Systems Analysis

Systems Analysis & Design

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

Full-time Adjunct Professor
Computer Engineering Program
School of Engineering
Universidad Distrital Francisco José de Caldas

2025-III

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

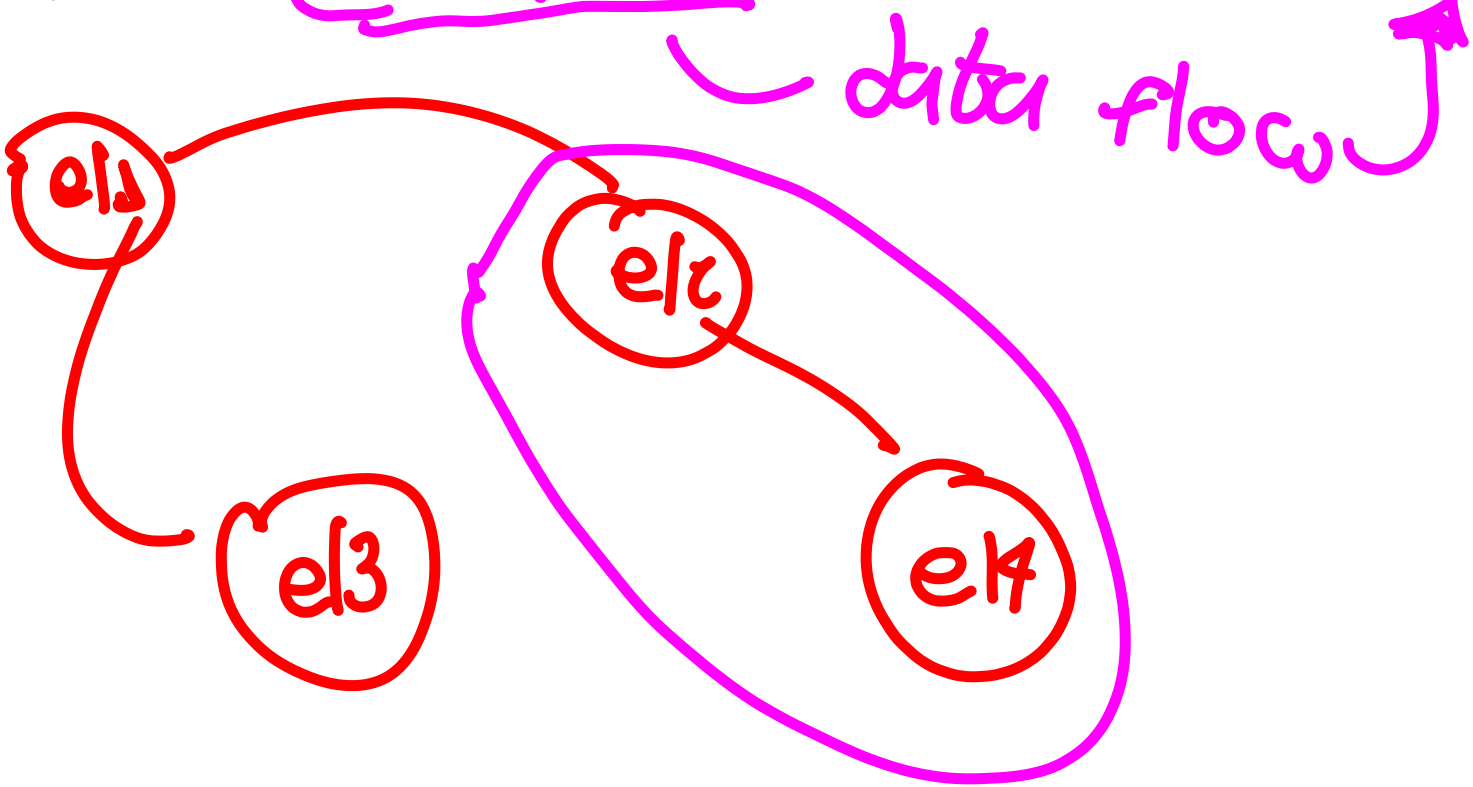
Outline

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Outline

What is a System?

- A **system** is a set of interacting components that *work* together to achieve a common goal.
- A **system** is a collection of elements organized in a specific way.
- A **system** is a structure designed to perform a specific function.



Systems Analysis Process

- **Systems analysis** is the *process* of studying a system in order to identify its components, interactions, and goals.
- **Systems analysis** is the *process* of understanding how a system works and how it can be improved.
- **Systems analysis** is the first step in the systems development lifecycle.

Systems Analysis Process

- **Systems analysis** is the *process* of studying a system in order to identify its components, interactions, and goals.
- **Systems analysis** is the *process* of understanding how a system works and how it can be improved.
- **Systems analysis** is the first step in the systems development lifecycle.

Optimization engineering

Systems Analysis Process

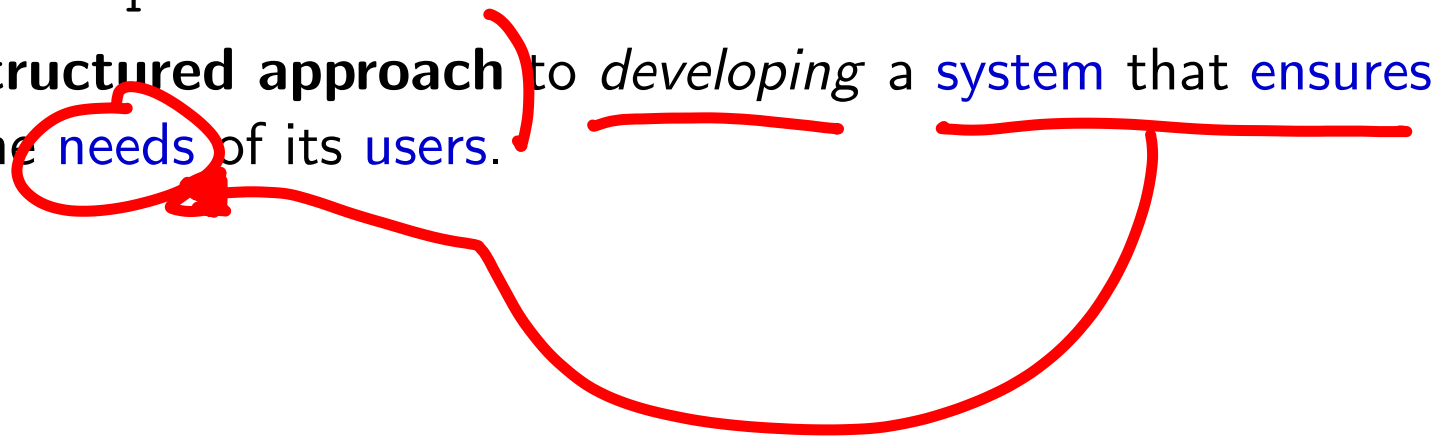
- **Systems analysis** is the *process* of studying a system in order to identify its components, interactions, and goals.
- **Systems analysis** is the *process* of understanding how a system works and how it can be improved.
- **Systems analysis** is the first step in the systems development lifecycle.

Systems Development Lifecycle

- The **systems development lifecycle** is a *process* that *guides* the development of a system.
- It includes planning, analysis, design, implementation, and maintenance phases.
- It is a **structured approach** to *developing* a system that ensures it meets the needs of its users.

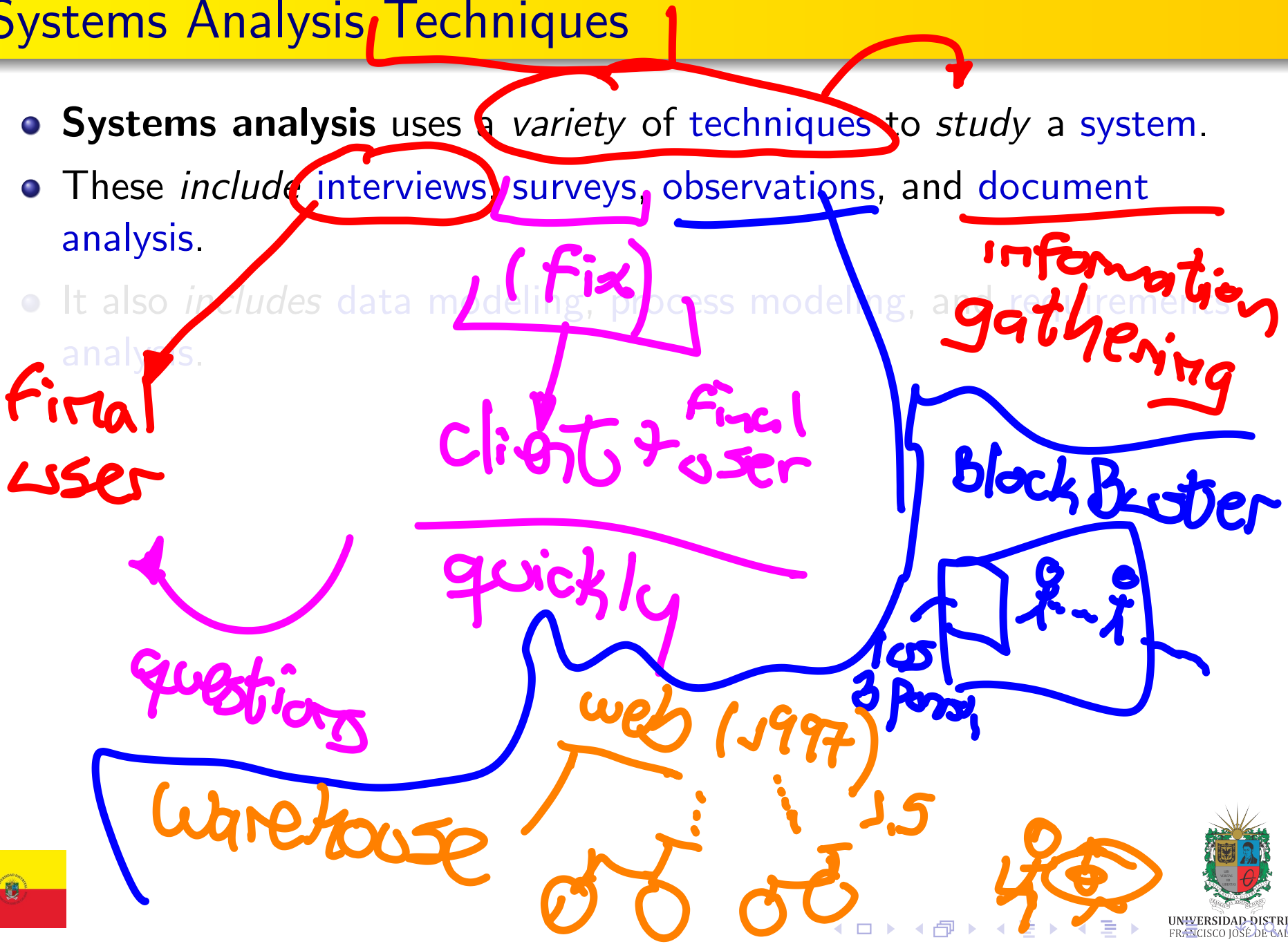
Systems Development Lifecycle

- The **systems development lifecycle** is a *process* that *guides* the development of a system.
- It includes planning, analysis, design, implementation, and maintenance `phases`.
- It is a **structured approach** to *developing* a system that ensures it meets the needs of its users.



Systems Analysis Techniques

- **Systems analysis** uses a *variety* of techniques to *study* a system.
- These *include* interviews, surveys, observations, and document analysis.
- It also *includes* data modeling, process modeling, and requirements analysis.



Systems Analysis Techniques

- **Systems analysis** uses a *variety* of techniques to *study* a system.
- These *include* interviews, surveys, observations, and document analysis.
- It also *includes* data modeling, process modeling, and requirements analysis.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Systems Analysis Tools

- **Systems analysis** uses a *variety* of tools to *study* a system.
- These *include* diagrams, charts, flowcharts, and data models.
- It also *includes* `software tools` such as spreadsheets, databases, and simulation software.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Systems Analysis Tools

- **Systems analysis** uses a *variety* of tools to *study* a system.
- These *include* diagrams, charts, flowcharts, and data models.
- It also *includes* `software tools` such as spreadsheets, databases, and simulation software.

Lateral Thinking

- **Lateral thinking** is a creative problem-solving technique that involves thinking outside the box.
- It is a non-linear approach to problem-solving that *encourages* innovation and creativity.
- It is a *useful* technique for *generating* new ideas and solving complex problems.
- Examples:
  - How can you improve the design of a product?
  - What are the benefits of failure?
  - Why is ignorance important?
  - When is failure better than success?

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Lateral Thinking

- **Lateral thinking** is a creative problem-solving technique that involves thinking outside the box.
- It is a non-linear approach to problem-solving that *encourages* innovation and creativity.
- It is a *useful* technique for *generating* new ideas and solving complex problems.
- Examples:
  - How can you improve the design of a product?
  - What are the benefits of failure?
  - Why is ignorance important?
  - When is failure better than success?

Lateral Thinking Training

- **Lateral thinking** is a *skill* that can be learned and developed through `training` and `practice`.
- It involves exercises, games, and activities that encourage creative thinking.
- Examples of lateral thinking exercises:
  - Brainstorming sessions.
  - Mind mapping exercises.
  - Role-playing games.
  - Problem-solving activities.

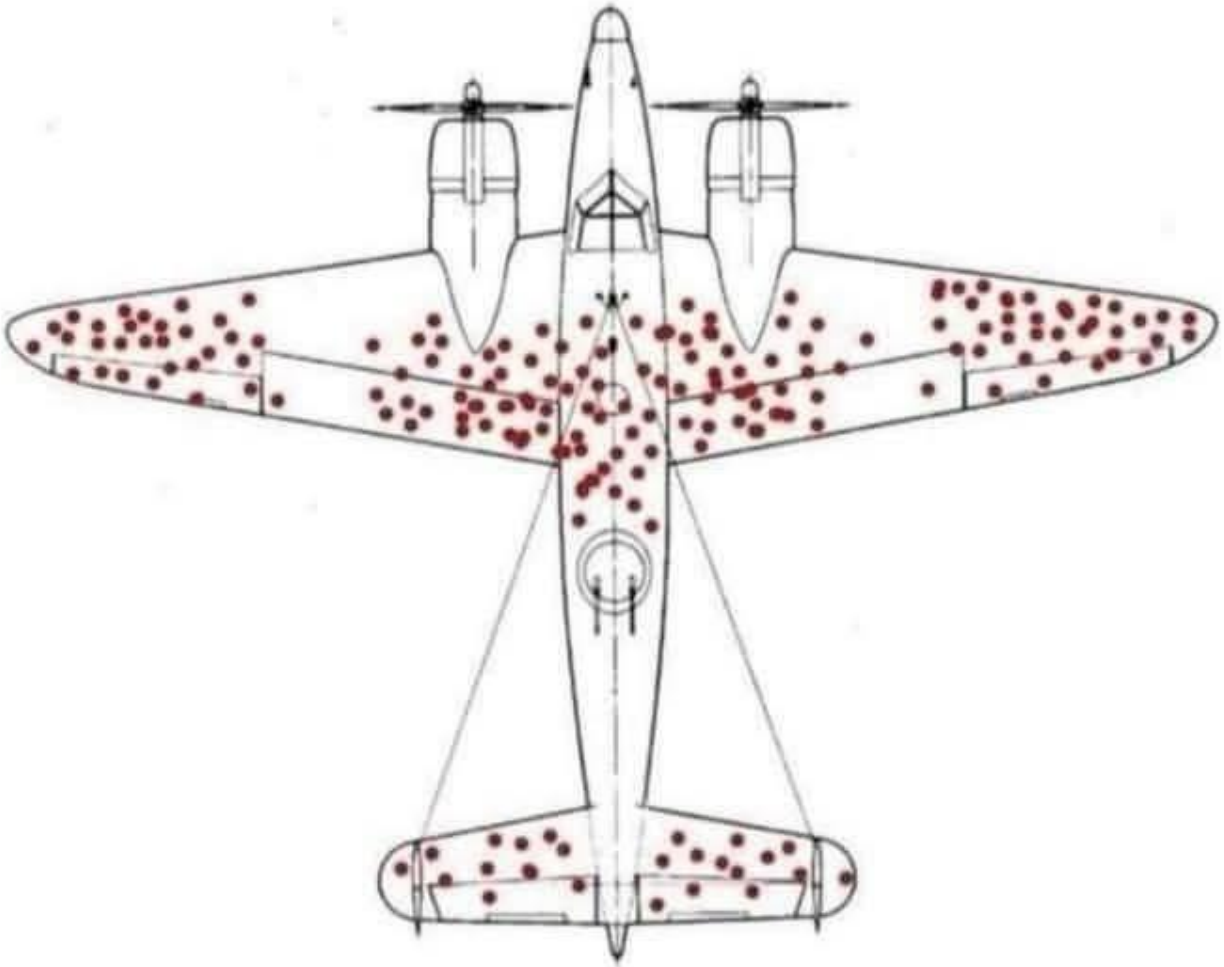
UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Lateral Thinking Training

- **Lateral thinking** is a *skill* that can be learned and developed through `training` and `practice`.
- It involves exercises, games, and activities that encourage creative thinking.
- Examples of lateral thinking exercises:
  - Brainstorming sessions.
  - Mind mapping exercises.
  - Role-playing games.
  - Problem-solving activities.

Lateral Thinking Exercise

`World War II`, the perspective of Abraham Wald:



Uncertainty and Risk

- **Uncertainty** is the lack of knowledge about the future outcome of a decision or event.
- **Risk** is the probability of a negative outcome or loss associated with a decision or event.
- **Uncertainty** and **risk** are *inherent* in complex systems and decisions.
- They can be managed through planning, analysis, and mitigation strategies.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Uncertainty and Risk

- **Uncertainty** is the lack of knowledge about the future outcome of a decision or event.
- **Risk** is the probability of a negative outcome or loss associated with a decision or event.
- **Uncertainty** and **risk** are *inherent* in complex systems and decisions.
- They can be managed through planning, analysis, and mitigation strategies.

Uncertainty and Risk

- **Uncertainty** is the lack of knowledge about the future outcome of a `decision` or `event`.
- **Risk** is the probability of a negative outcome or loss associated with a `decision` or `event`.
- **Uncertainty** and **risk** are *inherent* in complex systems and decisions.
- They can be `managed` through planning, analysis, and mitigation strategies.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Uncertainty and Risk

- **Uncertainty** is the lack of knowledge about the future outcome of a `decision` or `event`.
- **Risk** is the probability of a negative outcome or loss associated with a `decision` or `event`.
- **Uncertainty** and **risk** are *inherent* in complex systems and decisions.
- They can be `managed` through planning, analysis, and mitigation strategies.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Complexity and Emergence

- **Complexity** is the degree to which a system is difficult to understand.
- **Emergence** is the appearance of unexpected properties in a system that arise from the interactions of its components.
- **Complexity** and **emergence** are *common* in dynamic systems that are non-linear and chaotic.
- They can be studied and understood through systems analysis and modeling.

Complexity and Emergence

- **Complexity** is the degree to which a system is difficult to understand.
- **Emergence** is the appearance of unexpected properties in a system that arise from the interactions of its components.
- **Complexity** and **emergence** are *common* in dynamic systems that are non-linear and chaotic.
- They can be `studied` and `understood` through systems analysis and modeling.

Complexity and Emergence

- **Complexity** is the degree to which a system is difficult to understand.
- **Emergence** is the appearance of unexpected properties in a system that arise from the interactions of its components.
- **Complexity** and **emergence** are *common* in dynamic systems that are non-linear and chaotic.
- They can be studied and understood through systems analysis and modeling.

Complexity and Emergence

- **Complexity** is the degree to which a system is difficult to understand.
- **Emergence** is the appearance of unexpected properties in a system that arise from the interactions of its components.
- **Complexity** and **emergence** are *common* in dynamic systems that are non-linear and chaotic.
- They can be `studied` and `understood` through systems analysis and modeling.

Outline

What is Chaos?

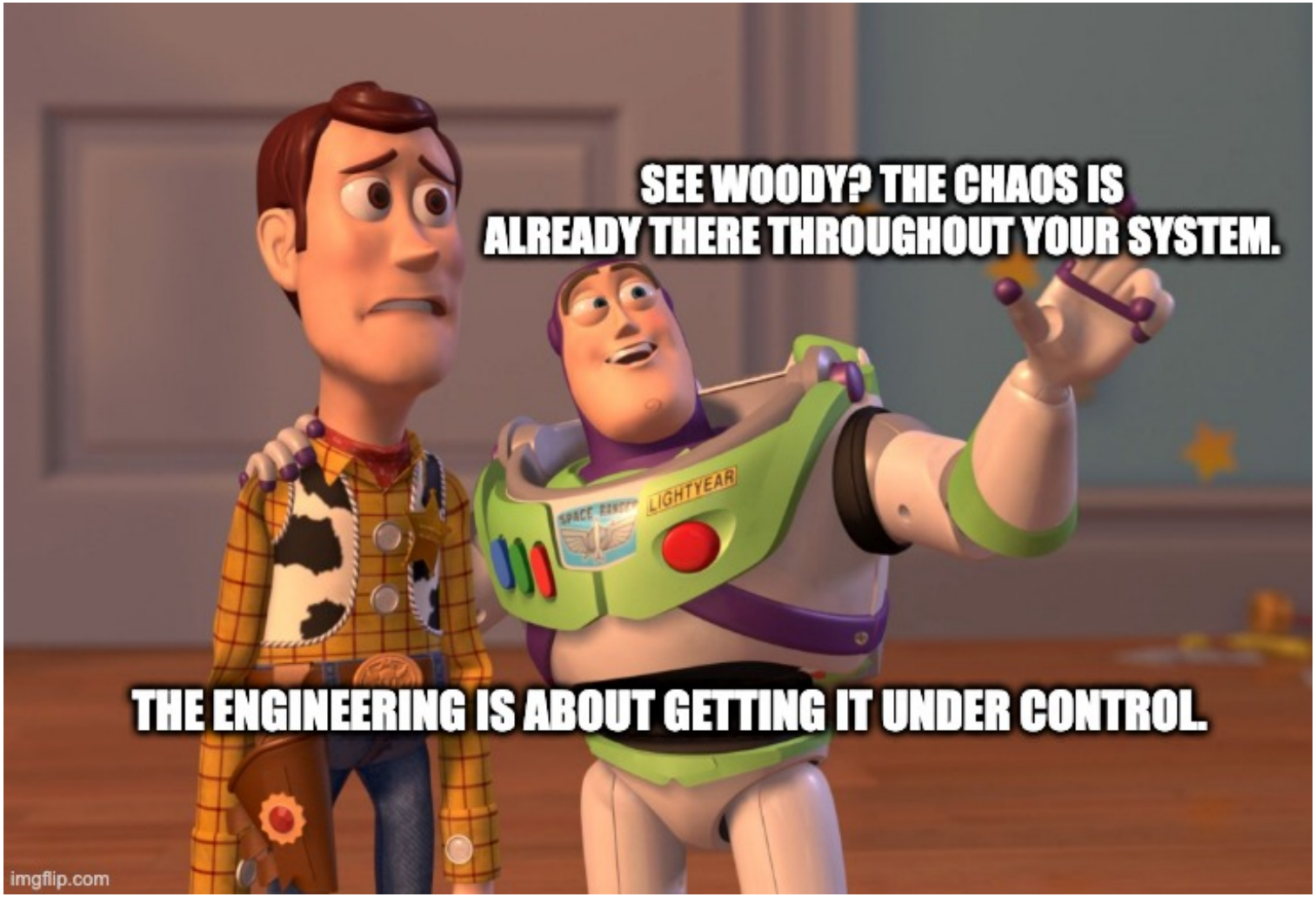
- **Chaos** is a *branch* of mathematics that *studies* the sensitivity of dynamical systems to initial conditions.
- **Chaos** is a non-linear behavior that is highly sensitive to initial conditions.
- **Chaos** is a deterministic behavior that is not predictable in the long term.
- **Chaos** is a complex behavior that is hard to understand.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

What is Chaos?

- **Chaos** is a *branch* of mathematics that *studies* the sensitivity of dynamical systems to initial conditions.
- **Chaos** is a non-linear behavior that is highly sensitive to initial conditions.
- **Chaos** is a deterministic behavior that is not predictable in the long term.
- **Chaos** is a complex behavior that is hard to understand.

Chaos is Everywhere!



What is a Dynamic System?

- A **dynamic system** is a system that changes over time.
- A **dynamic system** is sensitive to initial conditions.
- A **dynamic system** is non-linear.
- A **dynamic system** can be chaotic.

What is a Dynamic System?

- A **dynamic system** is a system that changes over time.
- A **dynamic system** is sensitive to initial conditions.
- A **dynamic system** is non-linear.
- A **dynamic system** can be chaotic.

Chaotic Attractors

A **chaotic attractor** is a set of points in a phase space that attracts the trajectories of a dynamical system.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Fractals in Nature

Watch this video: https://www.youtube.com/watch?v=kkGeOWYOFoA

Swarm Intelligence I

- Swarm intelligence is the collective behavior of *decentralized*, **self-organized systems**, natural or artificial.
- The concept is employed in work on artificial intelligence.
- The expression was introduced by *Gerardo Beni* and *Jing Wang* in 1989, in the context of cellular robotic systems. For example, watch this **video**.

Swarm Intelligence I

- Swarm intelligence is the collective behavior of *decentralized*, **self-organized systems**, natural or artificial.
- The concept is employed in work on artificial intelligence.
- The expression was introduced by *Gerardo Beni* and *Jing Wang* in 1989, in the context of cellular robotic systems. For example, watch this **video**.

Swarm Intelligence II

- The idea is: if you see an **individual**, it may seem random; **however**, several **individuals interacting** with each other and the environment show smart behaviors.
- **Yu Takeuchi** said: one colombian is more intelligent than one japanese, but two japanese are smarter than two colombians.
- There are interesting **population behaviors** in nature, specially in insects: bees, ants, termites, among others.
- There are also many examples in nature: schools of fish, birds, wolves.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Swarm Intelligence II

- The idea is: if you see an **individual**, it may seem random; **however**, several **individuals interacting** with each other and the environment show smart behaviors.
- **Yu Takeuchi** said: one colombian is more intelligent than one japanese, but two japanese are smarter than two colombians.
- There are interesting **population behaviors** in nature, specially in insects: bees, ants, termites, among others.
- There are also many examples in nature: schools of fish, birds, wolves.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Swarm Intelligence II

- The idea is: if you see an **individual**, it may seem random; **however**, several **individuals interacting** with each other and the environment show smart behaviors.
- **Yu Takeuchi** said: one colombian is more intelligent than one japanese, but two japanese are smarter than two colombians.
- There are interesting **population behaviors** in nature, specially in insects: bees, ants, termites, among others.
- There are also many examples in nature: schools of fish, birds, wolves.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Emergent Behaviors

- Emergent behavior is the **appearance** of **complex patterns** and behaviors from **many** simple interactions.
- Emergent behavior **results** from the **collective** behavior of the **individuals** in the system.
- Emergent behavior is **not planned** or **designed** by any individual, but **arises** from their **interactions**.
- Emergent behavior is **not** the **sum** of the **individual** behaviors, but **something more**: synergy.
- **Swarm intelligence** refers to interesting emergent behaviors.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

School Fish Algorithm

School Fish Algorithm

- **School fish** are interesting. When a predator attacks, they become confused by the large number of individuals and their diverse movements.
- The idea is simple: *"Don't touch me, don't come too close, but stay somewhat close."*
- This behavior is a chain of action and reaction. It confuses predators and helps the school move uniformly.
- Do you remember Nemo? The fish with a sword snout, the pirates, or Marlin's imitation of talking-all are somewhat similar. Watch **here**.
- The school fish algorithm is a **multi-agent system** that **simulates** the behavior of a **school of fish**.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

School Fish Algorithm

- **School fish** are interesting. When a predator attacks, they become confused by the large number of individuals and their diverse movements.
- The idea is simple: *"Don't touch me, don't come too close, but stay somewhat close."*
- This behavior is a chain of action and reaction. It confuses predators and helps the school move uniformly.
- Do you remember Nemo? The fish with a sword snout, the pirates, or Marlin's imitation of talking-all are somewhat similar. Watch **here**.
- The school fish algorithm is a **multi-agent system** that **simulates** the behavior of a **school of fish**.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

School Fish Algorithm

- **School fish** are interesting. When a predator attacks, they become confused by the large number of individuals and their diverse movements.
- The idea is simple: *"Don't touch me, don't come too close, but stay somewhat close."*
- This behavior is a chain of action and reaction. It confuses predators and helps the school move uniformly.
- Do you remember Nemo? The fish with a sword snout, the pirates, or Marlin's imitation of talking-all are somewhat similar. Watch **here**.
- The school fish algorithm is a **multi-agent system** that **simulates** the behavior of a **school of fish**.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Ant Colony Algorithm

- Ant colony algorithm is a **multi-agent system** that **simulates** the behavior of an **ant colony**.
- Ant colony algorithm is based on the **social behavior** of **ants** and the use of **pheromones**. Watch **here**.
- Ant colony algorithm is used to **solve optimization problems**. Watch **here**.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Ant Colony Algorithm

- Ant colony algorithm is a **multi-agent system** that **simulates** the behavior of an **ant colony**.
- Ant colony algorithm is based on the **social behavior** of **ants** and the use of **pheromones**. Watch **here**.
- Ant colony algorithm is used to **solve optimization problems**. Watch **here**.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Outline

What is Abstraction?

- **Abstraction** is the *process* of ignoring minor details in order to focus on the important aspects of a system.
- **Abstraction** is the *process* of simplifying a complex system to understand it.
- **Abstraction** is the *process* of generalizing a specific system to apply it to other systems.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

What is Abstraction?

- **Abstraction** is the *process* of ignoring minor details in order to focus on the important aspects of a system.
- **Abstraction** is the *process* of simplifying a complex system to understand it.
- **Abstraction** is the *process* of generalizing a specific system to apply it to other systems.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

What is Abstraction?

- **Abstraction** is the *process* of ignoring minor details in order to focus on the important aspects of a system.
- **Abstraction** is the *process* of simplifying a complex system to understand it.
- **Abstraction** is the *process* of generalizing a specific system to apply it to other systems.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

What is Modularity?

- **Modularity** is the *process* of dividing a system into smaller parts called modules.
- **Modularity** is the *process* of organizing a system into independent units that can be developed and maintained separately.
- **Modularity** is the *process* of reducing the complexity of a system by breaking it into smaller parts.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

What is Modularity?

- **Modularity** is the *process* of dividing a system into smaller parts called modules.
- **Modularity** is the *process* of organizing a system into independent units that can be developed and maintained separately.
- **Modularity** is the *process* of reducing the complexity of a system by breaking it into smaller parts.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

What is Modularity?

- **Modularity** is the *process* of dividing a system into smaller parts called modules.
- **Modularity** is the *process* of organizing a system into independent units that can be developed and maintained separately.
- **Modularity** is the *process* of reducing the complexity of a system by breaking it into smaller parts.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Abstraction and Modularity

- **Abstraction** and **modularity** are *two important concepts* in systems analysis.
- They help reduce the complexity of a system by ignoring details and dividing it into smaller parts.
- They help improve the understanding, development, and maintenance of a system.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Abstraction and Modularity

- **Abstraction** and **modularity** are *two important concepts* in systems analysis.
- They help reduce the complexity of a system by ignoring details and dividing it into smaller parts.
- They help improve the understanding, development, and maintenance of a system.

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Outline

Thanks!

Questions?

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