Automatic Management System for the AtlasCar Gearbox

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July 20, 2012

The Atlas Project (2003 - Present)

- Advanced Driver Assistance Systems (ADAS);
- Safety Systems Development;
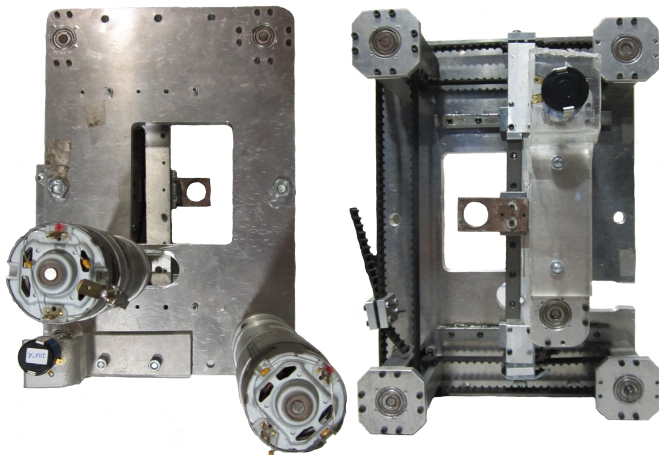- Acquisition of sensory data;
- Autonomous Navigation.

The AtlasCar Actuators

- Throttle;
- Brake pedal;
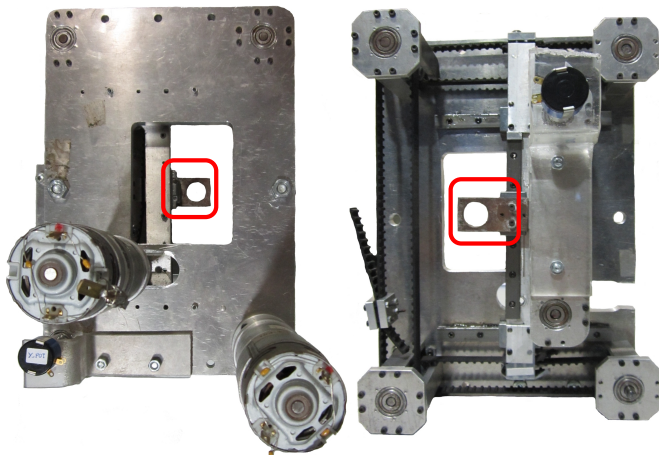- Clutch pedal;
- Handbrake;
- Ignition;
- Steering;
- Lights.

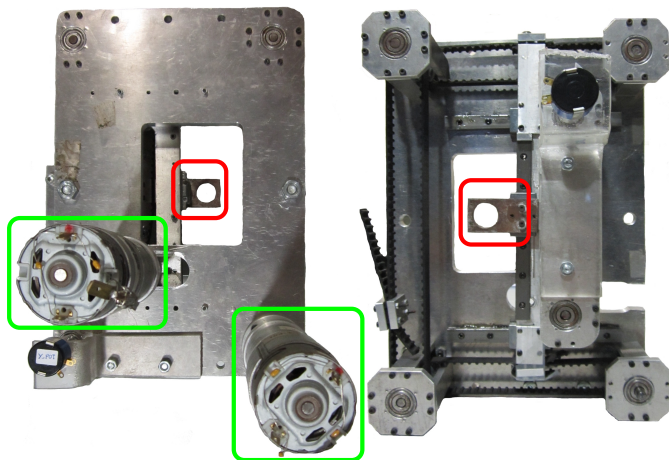# The Problem

What about the gearbox?
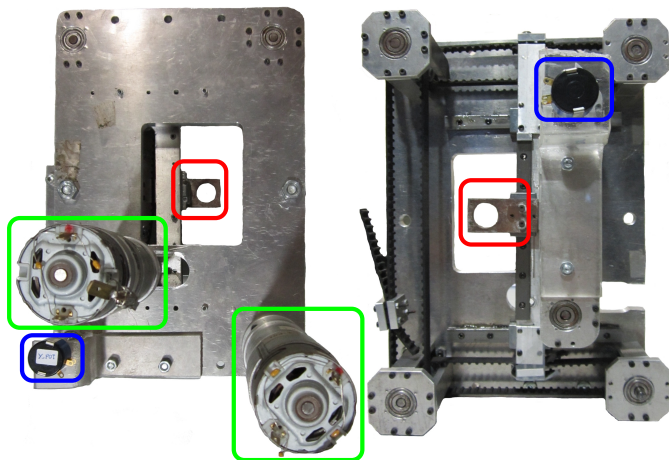
The Problem

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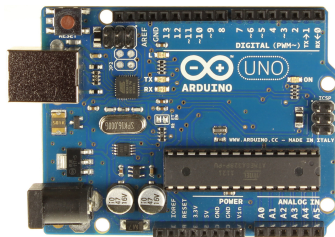# The Problem

What about the gearbox?

Objectives

- Slight changes on the mechanical system;
- Development of a control PCB;
- Controller firmware programming;
- Robust communication messaging system;
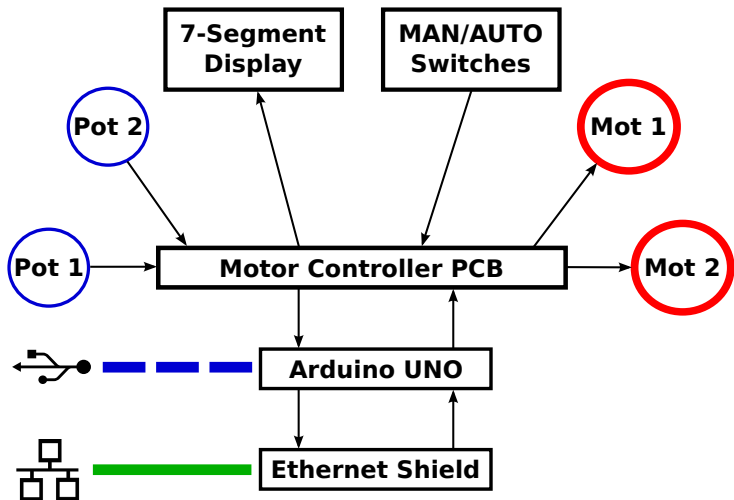- System simulation and laboratory tests.

The *Arduino* UNO

- Open-source;
- Flexible and robust;
- C++ similar language;
- Modularity.

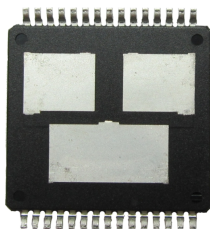# *Arduino* DC Motor Controller Tasks:

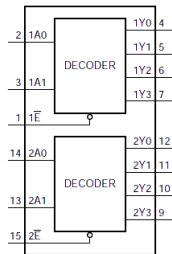# The Power Controller

- H-bridge IC VNH3SP30-E;
  - ▶ 12 V;
  - ▶ 20 A.
- Coded Inputs.

Top View

Bottom View

Multi-turn Potentiometers and MAN/AUTO Switches

Multi-turn Potentiometers:

- 3 Turns;
- Mechanically coupled to the shafts;
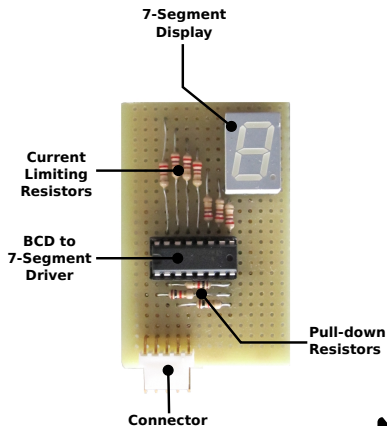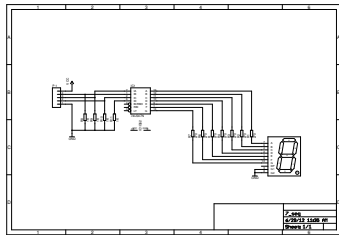- Analogue variable voltage output;

MAN/AUTO Switch:

- 3 Buttons;
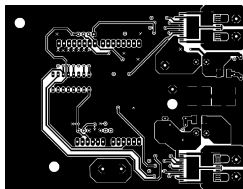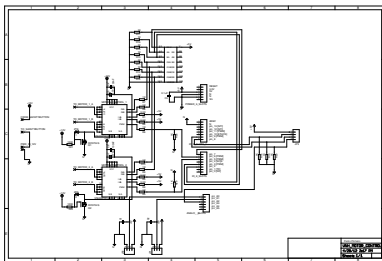 - ▶ Shift Up;
  - ▶ Shift Down;
  - ▶ Switch Mode.

Seven Segment Display

- BCD to 7-Segment Driver;
- Control 8 digits using only 3 bits;

7-Segment Display

Current Limiting Resistors

BCD to 7-Segment Driver

Pull-down Resistors
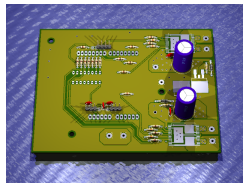
Connector

PCB Development
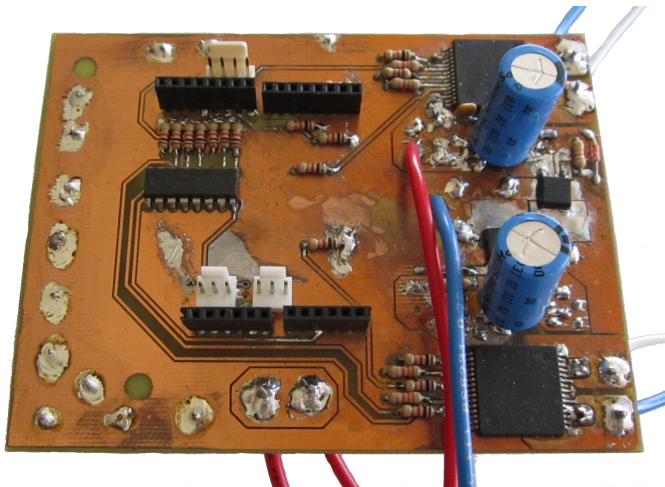

Top Layer
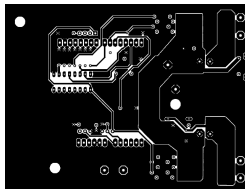
Bottom Layer

3D Model

Final Controller

Firmware Programming

Arduino's two main cycles:
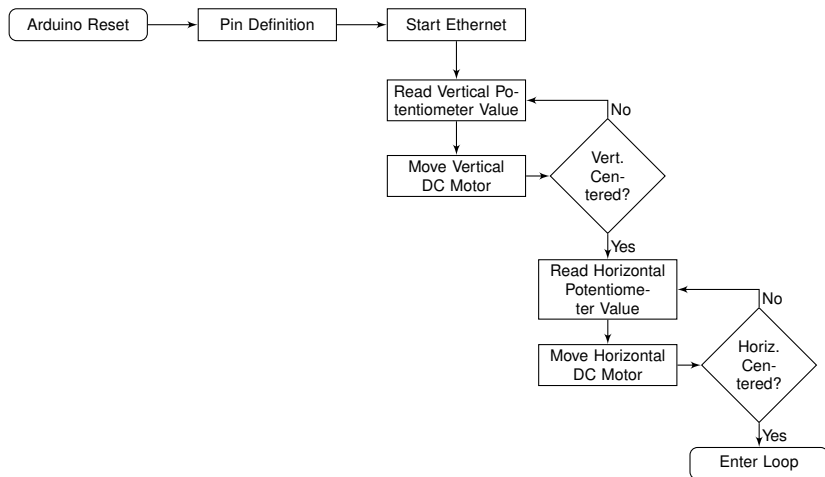
- The Setup Cycle:
  - ▶ Start communication settings;
  - ▶ Define pin functions;
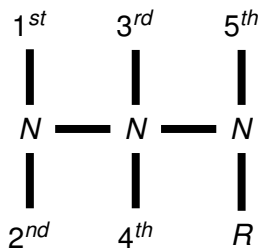 - ▶ Reset the mechanism.
- The Loop Cycle:
  - ▶ MAN/AUTO Modes;
  - ▶ 7-Segment Control;
  - ▶ DC Motor Management.

The Setup Cycle

The Loop Cycle

1st　　3rd　　5th

$|$　　$|$　　$|$

N — N — N
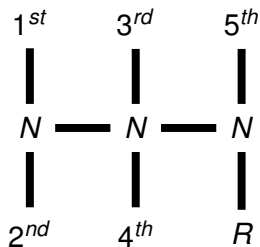
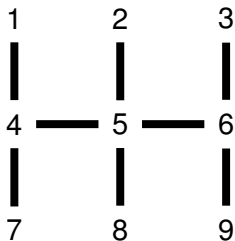$|$　　$|$　　$|$

2nd　　4th　　R

Gearbox H-Pattern

- Coexistence of Manual and Automatic modes;
- Sequential and non-sequential operation;
- Shortest path between two gear positions.

The Loop Cycle

1st 3rd 5th

N — N — N

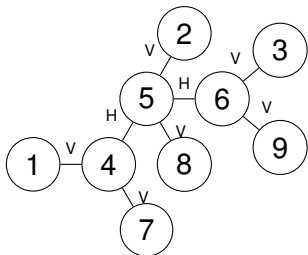2nd 4th R

Gearbox H-Pattern

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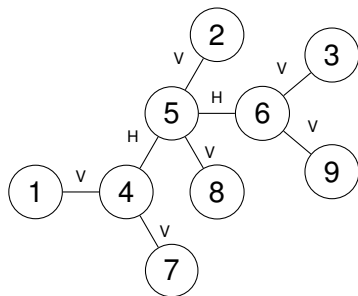
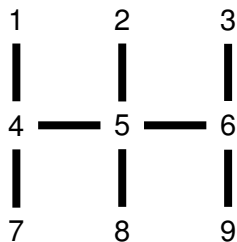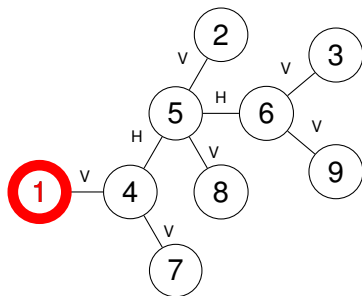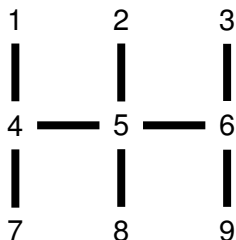# Dijkstra's algorithm

Point Numbering

Representative Graph

$$M = \begin{bmatrix} 5 & 5 & 5 & 1 & 5 & 5 & 5 & 5 & 5 \\ 5 & 5 & 5 & 5 & 1 & 5 & 5 & 5 & 5 \\ 5 & 5 & 5 & 5 & 5 & 1 & 5 & 5 & 5 \\ 1 & 5 & 5 & 5 & 0 & 5 & 1 & 5 & 5 \\ 5 & 1 & 5 & 0 & 5 & 0 & 5 & 1 & 5 \\ 5 & 5 & 1 & 5 & 0 & 5 & 5 & 5 & 1 \\ 5 & 5 & 5 & 1 & 5 & 5 & 5 & 5 & 5 \\ 5 & 5 & 5 & 5 & 1 & 5 & 5 & 5 & 5 \\ 5 & 5 & 5 & 5 & 5 & 1 & 5 & 5 & 5 \end{bmatrix}$$

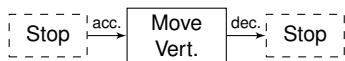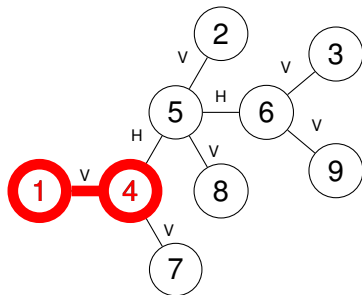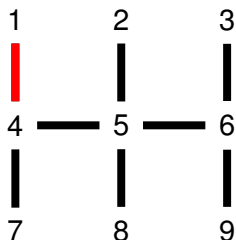# The Loop Cycle - Shifting from 1st to R
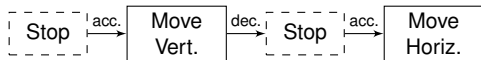
The Loop Cycle - Shifting from 1st to R

Stop

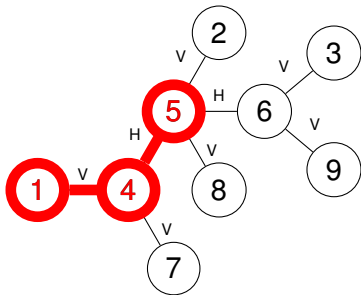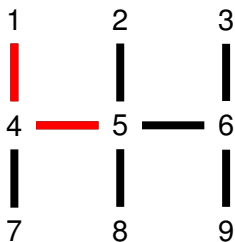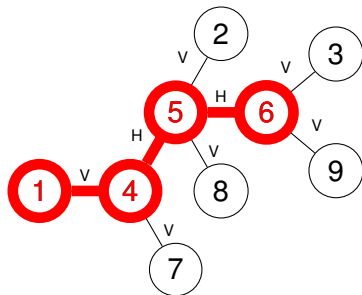# The Loop Cycle - Shifting from 1st to R

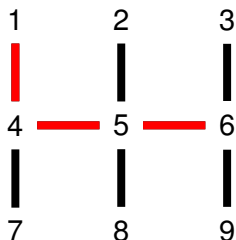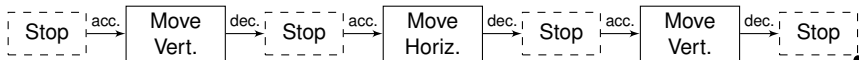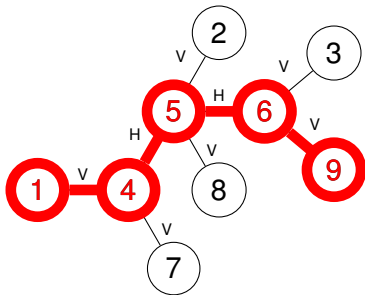# The Loop Cycle - Shifting from 1st to R

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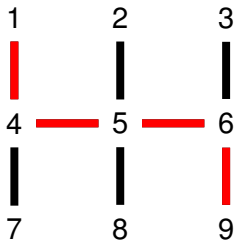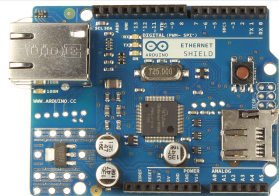
Resulting in...

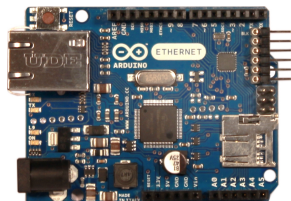# Communication Protocol

Ethernet Cable and TCP/IP.

- PC → *Arduino*:
  - ▶ Set Command;
  - ▶ Get Command.
- *Arduino* → PC:
  - ▶ Answer to Set Command:
    - ⋆ Invalid Gear ;
    - ⋆ Manual Mode;
    - ⋆ Gear OK.
  - ▶ Answer to Get Command:
    - ⋆ Changing from ... to ...;
    - ⋆ Current Gear;
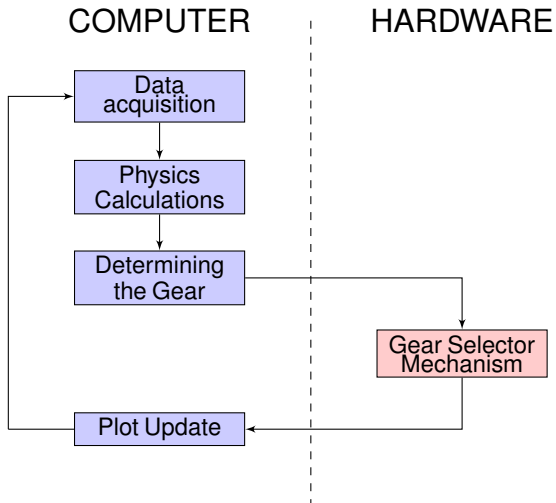 - ▶ Unrecognised Command.

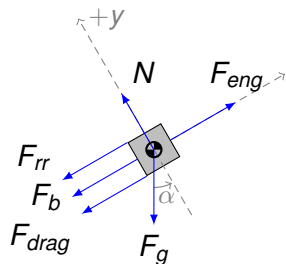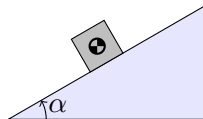*Arduino* Ethernet Shield

Arduino Ethernet

Hardware-in-the-Loop Simulator Structure
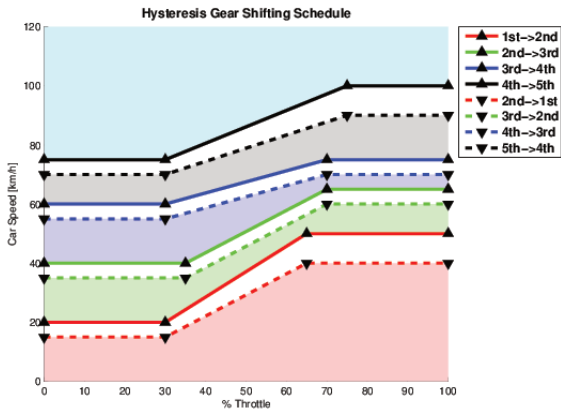
Vehicle Physics

Main forces acting on the Vehicle:
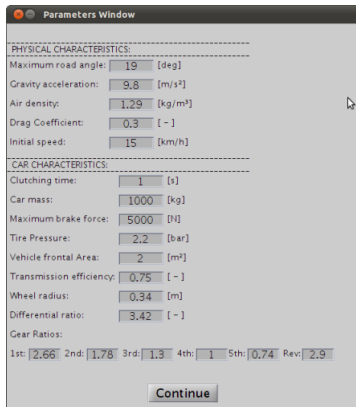
- Engine Force (F_{eng});
- Drag Force (F_{drag});
- Force of Gravity (F_g);
- Rolling Resistance Force (F_{rr});
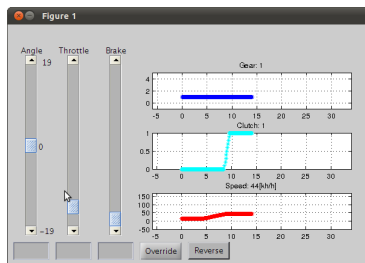- Braking Force (F_b).

Gear Schedule

Automatic Management System for the AtlasCar Gearbox
Hardware-in-the-Loop Simulator
Vehicle Physics

Simulator GUI
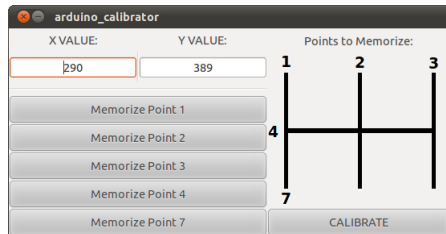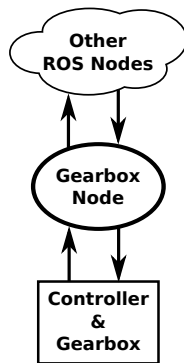

Parameters GUI

Simulator GUI

The Result

# Auxiliary Software

Calibrator

ROS Node

Conclusions

- Reliability of the controller;
- Successful firmware control solution, using the Dijkstra's algorithm to achieve the sequential and non-sequential modes;
- Robustness of the communication messaging system;
- Good results achieved when tested in laboratory;
- Mechanical belt and pulley system not suited for the task.

Conclusions
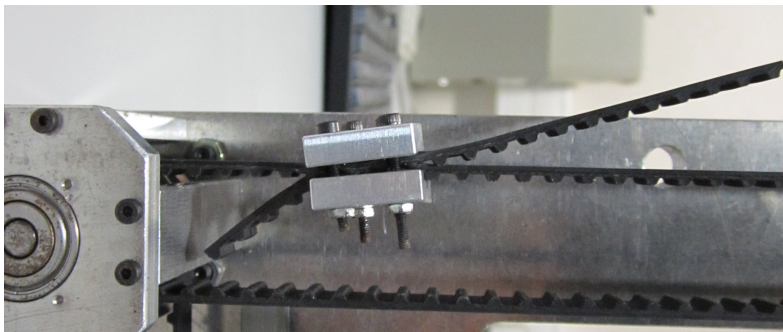
Future Work

- Remake of the power transmission system, probably replacing it by a chain and sprocket;
- Mounting the system on the AtlasCar;
- Closed-loop speed control using the gearbox;
- More complex manoeuvres (parking, biting-point and start of movement);
- Higher speed tests;
- ...

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