

# SYSTEMS ENGINEERING

## Systems Analysis & Design

Author: Eng. Carlos Andrés Sierra, M.Sc.  
[cavirguezs@udistrital.edu.co](mailto:cavirguezs@udistrital.edu.co)

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

2025-I



# Outline

- 1 Basic Concepts |
- 2 Human Activities |
- 3 Cibernetics and Technology )
- 4 Teams-Based Structure as a System |



# Outline

- 1 Basic Concepts
- 2 Human Activities
- 3 Cibernetics and Technology
- 4 Teams-Based Structure as a System



# What is Systems Engineering?

- **Systems Engineering** is a discipline that studies the design, implementation, and maintenance of complex systems.
- This discipline is based on interdisciplinary fields, such as control engineering, industrial engineering, software engineering, mechanical engineering, electrical engineering, organizational studies, project management, and others.
- **Systems Engineering** is a holistic approach to engineering that focuses on how to design and manage complex systems over their lifecycle.



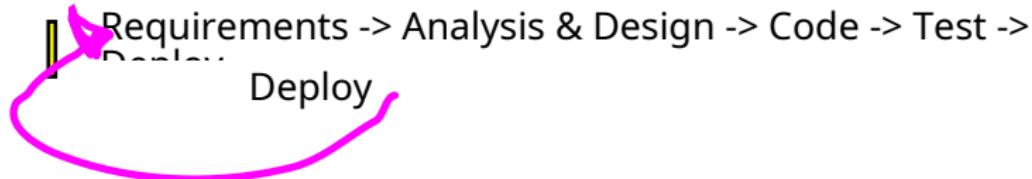
# What is Systems Engineering?

- **Systems Engineering** is a discipline that studies the design, implementation, and maintenance of complex systems.
- This discipline is based on interdisciplinary fields, such as control engineering, industrial engineering, software engineering, mechanical engineering, electrical engineering, organizational studies, project management, and others.
- Systems Engineering is a holistic approach to engineering that focuses on how to design and manage complex systems over their lifecycle.



# What is Systems Engineering?

- **Systems Engineering** is a discipline that studies the design, implementation, and maintenance of complex systems.
- This discipline is based on interdisciplinary fields, such as control engineering, industrial engineering, software engineering, mechanical engineering, electrical engineering, organizational studies, project management, and others.
- **Systems Engineering** is a holistic approach to engineering that focuses on how to design and manage complex systems over their lifecycle.



# Systems Engineer as a Professional

- A **Systems Engineer** is a professional who is responsible for **designing, implementing, and maintaining complex systems.**
- A **Systems Engineer** must have a broad understanding of engineering, mathematics, science, and technology.
- A **Systems Engineer** must be able to analyze and solve problems in a systematic and holistic way.



# Systems Engineer as a Professional

- A **Systems Engineer** is a professional who is responsible for designing, implementing, and maintaining complex systems.
- A **Systems Engineer** must have a broad understanding of engineering, mathematics, science, and technology.
- A **Systems Engineer** must be able to analyze and solve problems in a systematic and holistic way.

Xerox



# Systems Engineer as a Professional

- A **Systems Engineer** is a professional who is responsible for designing, implementing, and maintaining complex systems.
- A **Systems Engineer** must have a broad understanding of engineering, mathematics, science, and technology.
- A **Systems Engineer** must be able to analyze and solve problems in a systematic and holistic way.



# Outline

- 1 Basic Concepts
- 2 Human Activities
- 3 Cibernetics and Technology
- 4 Teams-Based Structure as a System



# Human Activities

- Human activities are complex systems that involve multiple components, interactions, and feedback loops.
- Systems Engineering can be applied to understand, analyze, and improve human activities.
- Systems Engineering can help us design and manage complex systems such as organizations, cities, economies, and societies.



live - 3 → live  
live < 3 → dead  
> 3 → dead  
dead → 3 → live



# Human Activities

- Human activities are complex systems that involve multiple components, interactions, and feedback loops.
- Systems Engineering can be applied to understand, analyze, and improve human activities.
- Systems Engineering can help design and manage complex systems such as organizations, cities, economies, and societies.



# Human Activities

- **Human activities** are complex systems that involve multiple components, interactions, and feedback loops.
- **Systems Engineering** can be applied to understand, analyze, and improve human activities.
- **Systems Engineering** can help us design and manage complex systems such as organizations, cities, economies, and societies.

7 1000 0.1  
7:05 0. 0.3

Algorithmic  
Trading



# Human Activities: Complexity

- Human activities are complex systems that involve multiple components, interactions, and feedback loops.
- Interactions are key to understanding and improving human activities.
- Organizations are complex systems that involve multiple departments, teams, and individuals.



# Human Activities: Complexity

- **Human activities** are complex systems that involve multiple components, interactions, and feedback loops.
- **Interactions** are key to understanding and improving human activities.
- **Organizations** are complex systems that involve multiple departments, teams, and individuals.



# Human Activities: Complexity

- **Human activities** are complex systems that involve multiple components, interactions, and feedback loops.
- **Interactions** are key to understanding and improving human activities.
- **Organizations** are complex systems that involve multiple departments, teams, and individuals.

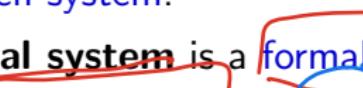


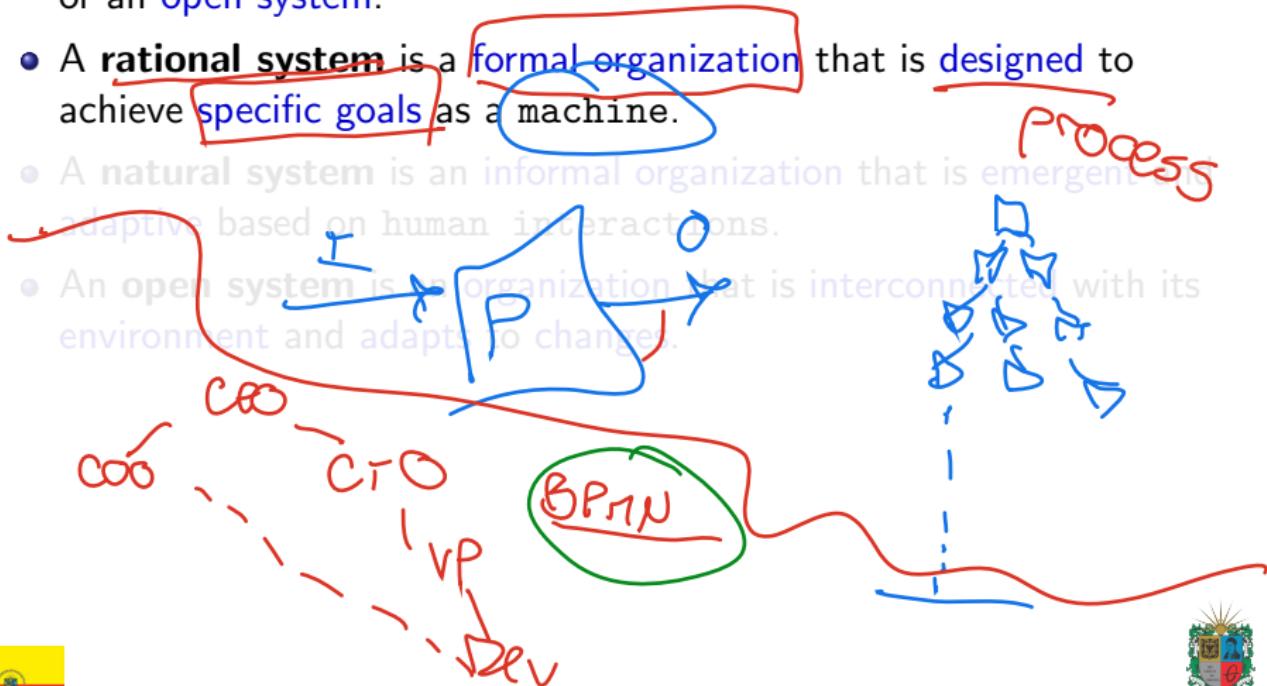
# Organizations as Systems

- **Organizations** can be viewed as: a rational system, a natural system, or an open system.
- A **rational system** is a formal organization that is designed to achieve specific goals as a machine.
- A **natural system** is an informal organization that is emergent and adaptive based on human interactions.
- An **open system** is an organization that is interconnected with its environment and adapts to changes.



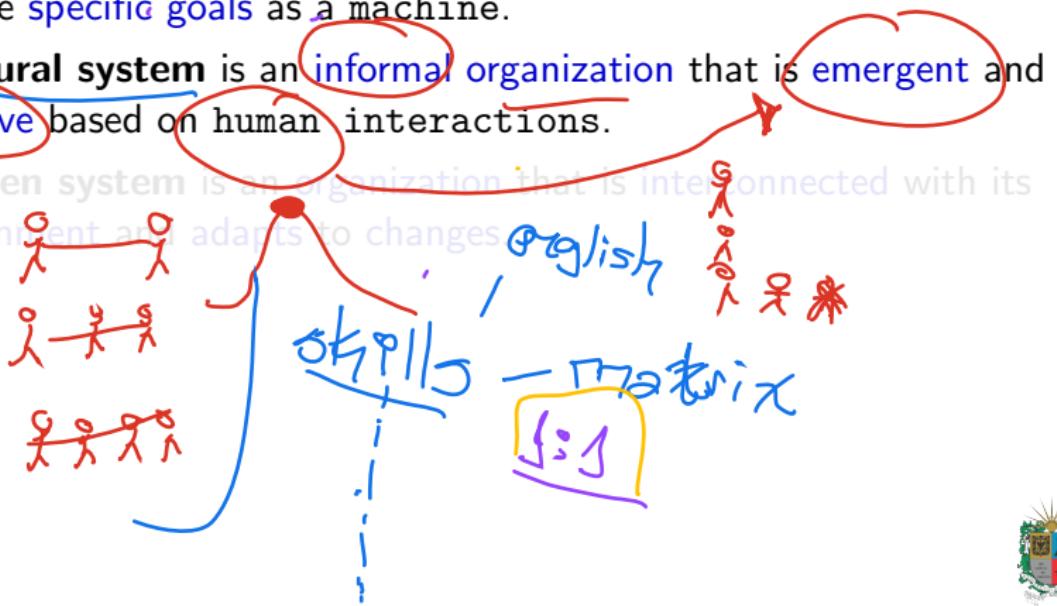
## Organizations as Systems

- **Organizations** can be viewed as: a rational system, a natural system, or an open system.
  - A **rational system** is a **formal organization** that is **designed** to achieve **specific goals** as a **machine**.
  - A **natural system** is an informal organization that is emergent and adaptive based on human interactions.
  - An **open system** is an organization that is interconnected with its environment and adapt to changes.



# Organizations as Systems

- **Organizations** can be viewed as: a **rational system**, a **natural system**, or an **open system**.
- A **rational system** is a **formal organization** that is designed to achieve **specific goals** as a machine.
- A **natural system** is an **informal organization** that is **emergent** and **adaptive** based on **human interactions**.
- An **open system** is an organization that is interconnected with its environment and adapts to changes.



# Organizations as Systems

- **Organizations** can be **viewed** as: a **rational system**, a **natural system**, or an **open system**.
- A **rational system** is a **formal organization** that is **designed** to achieve **specific goals** as a machine.
- A **natural system** is an **informal organization** that is **emergent** and **adaptive** based on human interactions.
- An **open system** is an **organization** that is **interconnected** with its **environment** and **adapts** to **changes**.

Ψ - 3000

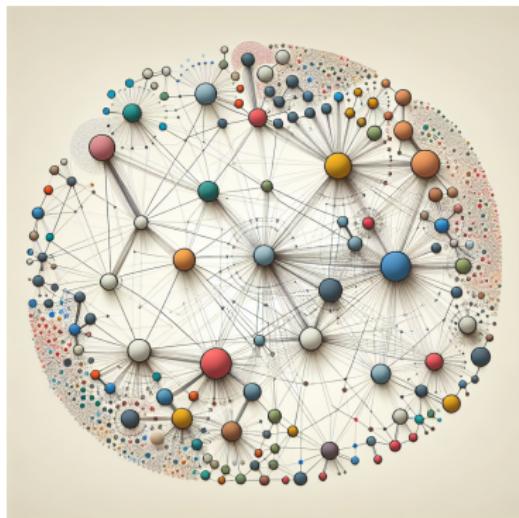


# Sinergy

- **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 computation.  
Based on graphs, you could define a computational machine.



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



# Sinergy

- **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**.

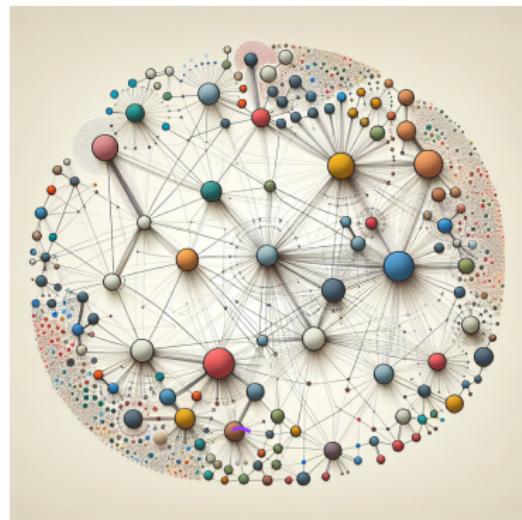


Figure: Prompt: Define a draw of clusters in social networks.



# Sinergy

- **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**.

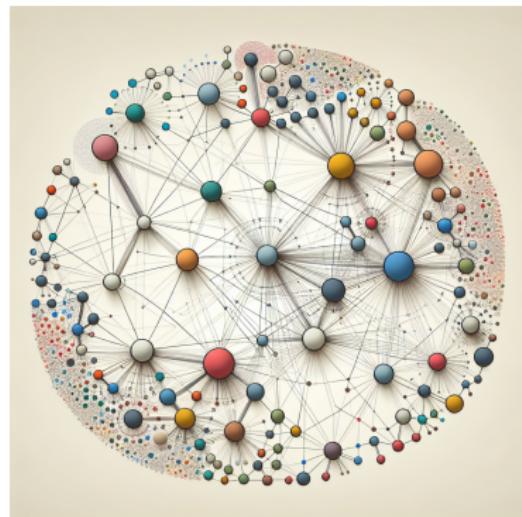


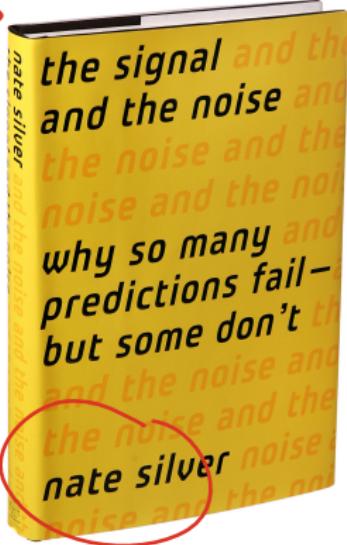
Figure: Prompt: Define a draw of clusters in social networks.



## Synergy: Money Ball

A child's drawing of a basketball court. The court is outlined in blue ink. A large circle at the top left contains the word "Athletics" in red and "S-T-G" in blue. A large circle at the bottom right contains the letters "T-H-O". There are several stick figures: one in a circle on the left, one near the top center, one in a circle on the right, one on the far right, and one near the bottom center. A large circle on the right side contains a stick figure and the letters "J-H-S".

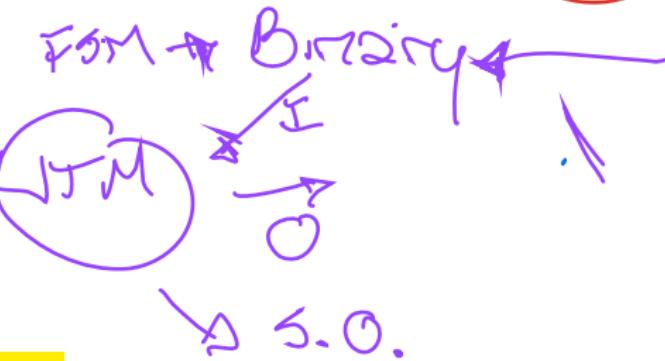
# The Outliers



# Talking with Machines!

Alongzo Chomsky (-18-26)

- ↳ Babbage Machine
- ↳ State Machine



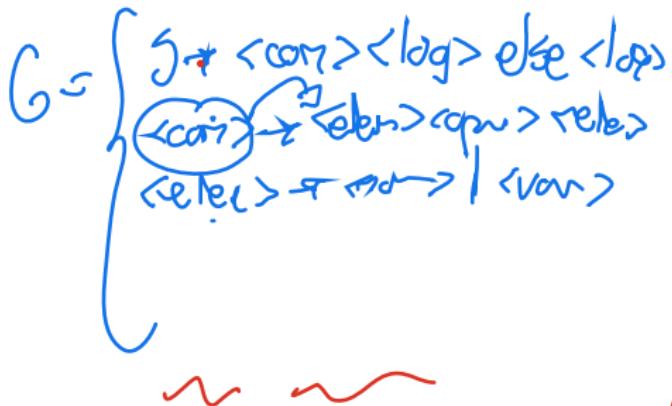
- Alan Turing proposed a hundred years ago an Universal Machine, capable of take any algorithm defined as a state machine, and process it in a binary language.

- Following after Noam Chomsky proposed the CFG based on generative grammars. Here is where the high-level programming languages appear.

Algorithm → FGM  
Machine



# Talking with Machines!



- 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 where the high-level programming languages appear.



# Programming Languages

- Programming Languages 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.  
    >> 03

**C++**

**Java**

$x > 5 ? \text{True} : \text{False} ;$

**Python**

True if  $x > 5$  else False

natural language



# Programming Languages

- 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 OpenAI said: nowadays, english is the more important programming language.

2023  
copilot → codex



# Applications of Systems Engineering



IPv6

- Systems Engineering can be applied to understand, analyze, and improve complex systems.
- Systems Engineering can be applied to design and manage complex systems such as organizations, cities, economies, and societies.
- Systems Engineering can be applied to design and manage complex systems such as software, hardware, and networks

Optimization

- \* Genetic algorithm
- \* Reinforcement learning

shutterstock

Vision

math

algorithms

soon

Rust

COSA

5G

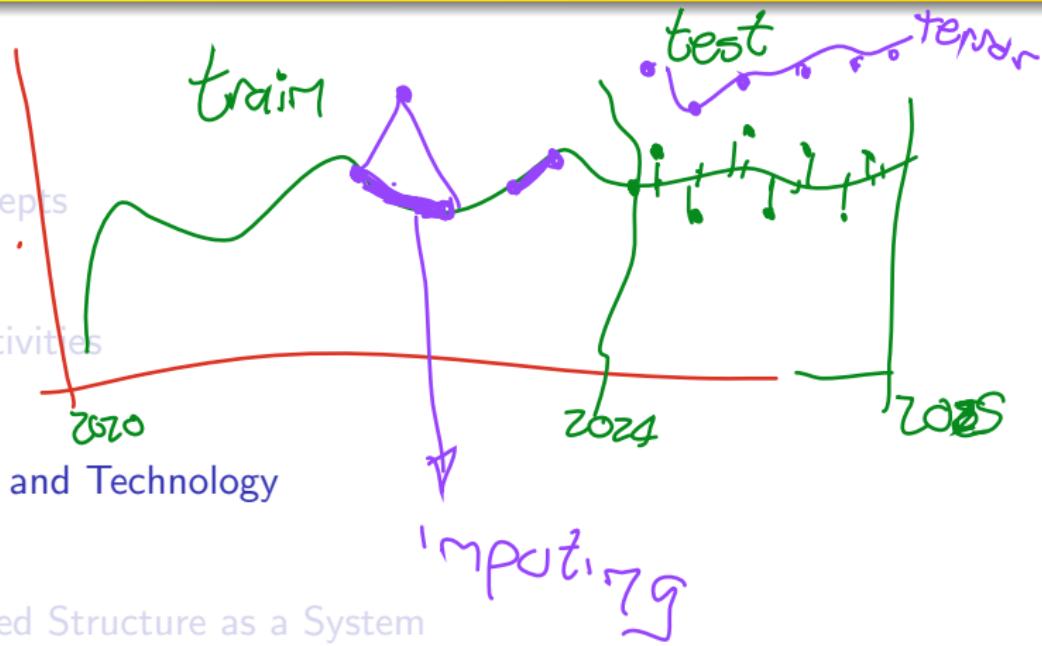
Huawei

Quantum Computer



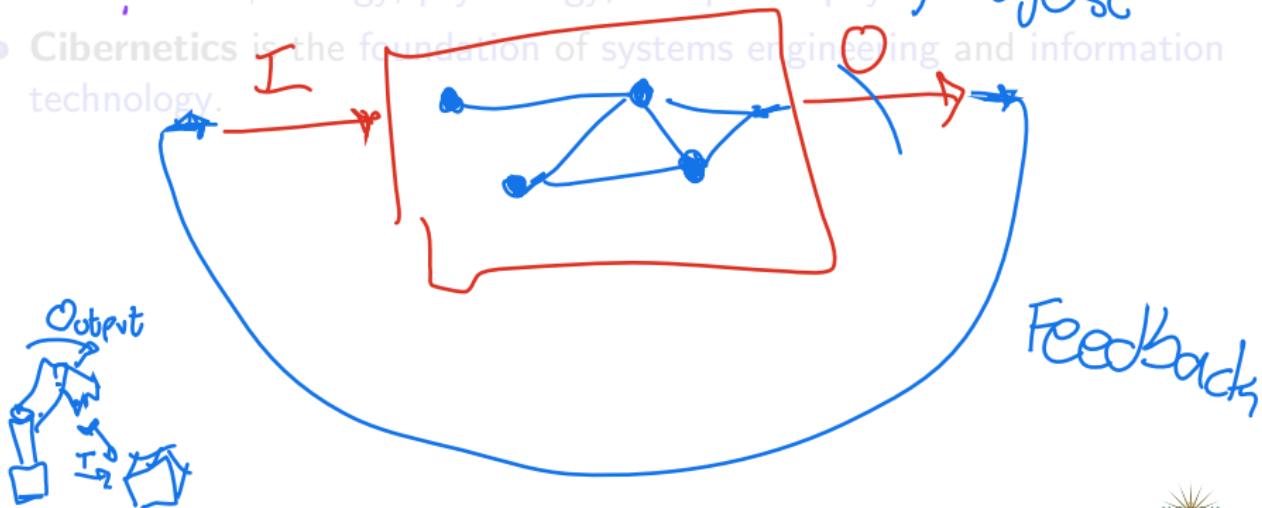
# Outline

- 1 Basic Concepts
- 2 Human Activities
- 3 Cibernetics and Technology
- 4 Teams-Based Structure as a System



## Cibernetics → Robots

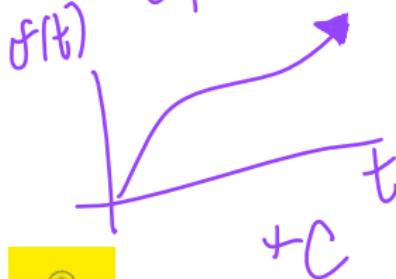
- **Cibernetics** is the study of systems, control, and communication in animals, machines, and organizations.
  - Cibernetics is a transdisciplinary field that combines engineering, mathematics, biology, psychology, and philosophy. *Adjust*
  - Cibernetics is the foundation of systems engineering and information technology. *I*



# Cibernetics

- Cibernetics is the study of **systems**, **control**, and **communication** in animals, machines, and organizations.
- Cibernetics is a **transdisciplinary** field that **combines engineering**, **mathematics**, **biology**, **psychology**, and **philosophy**.
- Cibernetics is the foundation of systems engineering and information technology.

derivatives  
differential equations



bio-inspirations  
robots

kid  
learning  
less errors

Control  
mechanic  
electronic  
system

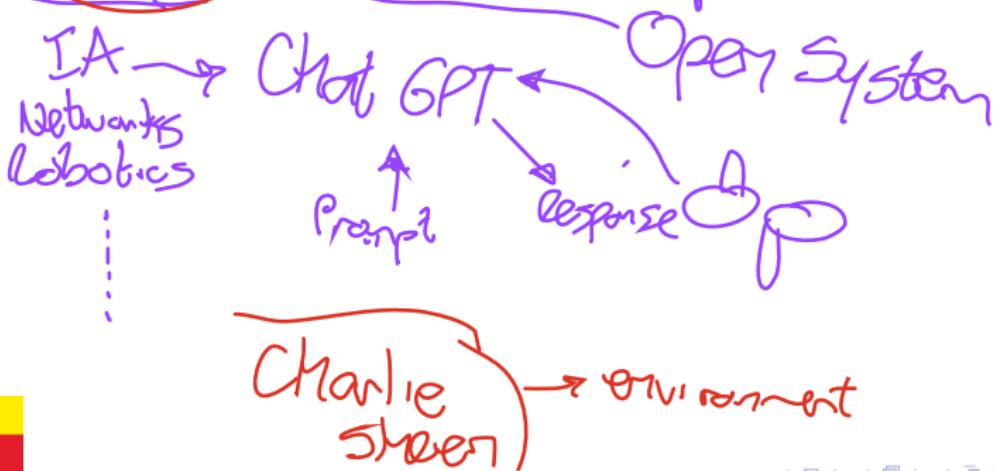
Yarn to  
Cotton  
Kangaroo



## Cibernetics

### • Accuracy

- **Cibernetics** is the study of systems, control, and communication in animals, machines, and organizations.
  - **Cibernetics** is a transdisciplinary field that combines engineering, mathematics, biology, psychology, and philosophy.
  - **Cibernetics** is the foundation of systems engineering and information technology.



# Technology



- **Technology** is the application of scientific knowledge to solve problems and improve systems.
- Technology is the foundation of systems engineering and information technology.
- Technology is the key to designing and managing complex systems such as organizations, cities, economies, and societies.

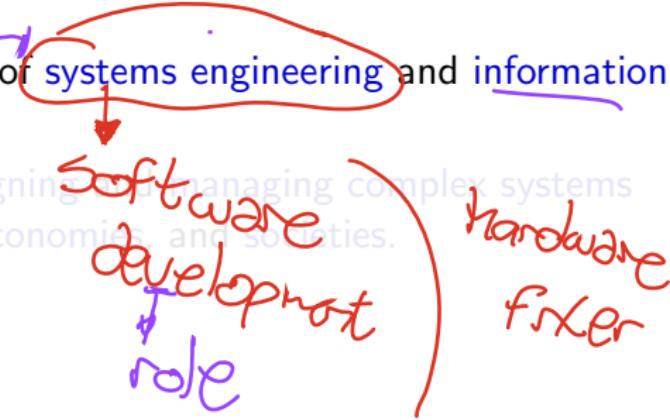
*Wall-e* *Memory* *weak*

system → multi-objective

sleep 8 hours,  
grades ≥ 4.5  
eat at lunch  
less gap between classes



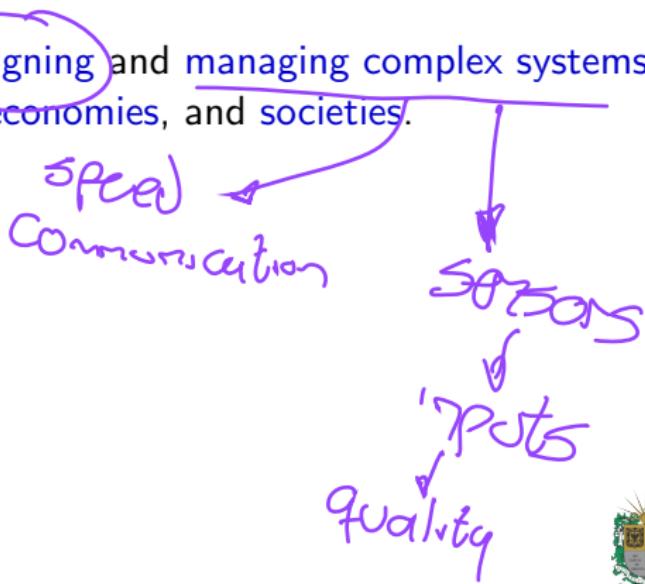
# Technology

- **Technology** is the application of scientific knowledge to solve problems and improve systems.
  - **Technology** is the foundation of **systems engineering** and **information technology**.
  - **Technology** is the key to designing and managing complex systems such as organizations, cities, economies, and societies.  
cell phones  
internet
- 



# Technology

- **Technology** is the application of scientific knowledge to solve problems and improve systems.
- **Technology** is the foundation of systems engineering and information technology.
- **Technology** is the key to designing and managing complex systems such as organizations, cities, economies, and societies.



# Technology: AI

Agents

- Artificial Intelligence is a field of computer science that studies how to design and implement intelligent agents.

- Artificial Intelligence is the key to designing and preparing complex systems such as smart-organizations, smart-cities, smart-economies, and smart-societies.

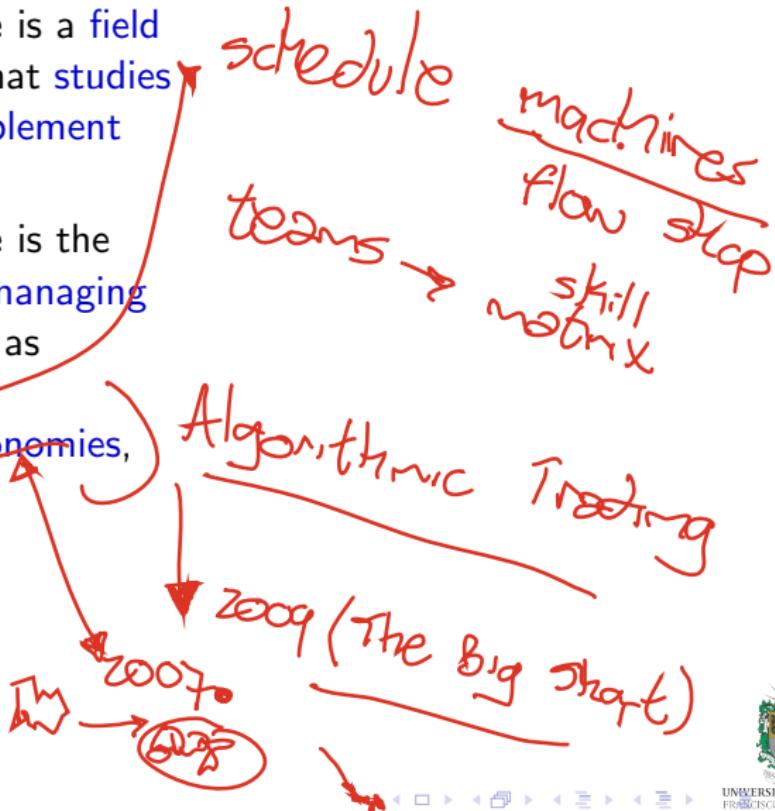


# Technology: AI

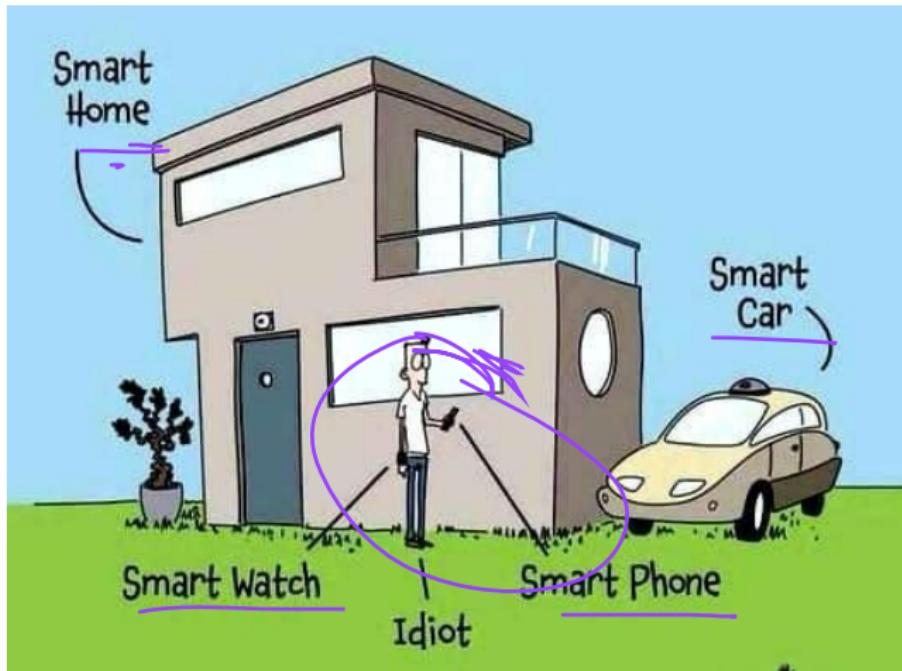
- Artificial Intelligence is a field of computer science that studies how to design and implement intelligent agents.

- Artificial Intelligence is the key to designing and managing complex systems such as smart-organizations, smart-cities, smart-economies, and smart-societies.

roadway  
lights smart



# Artificial Intelligence **not** as a System

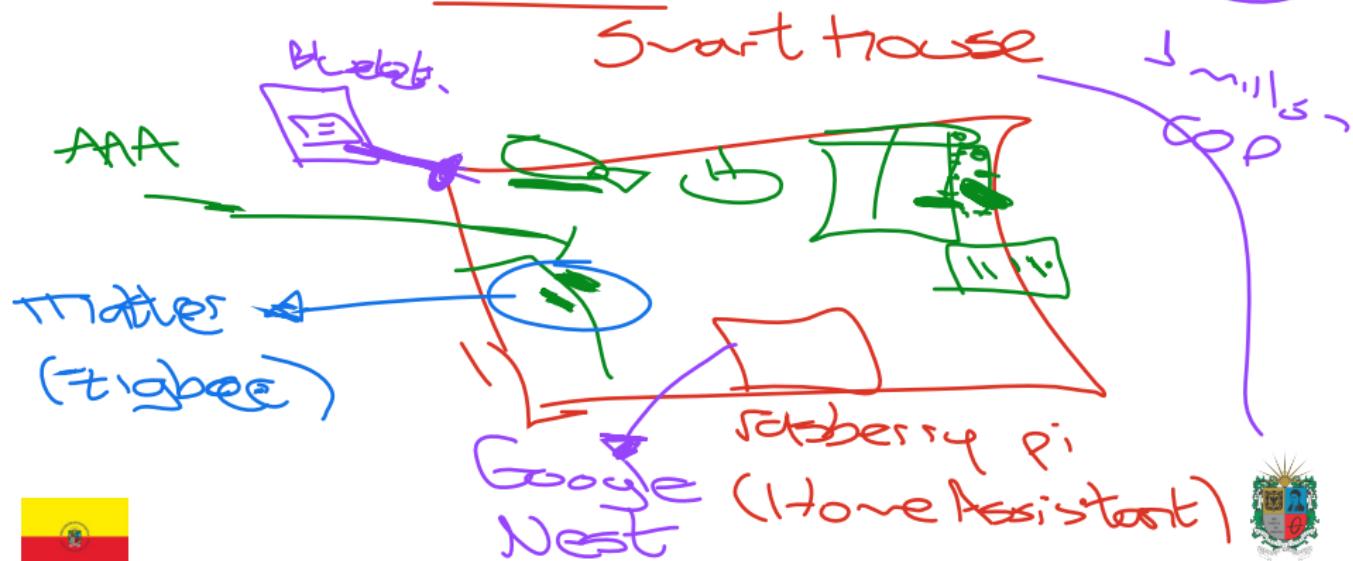


Cibernetics & Technology in Systems Context

## Feedback

- **Cibernetics** and **technology** are the foundation of **systems** engineering and **information technology**.
  - **Cibernetics** and **technology** are the foundation of **artificial intelligence** and **smart systems**.

34



# Outline

- 1 Basic Concepts
- 2 Human Activities
- 3 Cibernetics and Technology
- 4 Teams-Based Structure as a System



# Team-Based Structure Organizations

- Team-based structure organizations are a way to organize work and people in teams that are self-managed and cross-functional.

- Each team is responsible for a specific task or project and has the authority to make decisions and solve problems.



# Team-Based Structure Organizations

~~Trivora → Atom House~~

Moving Average



- Team-based structure organizations are a way to organize work and people in teams that are self-managed and cross-functional.
- Each team is responsible for a specific task or project and has the authority to make decisions and solve problems.

- Team-based structure organizations are flexible, agile, and innovative because they empower employees and encourage ownership.

~~Ownership~~

~~JWY ior~~

Globant  
MEL  
GIGANT

soft  
skills

Ferry

Hired-Selections Process

- ① Call Psychology - Recruiter / RHII → English
- ② i) Call Lead Tech
  - ii) Technical Test

$$\text{abs}(x_3 - x_1) = \text{abs}(q_2 - q_1)$$

~~Contest~~

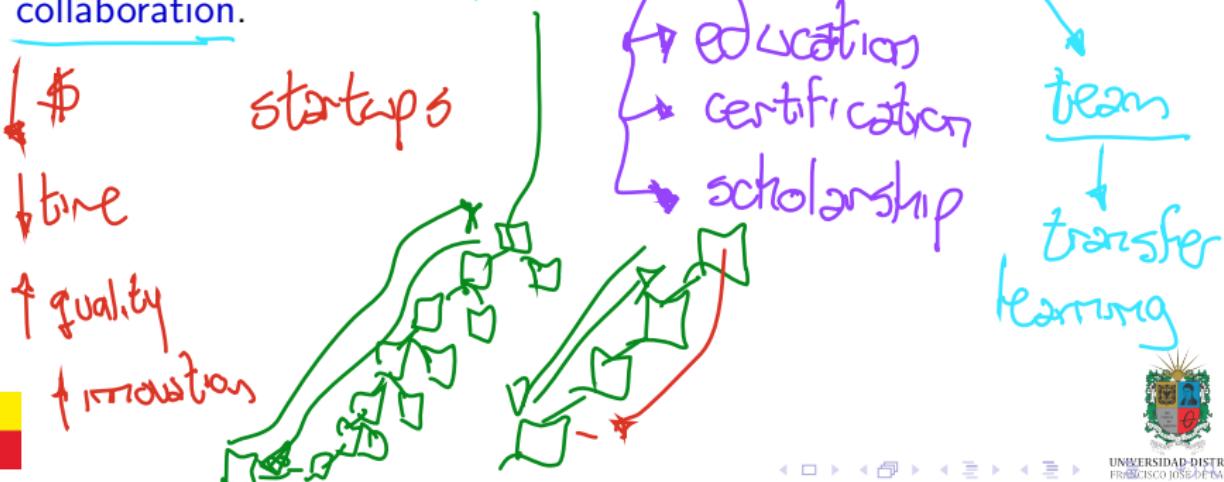
- HackerRank
- LeetCode



# Team-Based Structure Organizations

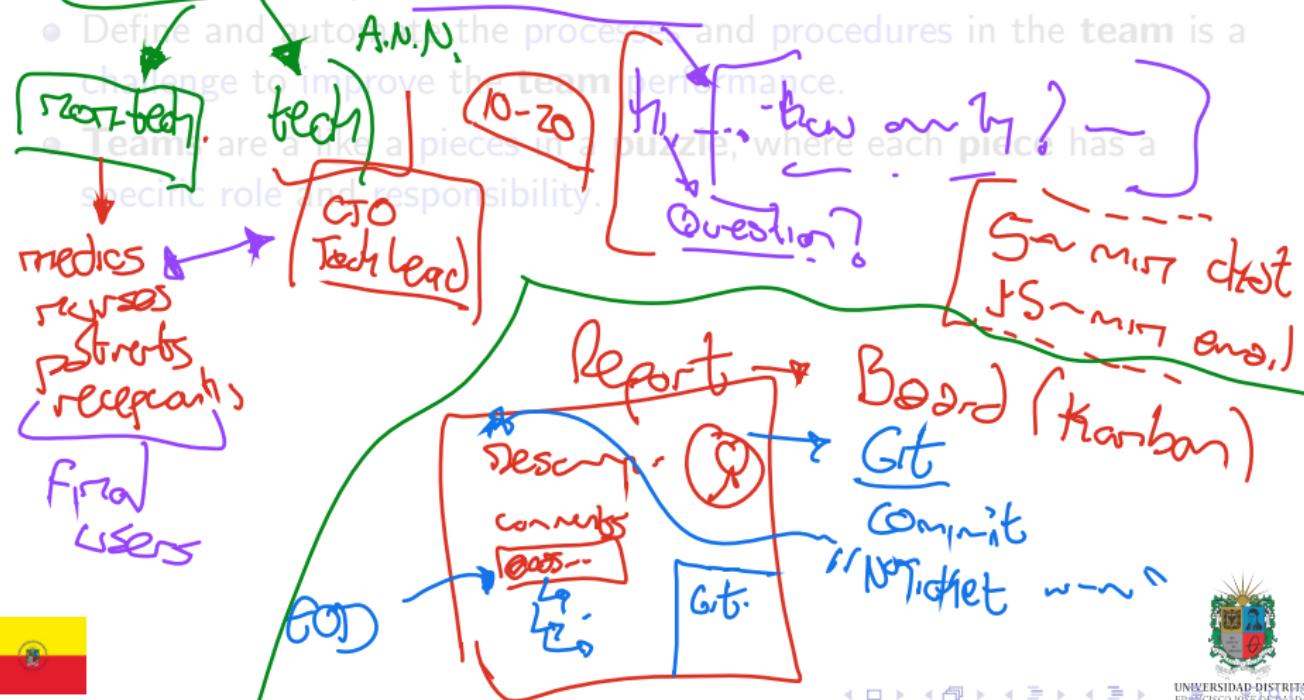
- Team-based structure organizations are a way to organize work and people in teams that are self-managed and cross-functional.
- Each team is responsible for a specific task or project and has the authority to make decisions and solve problems.
- Team-based structure organizations are flexible, agile, and innovative because they empower employees and encourage collaboration.

5-20  
m17



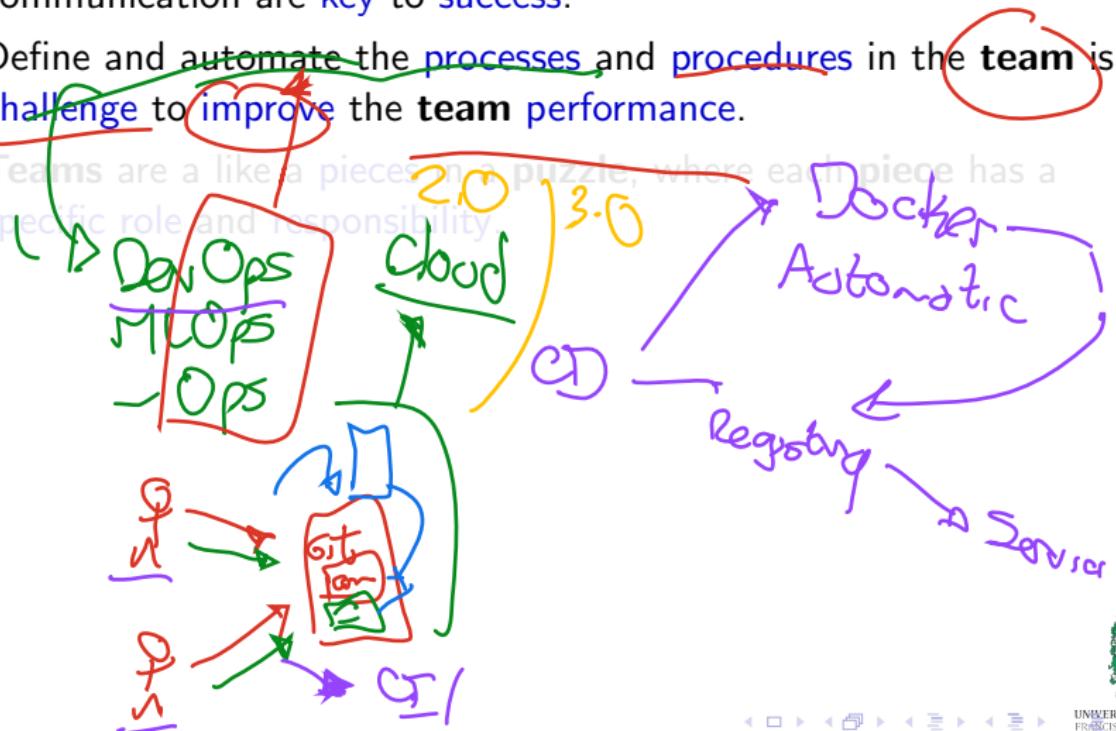
# Teams as a System

- Teams are a **system** where collaboration (sinergy) and communication are key to success.



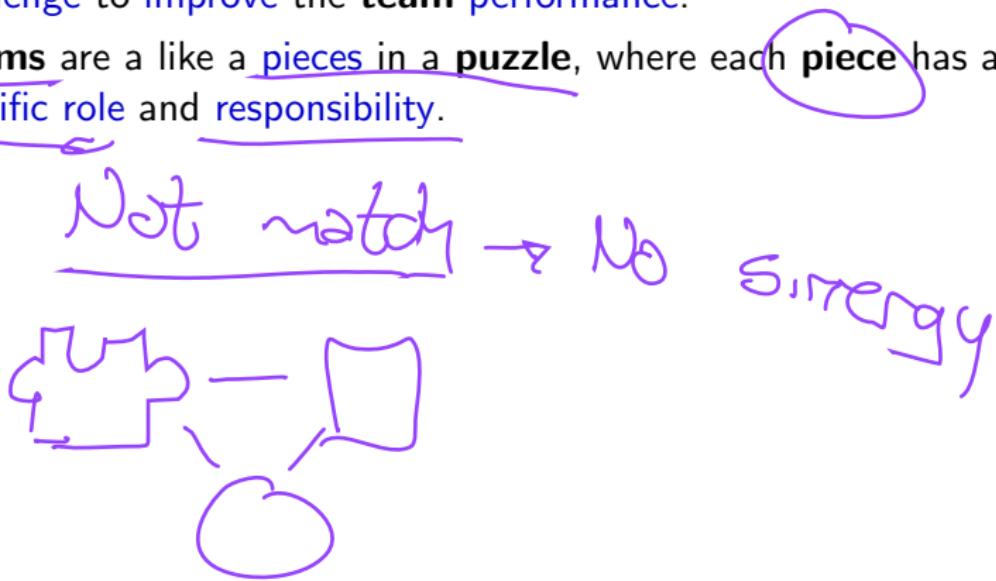
# Teams as a System

- **Teams** are a **system** where collaboration (sinergy) and communication are **key** to **success**.
  - Define and automate the **processes** and **procedures** in the **team** is a challenge to **improve** the **team** performance.
  - **Teams** are like a **pieces** in a **puzzle**, where each **piece** has a **role**.



# Teams as a System

- **Teams** are a **system** where collaboration (**sinergy**) and communication are **key** to **success**.
- Define and automate the **processes** and **procedures** in the **team** is a **challenge** to improve the **team** performance.
- **Teams** are like a **pieces** in a **puzzle**, where each **piece** has a specific role and responsibility.



# Soft Skills

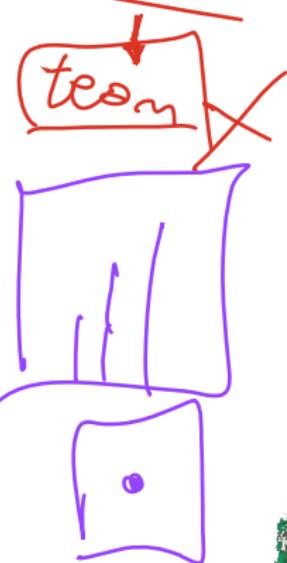
- **Soft skills** are personal attributes that enable someone to interact effectively and harmoniously with other people.

- Typical Soft Skills:

- Communication skills (verbal and written).
- Teamwork and collaboration.
- Problem-solving and critical thinking.
- Adaptability and flexibility.
- Time management and organization.
- Leadership and management.
- Emotional intelligence.
- Creativity and innovation.
- Conflict resolution.
- Networking and relationship building.
- Customer service and client management.

Hand

# Tools



Variaciones



# Computer Analyst

- Skills:

- Business process modeling and documentation.
- Data analysis and interpretation.
- Requirements gathering and management.
- Stakeholder management.

- Responsibilities:

- Analyzing business processes and identifying areas for improvement.
  - Gathering and documenting business requirements.
  - Collaborating with stakeholders to define project scope and objectives.
  - Creating and maintaining project documentation, including functional specifications and use cases.
  - Facilitating communication between business users and technical teams.
  - Participating in system testing and user acceptance testing.
- Providing support and training to end users.
- 
- The diagram illustrates the flow of business analysis. It starts with 'Business' at the top, which branches down to 'Activity' and 'Sequence'. 'Activity' leads to 'Development Client'. Below 'Development Client', there is a bracketed area containing 'Descriptive Analysis' and 'Prescriptive Analysis'. A green arrow points from 'Development Client' towards this bracketed area.



# Computer Analyst

- **Skills:**

- Business process modeling and documentation.
- Data analysis and interpretation.
- Requirements gathering and management.
- Stakeholder management.

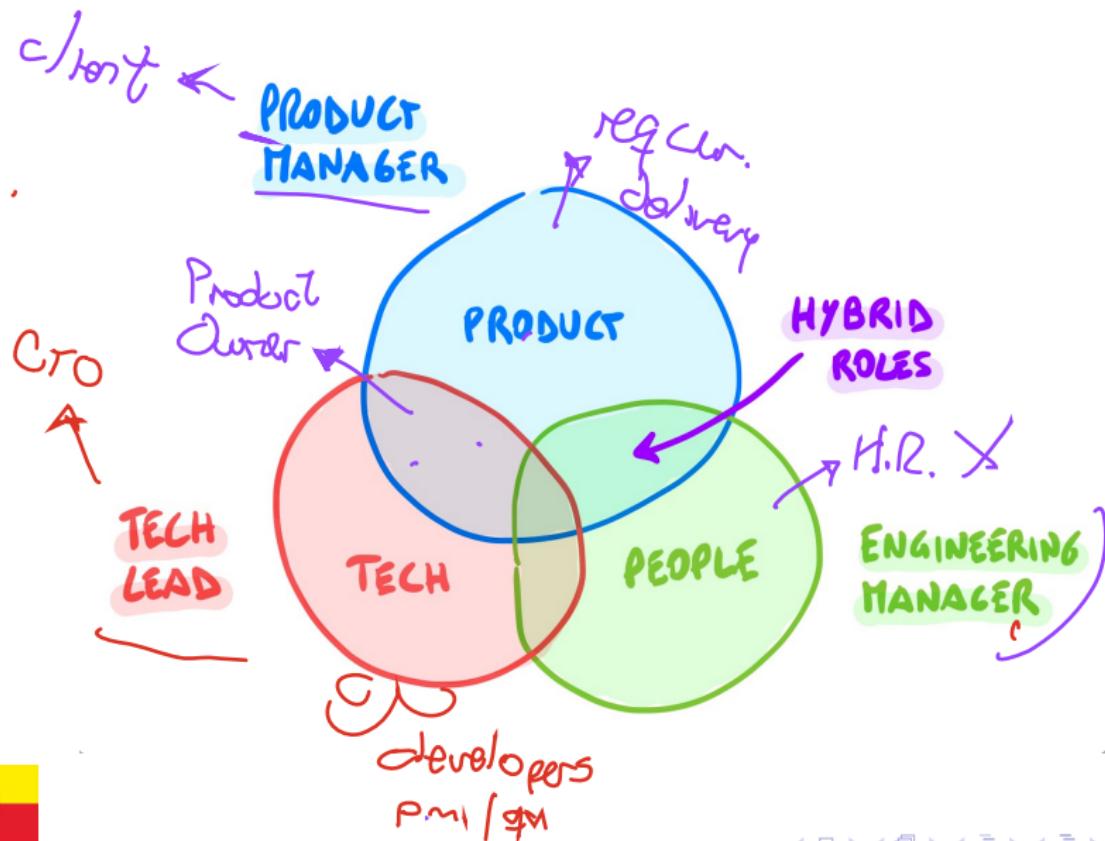
- **Responsibilities:**

- Analyzing business processes and identifying areas for improvement.
- Gathering and documenting business requirements.
- Collaborating with stakeholders to define project scope and objectives.
- Creating and maintaining project documentation, such as functional specifications and use cases.
- Facilitating communication between business users and technical teams.
- Participating in system testing and user acceptance testing.
- Providing support and training to end users.

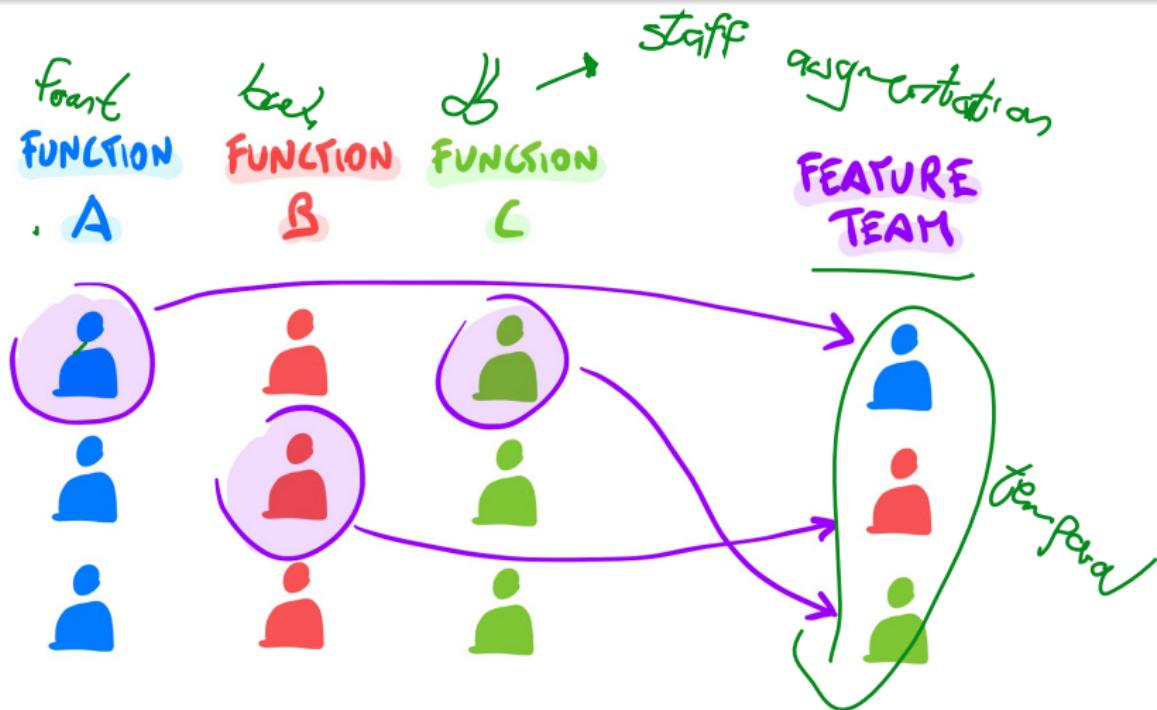
expectativa



# Tech Company Typical Structure



# Feature Teams



# What is to be a leader? I

- **Leading** a team is **not a role**. It is a decision, you could be a **leader** anytime and anywhere.

- Teamwork culture is pretty important. It creates habits, open communication, safety spaces for inclusion.  
*need? → why?*
- Psychological safety is a key point to have an effective team. You could develop technical skills, but it's not enough.  
*cert se sienten?*
- Hierarchy is very important. Anarchism tends to fail. Hierarchy exists by status and power.
- In a hierarchy experts lead to make better decisions. However, anyone must be careful to not leave people behind.



# What is to be a leader? I

- **Leading** a team is not a **role**. It is a decision, you could be a **leader** anytime and anywhere.
- **Teamwork culture** is pretty **important**. It creates **habits**, open communication, safety spaces for inclusion.
- Psychological safety is a key point to have an effective team. You could develop technical skills, but not enough.  
right? → communication?
- Hierarchy is very important. Anarchism tends to fail. Hierarchy exists by status and power.  
channel?
- In a hierarchy experts lead to make better decisions. However, anyone must be careful to not leave people behind.



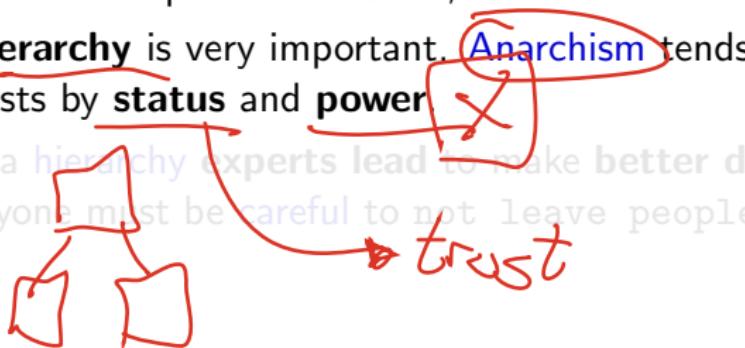
# What is to be a leader? I

- **Leading** a team is not a **role**. It is a decision, you could be a **leader** anytime and anywhere.
- **Teamwork culture** is pretty **important**. It creates habits, open communication, safety spaces for inclusion.
- **Psychological safety** is a **key point** to have an **effective** team. You could develop **technical skills**, but **it is not enough**.
- **Hierarchy** is very important. Anarchism tends to fail. Hierarchy exists by **status** and power.  
*2 days*
- In a hierarchy experts lead to make better decisions. However, anyone must be **careful** to not leave people behind.  
*Pythagoras*



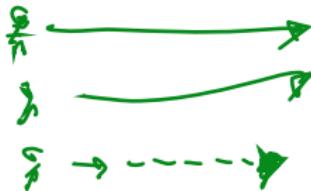
# What is to be a leader? I

- **Leading** a team is not a **role**. It is a decision, you could be a **leader** anytime and anywhere.
- **Teamwork culture** is pretty **important**. It creates habits, open communication, safety spaces for inclusion.
- **Psychological safety** is a **key** point to have an **effective** team. You could develop *technical skills*, but **it is not enough**.
- **Hierarchy** is very important. **Anarchism** tends to **fail**. **Hierarchy** exists by **status** and **power**
- In a **hierarchy** experts lead to make better decisions. However, anyone must be careful to not leave people behind.



# What is to be a leader? I

- **Leading** a team is not a **role**. It is a decision, you could be a **leader** anytime and anywhere.
- **Teamwork culture** is pretty **important**. It creates habits, open communication, safety spaces for inclusion.
- **Psychological safety** is a **key** point to have an **effective** team. You could develop *technical skills*, but **it is not enough**.
- **Hierarchy** is very important. **Anarchism** tends to fail. Hierarchy exists by **status** and **power**.
- In a **hierarchy** **experts lead** to make **better decisions**. However, anyone must be **careful** to not leave people behind.



$\therefore$  ~ week  
bi-weekly       $\int 5 \sim 30 \text{ min}$



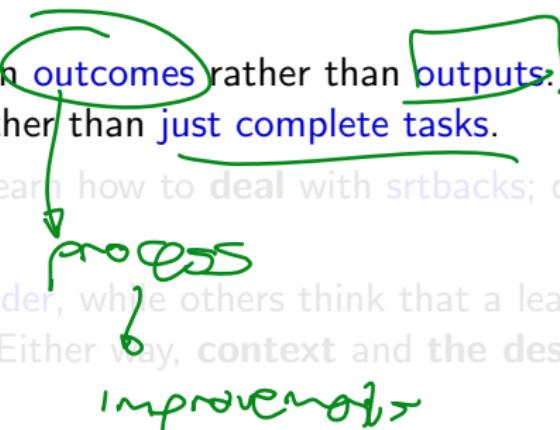
# What is to be a leader? II

- With **crystal-clear communications** and clarity about **business goals** and achievements, people feel **more comfortable** pursuing the same **goals as a team.**
- A good leader should focus on outcomes rather than outputs. This helps bring **business value** rather than just complete tasks.
- Failure** is always an option. Learn how to **deal** with setbacks; do not punish — just fix and learn.
- Some believe you're born a leader, while others think that a leader can be developed over time. Either way, **context** and **the desire** for self-growth are vital.
- Making **ethical decisions** is key; it leads to taking the right and better actions.



# What is to be a leader? II

- With **crystal-clear communications** and clarity about **business goals** and achievements, people feel **more comfortable** pursuing the same goals as a **team**.
- A **good leader** should focus on **outcomes** rather than **outputs**. This helps bring **business value** rather than just complete tasks.
- Failure is always an option. Learn how to deal with setbacks; do not punish — just fix and learn.
- Some believe you're born a leader, while others think that a leader can be developed over time. Either way, **context** and **the desire for self-growth** are vital.
- Making **ethical decisions** is key; it leads to taking the right and better actions.



# What is to be a leader? II

- With **crystal-clear communications** and clarity about **business goals** and achievements, people feel **more comfortable** pursuing the same **goals** as a **team**.
- A **good leader** should focus on **outcomes** rather than **outputs**. This helps bring **business value** rather than just complete tasks.
- Failure** is always an **option**. Learn how to **deal** with **srbbacks**; do not **punish**—just **fix and learn**. *root cause*
- Some believe you're born a leader, while others think that a leader can be developed over time. Either way, **context** and **the desire for self-growth** are **vital**.
- Making **ethical decisions** is key; it leads to taking the **right** and **better actions**.



# What is to be a leader? II

- With **crystal-clear communications** and clarity about **business goals** and achievements, people feel **more comfortable** pursuing the same **goals** as a **team**.
  - A **good leader** should focus on **outcomes** rather than **outputs**. This helps bring **business value** rather than **just complete tasks**.
  - Failure** is always an **option**. Learn how to **deal** with **srtbacks**; do not punish — just **fix and learn**.
  - Some believe you're **born a leader**, while others think that a leader can be **devveloped over time**. Either way, **context** and **the desire** for self-growth are **vital**.
  - Making **ethical decisions** is key; it leads to taking the **right** and better actions.
- The Others*



# What is to be a leader? II

- With **crystal-clear communications** and clarity about **business goals** and achievements, people feel **more comfortable** pursuing the same **goals** as a **team**.
- A **good leader** should focus on **outcomes** rather than **outputs**. This helps bring **business value** rather than **just complete tasks**.
- Failure** is always an **option**. Learn how to **deal** with **srtbacks**; do not punish — just **fix and learn**.
- Some believe you're **born a leader**, while others think that a leader can be **devveloped over time**. Either way, **context** and **the desire** for self-growth are **vital**.
- Making **ethical decisions** is **key**; it leads to taking the **right** and **better actions**.



# What is to be a leader? III

Hand

- It is important to maintain **psychological well-being**. You will be **stronger**, better able to **help** people, and have a better **perspective** on everything.
- A good leader builds **trust** relationships and has the emotional intelligence to communicate effectively and understand others.
- To develop as a leader some good guidelines are the **three C's**: Curiosity, Courage, and Commitment.



# What is to be a leader? III

- It is important to maintain **psychological well-being**. You will be **stronger**, better able to **help** people, and have a better **perspective** on everything.
- A **good leader** builds **trust relationships** and has the **emotional intelligence** to communicate effectively and understand others.
- To develop as a leader some good guidelines are the **three C's**: Curiosity, Courage, and Commitment.

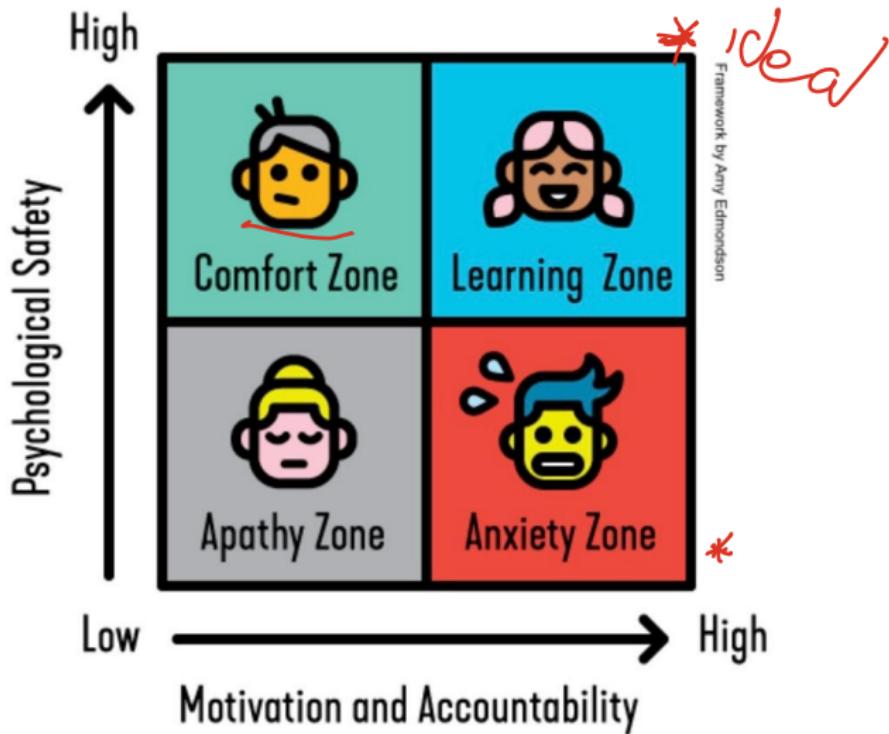


# What is to be a leader? III

- It is important to maintain **psychological well-being**. You will be **stronger**, better able to **help** people, and have a better **perspective** on everything.
- A **good leader** builds **trust relationships** and has the **emotional intelligence** to communicate effectively and understand others.
- To **develop as a leader** some good **guidelines** are the **three C's: Curiosity, Courage, and Commitment**.



# Working Zones



# Outline

- 1 Basic Concepts
- 2 Human Activities
- 3 Cibernetics and Technology
- 4 Teams-Based Structure as a System



# Thanks!

## Questions?



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

