Distributed and Parallel Systems

Semester Project – Truck Platooning

(Milestone 1)

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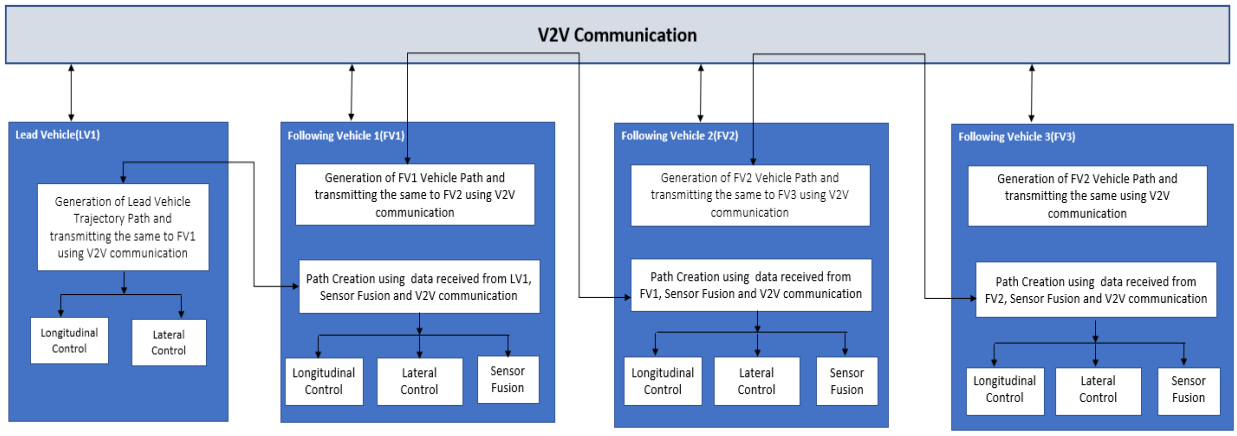
1. Develop an appropriate distributed and parallel architecture. What requirements and characteristics must be fulfilled?

Truck platooning systems will work independently in parallel and communicate with each other via V2V Communication in a Distributed Architecture format.



Note: Our system is considering a Lead Vehicle and one Following Vehicle

Transparency:

The system looks transparent in a way that only the driver in the Leading/Master truck controls the whole platoon but in real the preceding trucks can react to the environmental inputs. Since the precedence trucks are autonomous, logical algorithms for every truck is mapped to work in all environment scenarios independently.

Openness:

Components from any supplier can be integrated into the system and can interoperate with the other system components. For example, we will be using V2V communication which will be developed using another Protocol (for example Wifi, Bluetooth, MQTT) on another platform.

Scalability:

The system is scalable.

1. Size: In the case of platooning of large cargo trucks, the length of the fleet can easily reach 100 m considering the length of each truck to be 16.66 m. Thus, the number of trucks in one platoon is usually limited to 3 or 4, considering the safety of the nearby vehicles.

2. The platooning operation control system performs the function of join, maintain, leave, and gap change of the platoon vehicle.

3. The system is a scaled-out system where each truck has independent features (ACC, CMBS and so on) to perform tasks at an individual level.

Security:

The system needs to be highly secured and protected using Encryption and Decryption algorithms. If the system is not secured, then it can cause severe fatality on roads. The system should be robust enough to protect itself from any type of attacks in the form of interception.

Latency:

In truck platooning where services are managed autonomously it will result in a more efficient system but at the same time will have latency as services are operated independently. When the messages are not received from the front vehicle for a long period then an alive counter logic can implement to check the status of the platoon. In case when messages are not received then platoon can be decoupled, and every system can act independently using the data received from sensor fusion.

Models of interaction:

Message-based interaction normally involves one component creating a message that details the services required from another component. Through the system middleware, this is sent to the receiving component. The receiver parses the message, carries out the computations and creates a message for the sending component with the required results. In our scenario vehicles will interact with each other via Vehicle to Vehicle Communication model using different protocols (for e.g. MQTT, Wi-Fi, Bluetooth etc).

2. Identify which data/signal/events are required for the interaction / communication between the trucks.

Events: -
a. Acceleration
b. Braking (De-Acceleration)
c. Vehicle Detection
d. Coupling
e. Decoupling
f. Wireless Communication

Data/Signal: -
a. v_gap_distance
b. v_speed
c. v_id
d. v_accelerate_request
e. v_deaccelerate_request

3. Identify the relevant control behaviour for the trucks

- **How can the distance to the precedence truck be guaranteed?**

With Sensor Fusion technique, the system gets the ability to receive inputs from multiple sensors (lidars, cameras), the data is fused to have one common image of the environment around the vehicle. It becomes more efficient as the strength of different sensors is balanced out. With these techniques'

vehicles can then use the information provided through sensor fusion to support more-intelligent actions like distance precedence. Consider the initial position of Leader Vehicle (LV) as x which is a reference for platooning, where the position of the following vehicles can be considered in the following manner,

FV1 = x+25, FV2 = x+50, FV3 = x+75 (position in meters).

Each vehicle is considered to keep a gap of 10 meters(approximately) with the other vehicle in front.

Use case scenarios considered: -

Scenario 1: Truck platooning moving on the highway with no traffic travelling along a straight path. (Pre-conditions – curved path not found, no vehicle not detected, vehicle steering does not occur, and speed is maintained at 30mph).If all the pre-conditions are met platoon will keep moving forward.

Scenario 2: If an obstacle is detected in front of the leading vehicle on the highway while following a straight path the leading truck will apply breaks and send a message to the following trucks, accordingly the other truck will respond to the message by applying breaks.

Scenario 3: If an obstacle is detected in between the following trucks, the trucks will respond by decelerating its speed by applying the breaks and communicate the same with the master truck using a communication protocol. If there are any trucks following, they will also respond by decelerating using the sensor fusion techniques.

Scenario 4: If the leading truck finds a curve path on its ways, the driver will make the required turn and message is sent to all the trailing trucks using the communication protocol. The trailing trucks will then respond accordingly and keep following the master truck.

- **What happen in cases of a e.g. communication failure - > is your system robust/still stable?**

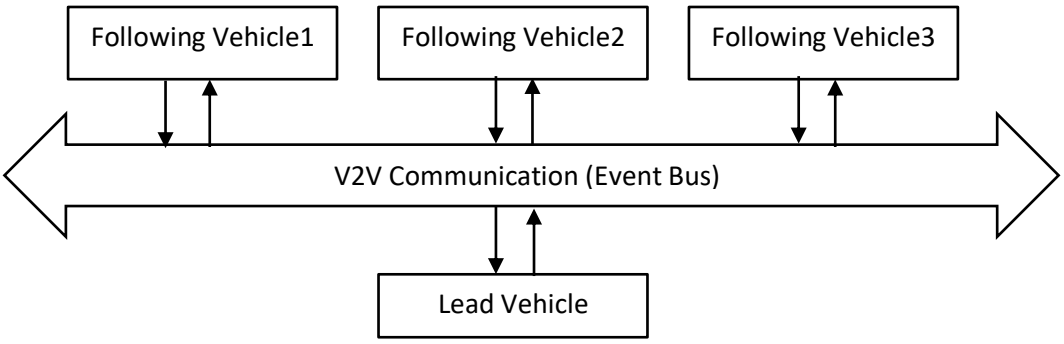
Truck platooning can be referred to us as the number of trucks run as a fleet with shorter inter-vehicular distance, this communication is easy and reliable using V2V communication. Autonomous driving of the following vehicles does not depend on GPS since the vehicle cannot receive correct GPS signals in a few conditions like when driving through a tunnel or when there is communication loss. So V2V communication is more reliable. If there is any communication failure i.e. V2V communication is disconnected during platooning operation, and longitudinal/lateral cannot be performed. The controller cancels platooning, and the control mode of each vehicle is changed to independent autonomous driving mode this notification is sent to the driver.
For example, the longitudinal control mode is changed to Adaptive Cruise Control mode and lateral control is switched to Lane Keeping System.

4. Which implementation is appropriate for your purpose.

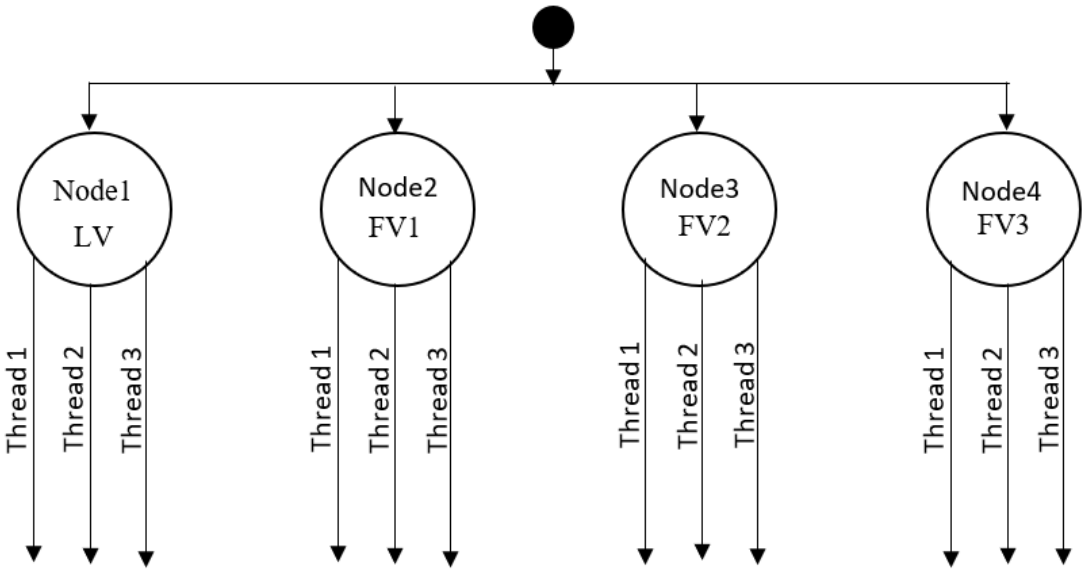
- **This includes the distributed communication and interaction as well as the node specific parallel implementation**
- **Which parallel programming model fits best for your purpose and which hardware do you have to choose.**

We are considering Truck platooning as a distributed system for data communication: -

1. Models of Interaction - In this Mode of interaction between vehicles can be done through Message-based protocol.
2. Architectural Pattern – For this platooning, we can use Master-slave architecture, in which the lead vehicle will act as a master and follower vehicles act as a slave.
3. Architectural Styles – Event-based architecture (We have considered message passing as an event).



Node Specific Parallel Implementation: -



Thread 1 - Get obstacle data from sensor fusion (Camera and RADAR)

Thread 2 - Get input from ACC module (acceleration, deceleration, steering control)

Thread 3 - Data communication between vehicles for aligning vehicles on same path

Proposed hardware: -

1) Ultrasonic sensor – For blind spot detection
2) RADAR – To find longitudinal range
3) Microcontroller – Any automotive grade controller (for e.g. RL78xx)

Reference:

1) *https://www.aptiv.com/insights/article/what-is-sensor-fusion*
2) *Article - A Novel Path Planning Algorithm for Truck Platooning Using V2V Communication.*
3) *DPS Lecture notes*