iTETRIS: SCENARIOS FOR SIMULATION OF REAL-TIME ROAD TRAFFIC MANAGEMENT SOLUTIONS OVER INTEGRATED WIRELESS COMMUNICATION AND TRAFFIC PLATFORMS

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Abstract—Wireless vehicular cooperative systems are an attractive solution to improve road traffic management. V2V-V2I communication technologies can improve traffic management through real-time exchange of data among vehicles and with road infrastructure. Field Operational Tests will get first insights into the benefits and problems faced by such cooperative traffic management strategies; there is yet the need to evaluate in long term and large dimension the traffic efficiency improvements. iTETRIS will be the first tool capable of addressing such dimensions. The aim of this paper is to present in detail the traffic management scenarios and strategies that will be supported by iTETRIS

Keywords—V2x communications, Simulation Platforms, Wireless Communications, Traffic Management Scenarios

Introduction

Mobility represents a key economical and social contribution to the development of modern and future societies. In particular, the close correlation between economic growth and increased movement - and, since 1945, the correlation between road traffic growth and economic growth - is seen as evidence of a close link between transport and the economy. The mobility importance on the economic development can in fact be observed through the fact that up to 40% of World Bank loans have been used on transport projects [1]. Transportation experts also argue that a transport improvement which reduces transport costs (through shorter journey times and lower vehicle operating costs) enables firms to sell their products more cheaply, which in turn stimulates greater demand, higher scale economies and results in a positive cost reductions and sales growth circle. A survey conducted among 12000 UK firms emphasized better transport and mobility as one of the top three future actions to prioritise in order to promote business competitiveness. Other interesting studies regarding UK roads also stressed that mobility time savings lead to productivity gains which in turn enhance growth [1].

Currently, it is estimated that there are still over 40.000 road fatalities on the 25 European Union roads every year, with 1.4 million accidents with a cost of around 200 billion €/year representing 2% of the EU GDP [2]. Moreover, according to DG TREN (Directorate-General for Energy and Transport) not only the number of cars per thousand persons has increased from 232 in 1975 to 460 in 2002 (with an increase of 3 million cars each year), but also the overall distance travelled by a European citizen has passed from 17 kilometres a day in 1970 to 35 km nowadays [3]. These facts, together with the 35% increase in road freight volume, have contributed to 7500 km or 10 % of the network being affected daily by traffic jams. The current mobility saturation is affecting not only the traffic safety but also the economical productivity, the efficient consumption of energy, and the environment. According to estimates from the European Commission, road transport consumed in 2002 represents approximately 26% of the total energy consumption in the EU (equivalent to 281 MToe - million tonnes oil equivalent), resulting in 835 million tonnes per year CO_2 emissions (85% of the total transport emissions). Transport energy demand in 2030 has been projected to be 21% higher than in 2000 [4]. Mobility has also been linked to the climate change problem with estimates that transport's share in greenhouse gas emissions, already accounting for 28% of greenhouse gas emissions in 1998, is likely to rise 50% between 1990 and 2010. Within this context, experts believe that road traffic generates 84% of emissions attributable to transport [3]. This is despite the European Union commitment in the Kyoto Protocol to reduce its greenhouse gas emissions by 2008-2012 by 8% as against their 1990 levels. Fortunately such important energy consumption, and its corresponding environmental pollution, could be further reduced given that up to 50% of fuel consumption is caused by congested traffic situations and non optimal driving behaviour [2].

In this context, road traffic congestions can represent a serious risk for Europe to loose economic competitiveness. In fact, the European Commission estimates that road traffic congestions costs currently amount 50 billion € per year or 0.5 % of Community GDP, with an estimate to increase to 1% by 2010 if the current situation persists [5]. Moreover, a majority of European citizens live in urban areas where there is a significant increase in demand for mobility of both people and goods. Given that urban environments do not generally allow for building additional roads to tackle the increased mobility demands, urban scenarios represent a challenge environment to deal with. In fact, in the next few decades, more "intelligent" and "cooperative" strategies to manage the urban scenario, employing novel technologies will be the preferred approach to maintaining, or even increasing, the economic and social welfare. In particular, some studies have estimated that additional capacities in excess of 20-30% can be realised by more effective use of existing road space using innovative traffic management techniques [6].

Despite the clear current and future mobility's economical and social impact, the current increase in number of vehicles and the higher mobility frequency is creating new problems and challenges that need to be holistically addressed to ensure safe, sustainable, efficient and environmentally friendly mobility systems. However, currently European ICT and Transport industry lack of a common, modular, pan-European, open and standardized platform where novel ICT-based traffic management solutions can be evaluated through intensive computing simulations over large areas, given duly consideration to the multiple aspects that are relevant to this issue – wireless communication environment, urban layout, traffic management policies, energy, environment. Therefore, iTETRIS (http://www.ict-itetris.eu) will leverage such platform and thus novel cooperative ICT solutions will be evaluated in unprecedented ways providing a completely new perspective to this field of activity.

The iTETRIS vision is to create a long-term (beyond the project development), global, sustainable, open, vehicular communication and traffic simulation platform facilitating large scale, accurate, multidimensional evaluation of cooperative ICT solutions for mobility management in order to increase European industry competitiveness and economic, social and environmental wealth.

Scope

As it will become apparent in the next Sections, the novelty of the iTETRIS platform lies mainly on four main pillars with the following distinct features:

- Development of a unique simulation platform
- Delivery of a highly accurate open-source evaluation platform
- Reliable and contextually dynamic vehicular communication protocols
- Self-configuring, granular, real-time, traffic management policies.

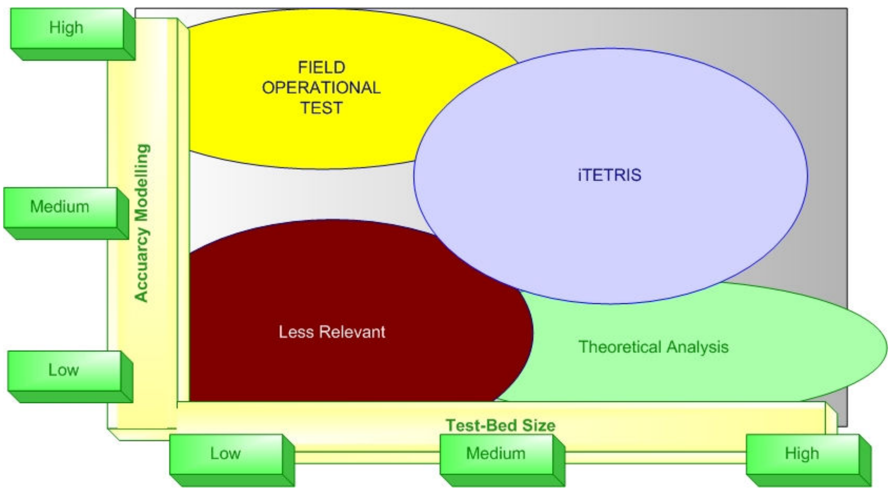

Figure 1 – Scope of iTETRIS Tool

The Figure above illustrates how iTETRIS covers an existing gap in the area of cooperative ICT-based traffic management R&D through its integrated wireless and traffic simulation platform. iTETRIS will bridge the gap between the low-medium modelling accuracy and medium-large test-bed size characteristic of theoretical analysis and the high modelling accuracy low-medium test-bed size characteristic of Field Operational Tests. Thus, iTETRIS will permit high modelling accuracy large test-bed size scenarios to be effectively addressed. This gap is very important for industry as it is necessary to carry out this sort of experiments to fully examine the potential of the technology before a massive role out is realised.

iTETRIS will permit that never before studied large-scales situations are considered in close to “real” conditions, that robust holistic traffic management solutions are developed taking full consideration of wireless, energy, pollution and networking constraints and that a deep understanding is built around V2V and V2I cooperative strategies to address the particular needs of gradual penetration of ICT-based traffic management solutions and low density V2V communication system population. This is especially important in early stages of market introduction where safety critical applications cannot be realized. Therefore, iTETRIS focuses on traffic efficiency applications that already show beneficial effects with low penetration rates and constantly improve with increasing penetration rates. Examples are V2I adaptive traffic lights and variable message signs as well as cooperative navigation and green light speed advisory.

iTETRIS Traffic Scenarios

In order to address the needs of such R&D initiative, a number of traffic scenarios need to be proposed. The use of such traffic scenarios is twofold:

- On one hand it allows that the particular problems faced by road traffic management authorities could be defined and exemplified.
- On the other hand, they provide a reference situation, which can serve to propose traffic management applications and to evaluate the improved performance of cooperative ICT traffic management solutions in a real situation.

iTETRIS has closely collaborated with the City of Bologna to address a sufficiently ample set of traffic situation that encompass the mostly common needs of traffic management authorities. Thus, iTETRIS proposes 4 scenarios which are common enough to represent the needs of most European cities.

Description of the geographical location

Bologna is the main town of the Emilia-Romagna Region and centre of the most ancient University of Europe (XI century), Bologna is an important interchange city in Italian national transport networks because it represents an obliged passage between North and South Italy. First Etruscan centre, then roman colony and free municipality during the middle age, the city of Bologna has got a very evocative historical centre, one of the best conserved in Europe, that attracts many tourists during the year. The city has an important Fair centre and one of the biggest universities in Italy.

Demographic structure and mobility profile.

The resident population in the city today is about 374,000 (the municipality area is 140,85 km2), while the metropolitan area, which extends to the neighbouring towns, more pertinent from the mobility’s point of view, counts nearly 600,000 residents. There are about 180,000 local workers in the municipal area, while the daily city users are around 300,000. The result of this demographic structure is that traffic flows within the network are very heavy and include:

- very short trips within the city;
- short distance trips among the main city and the towns belonging to the same province;
- medium distance trips taking place within the regional network of cities;
- long distance through traffic with areas outside the region.

The actual traffic plan and the future goals

The Master Plan of the Urban Traffic (PGTU) is a short-term planning instrument. In line with Ministerial directives, it aims at "improving traffic conditions and road safety, reducing noise and air pollution and achieving energy savings, in compliance with current urban planning instruments, with transport plans and having respect for environmental values" . The PGTU has a temporal horizon of 4 years, while regarding longer-term actions the Municipal Structural Plan foresees large-scale infrastructural works for collective transport (such as Metro-Tramway, new Railway Station, Optical guided Trolley-bus, monorail from airport to Railway Station) However, the PGTU will take into account the critical situations which the worksites for these large-scale undertakings will inevitably create.

In defining this Plan, account has been taken of the main critical issues (pollution, accidents, congestion) which daily affect citizens' lives, reflecting negatively on health, safety and quality of living; After analyzing them the Municipality of Bologna proceeded to quantify the goals to be achieved and to identify actions capable to provide effective solutions to the various problems and an overall improvement of citizens' quality of life. The interlinked developments intend to ensure sustainable and widely-available accessibility to all parts of the city. The context for this will be an increase in public transport and cycle-lanes, while safeguarding the most valuable environmental and architectural zones, but also an optimisation of motorised traffic flows especially through the improvement of ITS instruments.

Goals of the traffic plan

- To improve road safety
- To increase public transport and reduce private vehicles
- To encourage a more eco-compatible stock of vehicles
- To reduce air and noise pollution
- To achieve widely-available but sustainable access
- To save energy in the transport sector

Based on the descriptions above, the city of Bologna has been selected within the iTETRIS project for evaluation. iTETRIS should be able to demonstrate how the improvement actions that are part of the City of Bologna PGTU could be better operated with the support of cooperative ITS. Bologna is especially amenable to such cooperative strategies and a number of scenarios have been selected to exemplify very relevant problems. iTETRIS will permit that the effectiveness of new strategies are analysed in terms of mean travel times and other traditional metrics. However, it will be also possible to assess the impact on CO_2 emissions to ensure eco-friendliness of the strategies.

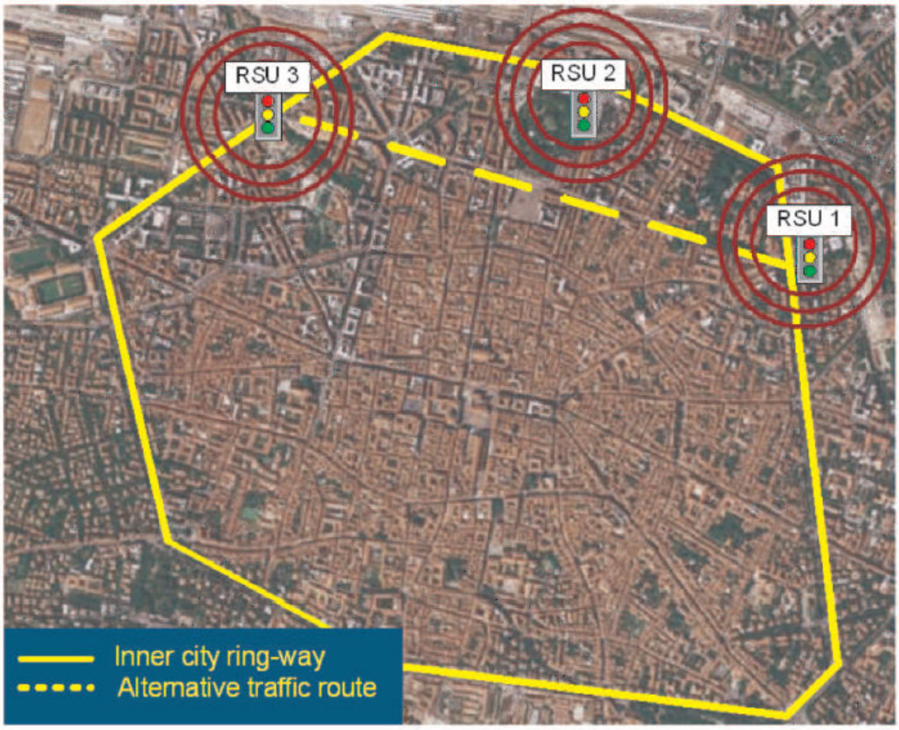

Figure 2 – Inner City ring Scenario

Bearing all these features in mind the following 4 traffic scenarios have been proposed.

- City Stadium. This scenario describes the traffic conditions when particular events take place in the city, e.g. football match.
- Open Market Fair. This scenario has characterised the traffic conditions when road traffic is modified due to open market fair takes place in the city centre.
- Inner City Ring. This scenario covers the inner city ring situation. The scenario can be visualised below.
- Orbital + Highway. This scenario permits the analysis of traffic management to access the city centre from the orbital and highway streets that surround the various entrances to the city.

Figure 2 illustrates a scenario where communication equipment (RSU, Road Side Units) has been placed at each intersection. Such elements gather information that is being transmitted by the vehicles. Moreover, each RSU can also transmit traffic related information to the vehicles and the Traffic Management Center (TMC). Such information (speed, acceleration, direction and vehicle position) can be collected through any relevant wireless communication (WAVE, UMTS, Wi-Max or DVB-H). iTETRIS permits that the effect of communications is properly characterised and the impact of "realistic" communications shortcoming into the traffic management strategies implemented can be made apparent. Through the information the TMC has updated and precise knowledge of the traffic conditions all along the inner city ring-way. Thus, as congestion is detected close to RSU2 it could recommend vehicles closet o RSU1 to take alternative routes towards RSU3 following the dotted line. It is worth noting that through V2I individualised information can be transmitted to the vehicles so that messages and strategies become more effective.

The set of scenarios present both representative situations for traffic congestion situations and different traffic dynamics. Furthermore, the scenarios also permit that intelligent re-routing and advanced Traffic Light Control algorithms could be proposed relying on advanced communication features. With the final objective of demonstrating the impact of V2I communications on cooperative ITS iTETRIS has proposed a number of Use Cases that could serve to handle effectively the traffic conditions presented by the 4 traffic scenarios above. The Use Cases have been defined so that both traffic estimation conditions and traffic management could be addressed.

	Use Case	Description
Traffic Condition Estimation Strategies	UC1 – Traffic Congestion detection	UC1 aims at detecting traffic congestion situations in a distributed manner, i.e. without making use of the communication infrastructure – RSU. Periodic message Exchange between vehicles is used to create accurate representation of traffic context and through advanced algorithms traffic congestion conditions could be extracted.
	UC2 – Travelling time Estimation	The objective of UC2 is to estimate through centralised means the transit times of each street or segment of interest in a scenario. Each RSU collects data through V2I and will send it to the TMC for operation of the traffic
Traffic Management Strategies	UC3 – Public Transport Lane Management	V2I communications will be employed in this third UC3 to detect in a centralised manner congestion situations and allow temporally the use of public transport lanes to private vehicles.
	UC4 – Restricted Access to Prioritised Vehicles	UC4 aims at the evaluation of traffic management strategies that would allow Access to city centre street to vehicles with high occupancy and/or low emission vehicles such as electric cars
	UC5 – Optimum route recommendation	UC5 is one of the use cases devoted to demonstrate the improvement of traffic efficiency. Vehicles request the TMC the best possible route for their destination. The TMC provides the optimum route in a personalised way. As a function of the information gathered through V2V-I2V, each vehicle decides the best possible route in a distributed manner.
	UC6 – Maximum speed limit information and dynamic traffic light adaptation	UC6 covers the management of crossing operated by traffic light control algorithms..As a first approach through I2V each vehicles receives information about the optimum speed to follow so that the car will get to the traffic light in green. As a possible enhancement the project will evaluate how the traffic light control algorithm could also adapt to the varying traffic congestion situations.
	UC7 – Emergency Vehicle Prioritisation	V2I communications will permit in UC7 that vehicles inform the RSU that an emergency vehicle is approaching. Traffic lights will change their phases so that the flow of the emergency vehicle could be prioritised. Public vehicles could also be informed about such event and they could cooperate to improve the progress of the vehicle in the middle of the traffic.

Table 1 – iTETRIS Use Cases

CONCLUSIONS

This paper has presented the EU project iTETRIS devoted to develop of a tool capable of analysing the benefits of cooperative communications for intelligent traffic management solutions. iTETRIS works on the development of an open platform where both traffic and wireless communications can be properly modelled. Bologna has been selected as the city for large scale evaluation of the traffic management strategies. The article has presented the 4 traffic scenarios considered and the use cases that have been derived to improve the traffic conditions in the scenarios proposed through cooperative ITS solutions. Once completed, as exemplified by the 7 Use Cases presented, iTETRIS will permit that individualised traffic management strategies could be analysed accurately based on the particular city structure and communication facilities deployed therein.

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REFERENCES

[1] "Transport and the economy: full report (SACTRA)", Department for Transport, UK Government.

[2] "On the Intelligent Car Initiative: Raising Awareness of ICT for Smarter, Safer and Cleaner Vehicles", Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions, Brussels, 15.2.2006, COM(2006) 59 final.

[3] "Energy and Transport. Report 2000-2004", Directorate-General for Energy and Transport, European Commision, 2004.

[4] "European energy and transport – Trends to 2030 - Update 2005", Directorate General for Energy and Transport, May 2006.

[5] "WHITE PAPER — European transport policy for 2010: time to decide", European Commission, 2001.

[6] Green Paper on urban transport, "Public transport, intermodality and intelligent transport", Third Technical Workshop, Hungary, 7 March 2007.