# A third weigh

**If you are undecided between a 'thin' or a 'fat' client, allow NORBERT SCHINDLER and ERICH ERKER to present you with a hitherto unavailable third option: the 'cubby' client**







**At the last ITS World Congress in Stockholm, a good number of papers addressed the subject of satellite-based tolling solutions. There was also an "Experience Park" outside the Exhibition Hall providing visitors, among other things, hands-on experience driving around the car park in golf-carts equipped with GNSS On Board Units (OBUs).**

For hardcore tolling professionals it was nothing extraordinary but for a broader clientele it was certainly an interesting and worthy experience. Slowly but surely, it seems, a broader interest in satellite-based systems is taking shape!

As is often the case when GNSS (Global Navigation Satellite System) approaches are presented, the subject of "thick" (or "fat") clients versus "thin" OBU clients is frequently brought up. A number of technology suppliers are, of course, very eager to sell thin-client On Board Equipment (OBE). On the other hand, there are the thick-client advocates, citing a number of good reasons for having all "tolling intelligence" within an OBU. In any case, there is in fact a wide spectrum of technological solutions ranging from very thin to very thick. We therefore attempt to establish a set of variants on the spectrum of thin to thick clients, pointing out to the merits of each and hopefully providing some useful thoughts to the ongoing discussion of introducing a European Electronic Tolling Service (EETS).

## Divide and Conquer

In an electronic tolling solution, the tolling application (i.e. the software behind the whole system) is divided into two parts: the OBE and the Proxy. The two parts need to be connected somehow, most commonly via the GSM network (Figure 1). Together they determine whether a toll should be charged and how much should be paid, based on where the vehicle travels. The Proxy communicates with the Back End, thus forming the Central System (also called the "Back Office").

Under normal circumstances, the Back End is a separate entity from the tolling process, dealing with issues such as user registration and billing, much like the IT systems deployed by telecommunication and utility companies.

The tolling application thus resides partly in the OBE, performing - at the very least - vehicle localisation. The Proxy then takes over rest of the tolling process. One of the major architectural decisions in designing a toll system is how to distribute the various steps in the tolling process. While the tolling process remains the same overall, leaning towards a Thick or a Thin Clients comes with corresponding advantages and drawbacks, which will weigh in differently depending on the requirements of the respective tolling scenario.

Not only the processing load, but also the quality and amount of data transmitted over the air interface vary significantly based on this distribution of tasks. Simple OBE requires only infrequent updates, while the road usage data volume is rather large. With increasing complexity of the OBE, this data volume is reduced, but more and more information is needed in the OBE to perform the necessary calculations. Therefore, the frequency and data load of updates increases.

## Used and abused

Where to place most of the "intelligence" of the software application is not only a matter of taste, but may also largely depend on whether the time is taken to actually invest in developing a sophisticated OBU that can endure all the physical abuse of an automotive environment. There is also the challenge of getting a robust application and low-level software onto this unique hardware platform.

The easy way out, of course, would be to merely install the software application onto the comfortable environment of a standard server platform and feed it with the data coming from a simple GPS device, common among commercial navigation systems. In fact, rumour has it that the basic components of tolling applications running on a server can be purchased on the market nowadays.

Recent tenders for large tolling systems have a tendency to divide the tolling system into several lots which are contracted separately. Therefore, the issue of interoperability emerges. An advantageous point of separation is the one also chosen by EETS and by recent standardisation efforts. It turns out that the air interface (i.e. GSM connection) between OBE and Central System is very hard to standardise, due to:

- Low bandwidth
- Unpredictable availability
- High variability depending of choice of OBE "thickness"

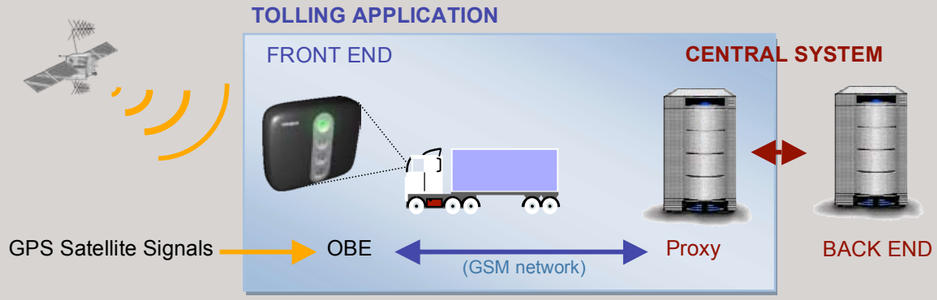


**Figure 1: The Tolling Application (Front End) divided between the OBU and Proxy, connected to the Back End part of the Central System**

The solution chosen was to move the open interface into the Central System, which is now divided into a Front End and a Back End. The former comes in one package with the OBE, performing the OBE communication and tolling-related processing (e.g. map matching for thin clients). The latter is more or less an off-the-shelf IT system which does not need to deal with processes and tasks specific to the tolling application. It is also possible that one system runs several Front Ends in parallel, offering different services to the road users, such as real-time traffic information.

## To EETS or not to EETS is not the question

At the technical sessions in Stockholm, several papers discussed a variety of issues that need to be addressed for EETS ever to become reality. There was even a presentation pointing out why EETS is unlikely to happen, since there isn't much of a business case behind it. Nevertheless, the EETS model is one on which the electronic tolling industry has begun to orient itself, since "EETS compliance" is becoming a standard requirement in the large European tolling projects currently being tendered. Furthermore, the "Decision on the Definition of the EETS" recently adopted by the EU Commission justifies the expectation that this comprehensive service will become reality within a few years.

Considerable advances have been made in standardisation efforts at the European level, where interfaces between the Front End and Back End of tolling systems have been defined.

The approach taken in the EETS specification gives considerable leeway in terms of technical solutions. It is possible that the variety of OBE implementations will be explored in this context, depending on the emphasis chosen by the providers such as cost efficiency, privacy protection, or a wide range of added value services. This choice will be influenced or even dictated by local or pan-European legislation and directives, taking the cultural and economic differences within the targeted customer range into consideration.

The main processing steps taken in the toll collection process are the same, irrespective of the technical implementation chosen:

- Collection of sensor data (mainly GPS);
- Sensor fusion;
- Recognition of tolling events;
- Calculation of the tolling fee;
- Billing and clearing.

Additionally, the data is compressed and security measures can be applied prior to the transmission from the OBE to the Central System. The various flavours of thick or thin clients differ mainly in the amount of processing performed in the OBE. The procedure is then completed in the Back End of the Central System.

## From Skeletons to Sumos

On the path from thin to thick, we decided to establish six levels of clients, inventing suitable names along the way. It would come as a surprise to us if this terminology would be ever appear in any other literature on the subject, but then again, you never know...

## The Skeletal Client

This is the thinnest client imaginable. It simply receives GPS signals (and possibly input from other sensors as well), establishes the vehicle position and passes the position data immediately on to the back office. This kind of equipment is easy to specify and to implement. The need for sending data from the server to the OBE is reduced to a minimum (e.g. software maintenance, or changing the GSM provider).

Nonetheless, high communication costs and privacy issues limit the suitability of this solution to special applications, such as the tracking of dangerous goods transported on the road network.

## The Anorexic Client

This very thin client can do a bit more than the "skeleton," since it does not just blindly pass all position information to the back office. "Geo-fencing" is used to limit the amount of data sent to the server. In other words, the transmission of data is turned on and off, depending on where the OBU actually is. This helps not only to reduce communication costs, but also to prevent unauthorised collection of data outside the tolling domain. A coarse geo-fence can be implemented by restricting communication to one GSM provider, so that when there is no GSM coverage (and communication is not possible), the OBE goes into a hibernation mode. For higher accuracy, the data describing the geo-fence must reside in the OBE and must be kept up to date.

## The Thin Client

Now we get to what we actually call a Thin Client. Here, GPS fixes or traces are not sent constantly but rather in packets to the back office so that the data transmission via GSM can be realised more cost-effectively. Interpolation can be used to improve the quality of the trace when the distance between GPS fixes are too far apart. A common feature of the three thin varieties presented so far is the transmission of traces to the Central System. While this leads to issues with communication cost and privacy, it also offers advantages, such as the use of location data for value-added services.

From a technical point of view, privacy protection is possible, e.g. by separating location data and person-related data in the central system. It is sometimes difficult, though, to convince the general public and the policy-makers behind the introduction of tolling schemes that this can be done reliably.

## The Chubby Client

With the Chubby Client, all tolled road sections are recognised in the OBE which has all relevant map information "on board." This approach is actually one of our favourites and is currently being implemented in the Slovak tolling system.

The main advantage is the considerable reduction in data transmitted from the OBE to the back office server. It appears that this approach found wide acceptance due to the fact that the data delivered from the OBE closely resembles the information gathered in widely deployed microwave-based systems.





Satellite-Based Tolling


GNSS OBUs being tried and tested at the Stockholm ITS World Congress Experience Park, September 2009

From the driver's perspective, the OBU passes one of the "virtual gantries" and the unit beeps to confirm that a tolled road section is charged. This useful feedback lets the driver know that the unit is working properly (often a legal requirement), and would not be possible with any of the "thinner" clients (which do not recognise toll sections).

For an OBU having this processing complexity, it is necessary to maintain a representation of the road sections to be tolled, something we usually call "geo-data." This data is subject to frequent changes and requires updates from the Central System to the Front End whenever a tolled road section is added, deleted, or modified. The chubby client also performs important functions in the OBE which would otherwise require large processing capacity in the central system. Using the distributed intelligence of modern microcontrollers in the OBE, the required processing power can be performed very cost-effectively.

## The Fat Client

Here we have an OBU in which the road sections and tariff information is stored locally so that the complete tolling calculation is performed on the OBE. Thus, for every road section passed, the driver can immediately see how much was charged. While this feature is appealing, it could also be considered overkill since, under normal circumstances, the section information would be required by the Back End anyway in order to issue an itemised bill for all sections travelled. In other words, more computational power and data communication costs would be required than the Chubby Client.

## The Sumo Client

This OBE can do just about everything on its own, including the booking of tolls directly from the user – for example by inserting credit card directly into the unit. The central system is reduced to a communication broker, relaying the payment information to the banking world, and to OBE management. It must also support claim management and enforcement. The Sumo approach is indeed an interesting one, but until now there has not really been much demand for this level of "heaviness" at the OBU side of the spectrum.

## Concluding remarks

Satellite-based tolling is now at the threshold of becoming commonplace in Europe. Tenders for highly ambitious nationwide schemes have recently been launched in France and in the Netherlands, and a number of other countries are already in the starting blocks for their own tenders. Standardisation groups are making significant progress in getting the European Continent ready for interoperability of these many nationwide schemes, and developments in technology have brought us a significant step closer to the ideal world in which EETS can actually happen. Thanks to the EETS approach, a nationwide scheme can choose whatever level of "thick" or "thin" client approach it finds most suitable.

In the case of Slovakia, the Chubby client has shown itself to be an ideal solution. While maintaining all geographic information on the OBE, the tariff information is kept in the back office where the tolling calculation is actually performed.

The issue of updating the OBE is resolved by deploying an optimised algorithm for defining and identifying road sections. The performance of this algorithm enables the effective implementation of the nationwide tolling scheme consisting of approximately 2,300km of roads, more than two thirds of which are secondary roads! There is no need for any supporting roadside infrastructure, since our algorithms ensure effective section recognition exceeding 99.8 per cent. Since the geographic information stored on the OBE is compact, even frequent updates of geo-data from the Back Office to the OBE can be realised without difficulty.

We have come a long way from those entertaining technology debates of recent years in which GPS-based solutions were measured against the roadside-intensive tag and beacon approach of the microwave advocates. The potential of satellite-based tolling technology is only beginning to be unleashed. E

*Norbert Schindler is Global Sales Manager for Siemens Electronic Tolling and can be contacted via email at norbert.m.schindler@siemens.com*
*Erich Erker is the Austrian Representative in European and ISO Standardisation and is Siemens' Expert on Electronic Fee Collection. He can be contacted via email at erich.erker@siemens.com*

www.thinkinghighways.com