Systems Thinking

Systems Analysis

Author: Eng. Carlos Andrés Sierra, M.Sc.
cavirguezs@udistrital.edu.co

Lecturer
Computer Engineer
School of Engineering
Universidad Distrital Francisco José de Caldas

2024-III

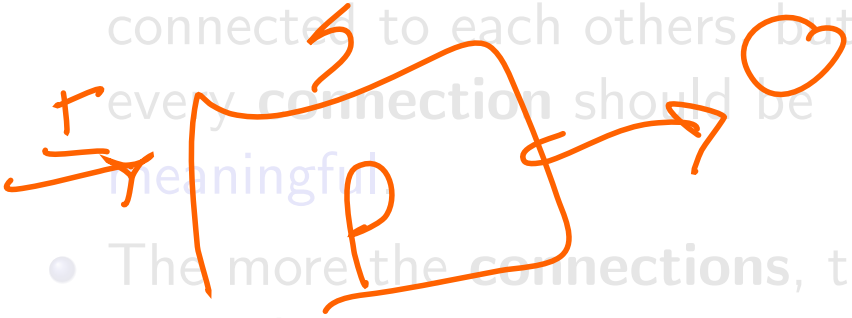
Outline

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Outline

Introduction to Systems Thinking I

- A **system** is just a set of elements interconnected with a common purpose.
- Not all elements must be connected to each others, but every **connection** should be meaningful.
- The more the **connections**, the more the system complexity. Representation must be feasible.
- Each element must have **at least** one connection. Isolated elements makes no sense in a system.



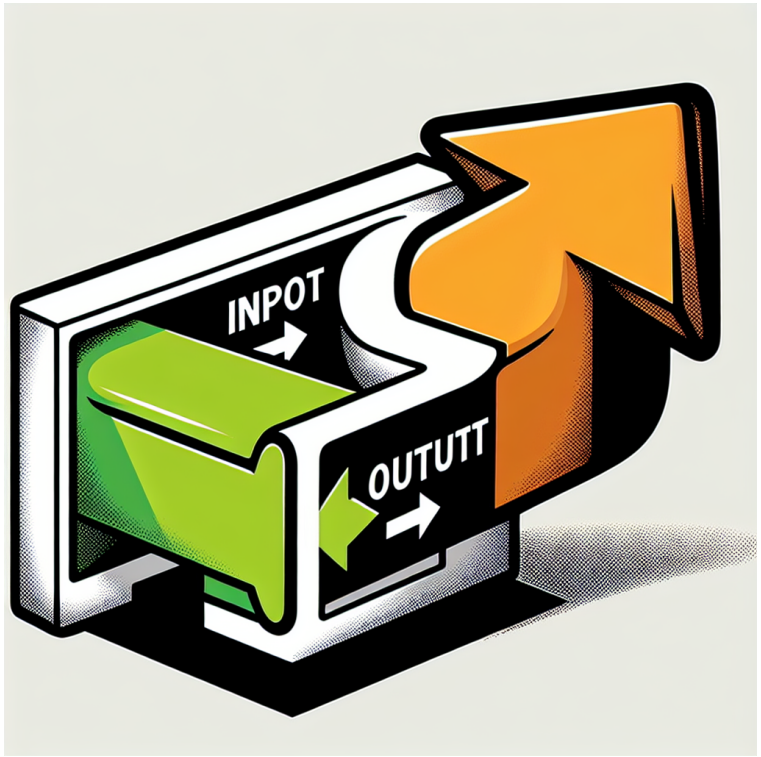


Figure: Prompt: Draw an image of a box with input and output arrows to a box.

Introduction to Systems Thinking I

- A **system** is just a set of elements interconnected with a common purpose.
- Not all elements must be connected to each others, but every **connection** should be meaningful.
- The more the **connections**, the more the system complexity. Representation must be feasible.
- Each element must have **at least** one connection. Isolated elements makes no sense in a system.

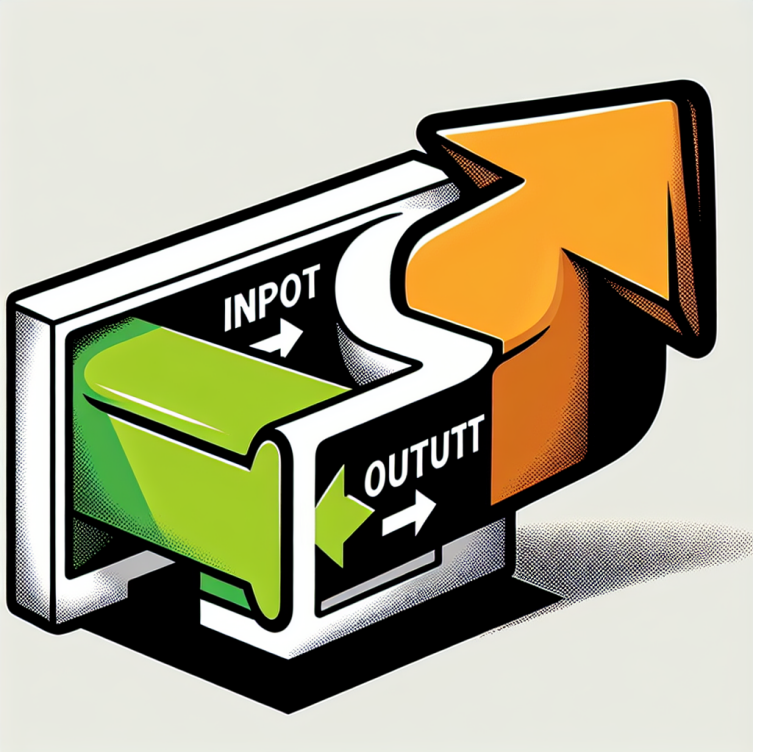


Figure: Prompt: Draw an image of a box with input and output arrows to a box.

Introduction to Systems Thinking I

- A **system** is just a set of elements interconnected with a common purpose.
- Not all elements must be connected to each others, but every **connection** should be meaningful.
- The more the **connections**, the more the system complexity. Representation must be feasible.
- Each element must have **at least** one connection. Isolated elements makes no sense in a system.

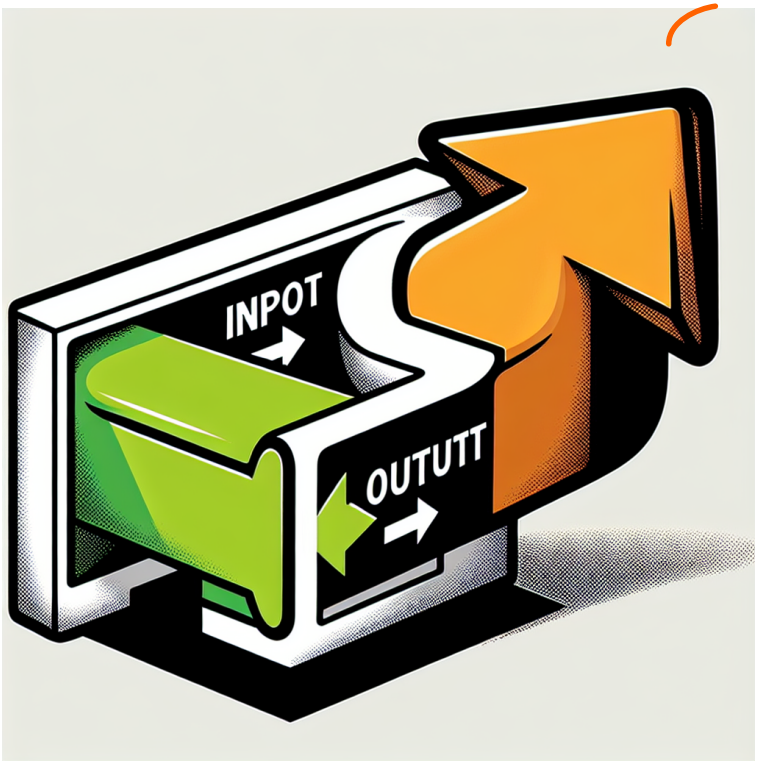


Figure: Prompt: Draw an image of a box with input and output arrows to a box.

Introduction to Systems Thinking I

- A **system** is just a set of elements interconnected with a common purpose.
- Not all elements must be connected to each others, but every **connection** should be meaningful.
- The more the **connections**, the more the system complexity. Representation must be feasible.
- Each element must have **at least** one connection. Isolated elements makes no sense in a system.

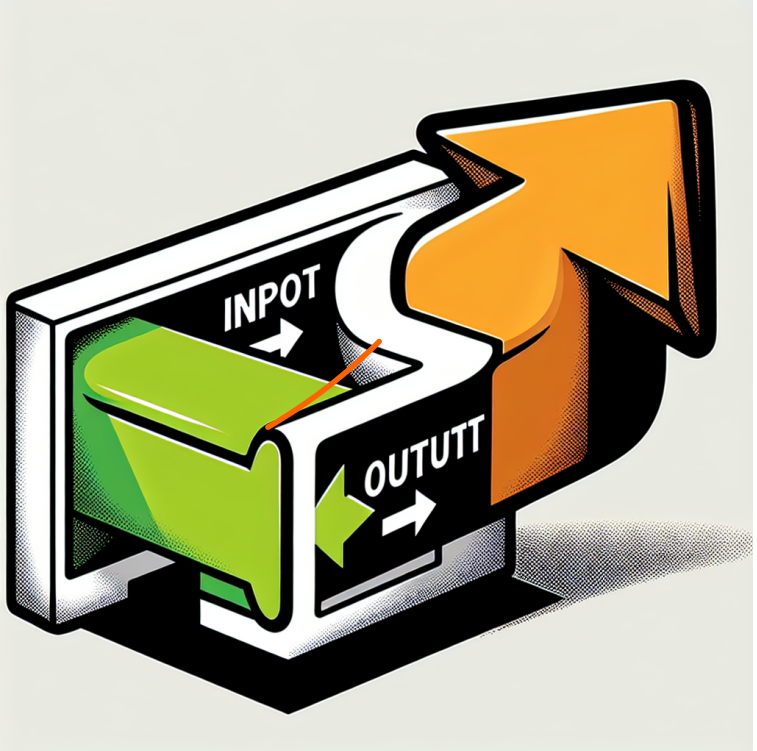
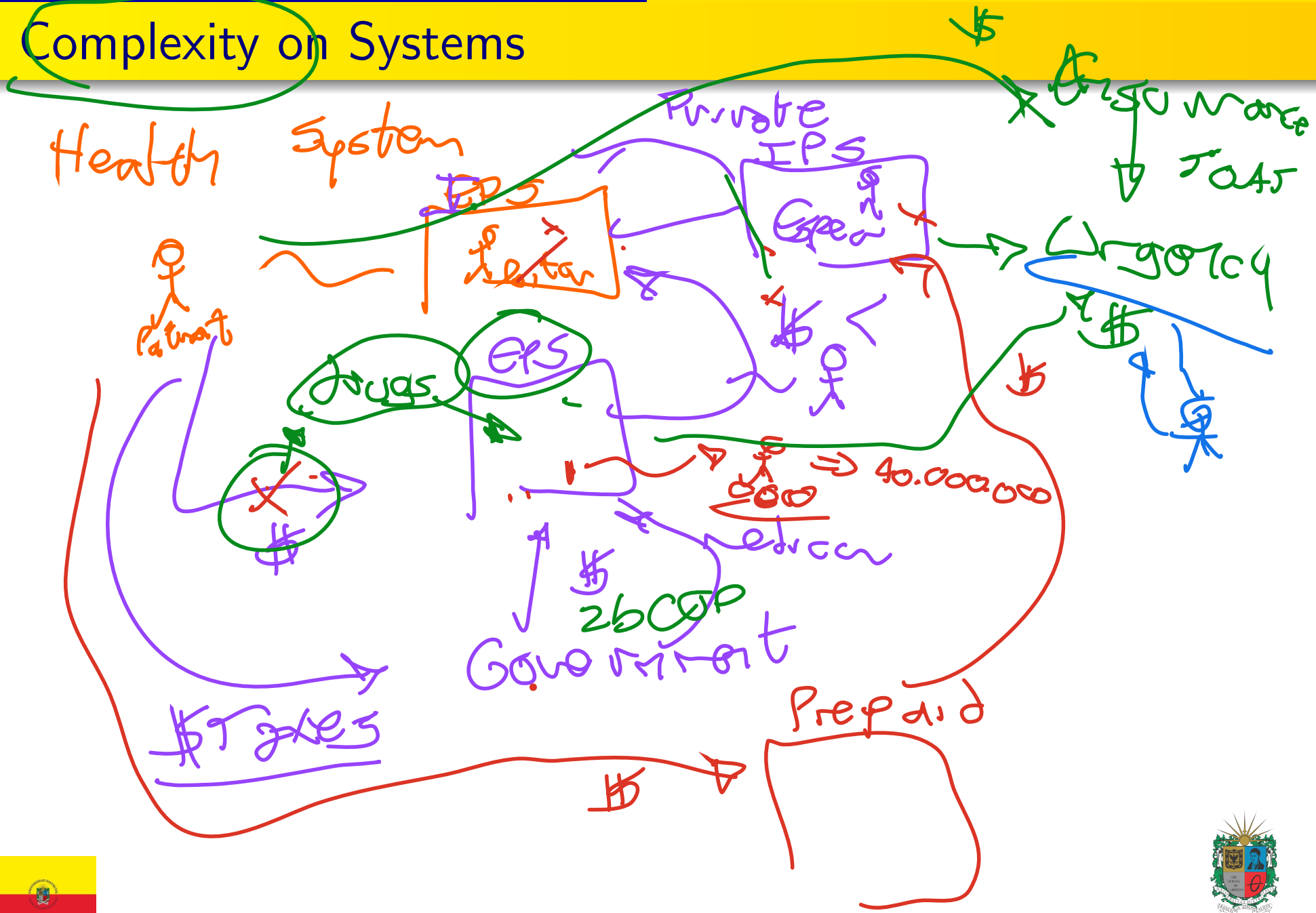
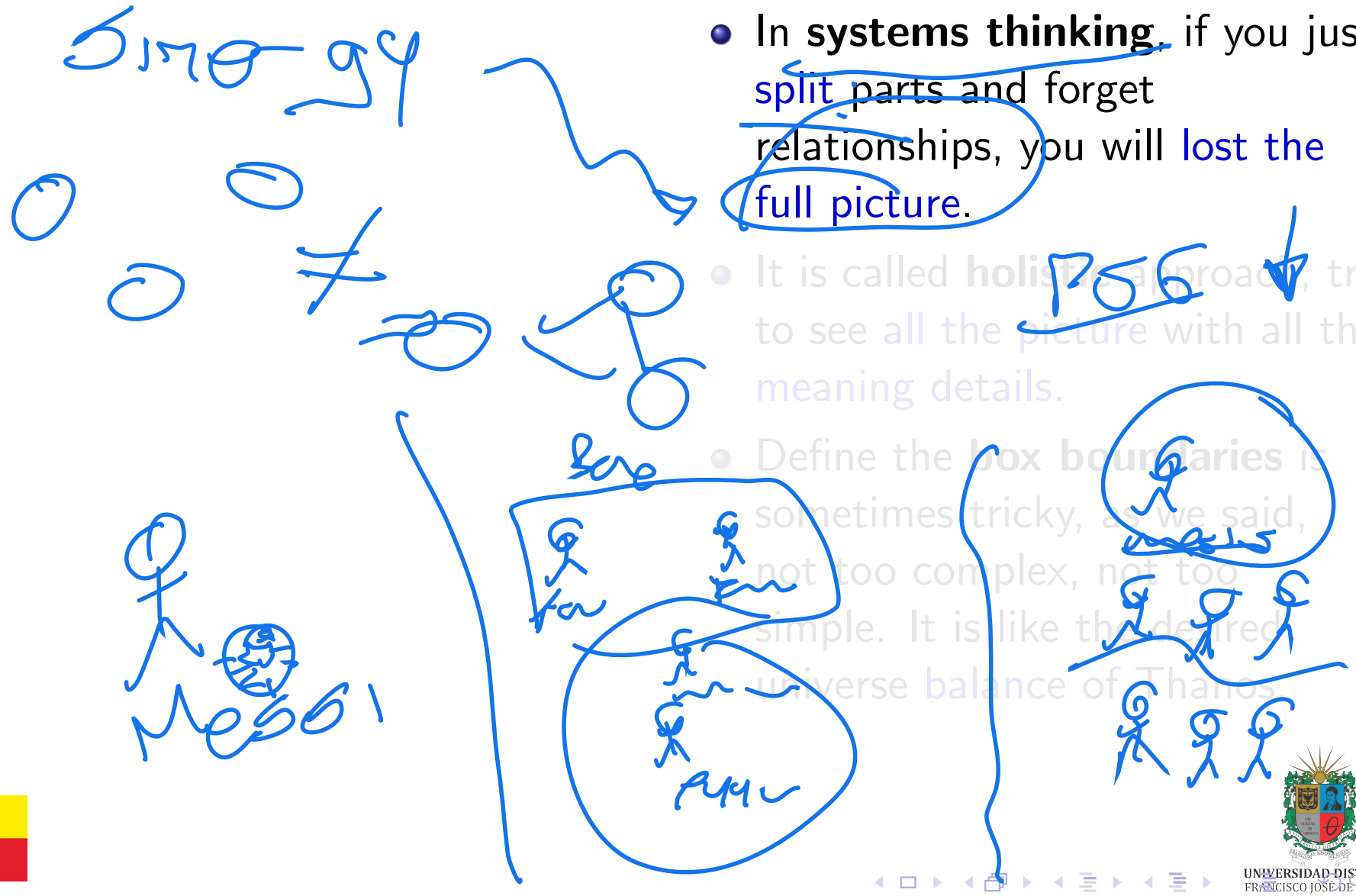


Figure: Prompt: Draw an image of a box with input and output arrows to a box.

Complexity on Systems

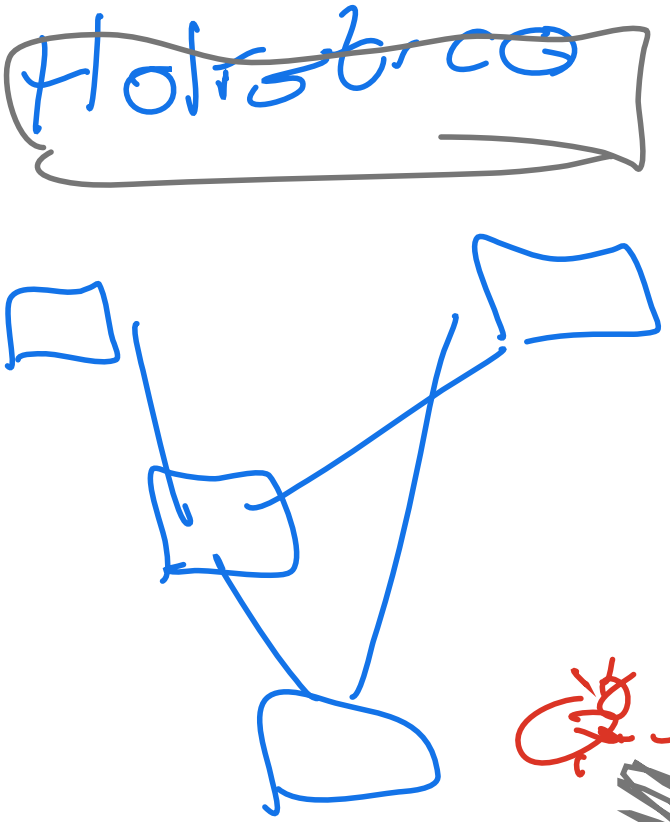


Introduction to Systems Thinking II

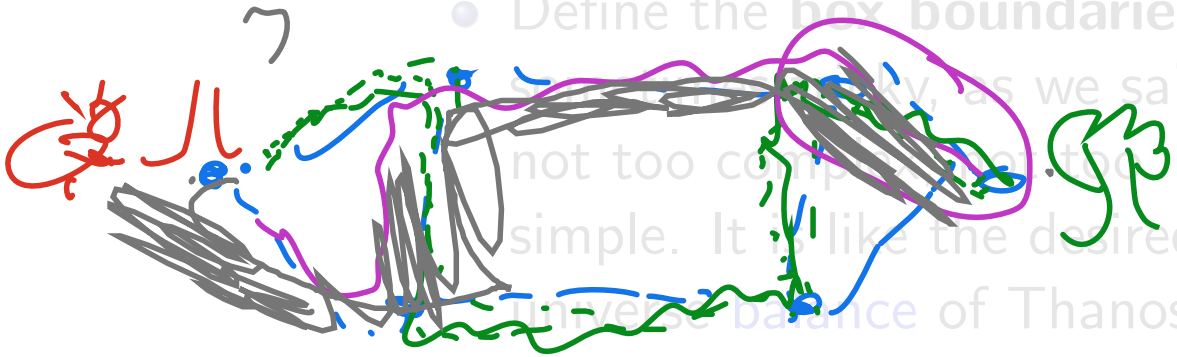


- In **systems thinking**, if you just split parts and forget relationships, you will lost the full picture.
- It is called **holistic** approach, try to see all the picture with all the meaning details.
- Define the **box boundaries** is sometimes tricky, as we said, not too complex, not too simple. It is like the desired universe balance of Thanos.

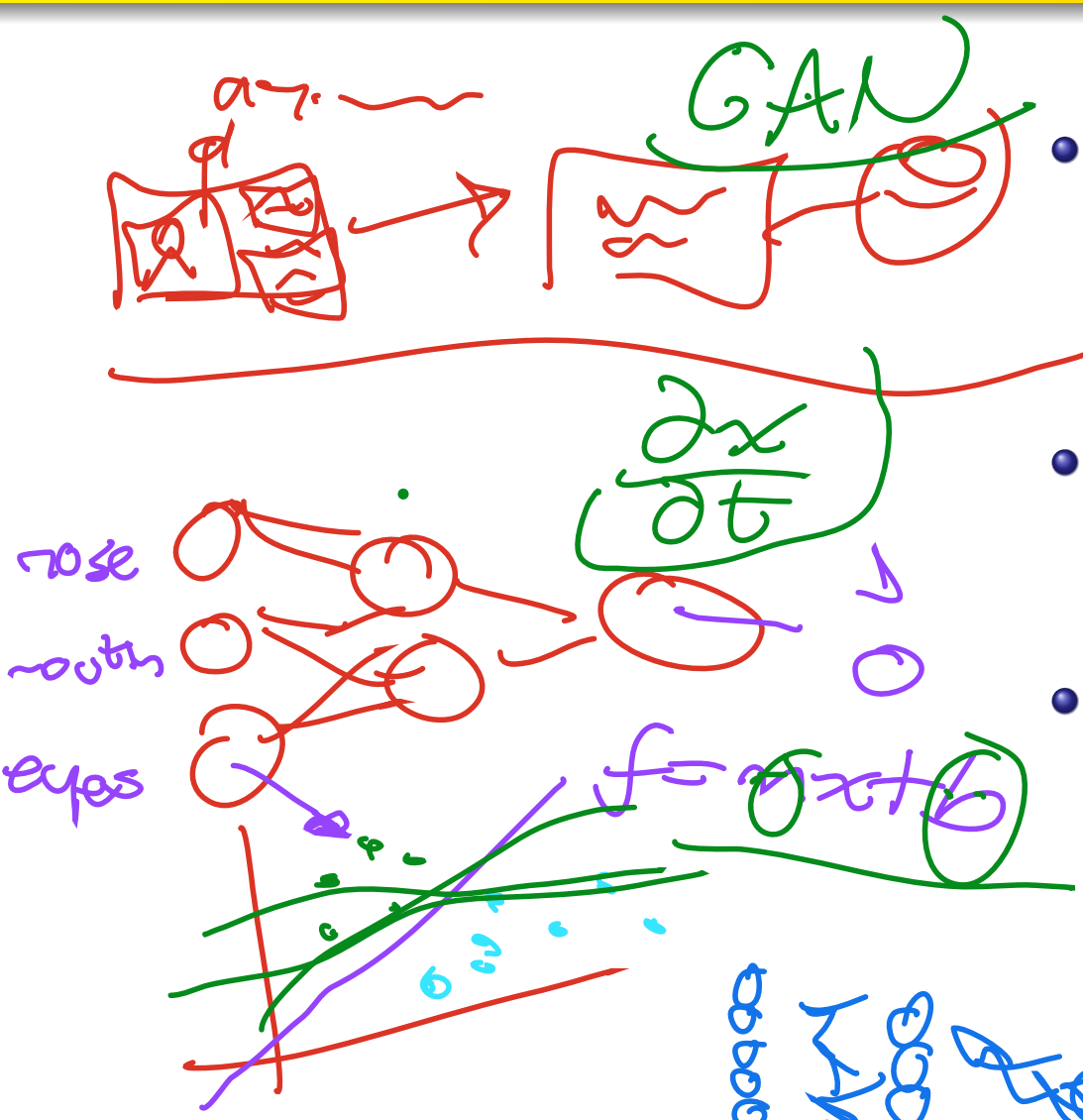
Introduction to Systems Thinking II



- In **systems thinking**, if you just split parts and forget relationships, you will lost the full picture.
- It is called **holistic** approach, try to see all the picture with all the meaning details.
- Define the **box boundaries** is subjective, as we said, not too complex, not too simple. It is like the desired Universe balance of Thanos.



Introduction to Systems Thinking II



- In **systems thinking**, if you just split parts and forget relationships, you will lost the full picture.
- It is called **holistic** approach, try to see all the picture with all the meaning details.
- Define the **box boundaries** is sometimes tricky, as we said, not too complex, not too simple. It is like the desired universe balance of Thanos.

Introduction to Systems Thinking III

- Another important concept is the **homeostasis**, it means to put a system in an equilibrium state. That is hard, **systems** are both not in equilibrium and resilient to change. **Chaotic attractors** study is useful here.
- A **system** is more than the sum of the parts. It means, relationships, behaviors, recovery capacity, are forgotten when you see the system just as its parts.

Introduction to Systems Thinking III

- Another important concept is the **homeostasis**, it means to put a system in an equilibrium state. That is hard, **systems** are both not in equilibrium and resilient to change. **Chaotic attractors** study is useful here.
- A **system** is more than the sum of the parts. It means, relationships, behaviors, recovery capacity, are forgotten when you see the system just as its parts.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Introduction to Systems Thinking IV

- **Systems thinking** is a way to understand and represent problems in order to find the best possible solution.
- Think in a **problem as a system** lets you understand details, involved elements, relevant information.
- **Systems** should be viable, auto-sostenible, provides internal feedback loops, and also looks like a whole live-entity.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Introduction to Systems Thinking IV

- **Systems thinking** is a way to understand and represent problems in order to find the best possible solution.
- Think in a **problem as a system** lets you understand details, involved elements, relevant information.
- **Systems** should be viable, auto-sostenible, provides internal feedback loops, and also looks like a whole live-entity.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Introduction to Systems Thinking IV

- **Systems thinking** is a way to understand and represent problems in order to find the best possible solution.
- Think in a **problem as a system** lets you understand details, involved elements, relevant information.
- **Systems** should be viable, auto-sostenible, provides internal feedback loops, and also looks like a whole live-entity.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Introduction to Systems Thinking V

- **Computation** helps to represent behaviors in a mathematical way. Also, it lets to find patterns and information, simplify process; an example of all this is the Artificial Intelligence.
- **Top-Down** approach is useful when you want to see the full picture, and then split it into parts.
- **Bottom-Up** approach is useful when you want to see the parts and then connect them to get the full picture.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Introduction to Systems Thinking V

- **Computation** helps to represent behaviors in a mathematical way. Also, it lets to find patterns and information, simplify process; an example of all this is the Artificial Intelligence.
- **Top-Down** approach is useful when you want to see the full picture, and then split it into parts.
- **Bottom-Up** approach is useful when you want to see the parts and then connect them to get the full picture.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Introduction to Systems Thinking V

- **Computation** helps to represent behaviors in a mathematical way. Also, it lets to find patterns and information, simplify process; an example of all this is the Artificial Intelligence.
- **Top-Down** approach is useful when you want to see the full picture, and then split it into parts.
- **Bottom-Up** approach is useful when you want to see the parts and then connect them to get the full picture.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Introduction to Systems Thinking VI

- It is important to understand the **sensitivity** of the problem, because it leads to make better decisions.
- The most simple **system definition** is: for some inputs, after apply them a designed process, you will get some outputs.
- In a **deterministic** world the same inputs get the same outputs. Real-life is not deterministic.

Introduction to Systems Thinking VI

- It is important to understand the **sensitivity** of the problem, because it leads to make better decisions.
- The most simple **system definition** is: for some inputs, after apply them a designed process, you will get some outputs.
- In a **deterministic** world the same inputs get the same outputs. Real-life is not deterministic.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Introduction to Systems Thinking VI

- It is important to understand the **sensitivity** of the problem, because it leads to make better decisions.
- The most simple **system definition** is: for some inputs, after apply them a designed process, you will get some outputs.
- In a **deterministic** world the same inputs get the same outputs. Real-life is not deterministic.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Introduction to Systems Thinking VII

- As **randomness** is normal in real-world, think in determinist processes is dangerous. Use **stochastic processes** is a better approach.
- **Stochastic processes** make use of probability, and this gets a better real-world behaviors representation.
- Here **Chaos Theory** becomes a useful tool. To make it simple, chaos could be defined as a harmonic balance between rules and randomness.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Introduction to Systems Thinking VII

- As **randomness** is normal in real-world, think in determinist processes is dangerous. Use **stochastic processes** is a better approach.
- **Stochastic processes** make use of probability, and this gets a better real-world behaviors representation.
- Here **Chaos Theory** becomes a useful tool. To make it simple, chaos could be defined as a harmonic balance between rules and randomness.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Introduction to Systems Thinking VII

- As **randomness** is normal in real-world, think in determinist processes is dangerous. Use **stochastic processes** is a better approach.
- **Stochastic processes** make use of probability, and this gets a better real-world behaviors representation.
- Here **Chaos Theory** becomes a useful tool. To make it simple, chaos could be defined as a harmonic balance between rules and randomness.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Systems Structure

Case of Study: Trasportation System

Outline

General Systems Theory I

- In **general systems theory** the idea is to see a problem since different autonomous study areas, it helps to create a better full-picture of a problem or situation.
- Systems are **dynamical**, for that reason you need to define boundaries and constraints to control analysis. Also, some systems are highly susceptible to changes from the environment.

Figure: Prompt: Draw systems a different levels in the context astronomy.

General Systems Theory I

- In **general systems theory** the idea is to see a problem since different autonomous study areas, it helps to create a better full-picture of a problem or situation.
- Systems are **dynamical**, for that reason you need to define boundaries and constraints to control analysis. Also, some systems are highly susceptible to changes from the environment.

Figure: Prompt: Draw systems a different levels in the context astronomy.

General Systems Theory II

- A biologist call **Ludwig Von Bertallanfy** created the General Systems Theory around seventy years ago.
- His idea was to undertand and represents in a very simple way some **individuals** and **populations behaviors**, also the interactions or different elements in nature.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

General Systems Theory II

- A biologist call **Ludwig Von Bertallanfy** created the General Systems Theory around seventy years ago.
- His idea was to undertand and represents in a very simple way some **individuals** and **populations behaviors**, also the interactions or different elements in nature.

General Systems Theory III

- He started to write a book, but he just had some ideas and not the enough background to develop them.
- He waited twenty years for mathematical and computational **concepts evolution**, and then he was capable to finish the book citing more applied concepts.

General Systems Theory III

- He started to write a book, but he just had some ideas and not the enough background to develop them.
- He waited twenty years for mathematical and computational **concepts evolution**, and then he was capable to finish the book citing more applied concepts.

General Systems Theory IV

- In nature, in real-world, **everything is a system**. However, more you go dive to understand the problem, more the complexity arises.
- In this point, **systems theory** is useful. Some **patterns** could be detected, some **details** could be discarded.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

General Systems Theory IV

- In nature, in real-world, **everything is a system**. However, more you go dive to understand the problem, more the complexity arises.
- In this point, **systems theory** is useful. Some **patterns** could be detected, some **details** could be discarded.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

General Systems Theory V

- **Systems hierarchies** are useful to split big problems into components, work on specific components, and then just connect as the context leads.
- A **system** could be represent by multiple internal systems. Big system is called **super system**, internal ones are called **subsystems**.

General Systems Theory V

- **Systems hierarchies** are useful to split big problems into components, work on specific components, and then just connect as the context leads.
- A **system** could be represent by multiple internal systems. Big system is called **super system**, internal ones are called **subsystems**.

General Systems Theory VI

- In nature ,you could think an ecosystem is a **super system** composed by different **subsystems**: water system, solar system, predator-victim , forest system,. . .
- The human body is a **system**, and inside there are many **subsystems**. Each **subsystem** it's basically connected to each other, and if one fails, it is like a domino effect.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

General Systems Theory VI

- In nature ,you could think an ecosystem is a **super system** composed by different **subsystems**: water system, solar system, predator-victim , forest system,. . .
- The human body is a **system**, and inside there are many **subsystems**. Each **subsystem** it's basically connected to each other, and if one fails, it is like a domino effect.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

General Systems Theory VII

- **Everything** in the real-world, in the universe, **is a system**. The hardest thing is to get the right representation.
- Remember **concepts** as: snowball effect, butterfly effect, domino effect, The message is the same, be careful with **details**, failures and changes, there is **not small impact**.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

General Systems Theory VII

- **Everything** in the real-world, in the universe, **is a system**. The hardest thing is to get the right representation.
- Remember **concepts** as: snowball effect, butterfly effect, domino effect, The message is the same, be careful with **details**, failures and changes, there is **not small impact**.

Representation of a System

General Systems Theory VIII

- Sometimes you have an **expected output**. Major part of the time it's hard to achieve it, you must be prepared for everything.
- **Black-box** is a type of model when you want to get the desired output based on specific input, but yo don't want to expose the **process** to achieve it.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

General Systems Theory VIII

- Sometimes you have an **expected output**. Major part of the time it's hard to achieve it, you must be prepared for everything.
- **Black-box** is a type of model when you want to get the desired output based on specific input, but yo don't want to expose the **process** to achieve it.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

General Systems Theory IX

- **White-box** are models where the processes are open to check, validate, follow step-by-step. It is useful when you want to understand how the **system works**.
- **Critical Systems Practice** is a methodology to deal with **Critical Systems Thinking** study field. CSP has 4 main stages: *Explore*, *Produce*, *Intervene*, and *Check* — $EPIC$.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

General Systems Theory IX

- **White-box** are models where the processes are open to check, validate, follow step-by-step. It is useful when you want to understand how the **system works**.
- **Critical Systems Practice** is a methodology to deal with **Critical Systems Thinking** study field. CSP has 4 main stages: *Explore*, *Produce*, *Intervene*, and *Check* — $EPIC$.

Systems Structure

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Outline

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Human Organizations I

- **Sinergy** is a simple but powerful concept: the aim of the parts is more than the parts itself.
- It means the **interactions** could boost the capabilities of the parts of the **system**. Also, it lets both understand **emergent behaviors** and define improvements in **systems**.
- One of the main concepts is the **theory of the computation**. Based on graphs, you could define a computational machine.

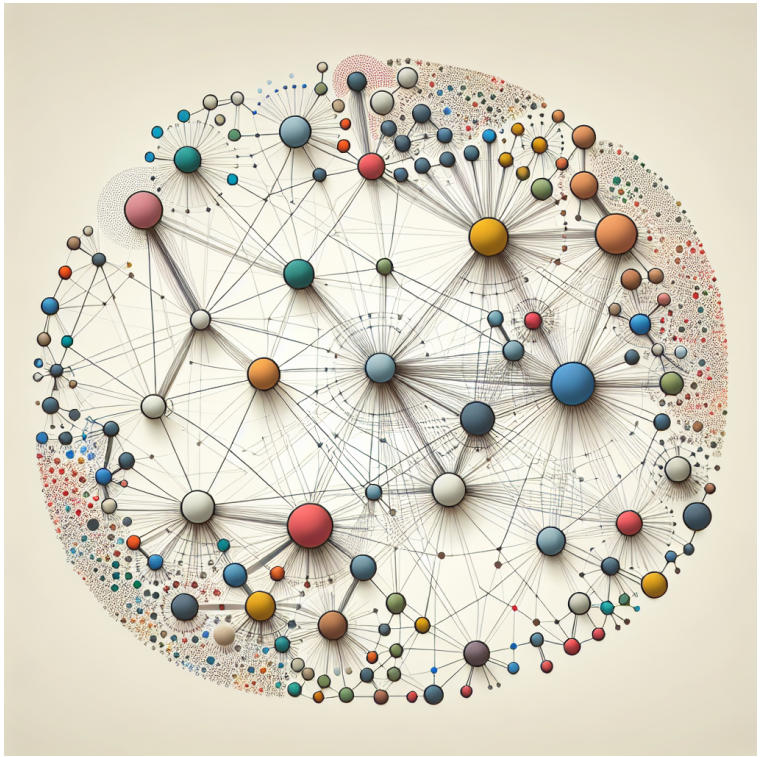


Figure: Prompt: Define a draw of clusters in social networks.

Human Organizations I

- **Sinergy** is a simple but powerful concept: the aim of the parts is more than the parts itself.
- It means the **interactions** could boost the capabilities of the parts of the **system**. Also, it lets both understand **emergent behaviors** and define improvements in **systems**.
- One of the main concepts is the **theory of the computation**. Based on graphs, you could define a computational machine.

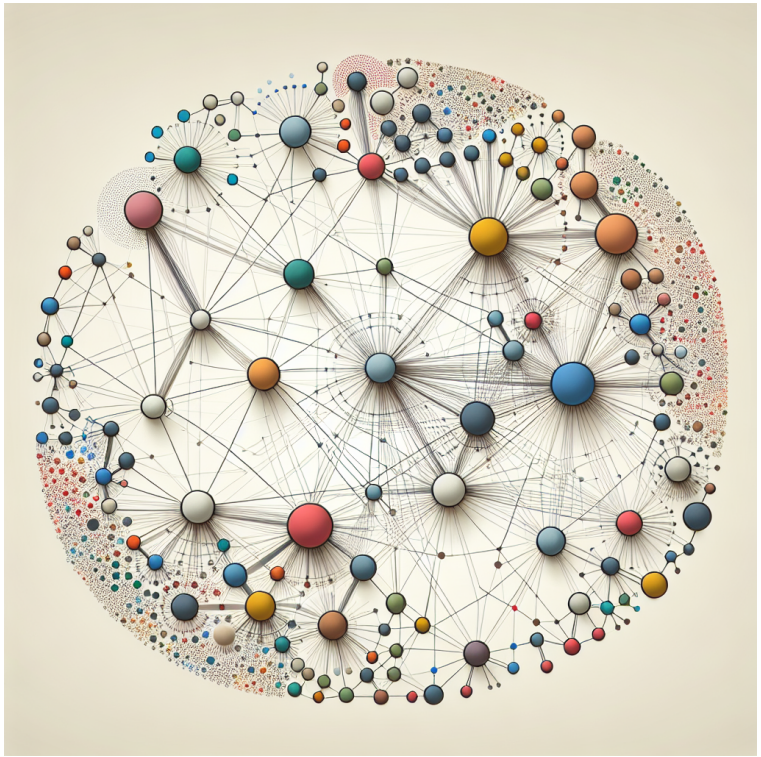


Figure: Prompt: Define a draw of clusters in social networks.

Human Organizations I

- **Sinergy** is a simple but powerful concept: the aim of the parts is more than the parts itself.
- It means the **interactions** could boost the capabilities of the parts of the **system**. Also, it lets both understand **emergent behaviors** and define improvements in **systems**.
- One of the main concepts is the **theory of the computation**. Based on graphs, you could define a computational machine.

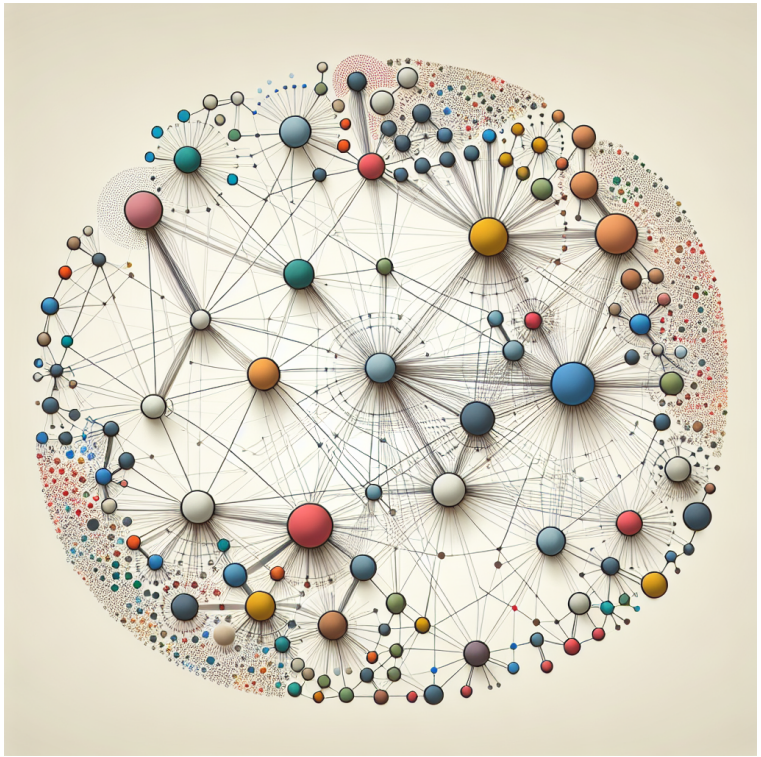


Figure: Prompt: Define a draw of clusters in social networks.

Human Organizations II

- **Alan Turing** proposed a hundred years ago an Universal Machine, capable of take any algorithm defined as a state machine, and process it in a binary language.
- Forty years after, **Noam Chomsky** proposed the formal languages based on generative grammars. Here is were the high-level programming languages appear.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Human Organizations II

- **Alan Turing** proposed a hundred years ago an Universal Machine, capable of take any algorithm defined as a state machine, and process it in a binary language.
- Forty years after, **Noam Chomsky** proposed the formal languages based on generative grammars. Here is were the high-level programming languages appear.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Human Organizations III

- **Programming Lenguajes** with more capabilities, easier comprehension had been created. Also, more people start to code into specific domain programming languages.
- **Andrej Kaparty**, hero in Tesla Company and now in Open.AI said: *nowadays, english is the more important programming language.*

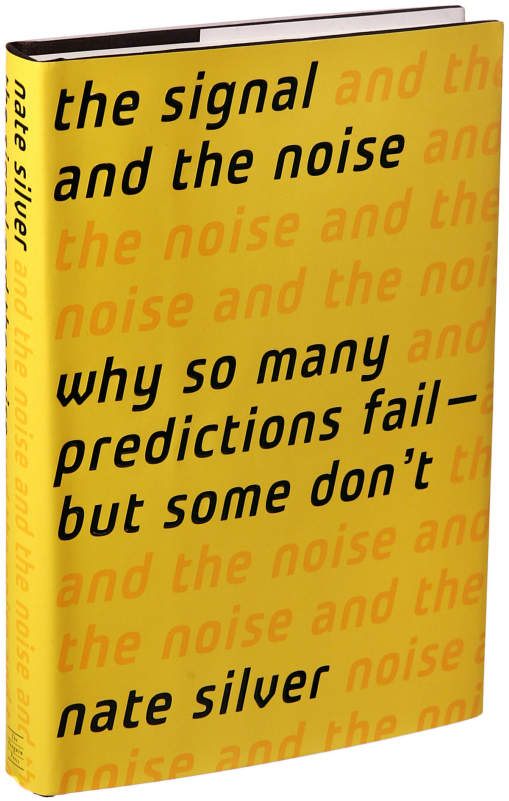
UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Human Organizations III

- **Programming Lenguajes** with more capabilities, easier comprehension had been created. Also, more people start to code into specific domain programming languages.
- **Andrej Kaparty**, hero in Tesla Company and now in Open.AI said: *nowadays, english is the more important programming language*.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Synergy: **Money Ball**



Outline

Thanks!

Questions?

Repo: *https://github.com/EngAndres/ud-public/tree/main/courses/systems-analysis*

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS