ARCHITECTURE MODEL AND ANALYSIS OF CYBER PHYSICAL SYSTEMS

(PART I – MODELIING AND ANALYSIS OF CYBER PHYSICAL SYSTEMS)

Submitted to Professor ANDREA CECCARELLI

THYMIO PLATOONING

Version – V1

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1. Introduction

1.1. Purpose

This project is aimed at realization of various thymio operating scenarios such as platooning, collision and simulation using Thymio simulator. The system of system under observation is composed of four thymio robots and a virtual map of a road with a roundabout traffic system. Two bidirectional circles in roundabout and external road map for other 2 thymio's considered for this experiment.

1.2. References

- Ref 1: http://wiki.thymio.org/en:asebalanguage
- Ref 2: https://wiki.thymio.org/en:asebastdnative
- Ref 3: https://wiki.thymio.org/en:asebaplayground
- Lecture Slides

2. Overall Description

The system of system is under observation is composed of four thymios. Each thymio further is composed of several sensors, actuators which enable it to send and receive critical information such as proximity distance, thymio speed, temperature. In this project intend to use several specific sensors and actuators for our desired test scenarios.

The thymio's are programmed in ASEBA language. The simulation is carried out in a special environment which requires curating of a custom map on which our thymio's can run and simulate desired scenarios. The map must be incorporated in the playground file and only then the required environment can be loaded to simulate the desired scenarios.

SOS: Road Traffic

The system simulates a typical traffic scenario where one vehicle intends to take over another vehicle. The DMV (Decision Making

vehicle) checks for nearby hindrances (If any) such as another vehicle, roadblocks, vehicles coming from the opposite lane, estimates their speed, adjust self-speed and make a move.

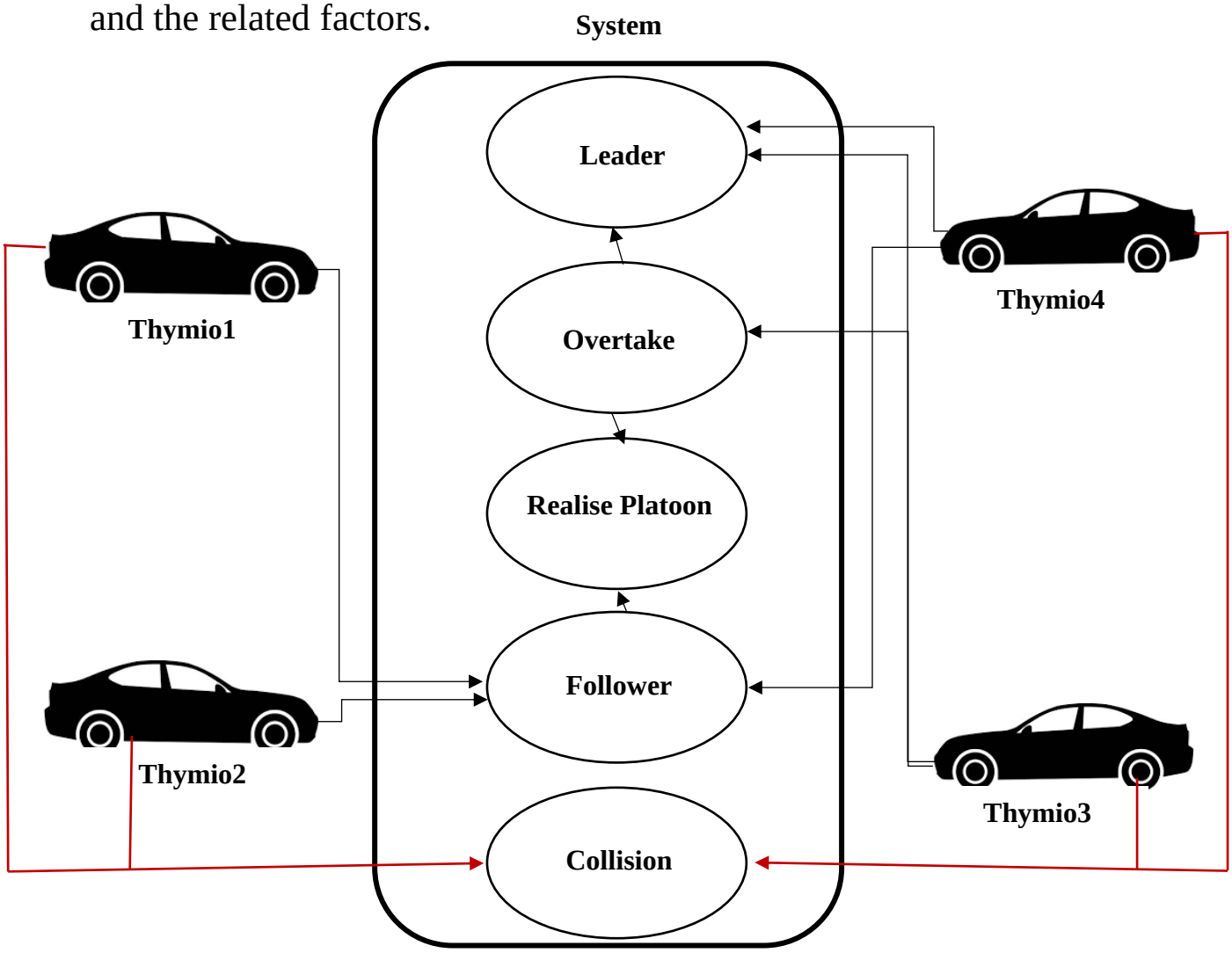
Thymios are Named Thymio1, Thymio2, Thymio3, and Thymio4.

Given thymios utilize proximity sensor and accelerometer to calculate the presence of another thymio in front of it and adjust its speed accordingly to initiate a move-in/move-out or stop process/running.

3. Requirements

3.1. Use Case Diagram

Here the use case is essentially a list of the main functionalities, and the related factors.



3.2. High level Use Cases

High Level Use Case – 1:

Use Case	Thymio platooning
Actor	Thymio1, Thymio2, Thymio3, Thymio4
Description	Thymio1, Thymio2, Thymio3, Thymio4 realize a platoon by following a safe distance among them.

Extended Use Case

Use Case	Thymio platooning
Actor	Thymio1, Thymio2, Thymio3, Thymio4
Description	Thymio3 decided to overtake Thymio4, Thymio2, Thymio1 and respectively. Thymio1, Thymio2 and Thymio3 are running on the given track. Thymio3 spot other thymio's on path it performed the overtaking feature and changed lane for some time and once overtaking is complete on side lane the overtaking thymio comes back to the original lane and starts running again. The preceding thymios Thymio1, Thymio2 and Thymio4, now becomes the followers and realize a platoon keeping a safe distance.
Pre-Condition	There must be a thymio in the front to overtake and realize a platoon.

Post Condition	Thymios are follow the path safe.
Assumption	Collision free running and overtaking.
Success Path	
Alternate Path	Thymio3 fails to overtake that is it will unfollow the path. Thymio will stop running.
Trigger	
Created On	18/01/2024
Created By	Muhammed Irfan
Revised on	N/A
Revised by	N/A

High Level Use Case – 2:

Use Case	Collision
Actor	Thymio1, Thymio2, Thymio3, Thymio4
Description	Thymio will collide back-side and on time of overtake.

Extended Use Case:

Use Case	Collision
Actor	Thymio1, Thymio2, Thymio3, Thymio4
Description	Thymio will collide back-side or front side.
Pre-Condition	Two thymios following the same/different path violate the properties.
Post Condition	Thymios will undergo for collision.
Assumption	Thymio will violate the properties.
Success Path	Thymio’s undergo collision.

Alternate Path	thymios fail-safe and stops working immediately upon violating the property.
Trigger	N/A malfunctioning.
Created On	18/01/2024
Created By	Muhammed Irfan
Revised on	N/A
Revised by	N/A

High Level Use Case – 3:

Use Case	Safe failure: Stop working of thymios if it loses the track and reaches white ground.
Actor	Thymio1, Thymio2, Thymio3, Thymio4
Description	the thymios stop working when they leave the black paths and encounter white flat surface.

Extended Use Case:

Use Case	Safe failure: Stop working of thymios if it loses the track and reaches white ground.
Actor	Thymio1, Thymio2, Thymio3, Thymio4.
Description	Thymio will collide back-side or front-side.
Pre-Condition	The thymios must follow the back path.
Post Condition	the thymios stop working when they land on the white sucrose, that is the velocity becomes zero.
Assumption	The thymios have moved-out of the black path and reached white

	surface and the velocity has become zero.
Success Path	Thymios leave the black path (Move-out) and encounter white lane outside the track, upon detecting the flat white surface the velocity reaches zero as sensors detect no movable surface.
Alternate Path	The thymios doesn't stop upon detecting the white flat surface and continue to run on white surface as well.
Trigger	disengagement from black path and engagement at white ground.
Created On	18/01/2024
Created By	Muhammed Irfan
Revised on	N/A
Revised by	N/A

High Level Use Case – 4:

Use Case	Thymio overtake.
Actor	Thymio3 overtakes Thymio1 and Thymio4.
Description	Thymio3 successfully overtakes Thymio1 and Thymio4.

Extended Use Case:

Use Case	Thymio overtake.
Actor	Thymio1, Thymio2, Thymio3: primary, Thymio4.
Description	Thymio3 detects the presence of Thymio1 and Thymio3 in front of it and performs proximity detection using its sensors, once it senses that the thymio's are in front, it performs

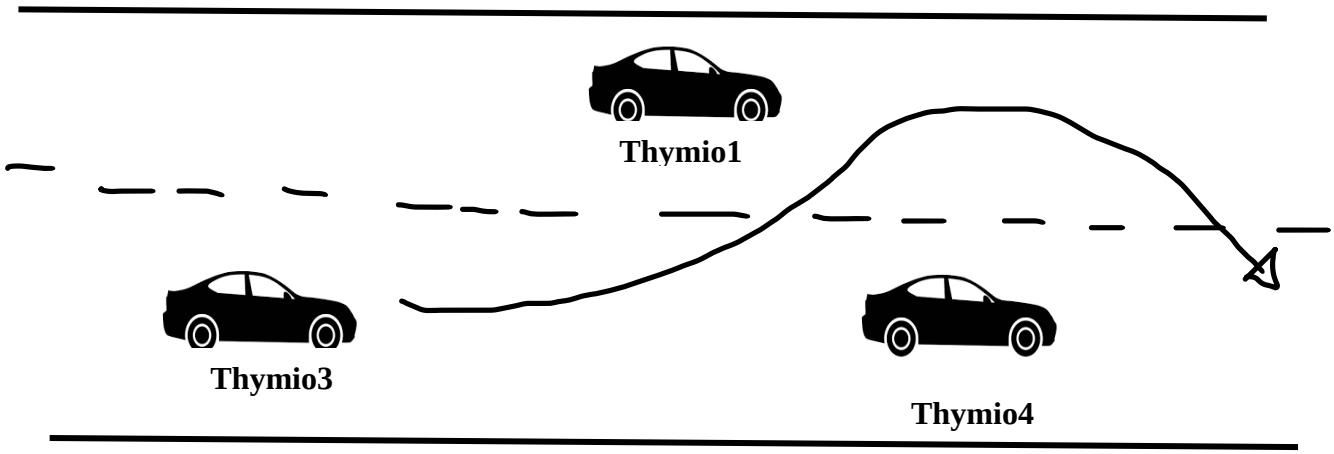
	the path change action i.e. move-out of the present path. Upon changing the path, it moves forwards with an increased velocity and upon realizing a safe move-in opportunity and space it performs move-in.
Pre-Condition	There must be a Thymio1 or Thymio4 in front of Thymio4 to initiate a overtake process.
Post Condition	Thymio3 successfully performs move-in and becomes the leader performing the successful overtake.
Assumption	There is no other thymio involved in this scenario to cause complicate the proper working of thymios in this case.
Success Path	Thymio3 successfully performs move-out and move-in and becomes the leader.
Alternate Path	Thymio3 fails to successfully overtake and encounters a forced stop or undergoes collision.
Trigger	Proximity sensor catches the presence of another thymio in front of it and initiates the path change: Move-out.
Created On	18/01/2024
Created By	Muhammed Irfan
Revised on	N/A
Revised by	N/A

4. System Features –Viewpoints

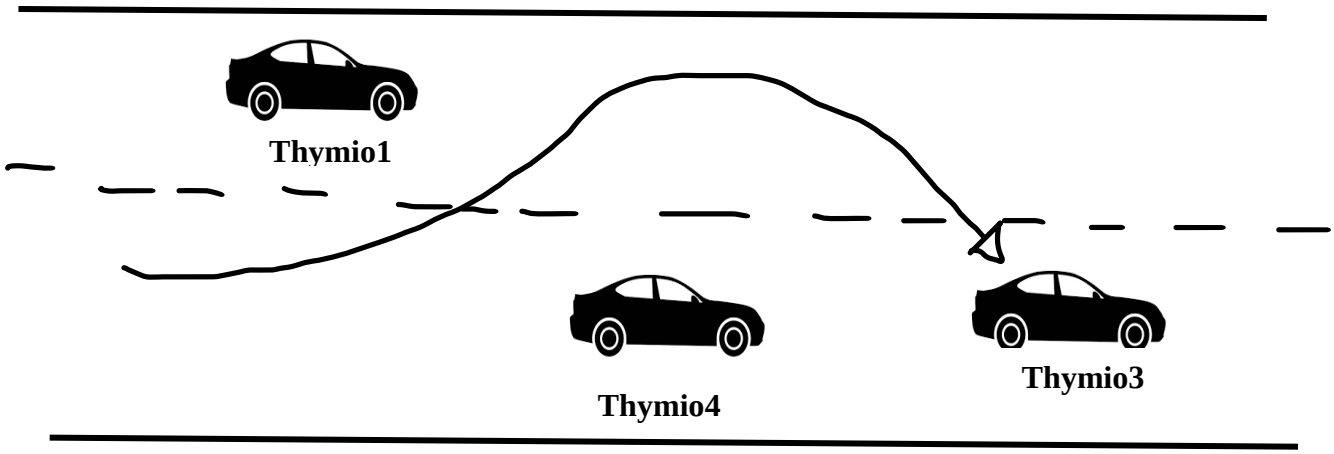
This system under observation is composed of Four Thymio which perform various activities at different positions and circumstances. Mentioned below are few services and features offered by the thymio's (all thymio not perform same functionality).

4.1. System Features 1: Overtake

This feature is Exclusive only to Thymio Thymio3 and. Mentioned thymios observe a leader thymio in front of it and initiate a move-out process. Upon successfully changing the path and moving ahead of the leader thymio in the other path Thymio3 perform a detection using a proximity sensor, once thymio has detected it is now safe to change, it performs the move-in and overtakes the thymio observed by it.



Before



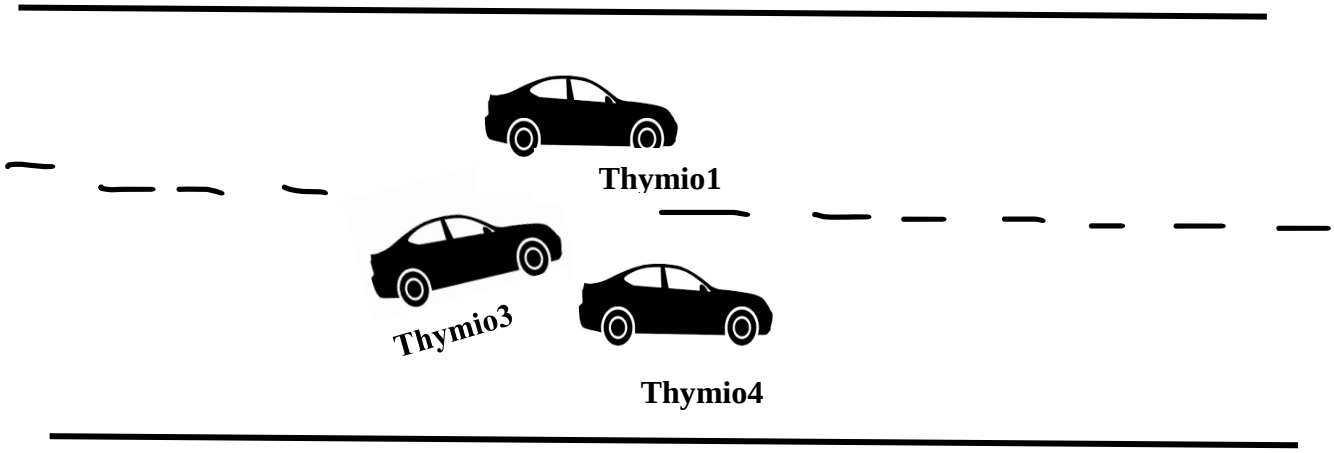
After

4.2. System Features 2: Platoon Realization

This feature is exercised under specific circumstances, thymio's realize a platoon by following the leader with distance. This feature is only exercised when the trailing thymio overtakes the thymio in front and becomes the new leader and other thymio keeps follow them.

4.3. System Features 3: Safe-Failure

All the thymio's are specifically programmed with this feature, it is expected form the thymios to carry out their movement on the designed black path, however under some circumstances if the thymio happens to leave that path and finds itself on white ground it must stop working as the sensor will stop giving any reading and velocity of that thymio will reach Zero.



Collision Scenario

5. Test Cases

Test case ID	Test Case Scenario	Process	Test Data	Expected Outcome	Result	Pass/ Fail
T1	Successful overtaking	As	Proximity sensor	Thymio	As Expected	Pass

		described in 4.1	readings	overtakes the leading Thymio.		
T2	Collision	Thymios violate the property and bump into each other.	Proximity sensor reading overridden.	Thymios collide into each other.	As Expected	Pass
T3	Safe-Failure	Thymios stop working upon reaching a white ground.	sensor reading, accelerometer reading reaches zero.	Thymio stops working on reaching a white ground.	As Expected	Pass

6. Project Glossary

Platoon: A group of two or more automated cooperative vehicles in path, maintaining a close distance

Velocity: A constant speed as maintained by the vehicle.

Decision Making Vehicle: the vehicle who decides to join a platoon/leave a platoon/ move in move-out.

Follower: Each vehicle that is following behind a member of the platoon, being every vehicle except the leading vehicle, when the system is in platoon mode.

Leader: The first vehicle of the platoon under observation

Move-in: A path change performed by vehicles from current path to adjacent path.

Move-out: A path change performed by vehicle from the present path to the adjacent path.