UML for Embedded Systems

Exam FALL 2025

Allocation of charging slots for Electrical Vehicles

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During the exam, you must not communicate with anyone, including AI, by any means (e.g., mobile phone, messaging apps, chat, etc.; see Assignment A below). You may bring one A4 sheet (double-sided) containing your own handwritten notes.

A grade is provided for each question. 1 bonus point is awarded for writing quality (report and models).

1 Objective

Your objective is to model the **software** of a global aggregator scheduling the charge of electrical vehicles.

You have exactly 3 hours to model this system and answer various questions: the time is very short. This means that **you have to make modeling assumptions**. **Keep your diagrams simple and readable**, in particular the analysis diagrams.

Your grade takes into account your report and your models. At the end of the exam, **report** (in **pdf** format) and one **model** file (in **TTool XML** format) **must be sent to me by email**, with Alexia Cepero and Romain Duplan in cc. The report is optional if you decide to put all explanations in your TTool model. If you were to send me a report, the report should contain explanations concerning your models, as well as relevant screen captures of models (e.g., interesting simulation traces, formal verification results).

2 System specification

Again, the system to model is the software of a global aggregator (GA), as described below.

2.1 Description

2.1.1 Overall description

A Global Aggregator (GA) allocates charging slots for electric vehicles (EVs) at charging stations (CS). EVs are on the road and need to recharge soon. The GA's primary objective is to assign each EV to the charging station with the lowest expected waiting time to complete a full charge.
When an EV needs to recharge, it sends a request to a centralized cloud service, referred to as the Global Aggregator, asking for the optimal charging station to travel to. The GA maintains a database of charging stations. For each station, the database includes relevant

operational data such as: the number of chargers, the power rating of each charger, the number of EVs currently charging, and the number of EVs waiting in queue.
Using this information, the GA computes the expected waiting time (EWT) for each charging station and replies to the EV with the station that has the lowest EWT. After receiving the GA's response and selecting the proposed station, the EV sends a confirmation message to the GA containing: the EV identifier, the EV type, the selected charging station, the estimated arrival time at the station, and the expected charging duration. The GA accepts this message and updates its database accordingly so it can incorporate this reservation into subsequent EWT calculations for other EVs.
All communication among the EV, CS, and GA is performed exclusively via 5G cellular networks. The system must account for communication delays and latency introduced by the network. If a message is detected as abnormally delayed, e.g., a missing response to a request, the sender may retransmit the same message several times before aborting.
When a vehicle has an accepted reservation, it must notify the GA of any abnormal situation that may cause it to arrive early or late at the selected charging station. The GA may then decide to propose alternatives. Charging stations must also notify the GA of incidents, including cases where an EV takes longer than expected to charge or where the station experiences a partial or total outage.
Finally, the system must ensure the confidentiality, authenticity, and integrity of all exchanged data, and it must comply with European regulations regarding data management.

3 Assignments

A. Personal work

Mandatory: Recopy the following text at the beginning of your report or as a note in your TTool model.

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I pledge on my honor that I will not
receive any unauthorized help on this
exam, that I will not help others in any
way on this exam, and that all my
answers will be my own personal work.
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B. Assumptions

1. Your assumptions should be clear. Do list them in the report: that list might evolve

according to the models you make afterwards. Make a clear separation between environment and system assumptions. [2 points]

C. Requirements

1. Create a requirement diagram. [3 points]

D. Analysis

1. Make a use case diagram. [3 points]
2. Continue the analysis in the form you want: activity diagrams, nominal scenario, error scenarios, . . . : you are free to use the diagrams you want. Of course, the idea here is to show important points of the specification. [3 points]

E. Design and validation

1. Make a block diagram. Put the emphasis on which blocks are used to model the system being designed, and which ones are used either to model the environment, or to prove properties (observers). [2 points]
2. Draw state machines, and provide a nominal simulation trace, as well as an error trace. [3 points]
3. Select one timing constraint of your choice and prove that is is always satisfied (or not always satisfied). Also, from requirements, define a property of your choice, and prove whether it is satisfied (or not!). And obviously, explain how you have modeled these two properties [3 points]

Good luck!