

# Challenging Service Extensions for Electric Vehicles in Massively Heterogenic System Landscapes

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**Abstract** The national goal of the federal government of Germany is to have one million fully electric vehicles in use until year 2020. Since an average tour of vehicles in inner-city logistic is about 80km, it is promising that such logistic companies use electric vehicles for their tours. However, there are some reasons for doubts in companies: unknown behaviors, inaccurate range forecasts, and high costs.

The research project Smart City Logistik will provide a service to optimize, monitor, and analyze electric vehicles in logistic scenarios for abolishing those barriers. There, the integration of a service system in existing IT-solutions by using predefined interfaces is challenging. This service system needs special implementations for each company solution, what could be avoided by using a more standardized way in logistic softwares. The overhead can be reduced by a harmonized terminology in combination with a standardized service bus to enable specific internal service extensions in existing logistic solutions.

**Keywords:** Reference architecture, electric vehicles, logistic, interface, transport management system

## 1 Introduction

To enable inner-city logistics with electric vehicles, the German Federal Ministry for Economic Affairs and Energy (BMWi) has started, amongst others, the collaborative research project Smart City Logistik (SCL). The project combines an intelligent tour planning system with dynamic range prediction, based on detailed knowledge of major influencing factors. The SCL service system is able to support dispatchers and drivers with real-time feedback, by optimizing the driving style, and by providing alternatives for a successful end of planned tours.

That SCL system should extend existing IT-solutions by using their data and by offering standardized interfaces for service requests rather than substitute them. However, the use case of proceeding external data about orders, customers,

drivers, and fleets to calculate optimized and energy efficient tours is not common – but in case of increasingly rapid innovation cycles more necessary.

As part of the project, SCL develops a reference architectural design for data exchanges between independent service systems in logistical scenarios based on a harmonized terminology. This design will describe how to enable or extend an existing IT-solution to provide data, how to receive them by newly created services, and how to embed the results back to existing IT-solutions. Furthermore, this design describes how to provide these results for other, more specific services.

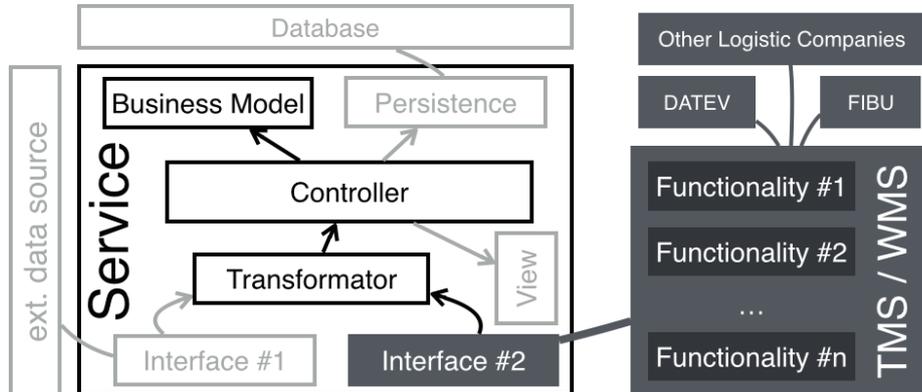
To achieve this goal, the paper starts with an explanation about the software landscape in logistic IT-solutions, how they are clustered and how they are used in companies (Section 2). Followed by that, there are multiple use cases as examples in which these state-of-the-art solutions will lead to problems (Section 3). Afterwards, a first draft for a reference architecture for service-based extensions in existing IT-solutions is derived in Sect. 4. Eventually, the paper considers related work (Section 5) and concludes with a short outlook into future work (Section 6).

## 2 Software Landscape in Logistic Companies

Enterprise resource planning (ERP) describes a wide range of tasks handled by companies to manage their resources e.g., financial accounting, data services, manufacturing, and human resources, as well as customer relationship management and supply chain management (SCM). One focus of companies with logistic background is the SCM while ignoring human resources and financial accounting at this point. This part of ERP describes a whole range of mechanisms and theories for supply chains. In detail, these chains start with acquisition, followed by production and distribution, and are finalized by sales [2]. SCM covers the whole production process and the logistic to handle these workflows. As a part of this, there are system solutions (transport management system (TMS) and warehouse management system (WMS)) to cover special parts of the SCM. These TMS and WMS handle requirements found in inner-city logistic scenarios like package, food, drug, and express delivery, as well as services, e.g., automate maintenance and restocking. A TMS covers functionalities about fleet, employee, order, and billing management. Furthermore, it contains tour and route calculation, tracking, statistics, and dispatching. A WMS on the other hand handles management of warehouses, positions, and amounts of stored articles, and helps to manage dispatching centers.

These functionalities of TMS and WMS will be combined to get a solution for each company to cover their needs. A closer look at these solutions will show a number of more than 50 different tools [1, 5]. Each tool has a unique set of interfaces and has more or less of the before described elements of TMS and WMS theories. Such interfaces mostly covers common DATEV and financial accounting interfaces, along with less interfaces based on electronic data interchange (EDI) standards<sup>1</sup> or proprietary REST, SOAP or COM solutions [5]. These interfaces

<sup>1</sup> A standardized set of document descriptions for data exchanges.



**Figure 1.** Abstracted service architecture based on the Model-View-Controller pattern.

are mostly designed to interact with other companies to realize transportation chains and managing orders.

An abstract Model-View-Controller based service to communicate with a TMS/WMS is illustrated in Fig. 1. This service shows an interaction with external datasources (like weather, traffic, and electricity rates information) on the left hand side, which is mostly unproblematic because of their public availability. The interaction with a TMS/WMS as illustrated on the right hand side is challenging, but necessary to enable ideas as described before.

### 3 Use-Cases for Services

In case of logistic, there is a wide range of innovations e. g., by using electric or hybrid vehicles. Those innovations could lead to required new services. Such services must be used to enable the innovations in existing environments. However, the current landscape in software solutions for logistic companies does not allow for their easy embedding as mentioned before. There are several use-cases for such services currently considered in research projects.

The first example is the optimization of energy consumptions and costs by using electrical cars in company fleets as energy buffer<sup>2</sup>. These buffers are used, when the provider's energy price is above a predefined threshold. To enable such solutions, the company needs an energy management system deciding which source of energy is used. In case of prices greater than the threshold, buffered energy can be consumed. In case of prices lower than this threshold, provider energy can be used. In case of a planned tour for a specific vehicle, that energy management system must ensure, that the vehicle is prepared in time. To realize such a management system, the service needs to know when vehicles have to start tours. For example, by using a read access to vehicle time sheets and planned tours from an existing TMS/WMS solution.

<sup>2</sup> iZeus Smart Grid [www.izeus.de](http://www.izeus.de)

Another example is the management of charge scheduling<sup>3</sup>. A lot of current installed energy systems are not suitable to handle the full amount of required power in case of simultaneous fleet charging. As a result of this, it is necessary to schedule the charging processes to avoid network peaks. Again, this could be done by using a special management system which decides, which vehicle is allowed for recharging now. Using a read access for vehicle time sheets and fleet information in existing IT-systems would enable such decisions.

A third example is an optimized routing algorithm for electric vehicles as suggested in the SCL project<sup>4</sup>. Currently, combustion engine based vehicles can refill their fuel when necessary. Because of missing charging infrastructure and a high amount of time to charge, this is not suitable for electric vehicles. To avoid stranded vehicles, a forecasting system should be used to plan energy-aware tours. Such a system could be used as extension by using data about vehicles, drivers and orders from a TMS/WMS. That extension would work as an external service with read access for required data. Additionally, this solution could push back the results to the TMS/WMS service, which requires an additional write access for tour data.

The examples illustrate situations in which an extension of TMS/WMS is necessary. In practice, this requires an individual extension in each system instance, developed by the original author of the applied solution. As an alternative, an external service can be based on available interfaces. In this case, there would be no standardized communication, the service has to use available REST, SOAP and COM interfaces and provide an individual implementation to access the data. Furthermore, this means an individual interface implementation in each TMS/WMS solution for each example.

## 4 Towards a Reference Architecture for Logistic Service Communications

A reference architecture is profitable for the integration of new services especially to reduce complexity in data exchanges. Such an architecture may define a communication structure to request internal process data between different services and to inform about state changes. We have derived those parts of the architecture in several steps for our own first approach:

The first step was to analyze business processes in inner-city logistic companies. Analyses were done by interviewing actors in inner-city logistic companies e.g., dispatchers and drivers, about their everyday work. Questions comprise among others for example: Which tools and software are used? Which workflows will be handled and which exceptions could occur?

The result of those interviews are business processes about tour planning, handling orders, managing picking, packing and delivery, and the knowledge about used software and tools.

<sup>3</sup> Econnect Duisburg [www.econnect-germany.de](http://www.econnect-germany.de), enviaM in sMobility [www.smobility.net](http://www.smobility.net), and SAP in iZeus

<sup>4</sup> SmartCityLogistik [www.smartcitylogistic.de](http://www.smartcitylogistic.de), and PTV Group in iZeus



**Figure 2.** Example of a bus architecture in case of extending a existing TMS/WMS. An optional adapter could be implemented as a proxy in case of missing support.

The analyses about the IT landscape in logistic companies and the interview results were used to create a knowledge base about entities and their relationships in the second step. This knowledge base is context dependent. e.g., the understanding of a tour can differ in international logistic and inner-city logistic. In our case, the context is based on inner-city logistic. This base leads, by using a suitable modeling method, to a well-controlled vocabulary, which will be used as a base for a data description language (DDL). In case of the SCL project the SCL-DDL covers all terminologies based on their well-structured entities and their relationships.

We got a loosely coupled set of services and functions with individual dependencies and communication flows in the third step by using the following ideas: (1) A single IT solution in a logistic company is a subset of functions described in TMS and WMS theory with internal dependencies. (2) Additional functions (services) enable new innovations by using dependencies to internal data represented by functions of TMS and WMS. (3) The union of all functions and services of steps (1) and (2) builds a loosely coupled IT solution for logistic with individual dependencies and communication flows. A communication bus can be used to handle such a set of functions: Large companies use a communication bus, see enterprise service bus (ESB), for arranging a large set of interacting systems. Vehicles use bus based systems to manage their vehicle systems (see CAN-BUS). By using a domain specific DDL and a standardized communication protocol, the bus can be used to interact between different services and functions.

A TMS/WMS solution could implement the bus feature and an additional service to handle the communication between services. In case of TMS/WMS solutions which do not implement the bus, an adapter may connect a subset of their available interfaces to the bus. However, a single service system must not be specialized to interact with one IT-solution. A single service system only needs an implementation for interactions with the standardized ESB infrastructure. Figure 2 shows how to use that bus in combination with the previously described use cases.

## 5 Related Work

Several approaches improve the modeling of logistic based architectures or specify the content and meaning of communications between companies. Often, such approaches describe single systems, architectures, or object models to manage situations within a single company instance [3, 4, 6, 7]. The integration of new services would lead to specific extensions.

In the case of standards, RosettaNet and UN/EDIFACT should be mentioned. RosettaNet offers a wide range of specific language, business objects and business processes [8]. United Nations Electronic Data Interchange For Administration, Commerce and Transport (UN/EDIFACT) is one of several international EDI standards. UN/EDIFACT offers a list of specifications for the description of a wide range of documents for e-commerce. This includes documents about routing instructions, orders, purchases, shipments, and billing for example. However, those documents describe data interchanges between companies, but not how to transport them.

## 6 Conclusion and Outlook

Electric vehicles in inner-city logistic scenarios could be a perfect synergy. Such vehicles are nearly soundless, may have zero emissions, and could help managing the raising number of freight transports without lowering living qualities in urbane areas. Because of range restrictions, missing e-specific infrastructures and long recharging rates, there is a need to handle those restrictions by supporting planning and monitoring processes.

The SCL project manages a system for optimization of plans, monitors, and analyses of tours for electric vehicles. The integration of that system in existent environments is currently an individual implementation which has to be done for each system. Alternatively, the logistic companies may wait for an integration by the producer of their systems, which leads to large delays or high costs in enabling new innovations.

The efforts in reaching one million electrical cars in 2020 leads to a wide range of different e-specific researching projects to help to provide solutions to enable them. Especially in case of inner-logistic it is possible to manage the restrictions of these cars. Unfortunately high acquisition costs and low profit margins will slow down the innovation processes. Reducing complexity and defining more common standards for internal process data in logistic IT-solutions could help to overcome this situation.

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