Application

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Information about application

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Descriptive data

Project info

Project title (Swedish)*

En ny metod för att studera prestanda inom nätverk för fordonskommunikation

Project title (English)*

A new approach to studying the performance of vehicular communication networks

Abstract (English)*

Vehicular communication technology has been proposed with a primary goal of enhancing traffic safety on roads. With more than ten years of standardization and research activities, the transportation authorities and car manufacturers are now in a stage to decide and plan for the deployment and use of this technology in the near future. In view of this, strong indications about the reliability performance of this technology are required to motivate the authorities to support their roll-out decisions. However, despite a considerably long period of research in the field, such indications are not adequately available yet due mainly to the improper approaches pursued in previous research efforts. A major flaw of this type is the high bias towards the investigation of reliability performance under generic and simplistic vehicular traffic scenarios, e.g. free flow traffic in highways. Consequently, a very important case of reliability behavior in safety-critical traffic conditions has been disregarded. In these scenarios, such as intersections, the accident risk is high and the wireless communication system is required to be highly reliable in order to be useful for safety enhancement. This project takes on a novel approach to fill the gap by addressing the reliability of vehicular communications under safety-critical traffic scenarios. This approach enables the prediction of the performance of communication system under worst-case traffic safety conditions, resembling the performance test of industrial systems or software applications under stress. For the safety-critical traffic scenarios subject to be studied in this project, we aim to incorporate the highest possible degree of realism to model the interactions of the communication and traffic systems, and use it to gain accurate insights into the performance of the communication system. To this aim, we apply the state-of-the-art traffic mobility and radio propagation models to describe the characteristics of the traffic systems corresponding to the safety-critical scenarios subject to study. The performance models developed in this project are intended to be used as a capstone framework for the assessment of the level of safety enhancement achieved by vehicular communication technology under worst-case traffic risk conditions.

Popular scientific description (Swedish)*

Fordonskommunikation är ett tydligt exempel på det som kallas "cyber-physical systems", där vägtrafiksystemet kan ses som ett värdsystem för ett trådlöst kommunikationssystem. Den primära rollen för dessa system är att öka säkerheten i trafiken. Det är av största vikt att att kunna modellera och förstå hur dessa system klarar av att leverera data till förare och automatiserade trafiksäkerhets system för att kunna förstå deras nytta och begränsningar. Till grund för detta ligger en djup förståelse för fordonsrörelser och interaktion på vägarna samt hur dessa påverkar prestandan i de trådlösa nätverken. Erfarenheten visar att trafikmönster uppvisar väldigt olika beteenden under olika förutsättningar och det har därför visat sig ytterst svårt att formulera en modell som fångar alla väsentliga aspekter av trafikens dynamik i alla omständigheter. Denna begränsning har lett forskningen inom kommunikationssystem att använda sig av starkt simplifierade scenarios såsom uniforma flöden på motorvägar i det initiala arbetet med att skaffa djup förståelse för prestandan i dessa nätverk. Vi angriper problemet på ett annat sätt. Vi definierar ett antal begränsade typfall och skapar trafikmodeller för dessa fall utan att generalisera till allmänfallet. Med hjälp av dessa typfall kan vi sedan spänna upp ett rum av ytterligheter och studera prestandan i dessa system under hög stress. Då systemen måste klara av även dessa fall kan vi fokusera arbetet genom att säga, "fungerar det i dessa fall fungerar de i alla fall".

Project period

Number of project years*

4

Calculated project time*

2016-01-01 - 2019-12-31

Classifications

Select a minimum of one and a maximum of three SCB-codes in order of priority.

Select the SCB-code in three levels and then click the lower plus-button to save your selection.

SCB-codes*	2. Teknik > 202. Elektroteknik och elektronik > 20203. Kommunikationssystem

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Enter a minimum of three, and up to five, short keywords that describe your project.

Keyword 1*

vehicular communication networks

Keyword 2*

traffic safety

Keyword 3*

network reliability performance

Keyword 4

Keyword 5

Ethical considerations

Specify any ethical issues that the project (or equivalent) raises, and describe how they will be addressed in your research. Also indicate the specific considerations that might be relevant to your application.

Reporting of ethical considerations*

This project does not raise ethical issues.

The project includes handling of personal data

No

The project includes animal experiments

No

Account of experiments on humans

No

Research plan

Research Program (Appendix A)

1. Purpose and aims

The idea of using vehicular communications was introduced more than ten years ago. It was envisaged that such networks would enable a plethora of new services and functions into road traffic networks including urban sensing, fleet management, unified tolling systems etc. [1] [2]. A primary goal of these networks is the augmentation of road traffic safety systems, which puts severe constraints on the performance of the wireless network whereas other applications have convenience nature with the objective of facilitating information and content access or discovery of local services while on the move. The rich range of applications from safety to convenience or commercially-oriented is highly interesting from the standpoint of transportation authorities, car manufacturers, and service providers.

Vehicular communication represents a tangible example of cyber-physical systems, where a traffic system hosts and interacts with a communication system. The traffic system, comprising vehicular mobility and the road network, affects the communication system in two major ways including the perceivable channel load (channel contention) and the quality of signal propagation. Channel load is determined by vehicular density and concentration, while signal quality is determined by multiple controllable and uncontrollable factors such as transmission power, relative positions of vehicles engaging in a communication, and signal attenuation due to the topological effects of the traffic network, such as moving and static obstacles [3]. Since the primary use of vehicular communications is to improve traffic safety, it is vital to ensure that the system performance is predictable and reliable at deployment. To achieve this, it is necessary to accurately understand the communication system performance, which in turn requires that the host system (i.e. the traffic system) is properly understood. However, conducting an inventory of the research in this area carried out to date results in large gaps in understanding. Although previous research efforts have led to some valuable insights into the performance of vehicular communications, they do not yield solid conclusions about the performance of this technology allowing predictions about its sustainability for the future. This deficiency stems mainly from the simplified approaches adopted for the investigation of communication performance aspects. We identify the following major deficiencies of existing studies in the literature:

- In previous studies, the key fact that the aim of vehicular communications is to improve traffic safety has been largely neglected. This can be verified by comparing the amount of research dedicated to traffic scenarios with high accident rates with those scenarios showing relatively marginal rates. A conspicuous example is the amount of attention dedicated to intersections compared to highway scenarios. While intersections account for more than 40% of all traffic accidents [4], the dedicated research using this scenario is negligible and by no means comparable to the efforts devoted to highway or other less critical scenarios.
- There have been countless efforts to derive universal performance models for vehicular communication systems. Unfortunately, they ended up with excessive oversimplification of the traffic behavior model, because universal performance modeling calls for a universal traffic model capable of explaining all possible road traffic behaviors. However, the civil engineering community has not been able to devise such a model for the underlying traffic flow even after several decades of research indicating the difficulty of the task. In contrast, we find a wide variety of traffic models developed by road traffic researchers, where each model is optimized to describe a certain traffic regime. For example, a traffic model for an uninterrupted arterial road is substantially

different from those applied to intersections. Despite the diversity in the traffic behavior, we do not observe a similar diversity in the modeling of communication performance where previous efforts are confined to limited cases such as (uninterrupted) highway traffic scenarios.

In this project, we do not propose to develop a universal performance model as in previous efforts. Instead, we take on a substantially different approach for the studying of performance aspects of vehicular communication systems. Our approach departs from the "one model fits all" approach, which has not been very successful. Instead, we believe that there must be multiple performance models each suitable for a major traffic scenario. In view of this, our approach for performance modeling will be traffic-driven; that is, we select a set of important traffic scenarios and develop appropriate performance models, one for each scenario. Therefore, we pose the question: which traffic scenarios should be chosen for the study of performance aspects? We intend to mobilize our efforts towards a potentially small set of traffic scenarios, but with substantial implications for both traffic and communication systems. Given the fact that safety applications are the primary focus, in this project, we address *safety-critical traffic scenarios* where the accident risk is high and the wireless communication system is required to be highly reliable in order to be useful for safety enhancement. An example for a safety-critical scenario is a capacity traffic state where the velocity of vehicles is high and the vehicles' spacing is short compared to drivers' reaction time [5]. Other examples are blind spots and intersections, according to the reports of road crash investigations [4] [6]. By addressing safety-critical scenarios, one can predict the performance of the communication system under worst-case safety conditions, resembling the performance test of industrial systems or software applications under stress. Surprisingly, safety-critical scenarios and their implications for the communication system are not addressed in previous studies or it is not clear how the used scenarios relate to traffic safety.

This project aims to address the case of safety-critical traffic scenarios by elaborating on each traffic scenario and modeling accurately the impacts of the traffic system on the performance of the communication system. In view of this, we use realistic traffic mobility and radio propagation models suitable for describing the dynamic of each traffic scenario under investigation. In addition, we intend to design new performance metrics understandable and usable by experts from both networking and vehicular traffic fields.

The aims and purposes of this project are summarized as follows:

- The primary goal of this project is to investigate the performance of vehicular communications in worst-case traffic scenarios where the accident risk is high.
- We aim to develop a framework capable of capturing the essential symbiotic relationships of the communication and traffic system. This framework is meant to effectively describe the effects of the traffic system on the communication system performance. The framework is substantiated by various communication performance models each suitable for a safety-critical traffic scenario.
- We aim to incorporate the highest possible degree of realism in the modeling of the traffic system. With regard to traffic mobility, we choose and apply a suitable traffic model for each traffic scenario identified as safety-critical. With respect to the effects of traffic network on signal propagation, we use the state-of-the-art channel models developed especially for vehicular traffic environments.
- We intend to design a set of unified performance metrics so that they can be used with minimum effort for the assessment of the level of traffic risk that can be mitigated by information exchange among vehicles. We use the proposed metrics to evaluate the level of support that vehicular communications can provide for a selected set of high priority safety applications envisaged for future deployment.

2. Survey of the field

There have been many efforts on the standardization and technological aspects of vehicular communications. These include the development of new specialized standards such as Dedicated Short Range Communications (DSRC) [7], devising new safety applications, and using the existing technologies such as Cellular, WiFi and LTE. The DSRC standard is aimed to improve traffic safety and to enable other applications of Intelligent Transport System (ITS) in the DSRC/WAVE [8] environments.
There are also a significant amount of research efforts dedicated to vehicular communications. For the most part, the research efforts have been substantially oblivious to the special features of vehicular traffic when addressing the wireless communication performance. This stems from the fact that the used techniques and methodologies have been borrowed from a more general field of mobile ad hoc networks (MANETs), and the efforts for the adaptation to the substantially different context of vehicular networks (VANETs) have led to oversimplification. This can be witnessed by the strong tendency in previous works towards using various forms of random traffic and random mobility models to describe vehicular traffic. Examples of this kind are [9] and [10], where the authors assumed random placement of nodes around a given transmitter. Ma et al. [11] [12] [13] and Ye et al. [14] assumed that traffic is Poisson distributed on a one-dimensional road, and obtained closed-form expression for some performance metrics. Khabazian et al. [15] [16] used a one-dimensional road scenario with homogeneous traffic density to address the performance of multi-hop vehicular communications. However, it has been shown that the assumption of homogeneous traffic is not applicable to urban traffic scenarios [17] [18]. Similar assumption was made by Vinel et al. [19] [20] [21] to study the reliability of safety message broadcast. Elbatt et al. [22] investigated the reliability of Cooperative Collision Warning (CCW) [2] in highway scenarios with random node velocities. Other research studies including [23] [24] [25] also assumed some forms of random node distribution to represent vehicular traffic. In addition to suffering from extreme simplification of traffic dynamic, none of these studies address the case of safety-critical traffic situations.

As another key aspect of vehicular traffic environments, it is essential to use appropriate radio propagation model(s) capable of accurately describing the vehicular system environment and its dynamic uncontrollable factors such as shadowing and path loss effects caused by moving and static objects [3]. For the most part of previous research, a common practice was to use general-purpose simplistic models mostly borrowed from the context of cellular networks. It has been shown that those models do not fully capture the radio propagation characteristics of vehicular traffic environments [3] [26] [27]. Unit disk graph model is a typical example of unrealistic models which have been frequently used in the study of vehicular communications. Some representative studies of this kind are [9] [10] [11] [12] [13] [15] [16], to mention a few. In [28], a deterministic free-space channel model was adopted to study the performance of safety message dissemination in vehicular networks. Vinel et al. [19] [20] [21] assumed ideal channel condition in their studies of vehicular networks. Other studies including [11] [12] [13] and [14] considered probabilistic models without any justification of suitability for vehicular environments.

Also, as a prevalent trend, the network performance studies have been mainly conducted by and targeted to communication researchers. In view of this, the performance metrics employed previously reflect solely the viewpoints of networking community. Examples of such metrics are packet delivery ratio (PDR) [13], packet reception ratio [13] [14], packet delay [15], and packet inter-reception time (IRT) [22]. Arguably, these metrics do not reflect the communication performance from the standpoint of traffic safety enhancement. Thus, it is essential to devise new performance metrics that are also understandable and useful for road traffic experts to assess the level of achieved safety.

We extend our background to address the implications of the traffic and radio propagation models for vehicular communication systems. It is important to note that none of the following works propose performance models, but they report some important facts about the complexity of vehicular environments. Koberstein et al. [27] argue that the general purpose radio propagation models do not fully capture the environmental factors in vehicular traffic systems, and thus do not provide good accuracy for vehicular communication scenarios. In [3] [26], it is stressed that vehicular communication environments exhibit several unique characteristics, hindering the direct application of generic propagation models. Gozalvez et al. [29] reveal that the results achieved in a study of safety and data applications in vehicular networks is noticeably dependent on the choice of the radio propagation model. The impacts of the traffic model on the communication aspects of vehicular communications are addressed in a number of other studies. Lan et al. [30] showed that the details of a traffic mobility model such as the presence of traffic lights, driver route choice, and car overtaking behavior exhibit significant impacts on the packet delivery ratio. The authors suggest that if simplistic mobility models are used for the evaluation of vehicular communications, the results may not be as close to reality as expected. Mahajan et al. [31] showed that the clustering effect of vehicles at intersections and acceleration or deceleration of vehicles affect the delivery ratio and packet delays in vehicular communications. Fiore et al. [18] studied the impacts of mobility models with different details on link duration, node degree, and node cluster sizes. They concluded that the realistic motion models cause unique cluster- and link-level effects.

3. Project description

This project is aimed to examine the performance of vehicular communication system in safety-critical traffic conditions. Our approach is to first identify those traffic scenarios that meet safety-critical conditions and the situations where they arise. Next, we select a minimal set of such scenarios which best represent the broad range of traffic scenarios with high traffic risks. For the selected scenarios, we choose suitable traffic models to formally describe them. With regard to radio propagation environment, the topological aspects of the identified scenarios are inspected to choose the radio propagation models suitable for capturing the behavior of signal propagation. The major step of this project is to develop communication performance models by combining the traffic and radio propagation models together with the model of the communication system. As a last step, we intend to address the implications of the performance results obtained in this project for a set of safety applications proposed by standardization bodies and transportation authorities. In the following, we describe the duration, contents and the methods of the planned consecutive tasks.

Task 1: Selection of safety-critical traffic scenarios M1-M4 (duration: Month1 – Month4)

This task involves the identification of those traffic scenarios considered as safety-critical. Traffic safety (or otherwise traffic risk) is an amalgamation of several factors such as human, vehicle, and road structures [32]. This project is focused on vehicular and topological factors. For the vehicular factor, we address those safety-critical scenarios emerging in certain traffic regimes (e.g. capacity traffic flow), and also the traffic risk conditions attributed to vehicles' dimension (e.g. blind spots caused by heavy vehicles obstructing the visibility of drivers). For topological factor, our main approach to identify the safety-critical scenarios is to rely on reports released about accident causations and road crash investigations. We use density-based clustering schemes to process the data gathered from such reports and to classify the different traffic landscapes for which car crashes have been reported frequently. The identified landscape classes are ranked with regard to their sample density, and a set of traffic landscapes with the highest densities are selected for further study in the following tasks. The task schedule presented hereafter is sketched with the aim of addressing capacity flow traffic state, blind spot scenario, and at least four major topology-dependent traffic scenarios identified by applying our clustering algorithm to the data collected from road crash reports.

Task 2: Modeling traffic scenarios *M5 – M9*

Our desired communication performance models require that the traffic scenarios identified in task 1 are described by parsimonious models such that they are analytically integrated into the performance models. To this aim, two different elements of each scenario must be addressed: mobility model and road topology. The mobility model is adopted from the context of traffic science. We select a suitable motion model per scenario and transform it to an equivalent but more tractable Cellular Automata (CA) based model, which has been proven to efficiently describe traffic behavior in various conditions [33]. Regarding the road topology, we use theories from computational geometry to model the topology dictated by a given scenario. The geometric model for a scenario must be adequately general such that it can describe a profile of configurations (scenario profile) characterized by a variety of parameters and a range of parameter values corresponding to the topological aspects of the scenario. To implement and verify the traffic models, we use Paramics [34], a commercial traffic simulation tool.

Task 3: Selection of appropriate radio channel models *M10 – M12*

In this task, we examine the topological aspects of those scenarios identified in Task 1. This examination is performed to characterize the environmental effects on signal propagation. More specifically, for each topology corresponding to a traffic scenario, the presence and intensity of various signal attenuation components such as fading and shadowing are studied. Then, for each topology we select a radio propagation model and the corresponding parameter values which best describes the signal propagation behavior for that topology. As an example case, we know that there are multiple channel models for intersection scenarios where line of sight (LOS) and non-line of sight (NLOS) situations are simultaneously present [35]. Thus, for this and similar scenarios it must be determined which channel model is the most accurate. The selected channel models are incorporated into the communication performance models, and implemented by a simulation tool for verification purposes.

Task 4: Performance modeling *M13 – M44*

In this task, we intend to develop a specialized performance model for every major safety-critical scenario identified in Task 1 and modeled in Task 2. The performance model corresponding to a traffic scenario is aimed to provide answers to questions about the performance behavior in different situations arising from the various instantiations of the scenario. Take an intersection scenario as an example, the envisioned performance model for this scenario is expected to describe the communication performance for different configurations distinguished by road segment features, speed limit, traffic light timing, intersection capacity, etc. Our preference is to propose analytical models, however, simulation models are also considered as an option if the former is unattainable. The proposed strategy for developing a performance model for a given scenario consists of the following subtasks:

Subtask 4-1: incorporating safety application features *M13 – M18*

Safety applications are differentiated based on which messaging scheme they rely on. In the periodic messaging scheme, the communication mode is single-hop broadcast, whereas in event-driven messaging scheme the broadcast mechanism must assume a multi-hop message forwarding in order to cover an area of interest. Furthermore, multi-hop forwarding can be performed in different ways such as flooding, probabilistic, and opportunistic, to mention a few. Obviously, it is infeasible to address the entire spectrum of such schemes. Therefore, an essential step of this task is to select few forwarding schemes with the highest approval from field experts, and apply those schemes to the performance models. We intend to incorporate periodic (in single-hop broadcast mode) and event-driven messaging schemes (in multi-hop broadcast mode) into the performance models to be undertaken in this project.

Subtask 4-2: applying physical and Medium Access Control (MAC) features *M19 – M35*

The MAC protocol adopted for vehicular communications is IEEE 802.11p [36], which is a customized version of the primary IEEE 802.11 protocol. Virtual carrier sensing is suppressed in 802.11p protocol since it is primarily used for broadcast communications. Thus, the protocol relies only on physical carrier sensing to detect whether the channel is idle or busy. In the absence of virtual carrier sensing, the hidden terminal interference becomes a dominant cause of packet failures especially in broadcast communication mode. The hidden terminal problem itself is substantially dependent on the signal propagation environment and also on the traffic intensity, both regarded as the key features of the traffic system and determined from the traffic scenario under question. Knowing the fact that the hidden terminal problem is a major source of interference [23], therefore, a substantial task is to develop an interference model to account for the interference from hidden terminals, and to combine this model with the MAC and application layer functions. To this aim, we use the channel models selected in Task 3 and the simplified traffic models developed in Task 2. We also use the interference model to account for another source of interference termed internal interference, which is attributed to the lack of sufficient time to detect whether the channel is busy before transmitting.

Subtask 4-3: designing performance metrics *M36 – M38*

This task addresses the design of suitable metrics to be employed for the evaluation of communication performance models. Currently, there is a considerable number of performance metrics used in the context of vehicular communication systems [13]. Examples of such metrics are packet delivery ratio, packet reception ratio, packet latency, and packet inter-reception time. We believe these metrics, at best, are usable by communication experts only. Our approach to performance metrics design is to propose entirely new metrics or enhance the available metrics with supplementary features that are meaningful to traffic safety. An example for a new metric is the quality of drivers' information about their surroundings, and an example for an enhanced metric is the reception ratio as a function of distance from a hazard.

Subtask 4-4: model verification *M39 – M44*

This task involves the implementation of the traffic scenarios and the communication system components (MAC, radio propagation, broadcast scheme, etc.), and combining these two in an integrated traffic and networking simulation framework. We use OMNeT++ [37] to implement the communication system and Quadstone Paramics traffic simulator to implement and deploy the desired traffic scenarios. The verification process involves using those traffic profiles identified in task 2 and the nominal values of communication system parameters specified by the associated standards, and compare the results of the proposed performance models with the simulations carried out using the integrated traffic and network simulator. For verification purpose, our preference is to use real traffic traces and use synthetic traffic as an alternative if the former is not adequately available. The verification will be performed with regard to the performance metrics designed in subtask 4-3.

Task 5: Assessment of impacts on safety applications *M45 – M48*

Our results in task 4 are used to assess the potential impacts of the achieved performance on the safety applications proposed by standardization transportation authorities. For this purpose, we select a set of safety applications which best represent the broad set of proposed applications and also fit the traffic scenarios covered by this project. In view of this, the main part of this task is to use the resultant performance metrics designed in task 4 and to check if the metric values fulfill the requirements of the representative safety applications. We expect our results in this task are directly used by traffic experts to assess the level of safety enhancement that can be achieved by vehicular communications.

This 4-year project will be carried out at the Department of Electrical and Information Technology (EIT) of Lund University by dr. Saeed Bastani. The project will also be conducted in close collaboration with wireless communication researchers at Mobile and Pervasive Computing Institute (MAPCI) at Lund University.

4. Significance

This project takes on a new approach to fill the research gaps in the investigation of reliability performance of vehicular communication networks. In contrast with previous approaches, we adopt a traffic-driven method to identify and select those traffic scenarios with the highest traffic risk, and develop specialized models for the performance evaluation of the communication system. This approach is in tune with the expectations from safety applications targeted by vehicular communication technology. In practice, the envisioned performance models in this project can be used as a gauge for testing a wide variety of safety applications in critical traffic scenarios. The outcome of this project is also expected to support traffic experts to assess the utility of vehicular communication networks from the standpoint of safety improvement, and traffic authorities to base their decisions about technology deployment on reliable source of information. The approach of this project also fits well the expectations of decision makers who usually have the tendency to examine worst-case behavior in addition to average system behavior. Moreover, the worst-case analysis helps wireless communication experts and standardization bodies discover the latent deficiencies of the technology, which otherwise could not be possible by relying only on performance behavior under trivial settings.

Also, knowing that it has been a relatively long period of more than a decade since the advent of vehicular communication initiative, it might very well be that the traffic authorities and car manufacturers are in a stage to undertake deployment plans to start using the technology. In view of this, the outcomes of this project can serve either as encouraging, if it is shown that the achievable performance is satisfactory in the most severe situations, or discouraging otherwise. The benefits of the first outcome are far-reaching, and the second outcome leads to saving the costs inflicted by the deployment of an unfledged technology.

Finally, this project is about modeling a real world cyber-physical system. More specifically, we face two inherently different systems with complex interactions. Also, the effects of the mutual interactions are uncertain, and their forms depend on many uncontrollable factors induced mainly by the traffic system as a container for the communication system. Even with predictable impacts of the traffic system, the behavior of the communication system itself is unpredictable. Therefore, in this project, we are concerned with a complex system. The theories to be developed in this project can help the research community approach similar problems, or exploit the methodology developed in this project in other similar contexts.

5. Preliminary results

Recently, we have performed a number of research works relevant to this project. In the following, we briefly introduce these works and mention the original published articles.

- We have developed a novel traffic density model for urban traffic scenarios [17]. In this model, we have considered the impacts of urban intersections on the traffic mobility. The traffic density model was employed to characterize the spatial-temporal behavior of radio overlapping as a predictor of communication interference and channel load. We found strong evidence that the use of data rates in the lower part of the nominal range specified for vehicular communication networks in the DSRC/WAVE standard is highly questionable in urban vehicular networks.
- We have developed an analytical model to predict the reliability indicators of safety applications in urban traffic scenarios [38]. Focusing on a road segment linked to a signalized intersection as the building blocks of urban traffic systems, we applied the traffic density model mentioned in the first contribution to investigate the spatial-temporal behavior of the reliability metrics. We found that the worst-case results take place in positions behind the traffic light queue where vehicles are decelerating from high velocity. It is notable that, from a traffic safety point of view, these positions are arguably the most important for timely alerting of dangerous traffic conditions, and their lower reliability may lead to an increased risk of serious incidents.
- We have developed an analytical framework to investigate the severity of hidden terminal interference with focus on safety-critical traffic scenarios [39]. In this study, a state-of-the-art shadow-fading path loss model was used as the channel model. Also, focusing on urban traffic scenarios with forced-flow traffic, we identified two major safety-critical traffic scenarios and find the upper-bound interference power induced by hidden nodes and the lower-bound reachable distance of the safety messages. We found that the hidden terminal interference causes a significant decline in the reachable distance of broadcast safety messages, which in several cases drop to distances shorter than the minimum required coverage of medium range safety applications.

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Interdisciplinarity

My application is interdisciplinary

☐

An interdisciplinary research project is defined in this call for proposals as a project that can not be completed without knowledge, methods, terminology, data and researchers from more than one of the Swedish Research Councils subject areas; Medicine and health, Natural and engineering sciences, Humanities and social sciences and Educational sciences. If your research project is interdisciplinary according to this definition, you indicate and explain this here.

Click here for more information

Scientific report

Scientific report/Account for scientific activities of previous project

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Budget and research resources

Project staff

Describe the staff that will be working in the project and the salary that is applied for in the project budget. Enter the full amount, not in thousands SEK.

Participating researchers that accept an invitation to participate in the application will be displayed automatically under Dedicated time for this project. Note that it will take a few minutes before the information is updated, and that it might be necessary for the project leader to close and reopen the form.

Dedicated time for this project

	Role in the project	Name	Percent of full time
1	Applicant	Saeed Bastani	75
2	Participating researcher	Björn Landfeldt	

Salaries including social fees

	Role in the project	Name	Percent of salary	2016	2017	2018	2019	Total
1	Applicant	Saeed Bastani	75	548,640	565,100	582,053	599,514	2,295,307
	Total			548,640	565,100	582,053	599,514	2,295,307

Other costs

Describe the other project costs for which you apply from the Swedish Research Council. Enter the full amount, not in thousands SEK.

Premises

	Type of premises	2016	2017	2018	2019	Total
1	Office and common areas	76,391	76,569	78,639	80,771	312,370
	Total	76,391	76,569	78,639	80,771	312,370

Running Costs

	Running Cost	Description	2016	2017	2018	2019	Total
1	Travel	Conferences and related events	60,000	60,000	60,000	60,000	240,000
2	Software	Software purchase and support	17,000	2,000	2,000	2,000	23,000
	Total		77,000	62,000	62,000	62,000	263,000

Depreciation costs

Depreciation cost	Description	2016	2017	2018	2019

Total project cost

Below you can see a summary of the costs in your budget, which are the costs that you apply for from the Swedish Research Council. Indirect costs are entered separately into the table.

Under Other costs you can enter which costs, aside from the ones you apply for from the Swedish Research Council, that the project includes. Add the full amounts, not in thousands of SEK.

The subtotal plus indirect costs are the total per year that you apply for.

Total budget

Specified costs	2016	2017	2018	2019	Total, applied	Other costs	Total cost
Salaries including social fees	548,640	565,100	582,053	599,514	2,295,307		2,295,307
Running costs	77,000	62,000	62,000	62,000	263,000		263,000
Depreciation costs					0		0
Premises	76,391	76,569	78,639	80,771	312,370		312,370
Subtotal	702,031	703,669	722,692	742,285	2,870,677	0	2,870,677
Indirect costs	211,404	211,897	217,625	223,526	864,452		864,452
Total project cost	913,435	915,566	940,317	965,811	3,735,129	0	3,735,129

Explanation of the proposed budget

Briefly justify each proposed cost in the stated budget.

Explanation of the proposed budget*

Salaries: Saeed Bastani will work 75% of the project. Wage costs include social security contributions and vacation costs and an estimated wage increase of 3% per year.
Travel: Travel costs to cover travel tickets, conference fees, and other expenses associated with attending conferences and outreaching actions. This cost has been calculated for a planned participation in a number of 4 international conferences/events per year, with each participation costing 15,000 SEK.
Software. The project leader intends to purchase Paramics, a commercial state-of-the-art traffic simulator. The cost of an academic standard package with lifetime license is 15,000 SEK. The cost per year for support of this software is 2,000 SEK.
Premises: charges imposed on offices and common areas, 12.21% (2015 *Debiteringsprocent*)
OH: Indirect costs was calculated with 33.79% (2015 *Debiteringsprocent*)

Other funding

Describe your other project funding for the project period (applied for or granted) aside from that which you apply for from the Swedish Research Council. Write the whole sum, not thousands of SEK.

Other funding for this project

Funder	Applicant/project leader	Type of grant	Reg no or equiv.	2016	2017	2018	2019

CV and publications

CV

Curriculum Vitae (Appendix B)

Saeed Bastani, 751201-7752

Education

- PhD in computer science, thesis: *Reliability and Efficiency of Vehicular Networks Applications*, University of Sydney, Australia. 2010-2013
- MSc in artificial intelligence and robotics, thesis: *Design and Implementation of a Small Scale Intelligent Web Search Engine*, Iran University of Science and Technology (IUST), Tehran, Iran. 1999-2002
- BSc in software engineering, Isfahan University of Technology (IUT), Isfahan, Iran. 1994-1998

Postdoctoral and Research Positions

- Postdoctoral Researcher, Lund University, Lund, Sweden. March 2014 - now
- Research Associate, University of New South Wales, Sydney, Australia. Sep. 2013 - Feb. 2014
- Visiting Researcher, Lund University, Lund, Sweden. Sep. 2012 - Oct. 2010

Present Position

- Postdoctoral Researcher, Lund University, Lund, Sweden. March 2014 - now

Previous Employments

- Large scale IP/MPLS network analyst and test developer, Iran Telecommunication Research Center (ITRC). 2008-2010
- Project manager, network management systems (NMS), Iran Telecommunication Research Center (ITRC). 2007
- Network management systems (NMS) analyst, Iran Telecommunication Research Center (ITRC). 2002-2006

Key scientific/research/teaching experience

- Performance modeling of vehicular communication systems
- Vehicular traffic modeling and simulation
- Distributed systems design and optimization
- Game theoretic modeling of cooperative wireless communications
- Teaching undergraduate and graduate courses (7 years)

Other Information Relevant to My Application

- Reviewer: Journal articles (e.g., IEEE Transactions on Vehicular Technology, Elsevier Computer Communication) and conference papers (LCN, MSWIM, WoWMoM, VTC).
- Project Leadership: Design and implementation of large scale network management systems, Iran Telecommunication Research Center, Iran.
- Awards: PhD scholarship, University of Sydney & National ICT Australia (NICTA).

Curriculum Vitae

Bjorn Landfeldt, 670825-0193

Education

Bachelor of Engineering (equivalent) Royal Institute of Technology (KTH)	1996
PhD in Telecommunications University of New South Wales, Australia Thesis Title: "Reactive Quality of Service Management from an End-User Perspective" Supervisor, Prof. Aruna Seneviratne	2000

Employment

Current Employment: Professor in Network Architecture and Services Department of Electrical and Information Technology Lund Institute of Technology	2012-
Scientific Leader and Director, MAPCI	2014-

Previous Employments:

Associate Professor School of Information Technologies The University of Sydney, Australia	2001-2012
Senior Researcher Ericsson Research, Networks and Systems Kista, Stockholm	2000-2001

Completed PhD students, primary Supervisor

Sanchai Rattananon	2005
Apichan Kanjanavapastit	2005
Kaychalya Premadasa	2007
Khaled Matrouk	2008
Mohsin Iftikhar	2008
Daniel Cutting	2008
Suparerk Manitpornsut	2009
Saeed Bastani	2013
Emma Fitzgerald	2013
Quincy Tse	2014

Post Doctoral supervision:

Jahan Hassan	2005-2007
Riky Subrata	2005-2007
Zainab Zaidi	2007-2009
Zhi Zhang	2015-
Mehmet Karaca	2015-

Evidence of Leadership and Impact in the Field

I am currently an associate editor of Journal of Communications, and Journal of Pervasive Computing and Communications. I have also been a Guest Editor for several special issues of Journal of Parallel and Distributed Systems, and Computer Communications.

However, in the networking field (as in most computer science fields), conferences play a role as important as journals where the leading conferences typically have an acceptance rate between 10 and 30% and employ a rigorous review process. I have had the following leading roles in conferences:

Conference Program Chairing

1) ACM MSWIM 2012 (Co-Chaired with Ravi Prakash)
2) ACM MSWIM 2011 (Co-Chaired with Luciano Bononi)
3) ACM International Symposium on Mobility Management and Wireless Access, MobiWac, Bodrum Turkey, Oct. 2010
4) ACS/IEEE International Conference on Computer Systems and Applications, AICCSA 2010 (Co-Chaired with Stephan Olariu)
5) IEEE ICCCN Symposium on Network Architectures and Protocols (Co-Chaired with Joe Touch) San Francisco, USA 2009
6) ACM International Symposium on Mobility Management and Wireless Access, MobiWac, Teneriffe, Canary Islands, 2009.
7) IEEE ICCCN Symposium on Protocols and Algorithms for Wireless Networks, (Co-chaired with Lavy Libman) Virgin Islands, USA, 2008
8) ACM International Symposium on Mobility Management and Wireless Access, MobiWac, Vancouver, Canada, 2008.
9) ACORN Workshop on Underwater Networks, Adelaide, Australia, 2007
10) IEEE International Conference on Networking – ICON, (Co-chaired with Tim Moors) Sydney, Australia, 2003

Recent Conference Program Committee Memberships

1) IEEE WCNC 2005, 2006, 2010, 2011
2) IEEE ICC 2005, 2006, 2007, 2008, 2009, 2011
3) IEEE WIOPT 2010, 2011
4) International Symposium on Smart Home, SH 2010
5) IEEE VON 09
6) IEEE and ACM FMN 2009
7) UIC 2009

In Australia I am widely considered to be a leader of my field. I was hired as the technical expert consultant to give policy advice to the Department of Broadband, Communications and the Digital Economy on the widely publicised study on the feasibility of implementing mandated Internet filtering at the ISP level. In addition, I have acted as an expert witness before a parliamentary hearing in Canberra by the Select Joint Committee on Cyber-Safety. I have further appeared on over 50 TV, Radio and Newspaper interviews over the past few years, both in Australia and Internationally. I was also invited by the dean, Faculty of Information and Communication Technologies at Swinburne University as technical expert and reviewed the research performance of the Centre for Advanced Internet Architectures (CAIA) in 2010.

Publication list

Publication List (Appendix C)

Saeed Bastani, 751201-7752

Refereed Journal Publications

- *S.Yousefi, S.Bastani, M.Mazoochi, A.Ghiamatyoun: Genetic Algorithm Approach for QoS-based Tree Topology Construction in IEEE 802.16 mesh networks, *Science China Information Series*, 55(12), 2013, 1–17 [Number of citations: 0].
- A.Ghiamtyoun, M.Mazoochi, S.Yousefi, S.Bastani: Joint call admission and scheduling for minimum delay UGS data delivery in WiMAX mesh mode, *Elsevier AEU-International Journal of Electronics and Communication*. 64(7), 2010, 640-649 [Number of citations: 3].

Refereed Conference Publications

- P.Amani, S.bastani, B.Landfeldt: Towards Optimal Content Replication and Request Routing In Content Delivery Networks, IEEE International Conference on Communications (ICC), 2015. (accepted)
- *L.Libman, S.Bastani, S.T.Waller: Real-time traffic monitoring using wireless beacons with the Cell Transmission Model", *IEEE* International Conference on Intelligent Transportation Systems (ITSC), 2014 [Number of citations: 0].
- *S.Bastani, L.Libman, S.T.Waller: Impact of Beaconing Policies on Traffic Density Estimation Accuracy in Traffic Information Systems, *Proc. IEEE International Symposium on a World of Wireless Mobile and Multimedia Networks (WoWMoM)*, Sydney, Australia, 2014 [Number of citations: 0].
- S.Bastani, B.Landfeldt, Ch.Rohner, P.Gunningberg: A Social Node Model for Realizing Information Dissemination Strategies in Delay Tolerant Networks, *Proc. ACM International Conference on Modeling, Analysis and Simulation of Wireless and Mobile Systems (MSWIM)*, Cyprus, 2012 [Number of citations: 4].
- *S.Bastani, B.Landfeldt, L.Libman: On the Reliability of Safety Message Broadcast in Urban Vehicular Ad hoc Networks, *Proc. ACM International Conference on Modeling, Analysis and Simulation of Wireless and Mobile Systems (MSWIM)*, USA, 2011 [Number of citations: 7].
- *S.Bastani, B.Landfeldt, L.Libman: A Traffic Density Model for Radio Overlapping in Urban Vehicular Ad hoc Networks, *Proc. IEEE Conference on Local Computer Networks (LCN)*, Germany, 2011 [Number of citations: 9].
- S.Bastani, S.Yousefi, M.Mazoochi, A.Ghiamatyoun: On the QoS Tree Construction in WiMAX Mesh Networks based on Genetic Algorithm Approach, *Proc. ACM International Symposium on QoS and Security for Wireless and Mobile Networks*, 2009 [Number of citations: 1].
- S.Bastani, S.Yousefi, M.Mazoochi, A.Ghiamatyoun: Delay and Throughput Tradeoff in WiMAX Mesh Networks, *Proc. International Conference on Communication Software and Networks (ICCSN)*, 2009 [Number of citations: 0].
- *S.Yousefi, S.Bastani, M.Fathy: On the Performance of Safety Message Discrimination in Vehicular Ad Hoc Networks, *Proc. European Conference on Universal Multiservice Networks (ECUMN)*, 2007 [Number of citations: 26].

- A.R.S.Shafigh, S.Bastani, S.Moherehkesh, M.Analoui: Haar Wavelet Prediction-Based Fair Queuing, *Proc. IEEE International Symposium on Computer Networks (ISCN)*, 2006 [Number of citations: 0].
- S.Moherehkesh, S.Bastani, A.R.S.Shafigh, M.Fathy: A Framework for Providing QoS Routing in MANETs, *Proc IEEE International Symposium on Computer Networks (ISCN)*, 2006 [Number of citations: 0].

Book Chapter

- *S.Yousefi, M.Fathy, S.Bastani: Vehicular Ad Hoc Networks: Current Issues and Future Challenges, chapter in the book *Mobile Ad Hoc Networks: Current Status and Future Trends* (J.Loo, J. L.Mauri, J. H.Ortiz, eds.), pp. 329–377, CRC Press, Boca Raton, 2012 [Number of citations: 0].

List of 5 publications with the highest citations

- S.Yousefi, S.Bastani, M.Fathy: On the Performance of Safety Message Discrimination in Vehicular Ad Hoc Networks, *Proc. European Conference on Universal Multiservice Networks (ECUMN)*, 2007 [Number of citations: 26].
- S.Bastani, B.Landfeldt, L.Libman: A Traffic Density Model for Radio Overlapping in Urban Vehicular Ad hoc Networks, *Proc. IEEE Conference on Local Computer Networks (LCN)*, Germany, 2011 [Number of citations: 9].
- S.Bastani, B.Landfeldt, L.Libman: On the Reliability of Safety Message Broadcast in Urban Vehicular Ad hoc Networks, *Proc. ACM International Conference on Modeling, Analysis and Simulation of Wireless and Mobile Systems (MSWIM)*, USA, 2011 [Number of citations: 7].
- S.Bastani, B.Landfeldt, Ch.Rohner, P.Gunningberg: A Social Node Model for Realizing Information Dissemination Strategies in Delay Tolerant Networks, *Proc. ACM International Conference on Modeling, Analysis and Simulation of Wireless and Mobile Systems (MSWIM)*, Cyprus, 2012 [Number of citations: 4].
- A.Ghiamtyoun, M.Mazoochi, S Yousefi, S.Bastani: Joint call admission and scheduling for minimum delay UGS data delivery in WiMAX mesh mode, *Elsevier AEU-International Journal of Electronics and Communication*, 64(7), 2010, 640-649 [Number of citations: 3].

Total number of citations:	50
Total number of publications:	14
Total number of publications with 4 or more citations:	4

APPENDIX C, Publication List

Björn Landfeldt, 670825-0193

The citation counts for the following publication list has been collected using Google Scholar. The list comprises publications since 2007 (8 years).

Refereed Journal Articles

- “Fair Flow Rate Optimization by Effective Placement of Directional Antennas in Wireless Mesh Networks”, Y. Li, M. Pioro and B. Landfeldt, Performance Evaluation 2015, doi: 10.1016/j.peva.2015.01.007 in print.
- “Interarrival Distribution of a Long-Range Dependent Workload Process”, M. Caglar, M. Iftikhar and B. Landfeldt, Applied Mathematics and Information Science 8, no 1L, pp. 15-26 (2014)
- “On the Provisioning of QoS Mapping in Cellular and IP Networks Using a Translation (Function) Matrix”, M. Iftikhar, W. Al-Salih, I. Shoukat, M. Uddin, M. Talha, B. landfeldt and A. Zomaya, Information, (06) 2012.
- “Improving Densely Deployed Wireless Network Performance In Unlicensed Spectrum through Hidden-Node Aware Channel Assignment”, S. Manitpornsut, B. Landfeldt and A. Boukerche, Performance Evaluation, Volume 68, Issue 9, September 2011, pp. 825-840. Number of citations: 2
- "Service level agreements (SLAs) parameter negotiation between heterogeneous 4G wireless network operators", M. Iftikhar, B. Landfeldt, S. Zeadally and A. Zomaya, Pervasive and Mobile Computing, Volume 7, Issue 5, 2011, pp. 525-544. Number of citations: 13
- “Real-time detection of traffic anomalies in wireless mesh networks (WMN)”, Z. Zaidi, S. Hakami, B. Landfeldt and T. Moors, Wireless Networks, Volume 16, No. 6, pp. 1675-1689, August 2010. Number of citations: 7
- “Cooperative Power-Aware Scheduling in Grid Computing Environments”, R. Subrata, A. Y. Zomaya and B. Landfeldt, Journal on Parallel and Distributed Systems, vol. 70. Issue 2, 2010. Number of citations: 45
- “Special Interest Messaging: A Comparison of IGM Approaches”, D. Cutting, A. Quigley and B. Landfeldt, The Computer Journal 53 (1) 2010, pp. 50 - 68. Number of Citations: 4
- “Detection and Identification of Anomalies in Wireless Mesh Networks using Principal Component Analysis”, Z. Zaidi, S. Hakami, T. Moors and B. Landfeldt, Journal of Interconnection Networks, Vol. 10, no. 4 (2009) pp. 515-532. Number of citations: 4
- “Towards the Formation of Comprehensive SLAs between Heterogeneous Wireless DiffServ Domains”, M. Iftikhar, B. Landfeldt and M. Caglar, Springer Telecommunication Systems special issue on Wireless networks Modeling, vol. 42, issue 3-4, December 2009. Number of citations: 15
- “Prolonging the System Lifetime and Equalizing the Energy for Heterogeneous Sensor Networks Using RETT Protocol”, K. Matrouk and B. Landfeldt, International Journal of Sensor Networks, vol. 6, no. 2, 2009. Number of citations: 9

- *“RETT-gen: A globally efficient routing protocol for wireless sensor networks by equalising sensor energy and avoiding energy holes”, K. Matrouk and B. Landfeldt, Elsevier Journal on AdHoc Networks, Vol.7 no. 3, May 2009, pp. 514-536. Number of citations: 40
- “Weighted Channel Allocation and Power Control for Self-Configurable Infrastructure WLANs” , S. Manitpornsut and B. Landfeldt, Journal of Interconnection Networks, Vol. 9, No. 3 2008, pp. 299-316. Number of citations: 3
- “A Cooperative Game Framework for QoS Guided Job Allocation Schemes in Grids”, R. Subrata, A. Y. Zomaya and B. Landfeldt, IEEE Transactions of Computers, vol. 57 no. 10, 2008, pp. 1413-1422. Number of citations: 51
- “Monitoring Assisted Robust Routing in Wireless Mesh Networks” Z. R. Zaidi and B. Landfeldt, ACM/Springer Mobile Networks and Applications (MONET), vol.13, issue 1-2, April 2008, pp. 54-66. Number of citations: 9
- “Multiclass G/M/1 Queueing System with Self-Similar Input and Non-Preemptive Priority”, M. Iftikhar, M. Caglar and B. Landfeldt, Journal of Computer Communications, vol. 31, issue 5, 2008, pp. 1012-1027. Number of citations: 25
- “SPICE: Scalable P2P Implicit Group Messaging”, D. Cutting, B. Landfeldt and A. Quigley, Journal of Computer Communications Special issue on Foundation of Peer-to-Peer Computing, Vol. 31 (3), 2008, pp. 437-451. Number of citations: 9
- “Trust-Based Fast Authentication for Multiowner Wireless Networks”, J. Hassan, H. Sirisena, B. Landfeldt, IEEE Transactions on Mobile Computing, vol. 7, no. 2, 2008, pp. 247-261. Number of citations: 25
- “Special interest messaging: A Comparison of IGM Approaches”, D. Cutting, A. Quigley and B. Landfeldt, The Computer Journal, Oxford Press, Published online December 2007, DOI 10.1093/comjnl/bxm076. Number of citations: 4
- “Experiences in Deploying a Wireless Mesh Network Testbed for Traffic Control”, Z. Wang, K.Lan , R. Berriman, T. Moors, M. Hassan, L. Libman, M. Ott, B. Landfeldt, Z. R. Zaidi and A. Senevirate, ACM SIGCOMM Computer Communications Review, vol. 37 (5), 2007, pp. 17-28. Number of citations: 21
- “A Game Theoretic Approach for Load Balancing in Computational Grids", R. Subrata, A. Zomaya and B. Landfeldt, IEEE Transactions on Parallel and Distributed Systems, vol. 19, no. 2, 2007, pp 1-11. Number of citations: 78
- “Artificial Life Techniques for Load Balancing in Computational Grids”, R. Subrata, A. Zomaya and B. Landfeldt, Elsevier Journal of Computer Sciences and Systems Special Issue on Network Based Computing, vol. 73, Issue 8, 2007, pp. 1176–1190. Number of citations: 46

Refereed Conference Publications

- “Towards Optimal Content Replication and Request Routing In Content Delivery Networks”, P. Amani, S. Bastani and B. Landfeldt, In Proc. IEEE ICC 2015, London, England June 2015, to Appear.
- The failure of CSMA in emerging wireless network scenarios, E. Fitzgerald and B. Landfeldt, In Proc. IFIP Wireless Days, Rio de Janeiro, Brazil, Nov. 2014.

- "Improving minimum flow rate in wireless mesh networks by effective placement of directional antennas", Y. Li, M. Pioro and B. Landfeldt, In Proc. ACM MSWIM, Barcelona Spain Nov. 2013 Number of citations: 1
- "On Road Network Utility Based on Risk-Aware Link Choice", E. Fitzgerald and B. Landfeldt, In Proc. IEEE Intelligent Transport Systems Conference (ITSC), The Hague, Netherlands October 2013
- *"Trading Accuracy and Resource Usage in Highly Dynamic Vehicular Networks", E. Fitzgerald and B. Landfeldt, IEEE Intelligent Transport Systems Conference (ITSC), The Hague, Netherlands October 2013
- "The Implementation of Novel Idea of Translation Matrix to Maintain QoS for a Roaming User Between Heterogeneous 4G Wireless Networks", M. Iftikhar, M. Zuair, A. Rahal, M. Rahal, J. Taheri, A. Zomaya and B. Landfeldt, in Proc. IEEE P2MNET, Clearwater, Fl; USA, October 2012.
- "A Social Node Model for Realising Information Dissemination Strategies in Delay Tolerant Networks", S. Bastani, B. landfeldt, C. Rohner and P. Gunningberg, In Proc. ACM MSWIM 2012, Paphos, Cyprus Oct. 2012. Number of citations: 5
- *"A System for Coupled Road Traffic Utility Maximisation and Risk Management Using VANET", E. Fitzgerald and B. Landfeldt, In Proc IEEE ITSC, Anchorage, USA, Sept. 2012, Number of citations: 7
- "Interference-Aware Geocasting for VANET", Q. Tse and B. Landfeldt, VTP 2012, In Proc. IEEE WoWMoM 2012. Number of citations: 3
- *"On the Reliability of Safety Message Broadcast in Urban Vehicular Ad hoc Networks", S. Bastani, B. Landfeldt and L. Libman, in Proc. ACM MSWIM, Miami, FL, USA, October 2011. Number of citations: 8
- *"A Traffic Density Model for Radio Overlapping in Urban Vehicular Ad Hoc Networks", S. Bastani, B. Landfeldt and L. Libman, in Proc. IEEE LCN 2011, October 2011. Number of citations: 11
- "Privacy preserving neighborhood awareness in vehicular ad hoc networks", Osama Abumansoor, Azzedine Boukerche, Bjorn Landfeldt, Samer Samarah, Proceedings of the 7th ACM symposium on QoS and security for wireless and mobile networks, Miami FL, USA October 2011. Number of citations: 1
- "Reducing Handoff Latency for WiMAX Networks using Mobility Patterns", Z. Zhang, A. Boukerche and B. Landfeldt, IEEE WCNC, Sydney Australia, April 18-21 2010. Number of citations: 9
- "Efficient Channel Assignment Algorithms for Infrastructure WLANs Under Dense Deployment", S. Manitpornsut, B. Landfeldt and A. Boukerche, ACM MSWIM, Tenerife Spain, October 2009. Number of citations: 9
- Performance Evaluation of Opportunistic temporal-Pairing Access Network (OPAN), L Wu, R, Hsieh and B. Landfeldt, Chinacom 2009, Xi'An, China, Aug. 26-28 2009.
- "The Problem of Placing Mobility Anchor Points in Wireless Mesh Networks", L. Wu and B. Landfeldt, ACM Mobiwac, Vancouver, Canada, October 2008. Number of citations: 5

- “Interarrival time distribution for a non-Markovian arrival process”, M.Caglar, M. Iftikhar and B. Landfeldt, in Proc. Association of European Operational Research Societies (EURO) Working Group on Stochastic Modeling, Istambul, Turkey June 2008.
- “Detection and identification of anomalies in wireless mesh networks using Principal Component Analysis (PCA)”, S. Hakami, Z. R. Zaidi, B. Landfeldt and T. Moors. in Proc. ISPAN, Sydney, Australia, 2008, Invited paper. Number of citations: 8
- "Monitoring assisted robust routing in wireless mesh networks", Z. R. Zaidi and B. Landfeldt, in Proc. IEEE/ACM MASS, Pisa, Italy, October, 2007. Number of citations: 8
- “Traffic Engineering and QoS Control between Wireless DiffServ domains using PQ and LLQ”, M. Iftikhar, M. Caglar, B. Landfeldt and T. Singh, ACM Mobiwac, in Proc. ACM MSWIM, Chania, Crete, October 2007. Number of citations: 8
- “Multiclass G/M/1 queueing system with self-similar input and non-preemptive priority”, M. Caglar, M. Iftikhar, B. Landfeldt and T. Singh, in Proc. APS Informs, Eindhoven Netherlands, July 2007.
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Dissertation title (en)
Reliability and Efficiency of Vehicular Network Applications

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Subject doctors degree	ISSN/ISBN-number	Date doctoral exam
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Dissertation title (en)
Reactive QoS Management from an End-User Perspective

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Bastani, Saeed has not added any publications to the application.

Publications

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Landfeldt, Björn has not added any publications to the application.

Register

Terms and conditions

The application must be signed by the applicant as well as the authorised representative of the administrating organisation. The representative is normally the department head of the institution where the research is to be conducted, but may in some instances be e.g. the vice-chancellor. This is specified in the call for proposals.

The signature*from the applicant*confirms that:

- the information in the application is correct and according to the instructions form the Swedish Research Council
- any additional professional activities or commercial ties have been reported to the administrating organisation, and that no conflicts have arisen that would conflict with good research practice
- that the necessary permits and approvals are in place at the start of the project e.g. regarding ethical review.

The signature *from the administrating organisation* confirms that:

- the research, employment and equipment indicated will be accommodated in the institution during the time, and to the extent, described in the application
- the institution approves the cost-estimate in the application
- the research is conducted according to Swedish legislation.

The above-mentioned points must have been discussed between the parties before the representative of the administrating organisation approves and signs the application.

Project out lines are not signed by the administrating organisation. The administrating organisation only sign the application if the project outline is accepted for step two.

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