On Board Unit for the European Electronic Tolling Service

Norbert Schindler
Global Sales Manager, Siemens Electronic Tolling
Siemensstrasse 90, 1210 Vienna, Austria
norbert.m.schindler@siemens.com

ABSTRACT

We present a new On Board Unit (OBU) which is being introduced to France in 2013 with the launch of the new French "écotaxe" system. This Hybrid OBU is operable both with Dedicated Short Range Communication (DSRC) microwave and Global Navigation Satellite System (GNSS) technologies. In France, the new OBU replaces existing DSRC tags to function in legacy toll domains based on proprietary DSRC interface protocols already in use. Additionally, this OBU is used for the new GNSS-based toll domains being introduced for the *écotaxe* system. With this new tolling approach, Europe is witnessing the first implementation of a fully interoperable hybrid tolling system. Furthermore, the new OBU is compliant to all currently defined standards of the planned Electronic Tolling Service (EETS), thus making it a commercially available "EETS compliant" unit.

Keywords:
European Electronic Tolling Service, Global Navigation Satellite System, Interoperable Electronic Tolling, Hybrid On Board Unit, French Écotaxe System, Toll Service Providers.

1. INTRODUCTION

Switzerland, Austria, Germany, the Czech Republic, Slovakia, and Poland have already introduced nationwide truck tolling schemes. The French approach will be unique, however, in that it will expand on its existing tolling policies currently operating on approximately 8,000 km tolled motorways (for all vehicles). By the end of 2013, all trucks in France above 3.5 tons will be equipped with new Hybrid On Board Units using GNSS technology for the automatic payment of tolls on the new tolled network of 15,000 km. These mandatory OBUs also contain a 5.8GHz DSRC microwave interface, allowing for the automatic payment at all of the existing toll plazas of motorways already subject to tolls. It is anticipated that over 800,000 new Hybrid OBUs will be distributed to the trucks driving in France, replacing the DSRC tags that are currently in use by those trucks. The new OBUs can be installed by the driver in a matter of minutes, and will be provided to the vehicle owners free of charge.

Europe is thus witnessing not only the first realization of a hybrid tolling system, but also the first major step towards the implementation of the Electronic Tolling Service which until now has only been theoretically discussed within the European Union. With its new truck tolling scheme, France will also be the first country to introduce a completely new business structure in which a Toll Charger is subcontracted by the state road authority for the creation and operation of the tolling infrastructure, and multiple Toll Service Providers (TSPs) can enable their clients to use the established tolling infrastructure. The TSPs register their clients in the tolling system, supply them with new Hybrid OBUs, handle all billing and payment issues, and ensure that they are fully compliant both in the old and new tolling domains. Due also to the fact that the new satellite-based *écotaxe* system will be interoperable with its traditional tolling schemes, also to neighboring Spain, France is taking a leading role in what will doubtlessly become a forerunner to EETS.

Figure 1. The windshield-mounted "plug & play" Hybrid On Board Unit from Siemens

Major TSPs in France will be offering their clients the windshield-mounted Hybrid OBU. The new "plug and play" OBU offers unique advantages, such as:

- The ability to operate in existing proprietary DSRC toll domains, new GNSS-based toll domains, and future toll domains based on the EETS DSRC standards;
- Compatibility with the Spanish VIA-T DSRC microwave standard;
- Capacity in the OBU hardware is provided to tackle new toll domains and value-added services without any need to physically access the OBU;
- Local Augmentation Communication is implemented via the DSRC interface to enhance position accuracy of the OBU in the GNSS domain when GNSS reception is not adequately available.

- The DSRC interface enables automatic electronic enforcement compliant to EETS, which can be performed on both DSRC and GNSS domains; recent toll transactions can be read directly from the OBU.

2. MOVING FROM FRANCE TO EETS

The tolling application software is divided into two "hardware" components: the OBU and the Proxy, which are connected to each other via the GSM cellular network. As shown in Figure 2, the OBU and Proxy form what in EETS terminology is called the "Front End." This basic diagram illustrates the solution implemented in France, which equally applies to an EETS environment in which the Toll Service Provider's Proxy interfaces with the Back End provided by the Toll Charger, for Charge Data Processing.

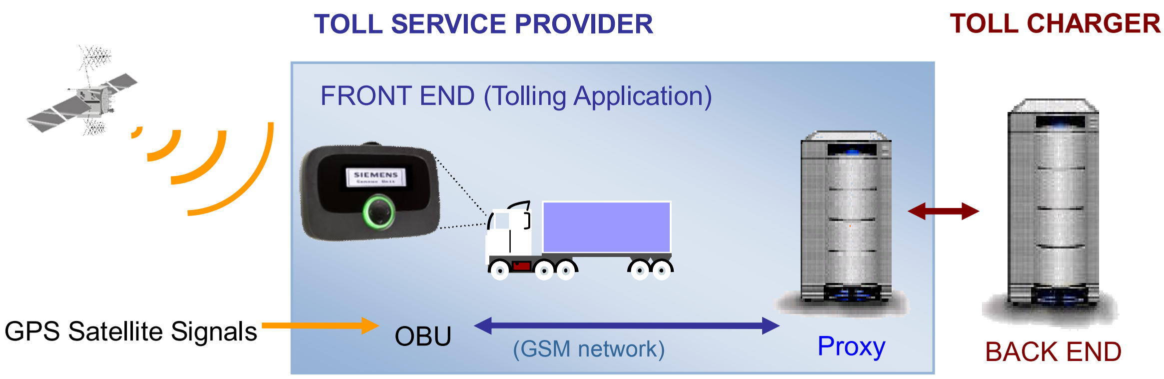

Figure 2: The Tolling Application is divided between the OBU and the Proxy

The Front End solution developed for the French project has been designed to support future EETS service providers by:

- meeting the requirements for ISO EN 12855 to facilitate standardized communication between EETS providers and Toll Chargers;
- being highly flexible in integrating software and data for new toll contexts (update over the air!);
- providing state-of-the-art security mechanisms for ensuring trust between EETS stakeholders, for non-repudiation and for privacy protection, conforming to the cryptographic recommendations of EETS;
- providing remote update capabilities for all toll contexts: the OBU never needs to be returned for upgrading when new toll domains are added; all the necessary software and settings can be updated over the air (using the cellular network). Thus, OBUs can be distributed directly from the factory to the TSPs.

This OBU platform is "intelligent", meaning that the unit has the ability to recognize when it is travelling on a tolled road section. Depending on the actual implementation, different levels of intelligence can be required in a GNSS-based tolling system. In other words, it may be required that the OBU be a “thin client”, a “thick client”, or something in between. In France, a relatively “thin” approach has been chosen in which the OBU client sends “toll events” (basically tracking information) to the Toll Charger who, in turn, determines the toll sections to be charged. The Toll Service Provider then bills its client based on the toll sections identified. However, in an EETS setting, toll recognition can also be implemented directly on the OBU device, and the recognized sections passed on to the Toll Charger.

The EU commission has issued a directive (2004/52/EC) and a decision (2009/750/EC) defining several aspects of EETS. Some standards are also listed as mandatory for all EETS stakeholders. On the other hand, other relevant standards are only recommended; the final decision about the requirements is still left to the Toll Chargers (TCs). Since a large number of toll chargers would take part in EETS (at least one per member state) this will lead to a huge body of diverging (if not contradicting) requirements, almost impossible to manage and implement. Unfortunately, most TCs still have to issue detailed requirements for their acceptance of EETS providers. Therefore a clear path does not exist to EETS certification, possibly one of the major reasons why no EETS provider has emerged yet to tackle the task. Our new OBU platform is prepared for these and other challenges along the path to EETS.

3. DATA SECURITY

In the development of the EETS standards, much attention was given to ensure a high level of data security within the tolling domain. The French *écotaxe* system requires an even higher level of data security than foreseen in EETS. In our new OBU platform, reliability, confidentiality and integrity are ensured end-to-end through the application of cryptographic mechanisms at the level of message transfer between the OBU and the Proxy. The following technologies are used:

- encryption (for data for which privacy is required)
- hashing (for data for which integrity is required)
- signing (for data for which non-repudiation is required)

These measures are applied to data in both directions (from the OBU to the Proxy, and vice versa). At the transport layer, the following data security measures are employed:

- Within the GSM network, a private Access Point Name (APN) is used. The resulting private Internet Protocol (IP) address range ensures that no IP packets are forwarded between this address range and any other. Thereby, it is not possible for intruders to inject malicious data from the outside.
- Between the termination point of the GSM network and the Proxy, a Virtual Private Network (VPN) is used, resulting in the same characteristics as described for the intra-GSM transfers above.

4. OBU HARDWARE

The main task of the OBU is to capture Road Usage Data from every vehicle liable to pay tolls, and to transmit the data to the back office for further processing. Consequently, the OBU is the key component of the Electronic Toll Collection System. OBUs can be installed by the drivers within a few minutes; they are connected to the windshield by means of a glued holder. The OBU is permanently connected to the vehicle's power supply, either through a cigarette lighter connection or by fixed cabling. Once installed, the OBU operates completely on its own, establishing a communication link to the Proxy. The OBU is automatically switched on and off either through the connection to the ignition or by a movement detector (when the power connection is made via the cigarette lighter). A built-in backup battery ensures that the OBU remains functional in case the main power connection is interrupted (either advertently or inadvertently). An illustration of all hardware components integrated into the OBU is provided in Figure 3.

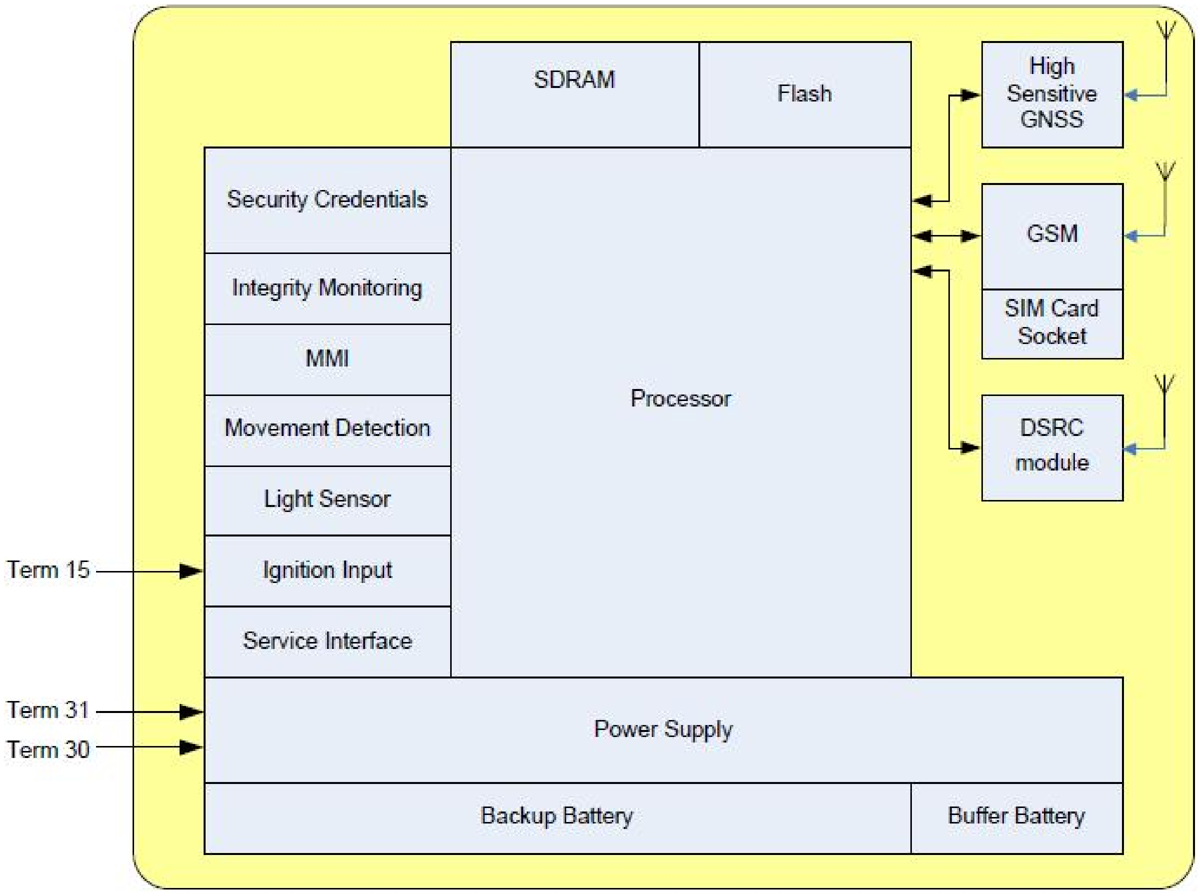

Figure 3: Block Diagram of the OBU Hardware Components

5. OBU APPLICATION ARCHITECTURE

The OBU software consists of two main parts:

- the basic software including the operating system, Java virtual machine, and low-level drivers;
- the toll application software.

All levels of software, including the firmware of the individual hardware components on the OBU, can be updated remotely from the Proxy, over the air (via the GSM cellular network). This unique capability enables a significant flexibility of the tolling environment throughout the course of tolling operations, and helps to minimize operational costs. Furthermore, thanks to the overall system architecture, full remote control of the toll domain – as well as any additional services provided – is possible via the Proxy.

An application programming interface (API) provides all functionality required by the applications to make use of the hardware features of the OBU. The underlying Java technology (J2ME) assures a high degree of flexibility, maintainability and portability. Figure 4 gives an overview of the software architecture and its layers.

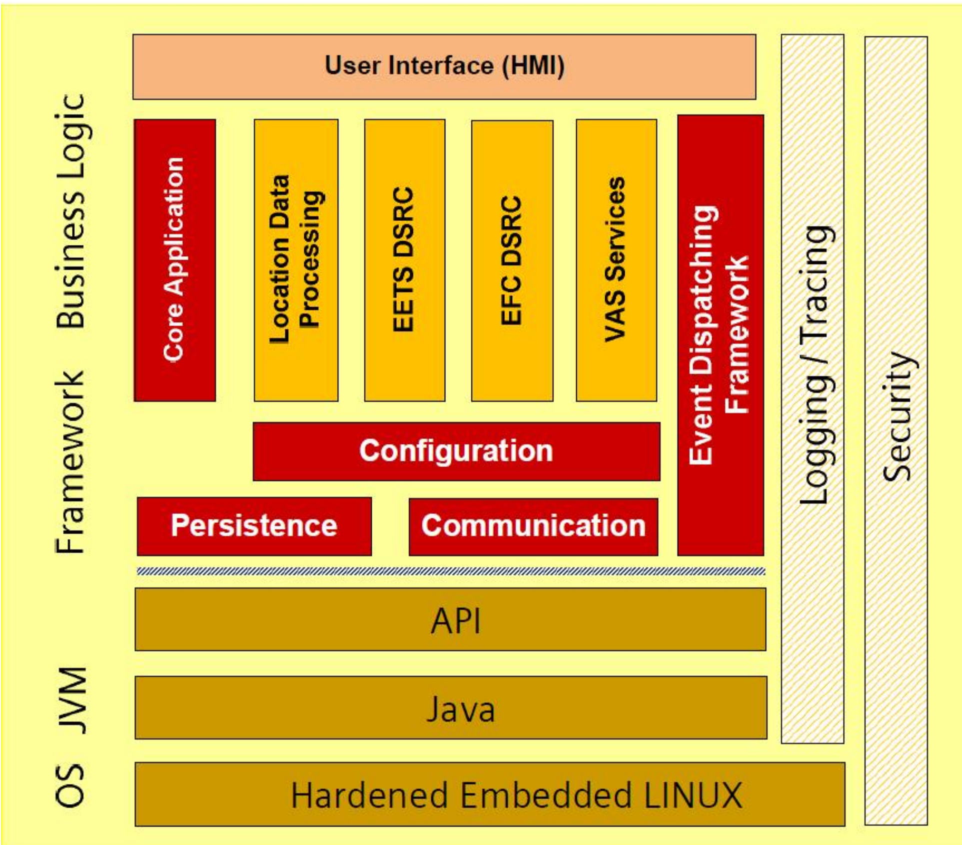

Figure 4: OBU Software Architecture

5. ADDITONAL SERVICES

In addition to the toll charging data, the Front End (either the OBU or the Proxy) can also be configured to send positioning data. This configuration could, for example, include:

- transmission of data depending on the location (i.e. data sent at specific locations of interest);
- transmission of data depending on certain events (e.g. when the driver presses a button on the OBU);
- configuration of the granularity of recorded positioning data.

Furthermore, information can be provided that can be used for other services, such as events recorded or determined by the front-end which can be used for:

- detecting accelerations exceeding certain limits (e.g. resulting in crash warnings);
- monitoring of GSM coverage for detection of blind spots.

Information provided by the OBU can be used as the basis for individual or global services. Depending on the service definition and the agreements of the affected persons, these services may be based on personal or anonymous data. Aggregation of information may open up a range of services in the interest of the public.

In order to be able to perform a clear separation of data, an architectural approach could be implemented as outlined in Figure 5.

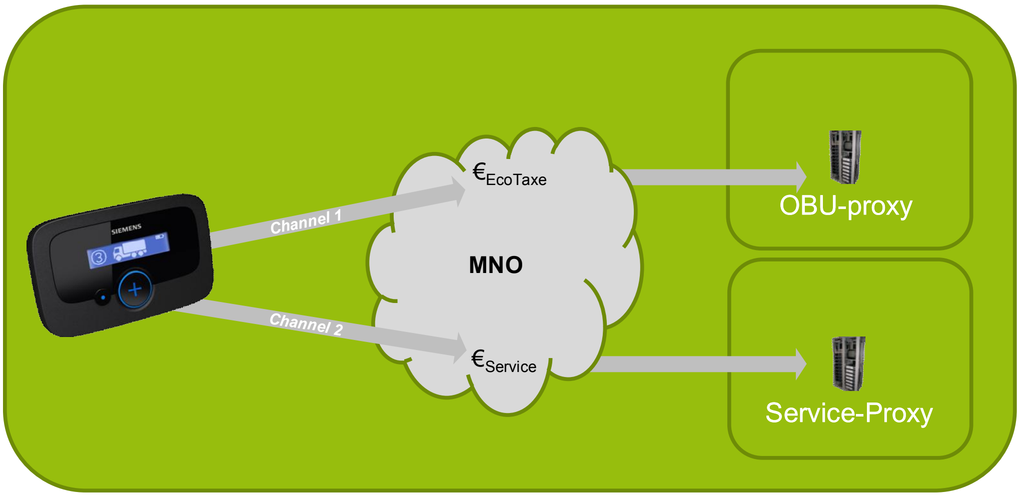

Figure 5: Potential Service Proxy Architecture

The service proxy can be deployed at the facilities of the Toll Service Provider or at the premises of a particular service provider. The independent logical data channel for data communication allows for clear separation from tax functionality.

6. CONCLUSION

France has taken the first significant step towards EETS, by implementing a system that is interoperable with the technology used for legacy toll systems (based on DSRC) and with the new tolled network of roads (based on GNSS). The French *écotaxe* system also supports the ability of multiple service providers to offer to truck drivers and truck companies the tolling service that is required by law, as well as other “value-added” services.

With this new OBU platform, all technical aspects of EETS have been realized. The French example demonstrates “EETS in the small”, i.e. on a national level and with interoperability with Spain. In order for EETS to move from theory to practice on the European level, international toll service providers need a plausible business case which would sufficiently motivate them to invest in the significant (mostly administrative) overhead that EETS would require.

Our new OBU solution fully implements all relevant standards and EU directives (2004/52/EC, 2009/750/EC), both with respect to the interfaces as well as to the data structures, thus making it ideally prepared to support EETS. However, not all standards are mandatory to all European stakeholders. Several EETS directives merely make recommendations which are then up to the individual Toll Chargers to actually implement. Since many Toll Chargers will take part in EETS (at least one per member state), a large body of diverging and contradicting requirements could emerge, making it extremely difficult to implement EETS throughout Europe. Most Toll Chargers still have to issue detailed requirements for their acceptance of EETS providers. Until now, a clear path to EETS certification has not yet been defined. This is possibly one of the reasons why no EETS provider has emerged until now that can overcome these difficulties.

In any case, the *écotaxe* project has led to the development and implementation of real solutions for the real needs of France and will set a much-needed practical example for EETS in the future. The OBU platform presented in this paper is prepared for these and other challenges along the path towards EETS.