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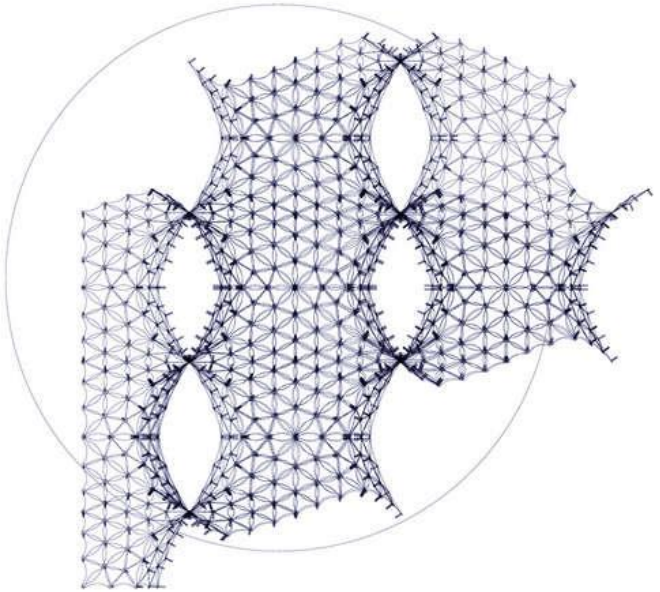

A SYSTEMS APPROACH TO SYSTEM DEVELOPMENT & MODELING

Tuesday April 12, 2016

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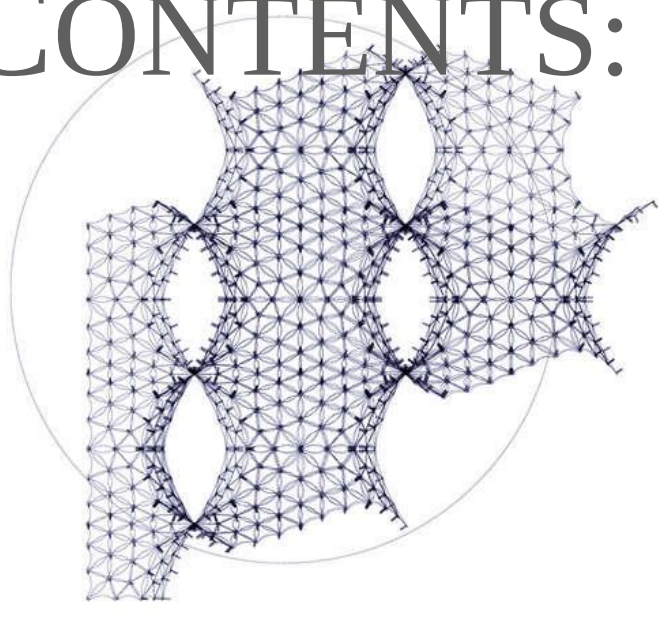

- INTRODUCTION
- SYSTEMS THINKING & SYSTEMS
  - ✓ An approach
  - ✓ A language
  - ✓ Tools
- SYSTEM DYNAMICS (SYSTEM MODELING)


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"Η Αγία Σοφία"
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ΕΠΑΝ ΙΙ
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Avidex
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"ΑΝΤΑΓΩΝΙΣΤΙΚΟΤΗΤΑ & ΕΠΙΧΕΙΡΗΜΑΤΙΚΟΤΗΤΑ"
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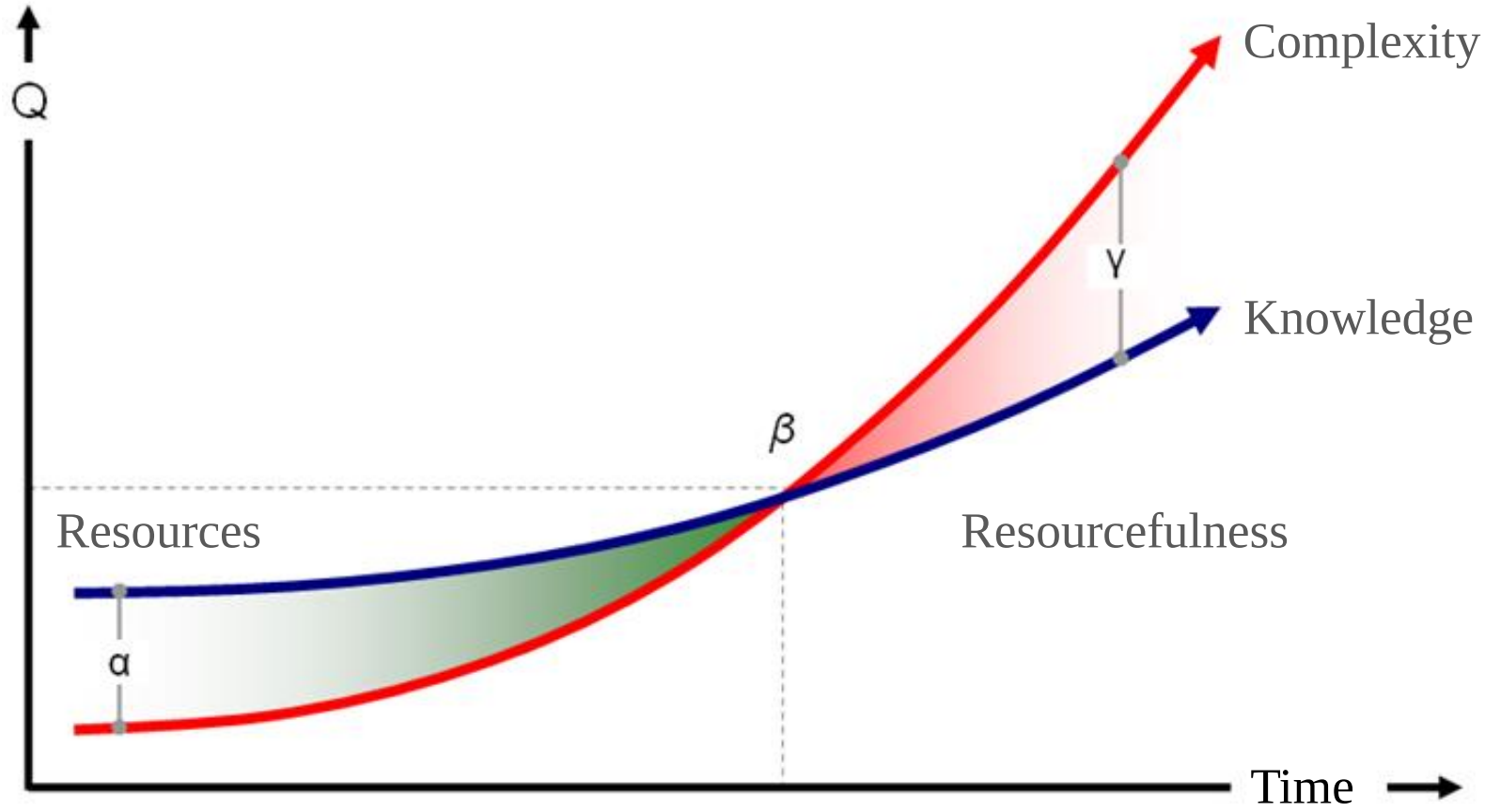
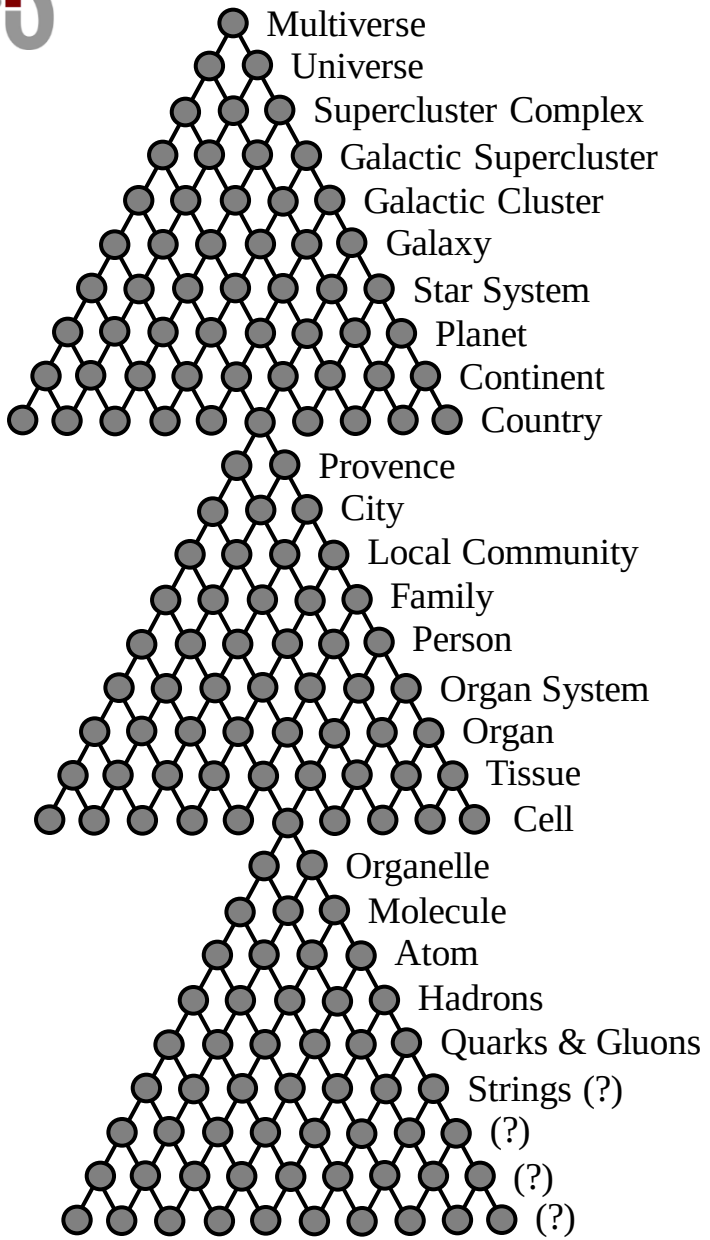
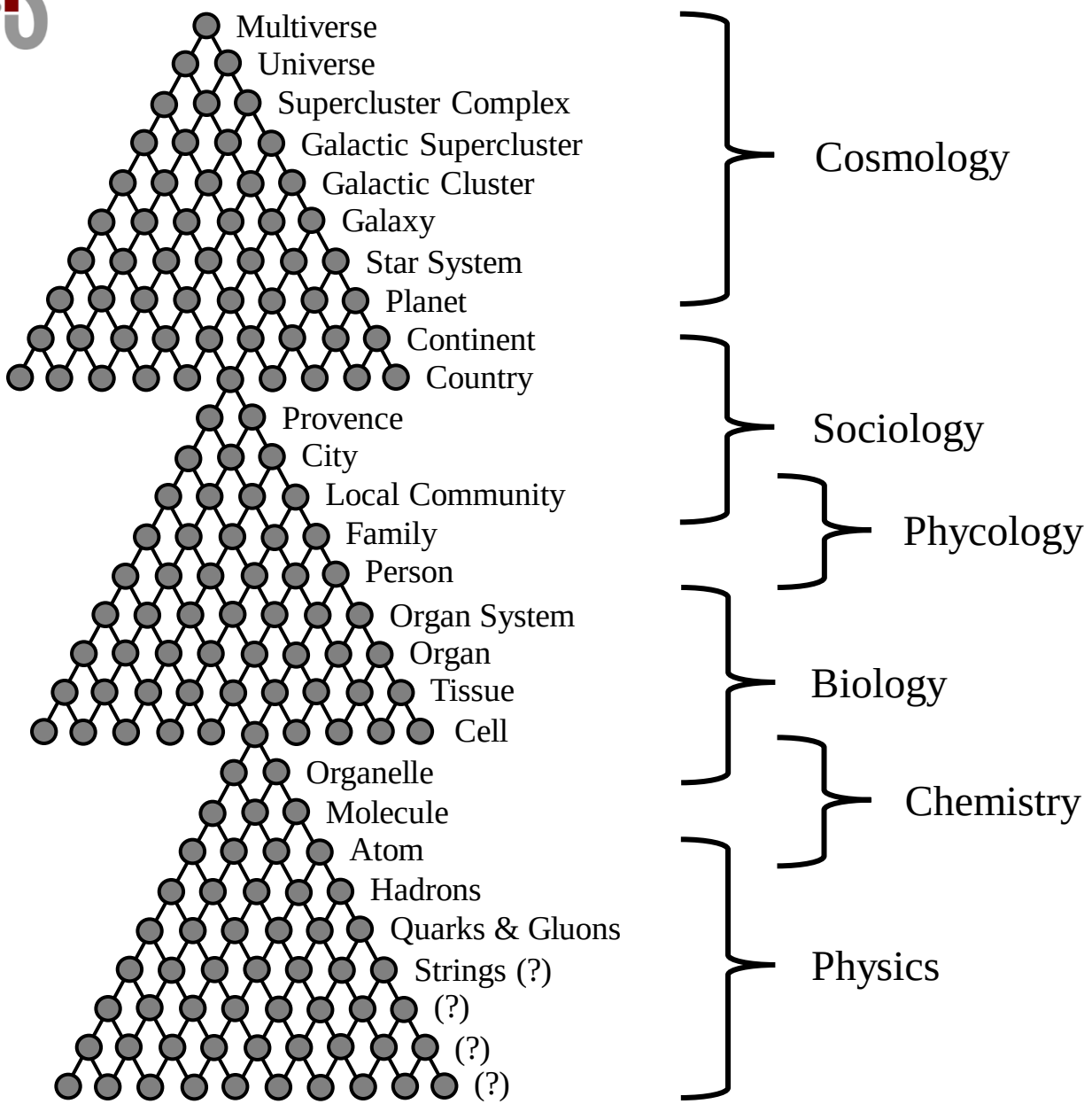
"The stuff of management is **complexity** and **variety** is the scientific name used to quantify complexity" Stafford Beer



How does nature deal with complexity?



Each level in the hierarchy represents an increase in **organizational complexity**, with each "object" being primarily composed of the previous level's basic unit.



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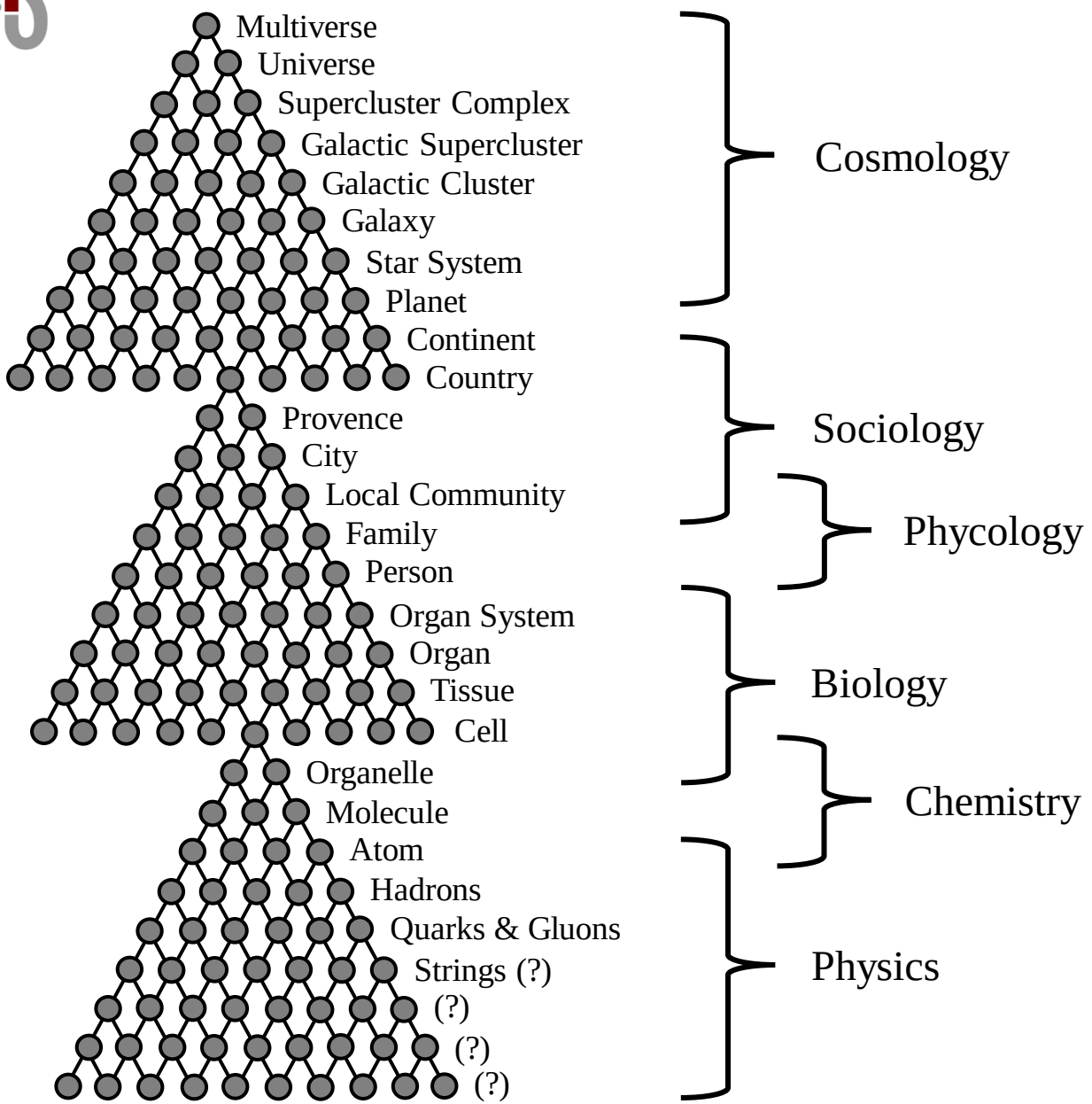


Each level in the hierarchy represents an increase in **organizational complexity**, with each "object" being primarily composed of the previous level's basic unit.

In **systems theory**, **emergence** is a process whereby larger entities, patterns, and regularities arise through interactions among smaller or simpler entities that themselves do not exhibit such properties.

Analytical Thinking	**Systemic Thinking** (Synthesis)
1. Take the thing you are trying to understand apart.	1. Identify the principle whole of which the system studied is a part.
2. Try to understand each part taken separately.	2. Explain the behavior and properties of that containing whole.
3. Aggregate your understanding of the parts, into an understanding of the whole.	3. Disaggregate understanding of the whole to identify the role or function of the system to be understood in the whole of which its is a part.
Analysis *tells us* ***"how"*** *a system works, which yields* ***knowledge***.	***Synthesis*** *tells us* ***"why"*** *a system works the way its does, which yields* ***understanding***.

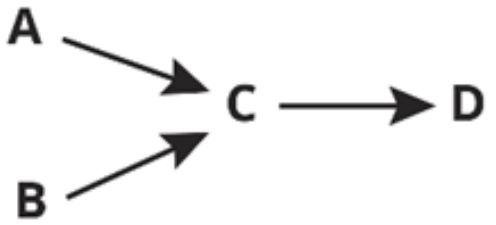
Systemic Thinking (Synthesis)

- An approach
- A language
- A set of tools

Approach

Event Oriented Thinking

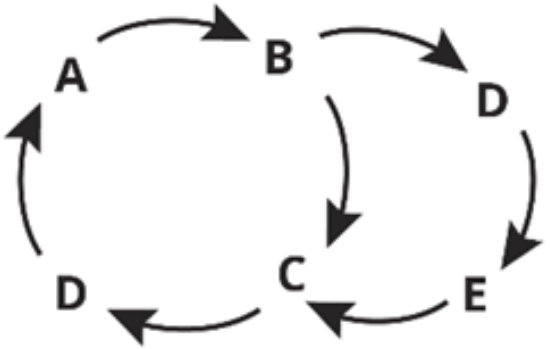
Thinks in straight lines
*(**Analytical Thinking**)*



In event oriented thinking everything can be explained by **causal chains of events**. From this perspective the **root causes** are the events starting the chain of cause and effect, such as A and B.

Systems Thinking

Thinks in loop structures



In systems thinking a system's behavior ***emerges*** from the structure of its feedback loops. **Root causes** are not individual nodes. They are the forces emerging from particular feedback loops.

What is a System:

A **System** is a whole that has one or more **defining function** and that consists of two or more **essential parts** that satisfy **three conditions**:

1. Every essential part can effect the behavior or the properties of the whole.

2. Non of the essential parts can have an independent effect on the defining function(s) of the whole.

3. If you put the parts together *(into subsystems)* they have the same properties that essential parts do.

Russell Ackoff *(1919 – 2009)*

Implications of this definition:

A. A system is a whole that **cannot be divided into independent parts.**

B. The properties of a system are **derived from the way the parts interact, not on how the parts act taken separately**.

Therefore:

When a system is taken apart, two critical things happen:

1. It looses all of its essential properties,

2. and so do its parts

Russell Ackoff *(1919 – 2009)*

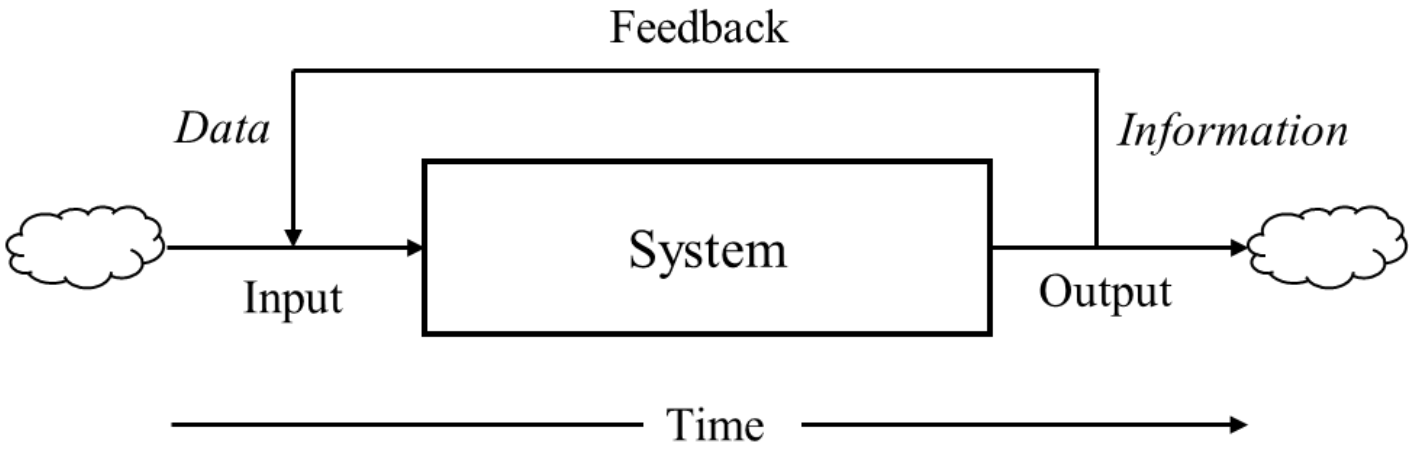
Conclusion:

When the performance of each part of the system taken separately is improved, the performance of the system as a whole may not be, and **usually isn't**.

Russell Ackoff *(1919 – 2009)*

System Function:

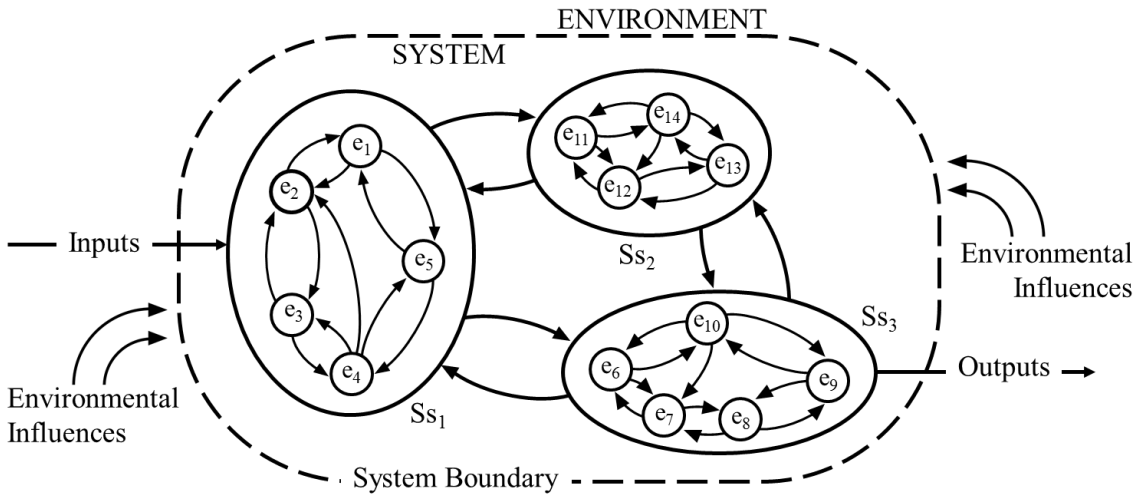
A system's ***function*** refers to the structured processes through which the **system transforms resources from one state to another in a given period of time**. The system receives environmental influences *(inputs)*, and through its function, produces *outputs* that influence its environment.



System Effectiveness:

An ***effective*** system is said to exist when individual structures interact in such a manner that their **input-output relationships constitute the operational utility of the function of the unified whole**.

The **effectiveness of the function of the whole is determined by the structural and behavioral relationships** that exist between the various parts of which the whole is composed.



System Efficiency:

A system's ***efficiency*** is expressed as the ratio between the resources that the system "absorbs" from its environment and the output that it releases to its environment through its function.

System Dynamics:

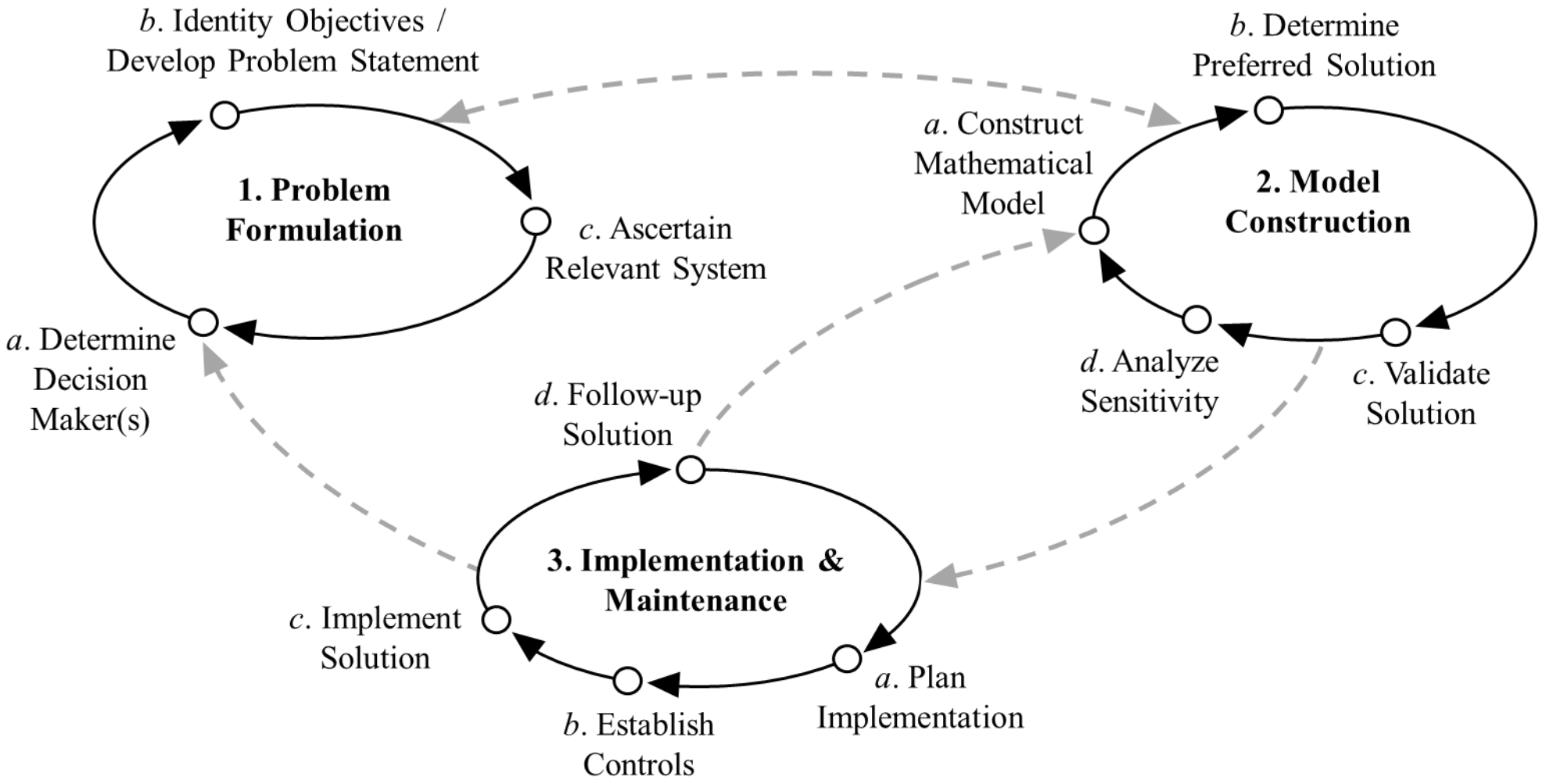
System dynamics has been successfully used to **understand the dynamic behavior of complex systems**. It uses **information feedback and time delays that affect the behavior of a system** as a means of evaluating business and other organizational and social contexts.

To fuse data and create **diagnostic networks** through which to **share knowledge** so as to provide **advance warning of problems** and **failures**.

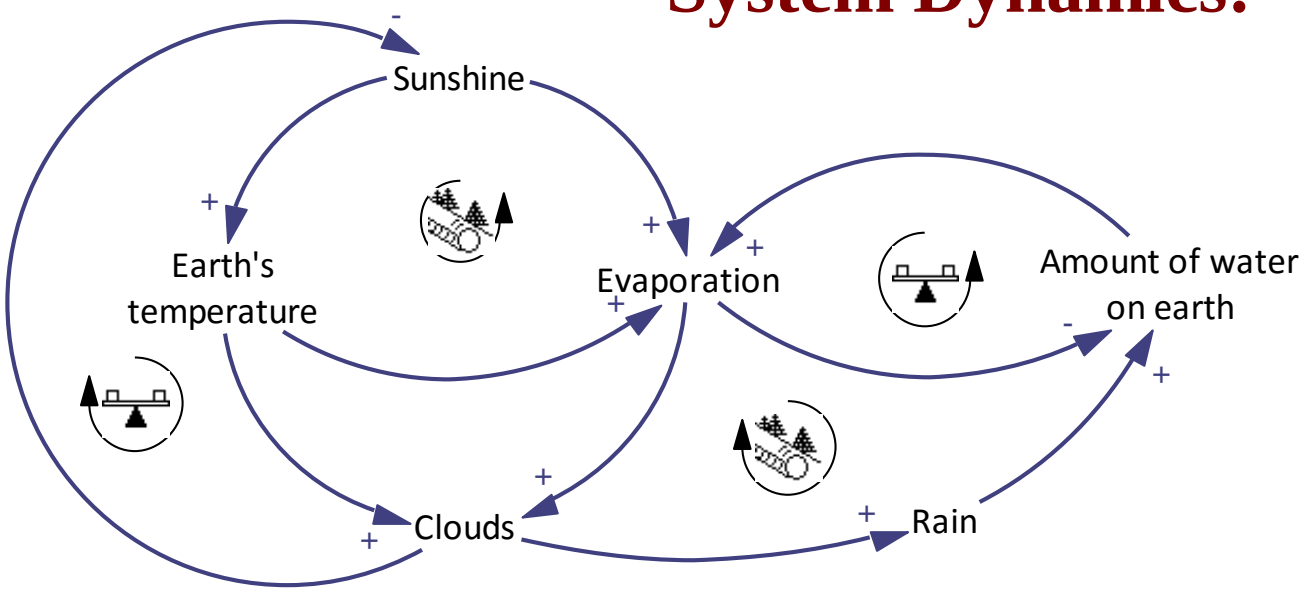
Predictive Analytics: Analyze ***current*** and ***historical facts*** to make predictions about future or otherwise unknown events.

Prospective Analytics: Take the knowledge gained through ***retrospective*** and ***predictive*** analytics to show available **options for changing the current state**, as well as the associated ***consequences*** of decisions taken.

The Modeling Process



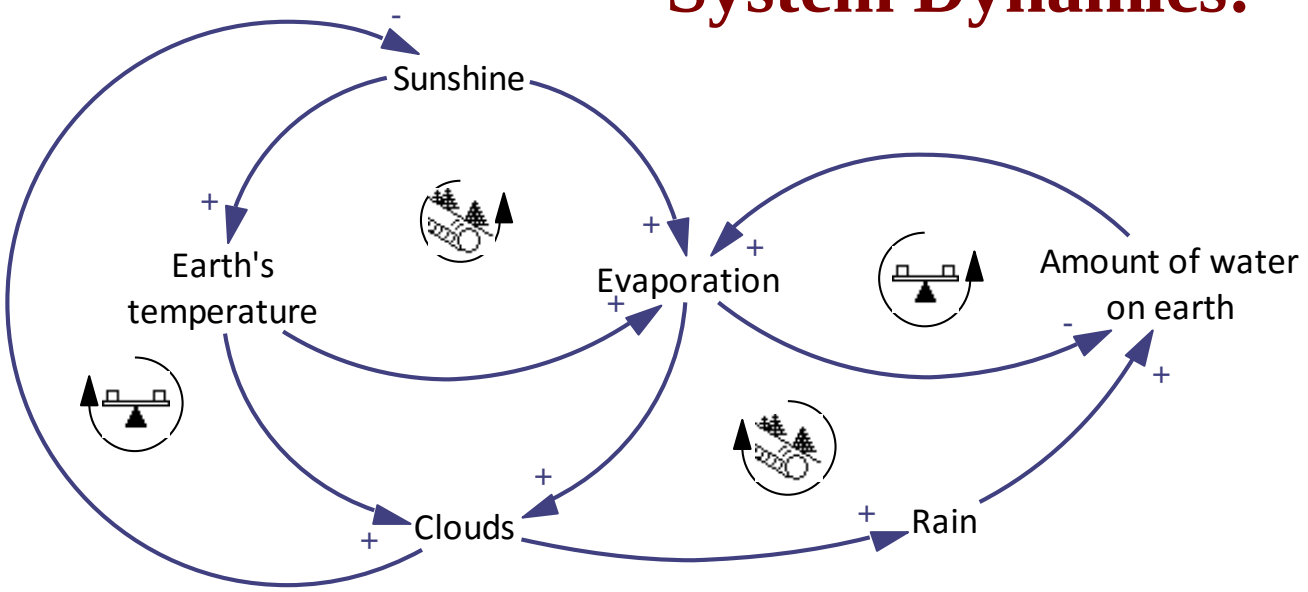
System Dynamics:



System Dynamics:

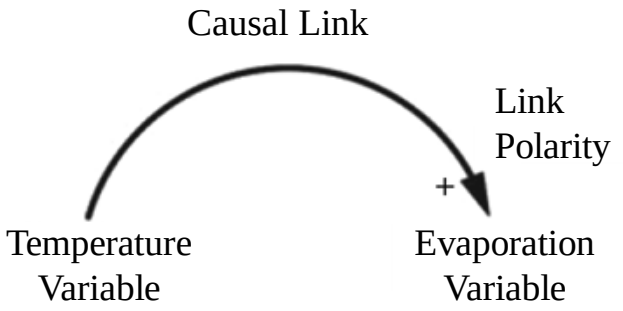
Construction of a causal loop diagram begins by ***identifying the system variables*** and denoting their **causal influences**.

The **causal links** among the system's variable are shown as **arrows**. Causal links are assigned a **polarity, positive (+), or negative (-),** indicating that a change in the value of variable X *(cause)* will result in a change in the value of variable Y *(effect)*.

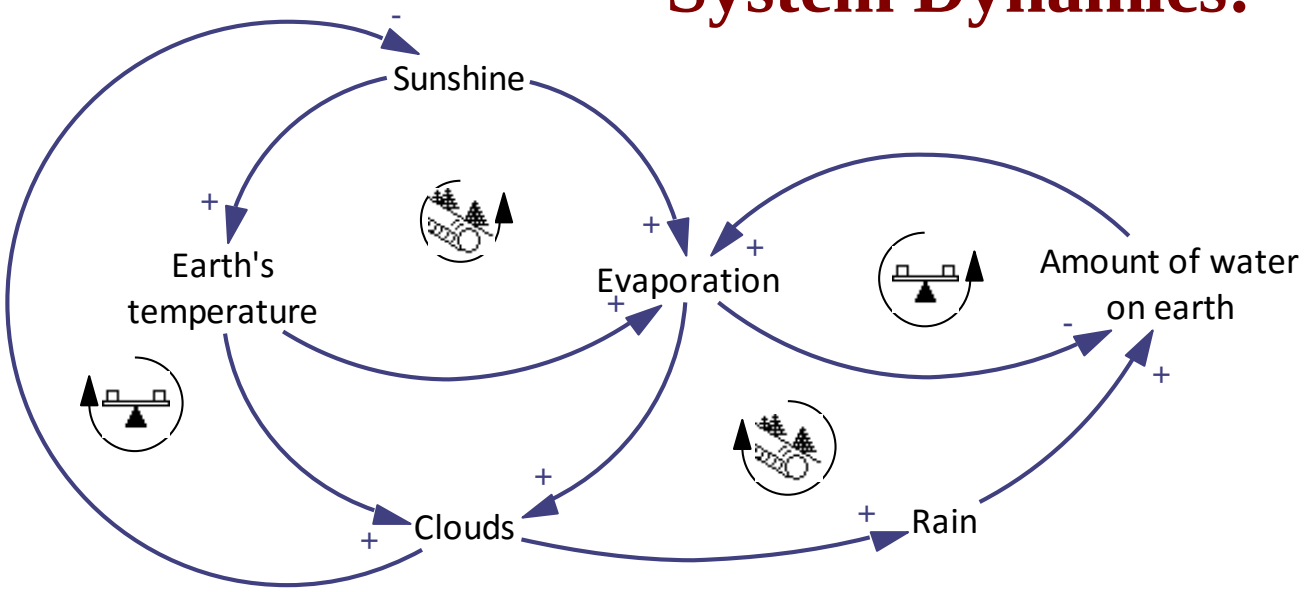


A **positive link** indicates that a change in the value of variable X will result in a change of the value of variable Y in the **same direction** above *(or below)* what it would otherwise have been.

A **negative link** indicates that a change in the value of variable X will result in a change in the value of variable Y in the **opposite direction**, above *(or below)* what it would otherwise have been.



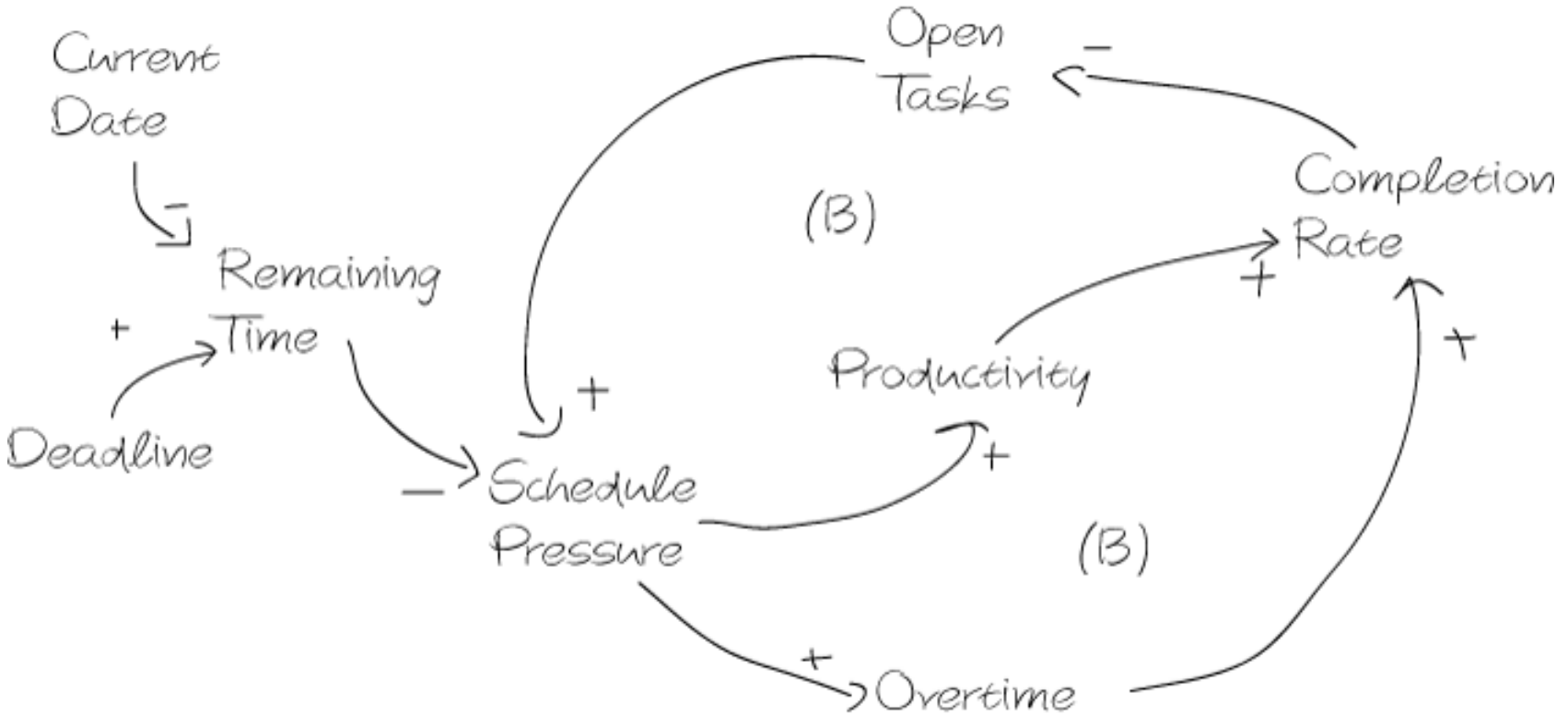
System Dynamics:



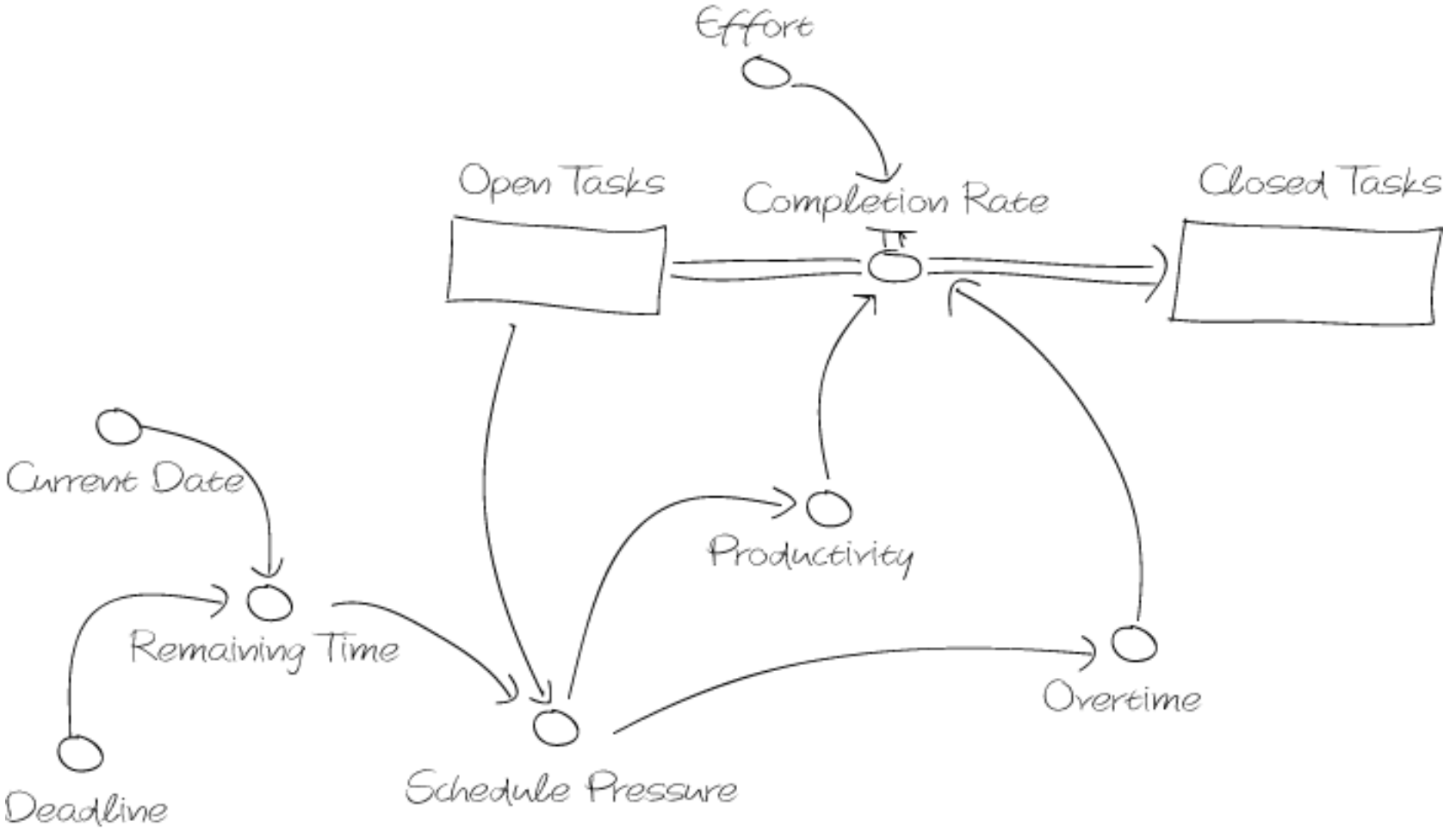
A **positive or reinforcing loop** supports change, amplifies deviations, and leads to rapid growth at an ever-increasing rate.

A **negative or balancing loop** resists change, seeks balance and provides a stabilizing effect towards a goal value.

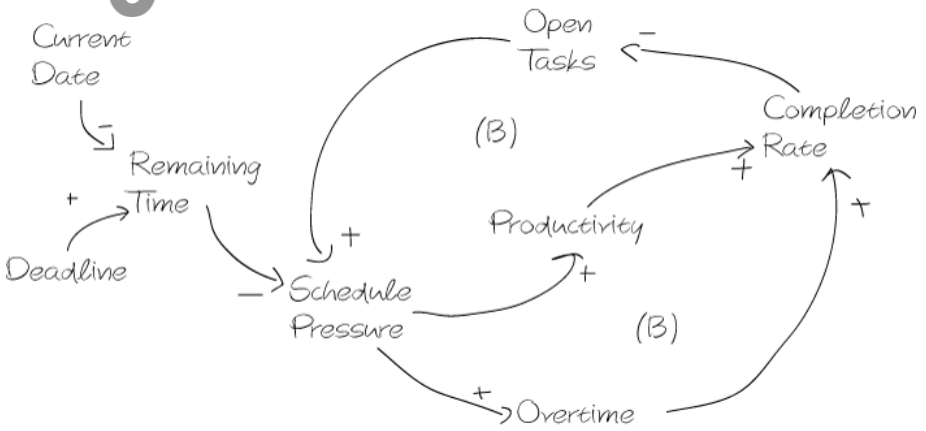
The Modeling Process: Causal Loop Diagram

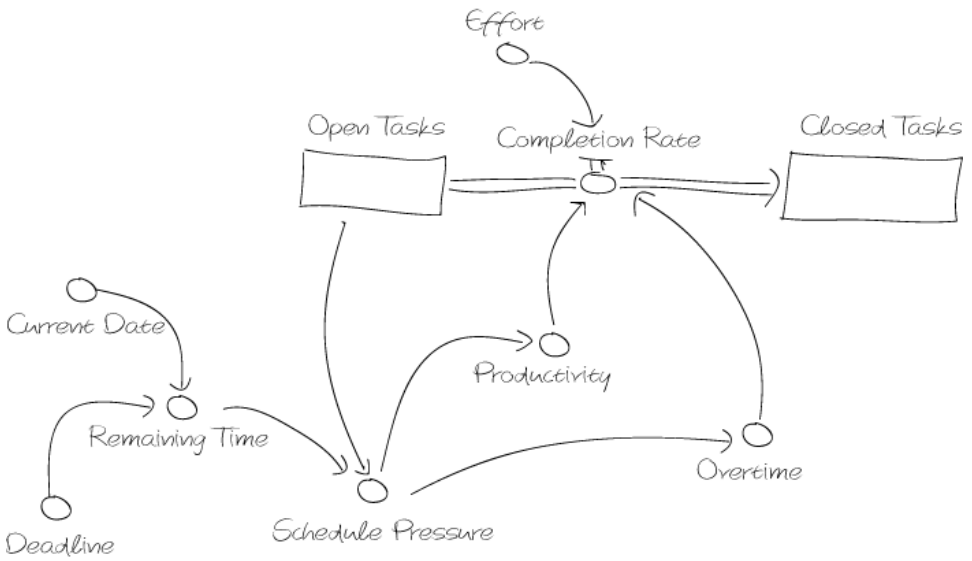


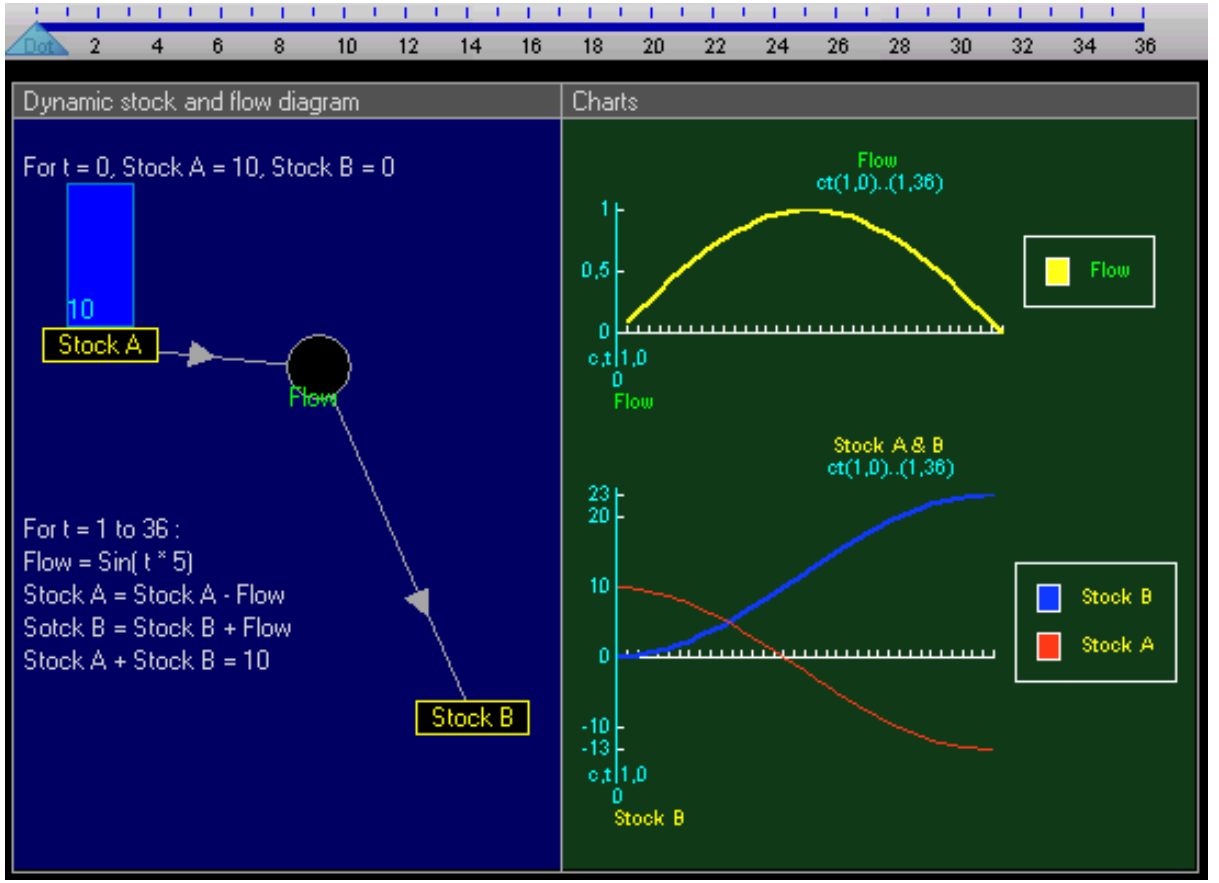
The Modeling Process: Stocks & Flows Diagram



The Modeling Process: Dynamic Simulation





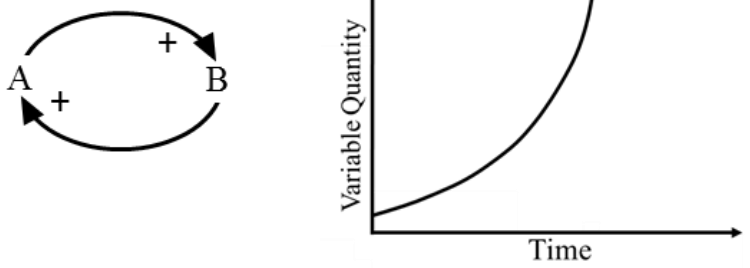


Equations that change the two stocks via the flow are: $\text{Stock A} = \int_0^t -\text{Flow}\ dt$ $\text{Stock B} = \int_0^t \text{Flow}\ dt$

System Dynamics:

System Structure

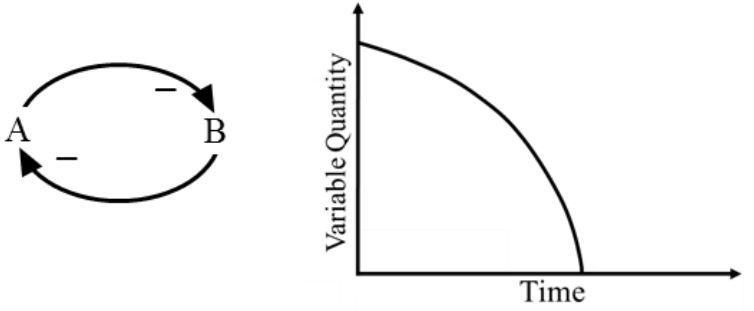
Pattern of Behavior



A. Positive Feedback - *Exponential Growth*

System Structure

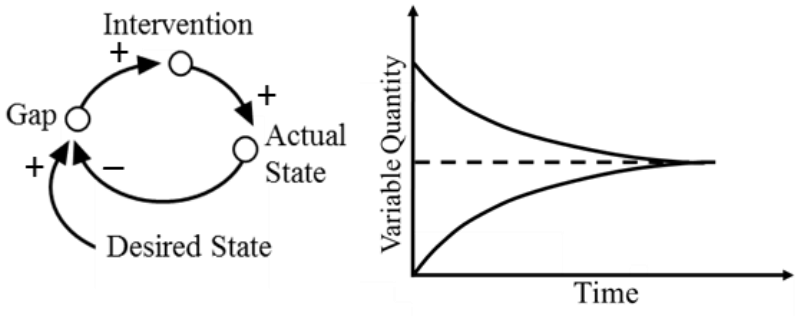
Pattern of Behavior



B. Positive Feedback - *Exponential Decline*

System Structure

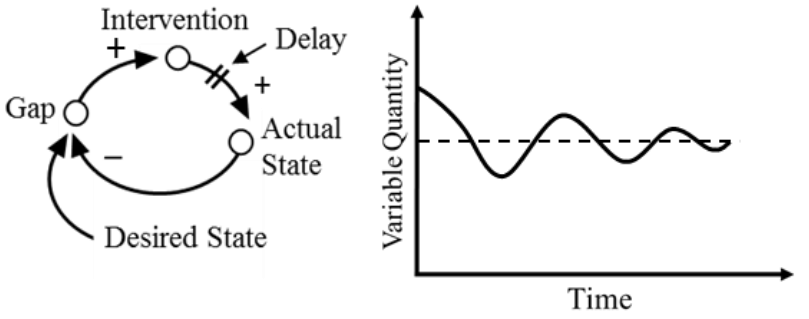
Pattern of Behavior



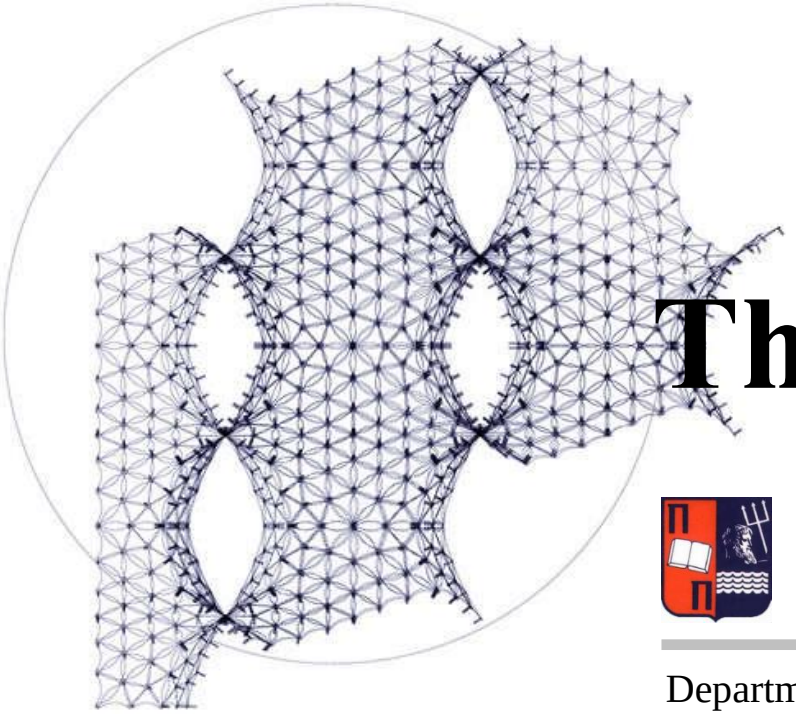
C. Negative Feedback – Goal Seeking

System Structure

Pattern of Behavior



D. Negative Feedback – Goal Seeking, with Delay



Thank you …

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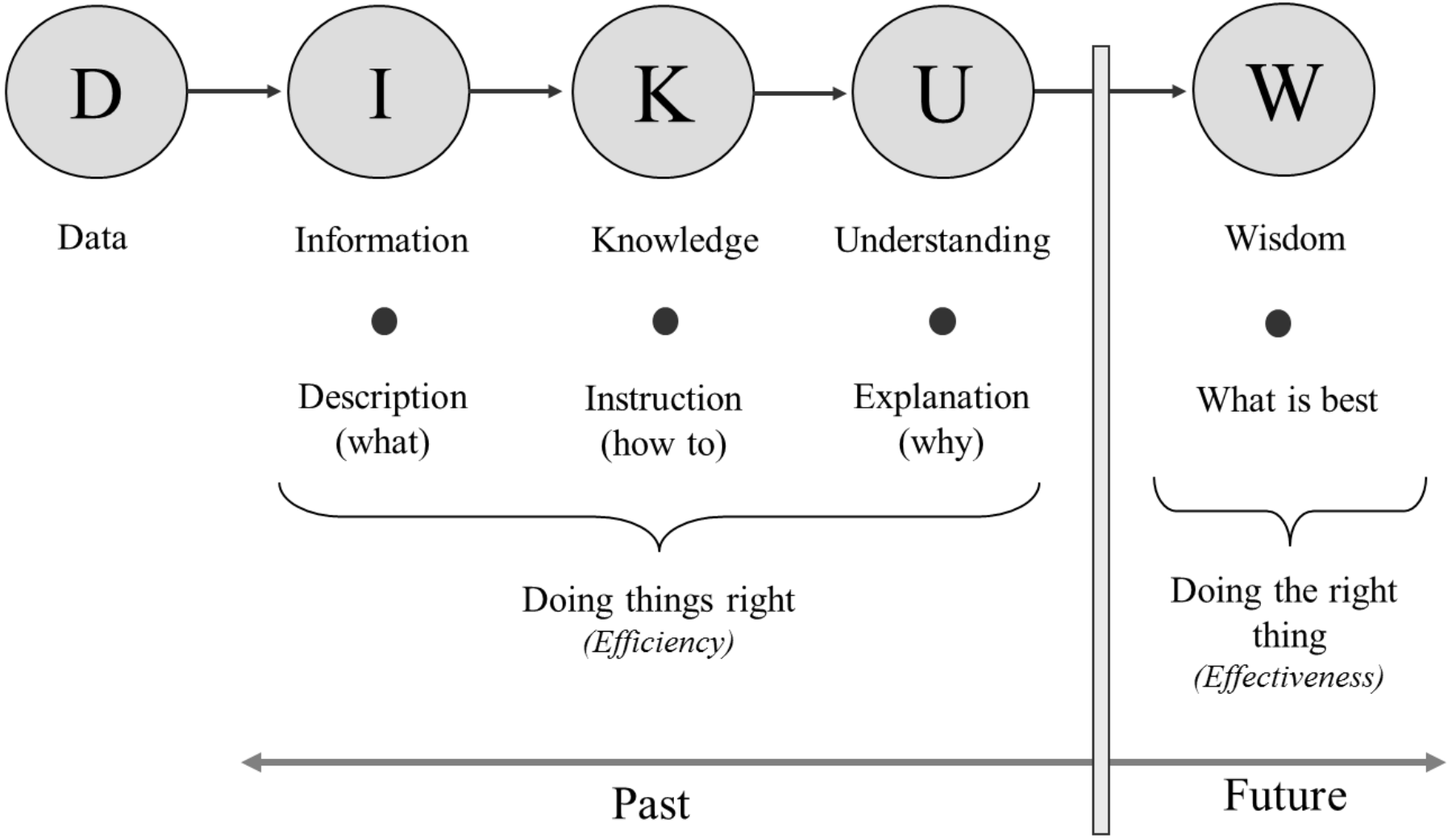
DATA - INFORMATION - KNOWLEDGE HIERARCH



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