Systems Thinking for Design

Session 5

https://sites.google.com/a/iiitdm.ac.in/sudhirvs/courses/systems-thinking-for-design

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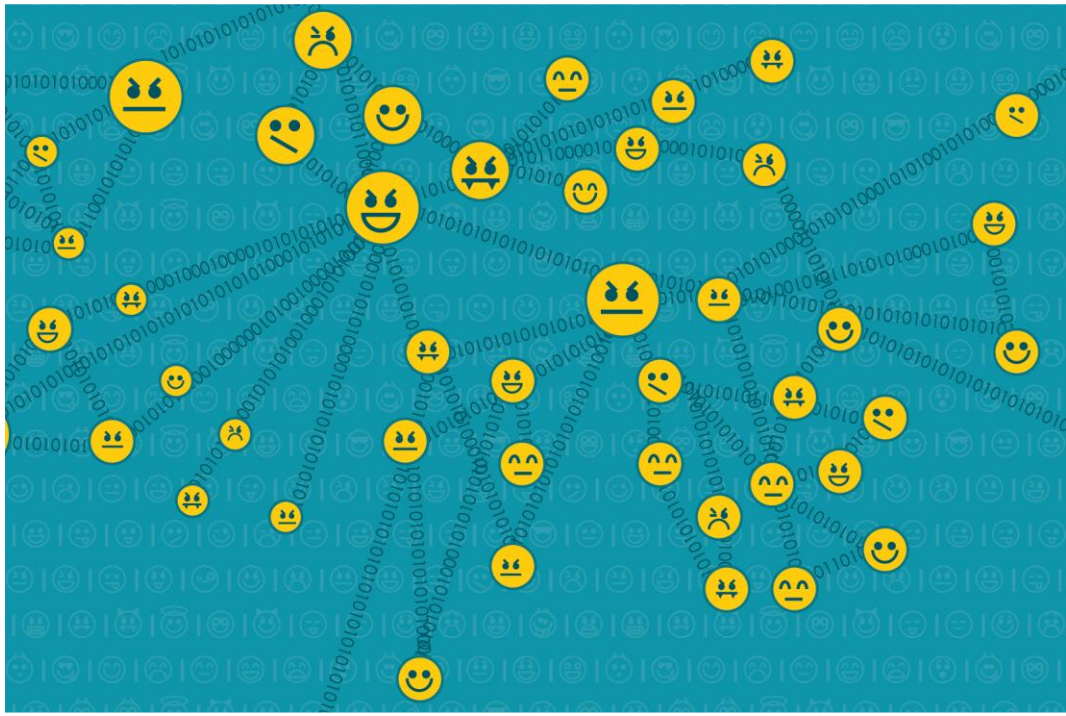
Recap: Complexity=Variety



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

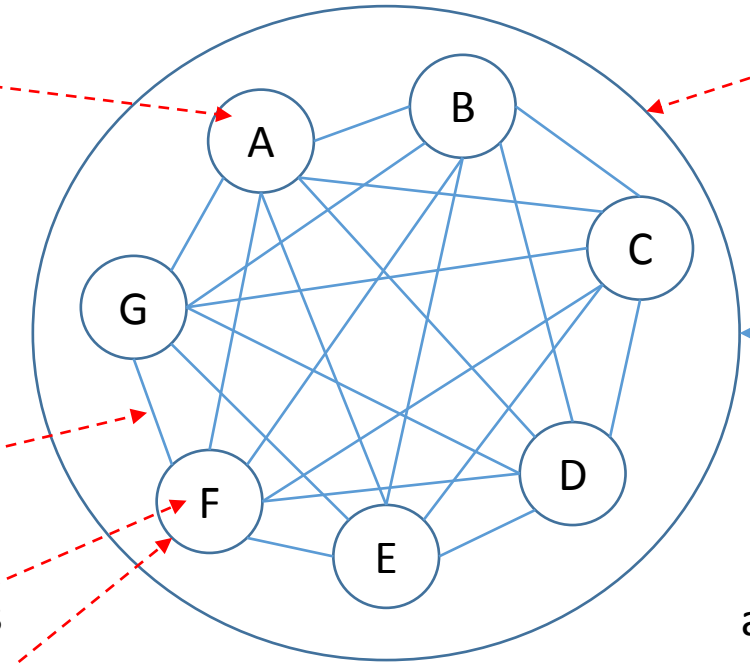
4. Structure

5. Form

4.3 Relations

4.2. Content of parts

4.1 Number of Parts

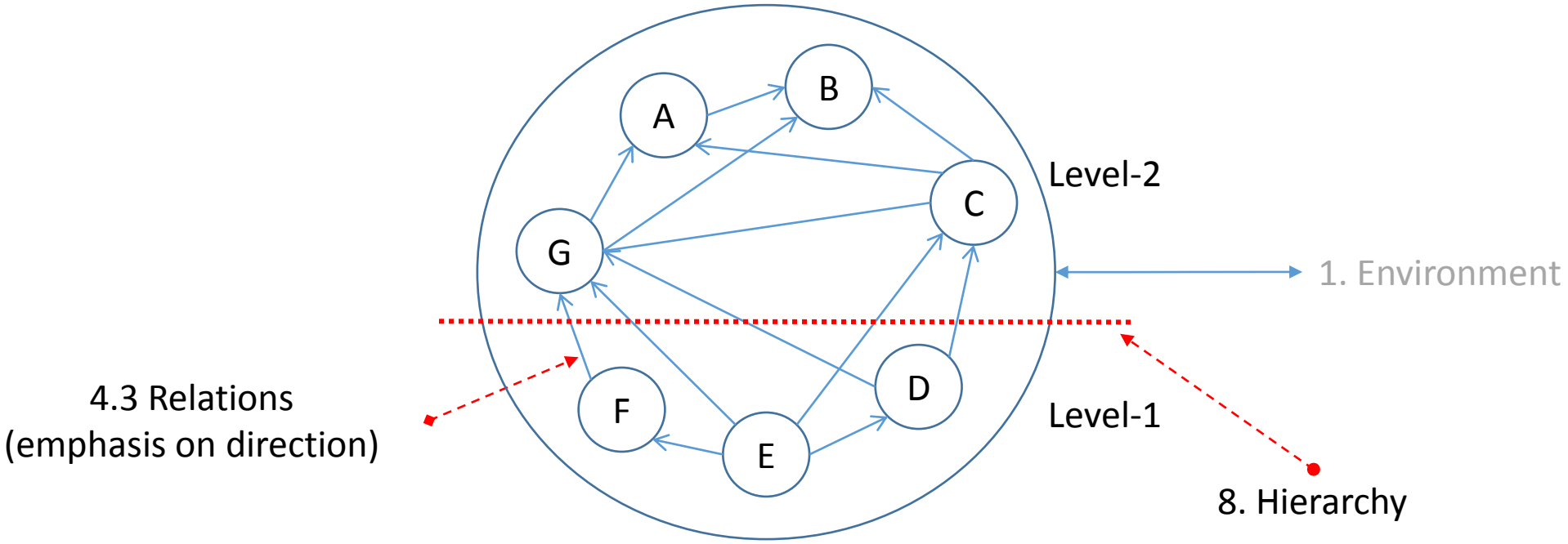


6. Boundary
(controls exchange of matter/energy/information)
Open & Closed Systems
Boundary separates the inside from outside … Important in many cases, Problematic in some cases

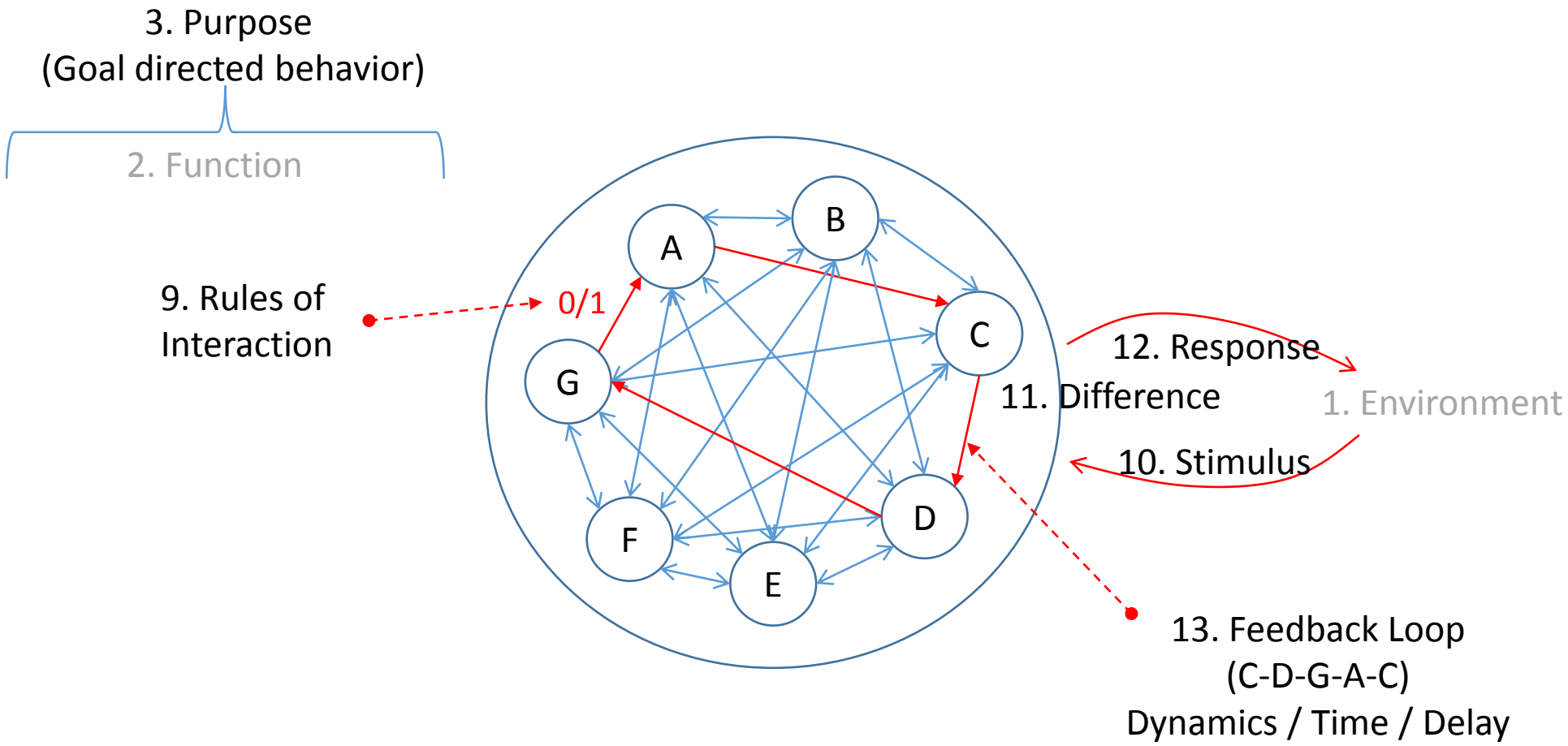
1. Environment

7. Behavior – emerges from interaction between system and environment

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



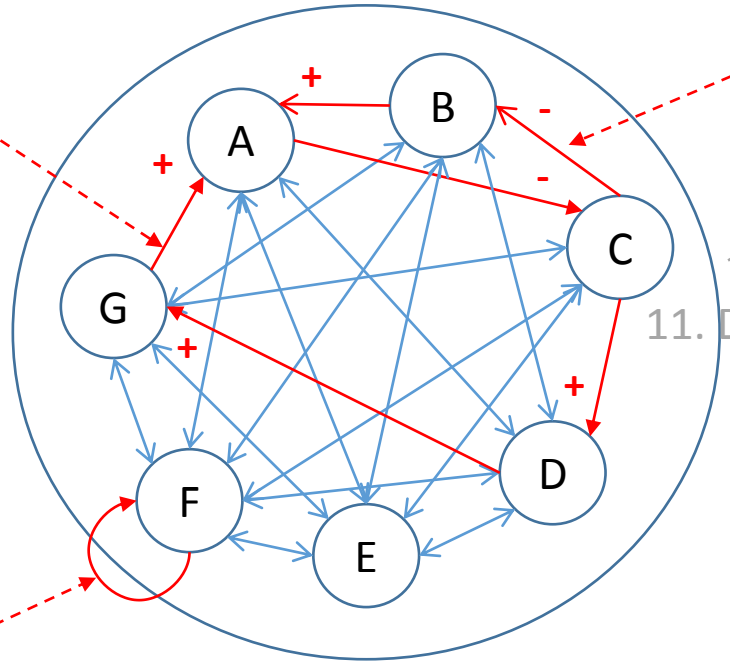
Principles of complex systems (3/8): Cybernetics



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

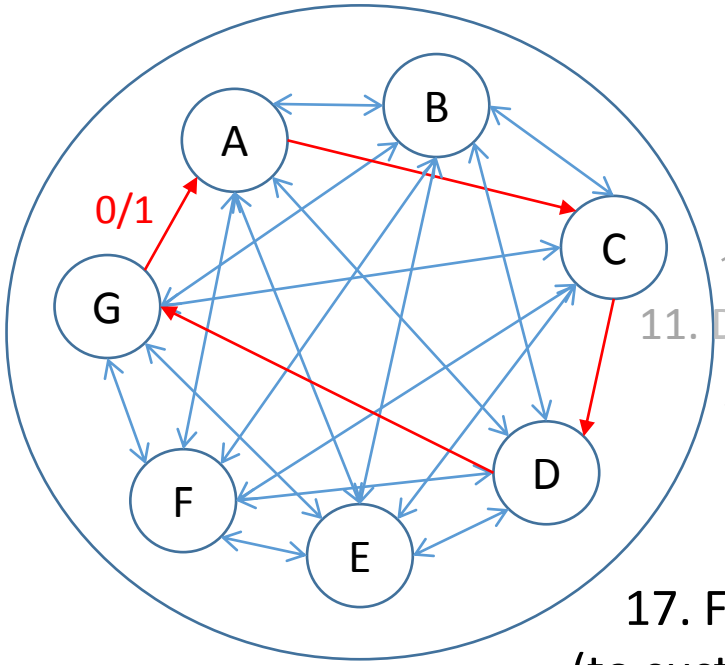
Principles of complex systems (5/8): Cybernetics

3. Purpose
(Goal directed behavior)

Expected outcome in line with the defined purpose

R

S	α	β	γ
1	a	b	c
2	c	a	b
3	b	c	a



12. Response

11. Difference

7. Environment

10. Stimulus

Transformation:
1-γ, 2-α, 3-β

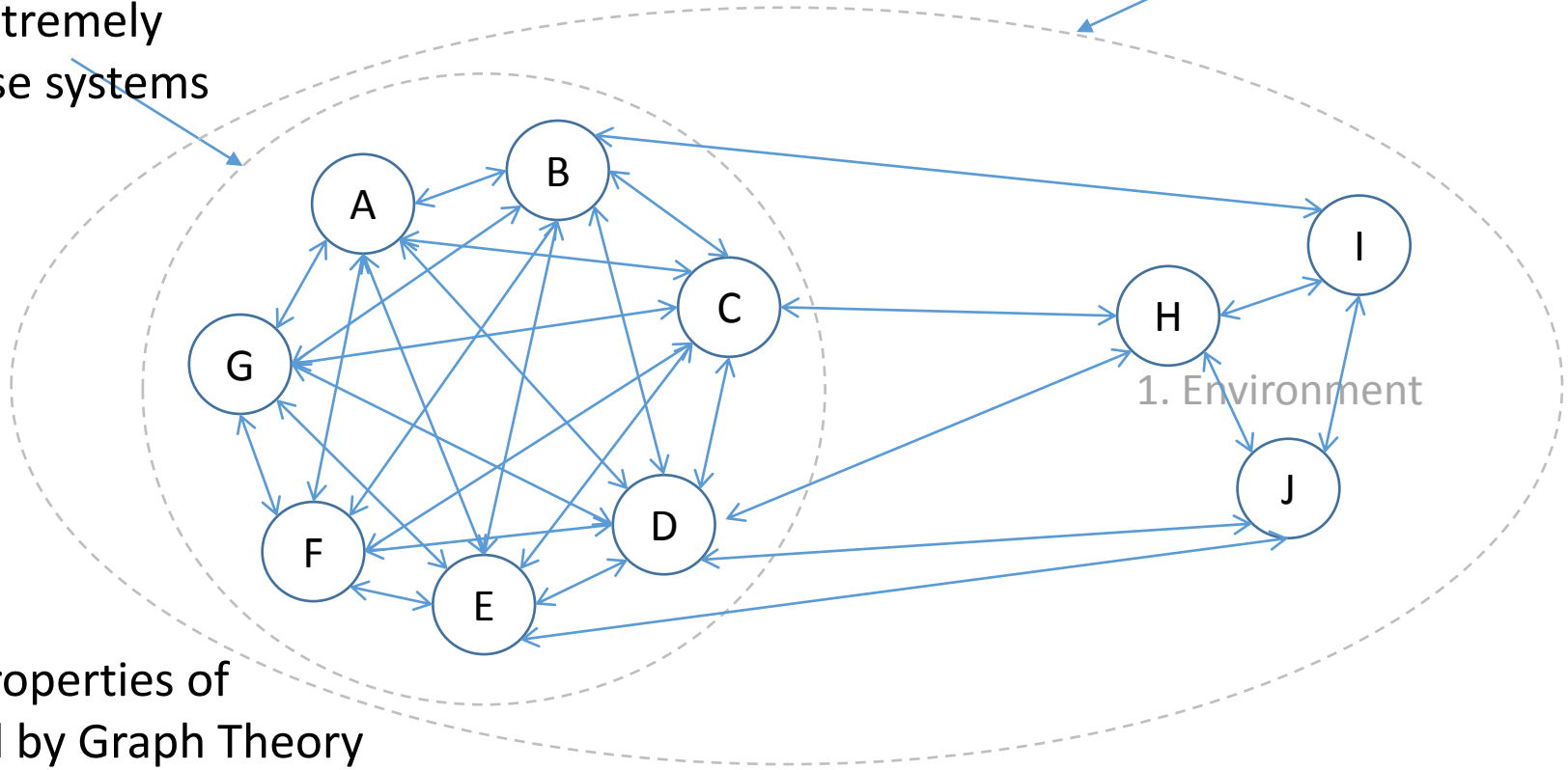
Black Box & Model

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

Principles of complex systems (6/8): Networks

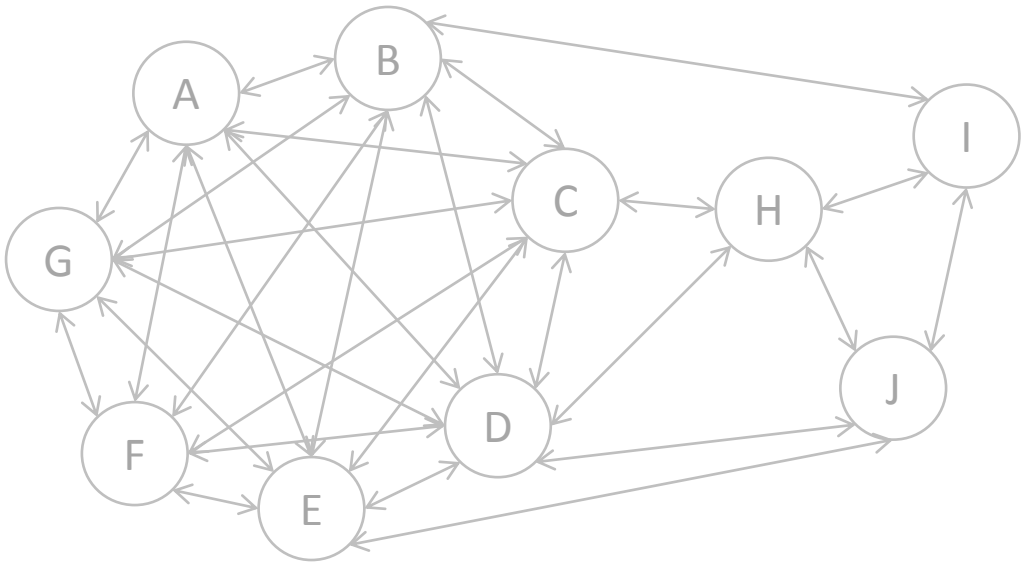
19. Everything is now part of a Complex Network
Boundary is now defined by the scope of study

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



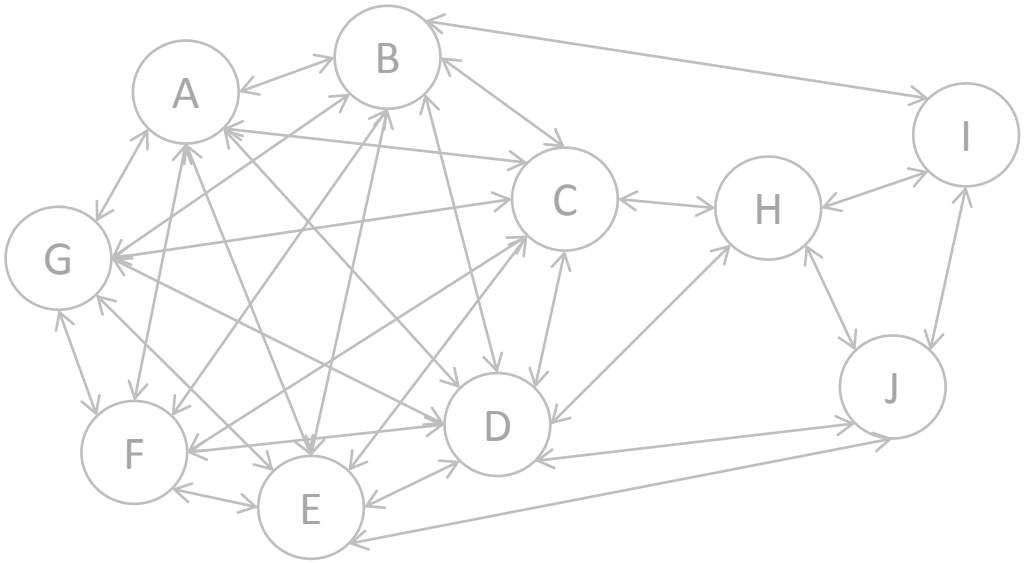
20. The focus is on acyclic properties of networks as a whole – aided by Graph Theory

Principles of complex systems (7/8): Networks

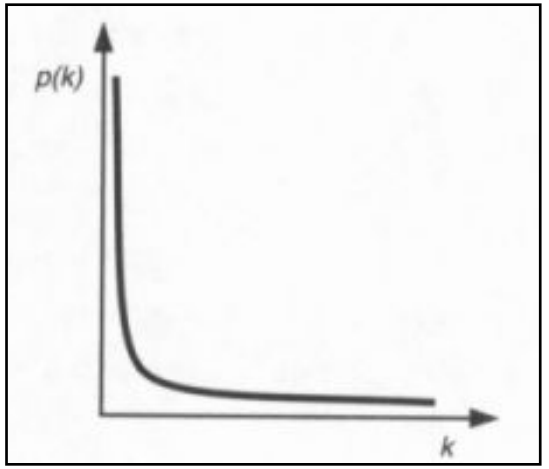


Typical Questions (to control networks)	Local metrics	Global metrics	
How tightly are the nodes grouped together by edges?	clique, n-clique, k-core	clustering coefficient	21
How many different influences does a node receive? (Merge) How many other nodes does it influence? (Burst)	degree, in-degree, out-degree	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

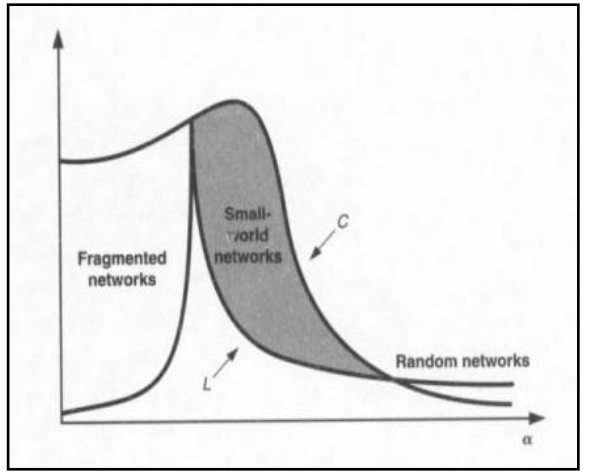
Principles of complex systems (8/8): Networks



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

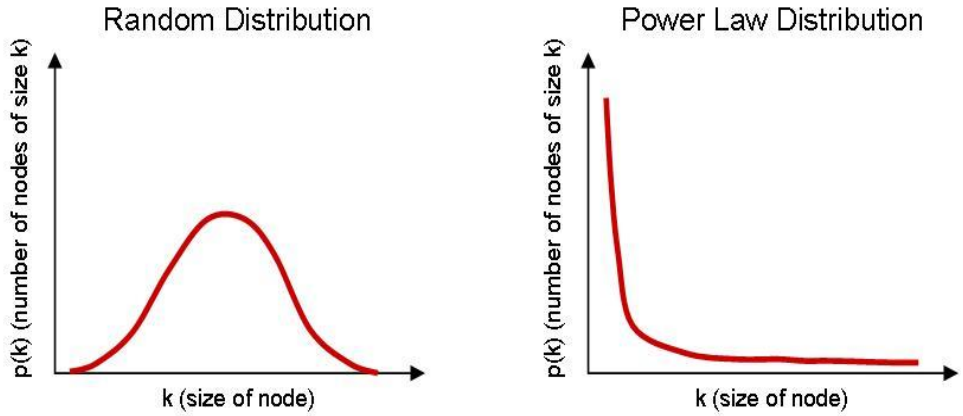
- Principles of Complex Systems
- Checking Completeness of Concept Map

Check the matrix for completeness

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

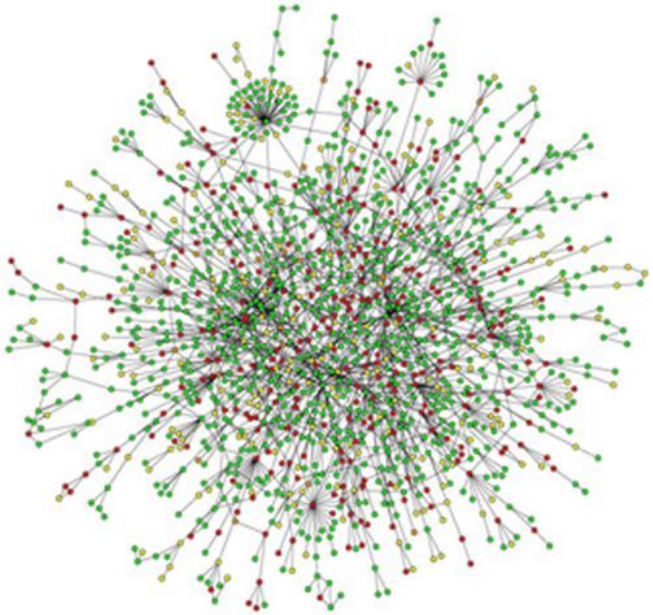
Identify key properties of the network

- 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



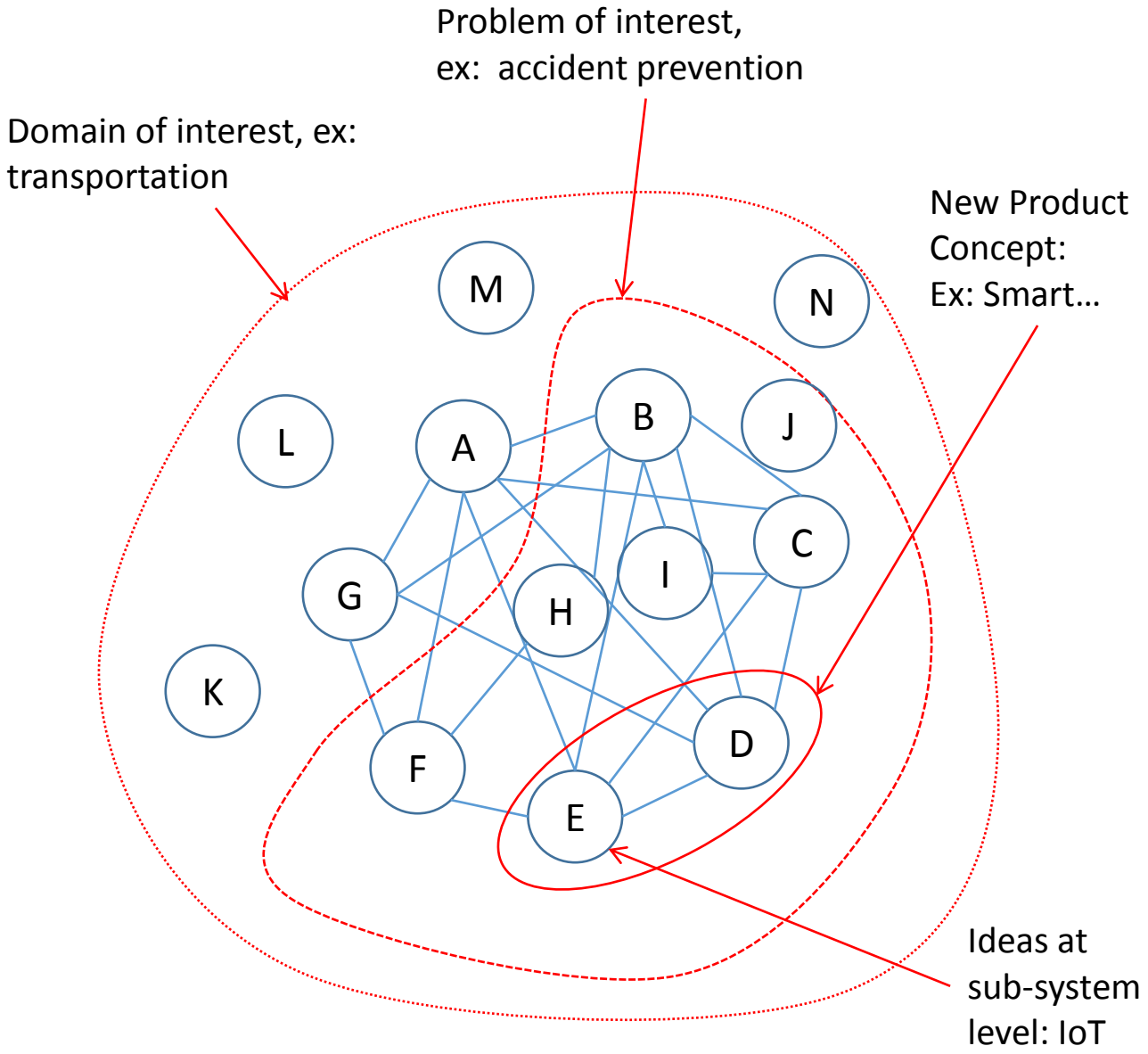
Discover the system-of-interest

- Develop a visual map of the matrix (on a A3 sheet)
  - 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)
- Use Post-it notes



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

Reflect on today's session and post your questions in the FAQ sheet