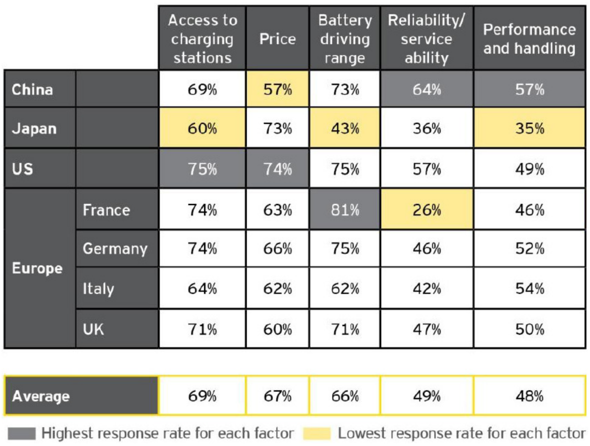
Proceedings of the Federated Conference on
Computer Science and Information Systems pp. 305–312
ISBN 978-83-60810-22-4

A Context-Aware Mobile Accessible Electric Vehicle Management System

Nils Masuch, Marco Lützenberger, Sebastian Ahrndt, Axel Heßler, and Sahin Albayrak
DAI-Labor, Technische Universität Berlin
Faculty of Electrical Engineering and Computer Science
Ernst-Reuter-Platz 7, 10587 Berlin, Germany
Telephone: +49 (0)30 - 314 74000, Fax: +49 (0)30 - 314 74003
Email: {firstname.lastname}@dai-labor.de

***Abstract*—In the coming years, the German traffic situation will undergo a challenging addition. Major car manufacturers have scheduled the year 2013 as cutoff for electric mobility. Yet, current studies indicate that range limitations and insufficient charging infrastructure endanger the acceptance for electric vehicles (EV). This is regrettable, and not only for the producer, but also for less obvious parties such as local energy providers which consider electric vehicles as remedy to one of their most severe problems of managing the grid load balance. In this paper we introduce a mobile accessible EV management system which accounts for the mobility of the user and also integrates web-based (commercial) services of third parties. Our objective is to counter the limitations of electric mobility and also to facilitate all of its (business) perspectives. We want to render electric mobility a success and support its trendsetting character.**

***Index Terms*—Mobile environments, Mobile commerce, Distributed system, Web-based services, Electric vehicles, Charging station**



		Access to charging stations	Price	Battery driving range	Reliability/ service ability	Performance and handling
China		69%	57%	73%	64%	57%
Japan		60%	73%	43%	36%	35%
US		75%	74%	75%	57%	49%
Europe	France	74%	63%	81%	26%	46%
	Germany	74%	66%	75%	46%	52%
	Italy	64%	62%	62%	42%	54%
	UK	71%	60%	71%	47%	50%
Average		69%	67%	66%	49%	48%

■ Highest response rate for each factor 🟨 Lowest response rate for each factor

Fig. 1. Answers to the question: “Which factors would make you most hesitant to choose a PHEV or EV as your next vehicle?”, raised within an *Ernst & Young* study [2].

I. THE AGE OF ELECTRIC MOBILITY

IN THE coming years the traffic situation on german roads will undergo a ground-breaking, futuristic, and yet ambiguous change. Major car manufacturers have scheduled the year 2013 as cutoff for electric mobility. This ambitious aim is facilitated by the german government, which proposes the magic number of one million electric vehicles on german roads by the year 2020 [1]. However, to the day, the optimism regarding the acceptance of electric mobility is most often cushioned by results of market analysis. One of these studies [2] has been performed by *Ernst & Young* most recently. Figure 1 illustrates the answers to one of the study's key question: “*Which factors would make you most hesitant to choose a Plug-in Hybrid Electric Vehicle (PHEV) or EV as your next vehicle?*”.

The presented numbers imply that, e-mobility is up against a set of severe problems. Beside the pricing issues, potential buyers are mainly scared by the limited range of electric vehicles and also by limited access to charging capabilities. Both problems necessitate considerations and planning of each intended ride. To support a driver in this task, we have developed an automated management system which operates on the daily schedule of the user.

Based on the location, the timing and the priority of the scheduled appointments, the system computes a fitting “driving-strategy”, proposes alternative charging intervals, and is also able to recommend optimised appointment sequences by rearranging less prior, non time-critical tasks. The computation also accounts for infrastructural conditions and proposes charging intervals only in close distance to charging capabilities. We applied a web-based approach for the management of the user's appointments and allow access not only from desktop computers but also from mobile devices in order to facilitate the system's flexibility and to ensure its application to real world situations.

However, the domain of electric vehicles is complex and not only affects the driver, but also opens new business perspectives and opportunities. Energy providers for example have high hopes in electric mobility and consider EVs as remedy for one of their most critical problems: Grid load balance. By using electric vehicles as “rolling batteries”, energy providers currently develop area-wide mechanisms to charge electric vehicles when there is little grid load and much energy (and preferably a lot of volatile energy) available, and avoid charging periods when there is large demand from the energy grid. Yet, having in mind the restrictions of EVs, it is obvious that an according mechanism has to account for the driver and his intended rides. For the reason of data integrity, it is also clear, that scheduled appointments undergo the privacy of the driver and cannot directly be forwarded to energy providers for optimisation purposes. We have designed our management system to act as loosely coupled middleware, able to comprehend many input channels, such as schedules provided by users, priority signals provided by an energy provider, infrastructure availabilities provided by energy infrastructure providers and many more.

We provide mobile access and allow users to manipulate their schedule at any time, each addition comprising re-optimisation. Previously computed charging intervals are again measured against the provided priority signal and possibly shifted to more effective time slots. Of course the shifting of already advised charging intervals can only be interesting for the energy provider to regulate his grid load. For the driver there seems to be no apparent benefit, yet, having dynamic energy tariffs in mind, the appeal becomes more obvious. With special conditions for the beforehand booking of particular charging intervals, customers may profit monetarily, while energy providers gain advantage in grid load regulation.

To sum up, electric mobility faces a lot of challenges, but also opens a lot of business perspectives. With our scheduling system we aim to do both, counter limitations and facilitate further possibilities. In this paper we describe the principle of our scheduling system and show how we designed the application to access web-based energy provider services (see Section II). To clarify our approach and to evaluate or work we use an exemplary scenario in which we also motivate the necessity for mobile access (see Section III). Subsequently we will classify and distinct our approach from related works (see Section IV). Finally, we wrap up with a conclusion (see Section V).

II. SUPPORTING THE DRIVER

The challenge of managing the usage of electric vehicles and their related limitations and potential benefits is a complex one that is dependent to different actors with sometimes conflictive interests. Further, due to the nature of each scheduling problem, the system has to be highly dynamic in order to adapt its decisions to changes in the environment. In the following we will first describe the structure of our management system approach followed by a definition of the distributed services that are relevant within our domain. Further the charging management approach will be described in detail and finally we point out the mobile aspects of our system and its interaction with third party services.

A. The management system approach

In order to support the driver comprehensively regarding the management of charging issues while utilising an electric vehicle, the management system requires access to various resources providing information about charging options, preferences and necessities. More specifically these can be prognosticated driving patterns, energy progression curves, energy price curves, wind energy curves and infrastructural availabilities. Such a distinct set of data types is typically not provided by a single party or company and therefore the different information parts have to be requested from multiple sources. In some cases – for example the energy price curve – it might be even reasonable to request the data from different providers in order to build up a larger amount of planning options.

The major challenge for the management system lies in the creation of a charging schedule for the driver's EV out of the provided information. Thereby the result has to satisfy the driver's standards. But how is the driver's standards be defined?

The biggest issue in that context is certainly the mobility warranty in terms of the driver's driving patterns. This means the driver wants to travel with his EV without any sorrow about the state of charge. Out of this reason the management system undertakes the task of selecting a charging interval within the day guaranteeing that the vehicle will have enough energy until then. At the same time, however, the system has to validate that at the place, where the driver aims to be during a potential charging interval, there can be found a respective charging station nearby, which has to be available furthermore. This is why the management system not only searches for charging intervals, but at the same time for concrete charging stations. If the properties of the station are appropriate our approach triggers the reservation of the desired time slots. Another aspect are the energy costs that arise for charging transaction. It can be assumed that in the near future the energy provider will propose variable power prices in order to regulate the demand according to their infrastructural needs. Doing so, the purchase of expensive regulating energy can be avoided and regenerative energy, with the disadvantage of unsteady production, can be adapted monetarily to the demand and is therefore more attractive even at unusual energy consumption times. In that context it makes sense to the driver of an EV to fall back on low priced time slots in times he is flexible. Therefore the charging management has to select a solution that fulfills either the mobility warranty as well as the monetary aspect with flexible weightings on both parameters depending on the driver's profile.

However, in order to be able to trigger the charging management process the management system must find a way to evaluate the energy progression curve of the EV's battery for a certain prospective time interval. This is in turn only possible, if some kind of driving pattern can be assumed. In our approach we decided to deduce the expected journeys out of the driver's personal calendar. Doing so, the appointments and its location information are being extracted in order to know where to drive to. In order to compute the journeys in an automated way we defined a tag pattern within the appointments location field. If the driver writes down only one location the system assumes that this is the target place and the journey will start from a predefined standard location. But if two locations are being named within the field, the system computes a route from the first to the second named location. Based on that, the system is able to build up a prospective energy progression curve and check whether additional charging events are necessary or not.

B. It's all about services

Due to the high level of distribution, which evolves from the different kinds of services being invoked, our management system is based upon a modular, service-oriented approach, which can be extended anytime with additional functionalities.

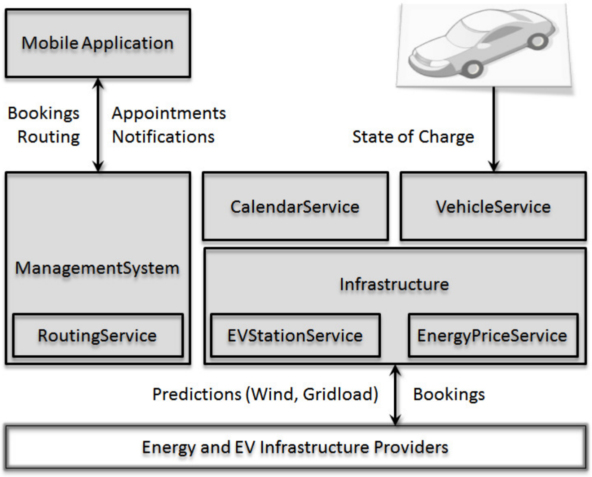


Fig. 2. The electric vehicle management system and related services

Figure 2 illustrates its structure and the external services which are being accessed during runtime. In the following the services and its functionalities are being described shortly.

- **Calendar Service:** The calendar service accesses a user-defined calendar resource and requests all prospective appointments from it. Furthermore the calendar service offers the possibility to easily add additional appointments to the source calendar.
- **Routing Service:** Proprietary service that provides the computation of routes regarding different preferences, such as length and speed. The result is the fundament for the computation of the energy progression curve.
- **Vehicle Service:** Wraps two separate services, namely the energy consumption service and the vehicle state service. The energy consumption service relies on the energy profile of the vehicle's battery and computes the energy consumption of routes in dependency to the expected state-of-charge. The vehicle state service is able to provide dynamic information like the actual SoC and position to the requester.
- **Charging Station Service:** Provides information about existing charging stations of a specific supplier near a requested location. Furthermore, offers information about the technical properties of the charging station and enables to book the charging station access for a certain time interval. According to this a charging station availability check is also possible.
- **Energy Price Service:** Provides a variable, time-dependent energy price curve of the energy provider, which is being continuously.

C. Charging interval selection

The charging management process is triggered by the management system after certain events. These can be the appearance of new appointments (initial planning) or the dynamic and significant change of the energy provider's price function (potential rescheduling). In these cases the charging management behaves as follows.

The starting point for the algorithm is the prospective energy progression function of the EV, deduced by the driver's appointments. By means of that, it is checked whether the EV's SoC is expected to fall below a predefined, fixed threshold somewhere in the future. If so, the system extracts all time slots, where the EV is being parked before the threshold violation will occur and where a potential charging event will lift the curve above the threshold. Each of the possible charging options is now analysed regarding the location of the driver at that time and whether there is a charging station located nearby. At the same time, the charging station related energy price curve is being requested and checked for the prices with the desired interval. Out of these information, a set of potential charging options is generated, sorted by the cheapest charging station - energy price combination. Finally the system selects the cheapest charging interval that is available for the current price conditions. Since the price curve might change for the selected time interval dynamically, we defined in our approach that the energy provider sells the energy at maximum for the current price and might be even cheaper if the curve is being corrected downwards. Afterwards the driver is being informed about the updated charging planning via the mobile accessible application and after a confirmation the necessary bookings will be performed.

D. Mobile user control

In our approach the user has two possibilities to control and interact with the management system. On the one hand, he is able to do that indirectly by inserting appointments in his personal calendar, which leads to a deduction of driving necessities and therefore to a triggering of the charging management process. On the other hand he can interact dynamically via a mobile EV management application. Doing so, the mobile application enables the user at every time to request the current planning state, to configure it and to initiate and control replanning actions due to dynamic events.

So the mobile application provides the configuration of user preferences, which enables the driver to orient the charging management more on the monetary aspects or the absolute mobility warranty. Further, a list of energy providers and their respective charging station infrastructure the system is planning on can be selected as well as a definition of a standard location the route planning is computing the journey from by default. Each modification within the user preferences leads to a rescheduling process.

In addition the user can look at his appointments in a calendar view. Within this perspective not only the synchronised appointments from the user's personal calendar are displayed but also the evaluated journeys and charging events. If the driver wants to start a journey he can select the appropriate one from the calendar, whereupon a route overview is being opened. Furthermore, it is possible to add new appointments directly within the mobile application calendar, which are finally synchronised to the user's background calendar.

The driver is also able to check the current state of his electric vehicle, if an activated vehicle state service is installed within the car. This offers the possibility being always informed about the current state of charge, even when not being at the vehicle's location. Therefore driver keeps a total overview about the processes that are happening within the car, for example when the car is charging and the user thinks about leaving the charging station a bit earlier than initially planned.

A very important task for the mobile application is the completion of charging booking decisions by interacting with the user. After the system has evaluated the optimal charging slot based upon the user preferences the driver gets an inquiry for confirmation. In that situation the driver can overview the costs for that event and compare them to alternate options. If he confirms a booking for the selected charging station time interval combination is being booked. Alternatively the driver can select other charging options if he is not satisfied with the system's decision. Consequently the driver is always able to fully control the planning of charging events and can also define charging events without any request to the charging management module.

Another aspect, which is covered by the mobile application, are the interaction mechanisms between user and system when unexpected events occur. These can be initiated either by the system or the user. So, for example, the driver is always able to cancel a booking if he recognises that he will not be at the place for the defined charging interval. In other cases the system initially informs the driver about some relevant state changes (unexpected, increased energy consumption, cheaper price curve, malfunctioning charging station) and proposes alternatives to him. For example, let us regard the price curve which changes during time. If some charging slots have been already booked and the system recognises that the price curve is now cheaper during another, later charging slot option than actual selected one, the user gets informed about that dynamically and can decide whether to change his booking or not.

Therefore the mobile management application can be described as a comprehensive interface to the user, which enables, besides configuration of the management system, the access to information about the energy providers infrastructure and the performance of usage rights transactions.

III. EVALUATION

In order to evaluate our approach of a mobility management system with a mobile application for user system interaction regarding the user's benefits, we describe a typical scenario in the following, where our application is intended to be used. In particular, we compare the differences to a static charging management system which does not provide *Mobile Commerce* access to energy providers and finally elaborate the advantages of our mobile solution.

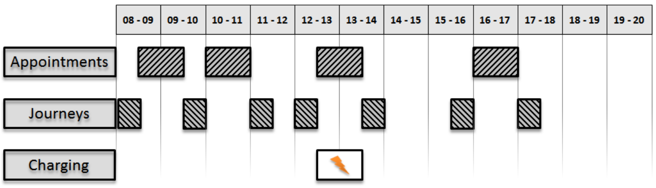


Fig. 3. The driver's appointment schedule and the initial journey and charging event results.

Figure 3 illustrates the appointment schedule of an electric vehicle holder. Taking the appointments into account the management system has deduced all relevant journeys and computed its expected energy consumptions (with regard to the specific vehicle characteristics). Out of it a time dependent energy progression curve for the specific day and without any charging events in it yet has been build up.

Based on these information the charging management algorithm analyses when a charging event has to be scheduled at latest in order to adhere the mobility warranty and not to undercut a predefined lower energy threshold. Doing so, different time intervals come into play for charging. In our case the undercut of the energy threshold without charging occurs during the journey from 13:30 to 14:00 h. In this respect all parking events before that journey are left for consideration as long as there exist charging stations nearby the respective appointment locations. Now the energy price curve is relevant for further decisions. Fig. 4 shows the curve for our scenario indirectly. In the foreground there are two curves, one of them representing the overall load within the energy network, the other the amount of wind energy. In our case both curves are the fundament for the energy price curve, which is represented by the different types of shade in the background. Darker intervals indicate expensive charging slots while bright ones are cheap.

The charging management now computes the quality of the remaining, potential charging events in consideration of the mobility warranty and the energy price curve. In our scenario the algorithm evaluates a charging event during the meeting from 12:30 to 13:30 h as optimal. When looking at the energy price indicator in the figure, it is obvious that these interval is brighter then all the other potential intervals before. Another aspect the algorithm looked at when selecting a charging event is the distance from the charging station to the appointment location. If it exceeds a certain length the solution option is discarded, which was not the case in our scenario. If nothing changes on the user's appointment schedule until the start of the first journey the charging management is finished after the confirmation of the user, which triggers the system to

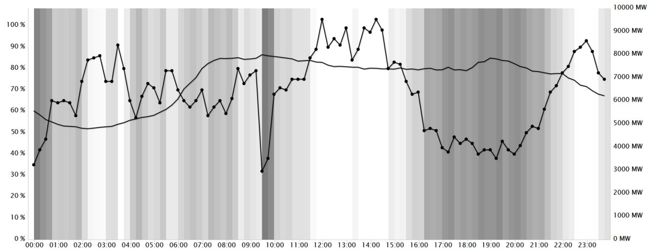
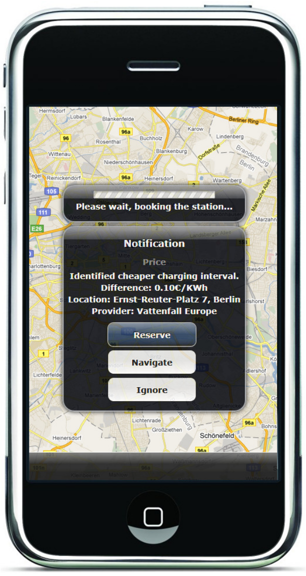


Fig. 4. Absolute amount of regenerative energy (line with dots; in MW) within the grid and its load. The background colors indicate the deduced energy price signal (Bright intervals represent cheap prices, dark intervals expensive ones)

communicate with the energy provider and to book the selected time interval at the actual conditions.

Until now, the management system has solely performed an initial charging event planning. In reality, however, cases will occur when the initial planning is not sufficient anymore and the user has to be involved in an interaction process. This will be shown in the following.

In our scenario the user starts his day and drives with his electric vehicle to his first meeting without any charging event being scheduled for that time. At 09:30 h he drives to the next appointment. Shortly before arriving, the appointment at 16:00 h is canceled by the organiser. The management system triggers the charging management process, which computes again the energy progression curve for the day and recognises, that, of course, no changes in the charging planning has to be done due to the omission of the journeys for the canceled meeting. But at the same time the management system checks for a energy price curve and notices a significant difference to the old price curve. Meanwhile, especially the prices at the current scenario time are much cheaper than our booked charging interval at 12:30 h. Therefore the system checks whether it is possible due to the omission of the late scheduled journeys to charge already earlier without triggering an energy threshold violation. Since this is the case in our scenario the charging management system searches for a charging station of the same energy provider nearby the immediately impended appointment. The system contacts the driver via his mobile application and offers him to shift his charging event to now and to directly drive to the evaluated charging station (see Figure 5). As a motivation the application displays the monetary benefit the user has when charging right now in comparison to the initial booked time slot. The driver confirms and drives immediately to the proposed charging station. When arriving he notices that the charging station parking lot has been illegally occupied by another vehicle and he is therefore not able to charge there. Because of that the user opens his mobile application and requests the cancellation of his booking and the search for an alternative charging station nearby. After processing the cancellation, the system checks for different charging stations and finds one from a different energy provider, which is available and has just a slightly more expensive energy rate than the occupied one. The mobile application informs the driver and shows the route to the aimed spot, whereby the user confirms the booking and drives to the charging station. After the arrival, the user authenticates itself with his personal RFID chip and the charging station opens the loading hatch. After connection is set up and the charging has started the user walks the few hundred metres to the appointment location.


Please wait, booking the station...

Notification

Price

Identified cheaper charging interval.
Difference: 0.10€/KWh
Location: Ernst-Reuter-Platz 7, Berlin
Provider: Vattenfall Europe

Fig. 5. Screenshot of our mobile application. Offering the driver to shift a charging event to now due to cheaper price.

The above described scenario shows in several respects how mobile interaction can serve the user when utilising electric vehicles in daily life. Especially in situations, when events occur very shortly like the cancellation of an appointment or the change of the energy price curve, the charging management can propose the result of his replanning process dynamically to the user, which can lead to a monetary benefit or simply keep the mobility warranty up. Using a static system, where the driver is just able to check the plans for example at the computer at his working place, such use cases can not be handled. This shows that a static system collapses every time when changes occur shortly, since they cannot be communicated between user and system. Within the scenario the driver is in the unpleasant situation that the aimed charging station, though booked, is physically not reachable. With the help of the mobile application the user was able to directly request a solution from the management system. In a static system the user would have had to search for an alternative charging station by himself which leads to significant additional expenses. In conclusion, the usage of dynamic, mobile management applications with an integration of *Mobile Commerce* services in the context of electric mobility leads to an significant additional benefit for the driver by supporting him comprehensively at every time and every place.

IV. RELATED WORK

It is difficult to provide a clear structure to this section since our work touches many different topics and domains of research. While the distributed nature of our system is to be assigned to the field of agent-oriented software development, the introduced scheduling and optimisation algorithms are unmistakably related to the comprehensive realm of operations research.

However, what our application clearly offers is mobile access to services which simplify, facilitate and support the management of electric vehicles. These services are web-based and in the case services provided by energy providers, feature a commercial character, since "rights to use services" are transfered.

Literature refers to this principle as *Mobile Commerce* for which *Tiwari* and *Buse* provide the following definition:

> *"Mobile Commerce is any transaction, involving the transfer of ownership or rights to use goods and services, which is initiated and/or completed by using mobile access to computer-mediated networks with the help of an electronic device."* [3]

Compared to the more common and superordinate domain of *Electronic Commerce* (or *E-Commerce*), *Mobile Commerce* emphasises on services which can be accessed at any time and from anywhere. As a matter of fact, *Mobile Commerce* accounts for an entire set of promising capabilities, such as location- and context-awareness.

In the following we present driver assistance systems which are similar to the one we have developed. In this survey, we try to answer the question in how far principles of *Mobile Commerce* have been applied for this type of application.

The *Blink Mobile Application* [4] is a mobile app from ECOItality[1] introduced at the Electronic Drive and Transportation (EDTA) conference[2]. It allows to access the Blink Network[3] anywhere and will be soon available for free via all major mobile device application stores. The Blink Network is an EV charging infrastructure including EV charging stations, software and online services. The mobile application allows to find available public and commercial charging stations. This can be done location-based via the mobile device's wireless or GPS coordinates or manually. Furthermore it allows to reserve charging stations, to receive charging status updates, to view additional informations about the charging station and to route to the chosen station. Nevertheless, the Blink Mobile Application do not cover all functions of the Blink Network. So it is not possible to use the scheduling function of the network from mobile access. However, many mobile devices can still access this feature using the website of the Blink Network. There they user is able to schedule a charge or plan reservations based on travel routes.

The *ChargePoint App* [5],[6] developed by Coulomb Technologies[4] allows to locate Charge Point Networked charging stations. It's available for Apple iPhone ad BlackBerry. The app allows to find charging stations near to a specified address (US, Europe, Australia), to receive status informations about the stations, to trigger the charging process and to receive real-time notifications of the running process. As the supported devices have the possibility to route, the app can show directions to charging stations, too. Also it can calculate the cost of a charge.

The *PlugShare App* [7],[8] helps EV drivers to find charging stations and homes or lots that will allow them to recharge for free. It is not developed by a EV infrastructure provider like the both introduced before and is driven by the idea to build up a community of people how share there resources (under the term *plug-share*). This is much similar to the couchsurfing[5] project and is driven by the idea that *"...the infrastructure to charge is everywhere."*[7].

Similar to this approaches there exists several others that allow to find charging stations by web or mobile access. The *Alternative Fueling Station Locator* [9] use Google Maps technology to show locations of EV charging and other alternative fueling stations. The *DriveAlternatives App* [10] does pretty much the same and offers additional features like favorite stations, photos, comments and email alerts for station changes. *CarStations* [11] offers a user driven international directory and mapping service for EV charging stations. Unlike the preliminary introduced approaches, these ones offer no functions to initiate or complete transaction in the purpose of *Mobile Commerce*.

To sum up, none of the examined approach provides dynamic planning which is triggered by environmental or user dependent changes. Nevertheless, the *Blink Mobile Application* combines scheduling features which *Mobile Commerce* aspects. In detail this means that the user is able to plan and reserve charging stations. In contrast to our approach this must be done manually and there is no automated planning behaviour based on variable price signal curves, which supports the user. As with the *ChargePoint App* the customer is able to initiate a charging process, monitor the costs of the running process and stop them if needed. Scheduling is widely missing here. Both applications have been developed by EV infrastructure providers and their extend of *Mobile Commerce* is limited to the manufacturer's products. The developers of *PlugShare App* present a different approach, which complies with the "rights to use services" specification. Locations for charging electric vehicles are proposed and can be booked free of charge via *SMS*, email or a call. The cost are actually borne by the provider of the charging station. The approach is based on the idea to provide a community-based backup network in case a driver measures his consumption wrong. No scheduling mechanism is implemented here.

---

[1] ECOItality, Inc. – http://www.ecotality.com/

[2] EDTA – http://www.electricdrive.org/

[3] The Blink Network – http://www.blinknetwork.com/

[4] Coulomb Technologies, Inc – http://www.coulombtech.com/

[5] CouchSurfing – http://www.couchsurfing.org/

V. CONCLUSION

In this paper we introduced a management system for electric vehicles. We motivated the necessity for such an application with the restrictions and limitations of the first EV generation. We also provided figures on the common acceptance towards electric mobility in order to emphasise the severity of its shortcomings and to support our motivation. Subsequently we introduced our management system and its basic functionality of optimising the use of an electric vehicle by accounting for the driver's appointments and additional data from a web-based energy provider service. After outlining the basic idea and functionality we described our implementation in detail and described a simple, yet expressive example in order to evaluate our work and to clarify it's principle. Finally we compared our work to related approaches.

A. Implications

As mentioned above, we used a rather simple scenario to evaluate our work. The idea was to clarify the functionality of our approach and to emphasise our main objective of providing mobility for the driver. However, by integrating the web-service of the energy provider for the optimisation routine we showed that e-mobility provides business perspectives beyond those of the car manufacturer and their customers. In our example both, the driver and the energy provider were able to profit from our management system. While the driver gained profit in a better pricing, the energy provider managed to shift one particular charging interval to a — from his perspective — far better period of time. Admittedly, the benefit of shifting a single charging interval is infinitesimal small, yet, on a large scale the principle is considered a remedy to one of their most severe problems of managing the grid load balance. Currently, there many research projects trying to provide solutions for this exact challenge. In fact, this work was actually done as a part of this initiative [12].

B. Contribution

The contribution of our approach is twofold. To start with, we have managed to support the driver of an electric vehicle in his daily routine. It was our objective to counter the limitations of electric mobility and based on our evaluation we can say, that we have managed to utilise the capabilities of electric vehicles in a far more effective way. Of course, the reliability of fuel driven cars is a dream of the future, but improvement here rather lies with the car manufacturers and battery producers.

Beside a more effective utilisation, we have shown, that our approach is able to support business perspectives around e-mobility. It is our belief, that the target group of electric mobility exceeds that of common "vehicle customers" and opens perspectives beyond that. We also think, that these services are not explicitly geared towards e-mobility, but also affect regular traffic. For our work we used a prototypical implementation from a national energy provider as an example, but many ground-breaking services are available today already. As an example, consider the many available parkingspot services (i.e. *Parkingspots*[6]), which are able to retrieve the best fitting parking lot (tariff and location) for a given online query. Another example is the *Waze*[7] service, which provides routing functionality, based on real-time traffic flow. It is our belief that service-based guidance systems as those, mentioned above will establish in the near future. In this work we presented a concrete way to merge the interests of a person with the recommendation of a guidance system.

C. Future Work

In short, we plan to extend our work to comprehend more third party services.

In some scenarios we had to deal with the problematic that the user's schedule exceeded the range capabilities of the electric vehicle. As an alternative we intend to propose multi-modal strategies to the user — involving public transport. It is our idea, to access online time-tables of a local public transport operator and use the data for our computation and to provide the user with detailed information on the planned journey (line, departure times, estimated arrival times, walking distances, parking lot, etc.).

As a second extension, we plan to integrate a car sharing capability for our system. We want to give users the chance to offer their scheduled rides to others, which are able to check in for desired rides by some mobile interface.

VI. ACKNOWLEDGMENTS

This work is partially funded by the *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety* under the funding reference number 16EM0004.

REFERENCES

[1] The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, "German federal government's national electromobility development plan," The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, August 2009.

[2] J.-F. Tremblay, "Gauging interest for plug-in hybrid and electric vehicles in ley markets," in *Proceedings of the 2nd German Electric Vehicle Congress*, June 2010.

[3] R. Tiwari and S. Buse, *The Mobile Commerce Prospects: A Strategic Analysis of Opportunities in the Banking Sector.* Hamburg, Germany: Hamburg University Press, 2007.

[4] ECOtality, Inc., "ECOtality announces blink mobile application for smartphones and mobile devices," ECOtality, Inc., April 2011.

[5] Coulomb Technologies, Inc., "Coulomb technologies announces iphone app for chargepoint networked charging stations," Coulomb Technologies, Inc., February 2010.

[6] Coulomb Technologies, Inc., "Coulomb technologies chargepoint network releases new mobile app for locating available charging stations," Coulomb Technologies, Inc., March 2011.

[7] T. Woody, "For electric car owners, a way to share juice," The New York Times, New York, NY, USA, March 2011.

[8] L. Whitney, "Plugshare app finds electric-car charging stations," Xatori, Inc., USA, March 2011.

[9] U.S. Department of Energy's National Renewable Energy Laboratory, "Mobile alternative fueling station locator," U.S. Department of Energy, April 2009.

[10] DriveAlternatives.com, "Drivealternatives – your green driving solution," www.drivealternatives.com (19.06.2011), October 2009.

[11] CarStations.com, "Carstations - find your charge," www.carstations.com, (19.06.2011).

---

[6] http://www.parkingspots.com

[7] http://world.waze.com/

[12] The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, “Erneuerbar mobil — martkfähige lösungen für eine klimafreundliche elektromobilität,” The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, April 2011.