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Team Imara

Informatique, Mathématiques et Automatique pour la Route Automatisée

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THEME NUM

Activity Report

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2. Overall Objectives

2.1. Overall Objectives

Keywords: *automated guided vehicle*, *environment*, *transportation systems*.

IMARA is a "horizontal" project at INRIA. Its objective is the coordination and the transfert of all the research done at INRIA which can be applied to the concepts of "la Route Automatisée". In particular, we will develop and transfer the results of a number of INRIA projects in the following domains:

- Signal processing (filtering, image processing,...);
- Control of the vehicle (acceleration, braking, steering);
- Communications;
- Modeling;
- Control and optimization of transportation systems.

The goal of these studies is to improve road transportation in terms of safety, efficiency, comfort and also to minimize nuisances.

- **Increase safety of road transportation** It is well known that road transport is not safe. This mode kills hundreds of thousands of people each year throughout the world and in particular young adults. Although safety has improved by one order of magnitude in the last decades through better infrastructure and safer cars, the limits of these improvements seems to have been reached if the travelling speeds remains constant (or are improved as is requested by the travelers). The techniques to improve drastically the safety are based on four approaches :
  - driver monitoring and warning;
  - partial control of the vehicle in emergency situations;
  - total control of some of the functions of the vehicle;
  - total control of all the vehicle.

  The technical approach proposed by IMARA is based on drivers aids, going all the way to full driving automation. This is the core of the project's research effort and our goal is both to demonstrate technical feasibility by creating new concepts of vehicles and to bring new technologies on the road.
- **Minimize energy consumption** Drastic reductions in the consumption of fossil fuels is one of the challenges of the next twenty years. Objectives have already been set for the reduction of carbon dioxide in many countries. Road transportation plays now the dominant role in the consumption of these fuels and the trend is towards great increases through two factors : increase in freight transport by road and very large increase in car ownership in emerging countries. Without a radical departure from existing technologies and practices, the goals set by the states cannot be met.

  This goal is not directly a research topic but by promoting new systems of transportation with clean vehicles which can be optimized, IMARA contribute to minimize energy consumption.
- **Minimize pollutions and nuisances** In all large cities through the world, air quality is now monitored at frequently unacceptable levels. Noise levels in cities and near highways is the main complain by a large percentage of the population. Citizen are not yet ready to change their habits on a voluntary basis but they are now supporting legislation to curb car usage in cities.

One of the objective of IMARA is to study new transportation modes and in particular to find ways to develop multimodality in order to find the most energy efficient way of satisfying transportation needs. In this respect, simulation and optimization of very complex transportation systems can give an insight of which solution should be deployed and where.

- **Offer a more pleasant living environment** Another nuisance often expressed by urbanites is the space taken by the automobile in cities which is responsible for many problems. The technical solutions to these problems of environment which are studied by IMARA are all based on a better usage of the resources : space and energy. It is well known that mass transportation is most efficient in terms of space and energy but not very flexible and that the reverse is true for the private automobile. The solutions lies therefore in three directions:
  - make a better use of existing infrastructures by minimizing congestion and increasing throughput,
  - use a multi-modal approach with the automobile at its proper place when the public transportation cannot offer a good service,
  - develop new public transportation modes close to the service offered by the automobile.
- **Offer new transportation means available to more people** Access to the automobile does not have to be exclusively through private ownership. This mode of access discourage strongly the use of alternative modes (such as public transportation or non-motorized modes) since the marginal cost of each trip is so low (unless penalized by parking cost or toll). New modes of access such as car-sharing, instant rental and self-service are now developed thanks to modern technologies. IMARA is strongly engaged in the development of such technologies as the team was involved in the Praxitele experiment.

The project provides to the different cooperating teams, some important means such as a fleet of a dozen of computer driven vehicles, various sensors and advanced computing facilitites including simulation tool. An experimental system based on fully automated vehicles is now being installed on the INRIA grounds at Rocquencourt for visitors and employees.

3. Scientific Foundations

3.1. Sensors and information processing

Keywords: *data fusion*, *evolutionary algorithm*, *image processing*, *laser*, *localization*, *magnetic devices*, *obstacle detection*, *radar*, *sensors*, *signal processing*, *stereovision*, *vision*.

3.1.1. Sensors and single-sensor information processing

The first step in the design of a control system are sensors and the information we want to extract from them, either for driver assistance or for fully automated guided vehicles. We put aside the internal sensors which are rather well integrated. Internal sensors give information on the host vehicle state, such as its velocity and steering angle information. The necessary information from external sensors (Laser, Radar, image sensors, etc.) are of several types:

- localization of the vehicle with respect to the infrastructure, i.e. lateral positioning on the road can be obtained by mean of vision (lane markings) or by mean of magnetic, optic or radar devices;
- localization of the surrounding vehicles and determination of their behavior can be obtained by a mix of vision, laser or radar;
- detection of obstacles other than vehicles: pedestrians, animals objects on the road etc. that require many types of sensors.

Since INRIA is very involved in image processing, IMARA emphasize the vision technique, particularly stereo-vision, in relation with MIT and ENSMP.

3.1.1.1. Disparity Map Estimation

Stereo vision is a reliable technique for obtaining a 3D scene representation through a pair of left and right images and it is effective for various tasks in road environments. The most important problem in stereo image processing is to find corresponding pixels from both images, leading to the so-called disparity estimation. Many autonomous vehicle navigation systems have adopted stereo vision techniques to construct disparity maps as a basic obstacle detection and avoidance mechanism.

We are working on a new approach for computing the disparity field by directly formulating the problem as a constrained optimization problem in which a convex objective function is minimized under convex constraints. These constraints arise from prior knowledge and the observed data. The minimization process is carried out over the feasibility set, which corresponds to the intersection of the constraint sets. The construction of convex property sets is based on the various properties of the field to be estimated. In most stereo vision applications, the disparity map should be smooth in homogeneous areas while keeping sharp edges. This can be achieved with the help of a suitable regularization constraint. We propose to use the Total Variation information as a regularization constraint, which avoids oscillations while preserving field discontinuities around object edges.

The algorithm we are developing to solve the estimation disparity problem has a block-iterative structure. This allows a wide range of constraints to be easily incorporated, possibly taking advantage of parallel computing architectures. This efficient algorithm allowed us to combine the Total Variation constraint with additional convex constraints so as to smooth homogeneous regions while preserving discontinuities.

3.1.1.2. The Fly Algorithm

As an illustration of an innovative approach, we present briefly the Fly Algorithm: an evolutionary optimisation applied to stereovision and mobile robotics.

Based on the Parisian approach, the Fly Algorithm produces a set of 3-D points (the "flies") which gather on the surfaces of obstacles. Flies are evolved following the classical steps of evolutionary algorithm.

A large number of internal parameters can affect the behaviour of the Fly Algorithm. An inappropriate set of parameters can lead to a high convergence time and a low precision in detection. In order to apply the Fly Algorithm to real time and real scene situations, efforts have been made to increase the processing speed of the algorithm and to improve its efficiency through the use of various genetic operators.

The choice of the fitness function plays a crucial role in the detection of obstacles. The comparison of different fitness functions showed that precision can be significantly improved, in particular by adjusting the size of the correlation window used.

Another possible use of the Fly Algorithm could be to use its output as an odometric sensor. The results obtained so far are rather rough, but are not sensitive to the terrain irregularities like the usual odometry.

3.1.2. Multi-sensor data fusion

Advance Driver Assistance System (ADAS) and Cybercars applications are moving towards vehicle infrastructure cooperation. In such scenario, information from vehicle based sensors, roadside based sensors and a priori knowledge is generally combined thanks to wireless communications to build a probabilistic spatio-temporal model of the environment. Depending on the accuracy of such model, very useful applications from driver warning to fully autonomous driving can be performed.

The INRIA-IMARA team has developed a framework for data acquisition, spatio-temporal localization and data sharing. Such system is based on a methodology for integrating measures from different sensors in a unique spatio-temporal frame provided by GPS receivers/WGS-84. Communicant entities, i.e. vehicles and roadsides exhibit and share their knowledge in a database using network access. Experimental validation of the framework was performed by sharing and combining raw sensor and perception data to improve a local model of the environment. Communication between entities is based on WiFi ad-hoc networking using the Optimal Link State Routing Algorithm developed by the HIPERCOM research project at INRIA.

The Collaborative Perception Framework (CPF) is a combined hardware/software approach that permits to see remote information as it own information. The CPF approach permits to a communicant entity to see another remote entity software objects as its own objects. For sensor objects, it permits to see sensor data of others entities as its own sensor data.

CPF relies on a software/hardware approach, a key component of the the hardware part is called the SensorHub (SH). The SH is a sensor gateway with very precise timestamping functionality based on an hardware based approach for fully parallel timestamping. The hardware part is a work done by the Joint Research Unit between the IMARA at INRIA team and the CAOR (Robotic Groups) team of the French engineering shool "Ecoles des Mines des Paris" (EMP). The software part of CPF was developed by a subset of the IMARA team; it consists in a Temporal Geographic Information System (TGIS) based on proxies to share information between communicant robotic entities.

The CPF approach was presented at the ITSC conference under the form of a cooperative driving demonstration with four communicant entities, two Cycabs, the LARA-INRIA vehicle and a static communicant entity on the roadside. An Intersection Collision Warning System (ICWS) application was built on top of CPF to warn a driver in case of potential accident. The ICWS relies on precise spatio-temporal localization of entities and objects to compute the Time To Collision (TTC) variables.

The SensorHub was chosen in complimentary with the RTMaps technology by the Localization Groups, a French research group on localization technologies for Advance Driver Assistance Systems. This informal group meet about six times a year. We are contributing to the evaluation of different data fusion methods for spatial localization. Several research groups are involved in the Localization Group: The University of Orsay/IEF group, the French Engineering school Ecole des Mines de Paris, the French Engineering School UTC, the LASMEA, the LIVIC, the LCPC laboratory and INRIA/IMARA.

3.1.2.1. Associated projects:

Sharp, Icare, Fractales, Complex.

3.2. Control

Keywords: *command*, *control*, *dynamic behavior*, *generating trajectories*.

The task is to develop a command system designed to execute at best the orders given by either the driver (aided by the system) or the automated driving system. The command system sends orders to the mechanical parts of the vehicles using all the information raised by the sensors. For example, one can imagine a steering system that acts not only on the wheels angle through the steering wheel but also on the brakes of each wheel. This would yield a much more secure behavior of the vehicle.

The real difficulty with this kind of control comes from the complexity of the dynamic behavior of the vehicle: response are highly non linear, particularly the response to forces of the tires on various soils. INRIA has a great expertise in these control problems and IMARA already demonstrated solutions for automatic driving of platoons of electrical cars. These research is still an active field. We want to enhance the system concerning the speed, the variety of wheel-soil contact. The lateral control problem is also studied, particularly in view of drivers assistance.

Another aspect of command systems is to generate correct trajectories which is another field of expertise for INRIA. These problems deal with obstacle avoidance or with generating complex trajectories in constraint environment (e.g. the parking problem).

3.2.1. Associated projects:

Sharp, Icare, Sosso.

3.3. System modeling and management

Keywords: *information*, *infrastructure*, *management*, *modeling*, *multi-modality*, *simulation*, *system*.

The demand of transportation is a rapid growing sector. Even if some big cities try to limit the use of cars, there must be alternate transportation means, e.g. metro, taxi, bus etc. The challenge to the community and for the research is to propose plan for the long term and solution for the integration of the new techniques into the real world. Since the problem of transportation (and particularly of cars) is most acute in cities, this is the place where we concentrate our research effort. Of course some system could be then transposed into medium-sized cities or into the countryside.

In each of the following sections, there are 4 steps to achieve a good transportation system:

- measurement and analysis of the traffic.
- modeling of the transportation system;
- analysis of the model using mathematical analysis or through simulation;
- optimization of the required performance.

There are several fields where system modeling and management are applied.

3.3.1. Better use of existing infrastructure and vehicles

One of the great challenge of automobile industry and of cities administrations in the next years is to integrate cars in a saturated environment (traffic congestion, parking...). Research are currently done on regulation methods such as passage toll, car park toll, users information and multi-modality. This is a very topical theme as illustrated by London toll zone. This implies modeling the traffic in urban areas, modeling the behavior of drivers and measure by mathematical analysis or on simulations the results of various scenario and eventually optimizing parameters (toll, etc.).

Real time infrastructures management is also a problem of resources optimization but a dynamic one. The question is to control accesses to avoid saturation phenomena which could make fall the performances of the system. Studies should be led on real cases, such as for example a by-pass in Paris area.

3.3.2. Designing new infrastructure

With new infrastructures, the problem is to redesign the city transportation system and to measure the improvement linked to another kind of management. Since the space is very rare in central areas, deploying new infrastructures (e.g. tramway) often means replacing part of the existing infrastructures (e.g. roads). This can only properly done when the impact of the new infrastructure has been well designed, which means, as for the optimization of existing infrastructures, measuring, modeling and optimizing.

3.3.3. Increasing the transportation choice

With the automated road, problems to be treated relate primarily to the dimensioning of the infrastructures and the management of these infrastructures. Dimensioning can be approached by techniques of stochastic modeling at the microscopic level or more traditionally by techniques of operational research. IMARA already used successfully these techniques for the Praxitèle program and account to develop them within the framework of the automated road to provide tools which will make it possible to justify (or to invalidate) the investments.

3.3.4. Telematics system

A growing category of vehicle-infrastructure cooperative (VIC) applications requires telematics software components distributed between an infrastructure-based management center and a number of vehicles. INRIA developed an approach based on a free software component suite under licence CeCILL. Such a framework for telematics runs inside an infrastructure-based operations center and is conceived to interact with external systems like Advanced Traffic Management or Vehicle Relationship Management.

Hence INRIA framework for telematics provides support for modular, flexible, prototyping and implementation of VIC applications. As a software infrastructure it allows to integrate different decision modules, vehicle-management center communication support and an extensible data module. The pluggable decision modules are the key part of the framework as they incarnate the logic for the VIC applications.

The user of the framework develops and combines such modules for specific applications. A chain of dependencies is provided for each decision module and each module dependency is represented as a directed acyclic graph. The framework resolves, performing a topologic sort over the graph, the correct order of execution. An event system has been developed to maintain low coupling between the software framework and the decision modules interaction. Two decision modules were implemented and validated during an experimentation (Project Mobivip, Nancy, June 2005): trip management for a Cybernetic Transportation System and dynamic traffic modeling.

This work has received the support of the European Commission in the context of the projects REACT and CyberCars.

3.3.4.1. Associated projects:

Preval, Metalau.

3.4. Communication

Keywords: *Communication*, *Ethernet*, *IPv6*, *LAN*, *MANET*, *NEMO*, *OLSR*, *VANET*, *ad-hoc network*, *dynamic routing*, *mobiles*, *radio*.

Communications will obviously play an essential part in ground transportation in a very near future and this is even truer for the automated road. Communications are indeed probably essential between close vehicles and between each vehicle and the infrastructure.

3.4.1. Ad-hoc networks

The traditional means of communication which are primarily in point-to-point mode or diffusion mode, do not seem adapted to the automated road. It seems that modes in hierarchical networks as for data processing would be better adapted to the problem. INRIA started to work on Ethernet type radio networks and with mobiles i.e. with a dynamic routing.

The so-called ad-hoc networks allow to dynamically connect to a local network (and potentially to internet if one node of the dynamic local network is connected itself to internet). This is very interesting for cooperative systems. For example, at a crossroad, vehicle can exchange local maps and so know much better where they are located, hence preventing or mitigating collisions.

This year, experiments in inter-vehicle communications using ad-hoc networks have been conducted (see Section 4.4). We are developing, in close collaboration with the Hipercom team, derived versions of the OLSR protocol, a dynamic routing protocol for vehicles communications. OLSR means: Optimized Link State Routing. Fine tuning of the parameters or new versions are necessary because the OLSR protocol was not intended for mobile ad hoc networks (MANET).

3.4.2. IPv6 Communications

As a follow up of last year's work on communications, we have this year started to investigate the use of IPv6 for vehicle-infrastructure communications and vehicle-vehicle communications. This is motivated for a number of reasons where Internet-based communications are necessary (such reasons are explained in [3], [2] authored by Dr. Ernst just before he joined us), particularly for navigation, multimedia and on-line monitoring applications, for which we are contributing to the specification of the relevant protocol architecture scheme and the requested extensions. This is mainly done as part of our involvment in two FP6 European projects, CVIS and ANEMONE [7]. On the other hand, the use of IPv6 is still questioned for time-critical safety applications, and this applicability is also currently investigated within IMARA. Below are details about our related activities this year:

3.4.3. Integration of MANET and NEMO

Mobile Adhoc Network (MANET) routing protocols and network mobility (NEMO) support protocols will be used in vehicular communications, MANET for vehicle-vehicle communications, and NEMO to maintain the Internet access for vehicle-infrastructure communications. interaction between MANET and NEMO (MANEMO) brings a number of benefits in terms of improved routing (routing optimization) and improved network accessibility (multihoming). However, protocols have been specified independently from one another and their interaction brings a number of technical and scientific issues. In order to analyze the issues, we have performed some experiments using the Optimized Link State Routing (OLSR, RFC 3626) MANET protocol and the NEMO Basic Support protocol (RFC 3963) integrated into five distinct topologies. We setup a real-field testbed with mobile subnetworks deployed in two of our eletric vehicles [10]. The network performance was evaluated and was reported in a paper [14]. The experimentation results show that combining MANET and NEMO improves the overall network performance.

3.4.4. Multihoming in Nested Mobile Networks with Route Optimization

Network mobility has the particularity of allowing recursive mobility, i.e. where a mobile node is attached to another mobile node (e.g. a PDA is attached to the in-vehicle IP network). This is referred to as *nested mobility* and brings a number of research issues in terms of routing efficiency. [4] was published as an output of our joint work on this topic with Keio University. Another issue under such mobility configurations is the availability of multiple paths to the Internet (still in the same example, the PDA has a 3G interface and the in-vehicle network has some dedicated access to the Internet) and its appropriate selection. This topic is investigated by a PhD student presently at Keio University in Japan under our direction. Some early results are reported in [8]

3.4.5. QoS

Late this year we started the analysis of Quality of Service (QoS) mechanisms in heterogeneous wireless technologies and wired networks with a focus on vehicle-vehicle and vehicle-infrastructure communications.

3.4.6. Associated projects:

Hipercom.

3.5. Tools for programming and certification

Keywords: *Programming*, *bugs*, *certification*, *distributed environment*, *hardware*, *software*.

Data processing will play an essential part — even critical — for the safety of automated guided vehicles or even for simply secured vehicles. It is thus of primary importance to minimize hardware or software failures and their consequences. For that, it became essential to bring new techniques of programming and certification. These work are already largely begun with INRIA and with the Ecole des Mines (Language ESTEREL and SynDEx) but the context of the automated road is even more critical than many applications than we try to approach. IMARA thus proposes to continue the development of its certification and programming tools ORCCAD and SynDEx in this automobile context i.e. in a very distributed — and thus necessarily redundant — environment.

3.5.1. Associated projects:

Sosso, Sharp, Icare

3.6. Ergonomics, Human-machine Interaction

Keywords: *Ergonomics*, *Human-machine Interaction*.

Systems of driving assistance as well as automated driving devices go undoubtedly to change deeply interaction between drivers (or passengers if this one does not drive any more) and vehicles. As the concerned population will not be formed for that, it is imperative that interfaces be of a great simplicity and cannot be interpreted in an incorrect way. The safety of the system depends on it.

It will be particularly important to study the perverse effects of a diverted use of the considered systems and to include/understand the mental image of the system that users will build, including in its degraded modes.

3.6.1. Associated projects:

Eiffel

4. Application Domains

4.1. Introduction

If the preceding section stressed methodology, in connection with automated guided vehicles, it should be stressed that the evolution of the problems which we deal with remains often guided by the technological developments. We enumerate three fields of application, whose relative importance varies with time and who have strong mutual dependences: Driving assistance, cars available in self-service mode and fully automated vehicles (cybercars).

4.2. Driving assistance

Keywords: *Driving assistance*, *information*, *modeling*, *path planning*, *system management*.

Several techniques will soon help drivers. One of the first immediate goal is to improve security by alerting the driver when some potentially dangerous or dangerous situations arise, i.e. collision warning systems or lane tracking could help a bus driver and surrounding vehicle drivers to more efficiently operate their vehicles. Human factors issues could be addressed to control the driver workload based on additional information processing requirements.

Another issue is to optimize individual journeys. This means developing software for calculating optimal (for the user or for the community) path. Nowadays, path planning software are based on a static of the traffic: efforts have to be done to put dynamic into softwares.

4.3. New transportation systems

Keywords: *Transportation systems*, *information system*, *on demand*, *self-service*.

The problems related to the abusive use of the individual car in large cities led the populations and the political leaders to support the development of public transport. A request exists for a transport of people and goods which associates quality of service, environmental protection and access to the greatest number. Thus the tram and the light subways of VAL type recently introduced into several cities in France conquered the populations, in spite of high capital costs.

However, these means of mass transportation are only possible on lines on which there is a keen demand. As soon as one moves away from these “lines of desire” or when one deviates from the rush hours, these modes become expensive and offer can thus only be limited in space and time.

To give a more flexible offer, it is necessary to plan more individual modes which approach the car such as we know. However, if one wants to profit from the advantages of the individual car without undergoing the disadvantages of them, it is necessary to try to answer several criteria:

- availability anywhere, anytime to all;
- lower air and soils pollution as well as sound levels;
- decrease the ground space occupied;
- secure;
- low cost;

Electric or gas vehicles available in self-service as in the Praxitèle system bring a first response to these criteria. To be able to still better meet the needs, it is however necessary to re-examine the design of the vehicles on the following points:

- ease empty car moves to better distribute them;
- better use of information systems inboard and on ground;
- better integrate this system in the global transportation system.

These systems are now operating (i.e. in La Rochelle). The challenge is to bring them to an industrial phase by transferring technologies to these still experimental projects.

4.4. Cybercars

Keywords: *B2*, *Cybercars*.

The long term effort of the project is to put automatically guided vehicles (cybercars) on the road. It seems too early to mix cybercars and traditional vehicles, but data processing and automation now make it possible to consider in the relatively short term the development of such vehicles and the adapted infrastructures. IMARA aims at using these technologies on experimental platforms (vehicles and infrastructures) to accelerate the technology transfer and to innovate in this field.

Other application can be precision docking systems that will allow buses to be automatically maneuvered into a loading zone or maintenance area, allowing easier access for passengers, or more efficient maintenance operations. Transit operating costs will also be reduced through decreased maintenance costs and less damage to the breaking and steering systems.

Regarding technical topics for Cybercars several aspects have been developed at IMARA this year.

First, we have stabilized a generic Cycab architecture involving INRIA Syndex tool and CAN communications. The critical part of the vehicle is using a real time Syndex application controlling the actuators via two Motorola's MPC555.

This application has a second feature, it can receive commands from an external source (Asynchronously this time) on a second CAN bus. This external source can be a PC or a dedicated CPU, we call it high level. To work on the high level, we have developed a R&D framework (Taxi) which takes control of the vehicle (Cycab and Yamaha) and also processes data such as gyro, GPS, cameras, wireless communications and so on. We compile C++ selected class, and we get a small footprint binary. We have demonstrated with this Taxi framework: automatic line/road following techniques, PDA remote control, multi sensors data fusion, collaborative perception via ad-hoc network.

The second main topic is inter-vehicle communications using ad-hoc networks. We have worked with the HIPERCOM team for setting and tuning OLSR, a dynamic routing protocol for vehicles communications (see Section 3.4). Our goal is to develop a vehicle dedicated communication software suite, running on a specialised hardware. It can be linked also with the Taxi Framework for getting data such GPS information's to help the routing algorithm.

5. Contracts and Grants with Industry

5.1. Introduction

The IMARA project is mainly funded by the numerous contracts obtained the past years and which show the guidelines of its works.

5.2. CyberC3

The CyberC3 Project will liaise with the existing IST European CyberCars Project and apply advanced IT&C technologies in cars and transport system, on one hand, aiming to propose an innovative transportation for the city of tomorrow based on fully automated vehicles (Cybercars), which has advantages of high flexibility, efficiency, safety; on the other hand, aiming to protect the environment and improve the quality of life for Asian sustainable development.

Contractor: EU & Asia IT&C Project duration: 24 months (2005–2006) R&D investment: euros 100 550

5.3. PreVent

Imara is part of the PreVent sub-project InterSafe.

The objective of the PReVENT subproject is to explore the accident prevention and mitigation potential of an integrated preventive safety system for intersections.

The effectiveness of the safety system for higher-risk scenarios is evaluated through implementation in a simulator environment as well as through demonstration of an application providing the driver with turning assistance and infrastructure status information.

Contractor: EU-IST
Project duration: 3 years (02/2004–01/2007)
R&D investment: euros 258 000.

5.4. MobiVIP

The project gathers 5 laboratories and 7 industrials to implement, evaluate and demonstrate the NTIC impact on a new mobility service.More precisely, the goals are to implement:

- a transportation service base on free-use vehicles,
- a multimodal information system,
- a toolbox for integration in global management policy at downtown scale.

Contractor: PREDIT
Project duration:
R&D investment: euros 82 000.

5.5. Puvame

An important number of accidents between vulnerable road users and moving traffic could be avoided by improving the abilities of visibility and estimation of the situation by the driver, and by putting in action an alarm system addressed to the driver and the road user in danger. This project will contribute to reduce the number of accidents of this type, by developing the principal following functionalities:

- Improvement of the abilities of perception of the driver in close and average distance environments by dated fusion;
- Detection and estimation of the dangerous situations, by analyzing current data relating on the "behavior of the driver" and to the estimation result of the "dangerosity" of the operations in progress;
- Activation of alert actions associated to vehicle and vulnerable users;
- Integration and experiments on vehicles and preliminary study on bus and/or trams.

Contractor: PREDIT
Project duration: 2 years (2004–2005)
R&D investment: euros 103 000.

5.6. REACT

The REACT project will represent a breakthrough towards the long-term vision of reducing traffic deaths significantly and improving transport infrastructure efficiency. Integrating state-of-the-art technologies, REACT will sense natural and infrastructure conditions within and in the vicinity of each equipped vehicle, will transmit sensed real-time data to a central server where they will be analyzed by a set of sophisticated prediction and decision-making models, and will generate

- safety alerts, speed and route recommendations, to be communicated to specific vehicle drivers;
- relevant information for road and law enforcement authorities.

Contractor: EU
Project duration: 2 years (2005-2006)
R&D investment: euros 241 000.

5.7. Anemone

The primary goal of the ANEMONE project is to provide them with such a playground and help inventing tomorrows world. The ANEMONE project will realize a large-scale testbed providing support of mobile users and devices and enhanced services by integrating cutting edge IPv6 mobility and multihoming initiatives together with the majority of current and future wireless access technologies.

Contractor: EU
Project duration: 2 years (2006-2008)
R&D investment: euros 100 000.

5.8. Citymobil

The objective of the CityMobil project is to focus on a number of cities in Europe and by careful study of their requirements design, evaluate and test the new approaches at three sites (Heathrow, Rome and Castellón). At the end of the project, we will have a better understanding of the capabilities of the new technologies and of what the gains to be expected in various city-situations could be and we will have proposals for certification of advanced transport systems on a European level. We will also have the tools to disseminate the results widely on the European level and therefore bring to the cities proven solutions to their problems while becoming, as was stated "a global leader in the development of a knowledge-based transport sector".

Contractor: EU
Project duration: 2 years (2006-2008)
R&D investment: euros 100 000.

5.9. COM2REACT

COM2REACT is a follow-up of the REACT project. COM2REACT's overall objective is to establish the feasibility of such a three-layer, scalable, cooperative system. Its implementation will involve the deployment of two two-way communication systems: vehicle to vehicle (V2V), and vehicle to infrastructure (V2I). This structure will facilitate significant improvement in the flow of information acquired by moving vehicles and in its quality and reliability, thereby enhancing road efficiency and traffic safety on urban, intercity arterials and rural roads.

Contractor: EU
Project duration: 5 years (2006-2011)
R&D investment: euros 355 000.

5.10. CVIS

CVIS will develop a multi-channel terminal capable of connecting with a wide range of potential carriers, including cellular networks (GPRS, UMTS), mobile wireless local area networks (WLAN, or Wi-Fi), shortrange microwave beacons (DSRC) or infra-red (IR). This will be based on the new international CALM standards, ensuring full interoperability between different makes of car and of traffic management systems.

Contractor: EU
Project duration: 4 years (2006-2010)
R&D investment: euros 266 000.

5.11. Cybercars 2

Cybercars 2 goal is to further improve the technologies of the CTS in order to make them into a truly efficient urban transport system of the future. The existing systems can offer a good alternative to the private cars but only if the transportation demand is not very high. To attain capacities of the same order of magnitude as private cars we have to improve our technologies by one order of magnitude since present day cybercars cannot transport much more than a few hundreds of passengers per hour on a single lane (compared to 2,000 with private cars and more than 10,000 with trams).

Contractor: EU
Project duration: 3 years (2006-2008)
R&D investment: euros 484 000.

5.12. LOVe

LOVe is an initiative to gather players around the automotive electronics for detection and protection of vulnerables users (pedestrians, cyclists...). This is part of the Num@tec cluster and of the System@tic French competitivity pole.

Contractor: France
Project duration: 3 years (2006-2009)
R&D investment: euros 151 000.

5.13. IETF and ISO Standardization

We are actively involved in the standardization process at the IETF. We lead two working groups, the NEMO (NEtwork MObility) WG and the MONAMI6 (Mobile Nodes and Multiple Interfaces in IPv6) WG. In the NEMO WG, we have authored 3 working groups documents, two of which have already been approved but not yet published as Informational RFCs [18], [17] and a third is pending [21]. In the MONAMI6 WG, we are also co-authoring 3 working group documents [19], [20], [22]. We are also contributing as the IETF liaison with ISO in the ISO Technical Committee 204 Working Group 16 which is specifying the CALM architecture based on IPv6 and NEMO and currently implemented by the CVIS European project in which we are also involved.

5.14. International cooperation

We are actively contributing to the French-Japanese Nautilu6 cooperation[1] on IPv6 mobility which aims at conducting further research on, demonstrating, validating and deploying IPv6 mobility mechanisms. This cooperation involves various labs in France (ENST-B, INT Evry, France Telecom R & D, ULP Strasbourg and INRIA) and in Japan (Keio University, Tokyo University, Internet Initiative Japan, and others, all from the WIDE organization[2]). As part of this cooperation, we are involved in several activities turning around IPv6 mobility, including the here above mentioned work on multihoming, routing optimization and MANEMO.

[1] http://www.nautilus6.org
[2] http://www.wide.ad.jp

5.15. Dissemination activities

As part of our work in vehicular communications, we served as co-chair of the 1st Workshop on Networking in Public Transport (WNEPT)[3] and the 2nd International Workshop on Network Mobility (WONEMO)[4] and as guest-editor in a special issue on Mobile Routers and Network Mobility in the IEEE Journal on Selected Areas in Communications. We also served in a number of conference TPCs, including ITST, UIC, WNS2, AINTEC, CFIP, and provided reviews for various journal and conference papers. We have also organized a technical session on the issue of IPv6 deployment for ITS during the European Commission IST Summut in Helsinki, November.

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