THE POSSIBILITY TO CONSTITUTE AN INTEROPERABILITY OF EFC IN THE CENTRAL AND EASTERN EUROPE

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Summary: The article describes critical situation concerning implementation of the EFC satellite oriented system in CEEC countries. Situation in the field of practical implementation of GNSS/CN is very critical at present due to lack of valid European standards. There is only one realistic possibility to build up interoperable system - to use "de facto" standards. The idea has been elaborated by expert group for the Ministry of Transport of the Czech Republic.

1. PRESENT SITUATION IN THE CZECH REPUBLIC

Tender for EFC for lorries above 12 ton was prepared at the beginning of 2003 by the Ministry of Transport. Tender published in 2005 called building-up and operation of the EFC system for about 2000 kilometers of highways and selected 1st class roads. Lorries above 12 ton with some exception for army and safety guards and busses have to pay. Ministry specified the average price for 1 km for 0,13 cents.

Complicated selection procedure has chosen microwave DSRC system and Kapsch as a general contractor. The regular operation of the DSRC started for 980 km highways on 1st January 2007, whereas the contract was signed only at the spring 2006. To built and operate 178 portals during 7 months was extremely serious task mainly for the Czech sub-suppliers. The basic description of the Czech system is:

- Central system and back office in Prague, hot line available;
- Enforcement center in Prague;
- 178 DSRC portals and data and power connection;
- 26 enforcement portals;
- Contact points with customers.

The first results after one year of operation show that revenues are even higher for 50% than it has been expected.

Additional considerations concern extension of charging system for 1st class and selected 2nd class roads evoked logical question if it is possible to extend present DSRC system. Minister of Transport nominated group of experts of the Faculty of Transportation Sciences of the Czech Technical University to answer this question in 2007. The answer showed that it is otherwise possible but it would be ineffective and still more ineffective for future telematics applications. The expert group reviewed the implementation plan and it brought the conclusion in March 2007, which was accepted by the Ministry of Transport later.

According to these conclusions the amendment with the supplier of the EFC system was signed in December 2007, which reduces original range of II. stage from 1218 km to 249 km which will cover roads connecting present highways to the boundaries. The amendment also warrants that new built highways and selected 1st class roads will use DSRC system namely until 2013. This rather complicated construction of amendment ensures to Ministry that original agreement with the supplier is not neglected.

Contemporary consideration supposes to extent charging system for 6000 km of 1st class roads and for about 2000 km of 2nd class roads. The new supplier of satellite technology GNSS will be taken by new tender according to European directive 2004/17/EN and according to legislation of the Czech Republic. The strict requirement will be applied to the supplier – both subsystems (DSRC and GNSS/CN) shall be integrated into one system with priority given to GNSS/CN system. The general contractor was obliged to prepare "open interface" to the central system enabling to connect also a general third party.

2. FAILURE OF EUROPEAN STANDARDIZATION

The Czech Republic works in the standardization committee CEN/TC278 "Road Transport and Traffic Telematics" as the only "eastern" country from the beginning. After very long way and tents of hours of discussions it was possible to say that DSRC standards were finished in 2004. Quite different situation is in the field of GNSS/CN.

There are two satellite systems working as charging system in Europe at present. German system is proprietary system covered by a set of patents. Document CEN N1934 "EFC standards and IPR" speaks about one hundred patents. Very similar situation is with the Swiss system in that sense that its technical specification has never been published.

There is only one possibility for countries desiring to introduce GNSS based system – to rely on European standard.

The first and until now the only realistic proposal of the GNSS/CN standard was elaborated by WG1 of the technical committee TC278 at the end of ninetieths. Standard 17 575 "Application interface definition for electronic fee collection (EFC) based on Global Navigation Satellite Systems and Cellular Network (GNSS/CN)" was formed rather sadly coming from two reasons:

- Since there was no common idea how future GNSS/CN were to be built it was decided that standard should be written as a "toolbox standard";
- The existence of cellular networks based on standard like GSM led to conclusion, that the communication stack according to the OSI/ISO 7 Layer Model was well covered.

Standard describes basic concept of GNSS/CN, scenarios of transactions description of application layer etc. at about 130 pages. During discussion in the CEN the standard was remitted to huge criticism. Only suggestions had more than 80 pages. After a number of meetings during the years 2005-2007 it was decided in Firenze last autumn to stop the works on this standard and split it into a few smaller parts:

1. Charging;
2. Communication: transactions and connections to lower layers;
3. On line updating of toll data and software;
4. Roaming.

Time schedule for part 1/2 is December 2008 (final draft) and for part 3/4 final draft is proposed to April 2009.

3. BASIC SYSTEMS DESIGN

The lack of European GNSS standards has been motivation to the discussion of the Czech expert group how to ensure acceptable feature solution. These discussions in the expert group directed to formulation of principal design of the II. stage of charging system, which shall be interoperable and it shall also integrate different telematics needs. Expert Group has requested from the general contractor (GC) at least:

- Evaluate interoperability issue for the present system,
- Evaluate openness of the enforcement system,
- Show a preliminary total cost model for interoperable interface.

The first proposal of a new system presented by GC emphasized next points:

- Preference of DSRC system;
- Tendency to centralize system;
- Cost models of the communication has been overestimated;
- Interoperability has been evaluated to DSRC system only.

Fig. 1 depicts that proprietary protocols that have been considered and the solution was orientated only to the thin client. This solution was not acceptable for next development of a satellite system in the Czech Republic.

As a result of many considerations the expert group elaborated more concrete concept in May 2007 and it has been named as **hybrid system**. The concept comes out from the theory of hybrid systems, which is used in the automation. The hybrid system is created by the two fully coincident components – DSRC and GNSS/CN, which are connected to the central system through universal interface. The central system regards with both systems as to be one with the same functionalities.

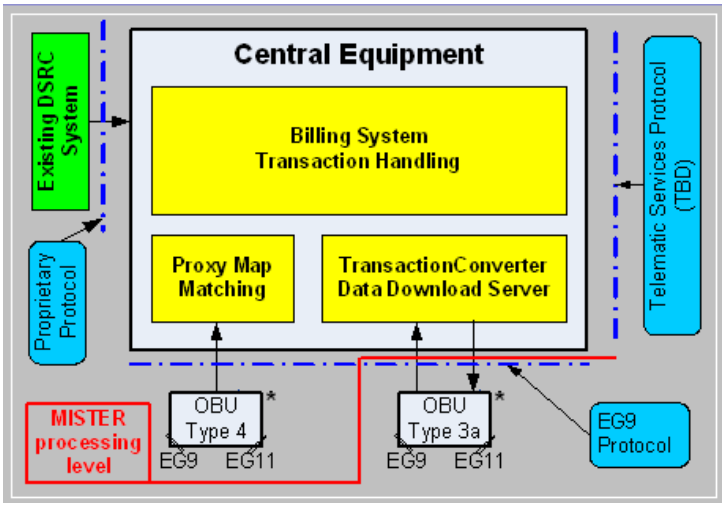

Fig. 1: The first solution presented by GC

The next points are only small parts of new system design worked out by expert group and authorized by the Ministry of Transport, ref. [1]:

- OBU shall work in the both modes – GNSS/CN, DSRC on bidirectional way;
- Central system could not limited arbitrary supplier of OBU;
- Central system taking and processing information from OBUs shall provide functions of evaluation and arbitration between equivalent data but transmitted by two different channels
- Central system has to have open and very well described interface for OBU´s different suppliers and for telematics functions.
- The future part of the system has to be based on the satellite navigation
- The redesign has to comply with European standards (even not accepted yet), e.g. EG9, EG11, MISTER etc.
- The price of the redesign has to be less than planned phases of DSRC system
- The redesign has to be modular using only one type of OBU unit
- The system architecture must be hierarchical with satellite system as a superior part

The basic idea is that charging system is not possible to see as an isolated system. Its benefit is multiplied if it is a harmonic part of open system of telematics services according to national and European ITS architecture.

Crucial time problem

As is possible to understand from the previous chapter the first drafts of first European GNSS/CN standards could be finished at the end of 2008 and the beginning of 2009. But it is still only beginning of approval of standard in the CEN where this process ends with voting of CEN countries. This process takes at least one year if there are no problems. It is possible to expect finishing of formal process in the CEN and publishing of standards as official document in 2011 knowing a processing of similar standards.

The problem of non-having GNSS standard is absolute crucial problem for the Czech Republic because the tender for III. stage of charging system for about 8 000 km roads is under preparation and it will be published this year.

4. SOLUTION HOW TO OVERCOME NON EXISTENCE OF STANDARDS

The worst scenario is that the Czech Republic will set up its own satellite system; the same will be in the Slovak Republic and Hungary. The quality and openness of interface will be only in the hands of suppliers and if there will be different we will have three incompatible EFC systems only in this region in 2009. Together with Germany and Swiss it could be in the worst scenario five incompatible systems. Harmonization of these systems will cost great amount of money if it will be even possible.

The expert group, being aware of this situation, has proposed to the Ministry of Transport the only probable solution. The solution is to prepare "de facto" standard describing data exchange only in one cross-section of the complex information chain between OBU and central system. One of possibilities which looks relatively simply is that definition of interface will be given by general supplier of the system. Supplier could define interface for different cutting of the chain, for example at a level of OBU as it is possible to see in Fig. 2a. Nevertheless this presumption is not too much realistic because supplier has to open its communication protocols for the third parties and it is not desirable for an arbitrary supplier.

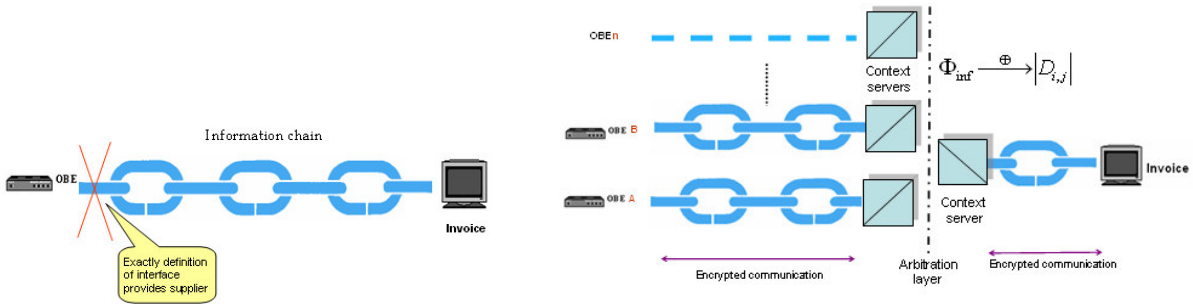

Fig. 2: a) Information chain; b) Interface open to the central system (right)

Much more realistic solution is possible to see in Fig. 2b. Information chain is interrupted near to the central system where it is possible to open data structure independently on supplier. Therefore it is necessary to plug context servers into information chain which transform encrypted data flow to open semantic form. Then it is possible to use different OBUs for example thick or thin clients for GNSS in combination with DSRC units. Important part of this solution is arbitration level, which control data

flows between different channels and it ensures that only one information from a few relevant information sources is valid. The idea could be expressed in symbolical form by equation

$$\Phi_{\text{inf}}^{n} \xrightarrow{\otimes(t)} \Phi_{\text{inf}} \xrightarrow{\oplus} \left| D_{i,j}^{p} \right|$$

where n means number of channels transmitting information, symbolic operator $\otimes(t)$ expresses functionality of the arbitration layer deciding which information from a set of n channels is valid. Symbolic operator $\oplus$ represents transformation of encoded data to database D created by p-dimensional matrix where ID, time, position, tariffs and all necessary information for charging are included.

The more detailed scheme of the hybrid system proposed for the Czech Republic is shown in Fig. 3. Data equipments delivered in the Phase 1, which is present DSRC system are connected to the central system by arbitration layer, see OSI reference model. This layer controls the data flows from OBUs of an arbitrary supplier to the central system.

The crucial point of the solution lies in the context servers, which are delivered by each potential supplier. The information chain delivered by a supplier starts by DSRC or GNSS (thick or thin) OBU and it is finished by context server. A context server transforms data to the form visible by the central system.

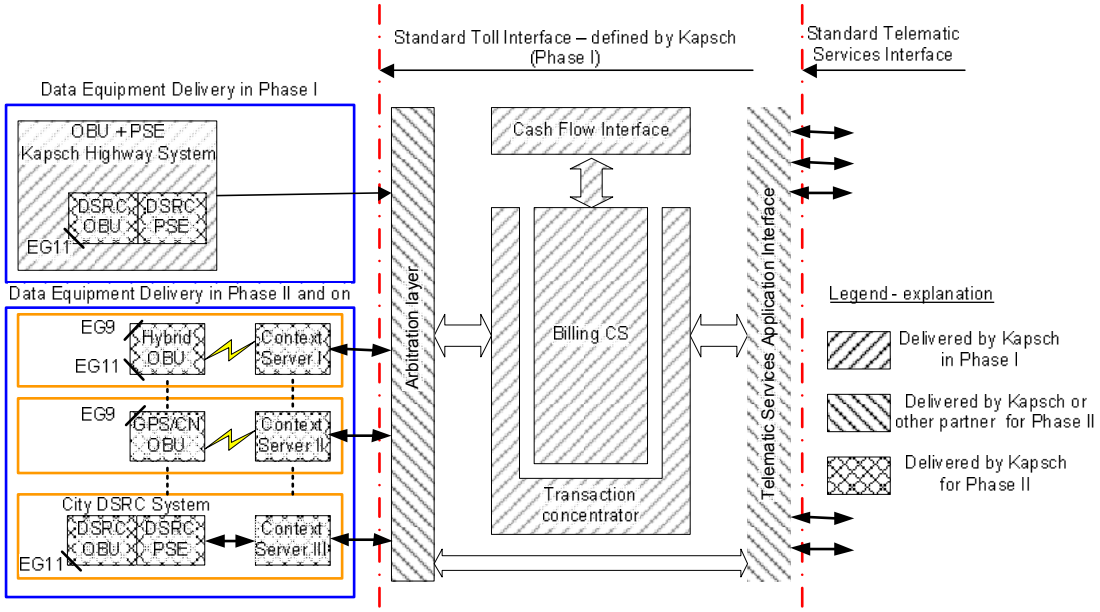

Fig. 3: Block scheme of the hybrid system designed as "universal" solution for the CEEC countries

5. CONCLUSION

Despite enormous effort of the European Commission the situation in the field of practical implementation of GNSS/CN is very critical due to lack of valid standards. The countries in the eastern part of Europe have published tenders for supplier of national EFC systems (the Slovak Republic and Hungary), the Czech Republic is going to publish tender in a few months. There is no valid standard orientated to the GNSS system at the present time and optimistic prognoses say that the first draft of necessary standard will be worked out in 2009. Next three incompatible EFC systems could rise up in the worst scenario.

Expert group working for the Ministry of Transport of the Czech Republic elaborated solution how to limit losses given by incapability by using "de facto" standard. It means that encrypted protocols of different suppliers will be interrupted at the central system level by context servers and arbitration layer. These components will work as a semantic interpreter whereby different OBUs of different suppliers could be used. This concept creates technical standard, which will be a part of tender.

REFERENCES

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