EVENT GRAPH MODEL OF THE EV CHARGING PROCESS

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ABSTRACT

This paper makes analyses of the research on Event graph model of the EV charging process. On this case, research has been conducted both theoretical and practical analyses. Research has been concluded with the major points of the outcomes and shortcomings as the whole.

Keywords : **Event, graph, model, EV, charging process, Uzbekistan**

INTRODUCTION

Charging electric vehicles with a minimum time while keeping a maximum of performances they provide is the current challenge of constructors and researches in the field. Among these performances we underline traveling long distances (autonomy) and unconditional use of the on board services (air conditioning, radio, lighting, etc.). Moreover, the limited cruising range and the ability to regain energy during deceleration are the main features of EVs. In this case, to suggest the nearest charging station is not enough. However, guiding vehicles into adequate charging stations could be effective and avoid serious problems such as long waiting and breakdown. In our recent research work subject to the management of EVs charging, we have addressed one of the most major issues related to the uncertainty of drivers to get a suitable and vacant place at a charging station. In our current work, we continue these efforts and try to propose a formal approach aiming to anticipate, plan and propose adequate charging solutions for EVs. The studied system can be seen as a discrete Event System (DES) managed by State/Transition concept. In this system a State represents, for example, charging operation of an EV, waiting for charging, traveling before/after charging, etc.; and a Transition models beginning/ending dates of each process state. It is worth noting that a transition may include the following optional features : event, a guard condition or a list of actions. In our current work a transition is an event signifying the transition form a state of the system to another one.

MAIN PART

Considering the chronological evolution of charging operations, the problem will be then modeled by a well-known powerful formalism already developed for DES. Todo so, we propose a unified methodology based on Petri nets (PN) combined with a mathematical algebra, called diode algebra, to model and evaluate the performances of the system using linear equations. Both formalisms have been chosen because of the specific advantages they present. Furthermore, the choice of these two complementary formalisms is motivated by their wide use to model and analyze synchronized and concurrent systems. More precisely, on one hand, PN can be used as a design language for the specification of complex processes. On the other hand, PN theory provides powerful analysis techniques with mathematical background which can be used to verify the correctness of modeled systems. Many sub-classes of PN are developed in the literature according to the studied system. For DES, Event Graphs (EG) are more suitable to address the phenomena such as synchronization, parallelism and concurrency. When the system behavior evolves over time, Timed Event Graphs (TEG) are a well-founded process modeling technique integrating the time factor for the evaluation of delays and beginning/ending dates of each process state. These extensions of PN facilitate the modeling of complex processes where time and data are important factors. Combined with TEG, dioid algebra provides a complete analysis of studied systems by studying and verifying some quantitative properties of the system. In addition this algebra is will-known as powerful formal fool for describing the behavior of systems characterized by delays and synchronization. In this paper we mainly use the (max, +) algebra for calculating the occurrence date, called also dater, of each system event.

Using these formalism, the proposed models in this paper describe the behavior of a developed collaborative platform for charging process for which the architecture is detailed in 1. Furthermore, the access control to provided services by the platform (e.g. suggestion of a suitable charging station foran EV, suggestion of a charging station with other interest point such as shopping, restaurant, etc.) is addressed by the proposed models. TEG will be used to prove graphically, and also analytically, some properties (reachability, deadlock, etc.) of the charging system and to evaluate some performance measures (waiting times, response times, occupation times, etc.). However, TEG model cannot offer the possibility to ensure a complete study of the proposed process. To remedy to this lack, we combine the obtained TEG model with a state representation in dioid algebra in order to describe its behavior with mathematical linear equations thereby allowing to reach suitable and convincing results. Through a case study, we show that allying TEG with dioid algebra is not only a powerful methodology for specification and modeling, but also an adequate tool for behavior prediction and decision-making.

ANALYSES

The remainder of this paper is organized as follows. The Section II represents a survey of related work. Our research context is given in Section III. In Section IV, the problem statement and modeling approach are presented. Section V presents how the system sizing can be carried out for performance tuning and improvement. The Section VI concludes the paper and giver some future directions of this work.

With the promotion of EVs many challenges are to be addressed such as charging and discharging process which can be a serious source of troubles. In fact, to charge their EVs drivers have no solutions except to put their EVs under charging gor several hours. To remedy to this problem of long waiting, many researches have been conducted in the literature and try to propose some solutions and alternatives. Otherwise, many researches have been conducted to schedule, control and optimize charging and discharging processes of EVs. In what follows we present some of these research works. Several methods and architectures for charging/discharging of EVs. Have been proposed. For example in a distributed architecture is proposed. This architecture achieves energy balancing at three levels: at the charging station level through controlled charging and at two other levels. The aim of this work is to guide EV users to a charging station to be charged optimally by using routing server. This server enables to dispatch the reservations on the basis of the rough availability of resources at certain selected charging stations.

In the same context, the authors of and proposed some approaches for effective planning charging times. In a reservation-based scheduling scheme is proposed for the charging station in order to decide the service order of multiple requests. The objective of this scheme is to improve the satisfiability of drivers of EVs by reducing the charge costs end waiting times. In an agent-based approach is developed to represent and control the behavior of charging and discharging operations of Plug-in Hybrid Electric Vehicles (PHEV). A comparative study was proposed in this work about reactive scheduling and proactive scheduling for reducing imbalance costs. Some simulations were worked out and obtained results show a reduction of imbalance costs by 14% with reactive scheduling. Contrariwise, using proactive scheduling the imbalance cost reduction is about 44%. The work presented in focused on an optimization problem of the charge pattern of a PHEV. The objective is double : minimizing the fuel and electricity costs and the battery health degradation over a 24 hours drive cycle. A stochastic optimization method is used model is adopted to reach the second objective. This model is based on an anode-side resistive film formation in lithium-ion batteries.

A genetic algorithm used for optimizing the charging behavior of a OHEV was proposed in. Though this study, the authors aim to maximize the energy trading profit in a V2G context,and second minimize the battery cost. Furthermore, the charging and discharging processes have been addressed in as a scheduling optimization problem. In this study, charging power is considered to minimize the total cost of EVs. Other charging algorithms are developed respectively in for fast charging and increasing battery life cycles. In authors have addressed the issue of management of parking lots and charging station management systems. They have proposed to manage charging process within parking lots by using sensors which detect whether a parking space is free or occupied. Furthermore, an existing luminary within charging stations guides customers in search of a parking space.

Regarding the combination of TEG and (max, +) algebra, the proposed modeling approach in this paper is based on what the authors have proposed and developed in. Allying TEG with (max, +)-algebra is proposed to describe and analyze the electronic signature process of contracts between clients and server to answer client requests. The objective of the study is to serve a maximum of requests using a minimum of servers. We make the an analogy between the problem addressed in this paper in the proposed approach and the objective is to serve a maximum charging request using a minimum charging stations without excessive waiting of drivers.

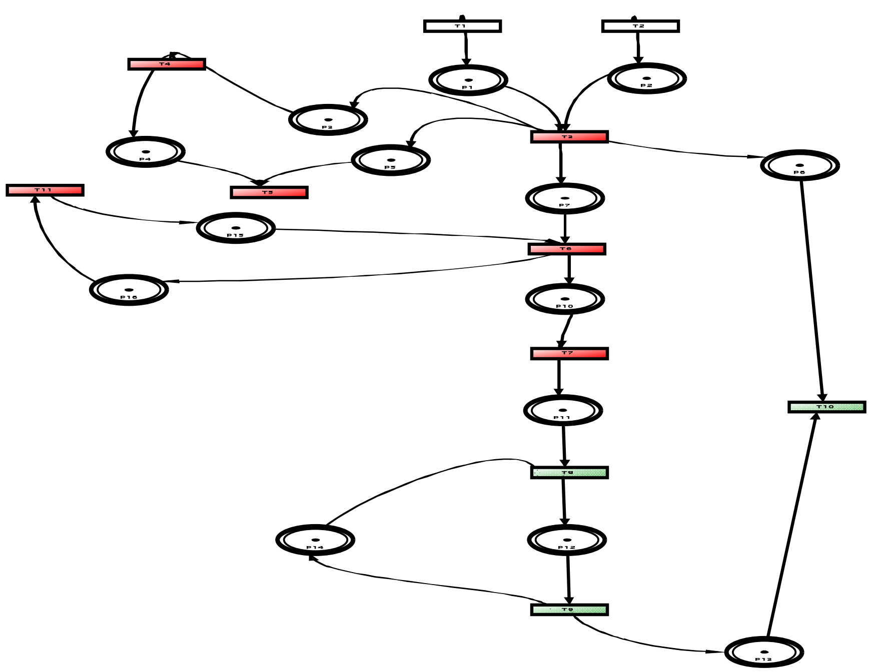

Figure 1. Event Graph model of the charging process.

CONCLUSION

All these steps are represented included in the EG model of figure 1. In table I we present all EG model nodes (places and transitions). Each place or transition has own short name (designation) and its significance.

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