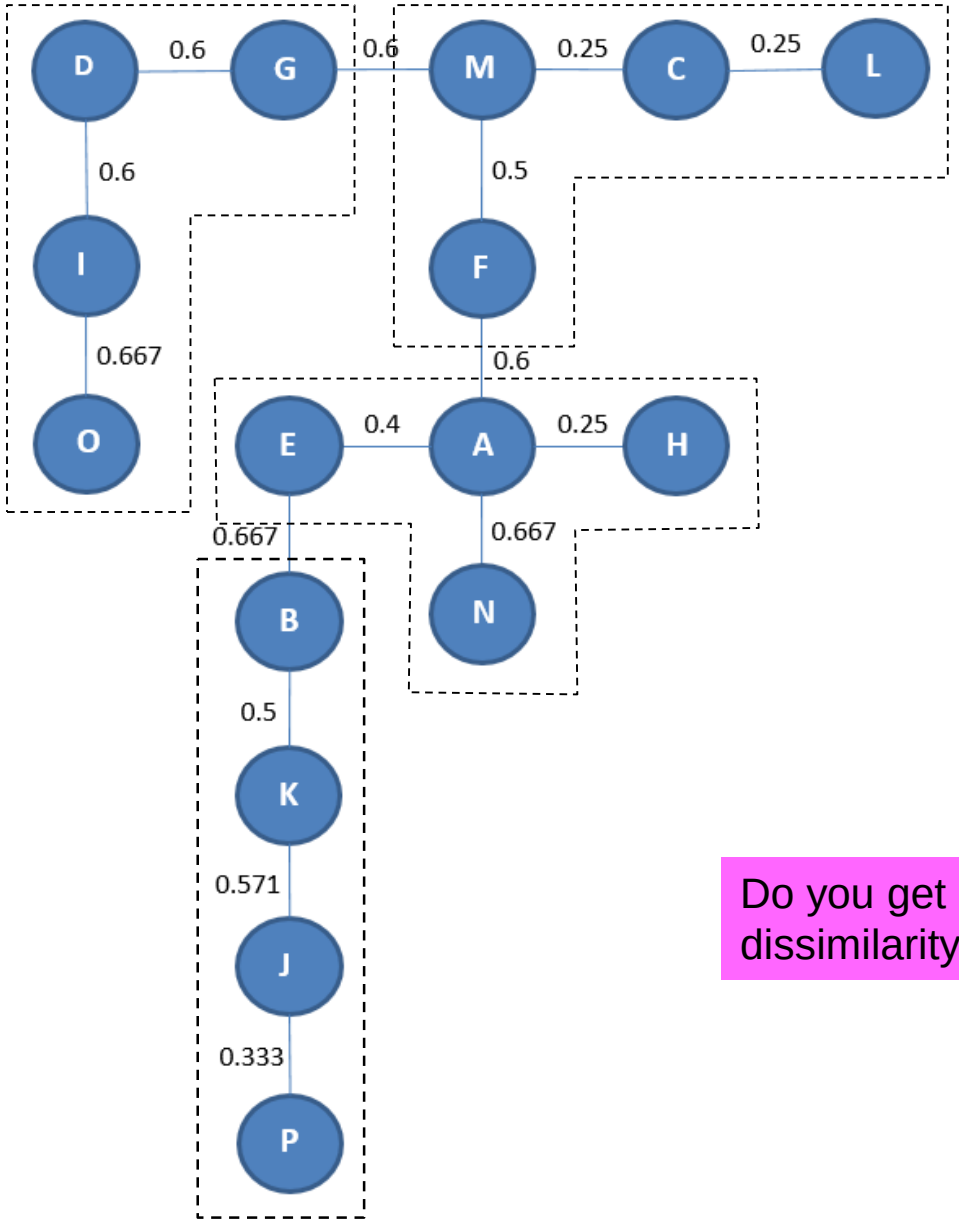


Note:
Node O is disconnected from Node N and connected to Node I

Total Dissimilarity = 6.855

Do you get a lower total dissimilarity with your groupings?

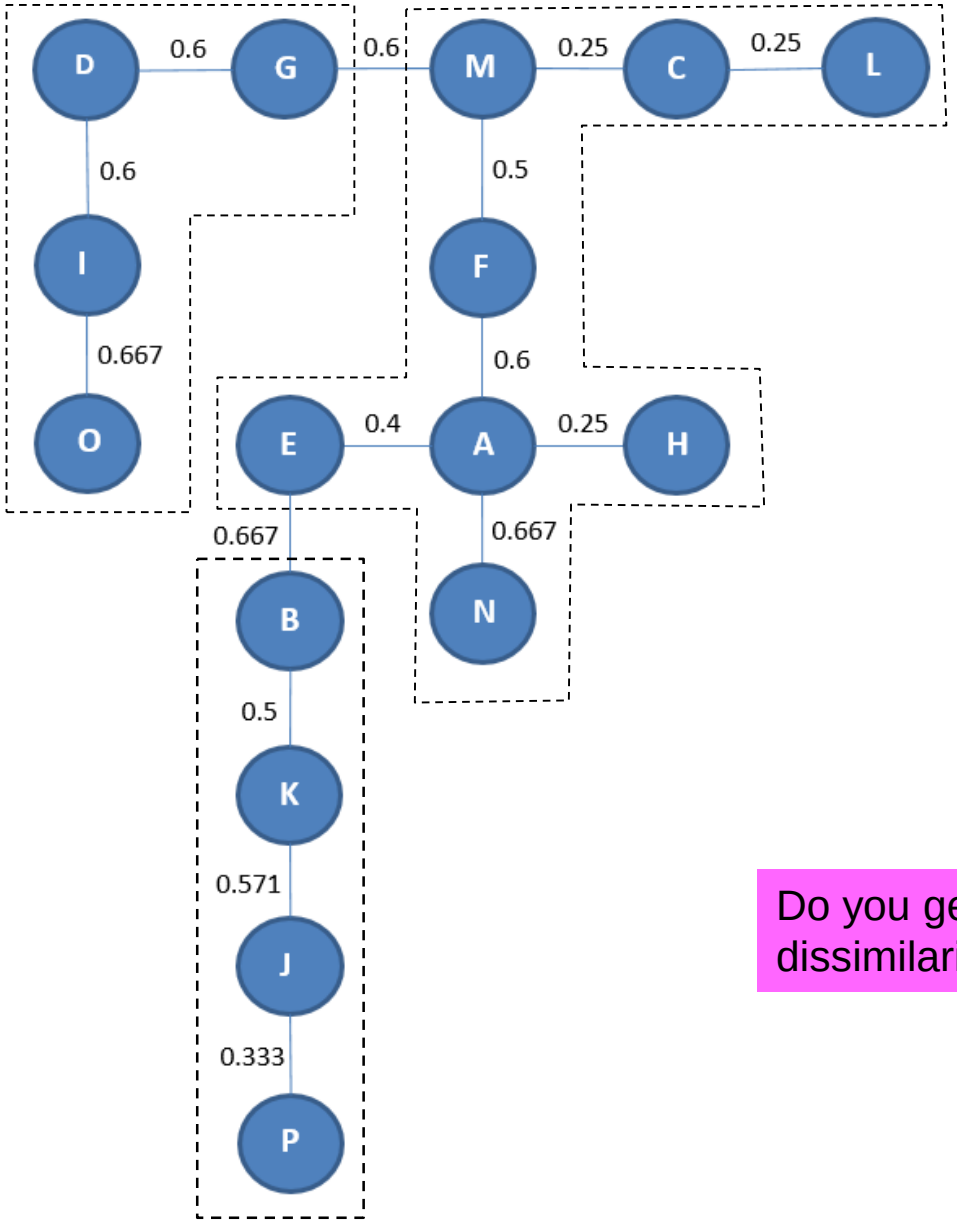
Grouping : 4 Teams of 4 Staff each



Total Dissimilarity = 5.588

Do you get a lower total dissimilarity with your groupings?

Grouping : 3 Teams (at least 4 staff, max 50% from same department)



Total Dissimilarity = 6.188

Check that not more than 50% in each team is from the same department

Do you get a lower total dissimilarity with your groupings?

Conclusion

- Dissimilarity index can be used to determine the degree of similarity of attributes between each pair of entities.

- In a network representation, arcs represent the dissimilarity indices while nodes represent people or objects. A minimum spanning tree can be constructed to connect entities with the most similar attributes together.

- Grouping (clustering) of people or objects can be performed effectively based on the minimum spanning tree constructed from the dissimilarity values.

Learning Objectives

- Define and calculate dissimilarity index.

- Apply dissimilarity index and Minimum Spanning Tree in the grouping of people or objects.

Overview of E210 Operation Planning Module