A Preliminary Self-Adaptive Software Solution for Electric Vehicle Charging Stations

POLITECNICO MILANO 1863

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1) Context

Electric vehicle charging stations (EVCSs) are an emerging and continually evolving industry. However, since there are several players in the market, a couple of crucial factors must be considered in order to become or stay competitive from a software perspective:

- the time it takes to get a new station up and running and
- the time needed to upgrade the software (including the firmware) of the EVCS network, to keep current and make the best of the latest technologies.

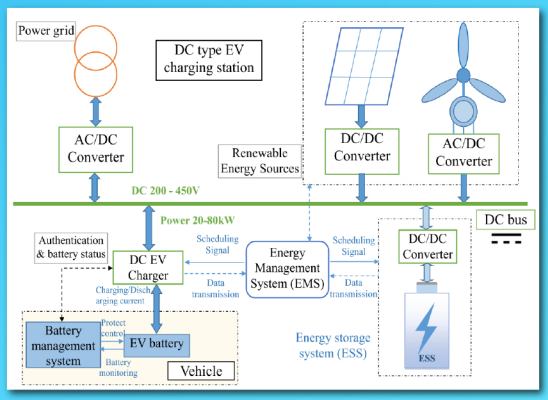

Figure 1a. DC EVCS [1].

Figure 1b. Communication protocols in the EV ecosystem.

Level	Activities	Technologies
Tertiary	Strategy, forecasting, pricing, and profit optimization	Cloud computing
Secondary	Station operations and energy allocation and optimization	Industrial and single-board computers
Primary	Power quality management and EV and ESS control	Microcontrollers, FPGAs, and PLCs
Physical	Power and energy density, dynamic features, thermal models, life estimation models	Transistors, capacitors, batteries, PV

Figure 1c. Hierarchical control of EVCSs. Based on [1].

2) Problem

While numerous cloud and edge solutions have been developed, there remains a notable gap in the scientific literature concerning the amalgamation of these technologies into a cohesive, self-adaptive system specifically meant for EVCS management.

This research endeavors to bridge that void by formulating a comprehensive approach that harmonizes cloud and edge components, fostering a self-adaptive system capable of autonomously optimizing resource allocation based on dynamic conditions.

3) Self-Adaptive Software

Self-adaptive software is a type of software that modifies its own behavior in response to changes in its operating environment. It can adapt to improve system response time, recover from failures, incorporate additional behavior during run-time, and support a wide range of autonomy, from fully automatic to human-in-the-loop. Self-adaptive systems can be open-adaptive or closed-adaptive, and the decision to adapt is based on cost-effectiveness. [2].

4) Solution

A preliminary self-adaptive software solution has been proposed taking into account the hierarchical control structure and industry requirements, which is possible nowadays thanks to the development of enabling technologies during the last decade. Concretely, such a solution may be referred to as a Software Management System (SMS) or Software Configuration Management (SCM) system: a set of tools, processes, and practices designed to efficiently manage and control the development, maintenance, and deployment of software products and projects.

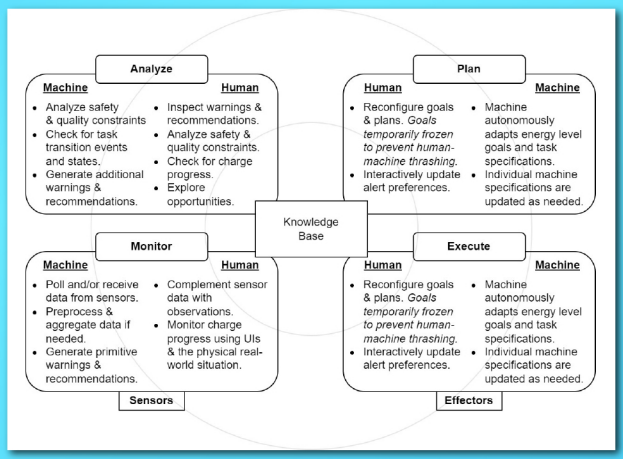

Figure 4a. EVCS MAPE-K_{HMT}. Based on [3].

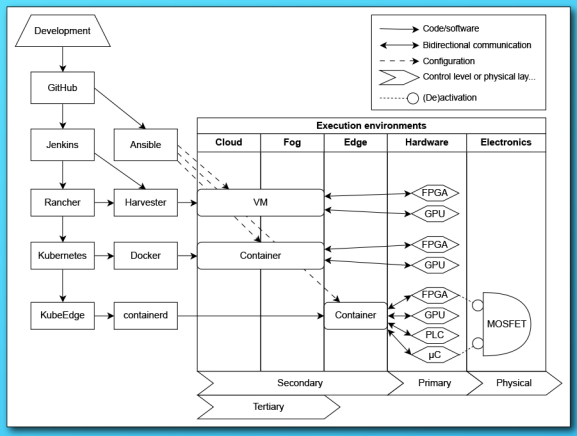

Figure 4b. Proposed Software Management System Architecture for EVCSs.

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5) Conclusion

This research delved into the EVCS application domain and software self-adaptation. Subsequently, the author proposed a preliminary self-adaptive software solution (i.e. an SMS architecture) for EVCSs. The next steps include the implementation and benchmark of such a solution.

References

[1] Wu, Y., Wang, Z., Huangfu, Y., Ravey, A., Chrenko, D. and Gao, F., 2022. Hierarchical operation of electric vehicle charging station in smart grid integration applications—An overview. International Journal of Electrical Power & Energy Systems, 139, p.108005.
[2] Oreizy, P., Gorlick, M.M., Taylor, R.N., Heimhigner, D., Johnson, G., Medvidovic, N., Quilici, A., Rosenblum, D.S. and Wolf, A.L., 1999. An architecture-based approach to self-adaptive software. IEEE Intelligent Systems and Their Applications, 14(3), pp.54-62.
[3] Cleland-Huang, J., Agrawal, A., Vierhauser, M., Murphy, M. and Prieto, M., 2022, May. Extending MAPE-K to support human-machine teaming. In Proceedings of the 17th Symposium on Software Engineering for Adaptive and Self-Managing Systems (pp. 120-131).