INTELLIGENT TRANSPORTATION SYSTEMS

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IEEE ITS SOCIETY NEWSLETTER

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Editor: Dr. Charles J. Herget, c.herget@ieee.org

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http://www.ieee.org/its
The Newsletter may be downloaded at no charge from the Society's Official web site shown above. You may subscribe to or unsubscribe from announcements at the same web site. These announcements are sent to approximately 10,000 ITS professionals from industry, academia, and government.

Information for Contributors

Announcements, feature articles, book and meetings reviews, opinions, letters to the editor, professional activities, abstracts of reports, and other material of interest to the ITS community are solicited

Please submit electronic material for consideration in any of the following formats: OpenOffice (preferred), plain ASCII, rich text format (rtf), portable document format (pdf), or Microsoft Word to the Editor-in-Chief at c.herget@ieee.org

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SOCIETY NEWS

From the Editor

by Charles Herget

Dear Readers:

It is a pleasure for me to take over as Editor-in-Chief of this Newsletter with this issue. I want to thank Bart van Arem and his assistant, Dorette Alink-Olthof, for their assistance in the transition. Some of you may recognize me from previous articles in this Newsletter. I served as president of the ITS Council during its last two years (2003-2004) and as the first president of the Society (2005).

The IEEE ITS Society will begin publishing a Magazine in 2008. When the Magazine appears, some changes in the Newsletter will take place. The intention is to move some of the technical content now contained in the Newsletter to the Magazine. The Newsletter will focus on news items. For now, the Newsletter should look the same as it has in the past.

Starting in 2008, the Society will have three publications, the Newsletter, the Magazine, and the Transactions, each published quarterly. In order to have one of the publications delivered to the members each month, the following schedule has been established.

Newsletter	Magazine	Transactions
January	February	March
April	May	June
July	August	September
October	November	December

Publications Delivery Schedule

Please look at the announcement for the Magazine in this Newsletter. As a new entity, it will require new participation from the members. Please take a look at the Calls for Papers and Volunteers.

I welcome any input you may have for the Newsletter. In particular, I would like to see more Letters to the Editor and Job Postings than have appeared in the past. Please send any input to me by email at c.herget@ieee.org .

Message from the VP Member Activities

by Christoph Stiller

I am glad to report that the IEEE Intelligent Transportation Systems Society (ITSS) has been IEEE's fastest growing society in the past year. Every month, new professionals join us, thus improving their network with interdisciplinary experts which is a keystone for a successful career.

Besides its newsletter, its other publications, its conferences, and its technical activities, the IEEE Intelligent Transportation Systems Society also spends considerable efforts in providing new services to its members. Some of these concern the recognition of distinguished experts in our field as well as our policies to enable student participation at our conferences. I am personally looking forward to see the winners of this years' awards at the ITSC conference in Seattle Sep. 30 - Oct. 3, 2007!

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IEEE ITSS MEMBERSHIP: OPENING THE WORLD OF ITS TECHNOLOGY

Remember to renew Your Membership for 2008

Join the IEEE Intelligent Transportation Systems Society

ITSS membership includes the Transactions on ITS

http://www.ieee.org/renew

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Report on IEEE Transactions on Intelligent Transportation Systems

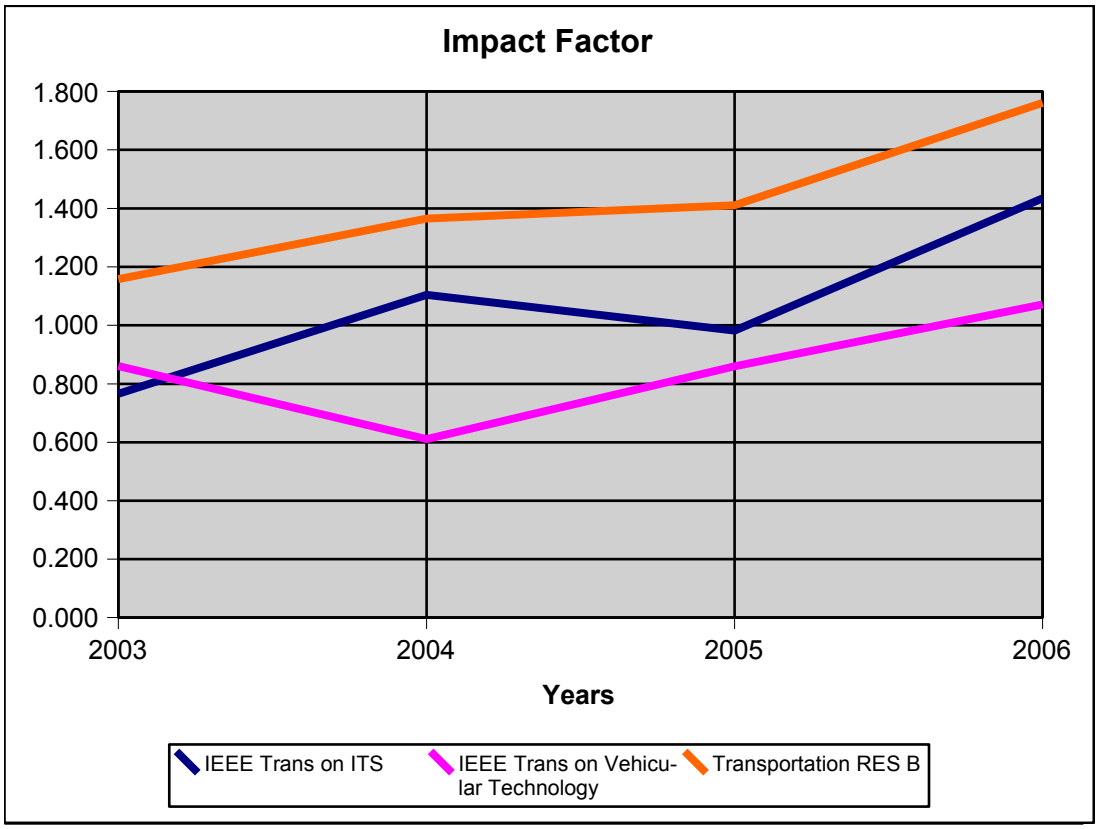
by Alberto Broggi

Dear Reader,

I'm sure you're familiar with the Impact Factor performance index, which is made available every year for each journal: it rates how interesting the readers have found the various articles published in the previous year by counting the citations to these articles.

The performance index of our journal has been increasing over the years. In 2006, it reached 1,434! For comparison, a graph comparing our Journal Impact Factor with other journals is attached. As a reference, the graph lists two well known journals: the *Transactions on Vehicular Technology* (the other IEEE publication in the field of Transportation) and *Transportation Research Part B* (which is

the journal with the highest impact factor for 2006).



Following is some more interesting data on our journal:

Year	Number of Published Articles in That Year	Number of Citations to Our Journal in That Year
2003	20	78
2004	35	141
2005	41	178
2006	49	327

which show that our articles are highly cited and are therefore regarded as interesting.

Clearly I would like to thank our very committed Editorial Board once again for their very hard work and share my congratulations on this very remarkable result with all the Reviewers and -indeed- with the Authors as well, whose work is the real substance of our Journal.

Finally, I would also like to announce that we will finally migrate our Manuscript Central Ver 1.8 website to the new version (Ver 4.0) very soon. The migration is scheduled to take place in late

September/early October. The new version is very promising and will certainly increase our efficiency in handling submissions, revisions, and up to the final manuscripts. I'm sure there will be problems in accessing the website during the final stage of the migration, and there will be probabiliy also problems with delays in managing the papers due to the same reasons. For this, I would like to apologize in advance with all the Authors, Reviewers, and the Readers.

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Type of accepted manuscripts:

From Jan 1, 2007, T-ITS accepts the following type of manuscripts:

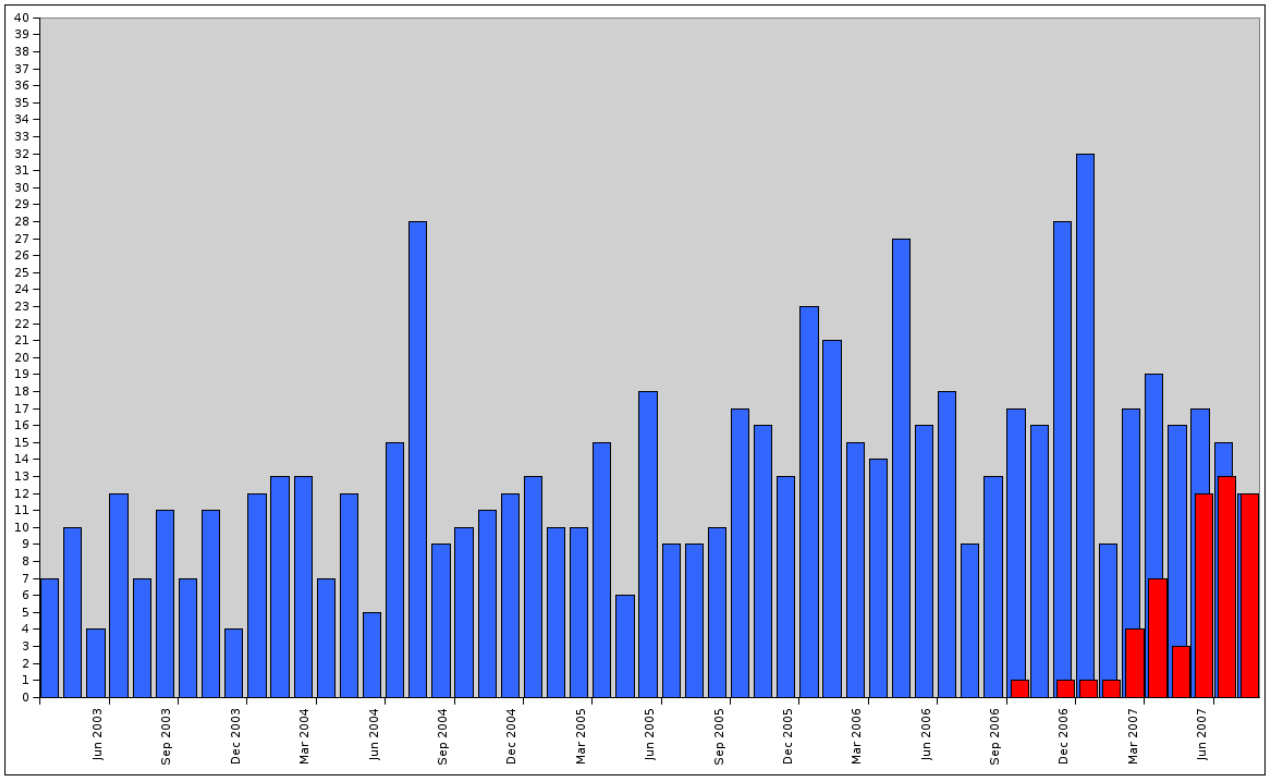
- regular papers
- short papers (formerly known as 'technical correspondences')
- survey papers (formerly known as 'reviews')
- practitioners papers

Maximum number of pages:

From the 2007 September issue, the policy on the maximum number of pages will change: regular papers will be allowed 10 pages, short papers and practitioners papers 6, while there will be no limit to survey papers.

Current status:

The following figure shows: in blue the number of papers submitted in each month from April 2003 (when we switched to electronic submission), and in red the number of papers sill without a decision; this means that either the first submission did not come to an end, or that a new revision is currently under evaluation. The figure shows that the trend is positive and, a part from isolated cases, all submitted papers



Transactions Abstracts

Following are abstracts of the papers to appear in the September 2007 (Vol. 8 No. 3) issue of the *IEEE Transactions on Intelligent Transportation Systems*.

Design and Evaluation of Intervehicle Dissemination Protocol for Propagation of Preceding Traffic Information

Saito, M. Tsukamoto, J. Umedu, T. Higashino, T.

Digital Object Identifier: 10.1109/TITS.2007.902650
Page(s): 379-390

In this paper, we propose an intervehicle information disseminatiProtocol called received message-dependent protocol (RMDP) that propagates the preceding traffic information to the following vehicles and discuss its performance. The proposed protocol autonomously changes the dissemination interval, depending on the number of reception messages and detected reception errors, in order to avoid message collision among vehicles. We have constructed a realistic simulation environment of intervehicle communication by combining a traffic-flow simulator and an ad hoc network simulator. Our simulation results show that, by using RMDP, a lot of vehicles can acquire their preceding traffic information within short periods at both the conditions with light and heavy traffic. In addition, we have also shown that selectiPolicy of disseminated data affects preceding-traffic-information acquisition time. Each vehicle holds other vehicles' traces for some period. Depending on the number of preserved other vehicles' traces and their preserved periods, the propagation ratio of the preceding

traffic information varies. Some simulation results are explained.

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Push-to-Talk Service for Intelligent Transportation Systems

Gan, C.-H. Lin, Y.-B.

Digital Object Identifier: 10.1109/TITS.2007.895297
Page(s): 391-399

Push to talk (PTT) is a walkie-talkie like service. In this service, several predefined group members participate in one PTT session. At any time, only one group member is allowed to speak. Therefore, a mechanism is required to determine the member that is permitted to speak. In Open Mobile Alliance (OMA), a central arbitrator coordinates the permission to speak among the group members. In the Intelligent Transportation System (ITS) environment, the centralized OMA approach is not appropriate. This paper proposes a distributed PTT mechanism for the ITS environment, which does not require any central arbitrator. The group member permitted to speak is automatically determined through distributed learning interaction. We also explore the properties and model the performance of the proposed PTT mechanism.

****

Local Density Estimation and Dynamic Transmission-Range Assignment in Vehicular Ad Hoc Networks

Artimy, M.

Digital Object Identifier: 10.1109/TITS.2007.895290
Page(s): 400-412

Vehicular ad hoc networks have several characteristics that distinguish them from other ad hoc networks. Among those is the rapid change in topology due to traffic jams, which also disturbs the homogeneous distribution of vehicles on the road. For this reason, a dynamic transmission range is more effective in maintaining the connectivity while minimizing the adverse effects of a high transmissiPower. This paper proposes a scheme that allows vehicles to estimate the local density and distinguish between the free-flow and the congested traffic phases. The density estimate is used to develop a dynamic transmission-range-assignment (DTRA) algorithm that sets a vehicle transmission range dynamically according to the local traffic conditions. Simulations of several road configurations validate the quality of the local density estimation and show that the DTRA algorithm is successful in maintaining the connectivity in highly dynamic networks.

****

Pedestrian Protection Systems: Issues, Survey, and Challenges

Gandhi, T. Trivedi, M. M.

Digital Object Identifier: 10.1109/TITS.2007.903444
Page(s): 413-430

This paper describes the recent research on the enhancement of pedestrian safety to help develop a better understanding of the nature, issues, approaches, and challenges surrounding the problem. It presents a comprehensive review of research efforts underway dealing with pedestrian safety and collision avoidance. The importance of pedestrian protection is emphasized in a global context, discussing the research programs and efforts in various countries. Pedestrian safety measures, including infrastructure enhancements and passive safety features in vehicles, are described, followed by a systematic description of active safety systems based Pedestrian detection using sensors in vehicle and infrastructure. The pedestrian detection approaches are classified according to various criteria such as the type and configuration of sensors, as well as the video cues and classifiers used in detection algorithms. It is noted that collision avoidance not only requires detection of pedestrians but also requires collisiPrediction using pedestrian dynamics and behavior analysis. Hence, this paper includes research dealing with probabilistic modeling of pedestrian behavior for predicting collisions between pedestrians and vehicles.

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Lane Change Intent Analysis Using Robust Operators and Sparse Bayesian Learning

McCall, J. C. Wipf, D. P. Trivedi, M. M. Rao, B. D.

Digital Object Identifier: 10.1109/TITS.2007.902640
Page(s): 431-440

In this paper, we demonstrate a driver intent inference system that is based on lane positional information, vehicle parameters, and driver head motion. We present robust computer vision methods for identifying and tracking freeway lanes and driver head motion. These algorithms are then applied and evaluated on real-world data that are collected in a modular intelligent vehicle test bed. Analysis of the data for lane change intent is performed using a sparse Bayesian learning methodology. Finally, the system as a whole is evaluated using a novel metric and real-world data of vehicle parameters, lane position, and driver head motion.

****

A Method for Vehicle Count in the Presence of Multiple-Vehicle Occlusions in Traffic Images
Pang, C. C. C. Lam, W. W. L. Yung, N. H. C.

Digital Object Identifier: 10.1109/TITS.2007.902647
Page(s): 441-459

This paper proposes a novel method for accurately counting the number of vehicles that are involved in

multiple-vehicle occlusions, based on the resolvability of each occluded vehicle, as seen in a monocular traffic image sequence. Assuming that the occluded vehicles are segmented from the road background by a previously proposed vehicle segmentation method and that a deformable model is geometrically fitted onto the occluded vehicles, the proposed method first deduces the number of vertices per individual vehicle from the camera configuration. Second, a contour description model is utilized to describe the direction of the contour segments with respect to its vanishing points, from which individual contour description and vehicle count are determined. Third, it assigns a resolvability index to each occluded vehicle based on a resolvability model, from which each occluded vehicle model is resolved and the vehicle dimension is measured. The proposed method has been tested on 267 sets of real-world monocular traffic images containing 3074 vehicles with multiple-vehicle occlusions and is found to be 100% accurate in calculating vehicle count, in comparison with human inspection. By comparing the estimated dimensions of the resolved generalized deformable model of the vehicle with the actual dimensions published by the manufacturers, the root-mean-square error for width, length, and height estimations are found to be 48, 279, and 76 mm, respectively.

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Anonymous Vehicle Reidentification Using Heterogeneous Detection Systems

Oh, C. Ritchie, S. G. Jeng, S.-T.

Digital Object Identifier: 10.1109/TITS.2007.899720
Page(s): 460-469

An innovative feature of this paper is the demonstration of the feasibility of real-time vehicle reidentification algorithm development at a signalized intersection, where different traffic detection technologies were employed at upstream and downstream locations. Previous research by the authors on vehicle reidentification has utilized the same traffic sensors (e.g., conventional square inductive loops) and detectors (e.g., high-speed scanning detector cards) at both locations. In this paper, an opportunity arose for the first time to collect a downstream data set from a temporary installation of a prototype innovative inductive loop sensor known as a “blade” sensor in conjunction with conventional inductive loops upstream. At both locations, advanced high-speed scanning detector cards were used. Although the number of vehicles for which data could be collected was small, encouraging results were obtained for vehicle reidentificatiPerformance in this system of mixed traffic detection technologies. In future large-scale applications of vehicle reidentification approaches for real-time traffic performance measurement, management, and control, it would be most beneficial and practical if heterogeneous and homogeneous detection systems could be supported. This initial paper yielded many useful insights about this important issue and demonstrated on a small scale the feasibility of vehicle reidentification in a system with heterogeneous detection technologies.

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Microsimulation of Freeway Ramp Merging Processes Under Congested Traffic Conditions

Sarvi, M. Kuwahara, M.

Digital Object Identifier: 10.1109/TITS.2007.895305
Page(s): 470-479

This paper describes a microsimulatiProgram developed to study freeway ramp merging phenomena under congested traffic conditions. The results of extensive macroscopic and microscopic studies are used to establish a model for the behavior of merging drivers. A theoretical framework for modeling the ramp and freeway lag driver acceleration–deceleration behavior guided the model development. This methodology uses the stimuli–response psychophysical concept as a fundamental rule and is formulated as a modified form of the conventional car-following models. Data collected at the two merging points are used to calibrate the hypothesized ramp and freeway lag vehicle acceleration models. Drawing on this behavioral model, the Freeway Merging Capacity SimulatiProgram (FMCSP) is developed to simulate actual traffic conditions. This model evaluates the capacity of a merging section for a given geometric design and flow condition. Validation of FMCSP is performed using the observed flow, vehicle trajectories, and lane-changing maneuvers. The simulation model is applied to investigate a variety of merging strategies. The results indicated that the FMCSP is capable of simulating the actual traffic conditions of congested freeway ramp merging sections and will aid in the development of traffic management strategies for complex freeway ramp merging areas.

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Development of Dual-Station Automated Expressway Incident Detection Algorithms

Mak, C. L. Fan, H. S. L.

Digital Object Identifier: 10.1109/TITS.2007.903433
Page(s): 480-490

Most automated expressway incident detection algorithms were successfully developed using loop-based traffic occupancy from their local conditions. However, the performance of these algorithms was not satisfactory on sites that have installed a video-based detector system. Due to different traffic detector technologies and varying driving behaviors from one region to another, it is of interest to develop an algorithm that uses video-based data. This paper used a total of 160 incidents collected along the 15-km Central Expressway (CTE) in Singapore to develop two new dual-station algorithms: the COmbined Detector Evaluation (CODE) and the flow-based CODE algorithms. On average, the flow-based CODE algorithm yielded better performance than the CODE in terms of average reduced false alarms of about 16%. Measures were also taken to ensure that the algorithms were properly developed and assessed. It was found that the CODE algorithm can detect, on average, up to 57% of the incidents faster than those of existing detection methods on CTE.

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High-Integrity IMM-EKF-Based Road Vehicle Navigation With Low-Cost GPS/SBAS/INS

Toledo-Moreo, R. Zamora-Izquierdo, M. A. Ubeda-Minarro, B. Gomez-Skarmeta, A. F.

Digital Object Identifier: 10.1109/TITS.2007.902642
Page(s): 491-511

User requirements for the performance of Global Navigation Satellite System (GNSS)-based road applications have been significantly increasing in recent years. Safety systems based on vehicle localization, electronic fee-collection systems, and traveler information services are just a few examples of interesting applications requiring onboard equipment (OBE) capable of offering a high available accurate position, even in unfriendly environments with low satellite visibility such as built-up areas or tunnels and at low cost. In addition to that, users and service providers demand from the OBEs not only accurate continuous positioning but integrity information of the reliability of this position as well. Specifically, in life-critical applications, high-integrity monitored positioning is absolutely required. This paper presents a solution based on the fusion of GNSS and inertial sensors (a Global Positioning System/Satellite-Based Augmentation System/Inertial Navigation System integrated system) running an extended Kalman filter combined with an interactive multimodel method (IMM-EKF). The solution developed in this paper supplies continuous positioning in marketable conditions and a meaningful trust level of the given solution. A set of tests performed in controlled and real scenarios proves the suitability of the proposed IMM-EKF implementation as compared with lowcost GNSS-based solutions, dead reckoning systems, single-model EKF, and other filtering approaches of the current literature.

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Space Partition for Conflict Resolution of Intersecting Flows of Mobile Agents

Mao, Z.-H. Dugail, D. Feron, E.

Digital Object Identifier: 10.1109/TITS.2007.902646
Page(s): 512-527

This paper studies the conflict resolution for intersecting flows of mobile agents based Planar space partition. The idea of space partition is first demonstrated for two intersecting flows of mobile agents. Then, for three intersecting flows, where simple decentralized conflict avoidance rules may not handle all traffic scenarios, it is proved that certain periodic partitions of space are able to provide conflict resolution for any distribution of agents in the flows. A computational procedure based on mixed integer programming is further proposed to find optimal space partitions. The approach of space partition is not an online optimization algorithm. An online algorithm may find optimal resolution of conflict for a specific set of mobile agents but has to be rerun each time when new agents arrive, whereas a periodic partition of space provides a priori geometrical configuration for conflict avoidance regardless of the number and arriving patterns of the agents. Moreover, the offline nature of space partition does not imply a decrease of performance. As demonstrated in an example involving three symmetrically arranged agent flows, the optimal space partition has found a tight upper bound for the magnitude of any conflict-free maneuvers.

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Queuing Network Modeling of Driver Workload and Performance

Wu, C. Liu, Y.

Digital Object Identifier: 10.1109/TITS.2007.903443
Page(s): 528-537

Drivers overloaded with information significantly increase the chance of vehicle collisions. Driver workload, which is a multidimensional variable, is measured by both performance-based and subjective measurements and affected by driver age differences. Few existing computational models are able to cover these major properties of driver workload or simulate subjective mental workload and human performance at the same time. We describe a new computational approach in modeling driver performance and workload—a queuing network approach based on the queuing network theory of human performance and neuroscience discoveries. This modeling approach not only successfully models the mental workload measured by the six National Aeronautic and Space Administration Task Load Index workload scales in terms of subnetwork utilization but also simulates the driving performance, reflecting mental workload from both subjective- and performance-based measurements. In addition, it models age differences in workload and performance and allows us to visualize driver mental workload in real time. Further usage and implementation of the model in designing intelligent and adaptive in-vehicle systems are discussed.

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A Real-World Application of Lane-Guidance Technologies—Automated Snowblower

Tan, H.-S. Bu, F. Bougler, B.

Digital Object Identifier: 10.1109/TITS.2007.902637
Page(s): 538-548

This paper describes the development process and the initial field test results of an automated snowblower, focusing on one of the more difficult snow removal operations: blowing snow off the freeway alongside a guardrail without the snowblower touching the guardrail. The development process includes transforming this highway winter maintenance operation into a control problem, modeling a snowblower, designing control algorithms, devising a human–machine interface, and equipping a 20-ton snowblower with sensors and an actuator. Specific challenges include modeling the low-speed tire-induced oscillation, designing high-gain automatic control on front wheels while keeping rear steering under driver control, and implementing such a system under practical limitations. A new dynamic deflection tire model is incorporated into a bicycle model to account for the additional lateral dynamics. A low-order controller was first generated based on the understanding of the specific control problem and, then, refined and tuned iteratively using linear-matrix-inequality optimization. The initial winter field tests were successfully conducted with embedded magnetic markers along the guardrails installed on the shoulders of Interstate-80 in the Sierra Mountain region close to Donner Summit, CA, during the winter of 2005.

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Sensor Fusion for Predicting Vehicles' Path for Collision Avoidance Systems

Polychronopoulos, A. Tsogas, M. Amditis, A. J. Andreone, L.

Digital Object Identifier: 10.1109/TITS.2007.903439
Page(s): 549-562

Path prediction is the only way that an active safety system can predict a driver's intention. In this paper, a model-based description of the traffic environment is presented—both vehicles and infrastructure—in order to provide, in real time, sufficient information for an accurate prediction of the ego-vehicle's path. The proposed approach is a hierarchical-structured algorithm that fuses traffic environment data with car dynamics in order to accurately predict the trajectory of the ego-vehicle, allowing the active safety system to inform, warn the driver, or intervene when critical situations occur. The algorithms are tested with real data, under normal conditions, for collision warning (CW) and vision-enhancement applications. The results clearly show that this approach allows a dynamic situation and threat assessment and can enhance the capabilities of adaptive cruise control and CW functions by reducing the false alarm rate.

CONFERENCE CALENDAR

Conference Calendar

by Massimo Bertozzi and Alessandra Fascioli

This section lists upcoming ITS-related conferences, workshops, or exhibits. Contributions are welcome; please send announcements to itsconfs@ce.unipr.it.

2007

September 18--22
PReVENT European Project Exhibition
Versailles, France
http://www.prevent-ip.org

October 9--13
14th World Congress on ITS
Beijing, China
http://www.itsworldcongress.cn

October 10--12
Intertraffic North America 2007
Fort Lauderdale, Florida (USA)
http://www.northamerica.intertraffic.com/intertrafficna2007/e

October 12--15
2007 IEEE International Conference on Vehicular Electronics and Safety
Beijing, China
http://www.ieeeves.org

October 17--19
European Transport Conference
Noordwijkerhout, The Netherlands
http://abstracts.etcproceedings.org

October 24--26
Automotive Testing Expo
Detroit, Michigan (USA)
http://www.testing-expo.com/usa/

November 23--25
ITIS 2007 International Conference on Industrial Technology and Intelligent Systems
Venice, Italy
http://www.waset.org/itis07

December 3--6
28th IEEE Real-Time Systems Symposium
Tucson, Arizona (USA)
http://retis.sssup.it/ReservedArea/Varie/rtss07

December 3--6
3rd International Conference on Intelligent Sensors, Sensor networks and Information Processing
Melbourne, Australia
http://www.issnip.org/2007/index.html

December 20--22
ICIS 2007 International Conference on Intelligent Systems
Bangkok, Thailand
Submissions due by: September 15
http://www.enformatika.org/icis07/

2008

March 5--6
Avionics Military and Civil Conference
Amsterdam, The Nederlands
http://www.avionics-event.com

March 18--19
5th International Workshop on Intelligent Transportation
Hamburg, Germany
Submissions due by: November 16, 2007
http://wit.tu-harburg.de

April 1--4
Intertraffic 2008
Amsterdam, The Nederlands
http://www.amsterdam.intertraffic.com

April 3--4
European Conference on Human Centred Design for ITS
Lyon, France
http://www.conference.noehumanist.org

May 19--23
IEEE International Conference on Robotics and Automation (ICRA 2008)
Pasadena, California (USA)
Submissions due by: September 14, 2007
http://www.icra2008.org

May 27--31
10th International Conference on Application of Advanced Technologies in Transportation
Athens, Greece
http://www.civil.ntua.gr/aatt/

August 6--8
3rd International Symposium on Transport Simulation
Queensland, Australia
Submissions due by: October 15, 2007
http://civil.eng.monash.edu.au/conferences/ists08

ANNOUNCEMENTS

- **IEEE Intelligent Transportation Systems Magazine**
- **ITSC'07**
- **ICVES'07**
- **IV'08**
- **PReVENT ProFusion e-Journal**

IEEE Intelligent Transportation Systems Magazine

IEEE has approved the publication of a new magazine by the ITS Society, called the IEEE Intelligent Transportation Systems Magazine. The Editor-in-Chief is Dr. Fei-Yue Wang, who has edited the first two trial issues in 2006 and 2007, respectively. Dr. Wang is a Professor of Systems and Industrial Engineering at the University of Arizona. He also directs the University's Program for Advanced Research in Complex Systems and the Key Laboratory of Complex Systems and Intelligence Science at the Chinese Academy of Sciences. The IEEE ITSM will be published in four issues next year. The first issue will appear in February 2008.

Scope

The IEEE ITS Magazine will publish peer-reviewed articles that

- provide innovative research ideas and application results,
- report significant application case studies, and
- raise awareness of pressing research and application challenges in all areas of intelligent transportation systems.

In contrast to the highly academic IEEE Transactions on ITS, the ITS Magazine will focus on providing needed information to all members of ITS society, serving as a dissemination vehicle for ITS Society members and the others to learn the state of the art development and progress on ITS research and applications.

High quality tutorials, surveys, successful implementations, technology reviews, lessons learned, policy and societal impact, and ITS educational issues will be published.

Cover of Trial Issue Published in September 2006

CALL FOR PAPERS

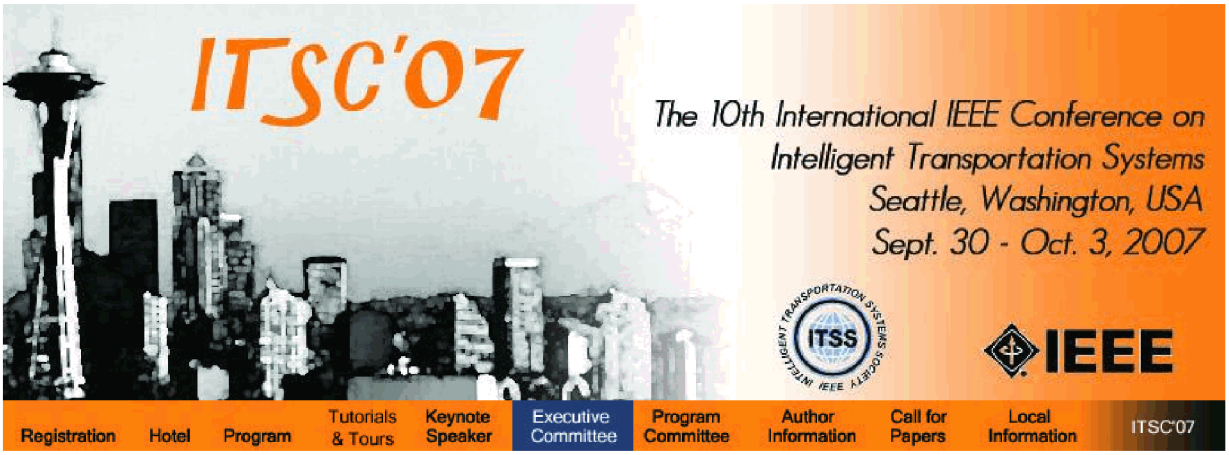
Suggested topics for authors include, but are not limited to, information technologies, infrastructure protection, public policy, and social and economic studies on ITS-related topics. Papers focusing on successful implementations, practical challenges, lessons learned, and policy considerations are encouraged.

If you are interested in submitting a paper, please contact the Editor-in-Chief, Dr. Fei-Yue Wang, at itseic@gmail.com for more information on submission procedures.

CALL FOR VOLUNTEERS

An editorial board for the new Magazine is now being established. If you are interested in serving as an Associate Editor, please send your curriculum vitae to the Editor-in-Chief, Dr. Fei-Yue Wang at itseic@gmail.com along with a cover letter indicating the topics on which you feel qualified to serve as an Associate Editor.

ITSC'07



ITSC 2007 is the premier technical conference on ITS and will be an international forum that brings together professionals from the fields of transportation, automotive technology, and information technology. In the long standing tradition of the IEEE ITS Conference, we are including a range of important program topics as listed below.

- Travel and Traffic Management
- Public Transportation Management
- Commercial Vehicle Operations
- Advanced Vehicle Safety System
- Electronic payment
- ITS Modeling and Analysis
- Emergency Management and
- Transportation Security

Who should attend: ITSC 2007 offers great value with presentations and discussions by international experts on their latest developments, as well as up-to-date technology to participants involved in Intelligent Transport Systems from the public sector (e.g., national governments, local authorities, pan-European organizations, planners, public transport authorities, academic institutions), the private sector (e.g., freight and transport operators, public transport operators, car manufacturers, service providers, telecom operators, system integrators, fleet owners, road operators, motoring organizations), and all those interested in transportation issues,

See you in Seattle in 2007!

Conference Web Site:
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ICVES'07

2007 IEEE International Conference on Vehicular Electronics and Safety
Organized by the Institute of Automation, Chinese Academy of Sciences

Sponsored by the IEEE Intelligent Transportation Systems Society

Beijing, China

October 12-15, 2007

The International Conference on Vehicular Electronics and Safety (ICVES'07) is an annual forum sponsored by the IEEE Intelligent Transportation Systems (ITS) Society. It gathers researchers from industries and universities to discuss research and applications for vehicle electronics, and vehicle safety systems.

Program Topics

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- Telematics
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- System-On-a-Chip
- Vehicular Sensor
- Vehicle Bus
- Sensor Network
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- Electro Magnetic Compatibility
- Inter-Vehicular Network
- Vehicle Testing
- Vehicle Hardware /Software System
- Navigation and Localization Systems
- Vehicular Measurement Technology
- Vehicular Signal Processing
- Micro-electromechanical Systems
- Image Sensor
- Vehicle/Engine Control
- Driver Assistance Driving Systems
- Adaptive Cruise Control Systems
- Pattern Recognition for Vehicles
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- Virtual/Digital System
- Others

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IV'08

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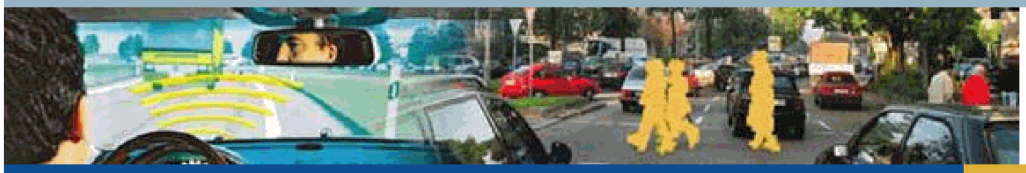

PReVENT ProFusion e-Journal	**Call for papers: 2nd Volume of the PReVENT Fusion Forum e-Journal** **PReVENT is an Integrated Project (IP) co-funded by the European Commission DG** INFSO to contribute to road safety.**ProFusion2 represents the automotive sensor data fusion research arena at European level**. It is a sub-project, part of the PRe-VENT integrated project which works on sensor data fusion (SDF), developing a common SDF framework for automotive preventive and active safety applications and carrying out research on environment modeling and data fusion algorithms.
Objectives	ProFusion2 is publishing 3 annual volumes of electronic scientific journals on "Advances on Sensor Data Fusion for Automotive Safety Applications". The objectives of the ProFusion2 e-Journal are: ● Publish unique peer-reviewed research papers on sensor data fusion for automotive environment and models. ● Promote research activities and developments of ProFusion2 project and in general inform about ProFusion2 and sensor data fusion activities within the framework of PReVENT. ● Promote the use of sensor data fusion to the automotive industry by invited or submitted contributions from the industry All volumes will be available to the ProFusion2 Fusion Forum, i.e. the key people in automotive sensor data fusion. The e-Journal will be also available on-line at http://www.prevent-ip.org/profusion. The first Volume (2006) is available on line.
Topics	**Topics of interest for the research papers are (not limited)**: Data association, target tracking, motion and environment modeling, image or sensor data fusion, target recognition and classification, performance evaluation of sensor data fusion systems, sensor data fusion architectures, fusion ontologies, artificial intelligence, situation awareness, sensor networks, theoretical advances on sensor data fusion, etc. Topics of interest for the industrial contributions are (not limited): Deployment and market issues, applications development using multi-sensor systems, products and prototypes, cost benefit analysis, R&D industrial projects, etc.
Submission procedure	Regular papers as well as correspondences in the above topics are actively encouraged. Authors are invited to submit papers describing advances, applications and new concepts on sensor data fusion. Manuscripts should be submitted in MS Word format to PreventFusionForum@iccs.gr. The research papers should not exceed 10 pages (Times New Roman, one column single spaced text, 12pt); the industrial and other contributions should not exceed 6 pages.
Closing date	Closing date of all submissions for the 2nd Volume is the **28th of September 2007**. Notification of acceptance for the research papers is the 10th of October 2007. Final manuscripts are due to 25th of October 2007. The Journal will be uploaded within December 2007.

PReVENT ProFusion e-Journal (CONT.)		
Editorial board	Chief editor:	Dr. Aris Polychronopoulos (ICCS, Greece)
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TECHNICAL CONTRIBUTIONS

Brian Park

The Associate Editor for Technical Contributions is Byungkyu "Brian" Park from the University of Virginia. The technical contributions section introduces state-of-the-art research and/or state-of-the-practice applications in the area of Intelligent Transportation Systems.

We are especially interested in receiving contributions from non-ITSS members and promoting interactions among sister societies within IEEE and other organizations advocating ITS. Original contributions, excerpts from IEEE Journals (with permission) and reprints from recent IEEE conferences (except those hosted by ITSS) can be submitted for consideration for publication in this section.

Please send your contribution to bpark@virginia.edu.

Angelos Amditis

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If you are interested in submitting a paper in this section, please send a short one page text with focus on the overview of research results and activities world wide.

Please send your contribution to a.amditis@iccs.gr.

This Newsletter contains two technical articles.

Protecting Transportation Infrastructure
by Daniel Zeng, University of Arizona, Sudarshan S. Chawathe, University of Maine, Hua Huang, Xi'an Jiaotong University, and Fei-Yue Wang, Chinese Academy of Sciences.

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and

A Data Dissemination Strategy for Cooperative Vehicular Systems
by Olivia Brickley, Chong Shen, Martin Klepal, Amir Tabatabaei, Dirk Pesch, Centre for Adaptive Wireless Systems, Department of Electronic Engineering, Cork Institute of Technology, Cork, Ireland.

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IEEE Intelligent Systems ITS Department Article appeared in IEEE Intelligent Systems September/October 2007 issue. Reprinted with permission.

Protecting Transportation Infrastructure

Daniel Zeng, ***University of Arizona***

Sudarshan S. Chawathe, ***University of Maine***

Hua Huang, ***Xi'an Jiaotong University***

Fei-Yue Wang, ***Chinese Academy of Sciences***

Protecting transportation infrastructure is an important component of today's homeland security effort. This article highlights related technical challenges and provides a brief survey of several IT research streams in this important application area, along with two case studies.

Keywords: Critical Infrastructure; Transportation Security

In the context of homeland security, critical infrastructures are "those physical and information technology facilities, networks, services and assets which, if disrupted or destroyed, would have a serious impact on the health, safety, security, or economic well-being of citizens or the effective functioning of governments."[1] Transportation infrastructures are a key component of a nation's critical infrastructures, covering physical assets such as airports, ports, and railway and mass transit networks as well as software systems such as traffic control systems. In effect, among various critical infrastructures spanning a range of economic sectors and government operations,[2] transportation is widely viewed as one of the most significant and impactful. A 2002 study concerning the significance of infrastructure components andand the consequences of a destructive event rated transportation as "extremely significant." Other components at this highest level of significance were communications, power, emergency response personnel and assets, and national security resources.[3]

Transportation infrastructures are frequent targets of terrorist attacks because of their significance in several dimensions. Because physical transportation networks attract large numbers of people, they're high-value targets for terrorists intending to inflict heavy casualties. Transportation infrastructures themselves are important to the modern economy, and related damages and destruction can have quick ripple effects. Operationally, transportation systems interact with and provide support for other systems, such as emergency response and public health, in complex ways. Terrorists can perceive an attack on such a link (that is, one that connects many systems) as an efficient means to create confusion, counter the counter-measures, and damage the targeted society as a whole. Furthermore, transportation infrastructures can be both the means and the end of an attack, making them a critical part of almost all terrorist attacks in the physical world.

Tables 1 and 2 further illustrate the importance of protecting transportation infrastructures. Table 1 lists a number of attacks involving transportation infrastructures.[4] Table 2 shows the yearly counts of transportation-related terrorist incidents from 1998 to 2004, broken down by transportation mode. The information in table 2 is based on the Global Terrorism Database (GTD), "an open-source database including information on terrorist events around the world" from 1970 to 2004 (www.start.umd.edu/data/gtd).

Table 1. A partial list of terrorist attacks involving transportation infrastructures.[4]

Year	Incidents
2006	Bombs planted on two German trains (but failed to explode) 209 people killed by bombs on commuter trains in Mumbai, India//**OK? yes**// A plot to flood Manhattan commuter rail tunnels uncovered
2005	London mass transit bombings; 52 killed and more than 700 injured
2004	A plot to bomb New York subway stations foiled Madrid commuter train bombing; 191 killed and nearly 2,000 injured Moscow subway explosions; 40 killed
2003	Al-Qaeda reportedly called off a planned cyanide attack on the New York subway system
2002	Truck loaded with propane detonated at a Tunisian synagogue, killing and wounding dozens
1997	A plot to bomb a New York subway station foiled
1996	Multiple suicide attacks on buses in Israel
1995	Cult members released sarin gas on the Tokyo subway; 12 killed, 50 severely injured, and nearly 1,000 experienced temporary vision problems

Table 2. Transportation-related terrorism incidents from 1998 to 2004 by transportation mode (based on GTD data).

Year	Transportation mode		
	Maritime	Air	Ground
2004	2	5	25
2003	1	5	41
2002	0	10	41
2001	2	12	28
2000	2	11	56
1999	2	9	54
1998	1	7	36

Major areas of transportation security

Here, we aim to alert AI and IT researchers to the challenges facing transportation infrastructure protection. We start by discussing the main areas of transportation security technology from an application perspective. We follow the program structure of the Department of Homeland Security's Transportation Security Laboratory,[5] whose mission is to "develop and evaluate next-generation

security technology that can lead to successful deployment of products across all modes of transportation and the related transportation infrastructure."

The first major area is concerned with enhancing the security of infrastructure critical to transportation. As we defined it earlier, this infrastructure includes physical facilities, equipment, assets, service networks, and communication and computing hardware and software that enable information access and transactions. Airports, rail stations, bridges and tunnels, maritime ports, and bus terminals are examples of relevant application contexts. Critical practical challenges include

* physical access management and control of employees and passengers,
* perimeter intrusion detection,
* vulnerability assessment,
* intrusion detection and access control in the cyberspace in which pertinent information systems operate and exchange data, and
* related simulation and decision-support tools.

The remaining three major areas are commerce inspection, passenger inspection, and conveyance protection.[5] These all directly relate to transportation infrastructure protection and, when combined with infrastructure protection, provide a comprehensive approach to addressing practical security needs. Commerce inspection mainly concerns threat detection in checked passenger baggage, mail, commercial cargo and logistical/supply chain shipments, and any other form of commercial transportation activity. Sensor technologies for detecting explosives and weapons are critical in this area. Effective, efficient management of various resource types (for example, equipment, its human operators, and their training) also plays an important role in commerce inspection practices. Passenger inspection refers to the capability to inspect passengers at transportation system screening and entry points for concealed weapons, explosives, or other prohibited items. Conveyance protection focuses on enhancing the conveyance security of the entire transportation system. Key conveyance-protection technologies include characterization of explosives, analysis of the effects of blasts and related structural response modeling and simulation, material sciences, and sensor technologies.

With a particular emphasis on IT, we now discuss several active technical research areas that can facilitate transportation infrastructure protection efforts. Many of these technologies can apply to more than one application area.

Video surveillance

This technology is invaluable for transportation security. For years, numerous major cities around the world have used video feeds to monitor airports, sea ports, and railway and subway stations. Recent developments in computer networks and video-capturing hardware, such as thermal and infrared technologies, and algorithmic advances in image processing and computer vision, have made video surveillance increasingly versatile and cost effective.[4] Researchers and practitioners are paying more attention to IT research on extracting useful information (for example, face recognition and intention detection) from video streams in real time, either in a fully automated operational mode or as to help human operators make decisions.[6,7]

Tracking and location technologies

Technologies such as GPS and RFID enable operators to monitor key assets or moving objects of interest in space and time. Their use in the transportation domain is widespread, as evidenced by increasing commercial activities and government initiatives in this space. Meanwhile, such technologies introduce their own information security vulnerabilities, which researchers are studying. From a research standpoint, finding interesting and relevant patterns from spatial data streams and

using them in transportation security applications present both opportunities and challenges.

Authentication and access control

In the transportation security context, access control ensures that only authorized individuals have access to secured areas. Biometrics is quickly gaining ground as an enabling technology to make authentication and access-control systems more effective and efficient. Two predominant biometric applications are fingerprinting and iris scanning. In addition to traditional biometric research topics such as pattern recognition and data management, researchers are starting to explore the role of biometrics in the broad context of authentication and study issues such as privacy and secure system interoperability.

Information sharing, fusion, and management

Effective information sharing across datasets and system boundaries, the ability to fuse information and data from sources that provide (partially) overlapping and complementary coverage, and efficient, secure data management have long been identified as key drivers of effective intelligence and homeland security-related information systems.[8] Information systems for protecting transportation infrastructure share the same design objectives. To support counterterrorism efforts such as preparing, detecting, and responding to terrorism events, large amounts of information in different modalities from many sources must be acquired, integrated, and interpreted in the right context, often in real time.[2] In addition, a critical need exists for a data-management infrastructure that can support information flows across jurisdictional and organizational boundaries (for example, intelligence, law-enforcement, and emergency-response communities). Despite existing efforts, researchers and practitioners must still make significant progress in this area from both technical and policy perspectives, with careful attention to laws and regulations, privacy considerations, and civil rights.

Target hardening

This aims to make transportation facilities less vulnerable. Many transit systems have implemented such efforts through their crime-prevention programs (for example, removing trash cans or using ballistic-resistant ones, installing blast-resistant glass, and eliminating dead spots where bombs might be hidden). On a much larger scale, strategic facilities such as bridges, tunnels, and terminals are being fortified to improve their chance of surviving attacks. Research on threat assessment and resource allocation that helps determine where and how to pursue target-hardening efforts can provide important actionable knowledge guiding such efforts in practice.

Human factors

Researchers in this area aim to optimize the human element in transportation infrastructure protection to make the overall human-machine system perform better. Researchers have actively pursued two lines of work, one of which focuses on recruiting and training. For instance, a systematic approach to selecting airport screeners, developing and evaluating screener-training programs, and developing procedures for measuring and improving screener performance has been put into practice.[5] The second line of work has traditional HCI goals: to improve operator performance by designing equipment and user interfaces that maximize user perceptual, cognitive, and physical abilities while minimizing errors.

Systems science and engineering

Systems science frameworks are helping practitioners understand complex transportation systems' performance and vulnerabilities and the interactions among their subsystems. In addition, the systems that protect transportation infrastructure are themselves complex engineering systems with data from networked sensors, complex workflow and command and control structures, and real-time intrusion detection and access control functions. Systems engineering principles provide important guidelines for

designing, developing, and implementing such systems.

In recent years, an academic discipline called intelligence and security informatics has emerged. ISI aims to develop advanced information technologies, systems, algorithms, and databases for national- and homeland-security-related applications, through an integrated technological, organizational, and policy-based approach.[9] Many of the technical research areas we've discussed are part of ISI study. Transportation infrastructure protection is an important application domain for ISI frameworks and techniques. It also presents interesting technical challenges motivating ISI research.

Example research projects

Two transportation infrastructure protection research projects illustrate these application context and research issues. The first, a critical infrastructure protection study in Virginia,[10] assessed the risks of terrorist attacks to the surface transportation system. Researchers jointly with government officials analyzed eight critical assets, including one intelligent transportation system traffic-control center, two major interstate interchanges, three bridges, one bridge-tunnel, and one tunnel. At each site, researchers performed a risk assessment study by soliciting from domain experts and practitioners answers to three questions:

* What can go wrong?
* What's the likelihood that something will go wrong?
* What are the consequences if something does go wrong?

In the follow-up risk-management step, the researchers first evaluated risk-management options. On the basis of input from the Virginia Department of Transportation domain experts, they put these options (including cost estimates) into two categories: prevention and response. Next, they selected optimal options using Pareto-optimal graphs, plotted separately for preventative and responsive options. (In multicriteria decision making, a Pareto-optimal option is one where an objective can be improved only at the expense of another.) This study, although preliminary, illustrates a direct application of a general risk-assessment and management framework in transportation infrastructure protection with real-world findings.

BorderSafe is a much larger, ongoing project. Although only indirectly related to transportation infrastructure protection, this project illustrates important data mining applications that generally apply to transportation security. It also demonstrates the value of cross-jurisdictional information sharing.[9] BorderSafe is a collaborative research effort involving the University of Arizona's Artificial Intelligence Lab, the San Diego Super Computer Center, and law enforcement agencies including the Tucson Police Department, the Phoenix Police Department, the Pima County Sheriff's Department, the Tucson Customs and Border Protection, and the San Diego Automated Regional Justice Information Systems. BorderSafe includes several cross-jurisdictional data sharing initiatives, such as one integrating TPD, PCSD, and CBP data sets. Using this integrated data set, the research team evaluated the impact of cross-jurisdictional information on crime analysis. They constructed a criminal activity network based on associations that occur when individuals or vehicles are listed together in a crime incident report. The research findings indicate that border-crossing activities generate useful leads for investigating certain types of crimes. In addition, automated data mining targeted at correlating stolen vehicle reports with border crossings and targeted individuals could help in many investigations, enabling real-time analysis that's prohibitively time-consuming using the traditional manual process.

Transportation infrastructure protection provides a potentially fruitful application domain for many subdisciplines of AI and closely related fields—from data mining, sensor networks, and video processing to risk analysis, real-time decision support, and human-machine interaction. We believe that cross-cutting research in AI, ISI, and critical infrastructure protection including transportation systems will produce tangible, practically relevant research results benefiting these research communities.

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A Data Dissemination Strategy for Cooperative Vehicular Systems

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Abstract— **Cooperative systems in transportation can bring new intelligence for vehicles, roadside systems, operators and individuals by creating a communications platform allowing vehicles and infrastructure to share information. The performance of this underlying communication system has a major impact on the effectiveness of the emerging applications for intelligent transportation systems. Similarly, the approach taken to the dissemination of relevant information throughout the vehicular setting is influenced by the network performance characteristics. This paper investigates the concept of data dissemination in a heterogeneous vehicular wireless environment. A communications architecture which consists of infrastructure based transmission for cooperative vehicular systems is described. Following this, a simple, policy-based solution to establish how best to disseminate the data for an envisaged ITS application is presented. This policy considers the application requirements and the quality of the wireless carrier in determining how the information can be propagated to the relevant recipients in the most effective and efficient manner.**

I. INTRODUCTION

Over the last decade, the nature of wireless communications has evolved rapidly. The introduction of 3G and WLAN technologies and the recent standardisation of WiMax has helped to realise the vision of ubiquitous connectivity. Currently, much research effort is focusing on exploiting this "always-on" feature for use in vehicular environments [1,2]. Projects such as DRIVE [3], GST [4] and SAFESPOT [5], among others, are advancing the area of Intelligent Transportation Systems (ITS). The primary objective of ITS is the creation of advanced road traffic systems for improved traffic safety, efficiency, and travelling comfort. Applications for collision avoidance, route planning, automatic tolling and traffic control, among others, are considered crucial in achieving this goal and require frequent information exchange between vehicles and infrastructure. The communications technologies used in ITS will play a pivotal role in the efficiency and effectiveness of such applications and is considered a primary concern in all ITS projects. The manner in which pertinent information is disseminated throughout the vehicular environment is also an important aspect of ITS and is critical to the successful operation of cooperative applications. Efficient and timely propagation of information among all affected vehicles is essential and highly dependent on the performance capabilities of the core communications platform.

As part of the EU IST FP6 "Cooperative Vehicle Infrastructure Systems" project (CVIS) [6], this paper proposes a simple data dissemination strategy for a cooperative vehicular environment. A communications framework for cooperative vehicular systems is presented with the aim of providing flexible, "always on" connectivity for vehicles travelling at high speeds. A simple, policy based dissemination management function responsible for the efficient propagation of application information is then proposed. Here, parameters such as the application characteristics and channel quality are used as inputs in determining the most appropriate means of propagating the application data throughout the considered traffic region.

This paper is organised as follows. Related work in the area of data dissemination for intelligent transportation systems is examined in the next section. Section III summarises the motivation and architectural solution to cooperative vehicular systems proposed by the CVIS project. Section IV introduces the concept of policy based systems and details the proposed data dissemination strategy. Section V describes the simulation environment used in evaluation of the proposed scheme and section VI demonstrates and accounts for the results gathered. Finally, the conclusions of this study and planned future work are discussed in section VII.

II. RELATED WORK

The concept of data dissemination in vehicular systems in an effort to advance the intelligence of modern transportation has received much attention within the research community over the last number of years. Many studies investigate information propagation using IEEE 802.11 ad-hoc based inter-vehicle communication (IVC) in isolation [7,8,9,10]. Others propose data dissemination which incorporates existing cellular infrastructure as a gateway technology to provide an internet connection or advertise regional services. The authors in [11], propose a data

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dissemination technique based on swarming. Here, 802.11 access points act as a gateway to the internet for passing vehicles. In [12], a cluster based communication system is proposed. In this study, the ad-hoc networking paradigm is used to form clusters of communicating vehicles while cellular infrastructure provides reliable inter-cluster communication.

Few papers consider the data dissemination challenge in scenarios where multiple wireless technologies are operating simultaneously, and hence pay very little attention to the development of a dissemination strategy with respect to this heterogeneous network environment. This paper proposes a policy based data dissemination strategy in which both lower data rate ubiquitous connectivity and higher data rate connectivity islands are considered for propagating application data throughout a vehicular region.

III. Architecture for Cooperative Vehicular Systems

In terms of data dissemination for intelligent transportation, IVC has gained a high level of attention. The authors in [9] state that vehicular ad-hoc networks are the preferred network design for future ITS. They argue that traditional vehicular networks where roadside infrastructure reports to a central controller are expensive and not scalable in design. While IVC has the attraction of being scalable, its sole use does not provide sufficient reliability for safety critical vehicular applications. Due to the highly dynamic environment in which they operate, VANETs are relatively unstable. They are prone to rapid topology changes and link breakages due to the high relative speed of vehicles [13]. This can result in fragmentation of the ad-hoc network where some nodes may experience connectivity isolation; an undesirable quality, particularly for transporting safety applications.

The CVIS project is based on a hybrid architectural approach for ITS. As illustrated in Figure 1, this comprises of a three tier hierarchical structure in which IVC and V2I communication are integrated to create a flexible communication platform. The upper tier is the central management layer, which monitors the vehicular environment on a system-wide level. The middle tier represents the roadside infrastructure and administers the vehicular system at a regional level. The lower tier corresponds to the vehicles themselves which generate and report on information at a local level.

In CVIS, this architecture will be realised using the Continuous Air Interface for Long to Medium range (CALM) communications standard [14] as illustrated in Figure 2. CALM is part of the ISO Standardization Program (ISO CALM TC 204) and aims to provide user transparent, continuous communication in support of emerging ITS applications. It combines complementary media, allowing vehicles to use the best combination in-vehicle and infrastructure communications technology locally available. The communication technologies envisaged to support cooperative vehicular systems include WiFi and Wimax for regional connectivity, cellular systems such as GSM and UMTS for terrestrial coverage, as well as satellite and broadcasting communication technologies. Ad-hoc communication standards such as DSRC, InfraRed and MM-Wave will permit short to medium range communications between vehicles.

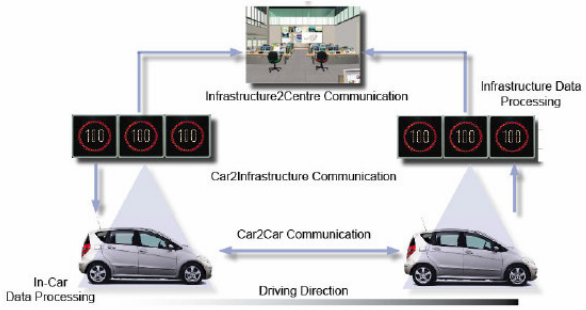

Figure 1: CVIS architecture for cooperative vehicular systems

This study utilises a subset of the complementary radio technologies identified in the CALM specification. The communications framework developed as part of this investigation includes UMTS and IEEE802.11 wireless protocols. The implementation of these technologies in a vehicular setting offers a comprehensive solution for cooperative application data dissemination and gains from their complementary characteristics; the wide scale availability of UMTS provides an "always on" feature, reinforcing its importance for ITS, while IEEE 802.11 enables vehicle-to-roadside communications providing regional higher speed coverage.

Vehicle-to-vehicle communication based on the ad-hoc mode specified in 802.11 is not examined in our work at this stage, however, this will be examine in a future extension of our work. The following section outlines the simple, first approach to the data dissemination decision in a heterogeneous wireless environment for intelligent transportation.

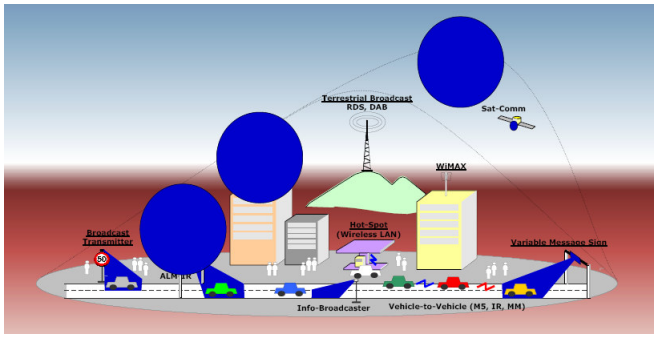

Figure 2: CALM Communications Standard

IV. Policy Based Data Dissemination for Cooperative Vehicular Systems

Data dissemination is an especially important feature of cooperative vehicular systems. Vehicles must be able to communicate with each other so as to ensure that safety and traffic management applications can function successfully. In a heterogeneous communications environment where multiple radio access technologies are available, the manner in which information is propagated between the key players is a major issue which ultimately impacts on driver safety.

The aim of data dissemination is to transport information to the intended recipients while meeting a number of design requirements. The convergence time and lifetime of the data, as well as the reliability of its transportation across the vehicular system are such considerations. Based on the communications architecture described in the previous section, a policy based strategy for the dissemination of application data across a multi-mode wireless environment is proposed.

A policy based system consists of a set of rules and instructions to determine a particular network operation [15]. They are a flexible means of evaluating and controlling system behaviour and can be easily implemented in the proposed ITS environment. Policy based systems consist of a policy repository, policy decision point and policy enforcement point. The policy repository is a database which stores the rules and policies required by the system. The policy decision point (PDP) evaluates the relevant input data using the policy rules and determines the appropriate action for the current circumstances. This decision is then carried out at the policy enforcement point (PEP). Based on the CVIS architecture illustrated in Figure 1, it is apparent that a data dissemination policy is required at three points. On the presence of multiple wireless technologies, the central application system, roadside equipment and participating vehicles will each require a dissemination policy. This policy system design is illustrated in Figure 3.

Determining the most appropriate dissemination strategy is a complicated decision encompassing an array of influential factors. The policy proposed in this work utilises parameters which indicate the achievable throughput and allowable load on the candidate networks.

A. Network Load

It can be assumed that the UMTS network is relatively unaffected by the speed of the mobile users. Therefore, at high user speeds, UMTS can theoretically deliver up to 144Kbps for users in moving vehicles [16]. The major inhibiting factor here is the load already on the network and the problem of sustaining the quality of service (QoS) for accepted calls. The data dissemination policy must consider the affect of additional data transmitted to/from the vehicular environment. This is carried out using the concept of capacity surfaces [17].

Capacity surfaces are used to characterise the residual capacity in multi-service networks. They define the maximum service mix that is simultaneously allowed access into the network at any one time. Capacity surfaces are used in the proposed policy based dissemination strategy to evaluate the current operating point of the UMTS network and hence, determine the ability of that radio interface to deliver the ITS related data to the relevant recipients. This capacity surface is illustrated in Figure 4.

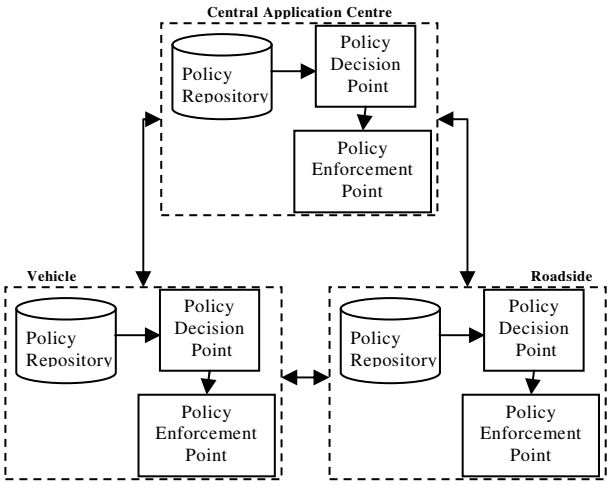

Figure 3: The proposed dissemination policy architecture

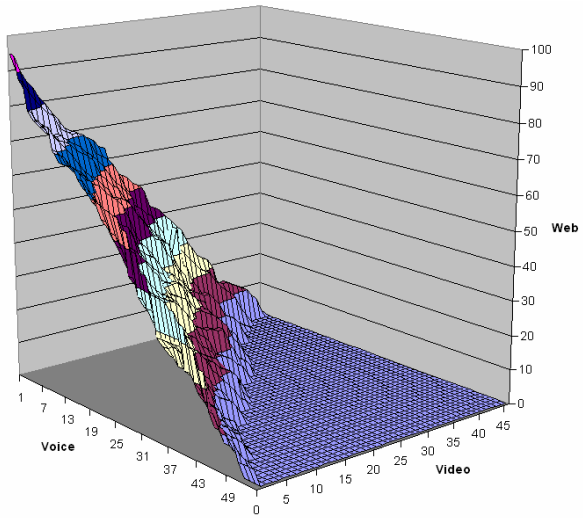

Figure 4: UTRAN Capacity Surface

B. Achievable Throughput

The primary concern in the UMTS network is in satisfying customers with regard to QoS. There is no such requirement for wireless hotspots servicing only the vehicle to roadside communication. The key indicator of the performance offered by the WLAN in the vehicular scenario is the throughput characteristics of the carrier at varying speeds. As WLAN was not designed for high speeds, the Doppler Effect has a major impact on the channel quality and achievable throughput for infrastructure based communications. We characterised, based on a series of experiments, the achievable

throughput for vehicle to roadside communication using the 802.11 standard as illustrated in Figure 5. An 802.11b access point was placed in a stationery position on a bridge over a major roadway. The vehicle was equipped with an 802.11 enabled laptop and GPS receiver. Data traffic monitoring software was used to gather the speed, link quality and throughput measurements. A number of tests were carried measuring the throughout achieved for fours different vehicle speeds of 50, 65, 80 and 100kmph. As expected, the results demonstrate that as the speed of the vehicle increases, the achievable throughput decreases dramatically from 520kbps at 50kmph to 250kbps at 100kmph.

The proposed dissemination policy considers the achievable throughput a measure of the channel quality when evaluating the suitability of WLAN for the dissemination of ITS application information.

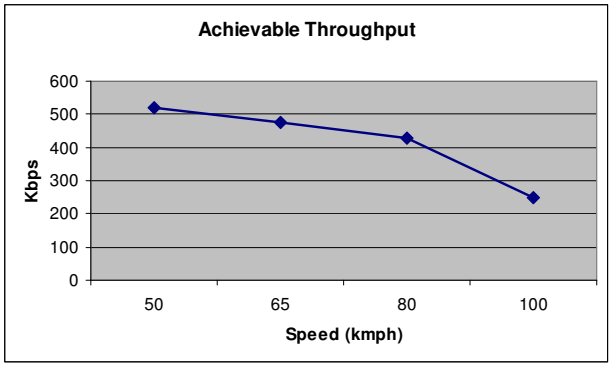

Figure 5: Throughput Characterisation of Infrastructure Communications at high speeds

Based on the candidate network evaluation parameters described above, the policy proposed in this study is shown in Figure 6. WLAN has the larger weighting in this policy; data is disseminated using UMTS only when the vehicle in question is out of WLAN coverage or when UMTS can provide the better throughput. The proposed policy attempts to ensure that the UMTS network operator can maintain a low call blocking probability and high customer satisfaction rating.

V. Simulation Environment

We performed computer simulation modelling of a heterogeneous wireless environment. Vehicles travel at random speeds ranging from 50-100kmph throughout the simulated environment. APs are placed at certain locations, e.g. bridges, junctions etc. providing islands of coverage which accommodate vehicle-to-roadside communication. UMTS is configured to provide wide-area coverage of the simulated environment and supports voice, video and web services. It is assumed that the roadside APs and central application centre are connected via a wired backbone infrastructure. Vehicles randomly move in and out of WLAN coverage and are assumed to have UMTS coverage for 100% of the simulation time.

VI. Results and Analysis

The data dissemination policy is implemented for an Enhanced Driver Awareness application (EDA). This is designed to inform subscribed drivers about emergency situations and traffic conditions in their immediate vicinity. This is a data push application where data is generated and transmitted by the application control centre at aperiodic intervals. The size of the information to be disseminated is randomly chosen and within a range of 200 and 1024 bytes and the dissemination "session" is treated as a web session when evaluating the UMTS capacity surface. It is assumed that the central management centre where the EDA is located has information on the speed and location of each subscribed vehicle when executing the proposed dissemination policy.

```
If: no WLAN coverage
        Choose UMTS
If: WLAN coverage
        Check load on UMTS network
        Calculate WLAN achievable throughput
        If: WLAN throughput > UMTS throughput
                Choose WLAN
        If: UMTS cannot accept traffic
                Choose WLAN
```

Figure 6: Proposed Data Dissemination Policy

Figure 7 illustrates the average network coverage ratio for vehicles travelling throughout the simulated environment. Cars are within coverage of the UMTS network 100% of the time while WLAN connectivity is present for approximately 48% of the simulated time.

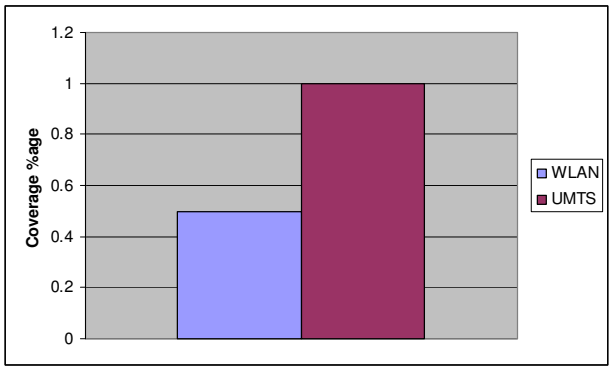

Figure 7: Average network coverage ratio

The speed profile of two cars is demonstrated in Figure 8. Vehicles move at fluctuating speeds in the range of 50-100kmph. The travel speed of vehicles has an effect on the throughput that can be obtained from WLAN connectivity and hence influences the policy decision. The second parameter which affects the dissemination

decision is the current load on the UMTS network. This is illustrated in Figure 9. When the UMTS load is high, the policy is biased towards WLAN selection. Since vehicles have no WLAN connectivity over 50% of the time as shown in Figure 7, UMTS, if capable, will be used to disseminate the application data. This accounts for the high number of web sessions at some points during the simulation since dissemination of ITS application data is recorded as a web session. Figure 10 depicts the policy decision statistics. As expected, WLAN is chosen on over 50% of occasions with UMTS disseminating the data in approximately 47% of decision scenarios.

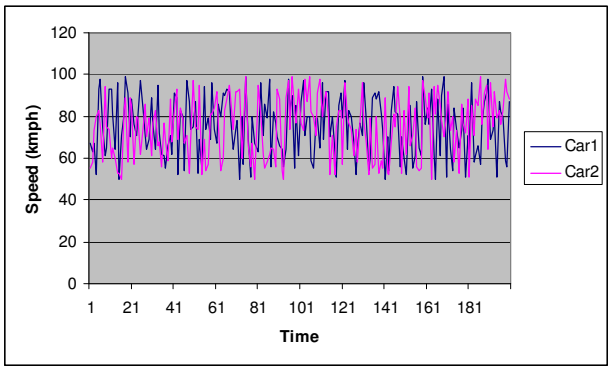

Figure 8: Sample Vehicle Speed Profiles

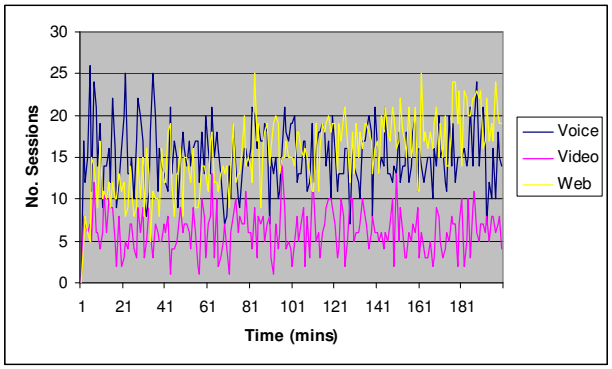

Figure 9: UMTS loading

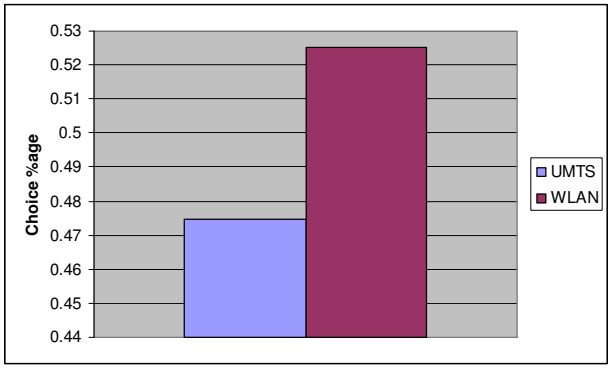

Figure 10: Network Choice Ratio

VII. Conclusions and Future Work

This paper presents a strategy for data dissemination in cooperative vehicular systems. A simple policy based dissemination management function responsible for the efficient propagation of application information is proposed. The UMTS network load and estimated quality of the wireless channel are used as inputs to the policy decision point and based on their values, an appropriate means of propagating the information is determined. A push-based ITS application is considered in the analysis of the dissemination policy. Results show that WLAN is the network of choice in over 50% of the choices made.

Future work plans to include more applications that require higher levels of cooperation among key players in the vehicular system. This will require the inclusion of the vehicle-to-vehicle communication scenario to provide a more flexible communication platform which can support a more diverse set of cooperative applications.

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