iTETRIS: An Integrated Wireless and Traffic Platform for Real-Time Road Traffic Management Solutions

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***Abstract*— Wireless vehicular cooperative systems have been identified as an attractive solution to improve road traffic management, thereby contributing to the European goal of safer, cleaner, and more efficient and sustainable traffic solutions. V2V-V2I communication technologies can improve traffic management through real-time exchange of data among vehicles and with road infrastructure. It is also of great importance to investigate the adequate combination of V2V and V2I technologies to ensure the continuous and cost-efficient operation of traffic management solutions based on wireless vehicular cooperative solutions. However, to adequately design and optimize these communication protocols and analyze the potential of wireless vehicular cooperative systems to improve road traffic management, adequate testbeds and field operational tests need to be conducted.**

Despite the potential of Field Operational Tests to get the first insights into the benefits and problems faced in the development of wireless vehicular cooperative systems, there is yet the need to evaluate in the long term and large dimension the true potential benefits of wireless vehicular cooperative systems to improve traffic efficiency. To this aim, iTETRIS is devoted to the development of advanced tools coupling traffic and wireless communication simulators.

***Index Terms*—V2x communications, Simulation Platforms, Wireless Communications**

I. 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 12.000 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 7.500 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 CO2 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 behavior [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 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.

II. 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.

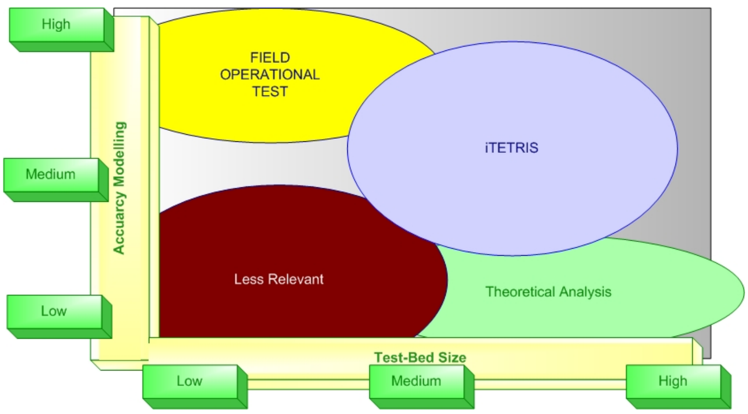


Figure 1 – Scope and novelty of iTETRIS

Figure 1 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.

III. iTETRIS Large Scale Simulation Platform

A. *iTETRIS and V2x Communication Initiatives*

European research activities with regard to cooperative systems started under the 6th Framework program where first projects looking at the potential of vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication were launched. However, to keep progressing on the development and implementation of wireless vehicular communication technologies, further research is needed to evolve from basic conceptual models towards integrated systems enabling functional testing and validation under realistic and large scale situations.

The development of ICT cooperative systems are yet at their earlier stages. The current work needs then to be evolved to more technological advanced solutions adequately optimized considering realistic conditions and end-user applications. The research needs also to be reinforced with actions demonstrating the benefits of cooperative systems and how they should be optimally used to maximise such benefits. FP7 is currently launching Field Operational Tests (FOT) to assess in real environments the impact of ICT-based Intelligent Car systems based on driver behaviour and on driving dynamics. Such FOTs would also be crucial to estimate the costs and benefits of the Intelligent Cars concept. Although extremely useful, FOTs will yet not be able to provide large-scale indications covering, for example, complete cities. These large scale evaluations are particularly critical as some insight needs to be built around the best traffic management strategy to deploy.

iTETRIS will address issues not yet being addressed in current research activities in a common research framework. In particular, iTETRIS addresses four important and distinct challenges combined under a single platform: (a) traffic and wireless integrated open-source platform, (b) large scale trials, (c) realistic V2V and V2I communication networking, and (d) dynamic, distributed and self-autonomous traffic management policies.

This Section reviews the existing V2x initiatives so that the impact of iTETRIS can be fully understood.

C2C-CC (Car 2 Car Communications Consortium) - http://www.car-to-car.org/. The CAR 2 CAR Communication Consortium (C2C-CC) is a non-profit organisation initiated by European vehicle manufacturers, which is open for suppliers, research organisations and other partners. The CAR 2 CAR Communication Consortium is dedicated to the objective of further increasing road traffic safety and efficiency by means of inter-vehicle communications. In this context, the C2C-CC aims to create and establish an open European industry standard for CAR 2 CAR communication systems based on wireless LAN components and to guarantee European-wide inter-vehicle operability, while pushing the harmonisation of CAR 2 CAR Communication standards worldwide.

It is important to emphasize that the iTETRIS architecture is in-line with the wireless vehicular cooperative research approach challenges described by the C2C-CC in its Manifesto. The manifesto summarizes and describes the main building blocks of the CAR 2 X Communication System as it is pursued by the consortium.

In this context, C2C-CC stresses the need to further research the network and transport layers in the C2C-CC Protocol Stack that are in fact addressed within iTETRIS in the case of dynamic, distributed and self-configuring traffic management schemes. The C2C Communication System also considers both receiver-centric and sender-centric dissemination of information, and a possible hybrid approach of packet-centric and information-centric information dissemination. C2C-CC also clearly indicates that different approaches need to be considered within dense and sparse traffic densities. In the case of dense traffic conditions, the C2C-CC identifies the need to control the wireless channel bandwidth while developing and operating the communications protocols. On the other hand, sparse traffic environments, representing low traffic density scenarios or a gradual introduction of V2V communication capabilities, would probably need enhanced forwarding strategies where messages will be cached or repeated. Both scenarios are considered within iTETRIS, the last one being addressed through the development of DTN policies and the integration of V2V and V2I communication units.

According to the C2C-CC, the vehicular cooperative transport protocols will not only have to deal with the packet losses, short connection durations and long round trip times of traditional ad-hoc networks, but will also have to carefully consider the highly varying path characteristics of the vehicular environment and its significant resulting transmission errors. Consequently, adequate network and transport research will have to go beyond current stage and consider its design, evaluation and optimisation in realistic scenarios accurately considering the radio transmission characteristics.

In the design of the wireless vehicular cooperative communication protocols, the C2C-CC has identified various key aspects specific for vehicular environments that need to be addressed in future wireless vehicular communications research. iTETRIS represents a C2C-CC complimentary research activity since it addresses such needs through next generation routing protocol and data distribution strategy research.

CVIS (Cooperative Vehicle-Infrastructure Systems) - http://www.cvisproject.org. The CVIS project aims to develop and test new technologies to allow road vehicles to communicate with any nearby roadside infrastructure. Based on such real-time road and traffic information, CVIS will develop novel applications for road safety and efficiency, and reduced environmental impact. Similar to iTETRIS, CVIS places a strong emphasis on the development of an open system architecture connecting in-vehicle and traffic management systems and telematics services at the roadside. As an Integrated Project, CVIS scope is much wider than iTETRIS, which is more focused.

With respect to **CVIS,** several distinctive and complementary iTETRIS features can be identified. The iTETRIS communication networking research will be based on the CVIS communications and system architecture, and the proposed protocols. However, iTETRIS will concentrate on advancing and optimising V2V and V2I communication networking protocols using the unique integrated iTETRIS simulation platform capable of accurately modelling the radio conditions and the interaction between vehicular cooperative systems and traffic flows. iTETRIS will also closely look at the role to play by road side infrastructure in disseminating and forwarding data within the vehicular network. Through this data, iTETRIS will also work on dynamic, distributed and self-autonomous traffic management solutions that will be complementary to the specific management use cases considered within CVIS. Finally, iTETRIS does not target specific scenario but aims to consider a large-scale traffic management approach to globally understand and study to which exchange the combined V2V and V2I communication capabilities can improve traffic management, and how they should best be combined to achieve such improvements.

SAFESPOT (Cooperative vehicles and road infrastructure for road safety) - http://www.safespot-eu.org/. SAFESPOT is an IP project aimed at preventing road accidents developing a Safety Margin Assistant that detects in advance potentially dangerous situations and that extends in space and time drivers´ awareness of the surrounding environment.

While SAFESPOT and iTETRIS have clear different objectives, both projects can be regarded as technologically complementary given that they are both based in V2V and V2I cooperative communication systems. In particular**,** iTETRIS can benefit from the developed SAFESPOT communications architecture and investigated ad-hoc networking techniques, while SAFESPOT can benefit from the integrated iTETRIS wireless and traffic platform and the advanced research, derived from the availability of the iTETRIS platform, in terms of networking and V2V/V2I integration schemes.

PRE-DRIVE. The PRE-DRIVE-C2X aims at developing a detailed system specification and a working and functionally verified prototype for inter-vehicle and vehicle-to-infrastructure communication that is robust enough to be used in future field operational tests of cooperative systems. Furthermore PRE-DRIVE-C2X develops an integrated simulation tool set for cooperative systems, which enables an integrated approach for estimation of the expected benefits in terms of safety, efficiency and environment. It will serve to evaluate systems under development and thus support the development process by providing a tool set for functional verification and testing of prototypes under realistic conditions; this holds for the development of both, the application and the communication systems including hardware and software

Whereas PRE-DRIVE-C2X concentrates its work more on an integrated tool set for testing and verification of Vehicle-2-X prototypes, iTETRIS has a more specific usage scenario, i.e. the in-depth analysis of large-scale traffic management by utilising Vehicle-2-Vehicle and Vehicle-2-Infrastructure communication. iTETRIS platform will be a useful tool to evaluate and test the cooperative system impact to traffic flow during different deployment stage. These resulted evaluation information will serve as important information for different stakeholders (public authorities, service providers, highway operators etc) for deployment strategy definition; while PRE-DRIVE-C2X will prove the technical feasibility and consolidate system architecture by demonstration and field site test using developed prototype.

GeoNet. The GeoNet Project aims at developing a reference set of implementation specifications of a geographic addressing and routing (geo-networking) protocols for vehicle to vehicle and vehicle to infrastructure communication systems, ensuring the support for IPv6. This implementation will be usede target is to support applications of Cooperative Systems, mainly active safety applications since Geo-networking is the key function required but such applications; on the other hand, with its interface withsupporting IPv6, non-safety applications such as traffic management and traffic information are also supported. The Another target of GeoNet isGeoNet is to develop, standardize andprovide 2 implementations with a geographic addressing and routing IPv6 compliant networking module.

SMART-NETS (Signal MAnagement in Real Time for Urban Traffic NETworkS) - http://www.smart-nets.napier.ac.uk. SMART NETS addresses urban traffic management via the use of new-generation signal control strategy TUC (Traffic-responsive Urban Control) that employs advanced automatic control methodologies to avoid the drawbacks of conventional UTC systems. The aim of the EU project was to quantify to which degree TUC technologies could improve saturated traffic conditions compared to other more adaptive traffic control solutions (in particular TASS - Traffic Actuated System Control Strategy, SCOOT and BALANCE). The type of studies conducted in SMART-NETS, and addressed in iTETRIS with regard to wireless vehicular cooperative systems, are clearly needed to truly estimate the potential benefits derived from a new ITS solution that will then help to promote its wide scale adoption. As a result, both projects considered the participation of end-users, in this case road traffic management authorities, although iTETRIS provides a stronger focus on communications and simulation modelling given the complexity involved in the analysis of wireless vehicular cooperative systems compared to technologies such as TUC.

COOPERS (CO-OPerative SystEms for Intelligent Road Safety) - http://www.coopers-ip.eu/. COOPERS provides vehicles and drivers with real time local situation based, safety related traffic and infrastructure status information distributed via dedicated Infrastructure to Vehicle Communication link (I2V). This approach extends the concepts of in vehicle autonomous systems and vehicle to vehicle communication (V2V) with tactical and strategic traffic information which can only be provided by the infrastructure operator in real time.

iTETRIS can be clearly identified as a complementary project to COOPERS in the sense that it extends the traffic management capabilities through the inclusion of V2V communications. Although iTETRIS traffic management can also benefit from the intervention of road traffic operators, iTETRIS extends the traffic management concept to a possible self-configuring and autonomous traffic management derived from the real-time data extracted from V2V and V2I communications. Another complementary aspects of iTETRIS and COOPERS is the possibility to allow for a personalised traffic management information thanks to the V2I communication capabilities. This approach considerably improves current solutions employing road signalling units that can only communicate on a location group basis.

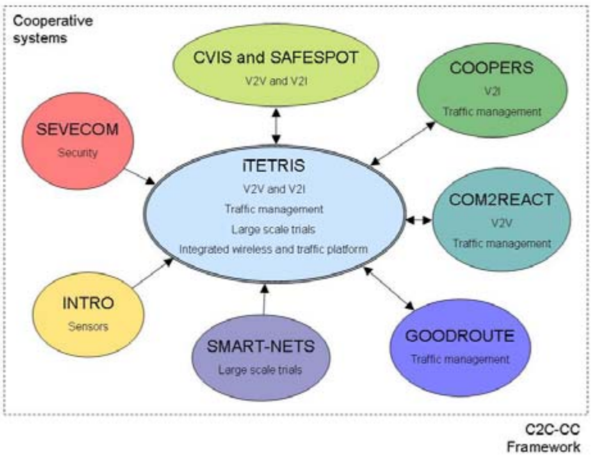
COM2REACT (COoperative CoMmunication System TO Realise Enhanced Safety And EffiCiency In European Road Transport) - http://www.com2react-project.org/. COM2REACT is based on a multi-level, scalable cooperative system involving two-way vehicle to vehicle (V2V) and vehicle to center (V2C) communication, designed to facilitate improvements in the flow of information acquired by moving vehicles, its quality and reliability. Rather than considering the COM2REACT intermediate medium control level, iTETRIS is based on a more distributed, autonomous and self-configurable traffic management approach. In terms of V2I, while COM2REACT considers this communication channel to transmit and receive data from a traffic control center, iTETRIS also envisions its application as an important relaying link in low density environments or as the V2V communication capabilities are gradually increased. Also, iTETRIS considers both V2V and V2I communications in the ad-hoc networking functionalities. A further distinctive iTETRIS feature is the design an optimisation of the adequate V2V and V2I communication protocols for efficient, dynamic, distributed and self-autonomous traffic management policies using the unique open-source integrated traffic and wireless iTETRIS platform.

MORYNE (Enhancement of public transport efficiency trough the use of mobile sensor networks) - http://www.fp6-moryne.org/. MORYNE aims to improve transport efficiency and safety through the development of Local Road Traffic Management Systems (LRTM) using public transport vehicles (e.g. buses) as elements of a network of mobile sensors, communicating with the infrastructure. Using such vehicles the The MORYNE approach is complementary to iTETRIS, since iTETRIS expands the data collection capability to all types of vehicles. Also, although an interaction with a Traffic Management Centre can be foreseen within iTETRIS, iTETRIS also addresses the possibility of self-management distributed traffic management policies. Finally, the MORYNE vehicles collecting data generally reduces its applicability to urban and sub-urban areas, while iTETRIS technology is applicable to all type of scenarios.

GOODROUTE (Dangerous Goods Transportation Routing, Monitoring and Enforcement) - http://www.goodroute-eu.org. GOODROUTE addresses the monitoring and re-routing of dangerous goods vehicles through the dynamic data collection and fusion achievable from V2V and V2I communications and a series of on-board sensors. The project also considers enforcement and driver support while seeking to develop a safe but economically sustainable dangerous goods transportation framework. In this context, GOODROUTE and iTETRIS can be seen as complimentary because of the common consideration of V2V and V2I communication technologies, and the development of rerouting schemes. However, GOODROUTE only considers a type of vehicles and is not aimed at defining overall efficient traffic management solutions. On the other hand, iTETRIS extends GOODROUTE's framework and complexity by considering innovative traffic management policies (including re-routing schemes) in a complete urban traffic network.

COVER (semantic driven cooperative vehicle infrastructure systems for advanced eSafety applications) - http://www.ist-cover.eu. COVER is targeting European car drivers with user-friendly, cost-effective, interoperable semantic-driven cooperative systems able to gain road transport efficiency as well as implement advanced eSafety applications.

COVER is then focused on cooperative applications, and can be regarded as a complementary research project with respect to iTETRIS that concentrates more on the underlying technologies, their adequate study and modelling, and their configuration and optimisation under various operating environments.



INTRO (Intelligent roads) - http://intro.fehrl.org/. The INTRO project was created to address the problems of road safety and capacity by combining sensing technologies and local databases with real-time networking technologies. INTRO places a strong emphasis on the complementing role of sensing technologies with regard to new wireless vehicular cooperative systems and into data fusion mechanisms (infrastructure or car based) to improve real time safety and performance indicators estimation and prediction. This technological approach significantly differs from the iTETRIS one (in particular, it requires deployment of additional road sensors) but represents an attractive complementary solution to that to be investigated within iTETRIS.

SEVECOM (Secure Vehicular Communication) - http://www.sevecom.org/. Sevecom addresses security in wireless vehicular cooperative systems, including both the security and privacy of V2V and V2I communications. Although iTETRIS will not address security aspects, it would closely follow security developments within Sevecom due to the impact of security signalling overheads on the performance of the V2V and V2I communications protocols within the iTETRIS work. In fact, security mechanisms can increase the channel load and transmission latency, which are important aspects to consider in road traffic management applications and in self-autonomous distributed communications systems.

B. *iTETRIS features*

Through the use of wireless vehicular communications, cooperative systems will be able to assist the driver in the driving functions providing dynamic, ubiquitous and real-time traffic information that will reduce congestions, optimise travel journey's and reduce energy consumption and therefore environmental solution.

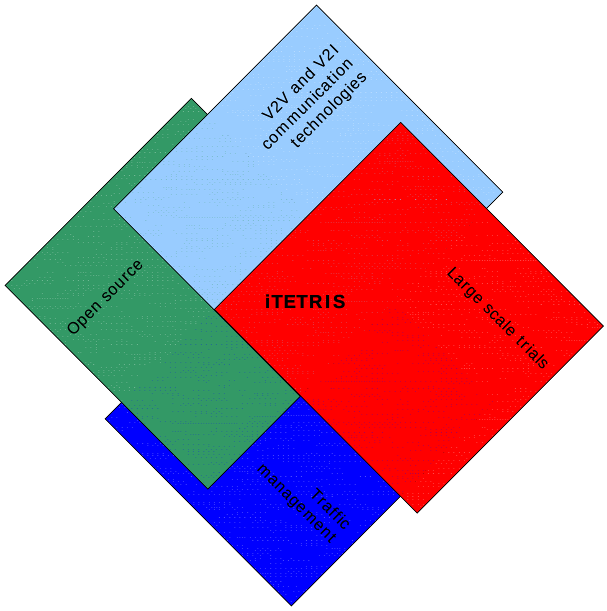


Figure 1 – iTETRIS Challenges

Despite the obvious advantages, currently only a fraction of the potential of such support systems is being utilized. To move such support to new levels, as illustrated in Figure 1, it is necessary to **address systemic challenges** from various knowledge fields. ITETRIS addresses the challenges below in the context of SUMO and ns-2 platforms to support accurate V2x wireless communication systems.

- **Instruments for large scale V2V and V2I cooperative ICT capabilities investigation.** Although some wide Field Operation Tests are being planned and put in place either as a European initiative or a countrywide test-bed, there is no large-scale identification as to which extend wireless vehicular communications can help alleviate traffic management problems. One may argue that for evaluating the impact of cooperative systems on traffic safety, very large scale test-beds are not needed. However, in order to truly estimate the potential benefits of cooperative systems in terms of traffic mobility and management, and more importantly to understand how both V2V and V2I communication capabilities need to be exploited to maximize the benefits of these novel technologies such large scale scenarios are key. Hence, under the current scenario scalability issues, cascading effects and the potential of relevant technologies is currently being underestimated and undermined.

As illustrated by Figure 2, a step beyond current state of the art is needed to permit large-scale evaluation studies, indispensable before cooperative ICT solutions can be largely adopted by industry and their potential leveraged.

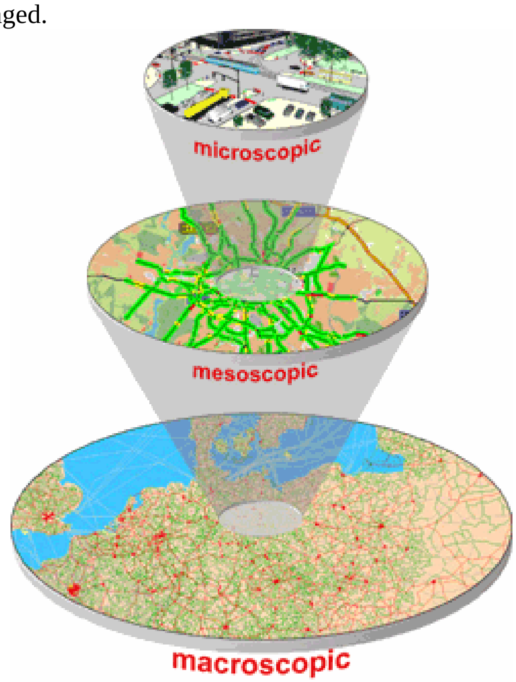


Figure 2 – Level of analysis reached by existing approaches vs. iTETRIS ambitions

- **Integrated standardised open-source traffic and wireless simulation platforms.** Although some commercial, scope-limited, proprietary tools exist, there is no open source platform that addresses in a common, integrated architecture the varying needs in terms of urban layout, traffic and wireless communication modeling with the required level of modularity and detail.

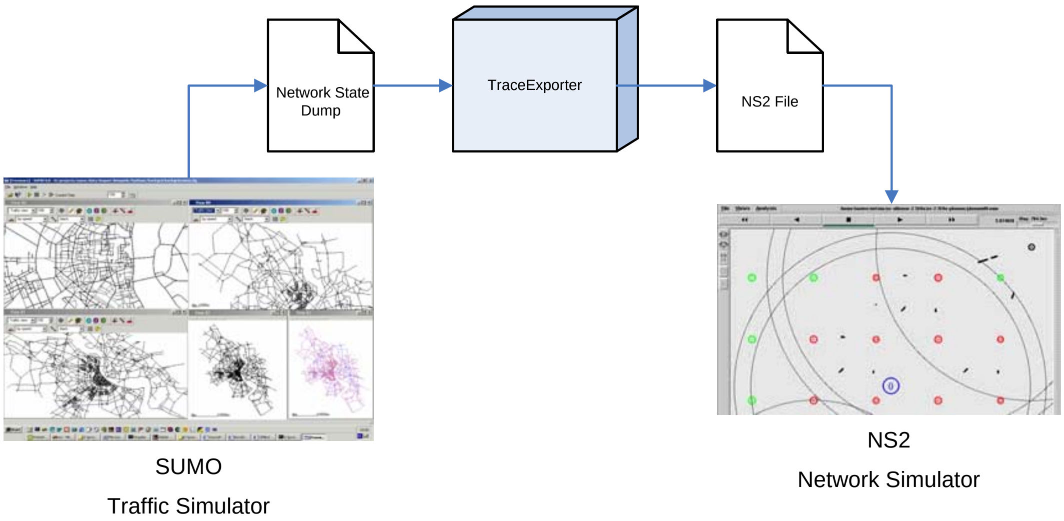


Figure 4 –Limited un-coupled V2x simulation environments

It is needed to progress from nowadays domain specific, inflexible, cumbersome tools and platforms into a fully systemic framework where innovative tailored solutions can be devised, swiftly developed, integrated through standard interfaces supported by well-defined Software Quality Assurance methodologies and the impact of inter-domain domain decision cross-correlation fully evaluated and visualized.

- **Next generation reliable and contextually dynamic vehicular communication protocols.** Although some approaches have been made in terms of developing efficient data distribution and routing mechanisms, the proposed solutions focus mainly on the networking aspects with little consideration to traffic management policy aspects, vehicular contextual definition, impact of radio medium transmission characteristics and are technology-driven rather than user-requirement driven. As a result, the protocols and cooperative solutions significantly underperformed when confronted with "real" situations since they only partially address the complexity of the managed scenarios.
It is needed so that a consistent multi-dimensional concept for vehicular situational awareness is built – networking & traffic condition perspective; and on the other hand a next generation of reliable, fast data distribution, routing and networking algorithms emerge from this decentralized and autonomous situational perception, ensuring continuous optimum application and system performance irrespective of the discontinuous availability of supporting infrastructure, vehicle dynamic concentration, and radio link congestion.
- **Self-configuring, granular, real-time, traffic management policies.** Although traffic management policies have been extensively investigated, the background for such policy development is based on the fact that the policies would be implemented from a central control unit that drives the traffic process. However, this approach does not exploit the fact that through cooperative ICT, traffic management policies can be devised so that they reach a new degree of scale and granularity. Current systems do not permit that traffic management policies are implemented on small group level or even at an individual basis, which limits the level of effectiveness they can reach both in terms of congestion alleviation, pollution and energy efficiency. It is needed that hybrid approaches (central traffic management center guidance and local unit refinement) autonomous, dynamic, small-group level, self-configuring and real-time traffic management schemes are defined to redistribute traffic flows ensuring minimum global journey times, fuel consumption and pollution. Moreover, as indicated above, current traffic management simulation platforms need to be augmented with accurate models in terms of energy efficiency and pollution so that these

dimensions can be included in the overall system optimisation.

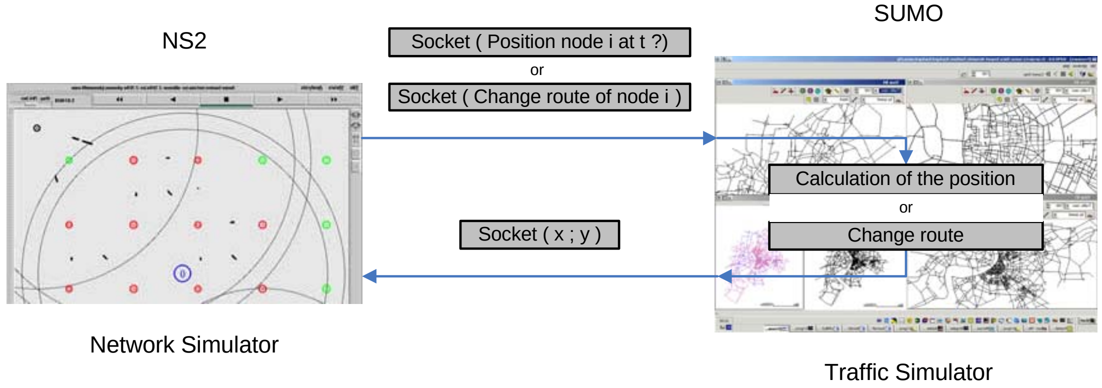


Figure 5 –Bidirectional coupling iTETRIS simulation environments

IV. CONCLUSION

This paper has presented the iTETRIS simulation platform and discussed limitations of existing simulation approaches. The key features and platforms to be supported have been presented and contextualized in terms of EU level initiatives. It has been made clear that iTETRIS permits that bidirectional coupling can be established between ns-2 and SUMO platforms and the advantages of such platform have been made apparent. These two platforms have been selected since they are both open source under GPL license and tolls accepted for R&D activities. iTETRIS will extend and made available key enhancements at the wireless and traffic mobility level so that V2x communication solutions can be studied to full extend.

Future work will clearly define the set of large scale scenarios to be addressed by ITETRIS and a simulation architecture will be establish.

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