# Systems Thinking for Design

Session 5

INDIAN INSTITUTE OF INFORMATION TECHNOLOGY,
DESIGN AND MANUFACTURING,
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# Recap

Assignment assessment

1. Presentation quality
2. Effort and time spent by you in writing the assignment
3. Effort in exploring the problem by talking to relevant stakeholders, friends, parents etc. (This is where most of you need to work)
4. Quality of work (lot more immersion required into the problem).

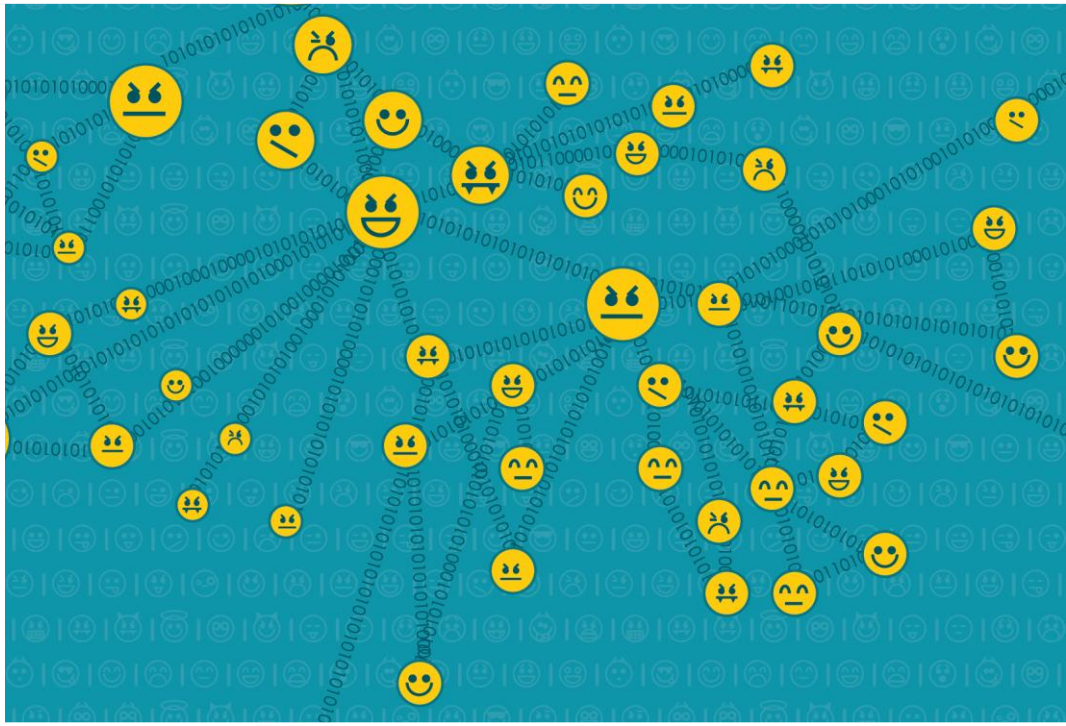
# Recap:

Complexity = Variety =

Function of (number of parts, relationships, nature of parts/relationships)

It can be inherent to the object and may be desirable for its existence (especially natural systems)

It can also indicate the amount of information required to understand an object. This is dependent on the observer



# Attention, abstraction and abduction

Function (Served Hot)

Medium (Transparent Cup)

Purpose (Health & rejuvenation)

Form (Black tea / Small)

Content

Proportion of different parts (structure)

Taste / Experience (Behavior)

TEA

Tea originated in East asia, it spread to the west because of Chinese merchants. In India it has a significant role in a person's life where they can enjoy a cup of tea and take a break and relax from their busy lives.

Actual Situation

**2nd Order Abstraction**

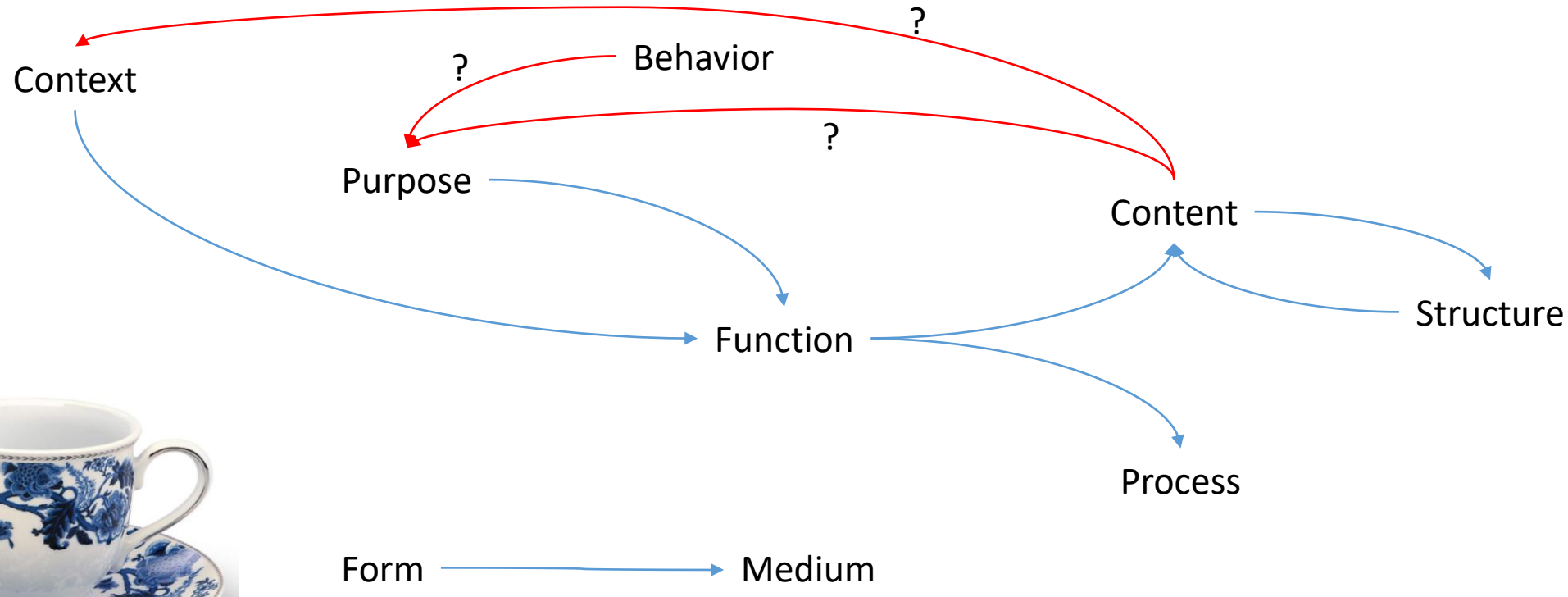
**1st Order Abstraction**

**Attention to the real-world**

**Abduction**

Something brewing?
Storm in the tea cup?

# Your understanding of ComplexiTea




# Session outline

- Principles of Complex Systems
- Checking Completeness of Concept Map

# Principles of complex systems (1/8): Systems theory

3. Purpose (from the hierarchy of functions)

2. Function (linked to needs in the environment)

Enables/Constrains

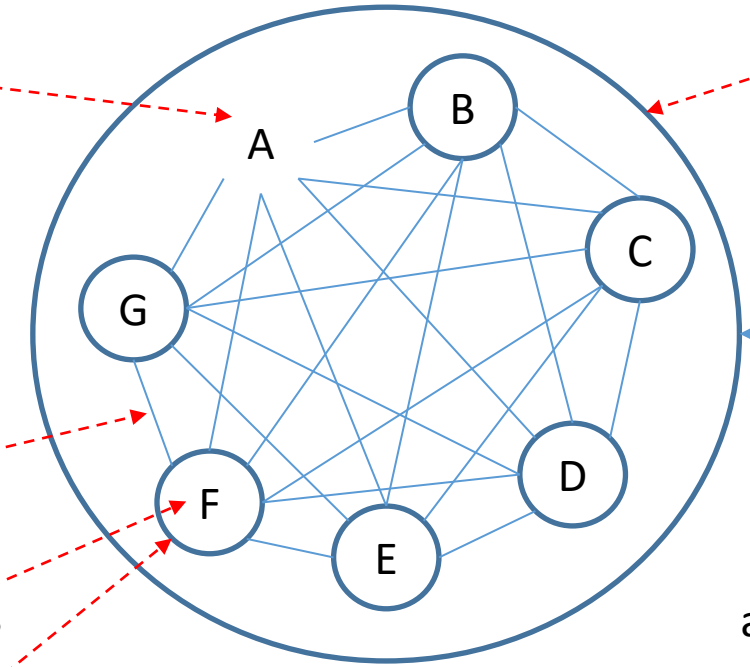
4. Structure

5. Form

4.3 Relations

4.2. Content of parts

4.1 Number of Parts

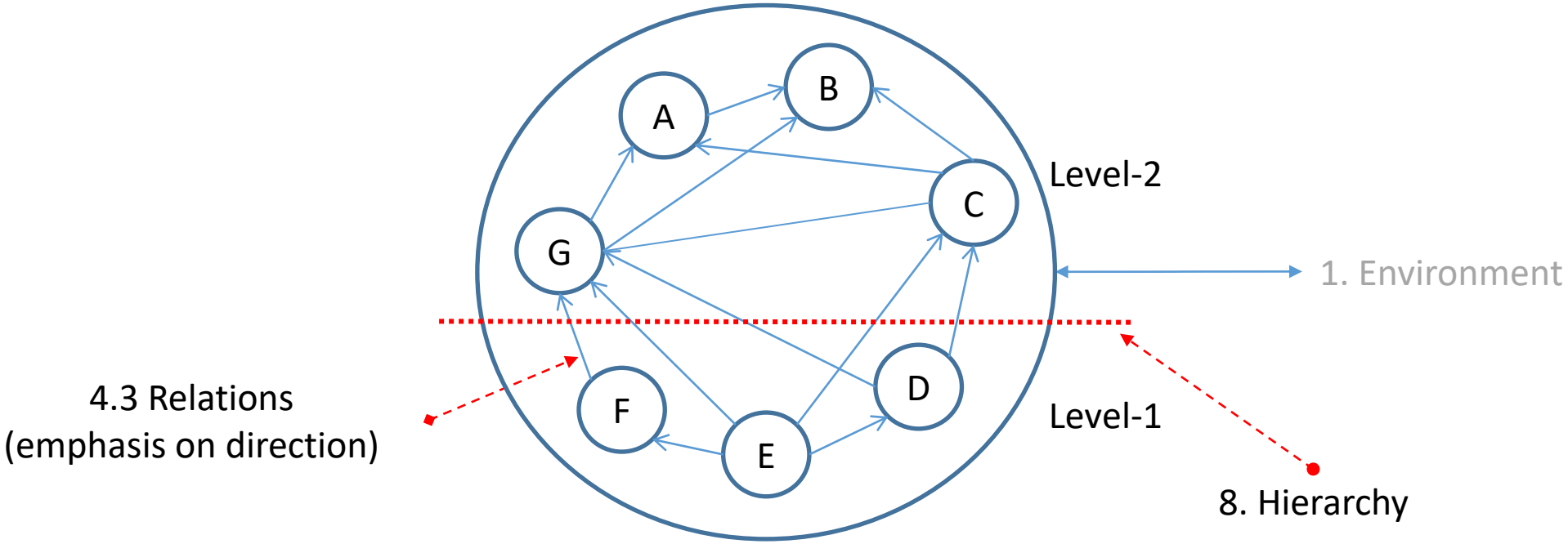



6. Boundary
(controls exchange of matter/energy/information)
**Open & Closed Systems**
**Boundary separates the inside from outside … Important in many cases, Problematic in some cases**

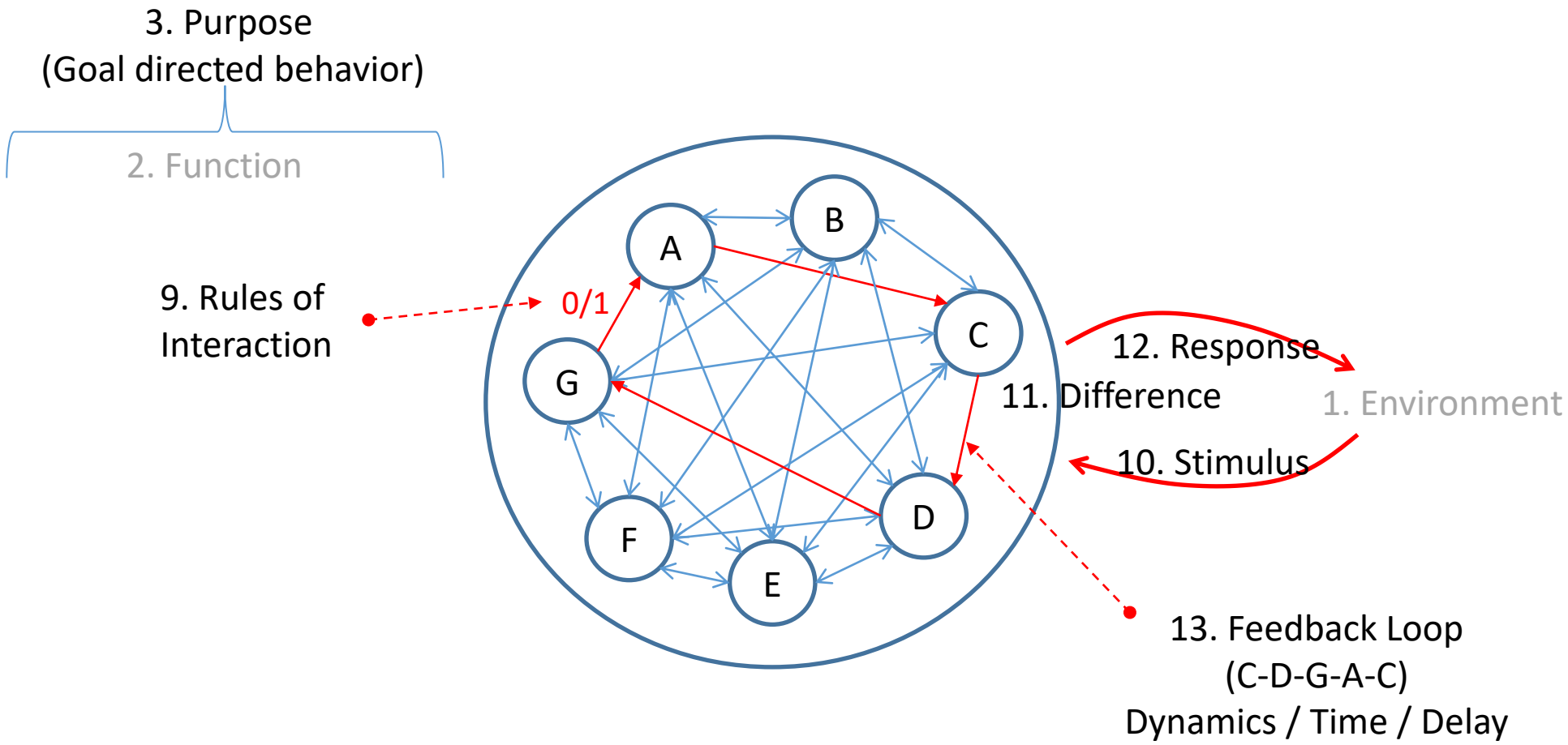
1. Environment

7. Behavior – emerges from interaction between system and environment

# Principles of complex systems (2/8): Systems theory



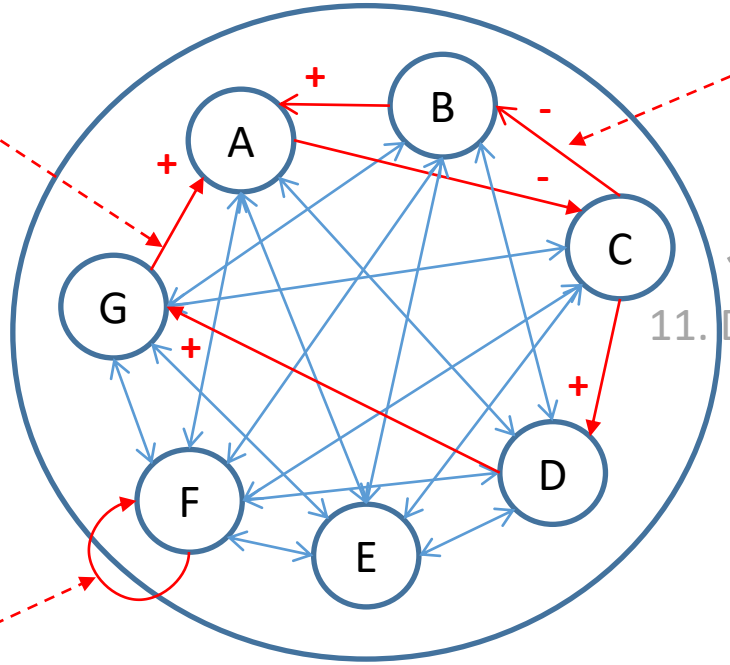
# Principles of complex systems (3/8): Cybernetics



# Principles of complex systems (4/8): Cybernetics

14. Self-regulation, Homeostasis, Negative Feedback (C-D-G-A-C)

15. Self-organization, deviance amplifying, Positive Feedback (C-B-A-C)




12. Response

11. Difference

1. Environment

10. Stimulus

16. Self-referential, Recursive, Self-producing, Self-similar/Fractal (F-F)

Explains some philosophical ideas

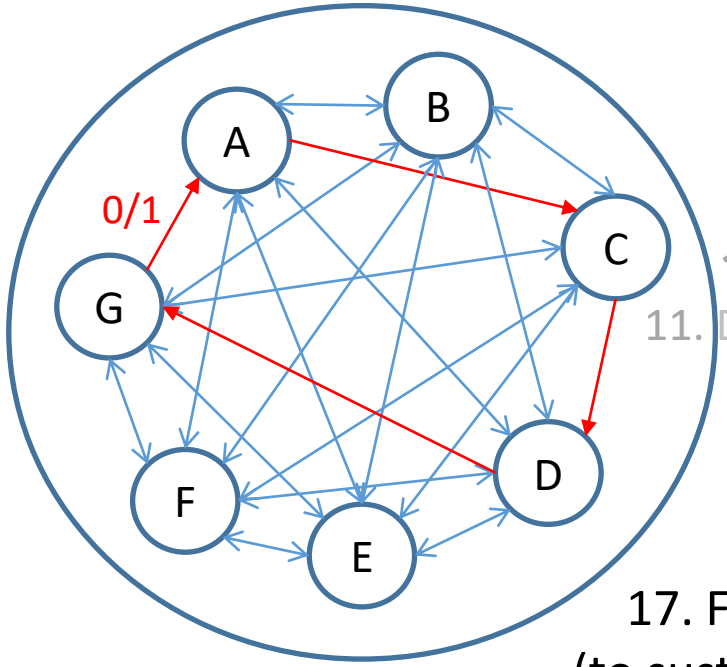
# Principles of complex systems (5/8): Cybernetics

3. Purpose
(Goal directed behavior)

Expected outcome in line with the defined purpose

R

| | α | β | γ |
|---|---|---|---|
| 1 | a | b | c |
| S 2 | c | a | b |
| 3 | b | c | a |




Black Box & Model

12. Response

11. Difference

7. Environment

10. Stimulus

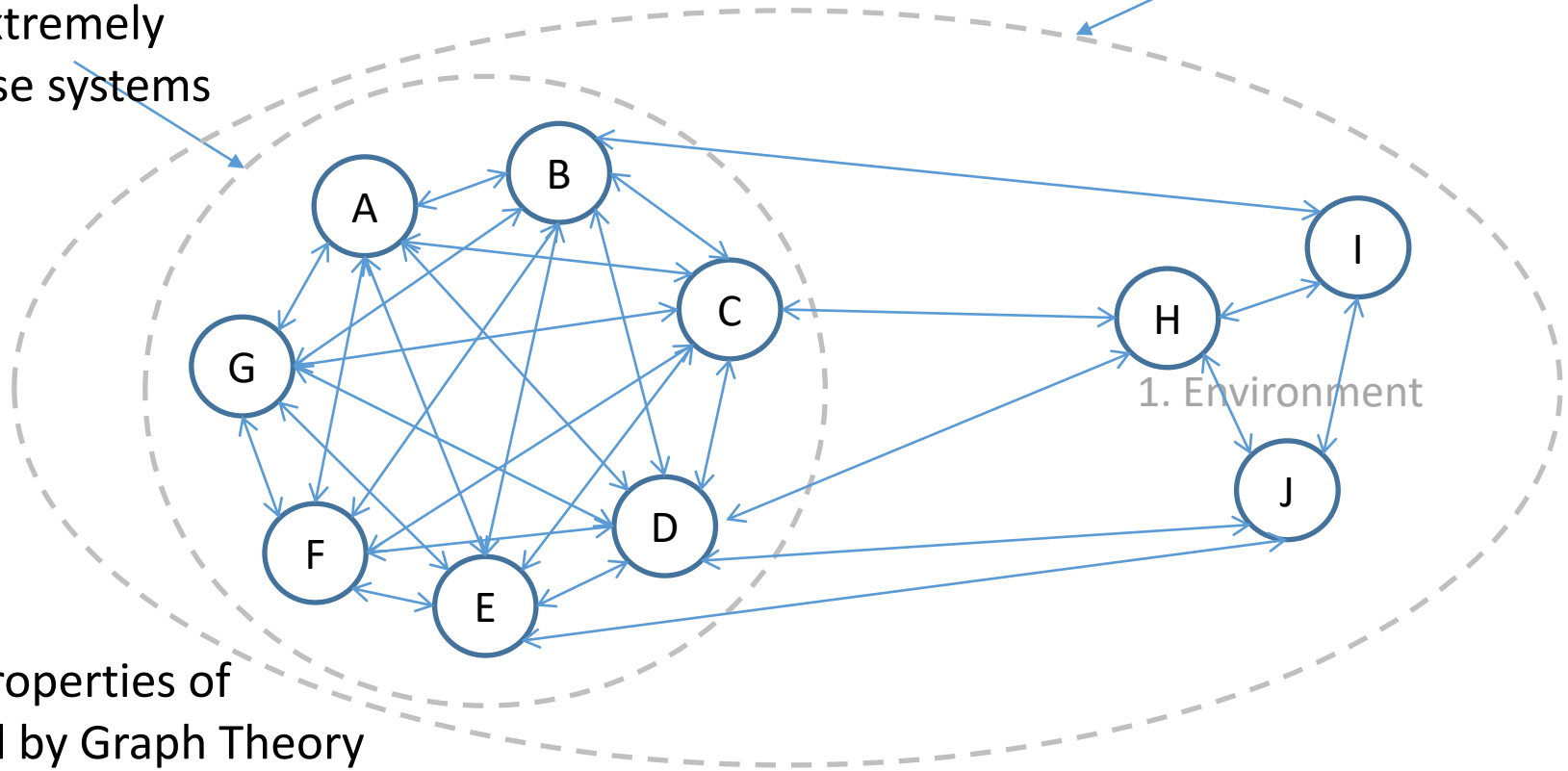
Transformation:
1-γ, 2-α, 3-β

17. For a viable system
(to sustain defined purpose)
Variety of R ≥ Variety of S

# Principles of complex systems (6/8): Networks

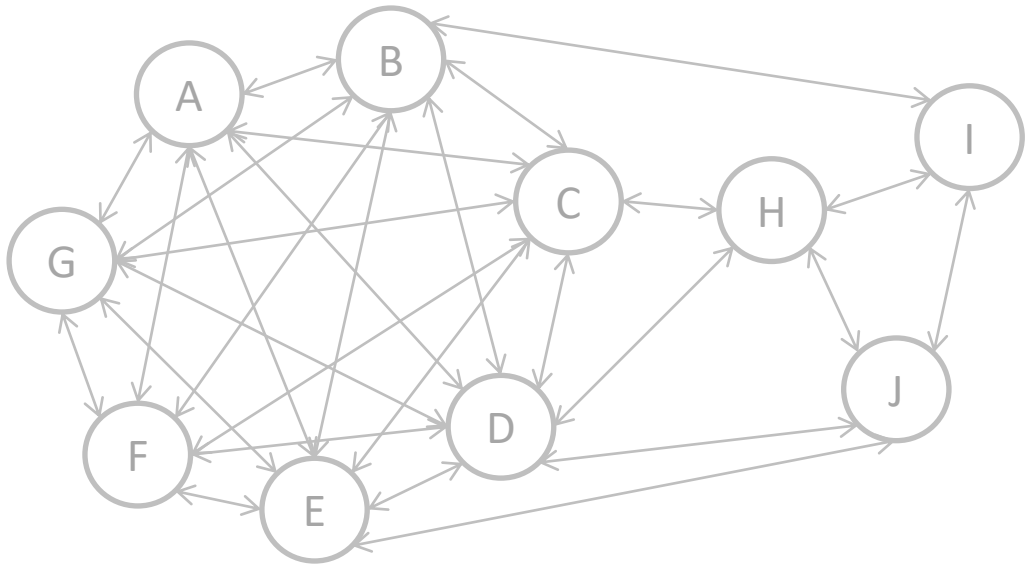
19. Everything is now part of a Complex Network
Boundary is now defined by the scope of study

18. In a network, the idea of boundary is less important. This is extremely useful for integrating diverse systems



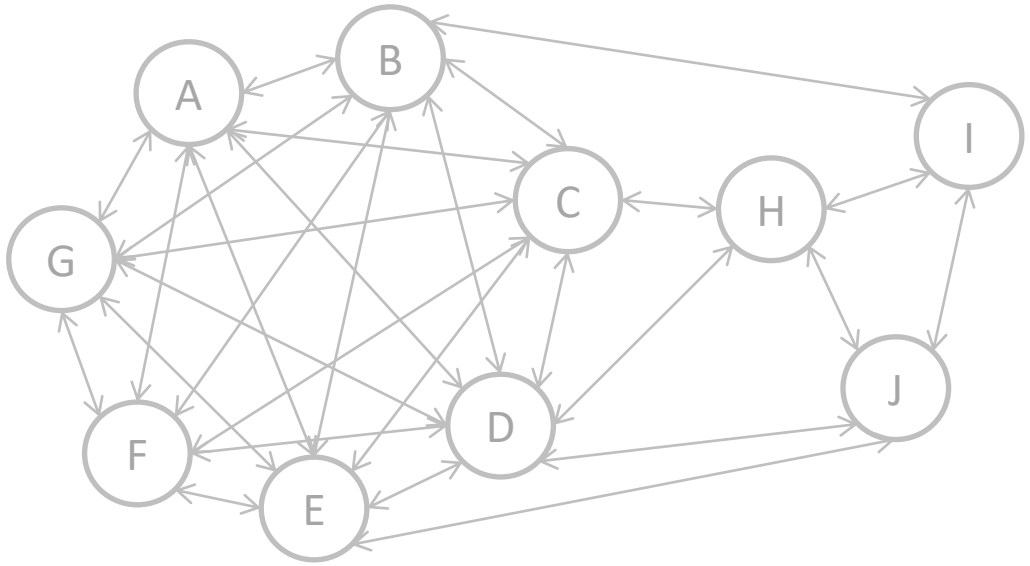

20. The focus is on acyclic properties of networks as a whole – aided by Graph Theory

# Principles of complex systems (7/8): Networks

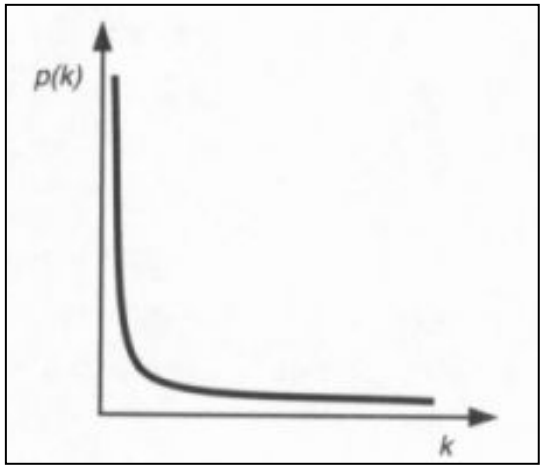



| Typical Questions (to control networks) | Local metrics | Global metrics | |
|---|---|---|---|
| How tightly are the nodes grouped together by edges? | clique, n-clique, k-core | clustering coefficient | 21 |
| How many different influences does a node receive? (Merge)<br>How many other nodes does it influence? (Burst) | degree, in-degree, out-degree | degree distribution | 22 |
| How long does communication between nodes take? | shortest-path length | diameter, radius | 23 |
| Do some nodes in a network play an important role in connecting the whole network? | Centrality | degree distribution | 24 |

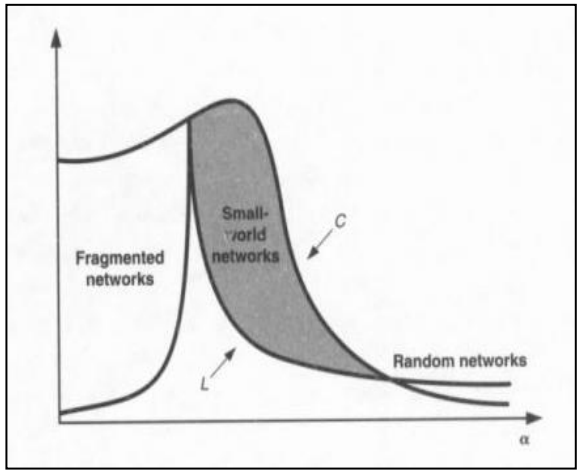
# Principles of complex systems (8/8): Networks




25. Random network (degree distribution is normal)




26. Scale-free networks (power-law for degree distribution)




27. Small-world networks (clustering & path length)

# Session outline

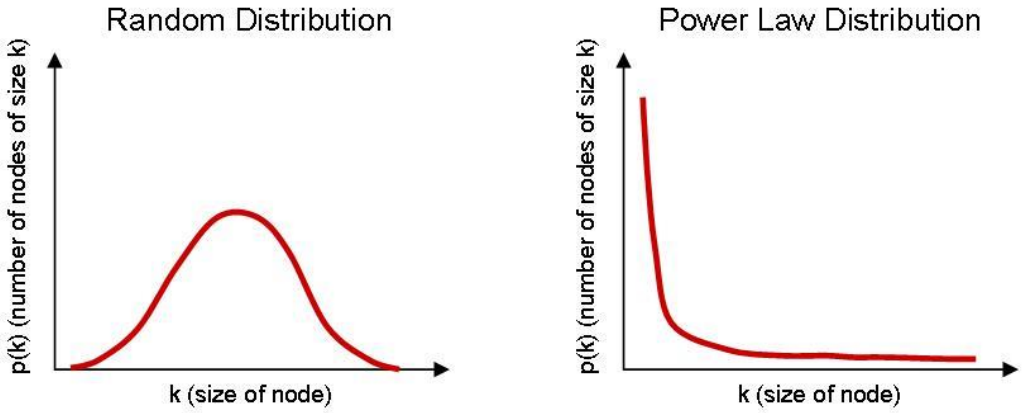
- Principles of Complex Systems
- Checking Completeness of Concept Map

# Check the matrix for completeness

| | |
|---|---|
| Check | Check if the key elements and relations and ask if they can explain everything in the problem description |
| Do | Do a quick test by checking relations with other elements and refine if necessary.<br>•Are you focused more on parts and sub-parts of the system?<br>•Are there elements that explain the larger whole? |
| Check | Check if some elements are redundant and can be abstracted into others |
| Check | Check validity of relations and eliminate those which are indirect, very weak<br>•Focus only on strong relations |
| Add | Add more elements if necessary and specify the direction of relations |

# Identify key properties of the network

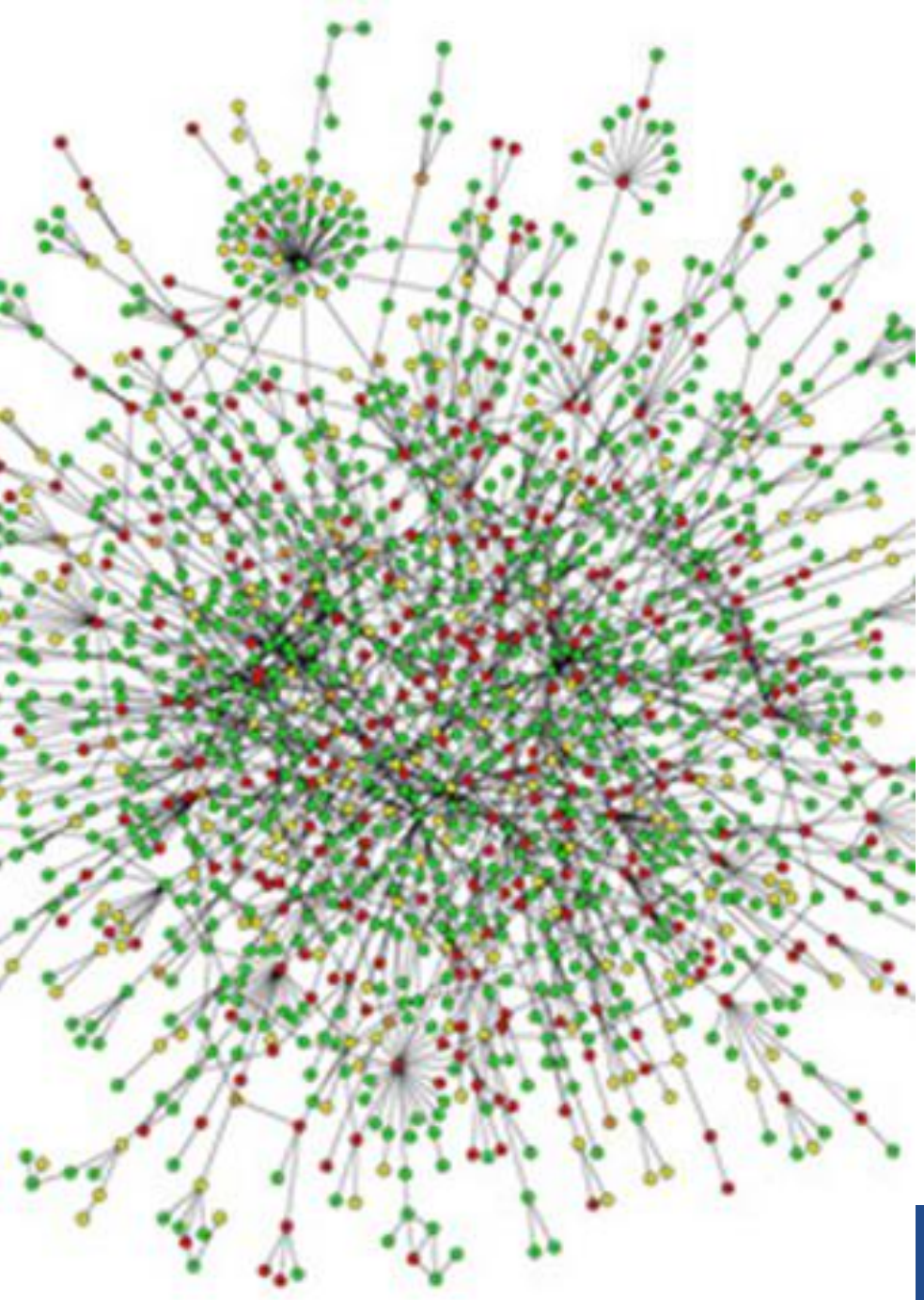
- Count the degree of each key element
  - in-degree is the total 1s in a column
  - out-degree is the total 1s in a row
  - total degree is the sum of in-degree and out-degree for each element
- Sort the elements by their degree (in, out, total)
  - Identify the top 5 elements by each type of degree
  - Draw the degree distribution (for total degree) and check the nature of the network
  - Check if there is a bias or incompleteness and make inferences



# Discovering Complexitea

| | Behavior (Tase, Nutrition, Energy) | Medium (Cup, Tumbler, Steel, Silver, Tray, etc.) | Structure (Chemical structure) | Function | Form (Color, Hot/Cold, TYpe- masala tea, black tea, Liquid etc) | Process (Sequence of steps, and time at each step, types of tools - spoons, stove, etc.) | Context (Physical, social, geographical) | Purpose (Entertainment, Energy, Ritual) | Content (Tea leaves/dust, sugar, milk, spices, etc.) | Total (Out-degree) |
|---|---|---|---|---|---|---|---|---|---|---|
| Medium | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 4 |
| Structure | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 3 |
| Form | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 6 |
| Process & Tools | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 6 |
| Behavior | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 4 |
| Purpose | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 5 |
| **Context** | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 5 |
| **Function** | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 5 |
| **Content** | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 6 |
| Total (in-degree) | 4 | 1 | 5 | 3 | 5 | 7 | 7 | 6 | 6 | |

| | IN | OUT | Total | Difference (out-in) |
|---|---|---|---|---|
| Process & Tools | 7 | 6 | 13 | -1 |
| Content | 6 | 6 | 12 | 0 |
| Context | 7 | 5 | 12 | -2 |
| Purpose | 6 | 5 | 11 | -1 |
| Form | 5 | 6 | 11 | 1 |
| Function | 3 | 5 | 8 | 2 |
| Behavior | 4 | 4 | 8 | 0 |
| Structure | 5 | 3 | 8 | -2 |
| Medium | 1 | 4 | 5 | 3 |

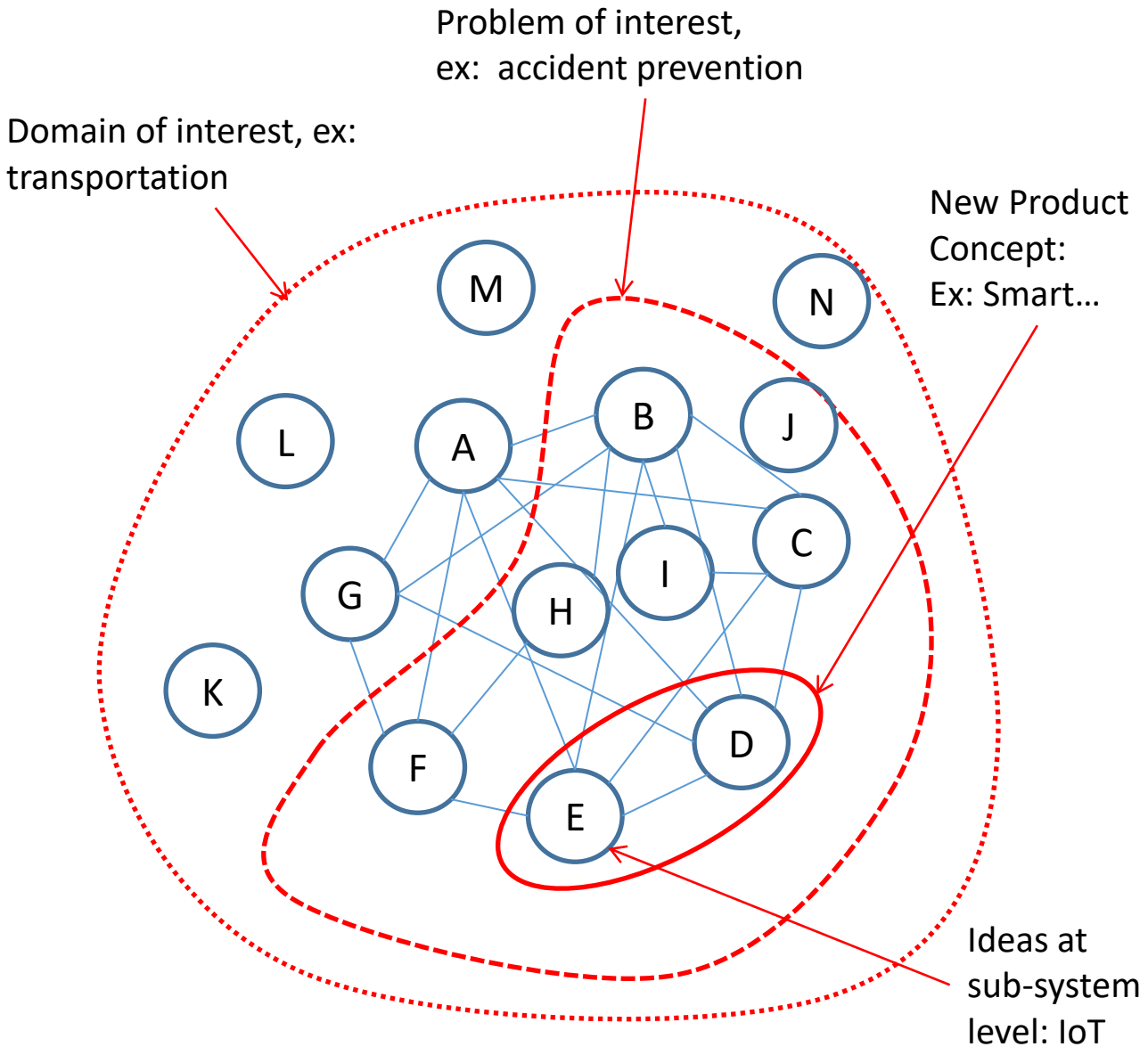


# Discover the system-of-interest

- Develop a visual map of the matrix (using any open source software)
  - Identify the system, boundary and its environment
  - Identify cliques and clusters of densely connected elements
  - Identify the exchanges between the system and its environment (stimulus-response)

# Exercise 5.1

- Check the matrix for completeness
- Identify network properties
- Develop a visual map
- Add the information to your document repository



# Next session: Probe specific stakeholders and their needs