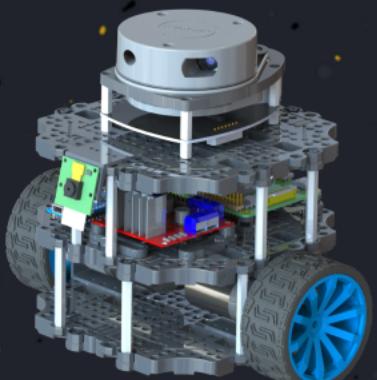


66

“Robotics is concerned with the study of those machines that can replace human beings in the execution of a task, as regards both physical activity and decision making”



Robotics,  
Sciavicco  
Siciliano Villani



Electronics

---

Mechanics

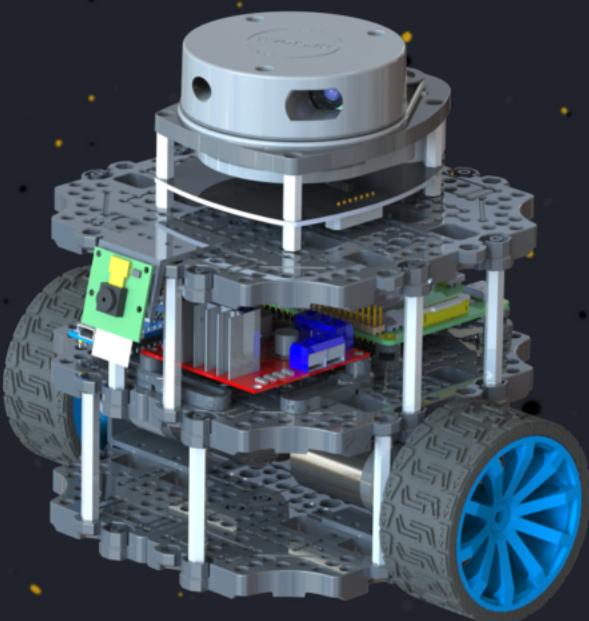
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Sensors

---

Network

---



Software

---

Control

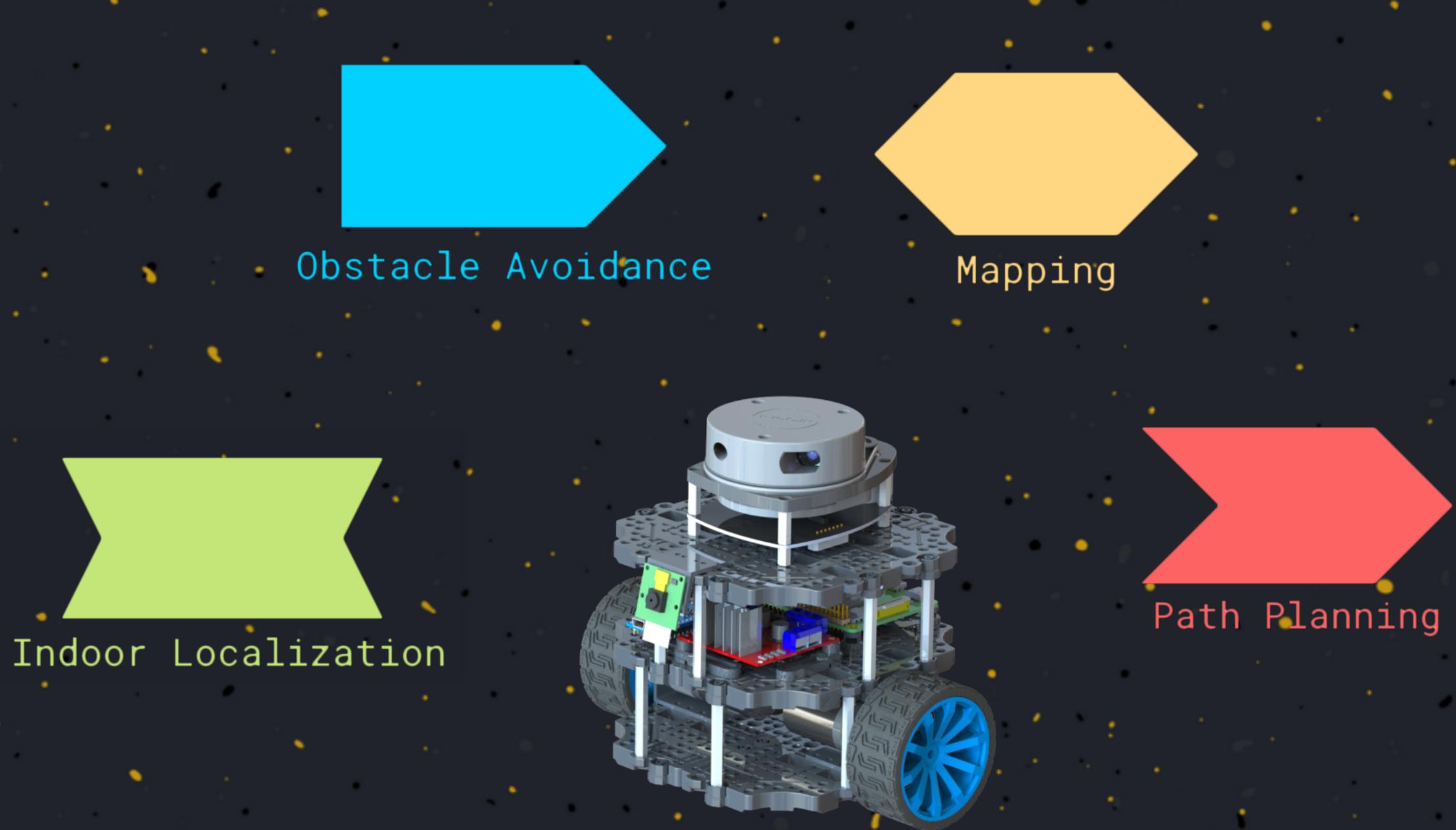
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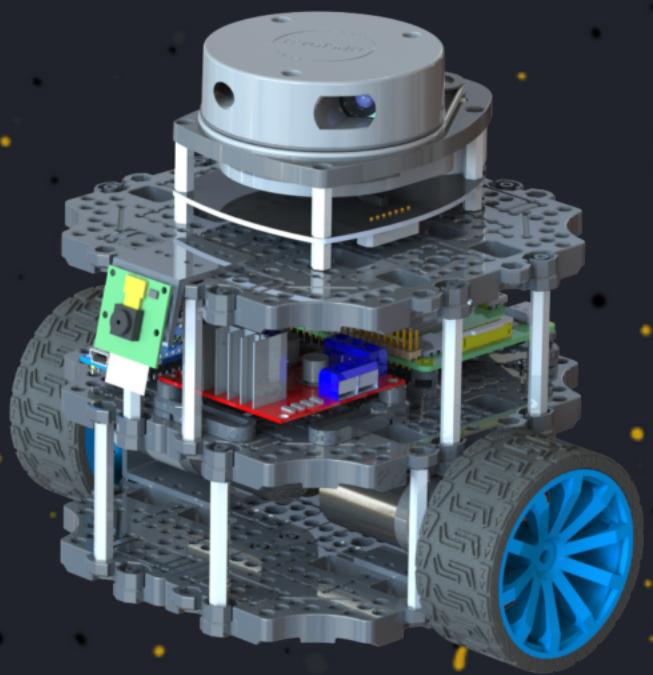
Computer  
Vision

---

Artificial  
Intelligence

---







Obstacle Avoidance

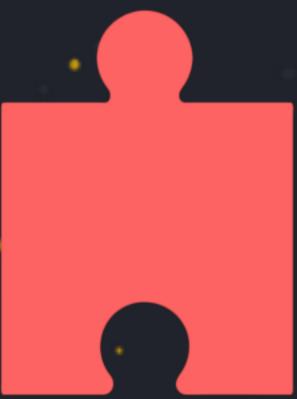
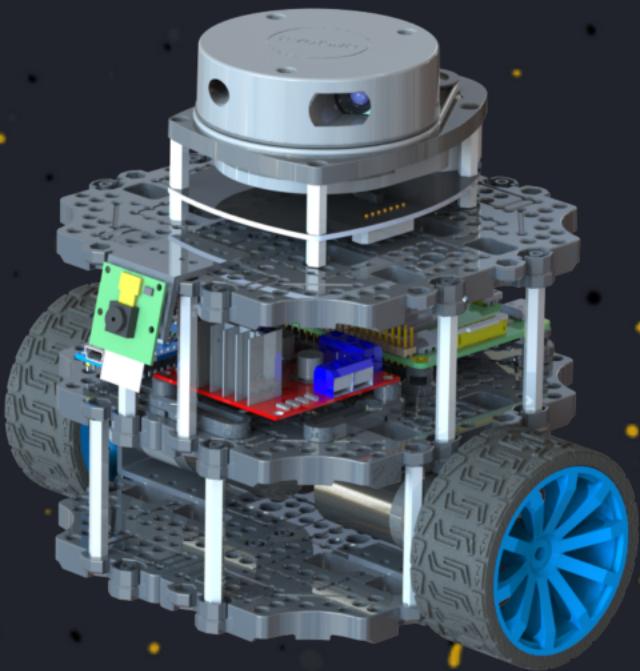


Mapping



Indoor Localization

ROS 2



Path Planning

# ROS 2



... 2007 2009 2013 2018 2021



Robotics Research centers and companies develop their own frameworks for robotics applications



Foundation of Willow Garage, a research center for robotics



First Distribution of ROS is released with the aim of avoiding reinventing the wheel



End of Willow Garage and ROS is maintained and developed by Open Source Robotics Foundation OSRF



ROS2 is released in order to overcome the limitation of ROS



NASA Announces VIPER Project a lunar rover running ROS2

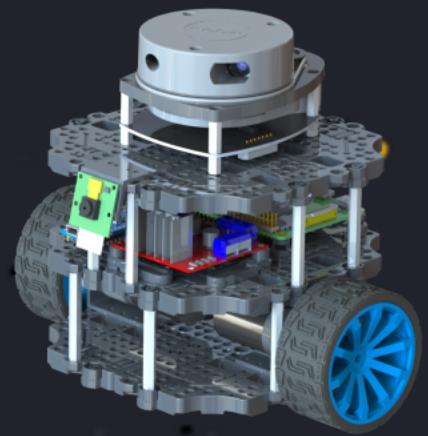


ROS 2



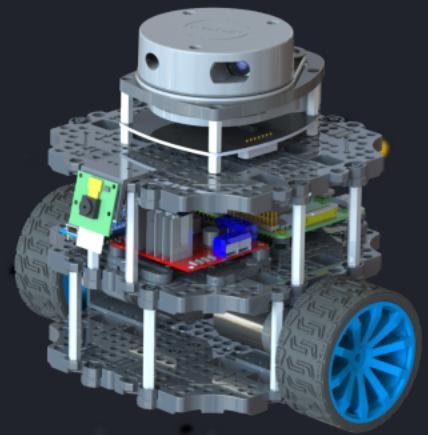
What is ROS 2?

# What is ROS 2?



person tracking  
and following

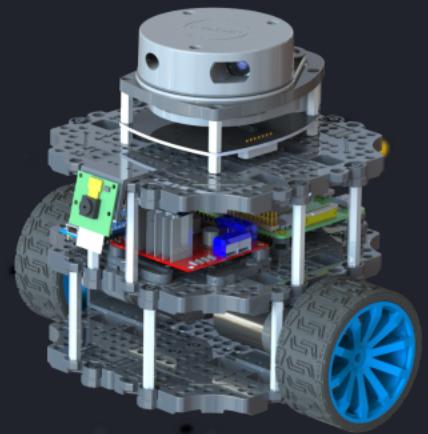
# What is ROS 2?



person tracking  
and following



# What is ROS 2?

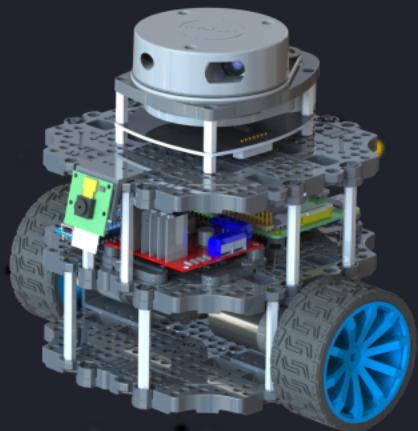


person tracking  
and following



person tracking  
and following  
v2

# What is ROS 2?



person tracking  
and following



person tracking  
and following  
v2



person tracking  
and following  
v2\_final

What is ROS 2?

What is ROS 2?

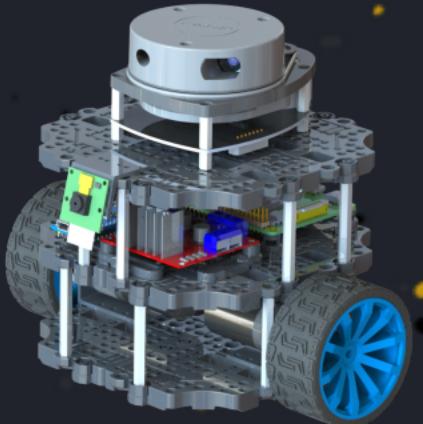


# What is ROS 2?



person tracking  
and following

# What is ROS 2?

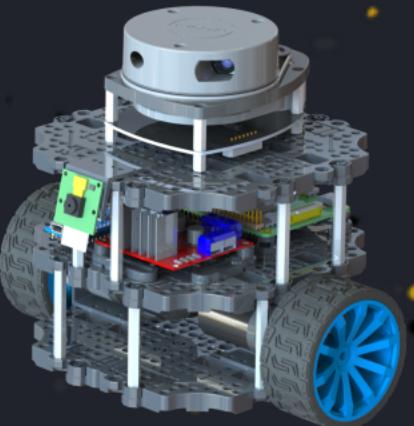


ROS 2



person tracking  
and following

# What is ROS 2?

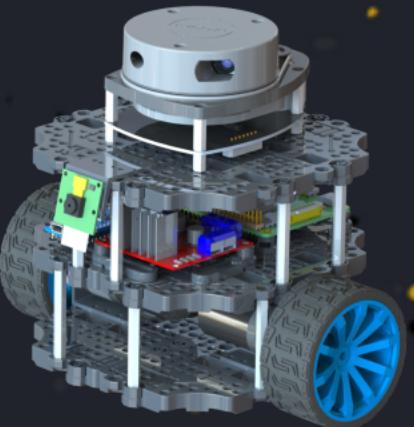


ROS 2



person tracking  
and following

# What is ROS 2?



ROS 2

person tracking  
and following

ROS 2



# Why ROS 2?

Unreliable  
Networks

Fleet of  
Robots

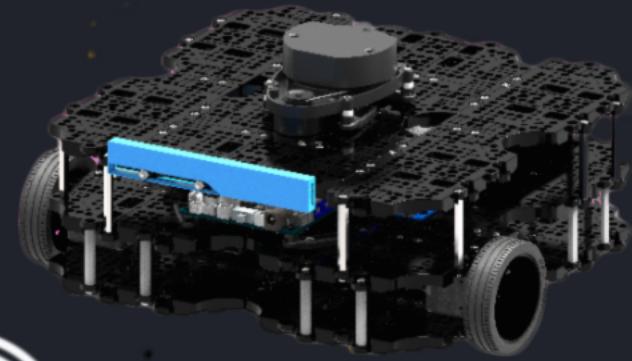
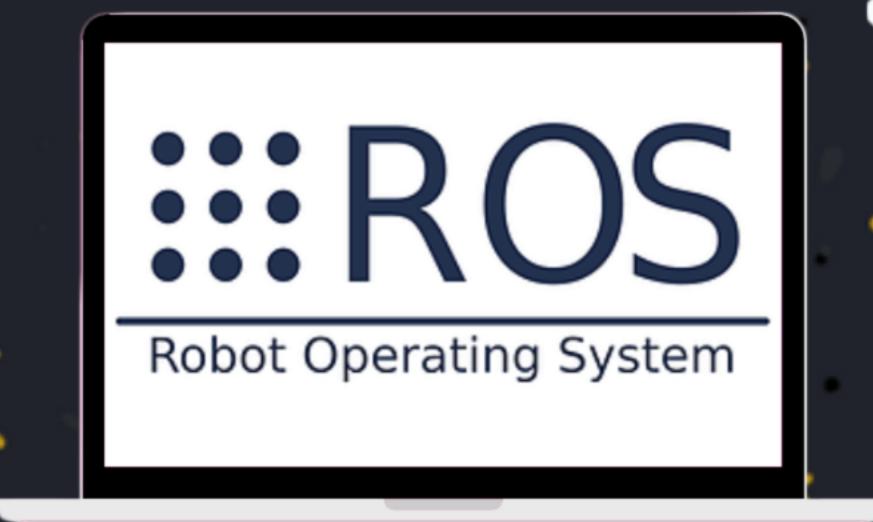
Embedded  
Platforms

ROS

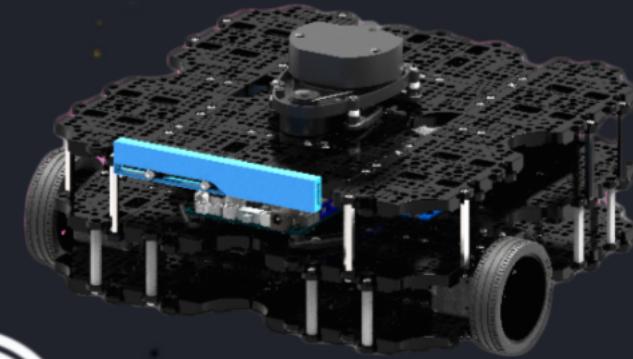
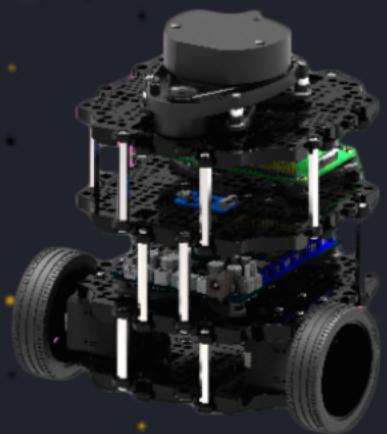
Secure  
Communication



# Unreliable Networks



# Unreliable Networks



# Why ROS 2?

Unreliable  
Networks

Fleet of  
Robots

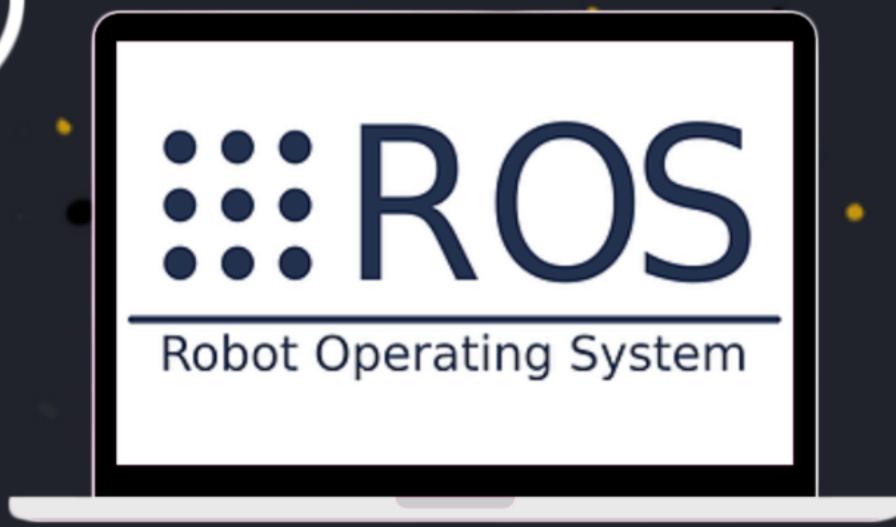
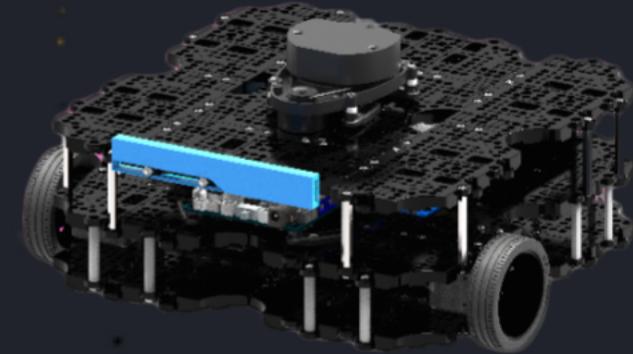
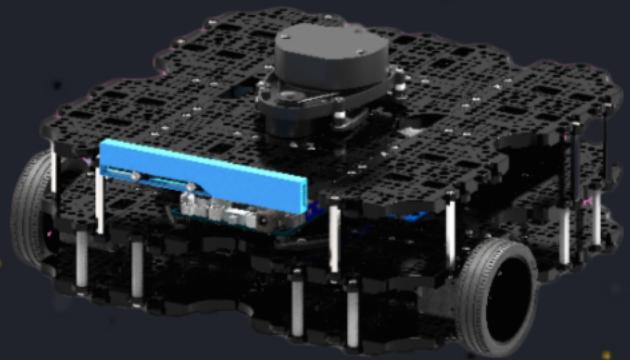
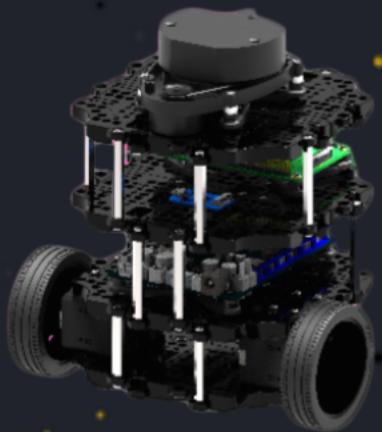
Embedded  
Platforms

ROS

Secure  
Communication



# Fleet of Robots



# Why ROS 2?

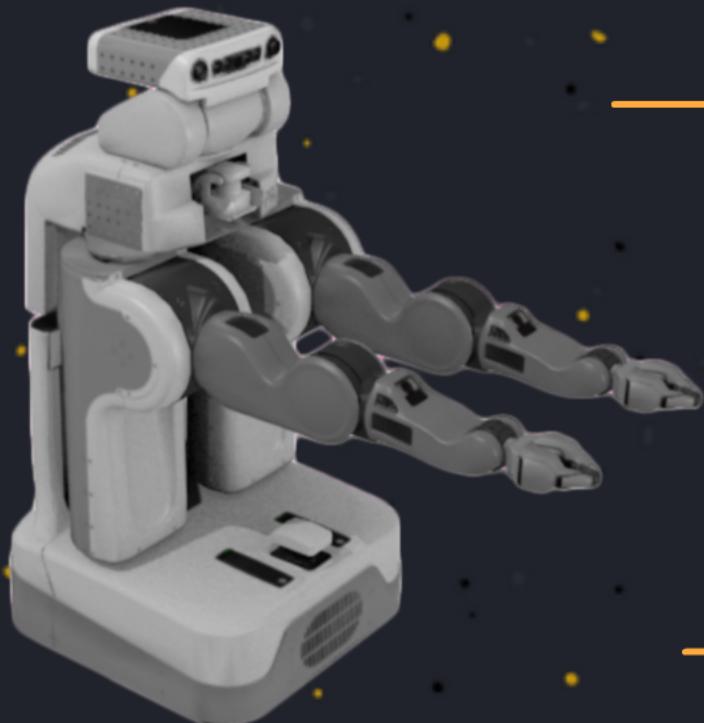
Unreliable  
Networks

Fleet of  
Robots

Embedded  
Platforms

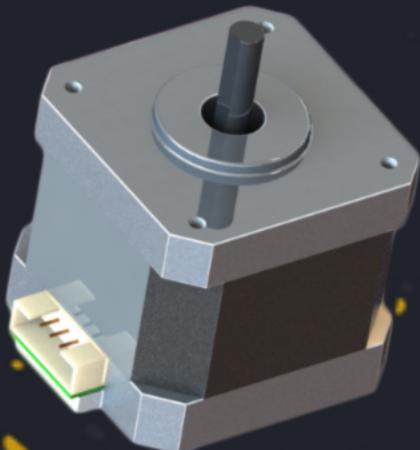
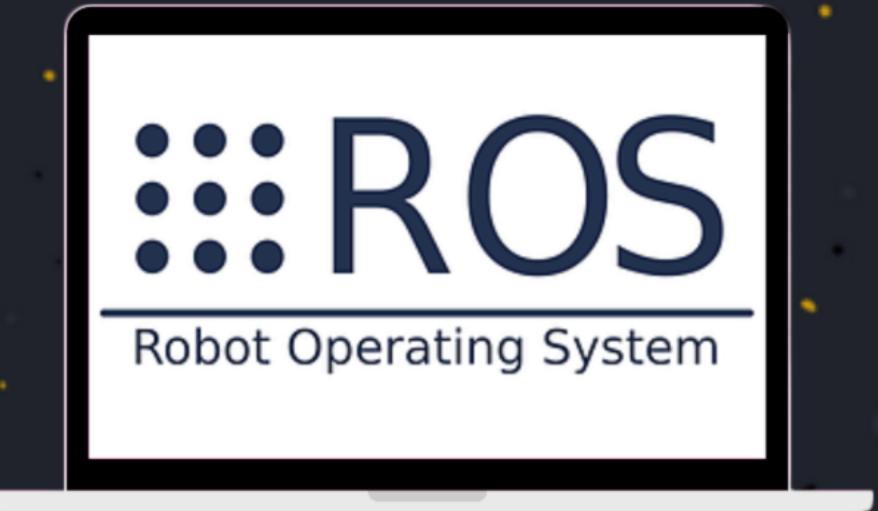
ROS

Secure  
Communication



Realtime  
Systems

# Embedded Platforms



# Why ROS 2?

Unreliable  
Networks

Fleet of  
Robots

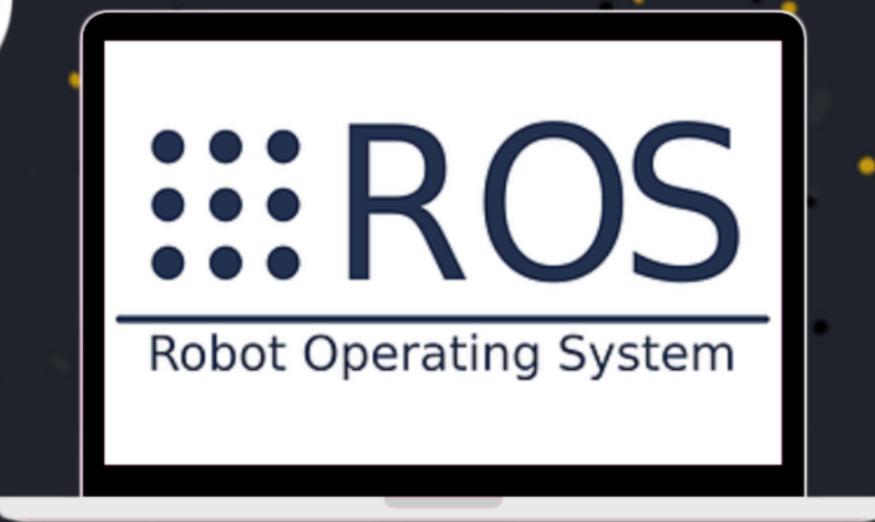
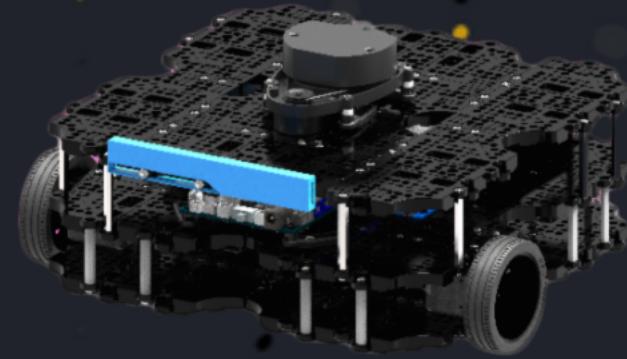
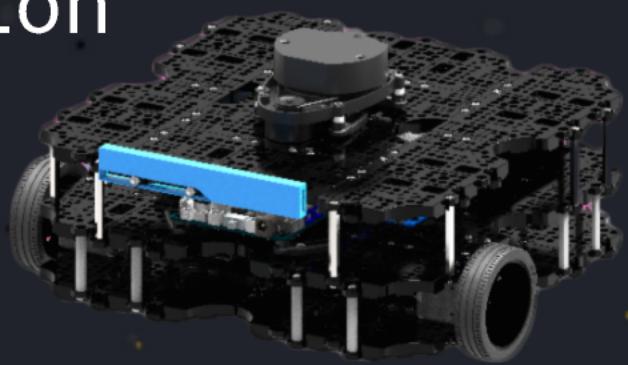
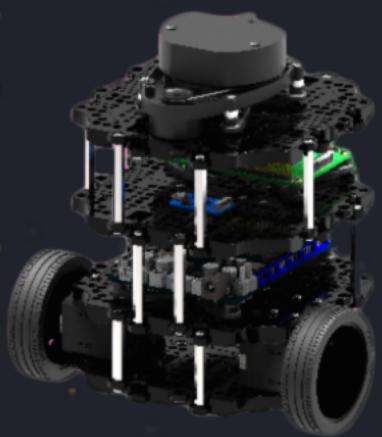
Embedded  
Platforms

ROS

Secure  
Communication



# Secure Communication



# Why ROS 2?

Unreliable  
Networks

Fleet of  
Robots

Embedded  
Platforms

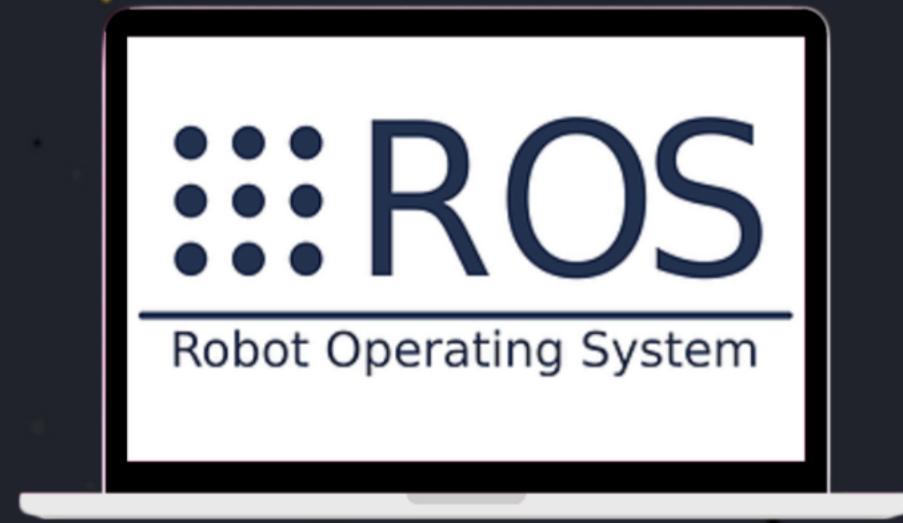
ROS

Secure  
Communication



Realtime  
Systems

Realtime Systems



# Why ROS 2?

Unreliable  
Networks

Fleet of  
Robots

Embedded  
Platforms

ROS

Secure  
Communication



Realtime  
Systems



DDS

Cyclone DDS

Fast DDS

Connext DDS



ROS 2

ROS 2 Middleware (rmw)

DDS

Cyclone DDS

Fast DDS

Connexxt DDS



ROS 2

ROS 2 C++ Client  
Library (rclcpp)

ROS 2 Python Client  
Library (rclpy)

ROS 2 Java Client  
Library (rcljava)

ROS 2 Client Library (rcl)

ROS 2 Middleware (rmw)

DDS

Cyclone DDS

Fast DDS

Connext DDS



User

Amazing ROS 2  
User Application

ROS 2 C++ Client  
Library (rclcpp)

ROS 2 Python Client  
Library (rclpy)

ROS 2 Java Client  
Library (rcljava)

ROS 2 Client Library (rcl)

ROS 2 Middleware (rmw)

DDS

Cyclone DDS

Fast DDS

Connext DDS

# Why ROS 2?

Unreliable  
Networks

Fleet of  
Robots

Embedded  
Platforms

ROS

Secure  
Communication



ROS 2





Obstacle Avoidance

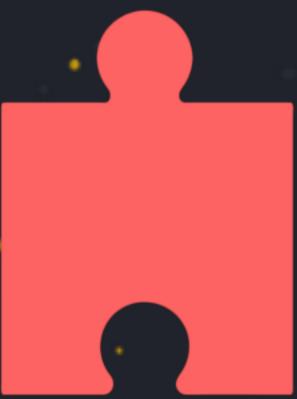
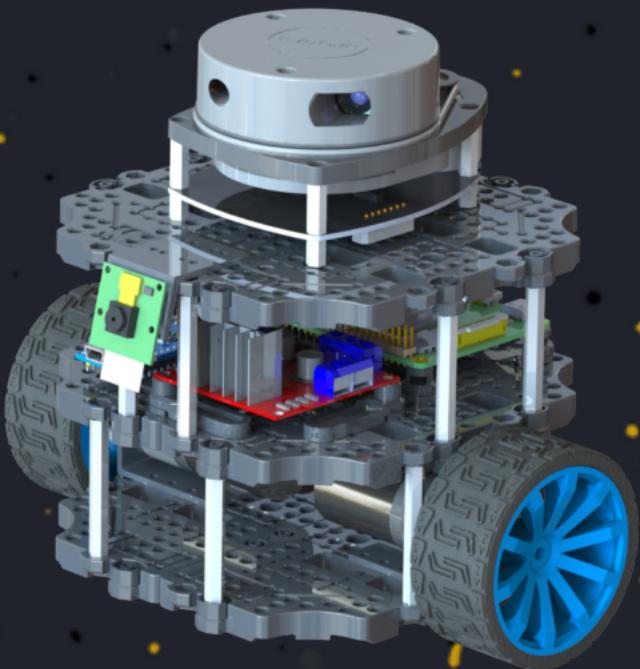


Mapping



Indoor Localization

ROS 2



Path Planning

Electronics

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Mechanics

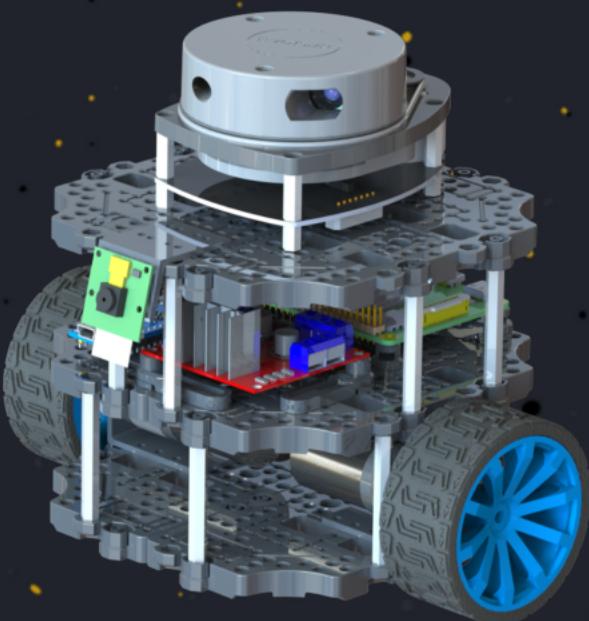
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Sensors

---

Network

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Software

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Control

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Computer  
Vision

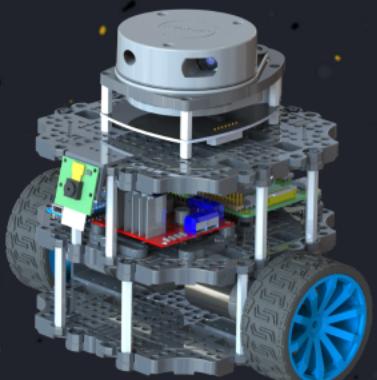
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Artificial  
Intelligence

---

66

“Robotics is concerned with the study of those machines that can replace human beings in the execution of a task, as regards both physical activity and decision making”



Robotics,  
Sciavicco  
Siciliano Villani



Hardware  
Abstraction

---



Low-Level  
Device Control

---

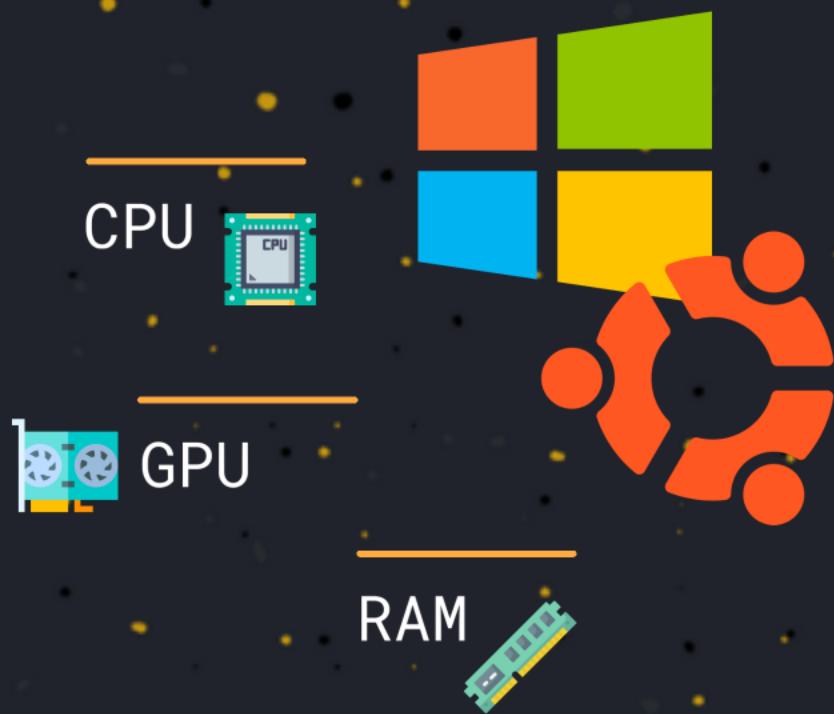
Communication  
Between Process

---

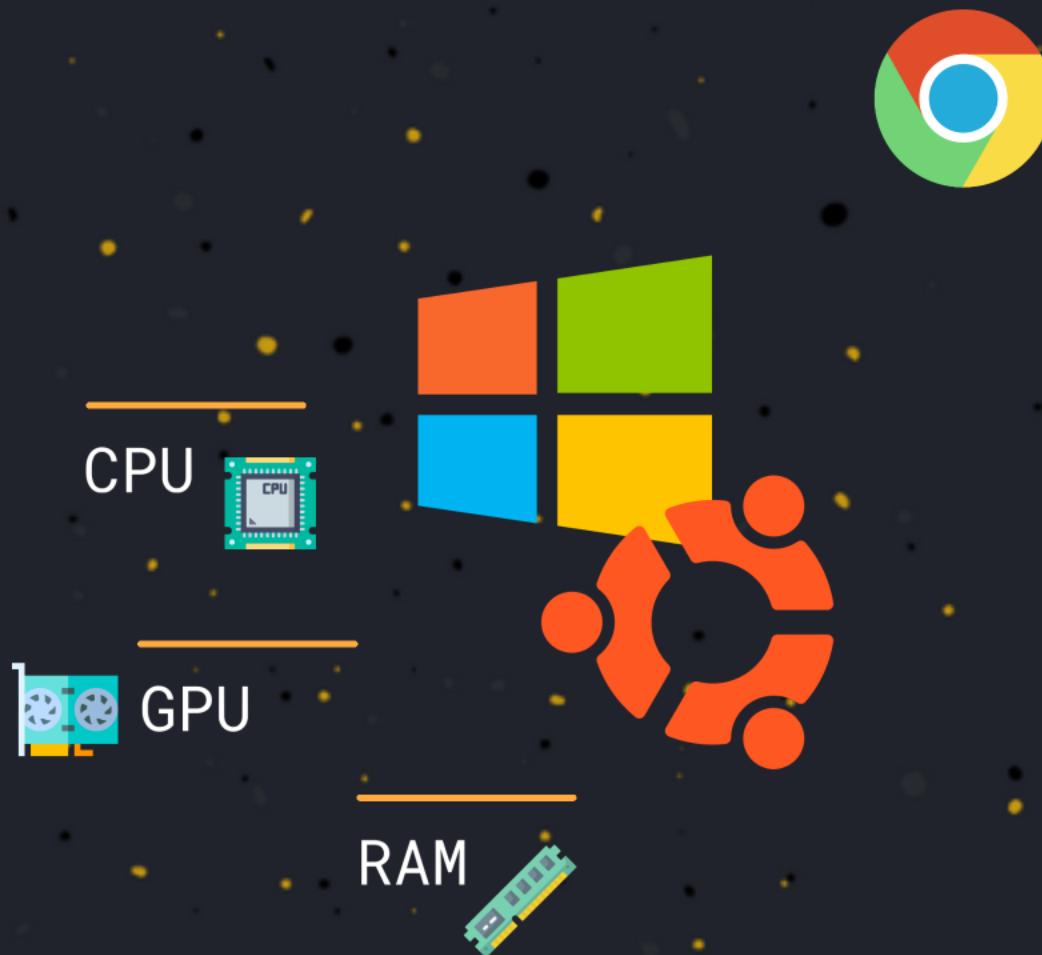
Package  
Management

---

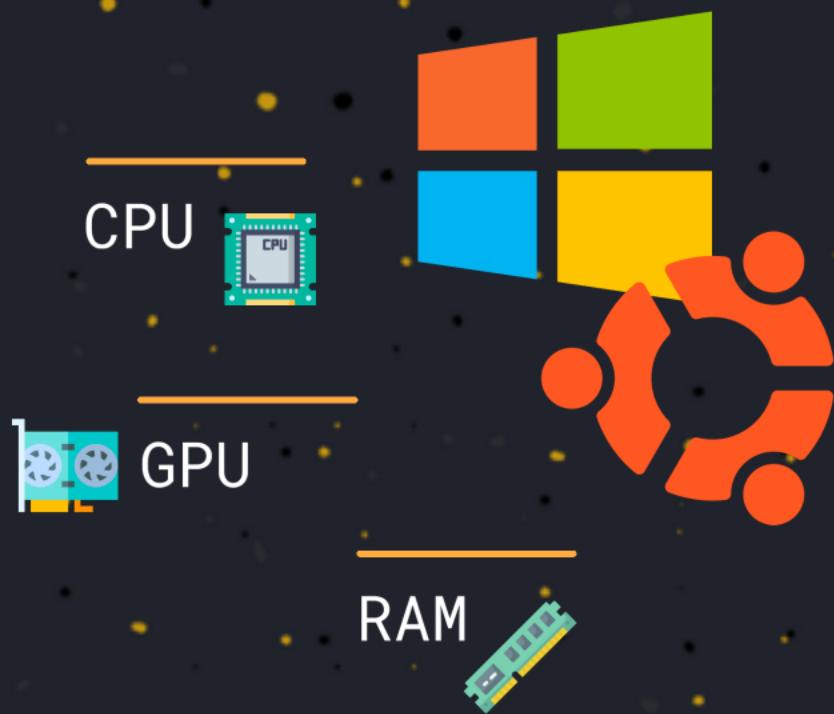
# Hardware Abstraction



# Hardware Abstraction

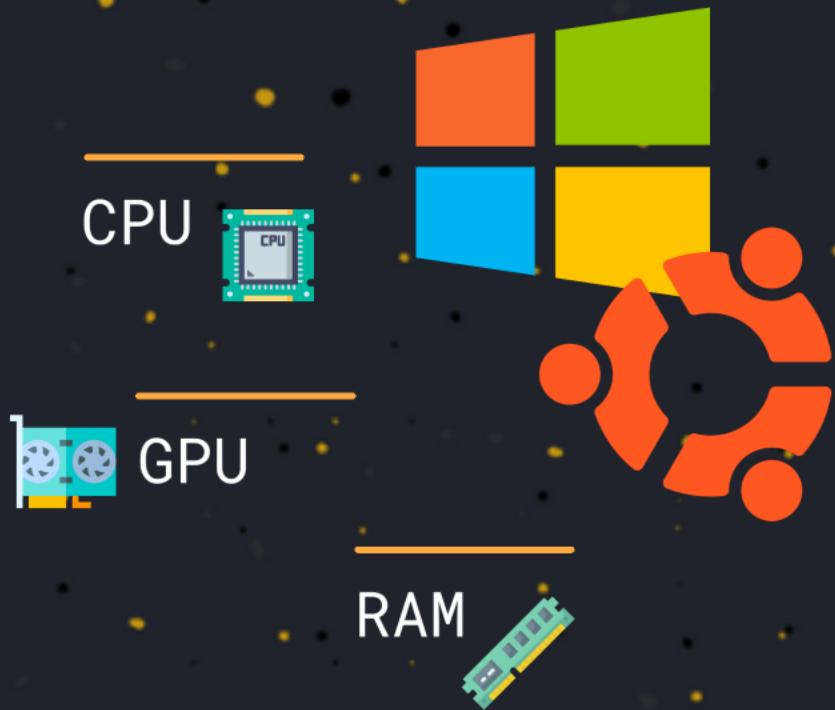


# Hardware Abstraction

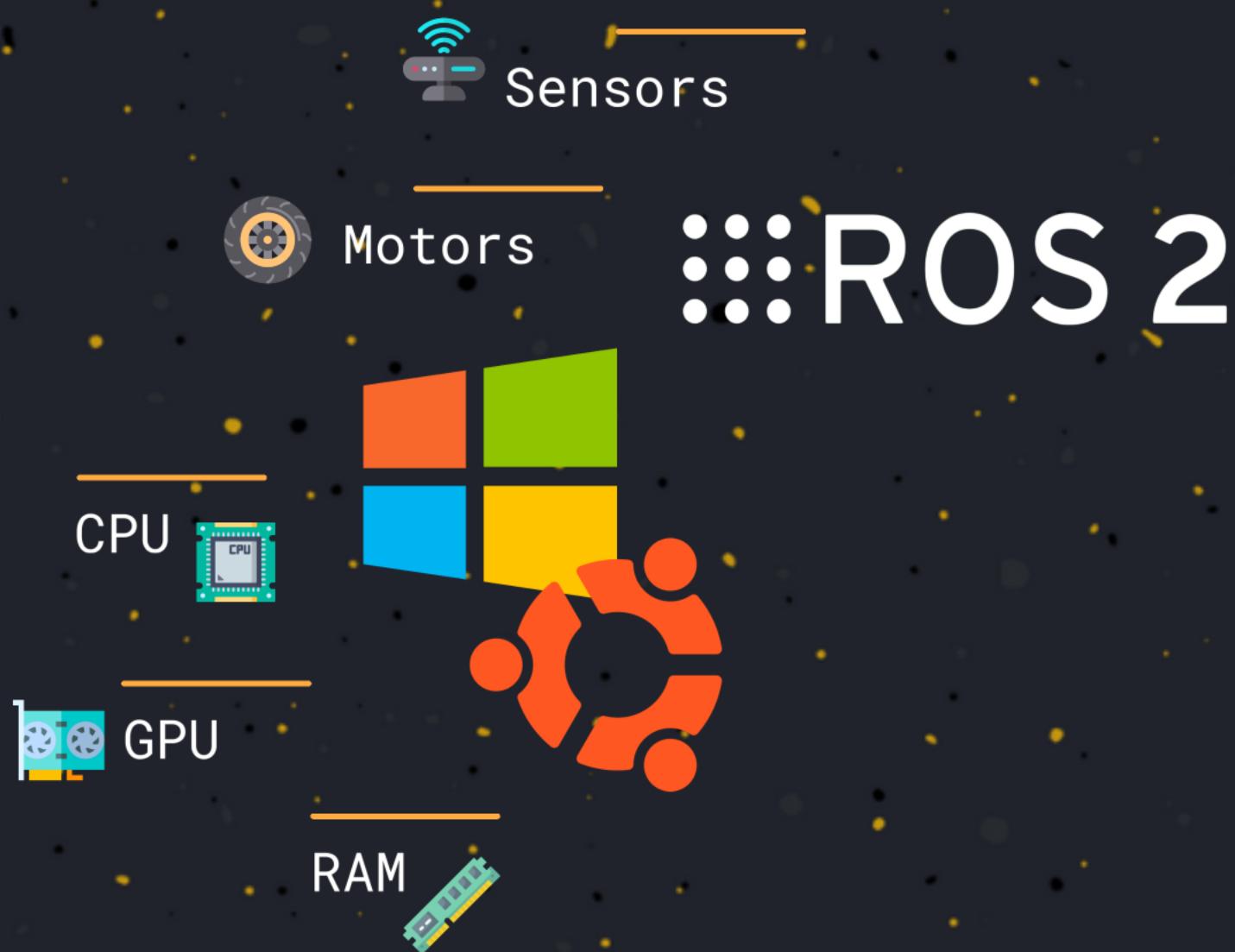


# Hardware Abstraction

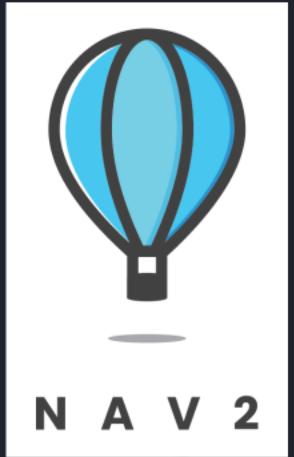
ROS 2



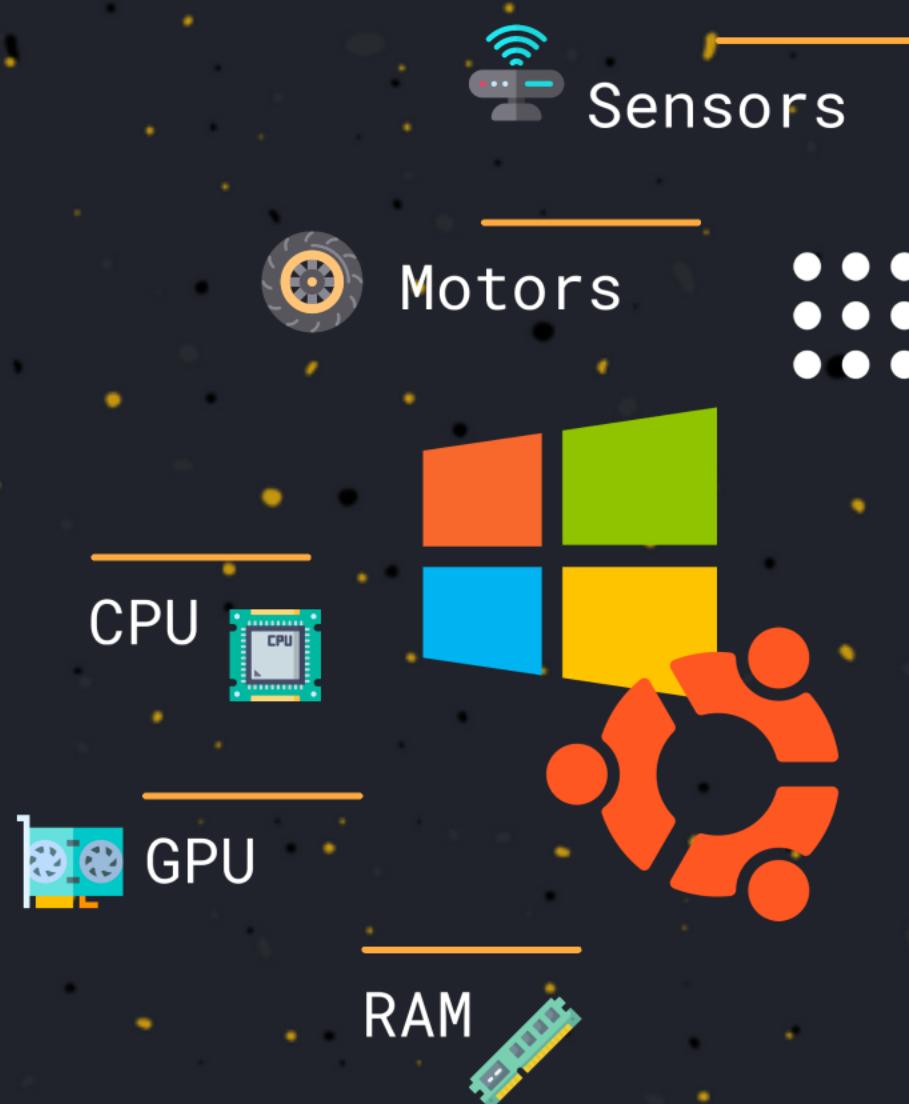
# Hardware Abstraction



# Hardware Abstraction



ROS 2



Hardware  
Abstraction

---



Low-Level  
Device Control

---

Communication  
Between Process

---

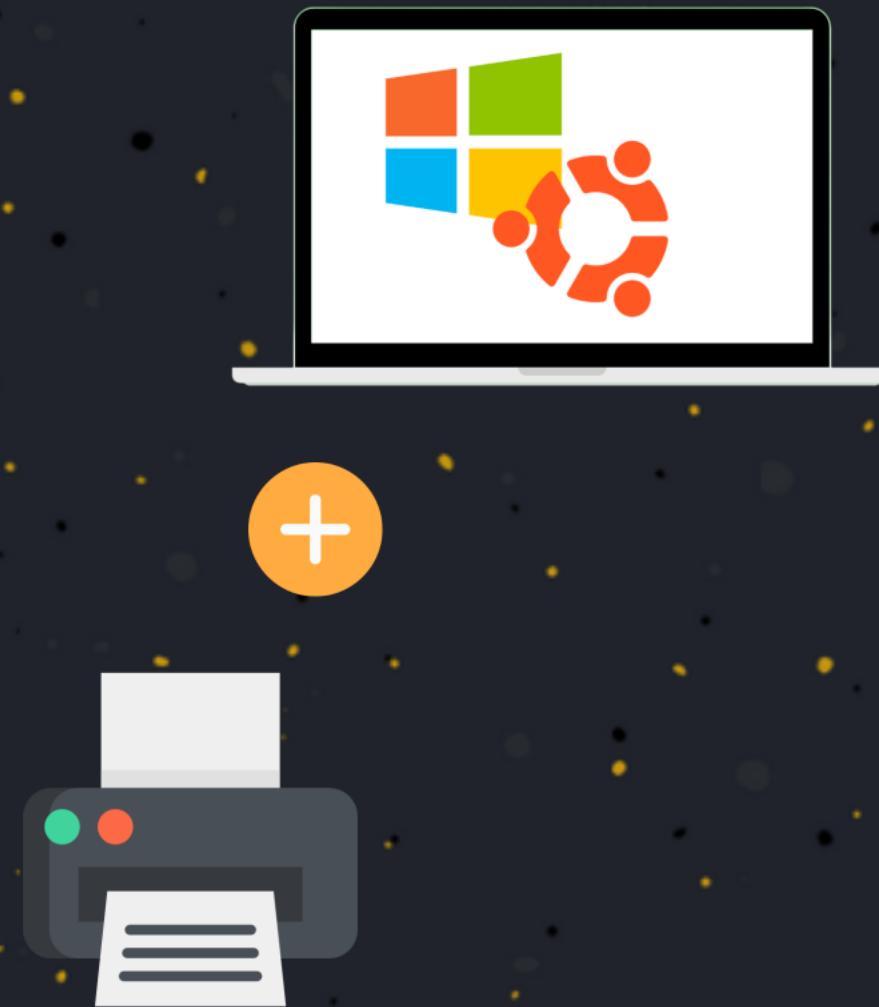
Package  
Management

---

# Low-Level Device Control



# Low-Level Device Control



# Low-Level Device Control

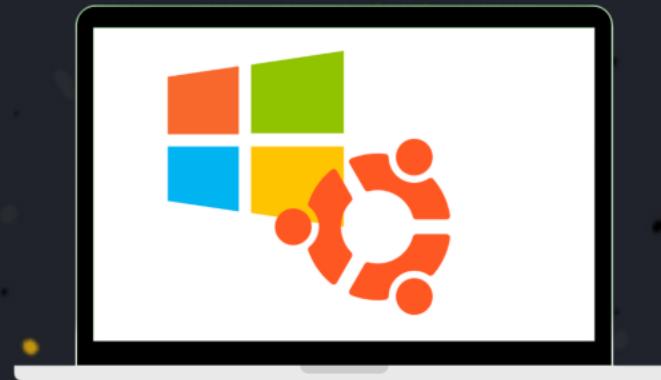


# Low-Level Device Control



ROS 2

# Low-Level Device Control



ROS 2



Hardware  
Abstraction

---



Low-Level  
Device Control

---

Communication  
Between Process

---

Package  
Management

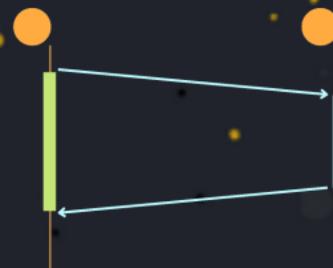
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# Communication Between Process

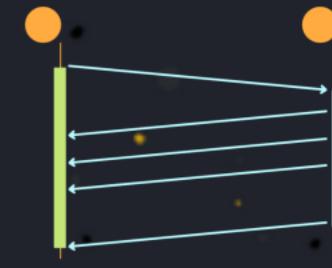
- Topic



- Service



- Action



# Topic



# Topic



# Topic



Topic

# Topic



Topic

Topic

/topic\_1



/topic\_2



Topic

Topic

/topic\_1



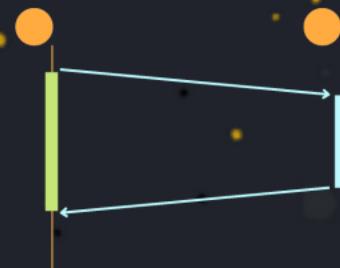
/topic\_2

# Communication Between Process

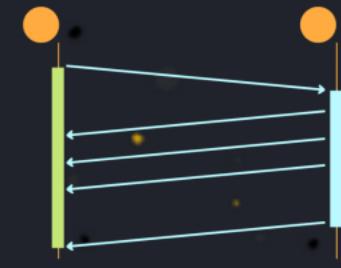
- Topic



- Service



- Action



Service



Client

Server

Service



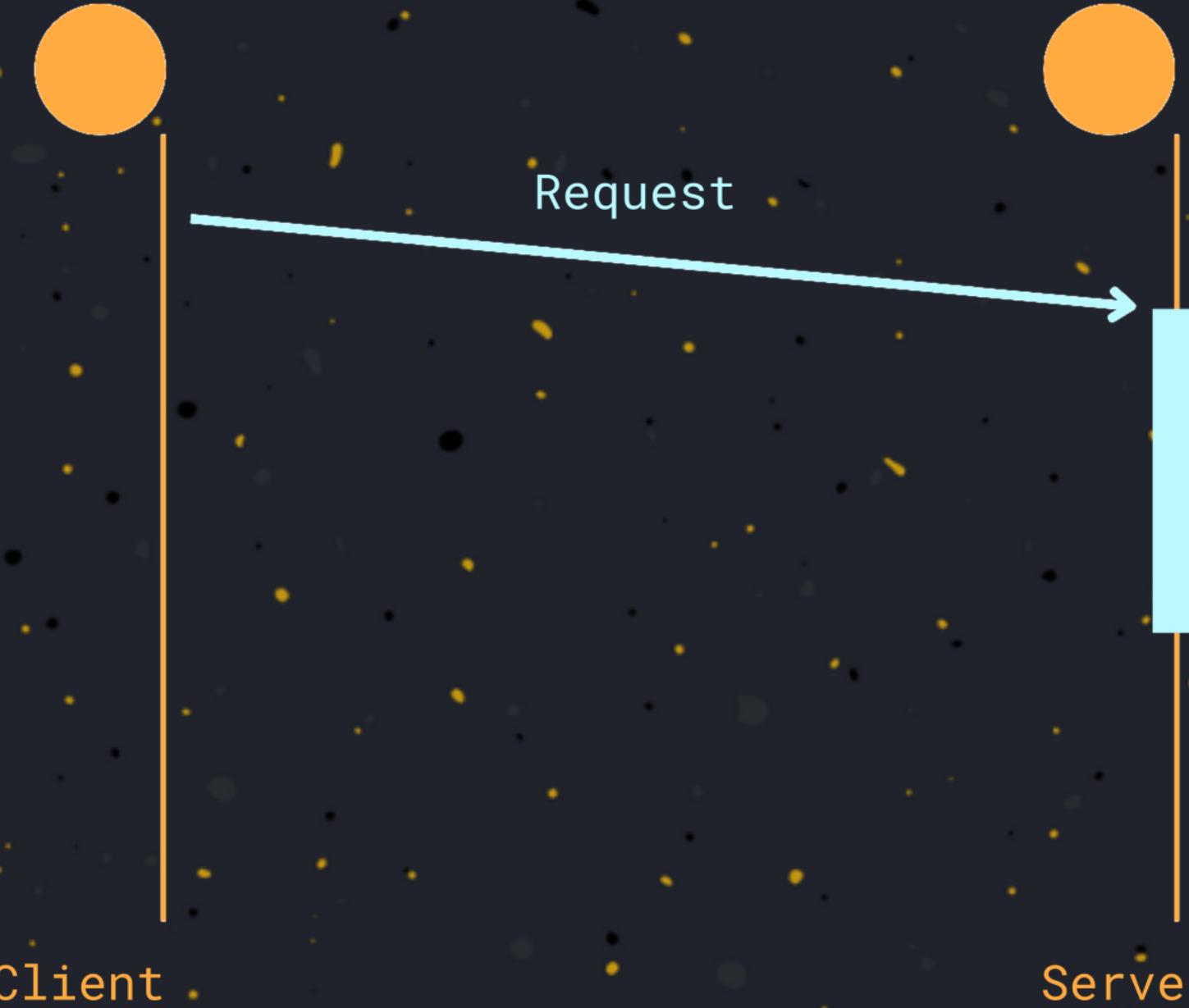
Request

Client

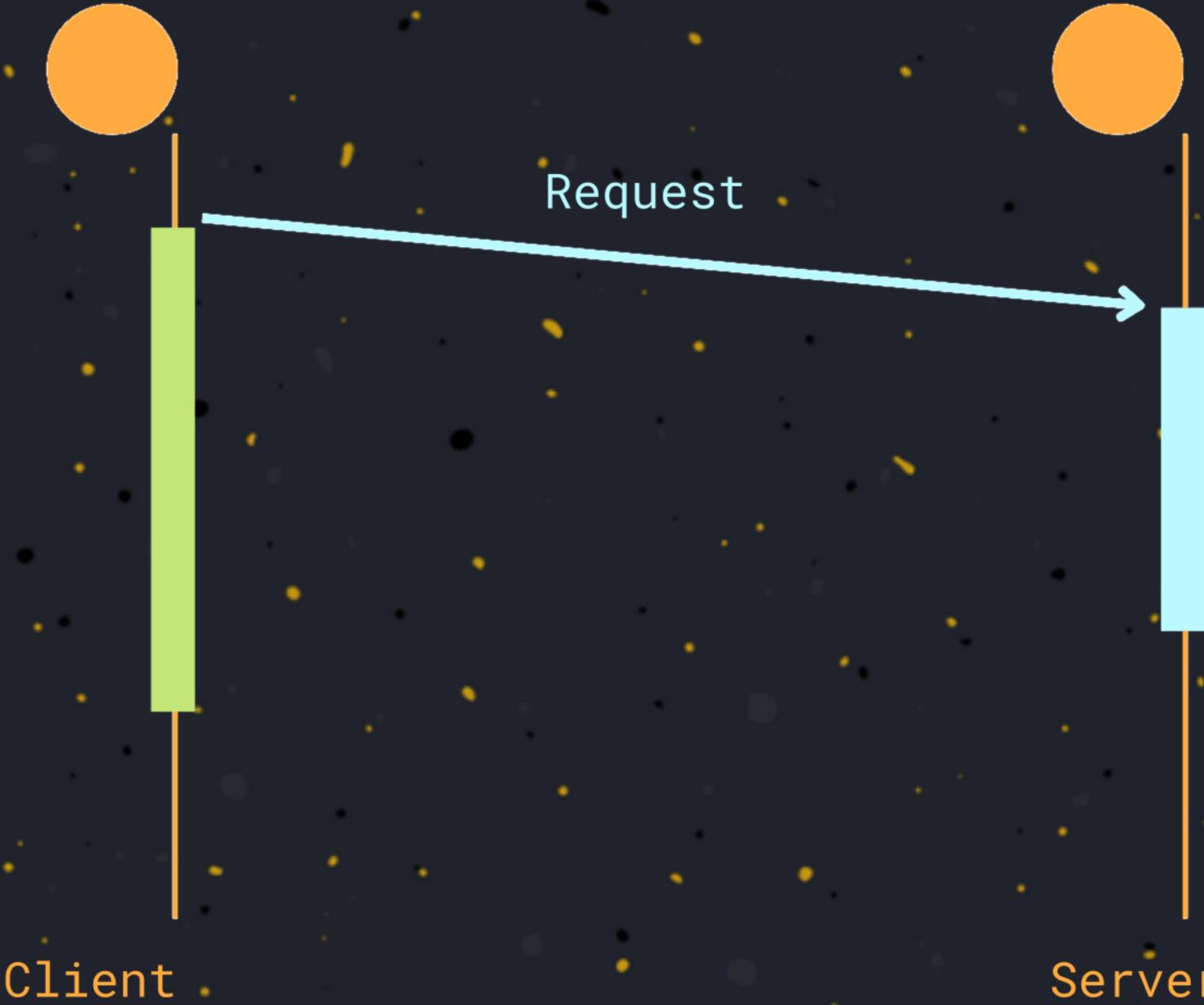
Server



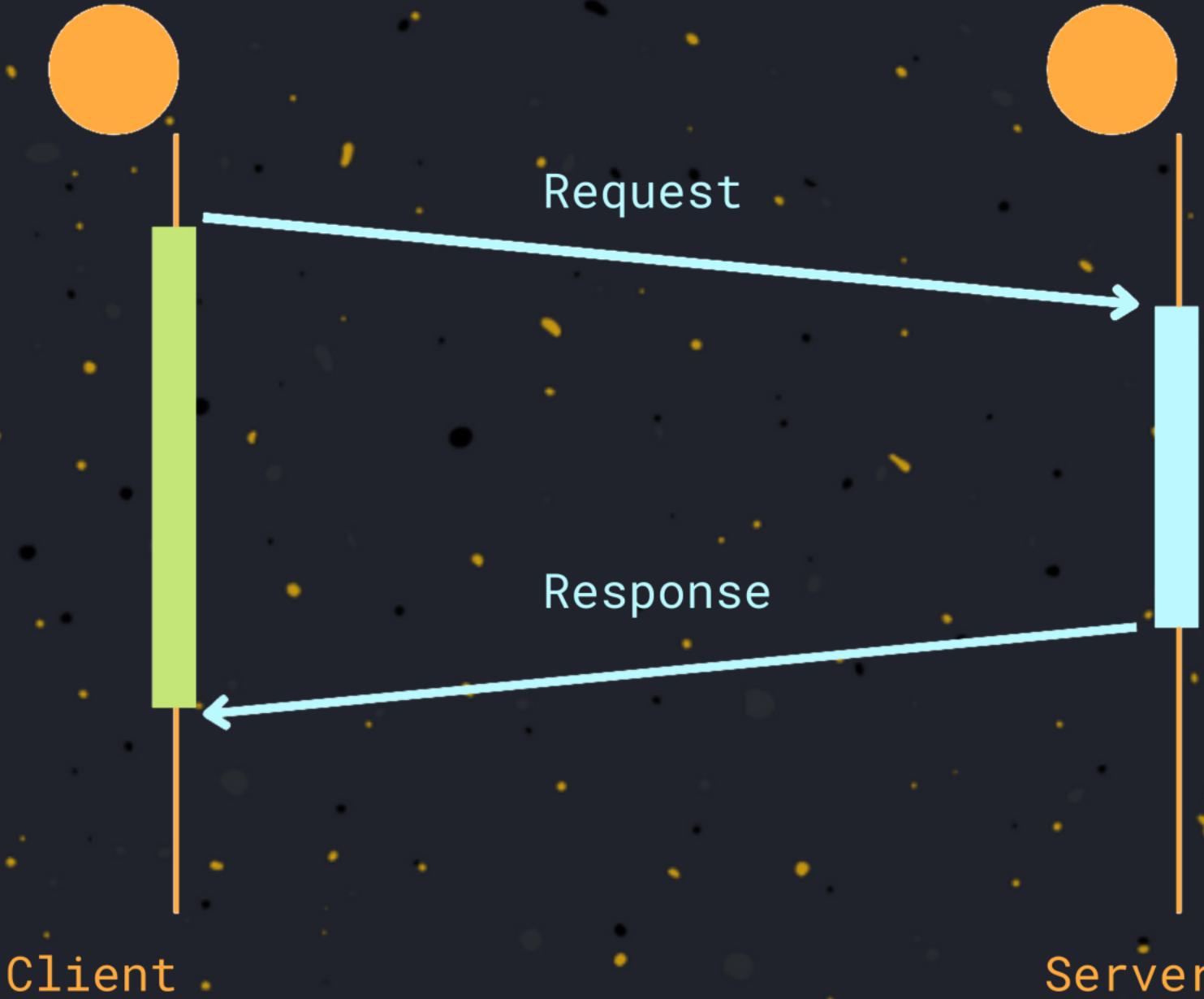
Service



Service



Service

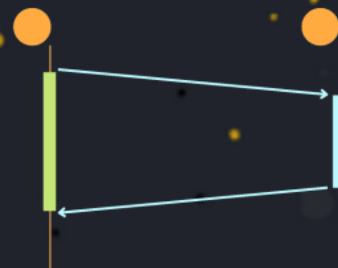


# Communication Between Process

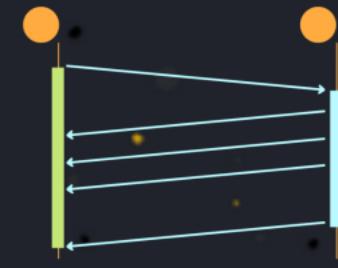
- Topic



- Service



- Action

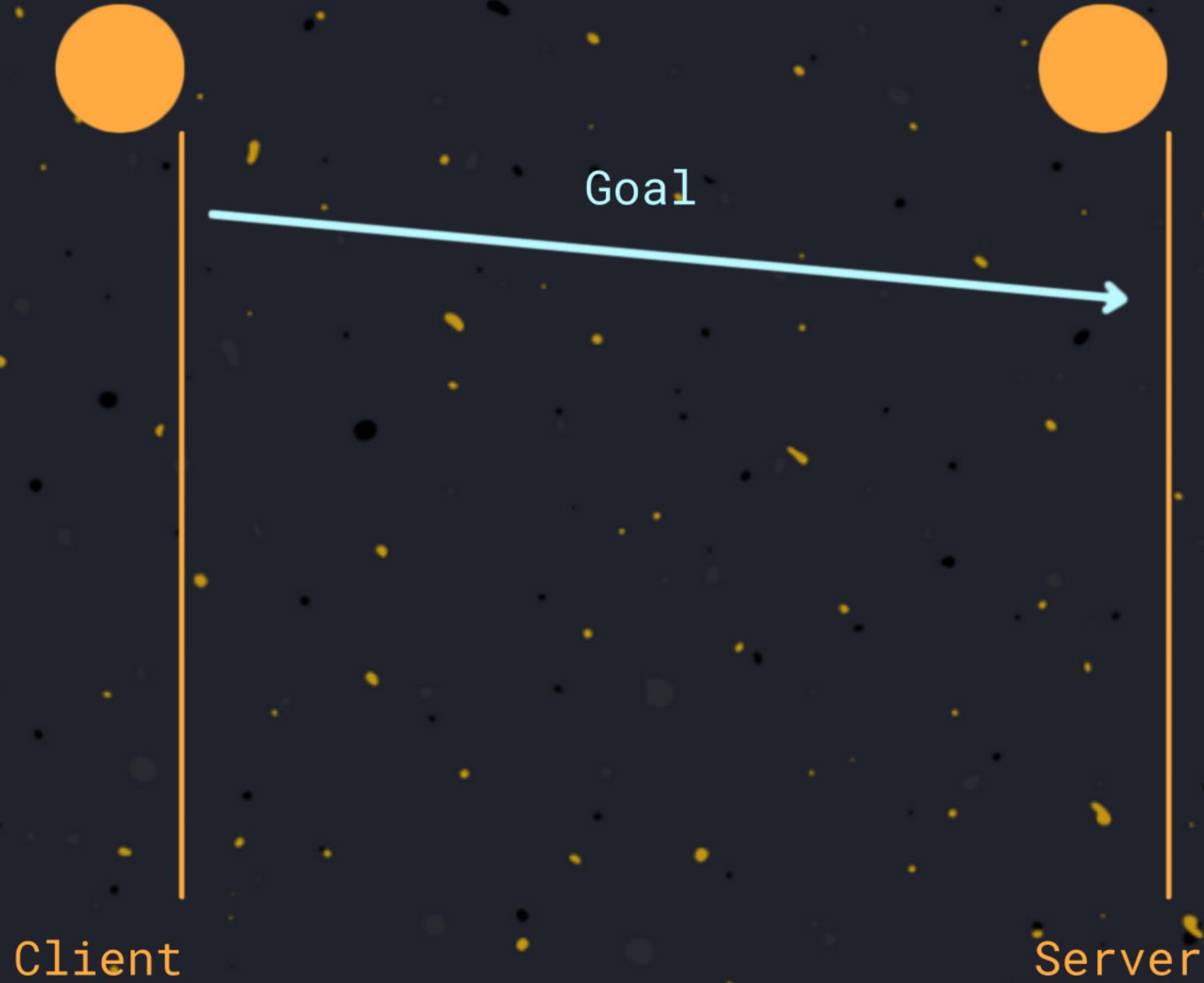


Action

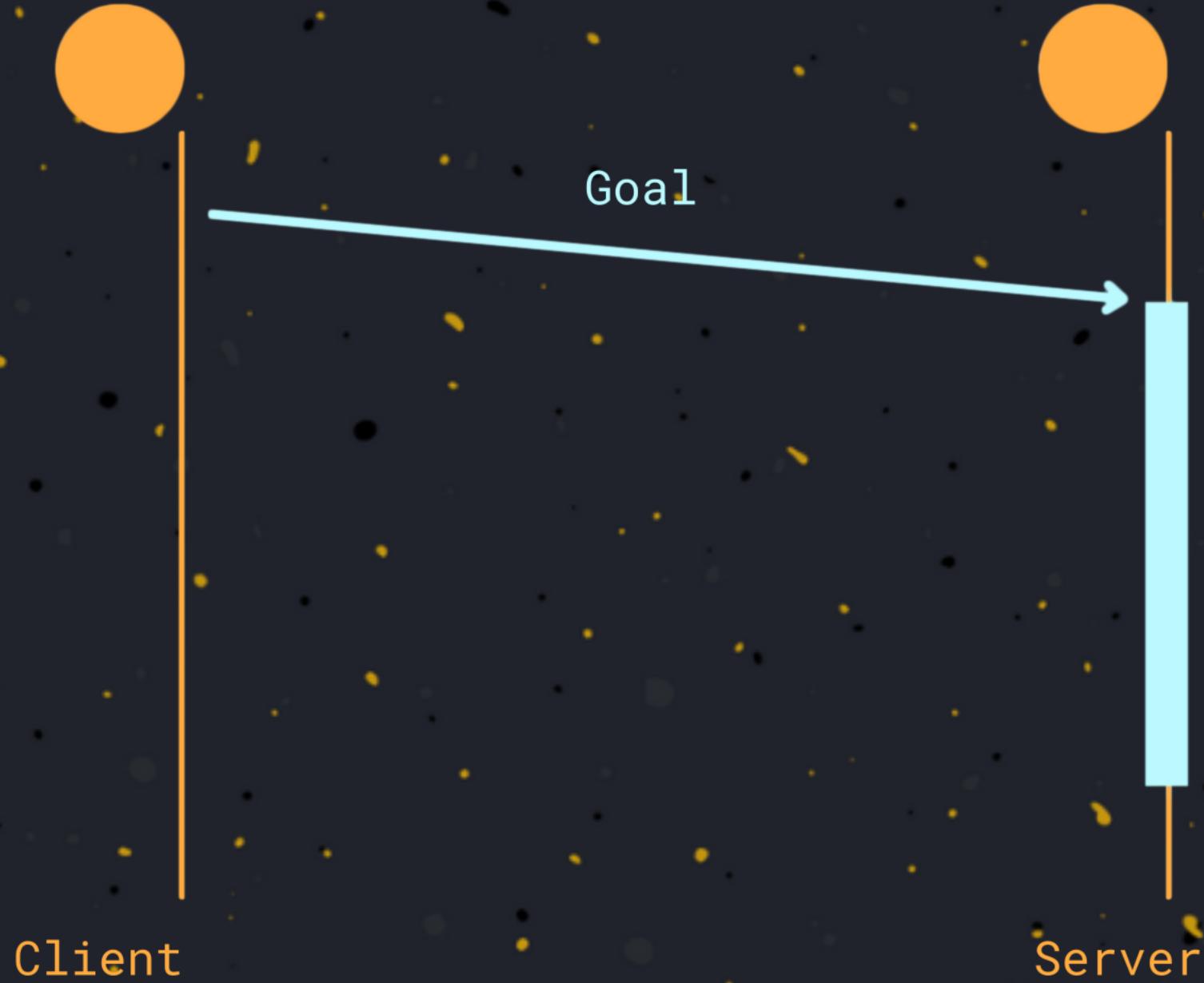
Client

Server

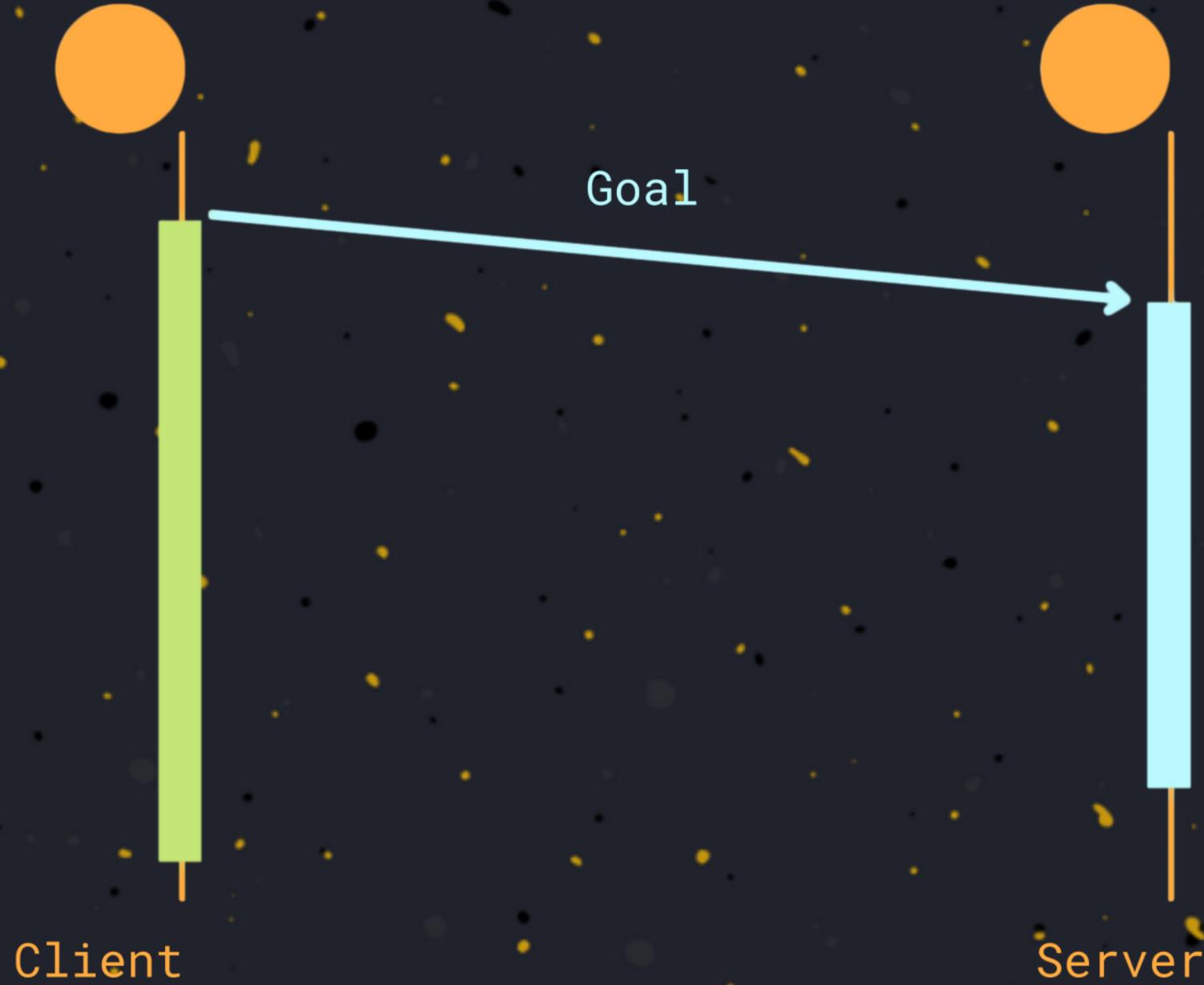
Action



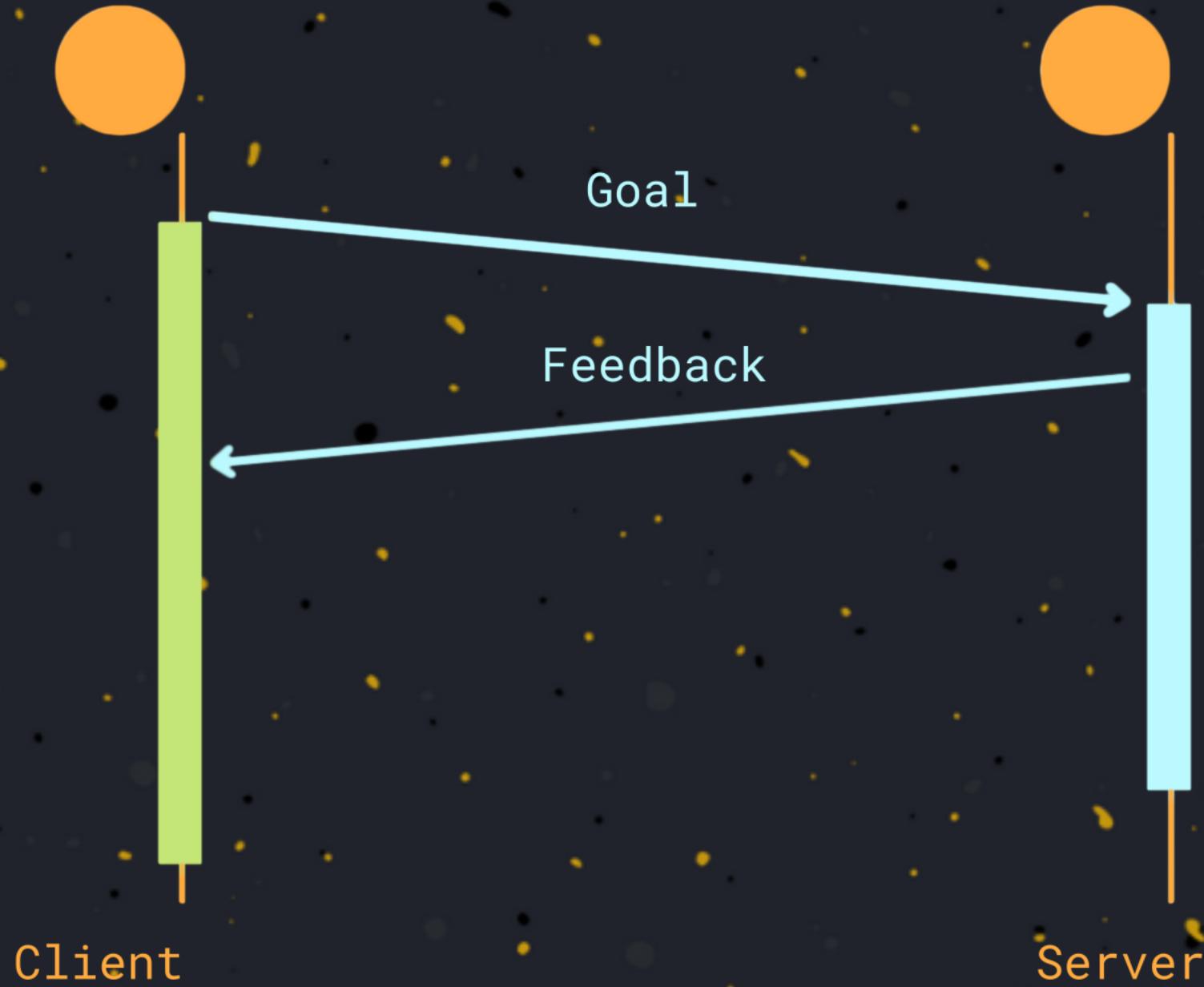
Action



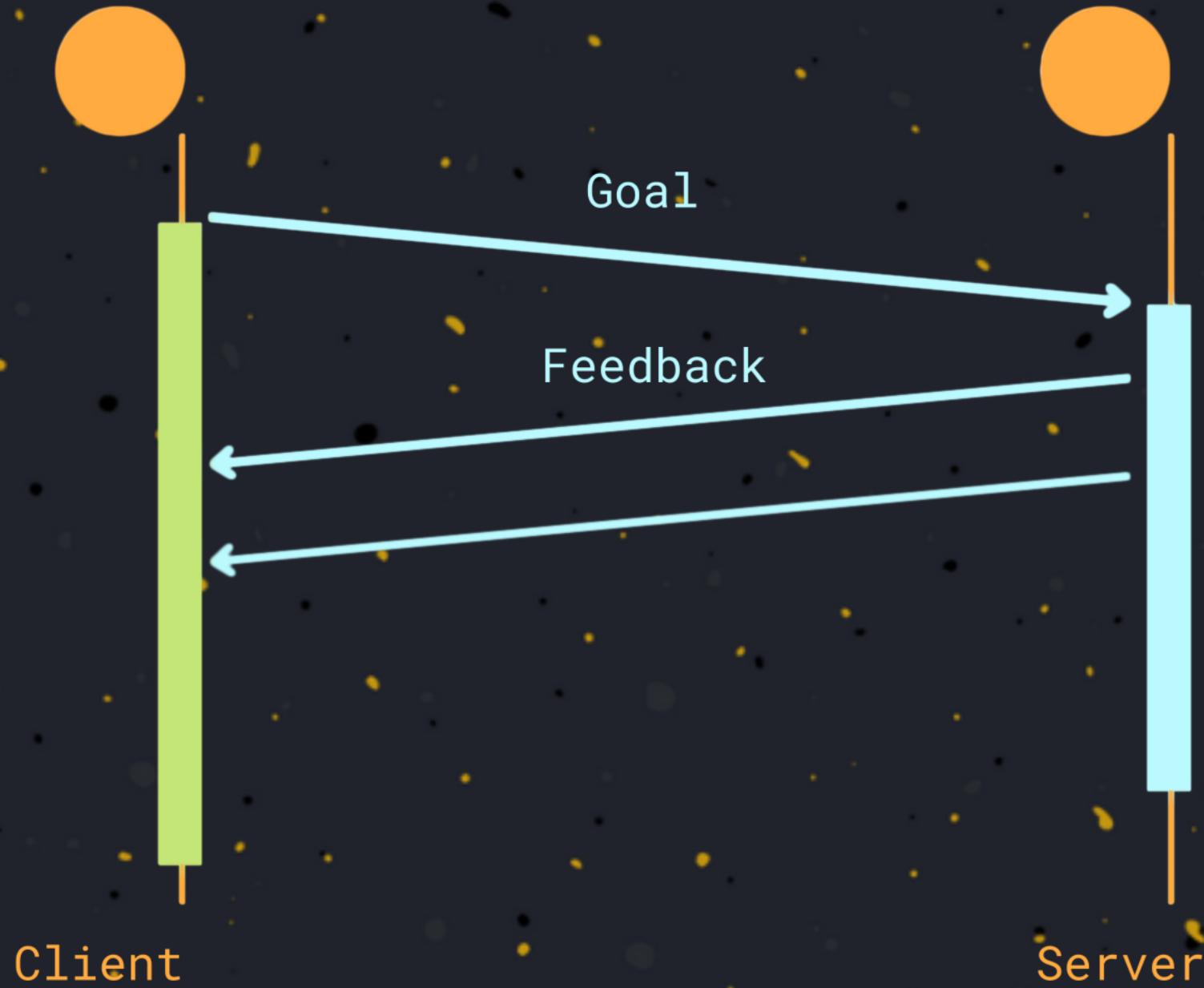
Action



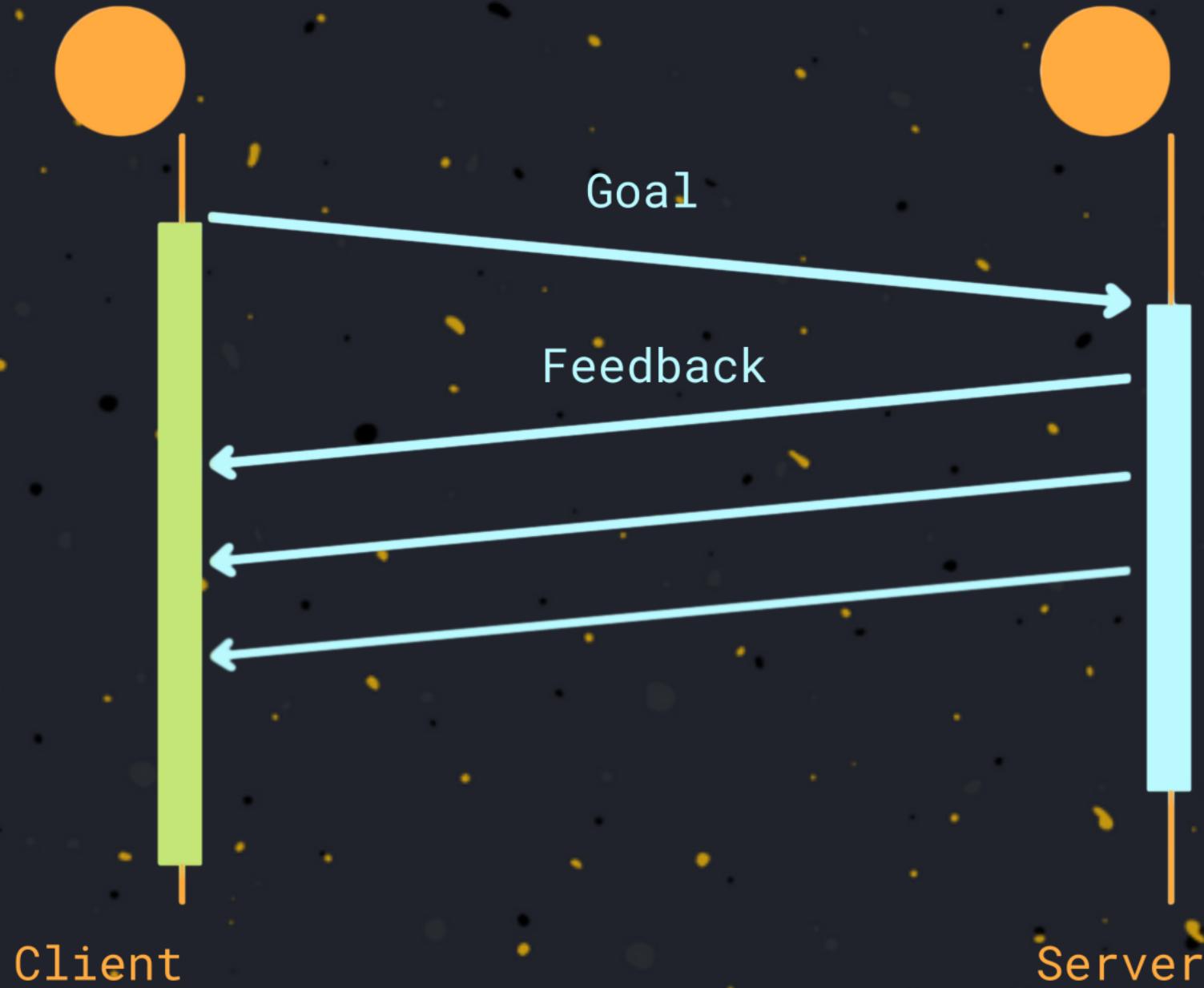
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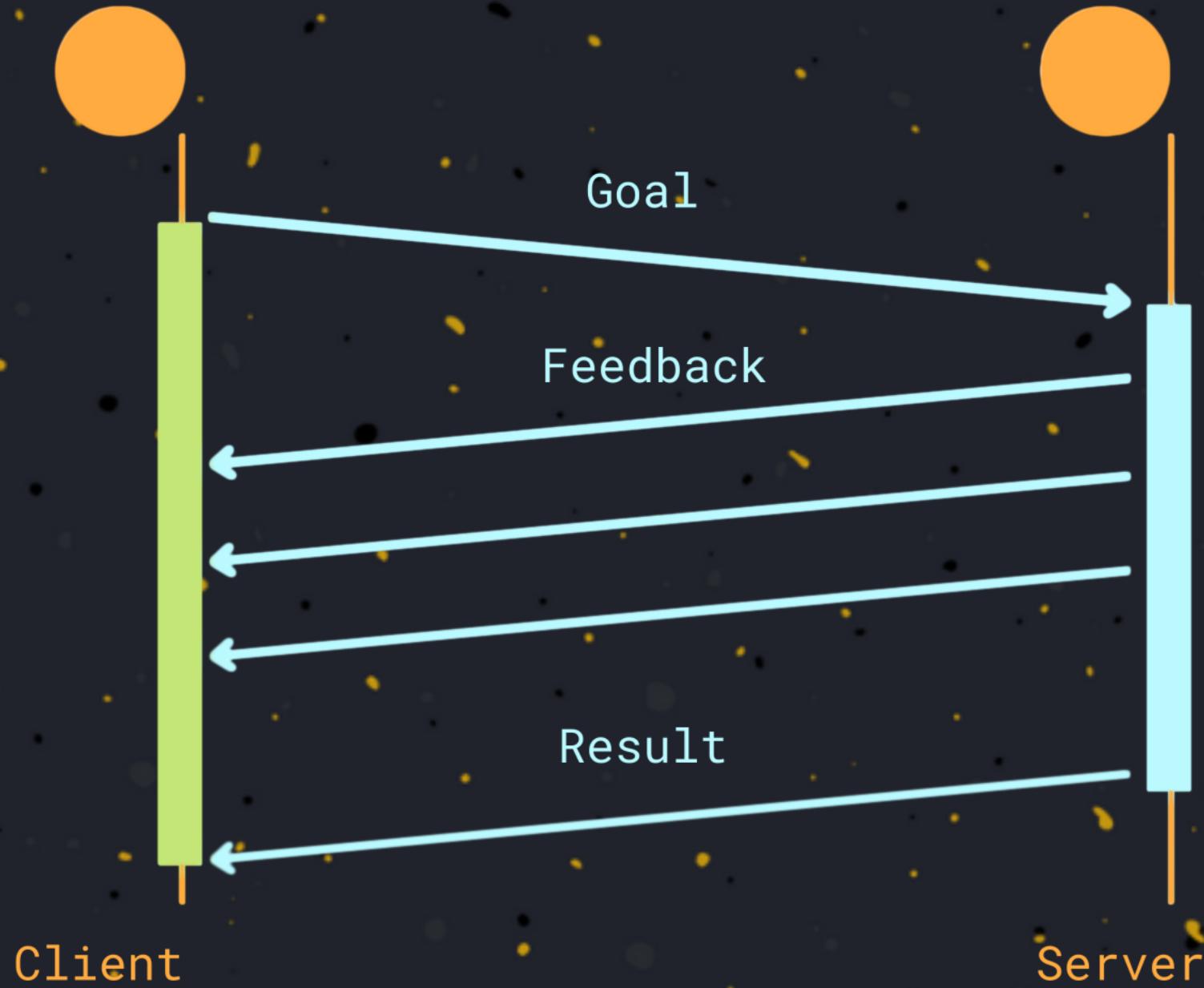
Action



Action



Action



Action

Client

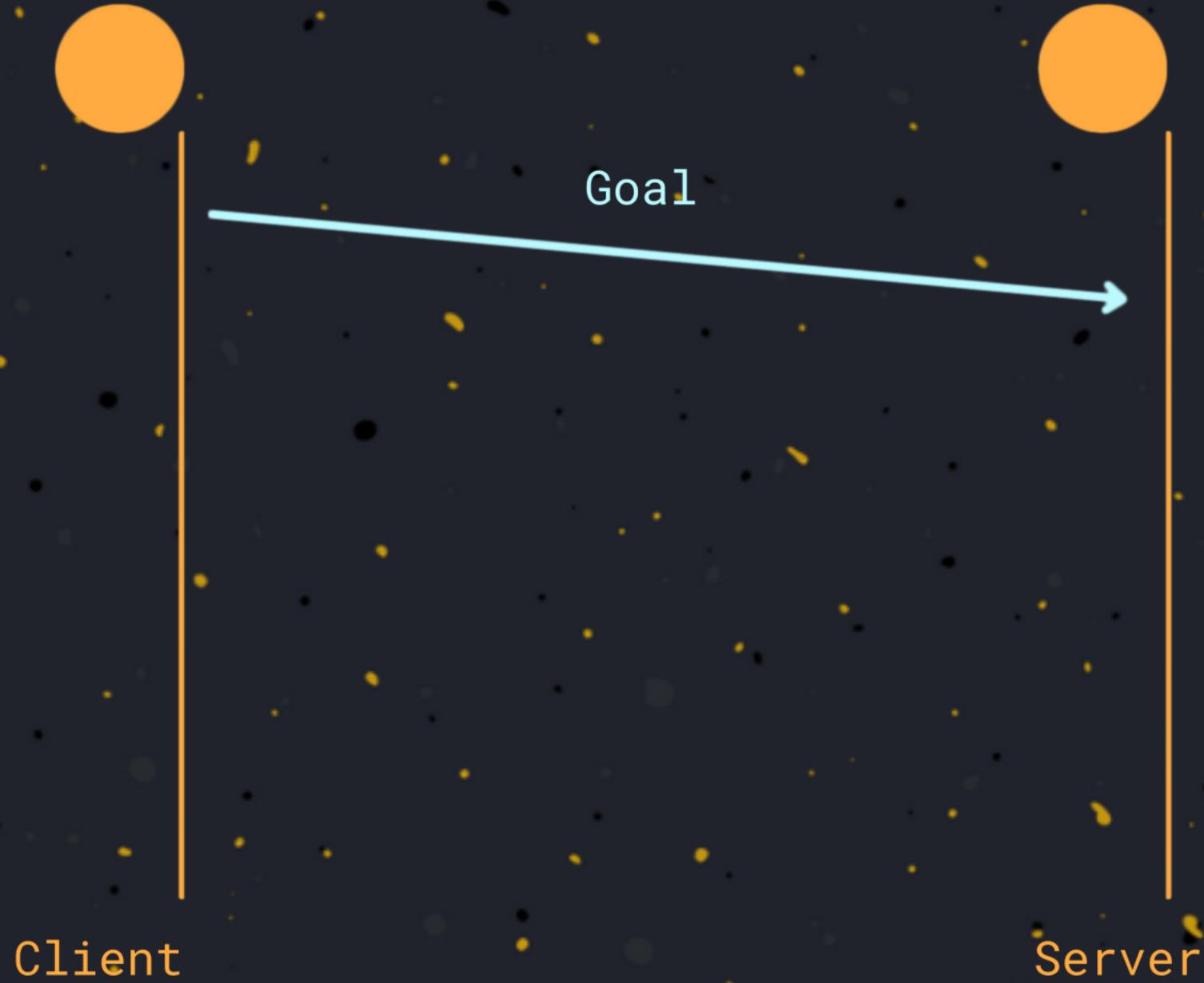
Server

Action

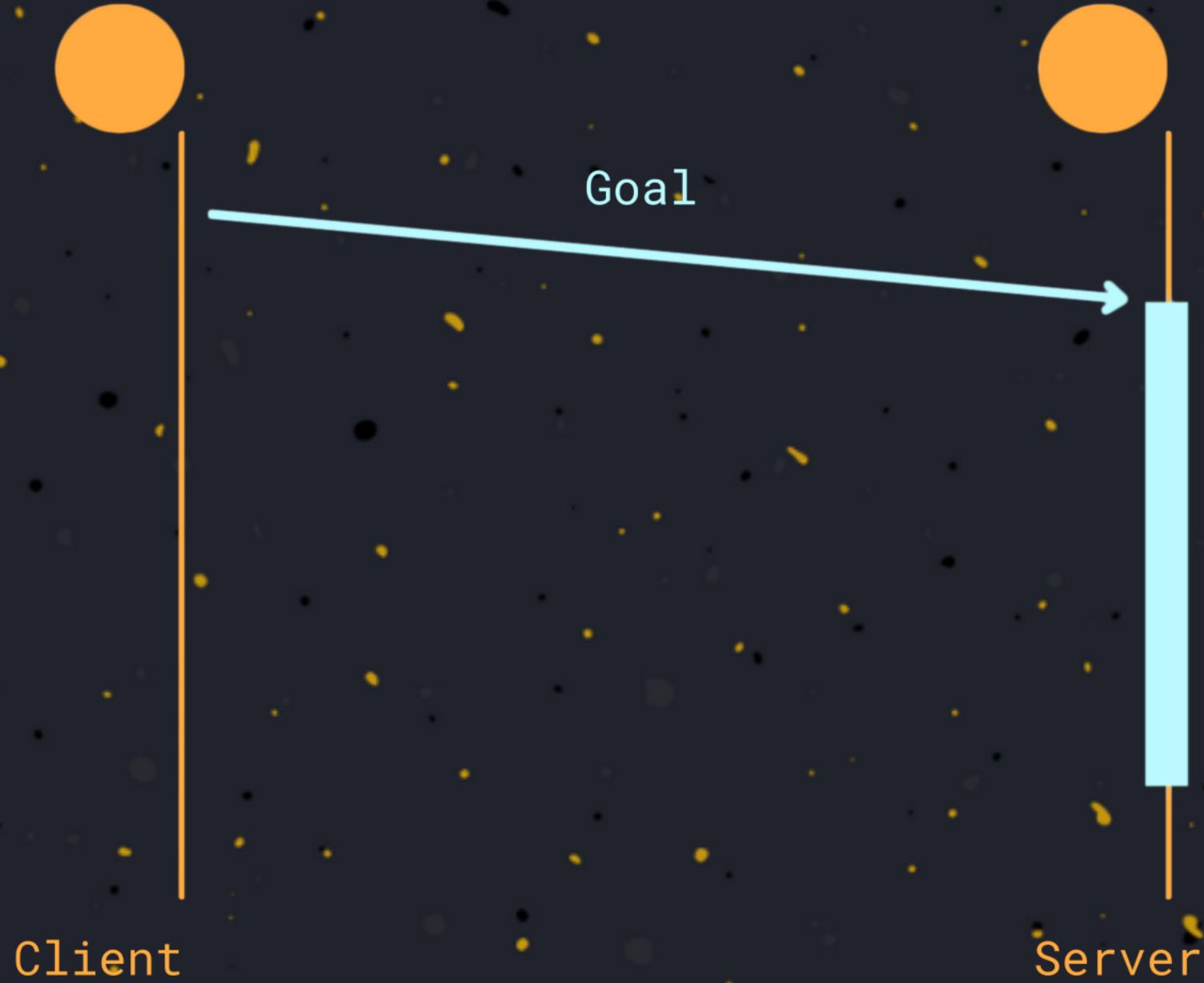
Client

Server

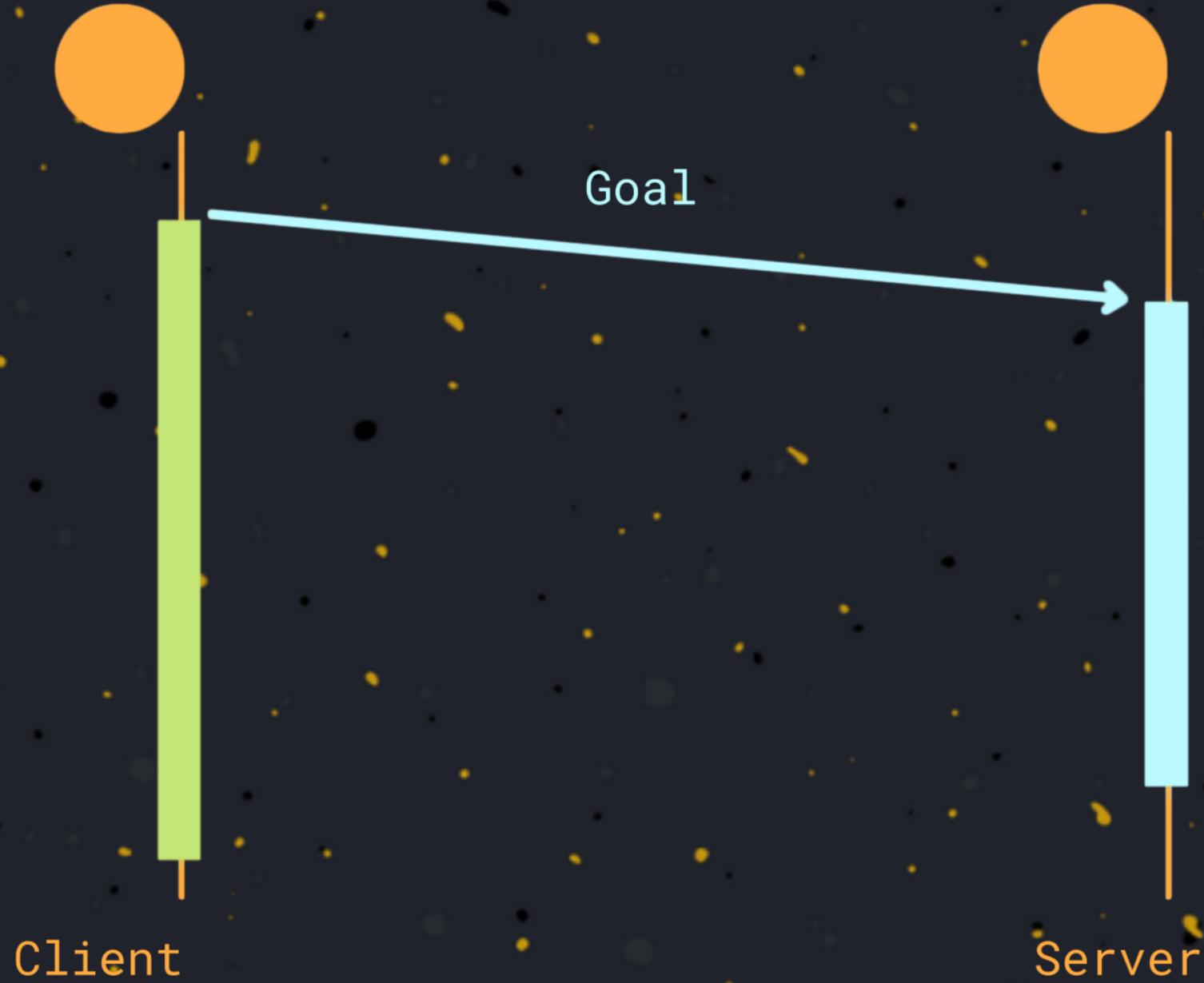
Action



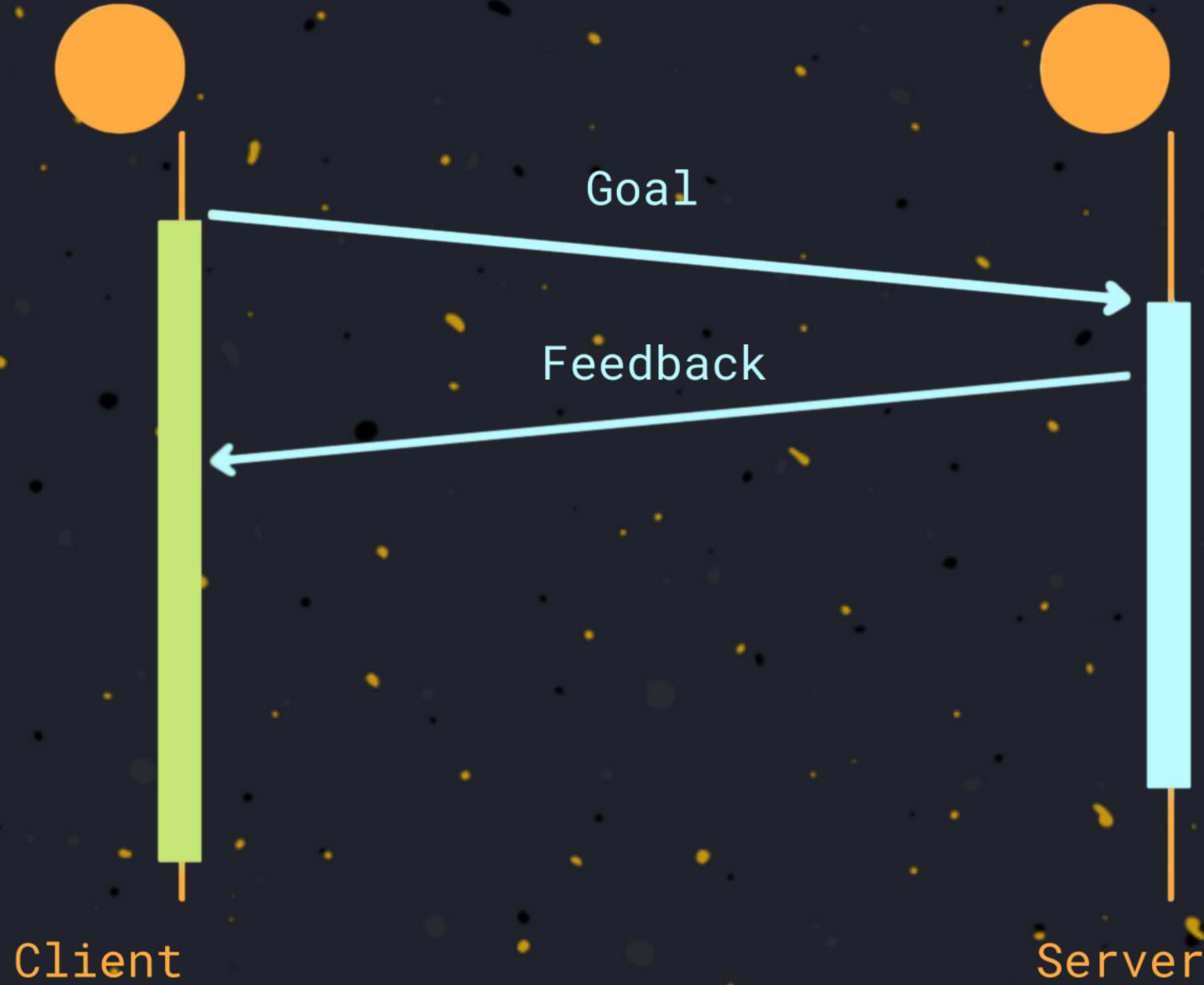
Action



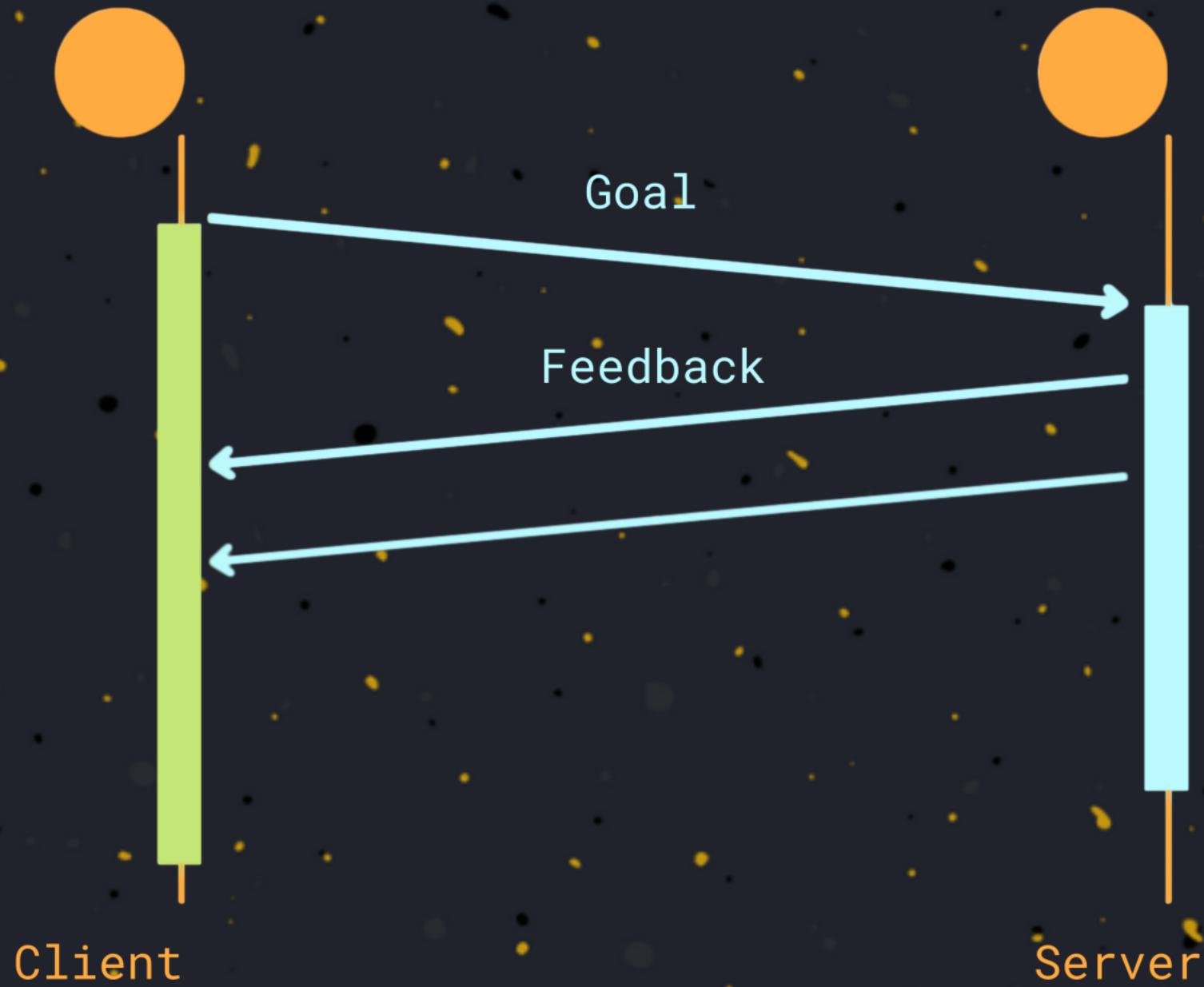
Action



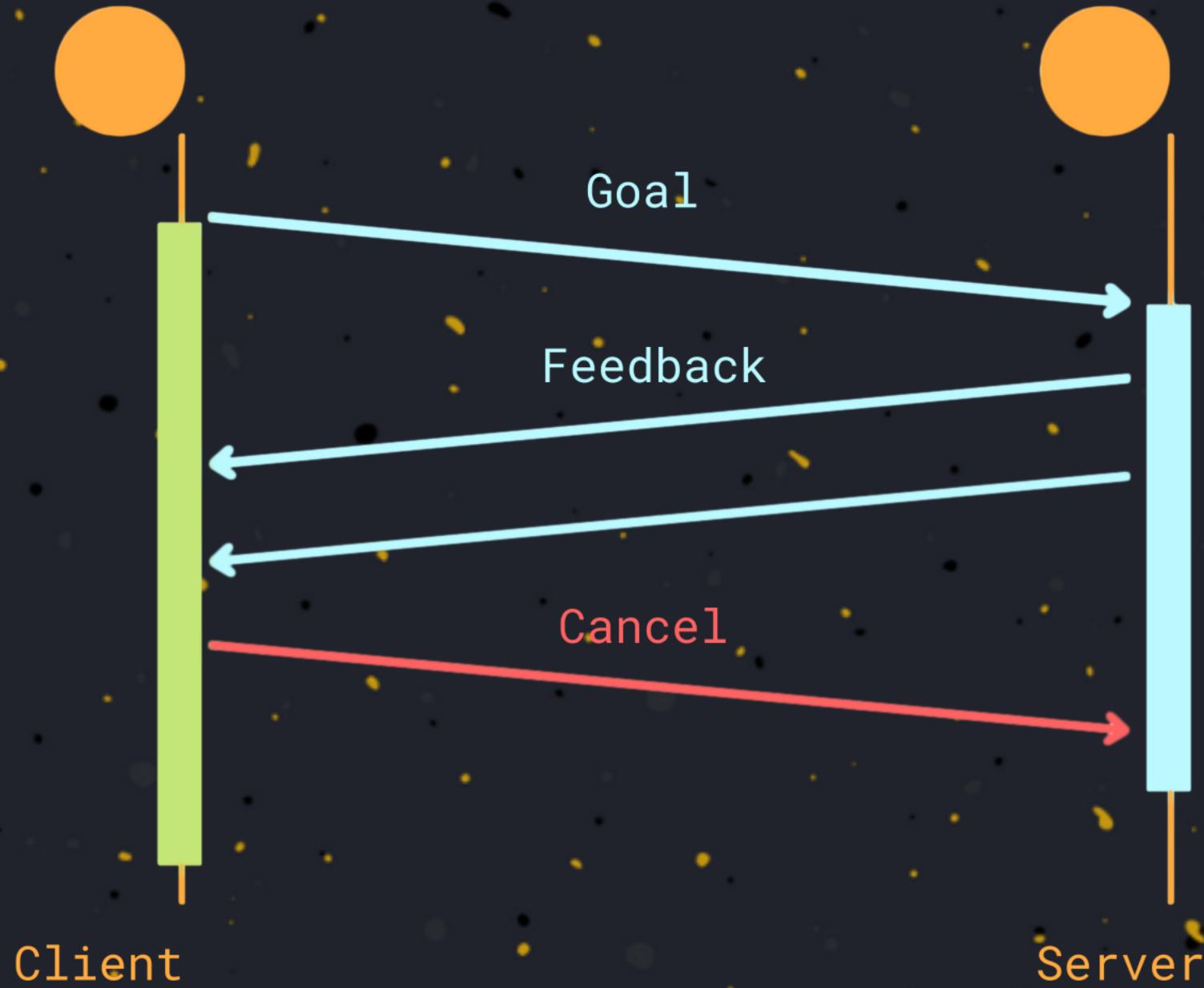
Action



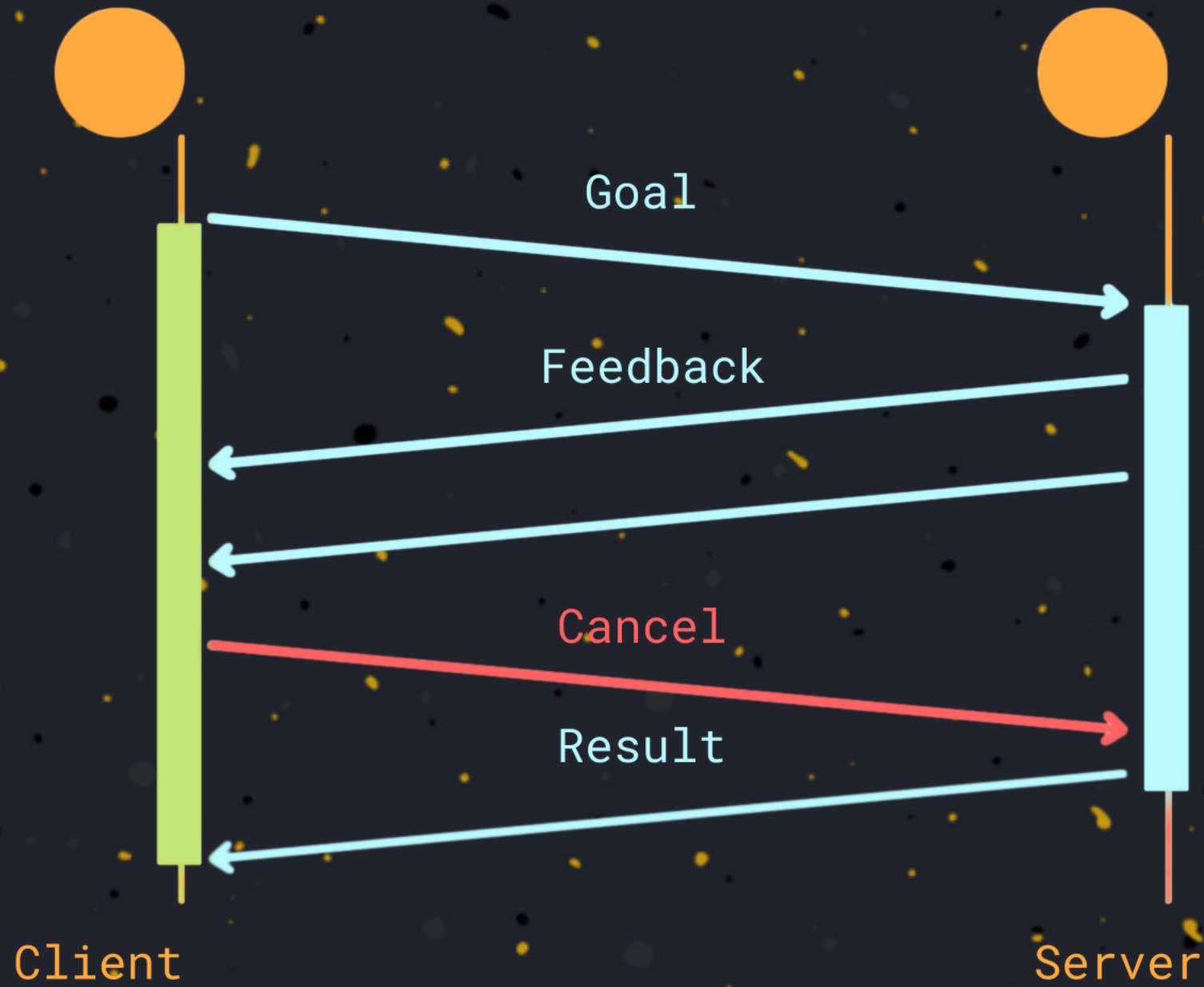
Action



Action



Action

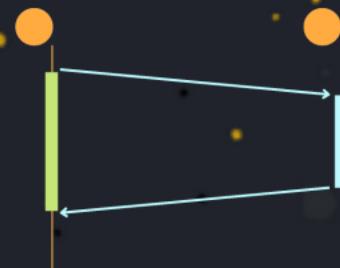


# Communication Between Process

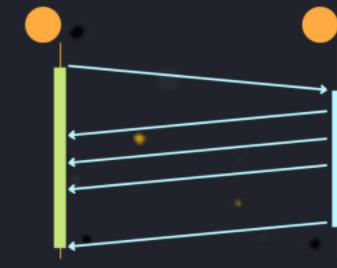
- Topic



- Service



- Action



Hardware  
Abstraction

---



Low-Level  
Device Control

---

Communication  
Between Process

---

Package  
Management

---

# Package Management

robot\_description

robot\_control

robot\_simulation

robot\_software

robot\_vision

nav2

voice\_recognition



# Package Management



# Package Management



description



simulation



control



vision



kinematic



voice  
recognition

Hardware  
Abstraction

---



Low-Level  
Device Control

---

Communication  
Between Process

---

Package  
Management

---



rviz2

gazebo

nav2

robot\_vision

camera\_driver

tf2

ros2\_control



## Workspace



rviz2

gazebo

nav2

robot\_vision

camera\_driver

tf2

ros2\_control

human\_tracking

robot\_vision

robot\_simulation



## Underlay

rviz2

gazebo

nav2

robot\_vision

camera\_driver

tf2

ros2\_control

## Workspace



human\_tracking

robot\_vision

robot\_simulation



## Underlay

rviz2

gazebo

nav2

robot\_vision

camera\_driver

tf2

ros2\_control

## Workspace



## Overlay

human\_tracking

robot\_vision

robot\_simulation



Underlay

rviz2

gazebo

nav2

robot\_vision

camera\_driver

tf2

ros2\_control

Workspace



Overlay

human\_tracking

robot\_vision

robot\_simulation



## Underlay

rviz2

gazebo

nav2

robot\_vision

camera\_driver

tf2

ros2\_control

## Workspace



## Overlay

human\_tracking

robot\_vision

robot\_simulation

## Package



C++ Node

Python Node

Launch File

Configuration  
File

Hardware  
Abstraction

---



Low-Level  
Device Control

---

Communication  
Between Process

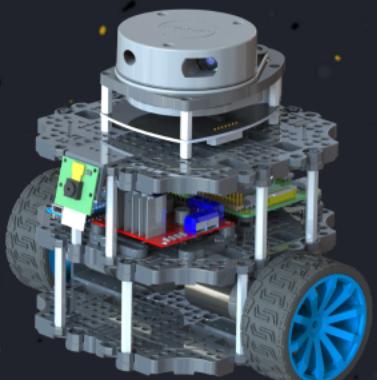
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Package  
Management

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66

“Robotics is concerned with the study of those machines that can replace human beings in the execution of a task, as regards both physical activity and decision making”



Robotics,  
Sciavicco  
Siciliano Villani

