Vetenskapsrådet

Application

2015-03-31

2015-05371	Vinel, Alexey	NT-14

Information about applicant

Name: Alexey Vinel

Doctorial degree: 2007-05-28

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Academic title: Professor

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Employer: Högskolan i Halmstad

Administrating organisation: Högskolan i Halmstad

Project site: Halmstad Embedded and Intelligent Systems research (EIS)

Information about application

Call name: Forskningsbidrag Stora utlysningen 2015 (Naturvetenskap och teknikvetenskap)

Type of grant: Projektbidrag

Focus: Fri

Subject area:

Project title (english): Is Live Video Delivery in Vehicular Networks Possible?

Project start: 2016-01-01

Project end: 2019-12-31

Review panel applied for: NT-14, NT-13

Classification code: 20203. Kommunikationssystem, 20204. Telekommunikation, 20205. Signalbehandling

Keywords: vehicular networking, video coding, medium access control, broadcasting, random multiple access

Funds applied for

Year:	2016	2017	2018	2019
Amount:	879,677	908,113	946,776	985,704

Participants

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Doctorial degree: 2009-03-24

Birthdate: 19810909

Academic title: Doktor

Gender: Male

Employer: No current employer

Descriptive data

Project info

Project title (Swedish)*

Är livevideoöverföring möjligt i trådlösa nätverk mellan fordon?

Project title (English)*

Is Live Video Delivery in Vehicular Networks Possible?

Abstract (English)*

ACTIVITIES. The purpose of the project is to develop a fundamental theory for distributed low complexity multiplexing of live video streams in mobile wireless random access networks. In other words, our objective is to find the ways, which would allow numerous interfering mobile objects to transmit live video to each other and to the infrastructure with low delay and high-visual quality without any central coordination enabling critical applications. This problem has not received much attention during the last decades since the applications motivating such a technology has not been considered until few years ago. The specific objectives of the project are:
1. The development of methods for performance evaluation of future vehicular random access networks (i.e. our key research goal is to characterize numerically and predict the performance of highly dynamic decentralized network with broadcast wireless communication channels).
2. The development of methods for low-complexity scalable video encoding with unequal packet loss protection and rate control (i.e. our key research goal is to propose the ways to compress video with low complexity and redundancy to be transmitted in a shared wireless communication channels).
3. The development of methods for efficient decentralized video multiplexing in vehicular random access channels (i.e. our key question is how to transmit multiple video flows concurrently between numerous mobile objects which mutually interfere each other).
IMPLEMENTATION. We develop basics of a new fundamental framework, which a synthesis between random multiple access theory, which studies how different devices share the common communication channel without central coordination and joint source-channel coding theory, which studies how to encode the video stream in accordance to communication channel quality. We refer to this new approach as joint source-channel coding in random access channels. At a lower level of abstraction the methods of information theory, stochastic processes, signal processing and optimization theory will be used. Simulators and some software tools will be developed. In this project a significant synergy effect is expected due to the combination of Alexey Vinel expertise (wireless networks, random access) and Evgeny Belyaev expertise (signal processing, video coding. The project is organized into 5 work-packages, which cover 4 years of project. Each WP has a specific research problem and further segmented into tasks.
SIGNIFICANCE. Few recent trends in information and communications technologies motivate this project:
1. Live video streaming has become an everyday life feature and applications such as the built-in FaceTime for iPhones enable new ways to interact with the environment.
2. Video content is already one of the dominant ones in the nowadays Internet, and the proportion of the live video is about to grow.
3. Video camera capability has been standard in premium cars and in certain special vehicles such as garbage trucks for several years to increase the awareness horizon for the drivers.
Now it is time to take it a step further and share what the video camera produces and distribute it to the mobile users in its neighborhood to enable a variety of new applications. Fully autonomous driving is considered a strategic direction for many vehicle manufacturers. Today it is already practically feasible to consider fully automatic operation of vehicles in restricted areas. In such use cases, trucks could be automatically loaded and unloaded in a harbor, a group of construction equipment could perform some joint task without the human interposal, a car could automatically drive to an available place in the parking lot. Reliable inter-vehicle and vehicle-to-roadside real-time live video delivery is crucial for safe (semi-)autonomous driving systems (both for human perception, e.g. surveillance system, as well as automated image processing, e.g. special signs recognition) and the proposed project supports this strategically important research.

Popular scientific description (Swedish)*

Strömning av video i realtid har blivit en del av vår vardag och applikationer såsom FaceTime i iPhonetelefoner skapar nya sätt att interagera med omgivningen. Att strömma filmer, fotbollsmatcher mm över Internet har varit möjligt i flera år. Ofta så är den sista sträckan fram till användaren (the last mile) baserad på den välkända allestädes närvarande tekniken för lokala trådlösa nätverk (WiFi), som också är basen både för trådlös kommunikation direkt mellan fordon och mellan olika typer av mobila användare.
Avancerade mobila enheter, och t.o.m. enklare mobiltelefoner, är nuförtiden utrustade med videokameror och WiFi. Videokameror har varit standard i premiumbilar och i vissa specialfordon såsom sopbilar i flera år, i syfte att öka medvetandehorisonten för föraren. Nästa steg är att dela med sig av vad kameran ser och distribuera ut det till mobila användare i närliggande omgivning, vilket kan göra diverse nya tillämpningar möjliga. Det kan bland annat handla om nya tjänster av typen ”infotainment” (t.ex. mobila gruppvideokonferenser) och nya tillämpningar inom trafik- och fordonsäkerhet (t.ex. för omkörningssituationer eller övergångsställen där fordon kan skymma sikten men där kameror kan hjälpa till).
För att göra ovanstående spektrum av tillämpningar möjliga så behövs bättre förståelse för hur ett stort antal mobila enheter (ofta enkla sådana) effektivt ska kunna leverera (ofta i realtid) video mellan varandra samt till/från infrastruktur, speciellt med den begränsade trådlösa överföringen med dynamiskt varierande kapacitet där det ofta uppstår överföringsfel. Många har upptäckt begränsningarna med dagens trådlösa system när det gäller videoöverföring och att det helt enkelt inte är tillräckligt robust. Dessutom, ju fler mobila enheter som försöker använda WiFi för videoöverföring, desto lägre blir den visuella kvalitén (till slut ingen bild alls). Detta beror på att datapaketen med bildinformation som ska överföras från olika enheter inte sällan hindrar varandras överföring och sannolikheten för dessa ”kollisioner” ökar signifikant i takt med ökat antal enheter eller användare. Dessutom så är det ofta höga krav som ställs på enheternas prestanda när det gäller realtidsvideo med Skype eller dylikt (ej förkodad video som vid nedladdning från YouTube). Enklare mobiltelefoner klarar helt enkelt inte av att koda videoströmmen tillräckligt snabbt för att garantera interaktiv prestanda.
Målet med detta VR-projekt är att tillhandahålla rätt metoder för videoöverföring i realtid mellan vanliga mobila enheter under de förutsättningar och krav som beskrivits ovan. Med andra ord så är vårt mål att tillåta ett stort antal ömsesidigt interfererande, mobila, energibegränsade enheter att överföra video mellan varandra samt till/från infrastruktur med låg fördröjning och hög visuell kvalité utan någon central koordinering. Vi kommer att utveckla metoder för prestandautvärdering av mobila trådlösa nätverk, ramverk för videokodning med låg komplexitet och metoder för decentraliserad videomultiplexering.
Ett nytt ramverk med namnet ”joint source-channel coding in random access channels", vilket är en syntes av ”random multiple access” och teorier för ” joint source-channel coding”, kommer att introduceras. Jämfört med majoriteten av existerande studier relaterade till projektet som är baserade på simuleringar så fokuserar detta projektet på utvecklingen av matematiska modeller. Resultaten från projektet kommer att tjänstgöra som en fundamental bas för verkliga praktiska implementeringar av nya tillämpningar baserade på allestädes närvarande videoöverföring mellan objekt i rörelse.

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

2. Teknik > 202. Elektroteknik och elektronik > 20204. Telekommunikation

2. Teknik > 202. Elektroteknik och elektronik > 20205. Signalbehandling

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

Keyword 1*

vehicular networking

Keyword 2*

video coding

Keyword 3*

medium access control

Keyword 4

broadcasting

Keyword 5

random multiple access

Research plan

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*

Not applicable

The project includes handling of personal data

No

The project includes animal experiments

No

Account of experiments on humans

No

Research plan

Is Live Video Delivery in Vehicular Networks Possible?[1]

Purpose and aims

The project is dedicated to a real-time live video delivery between vehicles as well as vehicles and roadside infrastructure for critical automotive applications with stringent visual quality and end-to-end latency requirements (e.g. road safety, public security, autonomous driving).

The purpose of the project is to develop a fundamental theory for distributed low complexity multiplexing of live video streams in mobile wireless random access networks.[2]

In other words, our objective is to find the ways, which would allow numerous interfering mobile objects to transmit live video to each other and to the infrastructure with low delay and high-visual quality without any central coordination enabling critical applications. This problem has not received much attention during the last decades since the applications motivating such a technology has not been considered until few years ago.

This project is not about ("It has been said before"): Pre-encoded video streaming (e.g. "YouTube"); Live Internet video conferencing (e.g. "Skype"); Mobile live video conferencing (e.g. "WhatsApp").

Our ongoing work is about ("It is a state-of-the-art"): Live video delivery between few vehicles for cooperative safety applications (e.g. "See-Through System" studied by us with Volvo Technology in ReViNET VINNOVA project in 2013).

This project is about ("It goes beyond the state-of-the-art"):[3] Live video delivery between numerous autonomous vehicles and roadside infrastructure for future automated highways (e.g. for "Drive Me" joint initiative between Volvo Cars, the Swedish Transport Administration, the Swedish Transport Agency, Lindholmen Science Park and the City of Gothenburg, who will test 100 self-driving cars on Swedish roads in 2017 and beyond).

[1] An alternative project title which captures the underlying fundamental problem is "Joint Source-Channel Coding for Live Video Transmission over Random Multiple Access Channels".

[2] Popular definition: "random access" is a way of communication in a broadcast channel when different nodes may transmit their packets simultaneously and thereby hinder (or "collide") each other. Wi-Fi is a good example of such a case. This in contrast to "deterministic access" when all the transmissions are scheduled, normally by a central coordinator, for the sake of collision-free operation.

[3] The nature of random access channels results in a fundamental video transmission problem, namely, since in congested environments video packets are lost not only due to the propagation conditions, but mostly due to the harmful interference of video streams from other nodes. Increasing levels of protection e.g. by applying more robust modes of unequal loss protection become, thereby, useless. In comparison to other types of traffic, live video delivery assumes "interactive" performance and thereby cannot be based on best-effort retransmissions and presume long "adaptation" periods. The situation becomes even more tricky since objects are moving at vehicular speeds and the topology of the network becomes highly dynamic. Our project aims at exploring fundamental tradeoffs of such a transmission system and proposing solutions for sustainable live video delivery via the quick distributed predictions of channel condition changes and proper reactions at the video encoder side.

The specific objectives of the project are:

1. The development of methods for performance evaluation of future vehicular random access networks (i.e. our key research goal is to characterize numerically and predict the performance of highly dynamic decentralized network with broadcast wireless communication channels).

2. The development of methods for low-complexity scalable video encoding with unequal packet loss protection and rate control (i.e. our key research goal is to propose the ways to compress video with low complexity and redundancy to be transmitted in a shared wireless communication channels).

3. The development of methods for efficient decentralized video multiplexing in vehicular random access channels (i.e. our key question is how to transmit multiple video flows concurrently between numerous mobile objects which mutually interfere each other).

Survey of the field

State-of-the-art approaches in the field of vehicular networks performance evaluation

Vehicular ad-hoc networks (VANETs) make vehicle-to-vehicle communications feasible while enabling a plethora of new intelligent transportation system services for drivers and the vehicles passengers. IEEE 802.11p (now it is a part of IEEE 802.11-2012 specification) has recently been ratified as an international standard to provide wireless access in vehicular environments. The communication protocol is based on the version of the simplest random access algorithm with carrier sensing. Its key principle is "listen before talk" and choose random "backoff" delay in case the channel determined as busy. Due to the principal lack of central coordination between the nodes, what is basic design principle of VANETs, the collisions i.e. simultaneous interfering transmissions are possible in the wireless channel.

Since historically inter-vehicle communication standard is based on IEEE 802.11 family (widely known as WiFi) the following two references [1], [2] should be considered as the basic pioneering works indirectly related to the VANET performance evaluation. In this papers the mathematical methods to compute the throughput of the single-hop IEEE 802.11 network with a given number of stations are introduced. During the last ten years hundreds of research papers extended the proposed analysis by considering e.g. non-saturated conditions [3], traffic priorities [4], multi-hoping [5], relaxing unrealistic standard specifications [6], etc.

Features of IEEE 802.11p protocol for VANETs have been modeled relatively recently and mostly in the context to the cooperative safety applications [7], [8]. Our recent work published in IEEE Transactions on Vehicular Technology (February 2012, see "Preliminary results" Section) also fits this research stream.

However, the main drawback of all the above works is that nodes are assumed to be static. In case of VANETs typically so-called "high-way" scenario [7] is considered where the nodes are placed on the line, but nevertheless are fixed. Such an approach allows considering the influence of hidden nodes, but fails to catch the dynamic nature of the network. Moreover, traditional and widely used assumption about Poisson packets arrival process into the queues of nodes [3] is not suitable for video traffic analysis, which is the scope of this project.

The first effort to overcome the above limitations is done in our recent works published in IEEE Transactions on Vehicular Technology (June 2012) and IEEE Communications Letters (2013) see both in the "Preliminary Results" Section) for the simple case of two video transmitters approaching each other on a highway. Generalizations of this result for numerous nodes and more sophisticated mobility patterns are our current work.

State-of-the-art approaches in the field of joint source-channel video coding

Taking into account high bit error ratio, packet losses and time-varying bandwidth, the scalable video coding (SVC) is the most preferable compression method for video transmission in VANETs [9, 10]. During the last decade, in a number of papers it was demonstrated that in a combination with unequal loss protection (ULP) of different video stream layers, SVC provides robust transmission even for channels with high packet losses [11]. ULP can be implemented on application layer using inter-packet Reed-Solomon (RS) codes. In this case, the base video stream layer is protected using RS codes with a high redundancy level while the remaining layers are protected with a lower redundancy level or not protected at all.

A scalable extension of the H.264/SVC standard, which is currently the most popular video coding approach, includes temporal, spatial and quality scalability and provides high compression efficiency due to motion compensation and inter-layer prediction exploiting the video source temporal redundancy and redundancy between different layers. However, high computational complexity is a significant barrier for usage of the H.264/SVC on mobile devices, personal computers and other systems such as high definition video surveillance, wireless home TV, mobile IPTV broadcast etc. [12, 13, 14], which compress one or more high resolution video sources in real-time.

In real-life applications the H.264/SVC encoder should be significantly simplified, resulting in a decrease of its rate-distortion performance [15]. However, even after simplifications, listed above encoding parts have relatively high computational complexity. Taking into account that the future video coding standard HEVC (High Efficiency Video Coding) is also based on hybrid video coding, its scalable extension is likely to have a high computational complexity too.

As an alternative to H.264/SVC encoders, scalable video encoder based on three-dimensional discrete wavelet transform (3-D DWT) can be used. During the last decade, several 3-D DWT approaches were proposed such as 3-D Set partitioning in hierarchical trees (3-D SPIHT) [16], Embedded video coding using zeroblocks of motion compensated 3-D subband/wavelet coefficients (MC-EZBC) [17], etc. Due to intensive investigation of Motion Compensated Temporal Filtering (MCTF), currently 3-D DWT schemes have a comparable rate-distortion performance with the H.264/SVC [18]. However, as in the previous case, these schemes require also high computational resources.

In [13], a real-time 3-D run-length wavelet video encoder was proposed, which, however, does not include a rate control algorithm which is a key component of any video codec. In [14] new rate control algorithms based on an extension of the Embedded Block Coding with Optimized Truncation (EBCOT) [19] were proposed. These rate controllers minimize distortion for a given bit rate budget, but require a lot of computations due to the use of lossless compression of wavelet subbands requiring Lagrange multiplier selection. Other works propose rate control algorithms based on heuristics and additional video source characteristics (see, for example, [20]) and also require extra computations.

Thus, an efficient low-complexity scalable video coder with unequal packet loss protection and rate control for vehicular networks, up to the authors knowledge, has not been considered in the literature so far, except for our recent work with some first results in this area accepted to IEEE Transactions on Vehicular Technology (2014, see "Preliminary results" Section). We are currently intensively continue our work in this direction.

State-of-the-art approaches in the field of statistical multiplexing of video sources

Statistical multiplexing of video sources is needed when two or more videos should be transmitted over the commonly shared channel. Traditionally the problem of statistical multiplexing is considered in the literature for video broadcasting in systems like wireless digital video broadcasting (DVB) or new broadband wireless infrastructure networks (LTE, 5G).

In such types of systems there is common rate controller (installed at the base station) which allocates the channel bandwidth between different video streams in a centralized manner. In the simplest case, the channel bandwidth can be allocated equally between the transmitted video sources.

But, taking into account that statistical properties of the sources can be significantly different (e.g. news programs with low motion level or sport programs with high motion level), in such a case some videos will have very good visual quality, while others will have unacceptably low visual quality.

Therefore, the channel bandwidth should be allocated unequally using some fairness-based visual quality criterion. Two well-know criteria of this type are the maximization of the overall video broadcast quality [21], the second one is maximization of the minimum video quality per program. There are following problems of the above framework, which have not been solved in the literature yet:

First, it is a high computation complexity caused by multi-pass coding [22] which is needed for calculation of bit rate and quality for each video program. The encoding complexity can be reduced by using pre-encoded scalable video stream [23] which allow to avoid multi-pass coding, but it cannot be used for real-time applications (like video surveillance or video conferencing), where the pre-encoding is not possible.

Secondly, packet losses and their influence to the video quality are not taken into account during the multiplexing. For such types of losses, the rate controller should use probabilistic average of visual quality as optimization criterion. In [24] the *min-max expected video distortion* criterion is proposed, but in this work the authors deal with a single video source and do not consider the statistical multiplication of the video programs.

Finally, in all previously described works, the video multiplexing operate in one central device which is installed on broadcast base station. In other words only centralized video multiplexing is considered. There are no papers, which the applicants would be aware of, which would consider video multiplexing in decentralized wireless networks which uses random multiple access for transmission over the shared channel like in IEEE 802.11p VANETs.

We address the above problems in our recent work published in IEEE Transactions on Vehicular Technology (June 2012, see the "Preliminary Results" section) for the simple case of only two video transmitters in IEEE 802.11p VANET environments and under the assumption that the statistical properties of captured video data for both transmitters are similar. Preliminary results for the case of more than two transmitters but with a one target node are presented in IEEE Communications Letters (2014). Generalizations of this result are our current work.

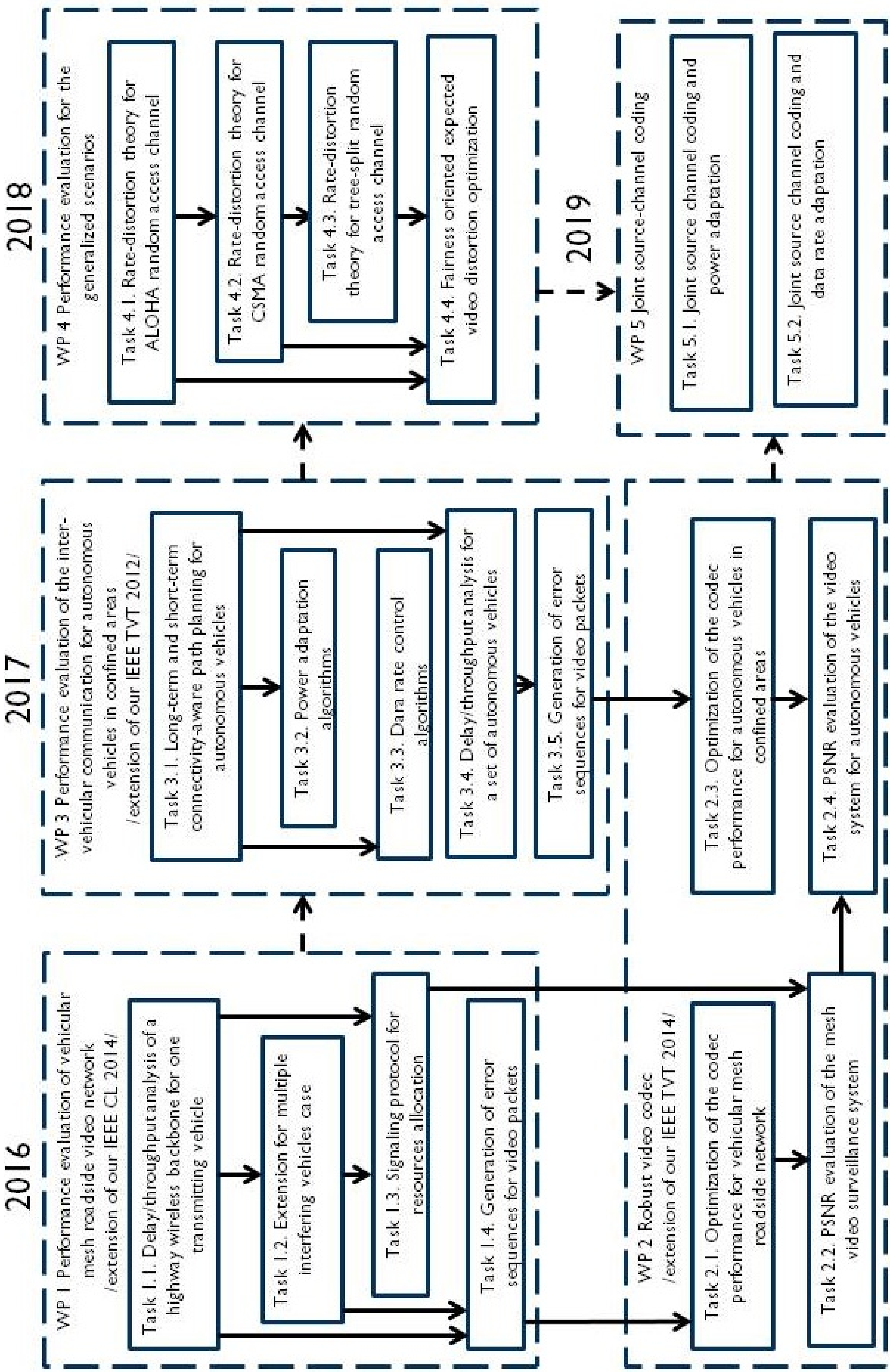
Project description

Methods: We develop basics of a new fundamental framework – a synthesis between **random multiple access theory**, which studies how different devices share the common communication channel without central coordination (R. Rom and M. Sidi, "Multiple Access Protocols: Performance and Analysis," Springer-Verlag, New York, 1990) and **joint source-channel coding theory**, which studies how to encode the video stream in accordance to communication channel quality (F. Zhai, A.K. Katsaggelos "Joint Source-channel Video Transmission", Morgan&Claypool Publishers, 2007). We refer to this new approach as **joint source-channel coding in random access channels**.

At a lower level of abstraction the methods of information theory, stochastic processes, signal processing and optimization theory will be used. Simulators and some software tools will be developed.

Implementation: In this project a significant synergy effect is expected due to the combination of Alexey Vinel expertise (wireless networks, random access) and Evgeny Belyaev expertise (signal processing, video coding). Intensive mutual visiting between Tampere University of Technology and Halmstad Univeristy is foreseen. The newly recruited Ph.D.-student will participate at national workshops (e.g. Swe-CTW) and international conferences (e.g. IEEE VNC) on a regular basis.

Timetable: The project is organized into 5 work-packages (WPs), which cover 4 years of project. Each WP has a specific research problem and further segmented into tasks. The detailed project timetable is presented in the Diagram below.


2016
2017
2018
2019
WP 1 Performance evaluation of vehicular mesh roadside video network /extension of our IEEE CL 2014/
Task 1.1. Delay/throughput analysis of a highway wireless backbone for one transmitting vehicle
Task 1.2. Extension for multiple interfering vehicles case
Task 1.3. Signaling protocol for resources allocation
Task 1.4. Generation of error sequences for video packets
WP 2 Robust video codec /extension of our IEEE TVT 2014/
Task 2.1. Optimization of the codec performance for vehicular mesh roadside network
Task 2.2. PSNR evaluation of the mesh video surveillance system
Task 2.3. Optimization of the codec performance for autonomous vehicles in confined areas
Task 2.4. PSNR evaluation of the video system for autonomous vehicles
WP 3 Performance evaluation of the inter-vehicular communication for autonomous vehicles in confined areas /extension of our IEEE TVT 2012/
Task 3.1. Long-term and short-term connectivity-aware path planning for autonomous vehicles
Task 3.2. Power adaptation algorithms
Task 3.3. Data rate control algorithms
Task 3.4. Delay/throughput analysis for a set of autonomous vehicles
Task 3.5. Generation of error sequences for video packets
WP 4 Performance evaluation for the generalized scenarios
Task 4.1. Rate-distortion theory for ALOHA random access channel
Task 4.2. Rate-distortion theory for CSMA random access channel
Task 4.3. Rate-distortion theory for tree-split random access channel
Task 4.4. Fairness oriented expected video distortion optimization
WP 5 Joint source-channel coding
Task 5.1. Joint source channel coding and power adaptation
Task 5.2. Joint source channel coding and data rate adaptation

Significance

Few recent trends in information and communications technologies motivate this project:

- Live video streaming has become an everyday life feature and applications such as the built-in FaceTime for iPhones enable new ways to interact with the environment. "Advanced" mobile devices and even simple cellular phones are now equipped with the video cameras and Wi-Fi wireless interface.

- Video content is already one of the dominant ones in the nowadays Internet, and the proportion of the live video is about to grow. Very often the "last mile" for delivery of video streams is also based on Wi-Fi technology.

- Video camera capability has been standard in premium cars and in certain special vehicles such as garbage trucks for several years to increase the awareness horizon for the drivers. Wi-Fi-based IEEE 802.11p standard enables vehicle-to-vehicle communications.

Now it is time to take it a step further and share what the video camera produces and distribute it to the mobile users in its neighbourhood to enable a variety of new applications. One can envision new infotainment services (e.g. group mobile videoconferencing), next generation public security systems (e.g. distributed context-aware mobile video surveillance) and novel road safety automotive applications (e.g. pedestrian crossing detour assistance, overtaking assistance).

Moreover, fully autonomous driving is considered a strategic direction for many vehicle manufacturers. Today it is already practically feasible to consider fully automatic operation of vehicles in restricted areas. In such use cases, trucks could be automatically loaded and unloaded in a harbor, a group of construction equipment could perform some joint task without the human interposal, a car could automatically drive to an available place in the parking lot. Reliable inter-vehicle and vehicle-to-roadside real-time live video delivery is crucial for safe (semi-)autonomous driving systems (both for human perception, e.g. surveillance system, as well as automated image processing, e.g. special signs recognition) and the proposed project supports this strategically important research.

Preliminary results

The applicants have a significant track record of publications dedicated to random access algorithms and performance evaluation of wireless network (Alexey Vinel), video compression and transmission (Evgeny Belyaev) and joint-source channel coding in random access channels (recent joint papers of Alexey Vinel and Evgeny Belyaev). Our most important recent results directly related to the proposed project are summarized below:

- In C. Campolo, A. Molinaro, A. Vinel, Y. Zhang, "Modelling Prioritized Broadcasting in Multi-Channel Vehicular Networks", *IEEE Transactions on Vehicular Technology*, Vol. 61, Issue 2, 2012, pp. 687–701, a broadcasting in IEEE 802.11p vehicular networks is studied. The proposed novel analytical approach accounts for mutual influence among nodes, frequent periodic updates of broadcasted data, standard network advertisement procedures, and 802.11p prioritized channel access with multichannel-related phenomena under various link quality conditions.

- In A. Vinel, E. Belyaev, K. Egiazarian and Y. Koucheryavy, "An overtaking assistance system based on joint beaconing and real-time video transmission", *IEEE Transactions on Vehicular Technology*, Vol. 61, Issue 5, pp.2319–2329, 2012, we have proposed a simple decentralized algorithm of video multiplexing for the simple case with two video transmitters in IEEE 802.11p wireless channel with random multiple access. In this work we have assumed that both video transmitters use the same video compression algorithm and that the statistical properties of captured video data for both transmitters are similar. Under these assumptions

the fairness criterion is achieved, when the available channel bandwidth is reallocated equally between two video sources. The network performance analysis is handled for Nakagami-m propagation model.

- In E. Belyaev, A. Vinel, K. Egiazarian, Y. Koucheryavy "Power Control in See-Through Overtaking Assistance System", *IEEE Communications Letters*, Vol. 17, Issue 3, pp. 612–615, 2013, we extended the above work and have proposed adaptive transmitter power control which helps decrease the packet loss probability caused by collisions, what allows increasing the channel bandwidth for each video transmitter.

- In B. Bellalta, E. Belyaev, M. Jonsson, A. Vinel "Performance Evaluation of IEEE 802.11p-Enabled Vehicular Video Surveillance System", *IEEE Communications Letters*, Vol. 18, Issue 4, pp. 708–711, 2014, a multi-hop transmission from the vehicle to the nearest roadside unit and then via other roadside units to the gateway is addressed. We assessed the feasibility of such system by analyzing the video end-to-end distortion for a target vehicle, located several hops away from the gateway, when it is alone or there are also other vehicles transmitting video. We demonstrate the importance of dynamic adaptation of the video bit rate of each vehicle depending on the number and positions of the participating vehicles.

- In E. Belyaev, A. Vinel, A. Surak, M. Gabbouj, M. Jonsson, K. Egizarian "Robust vehicle-to-infrastructure video transmission for road surveillance applications", *IEEE Transactions on Vehicular Technology*, doi 10.1109/TVT.2014.2354376 (accepted for publication) we proposed a low-complexity unequal packet loss protection and rate control algorithms for a scalable video coding based on the three-dimensional discrete wavelet transform. We have shown that in comparison with a scalable extension of the H.264/AVC standard the new codec is less sensitive to packet losses, has less computational complexity and provides comparable performance in case of unequal packet loss protection. It is specially designed to cope with severe channel fading typical for dynamic vehicular environments and has a low complexity, making it a feasible solution for real-time automotive surveillance applications.

International collaboration[4]

Alexey Vinel has an extremely wide professional international network. The list of existing active collaboration partners, which he already has **joint journal publications** is the following:

- Loo J., Mapp G., Sardis F. are with Middlesex University, UK;
- Ni Q. was with the Brunel University (now with Lancaster University), UK;
- **Bellalta B. and Oliver M. are with the Universitat Pompeu Fabra, Spain (stochastic models)**;
- Barcelo J. is with the Universidad Carlos III Madrid, Spain;
- Rodrigues J. is with University of Beira Interior, Portugal;
- Staehle D. was with the University of Wurzburg (now with DOCOMO Euro-Labs), Germany;
- Rak J. is with Gdansk University of Technology, Poland;
- **Campolo C. and Molinaro A. are with the Universit Mediterranea di Reggio Calabria, Italy (vehicular communications standards)** ;
- Petit J. was with the Paul Sabatier University, France (now with the University of Twente, Netherlands);

[4]The partners which are planned to be involved in the proposed project are **highlighted** and their relevant expertise is mentioned.

- **Gabbouj M., Egiazarian K., Belyaev E. are with Tampere University of Technology, Finland (live video processing)**;
- Zhang Y. is with the Simula Research Lab, Norway;
- **Trivedi K. is with Duke University, USA (Markov chains and queuing systems, optimization)**;
- Ma X. is with Oral Roberts University, USA;
- Jiang T. was with the University of Michigan, USA;
- Zeadally S. is with the University of the District of Columbia, USA;
- Xiao Y. is with the University of Alabama, USA;
- Tsai M.-F. and Shieh C.-K. are with the National Cheng Kung University, Taiwan;
- Xia F., Gao R., Wang L., Qiu T. are with Dalian University of Technology, China; Chilamkurti N. is with the La Trobe University, Australia.

Independent line of research

Joint-source channel coding in random access channels is completely new independent research line started by Prof. Alexey Vinel since few years and not considered in the works of his former supervisors (Prof. Vladimir Vishnevsky, Russian Academy of Sciences – queuing systems and optimization; Prof. Yevgeni Koucheryavy, Tampere Univeristy of Technology – quality of service in networks, machine-to-machine communications).

Type of employment

Main applicant Alexey Vinel is a **Professor in Data Communications** at the School of Information Technology, Halmstad University (HH) since 01 July 2015. Prior to that he has been a Guest Professor at HH. His appointment level at HH was gradually increased from 25% of the full-time equivalent (January 2013) to 50% (middle of 2013) and 100% (since January 2014).

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[1] G. Bianchi, "Performance Analysis of the IEEE 802.11 Distributed Coordination Function", *IEEE Journal on Selected Areas in Communications*, Vol.18, pp. 535–547, 2000.

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[3] D. Malone, K. Duffy, D. Leith, "Modeling the 802.11 Distributed Coordination Function in Non-saturated Heterogeneous Conditions", *IEEE/ACM Transactions on Networking*, Vol.15, pp. 159–172, 2007.

[4] Q. Ni, "Performance Analysis and Enhancements for IEEE 802.11e Wireless Networks", *IEEE Network*, Vol.18, pp. 21–27, 2005.

[5] Chi Pan Chan, Soung Chang Liew, An Chan, "Many-to-One Throughput Capacity of IEEE 802.11 Multihop Wireless Networks", *IEEE Transactions on Mobile Computing*, Vol.8, pp. 514–527, 2009.

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[9] H. Devos, P. Lambert, D. De Schrijver, W. Van Lancker, V. Nollet, P. Avasare, T. Clerckx, F. Verdicchio, M. Christiaens, P. Schelkens, R. Van de Walle, D. Stroobandt, "Scalable, Wavelet-Based Video: From Server to Hardware-Accelerated Client", *IEEE Transactions on Multimedia*, Vol.9, pp.1508–1519, 2007.

[10] M. van der Schaar, Y. Andreopoulos, and Z. Hu, "Optimized scalable video streaming over IEEE 802.11 a/e HCCA wireless networks under delay constraints", *IEEE Transactionns on Mobile Compuing*, Vol.5, pp. 755–768, 2006.

[11] E. Maani, A. Katsaggelos, "Unequal Error Protection for Robust Streaming of Scalable Video Over Packet Lossy Networks", *IEEE Transaction on Circuits and Systems for Video Technology*, vol. 20, No. 3, 2010.

[12] Z. Gu,W. Lin, B. Lee and C. Lau, "Low-Complexity Video Coding Based on Two-Dimensional Singular Value Decomposition", *IEEE Transactions on Image Processing*, Vol.21, pp.674–687, 2012.

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[15] X. Li, M. Wien, J.-R. Ohm, "Rate-Complexity-Distortion Optimization for Hybrid Video Coding", *IEEE Transactions on Circuits and Systems for Video Technology*, Vol.21, pp.957 – 970, 2011.

[16] B.J. Kim, Z. Xiong, and W.A. Pearlman,"Low bit-rate scalable video coding with 3-D set partitioning in hierarchical trees (3-D SPIHT)", *IEEE Transactions on Circuits and Systems for Video Technology*, Vol.10, pp.1374–1378, 2000.

[17] P. Chen and J. Woods, "Bidirectional MC-EZBC with lifting imple- mentation", *IEEE Transactions on Circuits and Systems for Video Technology*, Vol.14, pp.1183-1194, 2004.

[18] J. Xu, F. Wu, S. Li, "Barbell-Lifting Based 3-D Wavelet Coding Scheme", *IEEE Transactions on Circuits and Systems for Video Technology*, Vol.9, pp. 1256–1269, 2007.

[19] D. Taubman, "High performance scalable image compression with EBCOT", *IEEE Transactions on Image Processing*, Vol.9, pp. 1151-1170, 2000.

[20] F. Yang, S. Wan, E. Izquierdo, "Lagrange Multiplier Selection for 3-D Wavelet Based Scalable Video Coding", *IEEE International Conference on Image Processing*, pp.309–312, 2007.

[21] Z. He, D. Wu, "Linear Rate Control and Optimum Statistical Multiplexing for H.264 Video Broadcast", *IEEE Transactions on Multimedia*, Vol.10, pp.1237–1249, 2008.

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[23] Y. Wang, L. Chau, K. Yap, "Joint Rate Allocation for Multiprogram Video Coding Using FGS", *IEEE Transactions on Circuits and Systems for Video Technology*, Vol.20, pp.829–837, 2010.

[24] Y. Eisenberg, C. Luna, T. Pappas, R. Berry, A. Katsaggelos, "Optimal source coding and transmission power management using a min-max expected distortion approach", *2002 International Conference on Image Processing*, 2002.

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	Alexey Vinel	20
2	Other personnel without doctoral degree	New PhD-student	80
3	Participating researcher	Evgeny Belyaev	

Salaries including social fees

	Role in the project	Name	Percent of salary	2016	2017	2018	2019	Total
1	Applicant	Alexey Vinel	20	201,024	207,055	213,266	219,664	841,009
2	Other personnel without doctoral degree	New PhD-student	80	354,144	368,310	389,558	410,807	1,522,819
	Total			555,168	575,365	602,824	630,471	2,363,828

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 environment	48,000	48,000	48,000	48,000	192,000
	Total	48,000	48,000	48,000	48,000	192,000

Running Costs

	Running Cost	Description	2016	2017	2018	2019	Total
1	Travel	Conferences	50,000	50,000	50,000	50,000	200,000
	Total		50,000	50,000	50,000	50,000	200,000

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	555,168	575,365	602,824	630,471	2,363,828		2,363,828
Running costs	50,000	50,000	50,000	50,000	200,000		200,000
Depreciation costs					0		0
Premises	48,000	48,000	48,000	48,000	192,000		192,000
Subtotal	653,168	673,365	700,824	728,471	2,755,828	0	2,755,828
Indirect costs	226,509	234,748	245,952	257,233	964,442		964,442
Total project cost	879,677	908,113	946,776	985,704	3,720,270	0	3,720,270

Explanation of the proposed budget

Briefly justify each proposed cost in the stated budget.

Explanation of the proposed budget*

During 2013-2015 Halmstad University (HH) and Tampere University of Technology (TUT) has established a strong bridge, which will be exploited further through this VR project.

The application is targeted at the recruitment of a new Ph.D.-student under the supervision Prof. Alexey Vinel.

Dr. Evgeny Belyaev is funded from own TUT sources.

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

Curriculum Vitae: Alexey Vinel

1 Higher education qualifications

- 2003, Bachelor Degree (with honors) in Information Systems, Saint-Petersburg State University of Aerospace Instrumentation, Russia
- 2005, Master of Science Degree (with honors) in Information Systems, Saint-Petersburg State University of Aerospace Instrumentation, Russia

2 Doctoral degree

- 2007, Ph.D. in Engineering (Telecommunication Systems and Computer Networks), Institute for Information Transmission Problems, Russian Academy of Sciences, Moscow, Russia, thesis: *Development of methods for the analysis of multiple access control protocols in centralized wireless networks*, Supervisor: Prof. Vladimir Vishnevsky

3 Postdoctoral positions

- 2011-2013, Tampere University of Technology, Finland
- 2010-2011, Simula Research Laboratory, Norway
- 2009, University of Hamburg, Germany (**Alexander von Humboldt Foundation Fellowship**)
- 2008, University of Limerick, Ireland

4 Qualification required for appointments as a docent

- 2012, Halmstad University, Sweden

5 Current position

- 2015–, Full Professor of Data Communications, School of Information Technology, Sweden (full-time, 50% research activities)
- 2014–, Researcher, Department of Signal Processing, Tampere University of Technology, Finland (on-leave, 100% research activites)

6 Previous positions and periods of appointment

- 2012–, Guest Professor, School of Information Science, Computer and Electrical Engineering, Halmstad University, Sweden (gradual increase from 25% to full-time, 50% research activities)
- 2008–2012, Group Head and Senior Research Scientist, Saint-Petersburg Institute for Informatics and Automation, Russian Academy of Sciences, Saint-Petersburg, Russia (part-time)
- 2005–2009, Security Engineer, National Saving Bank of Russian Federation (North-West Branch), Saint-Petersburg, Russia (full-time)
- 2006–2008, Research Assistant, Saint-Petersburg State University of Aerospace Instrumentation, Saint-Petersburg, Russia (part-time)
- 2006–2007, Visiting Researcher, University of Wuerzburg (German Academic Exchange Service), Wuerzburg, Germany
- 2004–2005, Intern, Siemens AG, Munich, Germany (full-time)

7 Interruption in research

- Not applicable

8 Supervision

- Nikita Lyamin (doctoral student, main supervisor), Halmstad University, 2014–
- Hawar Ramazanali (doctoral student, main supervisor), Halmstad University and SAAB Military Training, 2015–
- Shih Yang Lin (postdoc researcher, main supervisor), Halmstad University, 2014-2015

9 Other merits of relevance to the application

- 2 Best Paper Awards at international conferences (IWCMC-2014, INISCOM-2015)
- IEEE Communications Letters, Associate Editor (2012–); Ad Hoc Networks (Elsevier), Associate Editor (2013–); IEEE Global Communications Newsletter, Regional Correspondent;
- Numerous Research Visits including Zhejiang University, China (2011), Univeristy of Brasilia, Brazil (2011), University of Waterloo, Canada (2012), National Cheng Kung University, Taiwan (2013)
- Opponent/member of grading committee for 5 PhD thesis defences (Russia, the Netherlands, Sweden)
- Best postdoctoral young researcher (2009), Best graduate student (2006) Awards by the City Government of Saint-Petersburg
- General Chair of the 11th International Conference on Telecommunications for ITS (ITST-2013), Steering Committee Member of the ITST conference series
- Co-establisher and co-chair of international conferences and workshops series (e.g. Nets4Cars, MACOM)
- IEEE Senior Member (2012), IEEE Member (2007)

Curriculum Vitae: Evgeny Belyaev

1 Higher education qualification

- 2005, Engineer Degree in Automated Systems of Information Processing and Control, Saint-Petersburg State University of Aerospace Instrumentation, Russia

2 Doctoral degree

- 2009, Ph.D. in Engineering (Systems Analysis, Control and Information processing), Saint-Petersburg State University of Aerospace Instrumentation, Russia, Thesis: *Control of video compression for data transmission in mobile communication systems*, Supervisor: Prof. Andrey Turlikov

3 Postdoctoral Position

- 2010–2011, Research Scientist, Saint-Petersburg Institute for Informatics and Automation, Russian Academy of Sciences, Saint-Petersburg, Russia

4 Qualifications required for appointments as a docent

- Not applicable

5 Present position

- 2011–, Researcher, Department of Signal Processing, Tampere University of Technology, Tampere, Finland (full-time, 100% research activites)

6 Previous positions and periods of appointment

- 2010–2012, Assistant Professor, State University of Aerospace Instrumentation, Saint-Petersburg, Russia (part-time)
- 2009–2011, Science consultant, JSC "Television and radio communication", Saint-Petersburg, Russia (part-time)
- 2007–2010, Research Engineer, Intel Corporation, Communication Technology Lab, Saint-Petersburg, Russia (full-time)
- 2006–2007, Software Engineer, Alarity Corporation, Saint-Petersburg, Russia (full-time)
- 2004–2006, XVD Corporation, Saint-Petersburg, Russia (full-time)
- 2002–2004, Software Engineer, JSC 'Techpribor', Saint-Petersburg, Russia (part-time)

7 Interruption in research

- Not applicable

8 Supervision

- Not applicable

9 Other merits of relevance to the application

- Reviewer for
  - IEEE Transactions on Multimedia, 2013
  - IEEE Journal of Selected Topics in Signal Processing, 2013
  - IEEE Transactions on Circuits and Systems for Video Technology, 2013-2014
  - IEEE Transactions on Intelligent Transportation System, 2013
  - IEEE Communications Letters, 2012-2014
- Finalist, Grand Video Compression Challenge, 30th Picture Coding Symposium, 2013
- Best paper award, The 11th International Conference on Next Generation Wired/Wireless Advanced Networking, 2011
- Supervisor of 7 successfully graduated Ms.Sc. students
- Visit to Xian University funded by The National Natural Science Foundation of China (2012–2014)
- IEEE Member (2012)

Publication list

List of scholarly publications

and bibliometrics according to Google Scholar

Alexey Vinel
Halmstad University, Sweden

March 30, 2015

1 Peer-reviewed original articles

1. **(*)** Belyaev E., Vinel A., Surak A., Gabbouj M., Jonsson M., Egiazarian K. Robust vehicle-to-infrastructure video transmission for road surveillance applications // *IEEE Transactions on Vehicular Technology*, DOI: 10.1109/TVT.2014.2354376, 2014 (in print).

2. Lee Y.L., Chuah T.C., Loo J., Vinel A. Recent Advances in Radio Resource Management for Heterogeneous LTE / LTE-A Networks // *IEEE Communications Surveys and Tutorials*, 16(4), 2014.

3. Yin X., Ma X., Trivedi K., Vinel A. Performance and Reliability Evaluation of BSM Broadcasting in DSRC with Multichannel Schemes // *IEEE Transactions on Computers*, 63(12), 2014.

4. Balasubramaniam S., Lyamin N., Kleyko D., Skurnik M., Vinel A., Koucheryavy Y. Exploiting Bacterial Properties for Multi-hop Nanonetworks // *IEEE Communications Magazine*, 52(7), 2014.

5. **(*)** Bellalta B., Belyaev E., Jonsson M., Vinel A. Performance evaluation of IEEE 802.11p-enabled vehicular video surveillance system // *IEEE Communications Letters*, 18(4), 2014.

6. Lyamin M., Vinel A., Jonsson M., Loo J. Real-time detection of Denial-of-Service attacks in IEEE 802.11p vehicular networks // *IEEE Communications Letters*, 18(1), 2014.

7. Maicke C. G. Paula, Joel J. P. C. Rodrigues, Joao A. Dias, Joao N. Isento, Vinel A. Performance Evaluation of a Real Vehicular Delay-Tolerant Network Testbed // International Journal of Distributed Sensor Networks, 2014 (in print).

8. (*) Belyaev E., Vinel A., Egiazarian K., Koucheryavy Y. Power Control in See-Through Overtaking Assistance System // *IEEE Communications Letters*, 17(3), 2013.

9. Campolo C., Molinaro A., Vinel A., Zhang Y. Modeling Event-Driven Safety Messages Delivery in IEEE 802.11p/WAVE Vehicular Networks // *IEEE Communications Letters*, 17(12), 2013.

10. Belyaev E., Molchanov P., Vinel A., Koucheryavy Y. The Use of Automotive Radars in Video-based Overtaking Assistance Applications // *IEEE Transactions on Intelligent Transportation Systems*, 14(3), 2013.

11. Le A., Loo K., Lasebae A., Vinel A., Chen Y., Chai M. The Impact of Rank Attack on Network Topology of Routing Protocol for Low-Power and Lossy Networks // *IEEE Sensors Journal*, 13(10), 2013.

12. Liu D., Chen Y., Zhang T., Chai K.-K., Loo J. Vinel A. Stackelberg Game Based Cooperative User Relay Assisted Load Balancing in Cellular Networks // *IEEE Communications Letters*, 17(2), 2013.

13. Sardis F., Mapp G., Loo J., Aiash M., Vinel A. On the Investigation of Cloud-based Mobile Media Environments with Service-Populating and QoS-aware Mechanisms // *IEEE Transactions on Multimedia*, 15(4), 2013. **Number of citations: 20.**

14. Isento J., Rodrigues J., Dias J., Paula M., Vinel A. Vehicular Delay-Tolerant Networks? A Novel Solution for Vehicular Communications // *IEEE Intelligent Transportation Systems Magazine*, 5(10), 2013. **Number of citations: 11.**

15. Bellalta D., Faridi A., Staehle D., Barcelo J., Vinel A., Oliver M. Performance Analysis of CSMA/CA Protocols with Multi-packet Transmission // Elsevier Computer Networks, 57(14), 2013.

16. Pignaton de Freitas E., Heimfarth T., Vinel A., Wagner F. R., Pereira C. E., Larsson T. Cooperation among Wirelessly Connected Static and Mobile Sensor Nodes for Surveillance Applications // Sensors, 13(10), 2013.

17. Bellalta B., Barcelo J., Staehle D., Vinel A., Oliver M. On the Performance of Packet Aggregation in IEEE 802.11ac MU-MIMO WLANs // *IEEE Communications Letters*, 16(10), 2012. **Number of citations: 17.**

18. **(*)** Vinel A., Belyaev E., Egiazarian K., Koucheryavy Y. An overtaking assistance system based on joint beaconing and real-time video transmission // *IEEE Transactions on Vehicular Technology*, 61(5), 2012. **Number of citations: 23.**

19. Vinel A. 3GPP LTE versus IEEE 802.11p/WAVE: which technology is able to support cooperative vehicular safety applications? // *IEEE Wireless Communications Letters*, 1(2), 2012. **Number of citations: 51.**

20. **(*)** Campolo C., Molinaro A., Vinel A. Zhang Y. Modelling Prioritized Broadcasting in Multi-Channel Vehicular Networks // *IEEE Transactions on Vehicular Technology*, 61(2), 2012. **Number of citations: 47.**

21. Vinel A., Campolo C., Petit J., Koucheryavy Y. Trustworthy Broadcasting in IEEE 802.11p/WAVE Vehicular Networks: Delay Analysis // *IEEE Communications Letters*, 15(9), 2011. **Number of citations: 22.**

22. Campolo C., Vinel A., Molinaro A., Koucheryavy Y. Modeling Broadcasting in IEEE 802.11p/WAVE Vehicular Networks // *IEEE Communications Letters*, 15(2), 2011. **Number of citations: 82.**

23. Ni Q., Hu L., Vinel A., Xiao Y., Hadjinicolaou M. Performance Analysis of Contention Based Bandwidth Request Mechanisms in WiMAX Networks // *IEEE Systems Journal*, 4(4), 2010. **Number of citations: 35.**

24. Vinel A., Ni Q., Staehle D., Turlikov A. Capacity Analysis of Reservation-Based Random Access for Broadband Wireless Access Networks // *IEEE Journal on Selected Areas in Communications*, 27(2), 2009. **Number of citations: 22**

25. Ni Q., Vinel A., Xiao Y., Turlikov A., Jiang T. Investigation of Bandwidth Request Mechanisms under Point-to-Multipoint Mode of WiMAX Networks // *IEEE Communications Magazine*, 45(5), 2007. **Number of citations: 116.**

26. Tsai M.-F., Chilamkurti N., Shieh C.-K., Vinel A. MAC-level Forward Error Correction Mechanism for Minimum Error Recovery Overhead and Retransmission // Elsevier Mathematical and Computer Modelling, 53(11-12), 2011.

27. Tsai M.-F., Chilamkurti N., Zeadally S., Vinel A. Concurrent Multipath Transmission combining Forward Error Correction and Path Interleaving for Video Streaming // Elsevier Computer Communications, 34(9), 2011. **Number of citations: 25.**

28. Xia F., Vinel A., Gao R., Wang L., Qiu T. Evaluating IEEE 802.15.4 for Cyber- Physical Systems // EURASIP Journal on Wireless Communications and Networking: doi:10.1155/2011/596397, 2011. **Number of citations: 38**

29. Andreev S., Galinina O., Vinel A. Performance Evaluation of a Three Node Client Relay System // IGI Global International Journal of Wireless Networks and Broadband Technologies (IJWNBT), 1(1), 2011.

30. Moltchanov D., Vinel A., Jakubiak J., Koucheryavy Y. Synchronous relaying in vehicular ad-hoc networks // IGI Global International Journal of Wireless Networks and Broadband Technologies (IJWNBT), 1(2), 2011.

2 Peer-reviewed conference papers

1. Belyaev E., Vinel A., Jonsson M., Sjöberg K. Live Video Streaming in IEEE 802.11p Vehicular Networks: Demonstration of an Automotive Surveillance Application // Proc. of the 33rd Annual IEEE International Conference on Computer Communications - INFOCOM-2014 - Demo/Poster Session, Toronto, Canada, 2014.

2. Vinel A., Belyaev E., Bellalta B., Hu H. Live Video Streaming in Vehicular Networks // Proc. of the Nets4Cars/Nets4Trains-2014, Offenburg, Germany, 2014.

3. Böhm A., Jonsson M., Kunert K., Vinel A. Context-Aware Retransmission Scheme for Increased Reliability in Platooning Applications // Proc. of the Nets4Cars/Nets4Trains-2014, Offenburg, Germany, 2014.

4. Shao C., Leng S., Zhang Y., Vinel A., Jonsson M. Analysis of Connectivity Probability in Platoon-based Vehicular Ad Hoc Networks // Proc. of the 10th International Wireless Communications and Mobile Computing Conference - IWCMC-2014, Nicosia, Cyprus, 2014.

5. Campolo C., Molinaro A., Vinel A. Understanding Adjacent Channel Interference in Multi-Channel VANETs // Proc. of the IEEE Vehicular Networking Conference - IEEE VNC-2014, Paderborn, Germany, 2014.

6. Lyamin N., Vinel A., Jonsson M. Poster: On the Performance of ETSI EN 302 637-2 CAM Generation Frequency Management // Proc. of the IEEE Vehicular Networking Conference - IEEE VNC-2014, Paderborn, Germany, 2014.

7. Lin S.-Y., Vinel A., Englund C., Chen L. Poster: Adaptive Wavelength Adjustment (AWLA) for Cooperative Speed Harmonization // Proc. of the IEEE Vehicular Networking Conference - IEEE VNC-2014, Paderborn, Germany, 2014.

8. Belyaev E., Vinel A. Target Packet Loss Selection for Inter-Packet Loss Protection for Video Streaming Over VANETs // Proc. of the IEEE Vehicular Networking Conference - IEEE VNC-2014, Paderborn, Germany, 2014.

9. Vinel A., Belyaev E., Lamotte O., Gabbouj M., Koucheryavy Y., Egiazarian K. Video Transmission over IEEE 802.11p: Real-World measurements // Proc. of the IEEE ICC-2013 (Workshop on Emerging Vehicular Networks), Budapest, Hungary, 2013.

10. Molchanov P., Vinel A., Astola J., Egiazarian K. Radar Frequency Band Invariant Pedestrian Classification // Proc. of the 14th International Radar Symposium, Dresden, Germany, 2013.

11. Vinel A., Bellalta B., Chilamkurti N. and Koucheryavy Y. Scalability analysis of infrastructure networks for vehicular safety applications // Proc. of the 2012 International Conference on Connected Vehicles and Expo - ICCVE-2012, Beijing, China, 2012.

12. Maicke C. G. Paula, Joel J. P. C. Rodrigues, Joao A. Dias, Joao N. Isento, Vinel A. Deployment of a Real Vehicular Delay-Tolerant Network Testbed // Proc. of the 12th International Conference on ITS Telecommunications - ITST-2012, Taipei, Taiwan, 2012.

13. Rak J., Vinel A. A Novel Reliable Routing Scheme for VANETs // Proc. of the 12th International Conference on ITS Telecommunications - ITST-2012, Taipei, Taiwan, 2012.

14. Vinel A., Belyaev E., Koucheryavy Y. Using of beaconing for robust video transmission in overtaking assistance applications // Proc. of the IEEE 76th Vehicular Technology Conference - IEEE VTC-2012 Fall, Quebec, Canada, 2012.

15. Campolo C., Molinaro A., Vinel A. Understanding the Performance of Short-lived Control Broadcast Packets in 802.11p/WAVE Vehicular Networks // Proc. of the 3rd IEEE Vehicular Networking Conference - IEEE VNC-2011, Amsterdam, Netherlands, 2011. **Number of citations: 28.**

16. Campolo C., Koucheryavy Y., Molinaro A., Vinel A. Characterizing Broadcast Packet Losses in IEEE 802.11p/WAVE Vehicular Networks // Proc. of the 22nd Annual IEEE International Symposium on Personal, Indoor and Mobile Radio Communications - IEEE PIMRC-2011, Toronto, Canada, 2011.

17. Huang C.-M., Yang C.-C., Vinel A. An Open Telematics Service Providing Framework Using the P2P-like Paradigm based on the Somecast Protocol // Proc. of the Baltic Congress on Future Internet Communications - BCFIC-2011, Riga, Latvia, 2011.

18. Gao R., Xia F., Wang L., Qiu T., Vinel A. Performance Analysis of Non-Beaconed IEEE 802.15.4 for High-Confidence Wireless Communications // Proc. of the Baltic Congress on Future Internet Communications - BCFIC-2011, Riga, Latvia, 2011.

19. Pyattaev A., Andreev S., Vinel A., Sokolov B. Client Relay Simulation Model for Centralized Wireless Networks // Proc. of the 7th EUROSIM Congress, Prague, Czech Republic, 2010.

20. Vinel A., Dudin A., Andreev S., Xia F., Performance Modeling Methodology of Emergency Dissemination Algorithms for Vehicular Ad-hoc Networks // Proc. of the International Symposium on Communication Systems, Networks and Digital Signal Processing - CSNDSP-2010, Newcastle, UK, 2010.

21. Campolo C., Koucheryavy Y., Molinaro A., Vinel A. On the Performance of Beaconing in 802.11p/WAVE Vehicular Ad Hoc Networks // Proc. of 10th International Conference on Intelligent Transport Systems Communications - ITST-2010, Kyoto, Japan, 2010.

22. Bellalta B., Vinel A., Oliver M. An Upper-bound Queueing Model for Multi-rate Downlink SDMA systems // Proc. of the International Congress on Ultra Modern Telecommunications and Control Systems - ICUMT-2010, Moscow, 2010.

23. Andreev S., Saffer Z., Turlikov A., Vinel A. Upper Bound on Overall Delay in Wireless Broadband Networks with Non Real-Time Traffic // Proc. of the 17th International Conference on Analytical and Stochastic Modeling Techniques and Applications - ASMTA-2010, Cardiff, UK, 2010.

24. Andreev S., Galinina O., Vinel A. Cross-Layer Channel-Aware Approaches for Modern Wireless Networks // Proc. of the 3rd International Workshop on Multiple Access Communications - MACOM-2010, Barcelona, Spain, 2010.

25. Sokolov B., Tsivirko E., Vinel A. Overview of broadband wireless access technologies and stochastic models for their performance evaluation // Proc. of the 9th International Conference Computer Data Analysis and Modeling, Minsk, Belarus, 2010.

26. Vinel A., Koucheryavy Y., Andreev A., Staehle D. Estimation of a successful beacon reception probability in vehicular ad-hoc networks // Proc. of the First International Workshop on

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27. Vinel A., Fedorov K. Random multiple access with successive interference cancellation for centralized networks // Proc. of the IEEE International Conference EUROCON-2009, Saint-Petersburg, Russia, 2009.

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- Not applicable

7 Open access computer programs or databases

- Not applicable

8 Popular science articles/presentations

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2. Mehmood R., Vinel A., Berbineau M. The Nets4Cars Nets4Trains Workshop Series // IEEE Global Communications Newsletter, Oct. 2012.

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Citation Indexes

Link to Google Scholar profile

List of scholarly publications

and bibliometrics according to Google Scholar

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March 30, 2015

1 Peer-reviewed original articles

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3 Monographs

- Not applicable

4 Research review articles

- Not applicable

5 Books and book chapters

- Not applicable

6 Patents

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3. E. Belyaev, A. Turlikov, Method and apparatus for image quality control in video data, *United States Patent Application* 20090086813, 2009.

4. E. Belyaev, Video compression and transmission system with transmitter side memory restriction, *United States Patent Application* 20090161751, 2009.

7 Open access computer programs or databases

- Not applicable

8 Popular sciences articles/presentations

- Not applicable

CV

Name: Alexey Vinel	**Doctorial degree:** 2007-05-28
Birthdate: 19830702	**Academic title:** Professor
Gender: Male	**Employer:** Högskolan i Halmstad

Research education

Dissertation title (swe)

Dissertation title (en)

Development of methods for the analysis of multiple access control protocols in centralized wireless networks

Organisation	Unit	Supervisor
Russian Academy of Sciences, Russia Not Sweden - Higher Education institutes		Vladimir Vishnevsky
Subject doctors degree	**ISSN/ISBN-number**	**Date doctoral exam**
20204. Telekommunikation		2007-05-28

CV

Name: Evgeny Belyaev	**Doctorial degree:** 2009-03-24
Birthdate: 19810909	**Academic title:** Doktor
Gender: Male	**Employer:** No current employer

Research education

Dissertation title (swe)

Reglering av videokomprimering för dataöverföring i mobila kommunikationssystem

Dissertation title (en)

Control of video compression for data transmission in mobile communication systems

Organisation	Unit	Supervisor
St.Petersburg University of Aerospace Instrumentation, Russia Not Sweden - Higher Education institutes	Department of Information Technology	Andrey Turlikov

Subject doctors degree	ISSN/ISBN-number	Date doctoral exam
20203. Kommunikationssystem		2009-03-24

Publications

Name: Alexey Vinel	**Doctorial degree:** 2007-05-28
Birthdate: 19830702	**Academic title:** Professor
Gender: Male	**Employer:** Högskolan i Halmstad

Vinel, Alexey has not added any publications to the application.

Publications

Name: Evgeny Belyaev	**Doctorial degree:** 2009-03-24
Birthdate: 19810909	**Academic title:** Doktor
Gender: Male	**Employer:** No current employer

Belyaev, Evgeny 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.

Applications with an organisation as applicant is automatically signed when the application is registered.