TRAFFIC DATA PLATFORM AS ITS INFRASTRUCTURE FOR INTELLIGENT TRAFFIC DATA MANAGEMENT

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ABSTRACT

Many industrial and research projects in the field of ITS need traffic data for realizing new and innovative applications. However, it is often costly and time-consuming to acquire or to access such data. That is where a complete traffic data platform with standardized access can increase the efficiency of research for current and future ITS projects. For this purpose, the Institute of Transportation Systems of the German Aerospace Center (DLR) is developing a modular and SOA based Traffic Data Platform (TDP) which provides all basic tools for storage, processing, fusion and management of traffic data from various sources. In this context, the TDP is especially designed to support "online" services and information in a most efficient way. Moreover, due to its modularity and extensibility, the platform itself can be used as a framework for testing and developing new methods and algorithms for data fusion and quality estimation, for example. This paper gives a general overview about the TDP and focuses on the technical aspects. The main functionalities, non-functional requirements, and the key players are mentioned as well as the supported data. Finally, a selected use case scenario shows the practical applicability of the TDP.

Keywords: traffic data collection, floating car data, probe vehicle data, loop detector data, data fusion, travel time, traffic model, congestion management, video, remote sensing

MOTIVATION

In research projects until now often series of ITS components to import, process and export traffic data from different sources are developed as isolated and standalone applications (see Figure 1). Sometimes they are integrated but starting new projects focusing on similar but additionally new aspects a new setup and integration is often realized. To save time and money and to contribute to more effective research by minimizing the effort of technical realizations and thus setting the focus on the real research contents of new projects, it was decided to integrate all existing standalone applications in a common integrated platform (see Figure 2) called *Traffic Data Platform* (TDP). TDP has been previously presented in [1, 2]. The main objective there was to provide an ITS infrastructure for intelligent traffic data management and dissemination as well as for research purpose in the field of traffic management

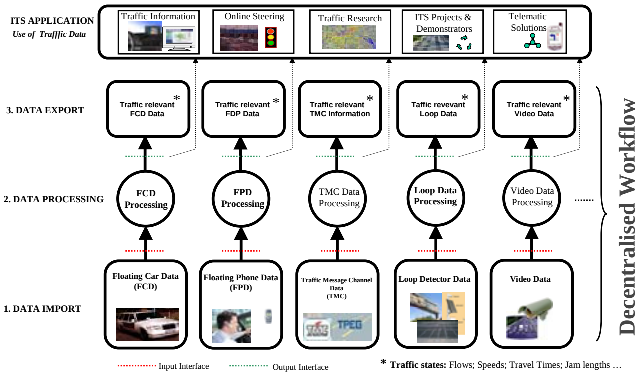

Figure 1: Single isolated applications as standalone

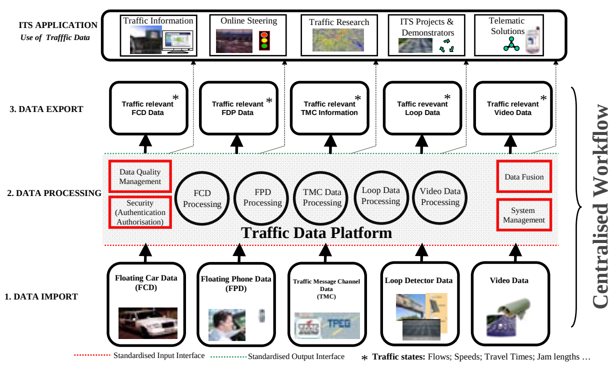

Figure 2: Integrated applications as platform

TDP MAIN FUNCTIONALITIES

Typically there are three main processes of TDP which are data import, data processing and data export. The aim of DLR Traffic Data Platform (TDP) is to provide standardized interfaces to import data (raw data) from various sources (Data provider and system) to store, filter, aggregate, fuse and finally to deliver the original, processed as well as fused data to clients or ITS applications (Data consumer or requester) which need these data for their own purposes. Internally, TDP also supports online services like multimodal routing. The TDP objective is achieved by eight main functions as follows

1. TDP as Data Pool: Data storage and archiving

An important function of TDP is the persistent storage and archiving of traffic data from different sources in distributed relational databases as well as the data management.

2. Standardized and flexible Data Input Interface for Data Provider

TDP will provide standardized und flexible interface to import data from different sources into the platform. Different communication protocols like web services (XML/SOAP, Restful/JSON), SQL, FTP will be supported

3. Data Filtering, Aggregation, Processing and Fusion

One of the main functionality of TDP is traffic data processing. In order to gain traffic information such as traffic flow or speed from some input data like floating car data, data filtering, aggregation and processing is required. For this purpose, processing modules will be implemented and integrated in the TDP processing layer. Moreover, another focus of TDP is on data fusion to improve the quality of provided data

4. Data Quality Management

The goal of TDP is to provide the basis for continuous quality assessment of input as well as output data. For this reason, a module for data quality check and assessment as an integral part of TDP will be implemented. The main task of this module will be the quality assessment within processing modules, the generation of quality indicators for output data and data quality checks for input data

5. Standardized and flexible Data Output and Services Interface

TDP will provide standardized and flexible interfaces for data export as well as for services provision like multimodal routing. TDP clients or ITS applications will be able to access raw data as well as processed data. The data and services interface will be transparent to the client.

6. Management Console for system control, configuration, monitoring and visualization of traffic information

TDP has a management console available for control, management and monitoring of the whole system. The system administrator or manager will be able to manage all run-time options such as the parameter configuration of TDP components or modules as well as to set, instantiate, start, monitor and stop processing modules via a web based interface. Additionally, the management console of TDP possesses a process state monitor function to manage and visualize all critical failures within the system in real-time.

7. Digital map and road network

Information about the road networks is required for the traffic data processing like loop detector or floating car data (e.g. map matching and routing). For this purpose, digital maps are provided by an integrated Map Server. Additionally, TDP will be able to manage and deliver digital network information (e.g. as shape files) to client applications that need it for their own purposes.

8. Security – User Management

Each client or ITS application interaction with TDP requires authentication and authorization. TDP will be able to manage and store client profiles like user name and password. Of course, sensitive client data such as passwords will be encrypted. The communication between client applications and TDP will be also secured. Another function is the TDP data provider registration and TDP data consumer registration.

TDP-SUPPORTED INPUT AND OUTPUT DATA

In this section the types of data are summarized which TDP will be able to support. These data are grouped in five categories as follows.

1. Ground based traffic data

Floating car data [3], loop detector data, traffic data from common camera observation [4], roadwork information, TMC data

2. Airborne traffic data

Traffic data from aerial radar or video images [5, 6] (extraction of relevant traffic information like speed, traffic flows, timestamp from single tracking vehicles), geo-referenced aerial pictures as GeoTIFF, jpg or png format. Metadata used for geo-referencing usually are coordinates of the vertices of an image.

3. Infrastructure data

Information about roads, bridges, tunnels, network states in case of exceptional events like natural disasters (e.g. floods, ..). Infrastructure data [7] is typically extracted from aerial radar or video images provided by special airplane or satellite systems (c.f. [5, 6]).

4. Digital map and road network data

Road network and map data as shape files and digital map resources like nodes and edges of a graph model

5. User/Client data

TDP user or client profiles (TDP Data Provider, data requester or consumer and system administrator) like username, password, user role and data exchange type will be managed within TDP and can be used by the authentication process.

Additionally, TDP will support modules for data prediction, traffic information, traffic state and routing information as well as data fusion. TDP is designed to facilitate an easy integration of further data sources like toll data or data from new upcoming sources like Car2Car or Car2Infrastructure (C2X).

TDP USER AND STAKEHOLDER

In this section, possible TDP key players or stakeholders are summarized. Three categories of TDP users can be distinguished:

- Data Provider and Data Provider System

TDP Data providers can be any private or public company like traffic data operators (e.g. taxi fleets, traffic management centers or freeway operators) as well as research organizations or institutes make traffic data available for research purposes. Using the standardized interfaces of TDP, the data provider systems can communicate with TDP to import traffic data from all sources mentioned above. TDP is able to handle different data providers simultaneously.

- Data requester or consumer / service user and data and service user system

TDP data consumers are currently primary DLR institutes and departments, partners within projects or cooperations that need traffic data for research and development of prototypical telematic applications and services. The data consumer or service user system will use standardized interfaces of TDP to retrieve required data.

- TDP system administrator

The TDP system administrator is responsible for the management of the TDP system. He has full access to the whole system and, for example, registers new data provider and consumer into the system. Moreover, he cares for improving the quality of the TDP system.
Only registered data providers or consumers are allowed to provide data to TDP or receive data from TDP

TDP NON FUNCTIONAL REQUIREMENTS

Figure 3 summarizes some aspects of non-functional requirements to TDP concerning databases and formats as well as availability and scalability. These non-functional requirements must be taken into account by the realization of TDP. For example, TDP must be able to support different types of database and digital road network formats as well as different communication protocols. The scalability and the performance of such system as well as the availability must be guaranteed.

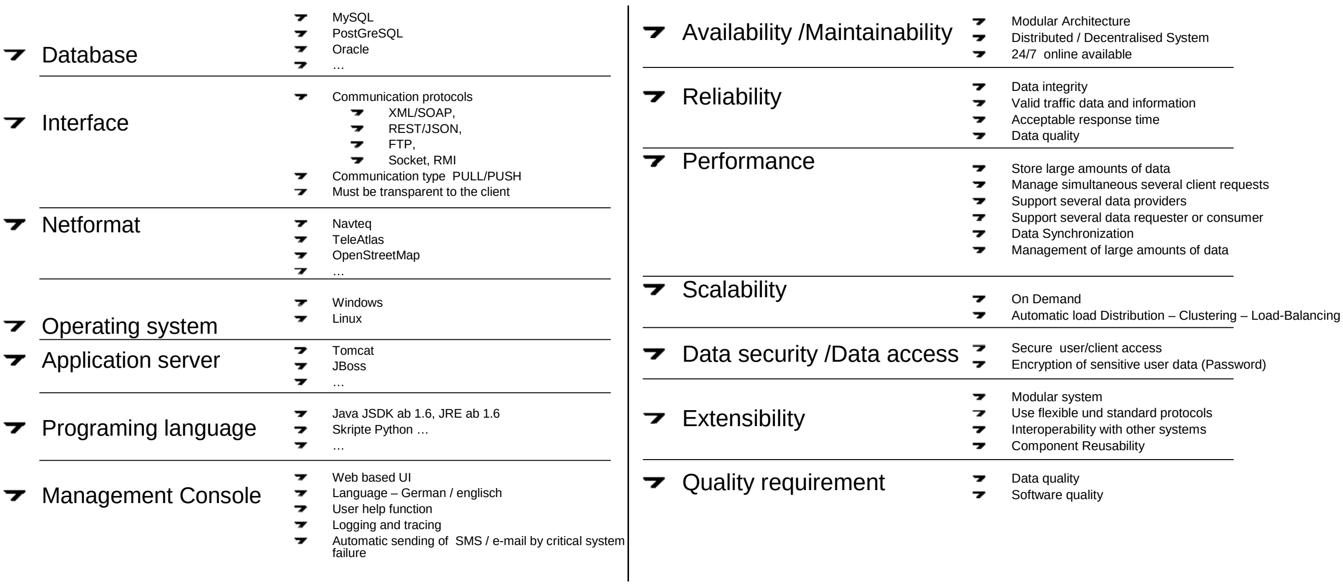

Figure 3: Some selected non functional requirements of TDP

TDP will support push (periodic and on occurrence) and pull communication mechanisms for data providers und data requesters or consumers. Moreover, it is planed to adapt the current implementation to be integrated or deployed into a cloud computing environment for taking advantage from the benefits of cloud computing infrastructure like virtualization, scaling on demand, automatic load balancing and for assuring the scalability and the performance of TDP which is based on service oriented architecture

TDP SYSTEM -TECHNICAL OVERVIEW

In this section, the technical aspects of the TDP are presented in detail. Figure 4 depicts the technical overview of TDP. As can be seen there, TDP consists of distributed autonomous components and modules with different functionalities that can be classified in four component levels:

- The data provider levels (internal and external): The TDP data provider systems can be found in this level
- The local distributed data import (LDDI) communicates with the data provider system to import the traffic data into TDP system.

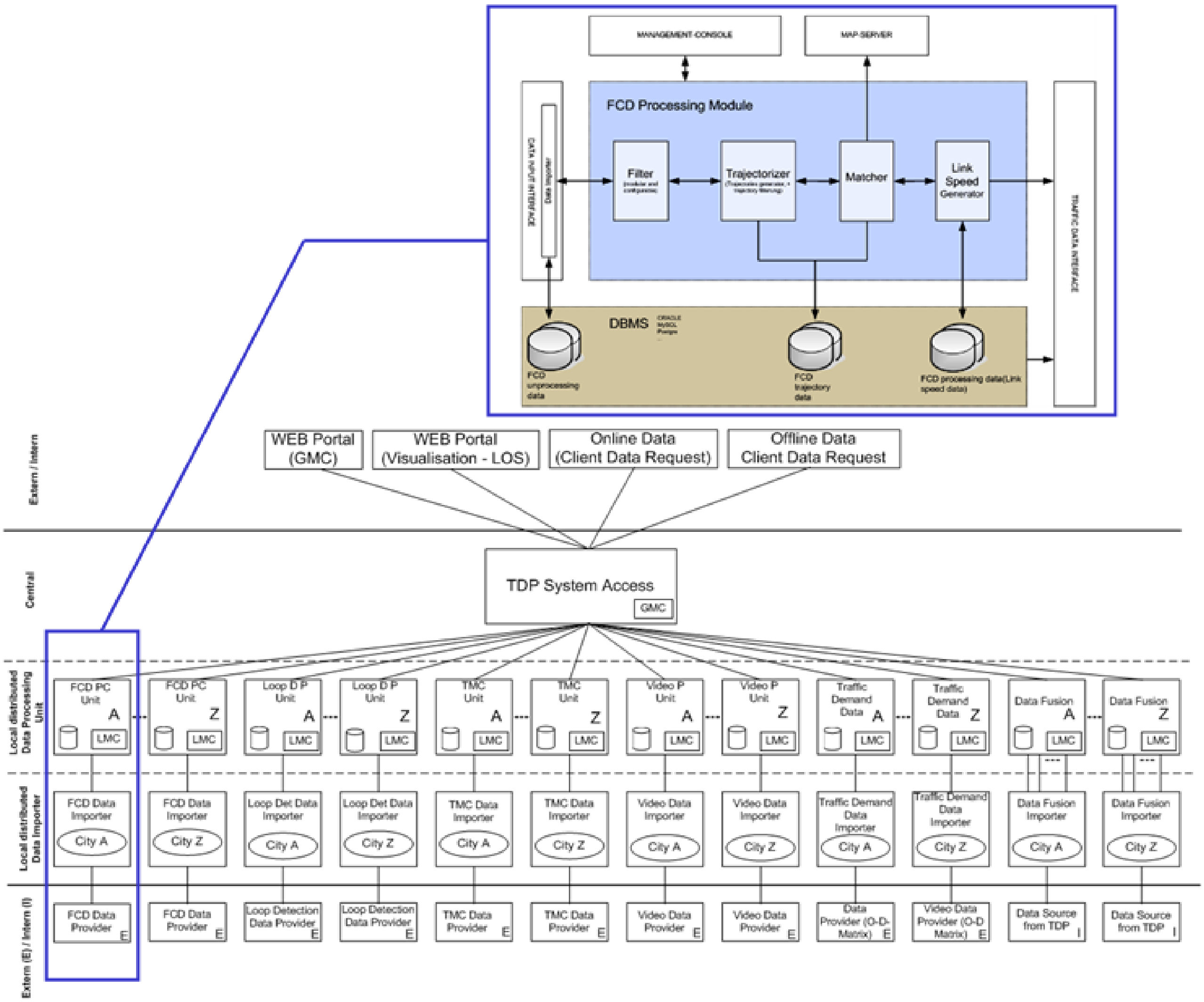

Figure 4: Technical overview of the TDP

- The local distributed processing unit (LDPU): There is one instance per city (e.g. Berlin) and per type of data (e.g. floating car data, loop detector data, video data, …). Each LDPU has a local management console (LMC)
- The central level. This level contains TDP system access for the provision of TDP data to the client. The standardized output and services interface as well as the business logic for the global management console(GMC) is implemented in this level
- The data export level. The data requester or consumer system can be found in this level as well as the graphical user interface like web based management console und visualization tools for traffic information (as level of service-LOS)

Each local distributed processing unit is responsible for the processing of traffic data of a particular city. The detailed view of FCD processing with internal business logic components like Filter Trajectorizer, Matcher and LinkSpeedGenerator are illustrated in Figure 4.

LOCAL DISTRIBUTED DATA IMPORTER

The local distributed data importer (LDDI) (cf. Figure 5) imports traffic data from the data provider system via a Receiver component. The Forwarder then stores these data into a database and/or forwards them to the corresponding local distributed processing unit using the web service interface provided by the Input connector of each local distributed processing unit.

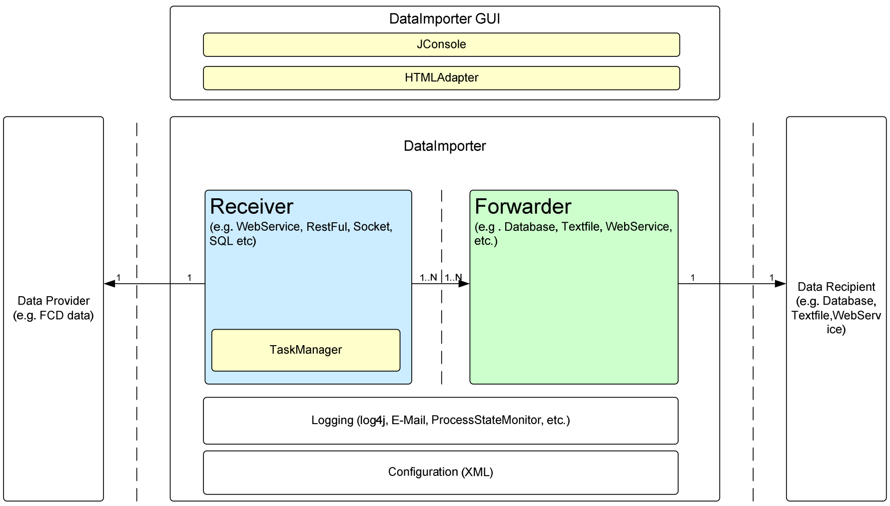

Figure 5: Architecture of local distributed data importer

LOCAL DISTRIBUTED PROCESSING UNIT

The local distributed processing unit (LDPU) is a central component that has the function to process traffic data like FCD or loop detector data. There is also a LDPU that is customized for data fusion. As shown in Figure 6, each LDPU has a model, an input connector to receive input data, an output connector to forward processed data and several database connector units or FTP connector units to store data into the databases resp. FTP servers or to retrieve data from the databases rep. FTP servers. A LDPU typically also consists of several components that implement the business logic of processing.

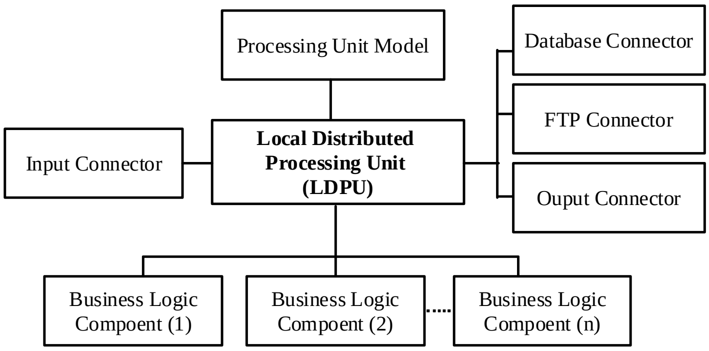

Figure 6: Model of a Local Distributed Processing Unit

LDPU Input Connector

As mentioned above, each local distributed processing unit has an Input Connector (PU IC). The input connector as an integral part of local distributed processing unit realize the interface between the local distributed data importer and the processing unit to exchange the traffic data .

LDPU Database Connector

Each local distributed processing unit has a database connector that is mapped to a single database. Using the LMC the user can create and manage the database connector. When creating an instance of a local processing unit via the LMC, the corresponding connectors in the system can be chosen and allocated to each component of the processing unit. Connector identification number and all table names contained in the mapped database are automatically detected and provided, the user only needs to select the table he wants.

Processing Unit Model

Each local distributed processing unit has a model (PU model) which organizes the parameters and run time options for the configuration and management of the corresponding processing unit. The model is in xml format. Using the local management console for the corresponding processing unit, the system administrator is able to configure the processing unit while running. The PU model also serves to restore previous states of the system for system restarts. Figure 8 shows the XSD scheme of a local distributed FCD processing unit representing its model.

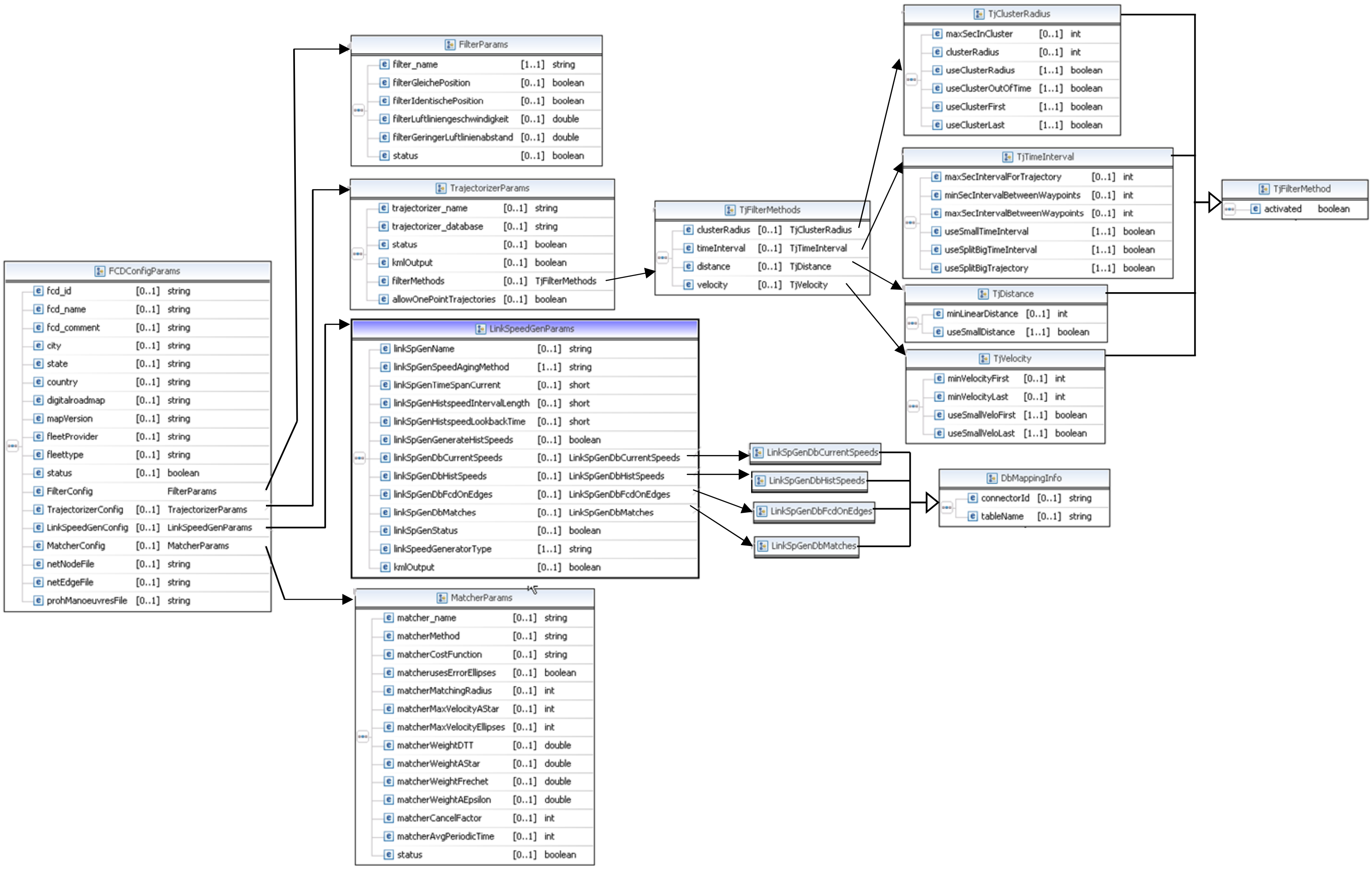

Figure 7: XSD Schema corresponding to the configuration model of a FCD processing unit

TDP MANAGEMENT CONSOLE

TDP has a global management console (GMC) and various local management consoles (LMC). Each local processing unit process continuously sends its current process state to the global management console. The functionalities of TDP management consoles are summarized below.

1. Global Management Console (GMC)
   a. Initialize instances of processing units
   b. Visualization of current states of processing units (OK, NO Signal …)
   c. Remove instances of processing units
   d. Provide meta links to local management consoles
   e. Monitoring in case of technical problems or system failure (automatic information sent to TPD administrator)
   f. Add update and remove TDP user/client profiles
   g. Visualization of current available data in the TDP
   h. User help
2. Locale Management Console (LMC)

a. Local Distributed Processing Unit
   i. Create, update remove new instance of a processing unit
   ii. Add database connectors to the processing unit
   iii. Start stop processing unit
   iv. Runtime option configuration (configuration of processing modules)
   v. Integrated user manual for processing unit (how to)
   vi. Live System Monitoring
b. Database Connector
   i. Create update and remove database connector
   ii. Start/ stop database connector
   iii. Runtime option configuration like setting parameters
   iv. Integrated user manual for database connector (as how to)
c. Low Viewer
   i. Logging
   ii. Visualization of log files (Different log levels like error, debug, warning)

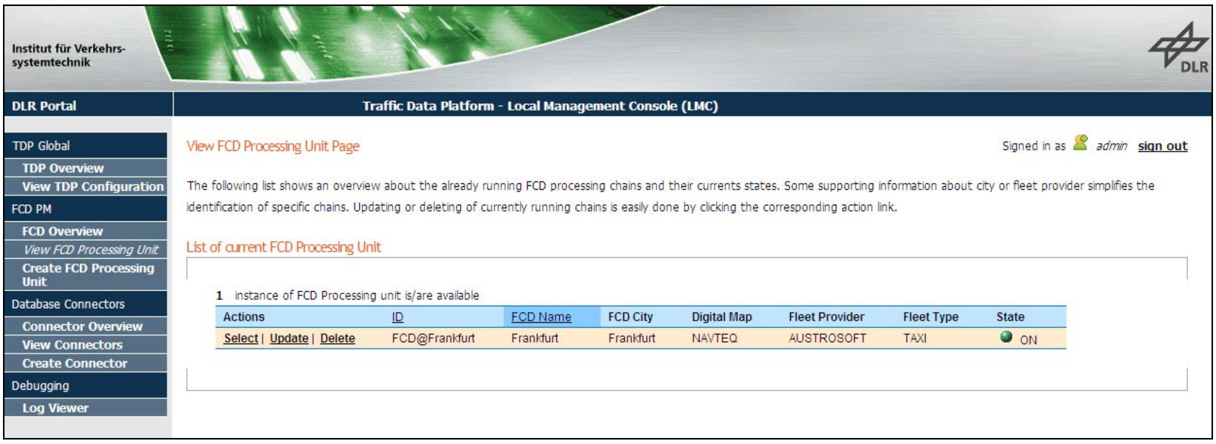

Figure 8: LMC – View TDP processing unit instance of FCD

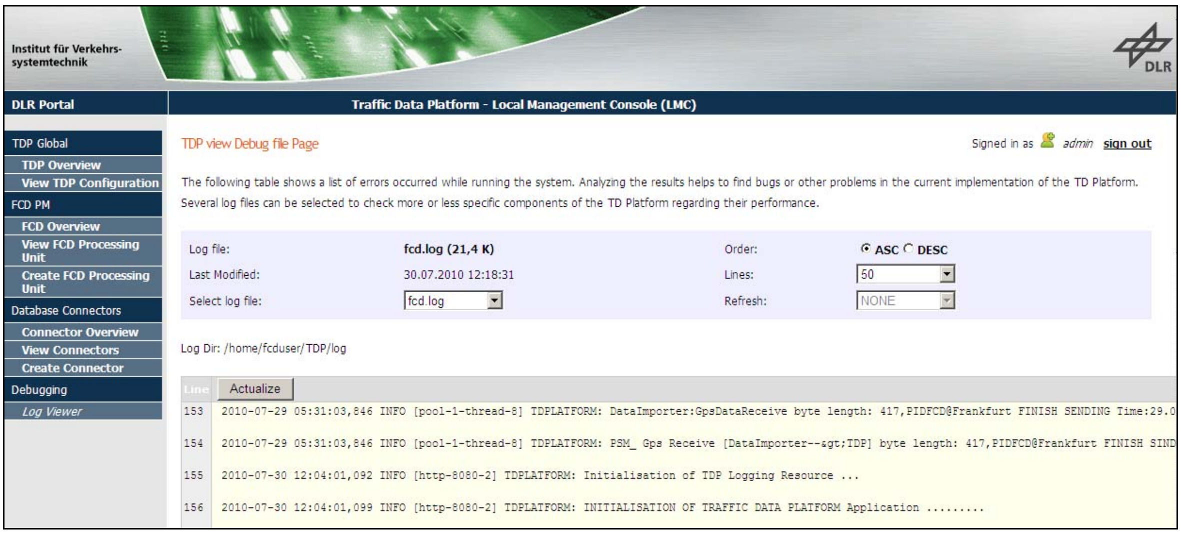

Figure 9: LMC - Log viewer

Figure 8 and 9 show screenshots of a web based graphical user interface of a local management console for FCD.

TDP USE CASE: DLR VABENE PROJECT

The project VABENE is an internal project by the German Aerospace Center (DLR) which started in January 2010 with duration of four years. Eight DLR institutes are involved in this project. The goal is to realize prototype software or support tools for Traffic Management in exceptional situations like disasters, major events, incidents or emergencies. As shown in the VABENE overview system architecture in the Figure 10, the Traffic Data Platform constitutes an integral part of this system and it's role is the intelligent management and provision of traffic and infrastructure data to other components of the VABENE system. In the project VABENE the TDP will also provide the main functionalities mentioned above. Additionally it is planned to realize a mobile and smart version of TDP with limited functionalities that can be run in the mobile ground station of VABENE environment. More information about the VABENE project can be found under the following address http://vabene.dlr.de

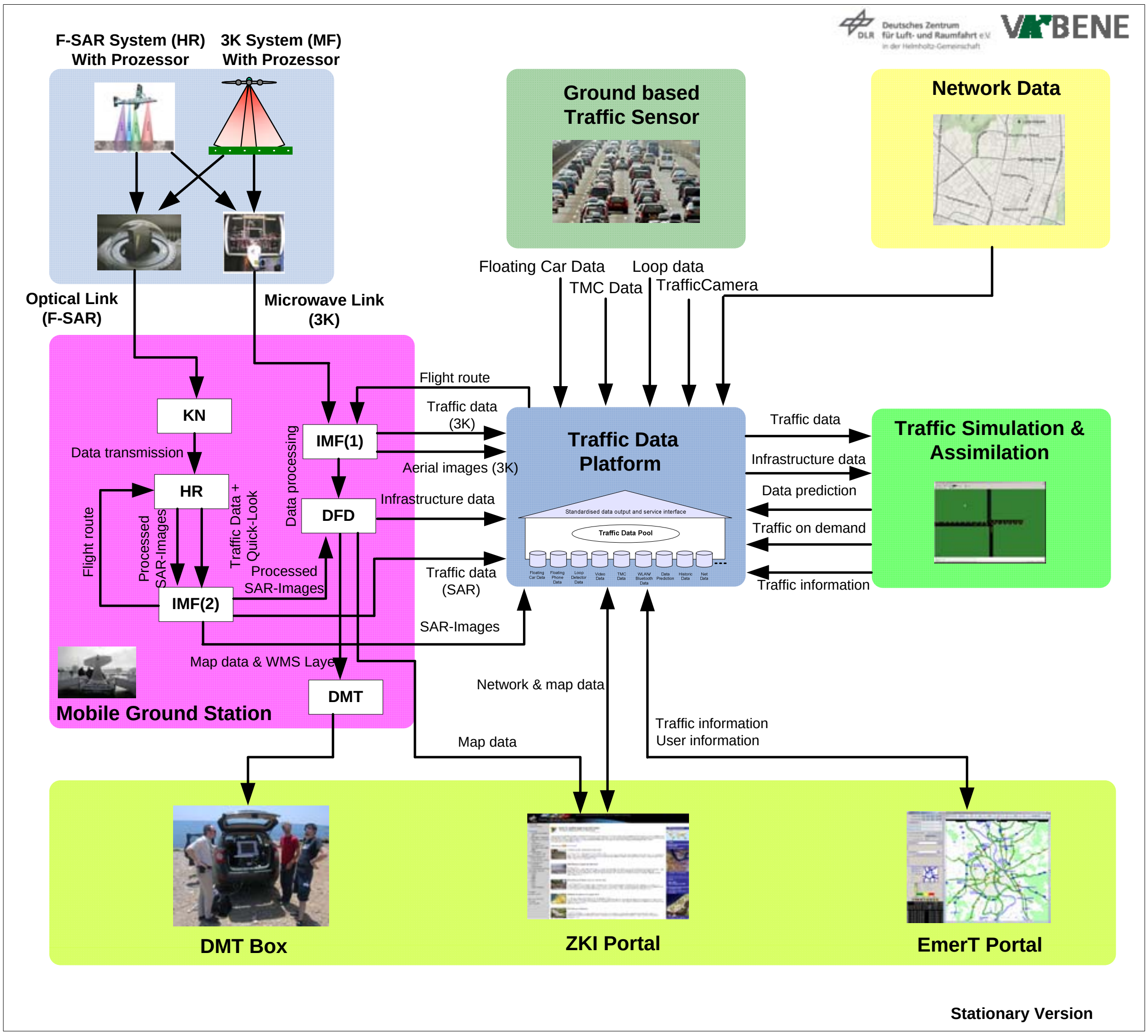

Figure 10: Overview on the system architecture of theVABENE system

CONCLUSION

In this contribution the technical aspects of the Traffic Data Platform (TDP) that is currently being developed by the German Aerospace Center (DLR) are presented. The main objective is the realization of a modular and integrated platform as ITS infrastructure for intelligent management of traffic data from different sources and types and dissemination. Having all these data in one platform with standardized unique access can contribute to more effective research in the field of traffic management and the development of new methods for data fusion and traffic state estimation can be done very quickly.

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