MobiliNet: A Social Network for Optimized Mobility

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ABSTRACT

In this paper, we present our vision of *MobiliNet*. *MobiliNet* is a user-oriented approach for optimising mobility chains with the goal of providing innovative mobility across different types of mobility providers – from personal short range battery powered mobility aids over different types of public transports (e.g. buses, short distance train networks) to personal mobility means (e.g. car sharing).

Our vision for *MobiliNet* is based on a social network-like system that is not limited to human participants. By including vehicles, corporations, parking spaces and other objects and spaces, the system could make traveling more comfortable and less stressful, and finally more efficient for the travellers.

MobiliNet allows high-level trip planning, but also pays attention to other important details of the supported means of transportation. Especially for user groups with special needs, *MobiliNet* actively supports self-determined mobility. Thus enables again an active participation of this user group in in social life. Besides supporting travellers, the system could also create new business opportunities for transport associations and car sharing corporations.

Keywords

Intermodality, mobile device, mobility chains, self-determined mobility, social networks, social transportation network, vehcile-to-x communication.

1. INTRODUCTION

Seamless mobility, provided by intermodal mobility chains, is a great challenge, especially in rural contexts. We understand intermodality as follows, though focusing only on human transportation: 'Intermodality is a quality indicator of the level of integration between the different modes: more intermodality means more integration and complementarity between modes, which provides scope for a more efficient use of the transport system. The economic basis for intermodality is that transport modes which display favourable intrinsic economic and operational characteristics individually, can be integrated into a door-to-door transport chain in order to improve the overall efficiency of the transport system.'[1] Providing efficient mobility across individual means of transportation and offered by several independent mobility providers, is a challenge for personal mobility in tomorrow's networked society.

In contrast to the trend of urbanisation where especially younger people move to the growing cities, elderly people are staying in rural environments. These creates additional challenges to the mobility chains, i.e. be accessible for people with special needs such as elderly people, people with limited physical mobility (i.e. due to handicaps), people with baby carriages, etc. Barrier free accessibility according to the existing norms can address these problems only partially. Broader and holistic concepts are needed here. In rural areas, even fit people that do not need to carry anything around can have problems traveling only a few kilometres when they do not own a private car. Given that most privately owned cars are standing for more than 90% of the day and the costs of ownership and mobility, alternatives are needed that ensure personal mobility in the future. Therefore, many people are dependent on the assistance of people owning a car, or have to stick to the sparse public transportation schedules.

In order to improve the mobility situation with these users in mind, we have designed our vision of *MobiliNet*. *MobiliNet* is an user-oriented approach for optimising mobility chains for all kinds of user groups, not limited to people needing barrier-free access or other support. Our social network-like system allows for allocation and coordination of mobility services and can be accessed by all Internet-connected devices. We, by this approach, treat the network of vehicles like a social network, as it has e.g. be done with objects in the context of the Internet of Things [10]. This allows using the system from everywhere. And due to the great success of smartphones and tablet PCs, most people could even use the system while traveling. The usage of modern Internet connected devices does not automatically mean the exclusion of elderly people. For example, Kobayashi et al. have evaluated the touchscreen interaction of elderly users and created a set of guidelines for creating user interfaces that can satisfy the demands of all age groups [7]. Following rules like that, one should be able to create a system that could be operated by everybody.

MobiliNet is based on a platform which interlinks not only people with each other, but also vehicles, public transport stations, parking lots, and other mobility related systems and services. The integration of "things" into Internet-services is often referred to with the term "Internet of Things" [11]. Adapting this term to our approach, one could say that *MobiliNet* is a service for the "Internet of Mobility".

The remainder of the paper is structured as follows: We first situate our vision with respect to future visions and

[1] ftp://ftp.cordis.europa.eu/pub/transport/docs/intermodal_freight_transport_en.pdf, last accessed August 24, 2012.

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existing systems. Then, we describe the concept behind *MobiliNet* and discuss technological possibilities for the realisation of the system. After that, a sample trip plan shall, in form of a scenario, highlight the capabilities of the system. In the conclusion, we give a summary and provide an outlook towards a working prototype we are currently working on.

2. RELATED WORK

When talking about networks of vehicles, most people are thinking of vehicle-to-x (V2X) communication and VANETs (vehicular area networks) and not of social networks, but actually both can be the case. V2X has been named the 'first social network for automobiles'[2]. Ford's concept car Evos even goes one step further: this car can directly social network with the car driver's friends[3]. Additionally, the modern car behaves' like a personal assistant that suggests routes and keeps an eye on the driver's work schedule as well as on the traffic situation and weather conditions.

There are also several social network like systems for cars that are based on mobile devices. For example, *SignalGuru* [8] uses windshield-mounted phones for detecting current traffic signal states with their cameras. By combining multiple measurements, the service creates a schedule and gives its users a so called green light optimal speed advisory (GLOSA) or suggests an alternative route that efficiently bypasses the predicted stops. Test drives have shown a potential of saving 20.3% vehicle fuel consumption on average. Another example is WAZE[4], a crowd souring approach targeted at more efficient transportation, employing also ramification to encourage participants to contribute and compare themselves against other contributors. Mobile device integration in the automotive domain is also an enabler for various services and can have multiple benefits for the driver [4]. For example, the device can be used as head unit replacement which allows using the same interface and preferences in different vehicles. This is especially an advantage for car sharing scenarios. The mobile device is becoming either a replacement for an in-vehicle information system (IVIS), or is complementing it, providing extended additional features.

Yasar et al. have developed a social ubiquitous-help-system (UHS) for vehicular networks [14]. By using friend-of-a-friend (FOAF) relations for sharing information, they ensure that only relevant and reliable information has to be shared between the nodes. The context-awareness of this approach allows improving the efficiency of a vehicular network, since data necessity, data locality and data routing can be determined before sharing the information.

Clique Trip [6] allows connecting drivers and passengers in different cars when traveling as a group to a common destination. In order to establish the feeling of connectedness, the system automatically switches to an alternative navigation system when the cars tend to loose each other. In that way, the cars are following the leading car and can find each other again. Whenever the cars are within a defined distance, the system further establishes a voice communication channel between the vehicles. In order to form such a multi-car traveling group, it is necessary that the trip is registered beforehand via a mobile device. The mobile device is further responsible for providing the information from the central *Clique Trip* server to the car's infotainment system during the travel.

[2] `http://media.daimler.com/dcmedia/0-921-881044-1-1519299-1-0-0-0-0-1-12759-614216-0-0-0-0-0-0-0.html`, last accessed August 24, 2012.

[3] `http://mashable.com/2011/09/01/evos-social-networking-car/`, last accessed August 22, 2012.

[4] `http://www.waze.com`, last accessed August 22, 2012.

3. MOBILINET – CONCEPT AND TECHNICAL REALIZATION

We named our system *MobiliNet* since we want to optimize users' individual and personal mobility by connecting each other and complement this approach by mobility-related services. For that reason, the platform supports numerous participants (stakeholders). An incomplete example selection of possible *MobiliNet* stakeholders is depicted in Figure 1. Besides the potential end users, also institutions, systems, and services can be part of the network.

In our vision, we assume that the user is accessing *MobiliNet* with a modern personal portable device, such as a smartphone or a tablet PC, that has mobile Internet access. We further assume that the user is used to so-called apps and interacting with them. The user will be employing a special *MobiliNet* client application that allows for a better integration in the mobile platform, e.g. Android.

3.1 Participants' Roles and Available Functions

The main functionality of our envisioned system is the support of the end user by providing more efficient means of personal transportation across modality borders. In order to be able to optimally assist the user, s/he has to create a profile on *MobiliNet*. By default, the profile is private, but parts of it can also be made publicly available so that friends can find each other. The profile consists of mobility preferences (cost limits, requirements, restrictions, ...), and travel-related information. For example, the user can configure whether s/he has a driver's license, needs barrier-free access, or owns a private car that s/he is additionally potentially willing to share. Additionally, available public transport tickets and personal subscriptions can be set for calculating pricing alternatives. Other preferences, such as the preferred mode of transportation (e.g. with the private vehicle) can be used to refine the system's behavior. A central part of each user's profile is a calendar. The calendar can be synchronized with common online and desktop calendars. Users can also connect to friends and other known people. Depending on the degree of confidence, they can share their profile information as well as their calendar. The well-known means of sharing information on social networks are used to implement this feature, e.g. the circle model of 'Google+'. This feature allows, for example, creating car pools by scheduling appointments next to each other. The user utilizes *MobiliNet* to plan her/his trips. This can be done for future trips from a defined start point to a destination (for example, an appointment planned via the system), as well as for ad-hoc trips from the current location to any destination.

Organisations, authorities, and shops can also register for *MobiliNet*. They can also connect their calendar with their profile. This feature can, for instance, be a common base for scheduling appointments. The scheduling algorithm could take the user's journey into account and only offers appointments for defined slots. When trusted neighbours have an appointment nearby or even at the same place in the future, and the next appointment for the client falls in same period

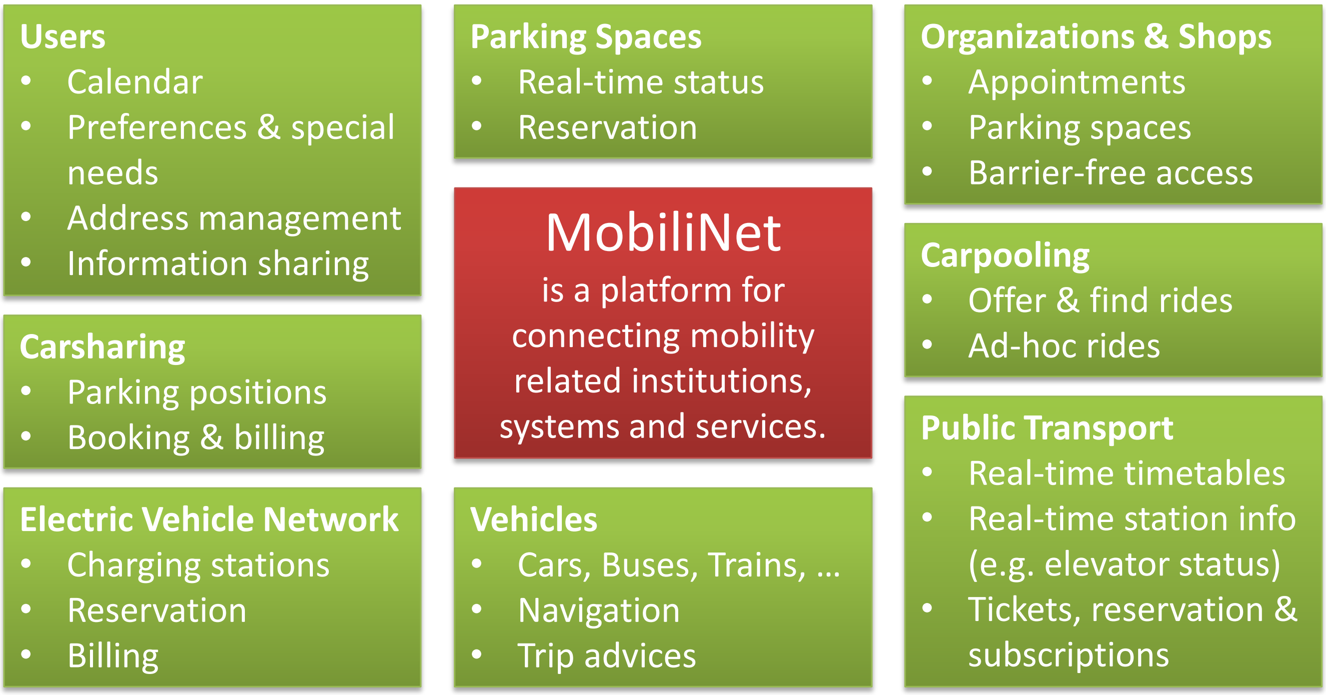

Figure 1: Overview of possible *MobiliNet* participants. Our platform should be able to connect all mobility related things.

of time, the system could offer the client an appointment so that they can create a car pool. Of course, the system would only suggest this when one of the clients plans to go there by car and is accepting car pooling for that journey. Additionally, the corporations or authorities could offer and reserve parking spaces for their clients for their next appointment. This would especially be easy when an intelligent parking solution is used.

Intelligent parking solutions could as well be directly linked with *MobiliNet*. Parking spaces can either be managed by participating organisations, or they can be available for all users. When planning a trip, the user can, for example, reserve a parking space for the desired time. Additionally, organisations can provide parking spaces for their clients. By binding the parking space reservation to the user's trip, the user's navigation application can directly lead her/him to the reserved parking space. Since the network knows about special needs of the users, it could also take care of them. People with a mobility handicap can, for example, get a nearer parking space, and people with babies or toddlers could get assigned a broader parking space so that the getting in and off would be more comfortable. When a user is traveling with an electric vehicle, the system could automatically choose a parking space with a charging station, when available and not reserved at the moment. We assume that this will be realised in connection with the politically supported introduction of e-mobility. At the 'Nationale Strategiekonferenz Elektromobilität' in November 2008 in Berlin, the German government announced a national target of 1 million Electric Vehicles by 2020[5]. The inclusion of these services is therefore a logical consequence.

The incorporation of existing public transport options into *MobiliNet* could make journeys more comfortable and less stressful. This could not only be helpful for people without private cars or driver's licenses, but also save time and additional reduce CO_2 emissions. In cities, there is often heavy traffic, and usually, the parking situation is already at or over its limits. For that reason, it could be beneficial to park outside the inner city and to use public transport to get to the final destination in the city - if a convenient travel alternative could be provided. In order to find the optimal multimodal route, *MobiliNet* would estimate the traffic situation for the planned time of travel, e.g. by incorporating historic traffic data. When a user has to transport something (like Billy shelves from IKEA), or when she/he does not want to take public transport, *MobiliNet* would not consider public transport. For users with special needs, the public transport operator could offer real time information for elevators and other accessibility relevant systems. In that way, *MobiliNet* could also react during the trip and provide alternative routes and information to the user. Real time information could also be provided by the transport vehicles. This would allow, for example, the user to estimate whether a connection could be reached, when she/he is already late, or is going to arrive late.

Car sharing operators and car pooling initiatives/portals could also get part of the network. By providing the possibility to book or reserve cars (or at least places in cars), these mobility alternatives could get a fixed part of mobility chains. For short-term journeys, car sharing and car pooling are only attractive when reliable real-time information and binding booking is available. This information and booking functionality could be directly provided by *MobiliNet* when the user plans a route.

Participation in the *MobiliNet* network could also be inter-

[5]`http://ec.europa.eu/clima/policies/transport/vehicles/docs/d1_en.pdf`, last accessed August 22, 2012.

esting for electric vehicle charging station operators. They could, for example, provide a booking mechanism for their charging stations and make use of *MobiliNet*'s seamless payment possibilities for billing. Real-time information about the current price per kilowatt-hour could further be displayed directly to the user, when she/he is searching for a recharge station.

3.2 Vehicles as Part of MobiliNet

A special of *MobiliNet* is that also vehicles (conventional cars, electric bikes, or personal mobility platforms like a Segway or a Renault Twizy[6]) can participate in the social network-like service. Since the service can be accessed via all Internet-enabled devices, modern vehicles with mobile data connections can directly be linked with it. In contrast to safety critical V2X applications, standard IP connectivity with higher delays over 3G/4G would be sufficient for the system. It is also thinkable that the user's mobile device gets connected to the vehicle's infotainment system for providing the desired information from *MobiliNet*.

When a normal user account is coupled to the in-vehicle system, *MobiliNet* provides the route chosen by the user for the vehicle's navigation system. When a parking space is assigned to the user for a trip, the reservation is automatically updated with the license plate information of the utilised vehicle. This ensures that the parking space is reserved for the user, no matter what vehicle she/he is using. In addition, the system could broadcast the estimated time when a user arrives at a destination. An example scenario for this functionality could be when another user shall be picked up, she/he could check whether the car is on time, or not.

Additionally, cars can participate in *MobiliNet* without being linked to a user. In that way, they could, for example, detect and report free parking spaces [1], or report traffic data to *MobiliNet*'s central route calculation system. Electric vehicles could use the system for requesting nearby charging stations that are in range of the current battery level. Additionally, when a user plans a trip with a private electric vehicle that is assigned to his *MobiliNet* account, the current battery state reported by the car could be taken into account. That means that the system would automatically choose a parking place with charging station, or suggests to park somewhere, where the user could get back home without charging.

Public transport vehicles running at regular service could also be linked to the respective connection and time slot. This would allow broadcasting information, such as the delay or the utilisation, in real-time. This could be important information for users that are already late and want to get their connection. For people in wheelchairs, people with baby carriages, or people with large luggage, the information about the utilisation could also be critical, since often the number of places for such user groups are strongly limited. When other passengers in the transport vehicle are also part of *MobiliNet*, the system could further try to create an estimation, whether there should be enough places, or not.

The flow of information is not limited from vehicles to other participants, but also the vehicles could be provided with information. For example, when an underground train arrives late and a bus on a line that is scheduled at 30-minutes interval is part of the trip for some travellers, the bus could inform the driver about the lateness and the expected time to wait. In that way, the driver could decide whether she/he wants to wait, or not. When users in wheelchairs or with carriages want to get on a vehicle that is not barrier free by default, *MobiliNet* could also inform the driver to prepare the loading ramp, to lower the bus, or to get ready to help someone with special needs entering the vehicle.

[6] `http://en.wikipedia.org/wiki/Renault_Twizy`, last accessed August 22, 2012.

3.3 Accessing User Profile Information and Billing

For offering matching mobility services to a user, organisations and service providers would need access to some user data that is stored in her/his profile. One of the fundamental design principles of the system should be the protection of the user's privacy. Thus, only approved users and trusted services would be able to access her/his data. For that reason, the system should have a fine graded user-managed access control [2]. A sample protocol that could be used for giving access to third parties is OAuth 2.0[7]. It provides authorisations flows for web applications, desktop applications, mobile applications as well as for consumer media devices.

The linking can, for example, be realised by scanning a QR code with the *MobiliNet* running device, or via near field communication (NFC). This could trigger an access screen that shows what service wants to access what kind of data. The user could then either accept or decline the request. In that way, she/he would not have to enter her/his password in an insecure environment. The coupling could either grant an one-time access, for example, when a corporation wants to create an appointment in the client's calendar, or a not-time limited access. In the second case, the user could manage and revoke the access permission for each service at any time. The one-time access could, for instance, also be used for coupling car sharing vehicles on a per trip basis. This would allow using *MobiliNet* on the vehicle's system as long as the car is booked.

Billing is another interesting part of *MobiliNet*. Especially for people that are not used to ticket vending machines, or have difficulties in understanding network and fare plans, an active support with billing could take away the fear from public transport of these people. Since most larger public transport associations are supporting online or mobile phone ticketing, the system could directly buy the tickets when the users agrees in taking a route proposal. For systems without advanced ticketing, the public transport operators could provide step by step instructions for the most common available tickets. This step by step guide could then be displayed when the person enters the area where a ticket vending machine can be found. For car sharing operators and car pooling scenarios, it would be possible that the payments could be carried out via *MobiliNet*. The payment service could be realised by linking with immediate transfer services, online payment services, or common credit institutes.

3.4 Multimodal Route Calculation

In order to create multimodal trips, several data from different sources has to be combined. Basic routing information could, for instance, be derived from OpenStreetMap data. The OpenStreetMap (OSM) project "creates and provides free geographic data and mapping to anyone who wants it"[8]. The data already includes barrier free accessibility information for some buildings. And, since everyone can contribute

[7] `http://oauth.net/2/`, last accessed August 27, 2012.

[8] `http://wiki.openstreetmap.org/wiki/Main_Page`, last accessed September 2, 2012.

to the data, way and buildings could be added and corrected by everyone. This would ensure, for instance, that also parking spaces from companies could be found by the system. The routing system could be based on one of the open source routing implementations for OSM. For example, *Gosmore* offers a full route calculations for vehicles and pedestrians[9].

For public transport, the respective data sources from the different transport operators and associations have to be queried. The popular Android application *Öffi* is already successfully using many existing application programming interfaces of public transport operators and demonstrates that this data is accessible and reliable[10]. Nevertheless, there are not yet standardized interfaces for transportation systems available that can be used in third-party implementations.

Besides the route and the duration under normal conditions, the system could also use other sources for determining a more comfortable route, or for creating a better estimation of a journey. For example, the system could include weather conditions when planning outside walking route parts [12]. Or, it could make use of historical floating car data (FCD) for predicting the traffic at on a special day, similar to TomTom's route planning assistant that makes use of gathered live traffic information from mobile phone operators and GPS navigation systems[11]. Since the user always carries her/his personal portable device while traveling, the algorithms could further adapt themselves in various manners. For example, the system could optimise the estimation of the user's walking speed or her/his driving behaviour, by measuring the speeds and other sensors' values.

3.5 User Tracking for Advanced Service

When a user travels with *MobiliNet*, she/he could also make use of advanced services when tracking is enabled. Advanced services could be, for example, the notification of traveling or appointment partners, when the user is running late, or the on-the-fly alternative route calculation when something changes.

When traveling outside, the application could make use of the device's localisation technologies. This could, for example, be the GPS system or localisation via cell ID or WiFi access points or other built-in radios of personal mobile devices, even DECT [9] or FM radio [13]. To detect and support passengers traveling with *MobiliNet*-support in public transport, the vehicles and stations could, for example, be equipped NFC service point where a user can check-in and check-out with her/his NFC-enabled mobile device, or provide a free WiFi that can only be accessed when the *MobiliNet* application is running on the device.

4. MOBILINET SCENARIO

In Figure 2, a possible route suggestion from *MobiliNet* is shown. For this scenario, a user with a private electric car wants to drive to the centre of Munich, Germany. The user does not need barrier free access or any other special support. S/he has further no public transport subscription.

At a first glance, the output looks similar to standard public transport trip planers (like Öffi). But *MobiliNet* combines multiple things: Routing for a private vehicle, parking, and planning the final part of the journey with public transportation. Additional to the route, it also displays and incorporates the electric vehicle's battery state in the trip preview. Since the battery is charged enough to get back fully electric, the system does not output a warning, but chooses a parking place that also offers recharging stations. The recharging station could further be directly reserved from the route preview.

Since the user has no subscription for the transport network, the system calculates the cheapest available fare and allows buying the ticket directly via the application. In case, a user would have planned multiple journeys within the public transportation network, *MobiliNet* could also suggest buy-

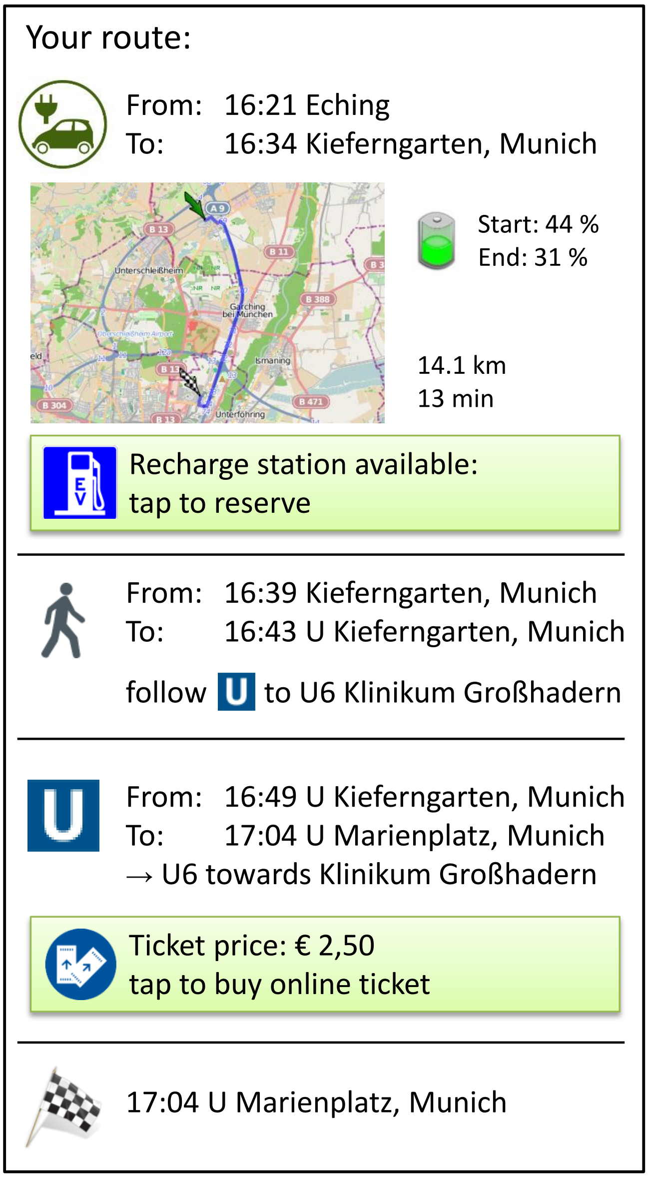

Figure 2: Our mock up shows how a possible route output of *MobiliNet* could look like. It could, for example, offer possibilities for reserving a charging station for the electric vehicle and for buying a public transport ticket. Map source: OpenStreetMap

9 `http://wiki.openstreetmap.org/wiki/Gosmore`, last accessed September 2, 2012.

10 `http://oeffi.schildbach.de/participate.html`

11 `http://routes.tomtom.com/`, last accessed September 2, 2012.

ing a day, week, or month ticket, whenever a cheaper alternative is available.

5. CONCLUSIONS

In this paper, we have introduced our vision of *MobiliNet*. Based on a social network-like system, it could optimise the mobility chains for all kind of user groups. Besides optimising the individual mobility, it contributes also to an overall more efficient mobility since it allows connecting people that are traveling to the same destination. The system does not only provide a high level trip planning, but also incorporates important details for all supported means of transportation. Since the system handles a lot of personal data, privacy and security is an important point. For that reason, we think that such a system could, for example, be run by the government financed by the participating public transportation associations and other benefiting corporations.

MobiliNet could also contribute to the optimisation of travel demand management strategies [15] since trips could be planned far ahead in most cases. This can, for example, be used to optimise public transportation systems by choosing different transportation vehicle sizes.

We have already realised some basic parts, which could contribute to the proposed system. With *DriveAssist* [5], we have created a fully working Android-powered driver-awareness system, that can combine traffic information from central traffic services and V2X communication. Our approach for integrating mobile devices with V2X communication would further allow sharing mobility related information directly between nearby vehicles [3].

In future work, we are planning to create a working prototype of the proposed vision. Our focus will be on electric vehicles as core part of private transportation combined with public transportation, and the electric vehicle charging network.

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7. REFERENCES

[1] M. Caliskan, D. Graupner, and M. Mauve. Decentralized Discovery of Free Parking Places. In *Proceedings of the 3rd International Workshop on Vehicular Ad Hoc Networks*, VANET '06, pages 30–39, New York, NY, USA, 2006. ACM.

[2] A. Chinaei and F. Tompa. User-Managed Access Control for Health Care Systems. In W. Jonker and M. Petkovic, editors, *Secure Data Management*, volume 3674 of *Lecture Notes in Computer Science*, pages 63–72. Springer Berlin / Heidelberg, 2005.

[3] S. Diewald, T. Leinmüller, B. Atanassow, L.-P. Breyer, and M. Kranz. Mobile Device Integration and Interaction with V2X Communication. In *Proceedings of the 19th World Congress on Intelligent Transport Systems*, ITS, Oct. 2012.

[4] S. Diewald, A. Möller, L. Roalter, and M. Kranz. Mobile Device Integration and Interaction in the Automotive Domain. In *AutoNUI: Automotive Natural User Interfaces Workshop at the 3rd International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI 2011)*, Nov.–Dec. 2011.

[5] S. Diewald, A. Möller, L. Roalter, and M. Kranz. DriveAssist - A V2X-Based Driver Assistance System for Android. In *Automotive HMI Workshop at Mensch und Computer*, MuC '12, Sept. 2012.

[6] M. Knobel, M. Hassenzahl, M. Lamara, T. Sattler, J. Schumann, K. Eckoldt, and A. Butz. Clique trip: feeling related in different cars. In *Proceedings of the Designing Interactive Systems Conference*, DIS '12, pages 29–37, New York, NY, USA, 2012. ACM.

[7] M. Kobayashi, A. Hiyama, T. Miura, C. Asakawa, M. Hirose, and T. Ifukube. Elderly User Evaluation of Mobile Touchscreen Interactions. In *Proceedings of the 13th International Conference on Human-Computer Interaction*, INTERACT'11, pages 83–99, Berlin, Heidelberg, 2011. Springer-Verlag.

[8] E. Koukoumidis, L.-S. Peh, and M. R. Martonosi. SignalGuru: Leveraging Mobile Phones for Collaborative Traffic Signal Schedule Advisory. In *Proceedings of the 9th International Conference on Mobile Systems, Applications, and Services*, MobiSys '11, pages 127–140, New York, NY, USA, 2011. ACM.

[9] M. Kranz, C. Fischer, and A. Schmidt. A comparative study of DECT and WLAN signals for indoor localization. In *8th Annual IEEE Int'l Conference on Pervasive Computing and Communications (PerCom 2010)*, pages 235–243, Mannheim, Germany, March 2010. IEEE.

[10] M. Kranz, L. Roalter, and F. Michahelles. Things That Twitter: Social Networks and the Internet of Things. In *What can the Internet of Things do for the Citizen (CIoT) Workshop at The Eighth International Conference on Pervasive Computing (Pervasive 2010)*, May 2010.

[11] M. Kranz, A. Schmidt, and P. Holleis. Embedded interaction: Interacting with the internet of things. *IEEE Internet Computing*, 14(2):46 – 53, March-April 2010.

[12] M. Panou, K. Touliou, E. Bekiaris, and E. Gaitanidou. Pedestrian and Multimodal Route Guidance Adaptation for Elderly Citizens. In *IST-Africa, 2010*, pages 1 –7, May 2010.

[13] A. Popleteef, V. Omami, and O. Mayora. Indoor positioning using FM radio. *International Journal of Handheld Computing Research*, 1(3):19–31, July-September 2010.

[14] A.-U.-H. Yasar, N. Mahmud, D. Preuveneers, K. Luyten, K. Coninx, and Y. Berbers. Where People and Cars Meet: Social Interactions to Improve Information Sharing in Large Scale Vehicular Networks. In *Proceedings of the 2010 ACM Symposium on Applied Computing*, SAC '10, pages 1188–1194, New York, NY, USA, 2010. ACM.

[15] Y. Zhao, K. Triantis, D. Teodorović, and P. Edara. A travel demand management strategy: The downtown space reservation system. *European Journal of Operational Research*, 205(3):584–594, 2010.