

Systems Thinking for Design

Session 7



INDIAN INSTITUTE OF INFORMATION TECHNOLOGY,
DESIGN AND MANUFACTURING,
KANCHEEPURAM

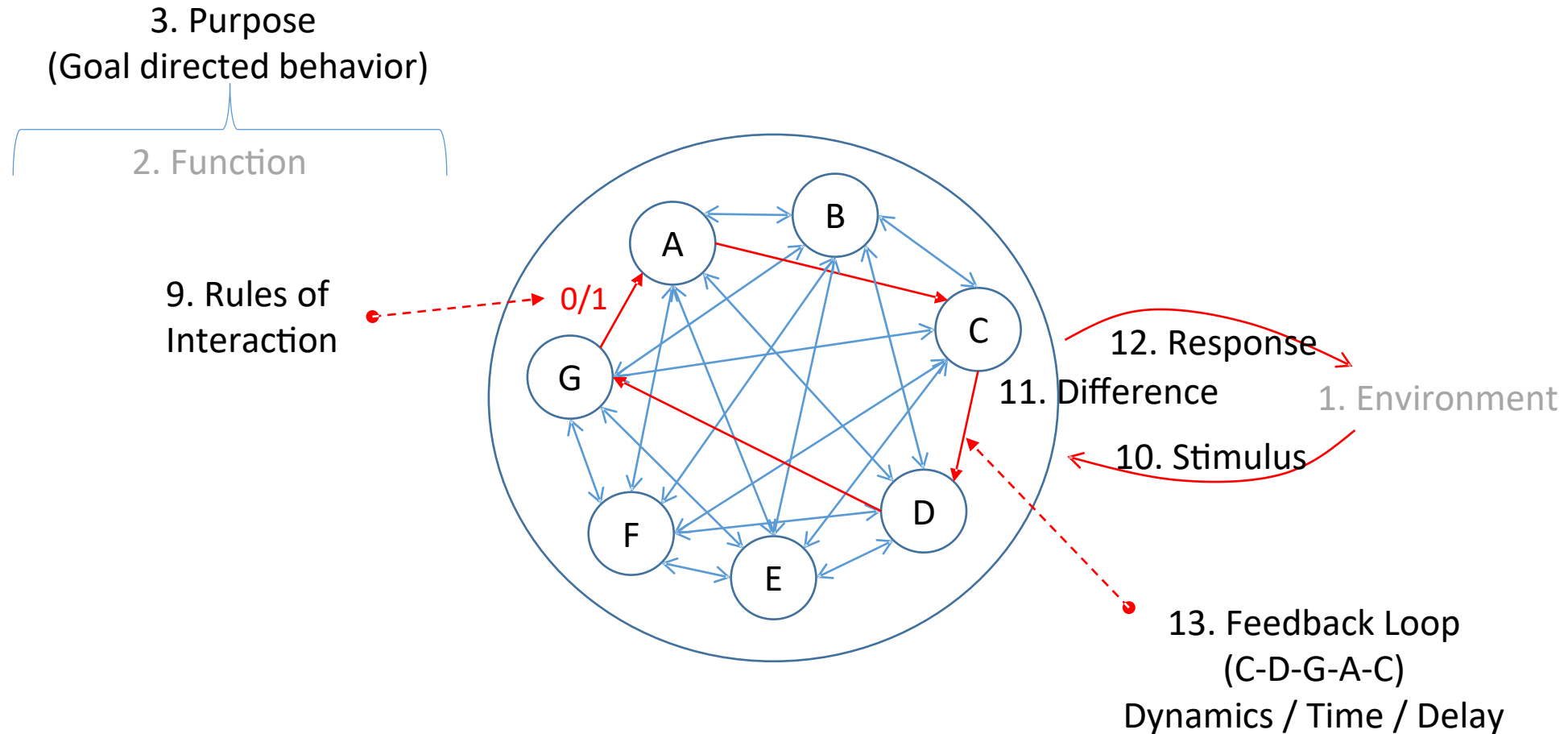
Dr.Karthik Chandrasekaran

Session outline

Diagnosing the system's ability to change (Cybernetics)

Examples

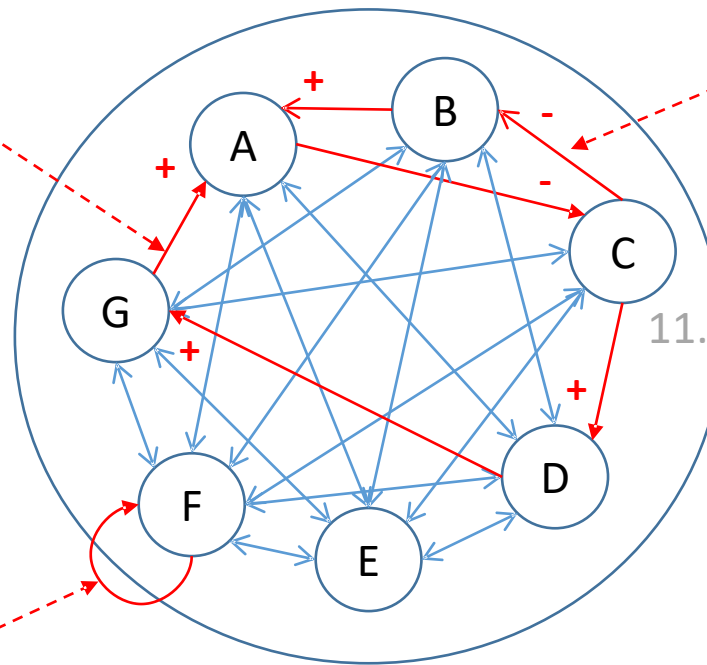
Principles of complex systems (3/8): Cybernetics



Principles of complex systems (4/8): Cybernetics

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

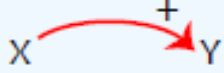
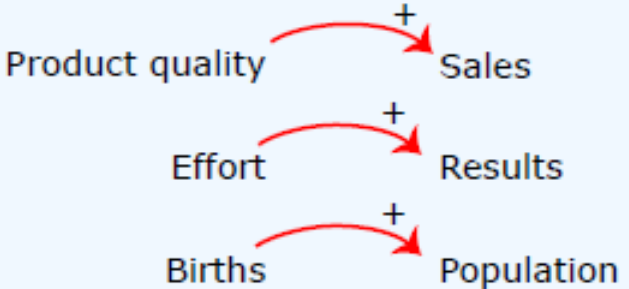
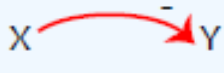
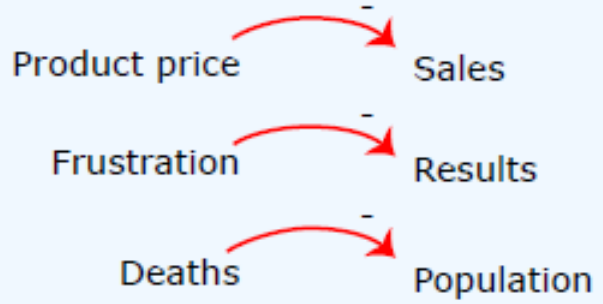
15. Self-organization,
deviance amplifying,
Positive Feedback
(C-B-A-C)



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

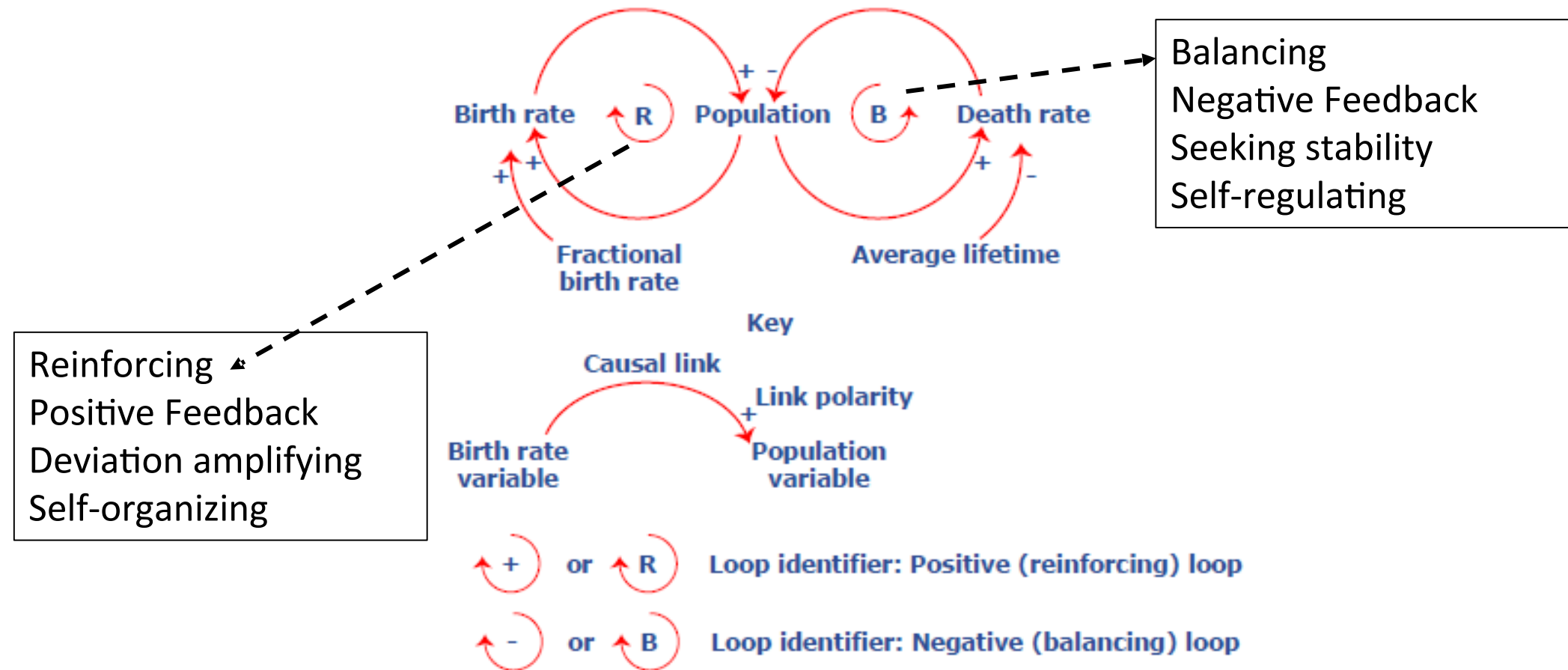
Explains some philosophical ideas

Guidelines for adding polarity to relations

Symbol	Interpretation	Mathematics	Examples
	<p>All else equal, if X increases (decreases), then Y increases (decreases) above what it would have been.</p> <p>In the case of accumulations, X adds to Y.</p>	$\partial Y / \partial X > 0$ In the case of accumulations, $Y = \int_{t_0}^t (X + \dots) ds + Y_{t_0}$	
	<p>All else equal, if X increases (decreases), then Y decreases (increases) below what it would have been.</p> <p>In the case of accumulations, X subtracts from Y.</p>	$\partial Y / \partial X < 0$ In the case of accumulations, $Y = \int_{t_0}^t (-X + \dots) ds + Y_{t_0}$	

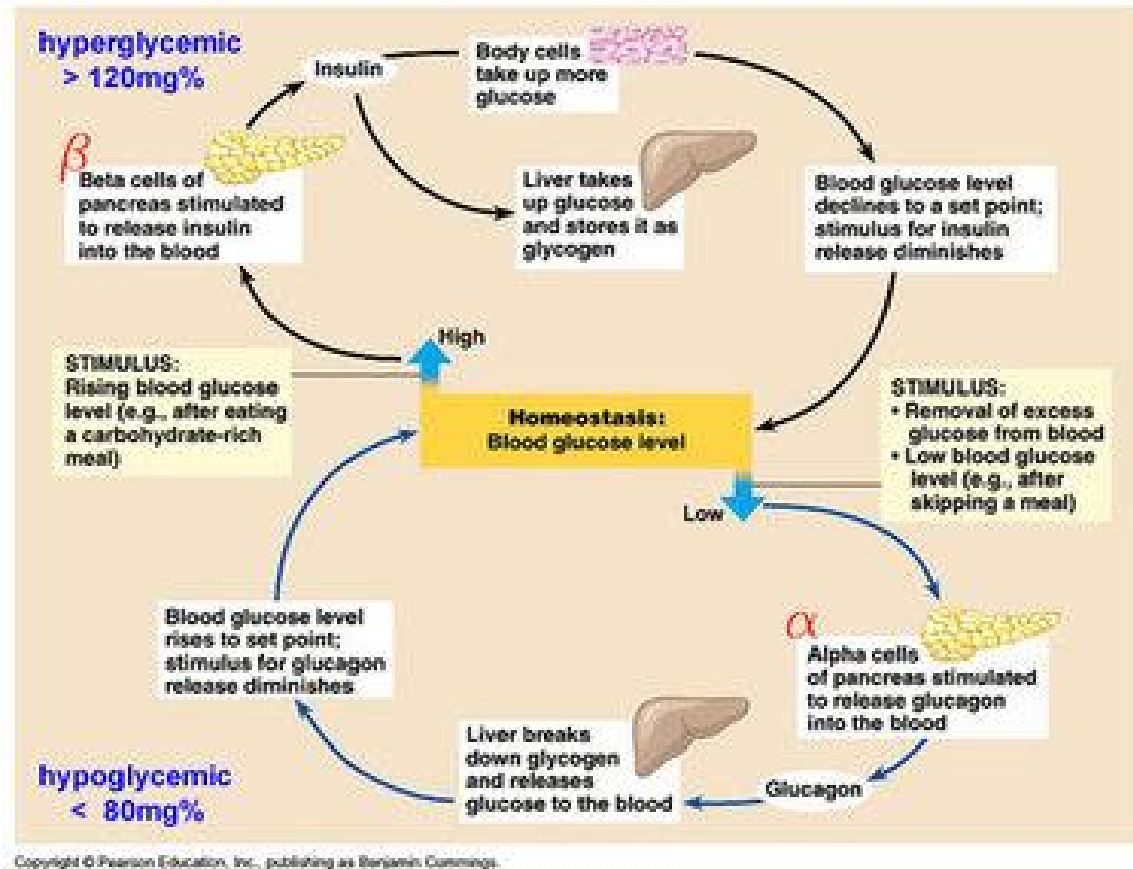
Source: Public (Internet)

Identifying loops affecting system behavior



Source: Public (Internet)

It takes several negative feedback loops to keep human body stable

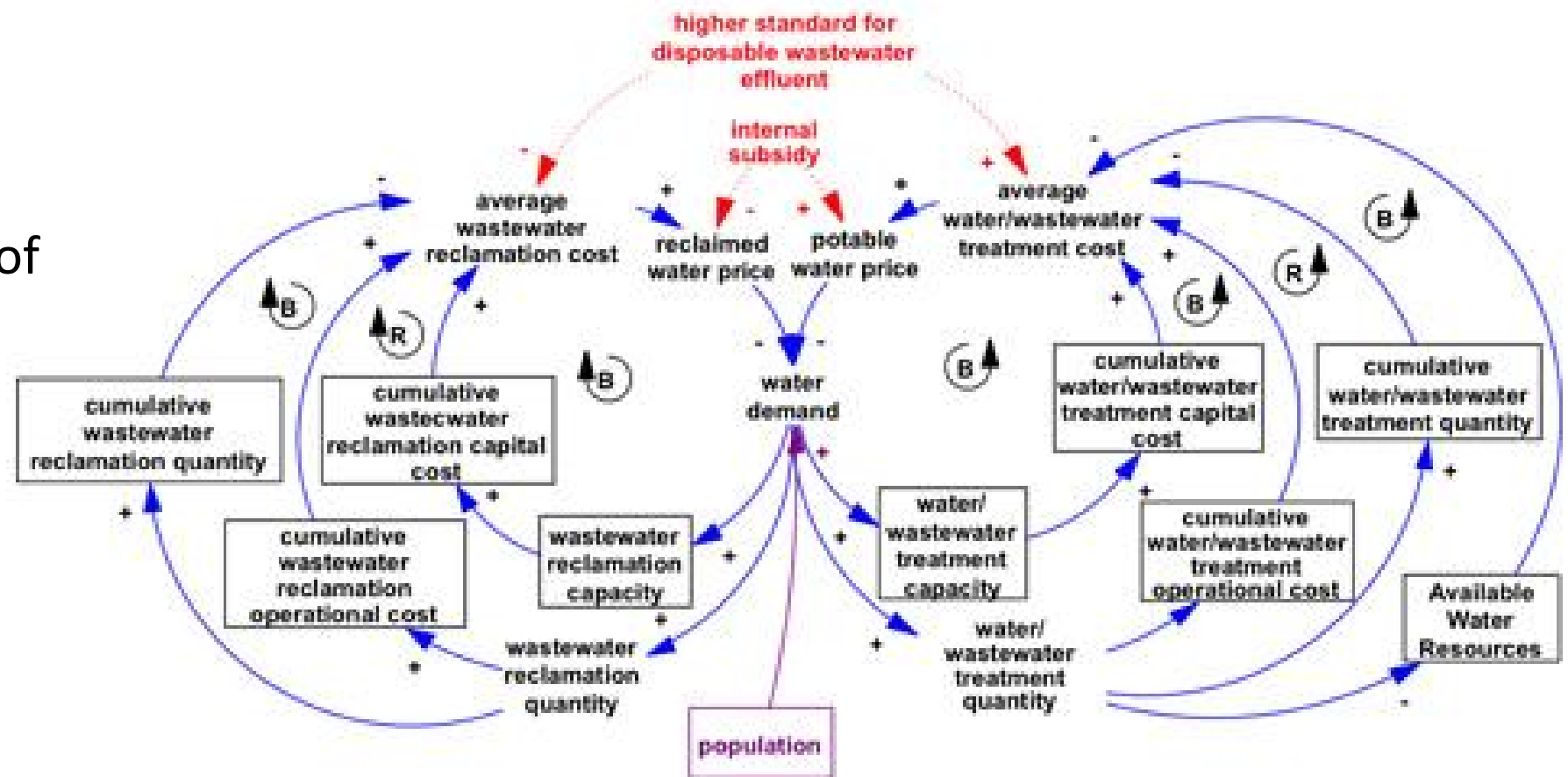


Source: Public (Internet)

Identifying and designing appropriate negative feedback loops to support bio-mechanics is a key principle in robotics ... self-balancing bicycle etc.

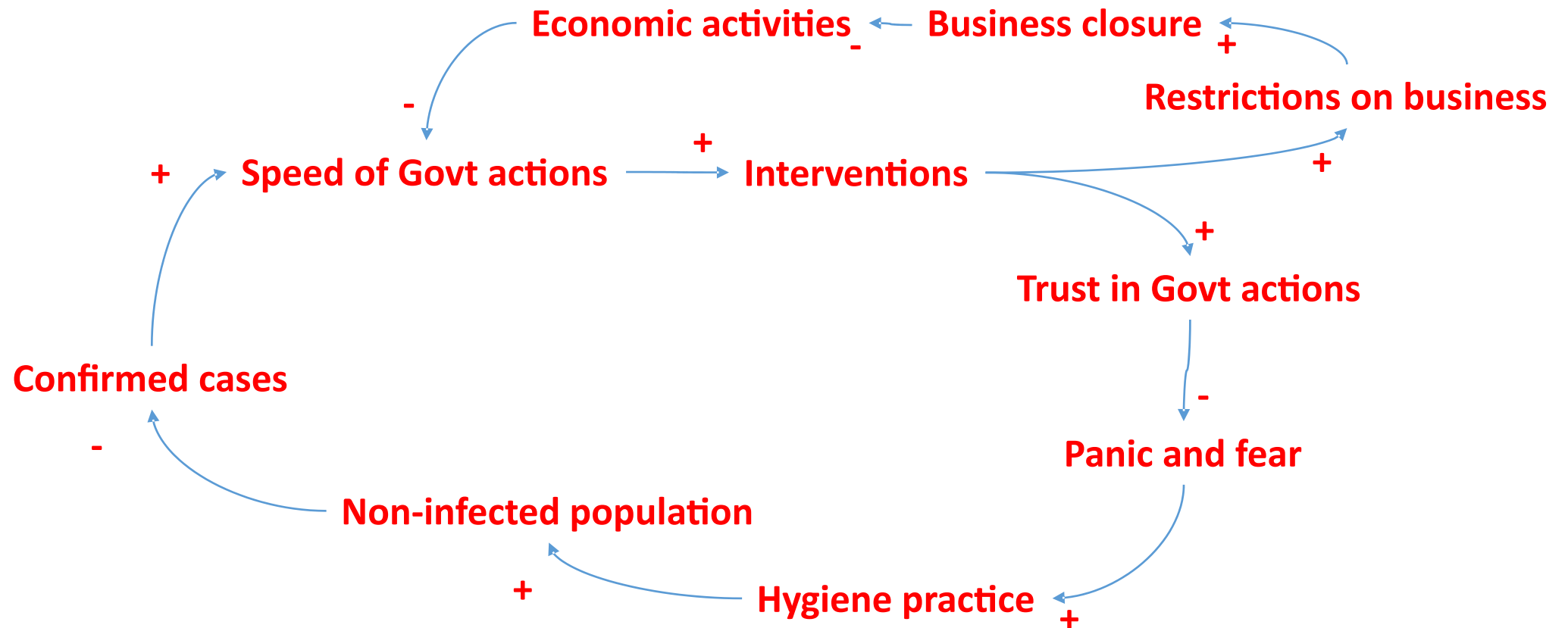
Multiple loops shape system behavior

Water Resources Management: A complex system of balancing & reinforcing loops



Source: Public (Internet)

Delays and errors can make the system unstable ... and sometimes produce counter-intuitive behaviors



Source: Shahin et al (2020); Developing a Preliminary Causal Loop Diagram for Understanding the Wicked Complexity of the COVID-19 Pandemic, Systems, 8 (20)

Multi-level feedback is critical for Learning and adaptation

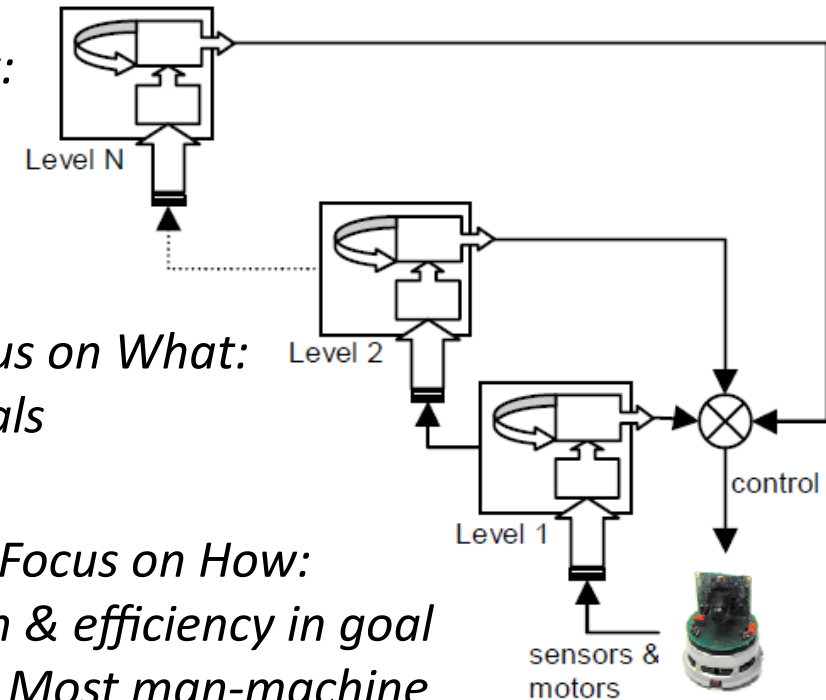


Implications for human-machine interfaces

*Level-3: Focus on Why:
Redefining Purpose*

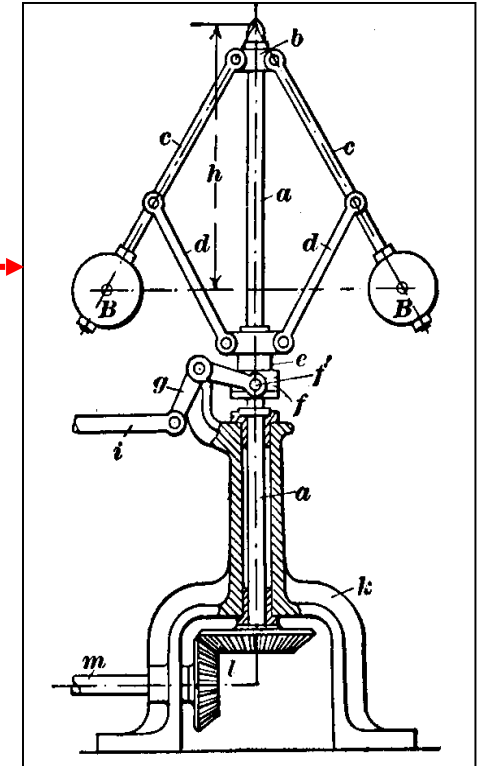
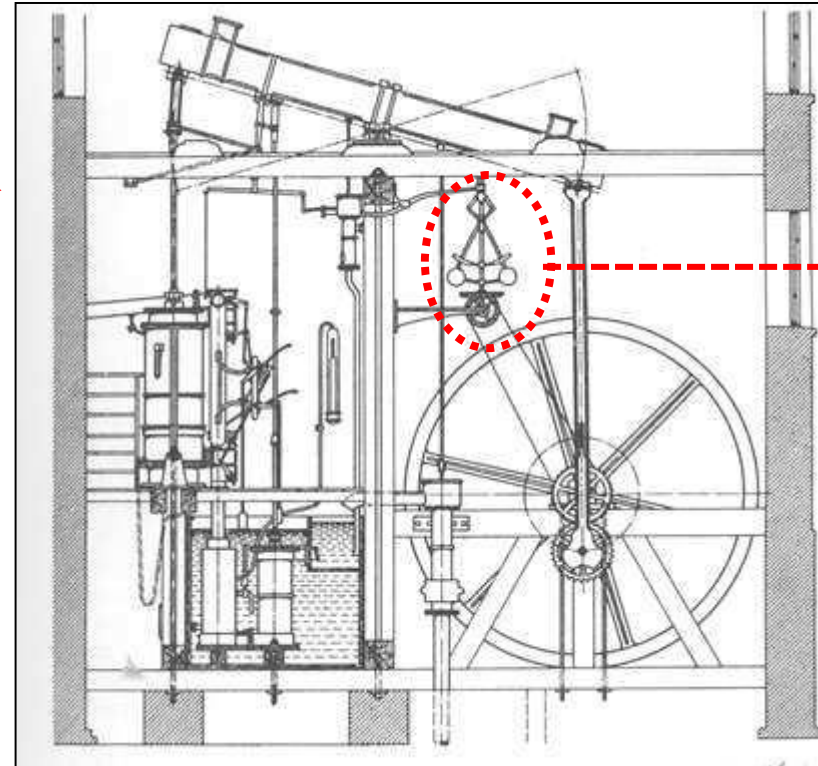
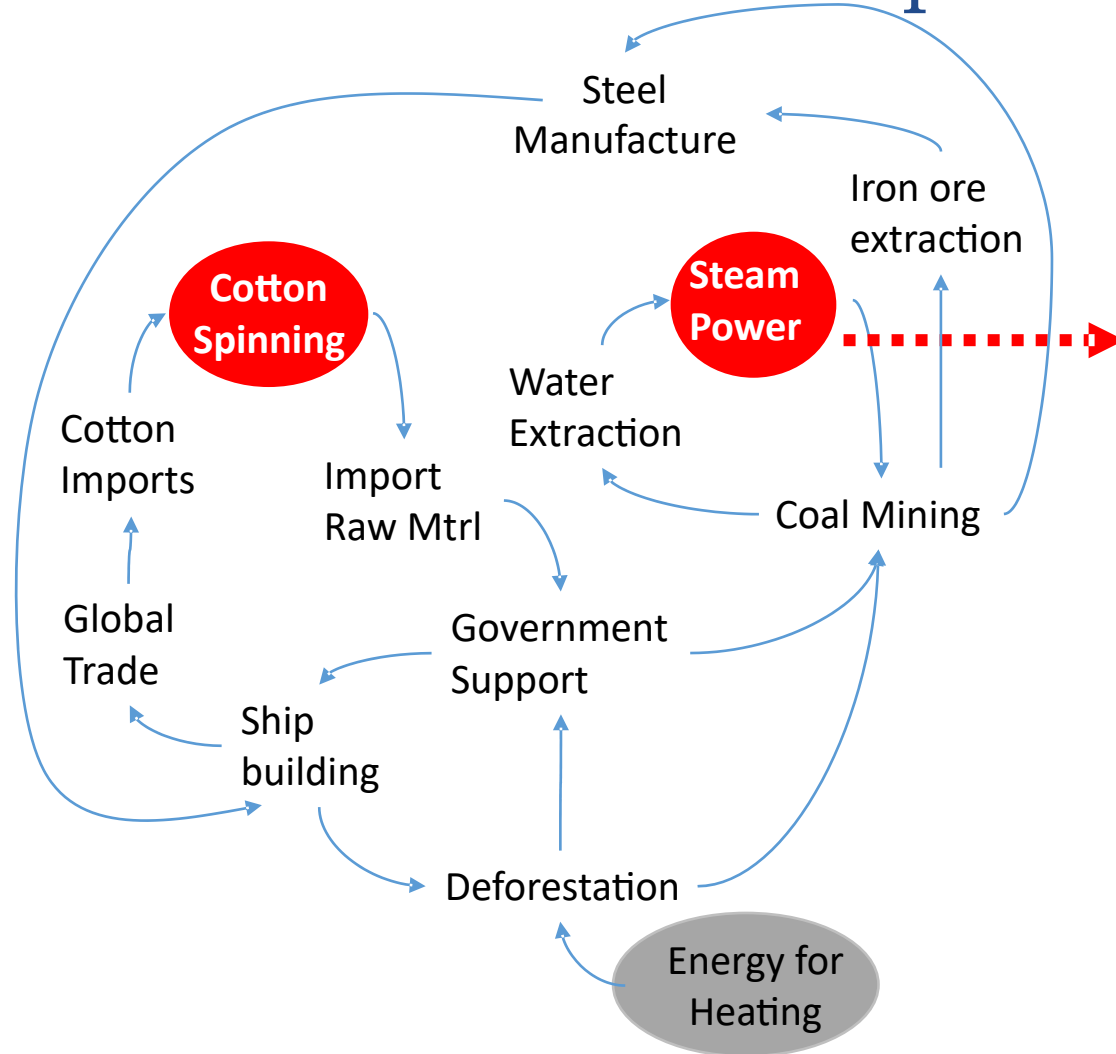
*Level-2: Focus on What:
Revising Goals*

*Level-1: Focus on How:
Precision & efficiency in goal
seeking. Most man-machine
interaction & automation is at
this level, example: robotics*



Source: Public (Internet) A general developmental robotics architecture.

Constraints & loops that fueled Industrialization



Watts speed governor

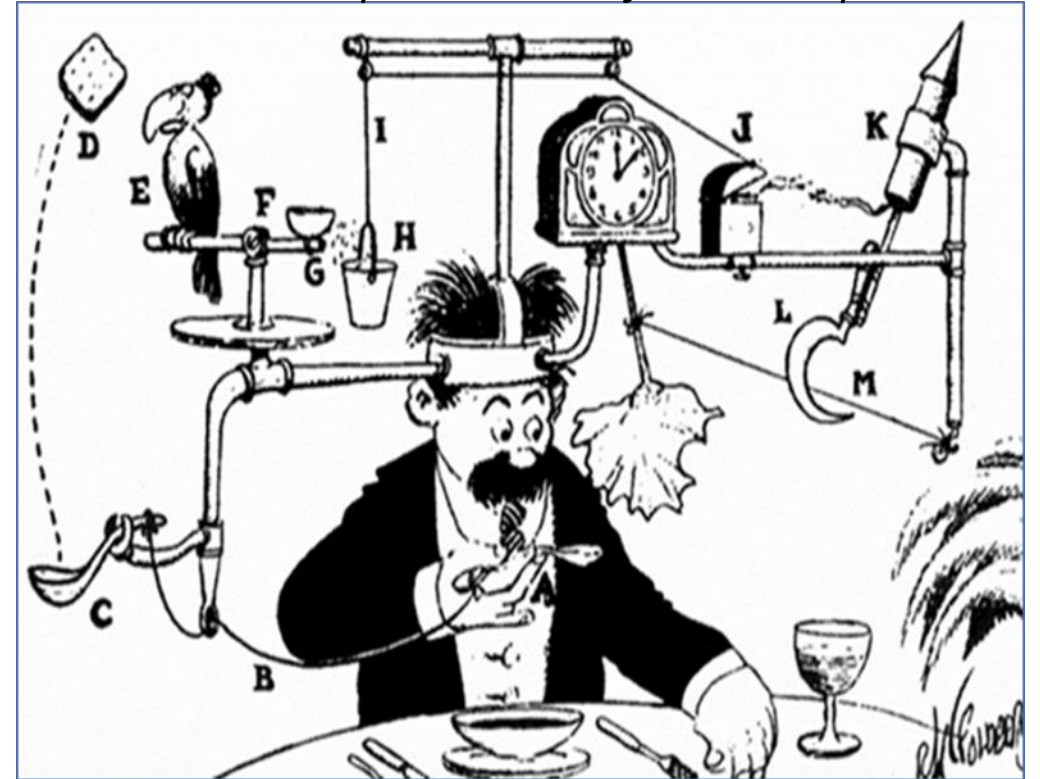
Innovative designs through use of feedback

Innovative solutions/designs can emerge by adding new linkages that connect unique elements in the context through negative or positive feedback loops

For example, soft rock chair powered by energy harvesting



... and some complicated ones for human productivity



Exercise 7

- Identify the feedback loops in the model
- List down those loops that keep the system stable
- List down those loops that have potential to de-stabilize or change the system
- Identify critical intervention points

Appreciate unique aspects of the problem

Reflect on today's session and post your comments.

