Elisabeth Uhlemann

Workshop Report: Wireless Vehicular Communications

On 30 November 2012, the IEEE Vehicular Technology Society sponsored a workshop on wireless vehicular communications organized by the Centre for Research on Embedded Systems (CERES) at Halmstad University in Sweden. Forty participants from industry and academia attended the workshop. Andreas Festag from NEC Laboratories, Europe, in Germany was the invited speaker. Researchers from Lund, Chalmers, and Halmstad Universities in Sweden delivered presentations on the topic of wireless vehicular communications.

Wireless Vehicular Communications

Vehicular ad hoc networks (VANETs) have been a research subject for more than a decade. Standardization development organizations in Europe and North America have already released an initial set of VANET standards. Field operation tests (FOTs) are currently being carried out. Industry consortia are planning deployment of the first basic system. However, even though there are some areas where sufficient solutions already are operational, substantial research is still needed in other areas. Thus, wireless vehicular communications still remains a highly interesting and challenging research area.

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Workshop Contents

The workshop started with a presentation given by Andreas Festag titled "Protocols for Car2X Communications." His presentation analyzed Car2X communication in the triangle between research on technologies, standardization, and deployment aspects (Figure 1). Ideally, the efforts from these three aspects should converge in the FOTs currently being carried out to assess the matureness of Car2X communication and to validate the positive impact of the technology on road safety and traffic efficiency. Motivated by a classification of the applications and identifying the target applications of the system to be deployed, the presentation gave an overview of the core elements of Car2X communication, covering key characteristics of 802.11p/ Intelligent Transport Systems (ITS) G5 radio operating in the 5-GHz frequency band, networking, messaging, and security, focusing on the European system for Car2X communication. This overview was linked to existing

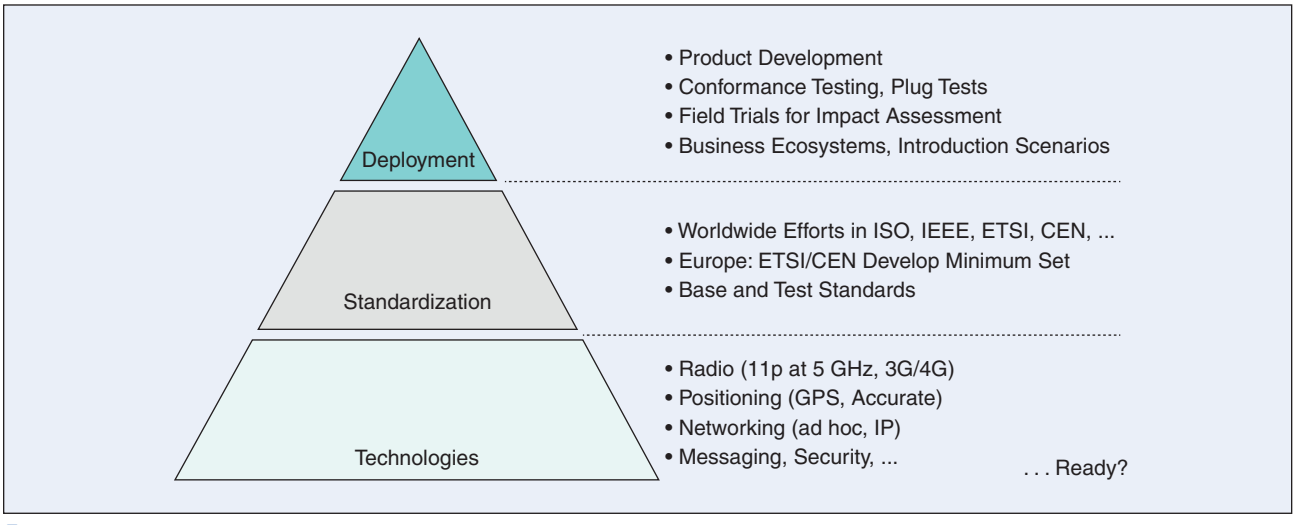

FIGURE 1 In recent years, wireless vehicular communication has developed from a new, exciting research area to standardization, field trials, and serious deployment plans. (Figure courtesy of Andreas Festag.)

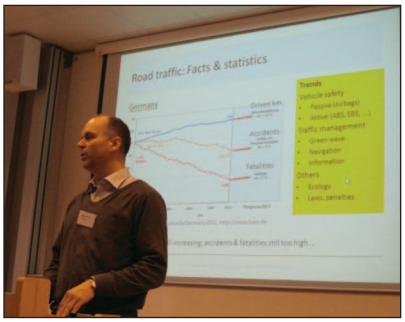

FIGURE 2 Andreas Festag outlines the driving forces behind cooperative intelligent transport systems. (Photo courtesy of Elisabeth Uhlemann.)

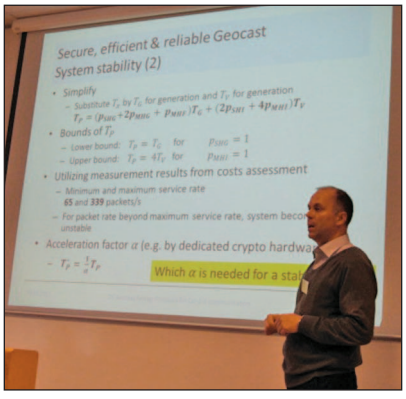

FIGURE 3 Andreas Festag explains geocasting. (Photo courtesy of Elisabeth Uhlemann.)

FIGURE 4 From research through standards to initial deployments—what comes next? (Photo courtesy of Elisabeth Uhlemann.)

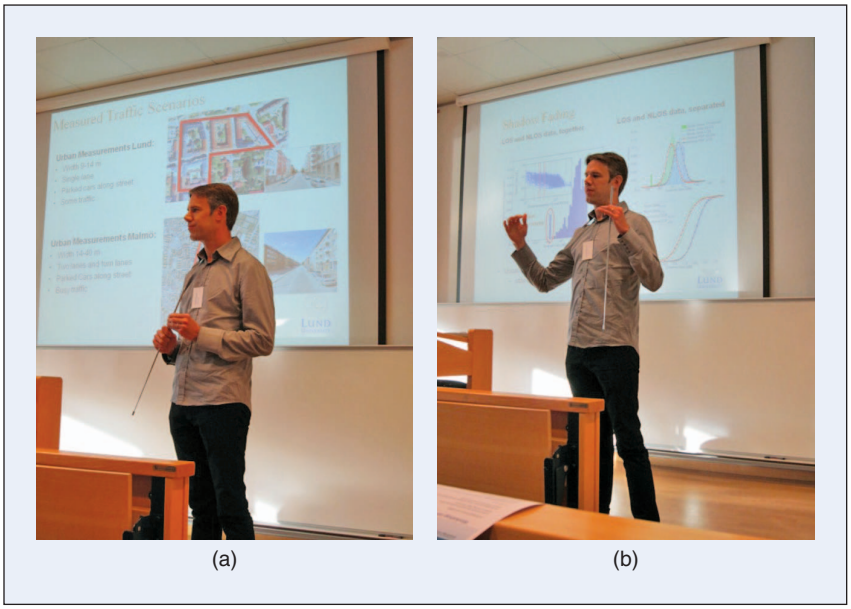

FIGURE 5 Fredrik Tufvesson explains shadow fading. (Photo courtesy of Elisabeth Uhlemann.)

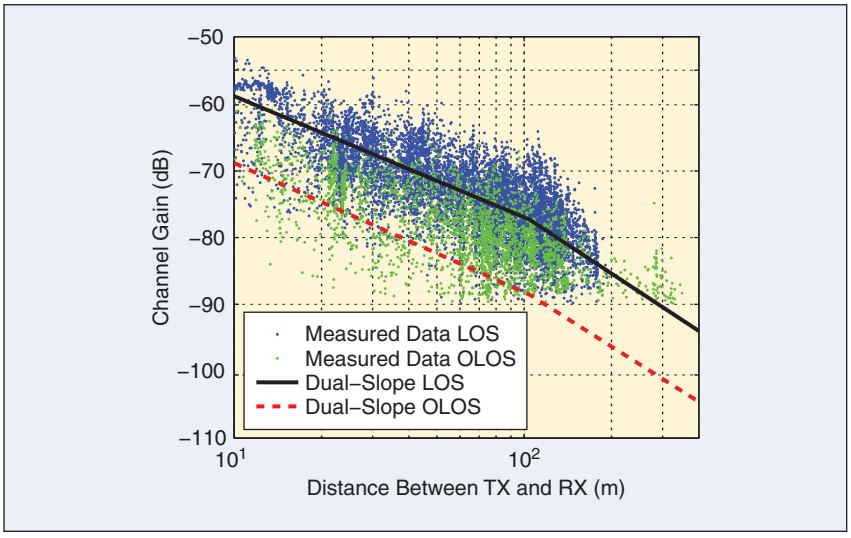

FIGURE 6 Measured channel gains in an urban scenario when there is line-of-sight between the vehicles and when the line-of-sight is obstructed by another vehicle. (Image courtesy of Taimoor Abbas and Fredrik Tufvesson.)

standards developed in the European Telecommunications Standards Institute (ETSI) and the European Committee for Standardization (CEN), which, in fact, represent a timely snapshot of the research approaches that have been successfully transferred into the real world. Likewise, the deployment plans for Car2X in Europe set stringent requirements on the reliability, robustness, and security of the system, as well as the timely completion

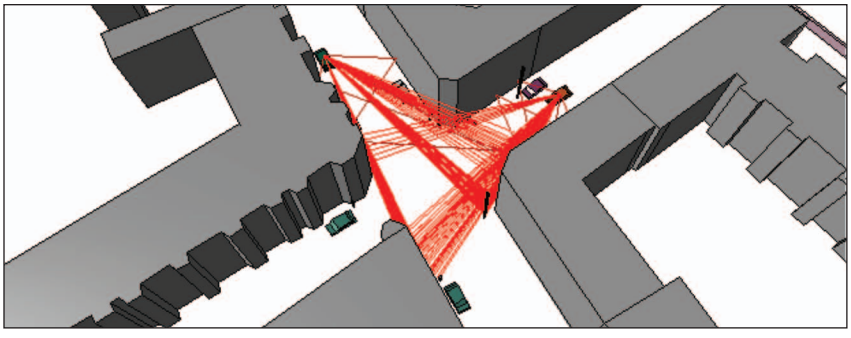

FIGURE 7 A ray-tracing simulation is carried out at an urban intersection for V2V communications. (Image courtesy of Taimoor Abbas and Jörg Nuckelt.)

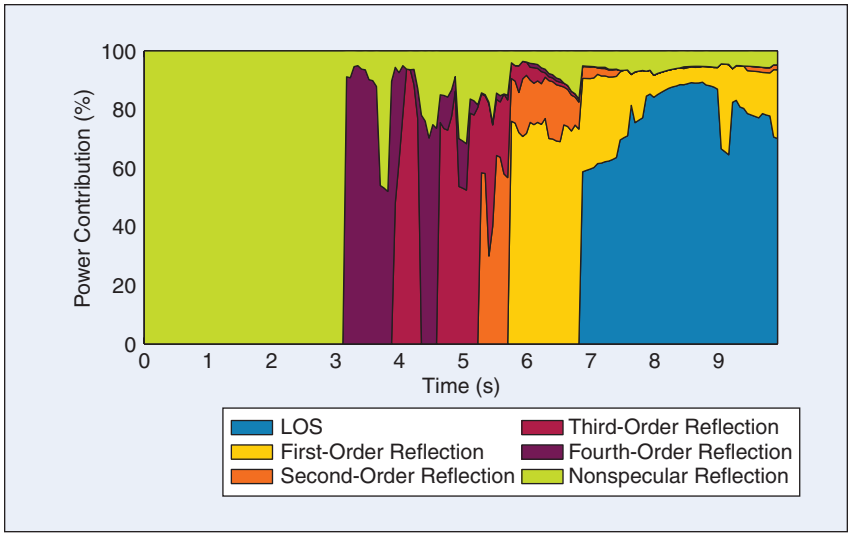

FIGURE 8 Relative power contributions of LOS up to fourth-order specular and first-order nonspecular reflections in the simulated scenario are shown. (Image courtesy of Taimoor Abbas and Jörg Nuckelt.)

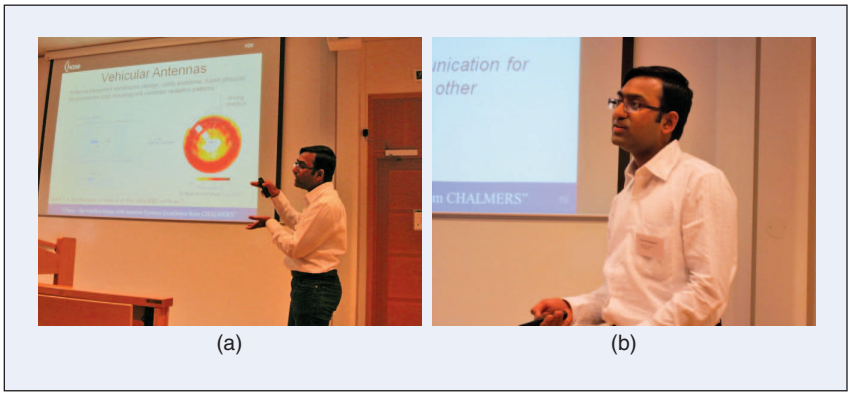

FIGURE 9 Keerthi Nagalapur explains how to exploit multiple antenna technologies for increased reliability in V2X communications. (Image courtesy of Elisabeth Uhlemann.)

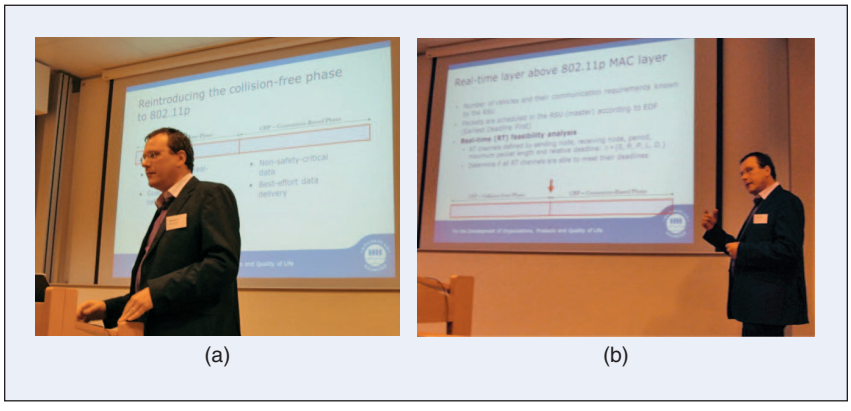

FIGURE 10 Magnus Jonsson proposes to introduce a collision-free phase in IEEE 802.11p to increase the reliability of delay-sensitive V2X applications. (Photo courtesy of Elisabeth Uhlemann.)

of the standards and system specifications prepared by industry organization such as the Car-to-Car Communication Consortium.

The second part of the presentation introduced Geocast—an ad hoc networking protocol that uses geographical positions for addressing geographical areas and for forwarding data. Compared to the U.S. wireless access in vehicular environments (WAVE) system with single-hop communication, Geocasting applies multihop forwarding and is a specific aspect of the European system, where it is used to disseminate messages or more precisely decentralized environmental notification messages in a geo-area. While it is known that simple forwarding algorithms cause redundant retransmissions that may lead to the so-called broadcast storms in the geo-area, advanced forwarding algorithms take smarter forwarding decisions by observing the forwarding behavior of neighboring nodes. At the same time, some redundant retransmissions are tolerated as the load caused by redundant retransmission is strictly controlled. The talk presented the design and performance evaluation of one of the algorithms for efficient and reliable Geocast, including its cryptographic security enhancements, combining results from measurements with an experimental prototype, analysis for system stability, and simulations for system scalability.

Finally, the presentation raised the question whether the system is ready for deployment and identified four hot spots that deserve further consideration:

1) *Decentralized congestion control*: although this can be regarded as a toolbox of mechanisms to control transmit power, transmit rate, message rate, and sensitivity threshold, it has not yet been finally decided which mechanism to use and how to combine different ones.
2) *Multichannel operation*: for ITS-G5 enables the efficient usage of the channels allocated for road safety. The WAVE approach for synchronous channel switching using a single transceiver has not (yet) been adopted, and thus, on-demand asynchronous channel switching with a dual transceiver is still the most common approach.
3) *Security:* the cryptographic protection of Geocast is challenging

for multihop communication, and a solution needs to be standardized that secures the critical packet header fields from manipulation and that at the same time is efficient in terms of packet processing.

4) *Cross-layer information exchange:* needs to be structured and efficient. Naturally, these selected aspects are currently being addressed from a research, standardization, and deployment perspective but will likely persist as challenges even when short-term solutions can be found for the planned deployment of a basic Car2X communication system in Europe.

Next, Fredrik Tufvesson from Lund University gave a talk on developing a "Measurement Based Shadow Fading Model for Vehicle-to-Vehicle (V2V) Communications." In the talk, he highlighted the importance of taking shadowing into account in models as well as performance predictions. A single obstructive vehicle typically causes an attenuation of 10 dB in the received signal strength, which in turn results in a three-fold reduction in the range (Figure 6). Fredrik presented a simplified channel model aimed for V2V network simulations that takes vehicle shadowing into account.

Following this, Taimoor Abbas from Lund University talked about a comparison between ray tracing simulations and channel measurement results. Channel simulation results for a specific street intersection in Lund, obtained from a ray-tracing model developed by TU Braunschweig (Figures 7 and 8), were compared to measurement data gathered during the DRIVEWAY V2V channel measurement campaign in the same intersection: an urban four-way intersection. The main focus of the discussion was to analyze the accuracy of a deterministic channel model for V2V communications, as well as the differences between the results obtained using the two approaches.

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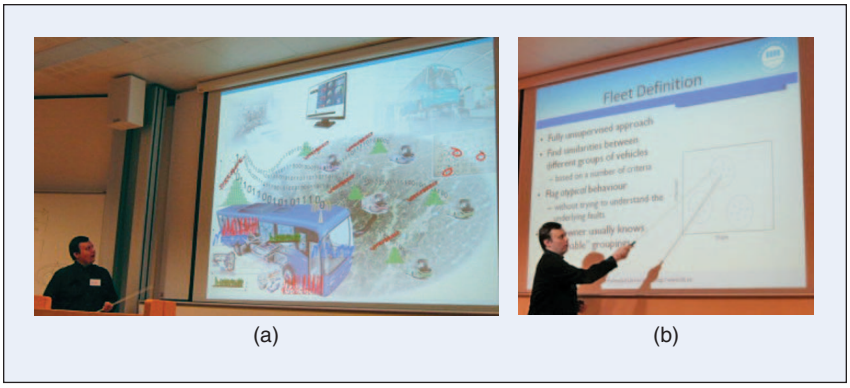

FIGURE 11 Slawomir Nowaczyk talks about remote diagnostic algorithms enabled by wireless vehicular communications. (a) Deviations are detected in a continuous manner and flagged for repair or for further analysis. (b) Using machine learning, similarities between different groups of vehicles can be determined such that atypical behavior can be detected. (Photo courtesy of Elisabeth Uhlemann.)

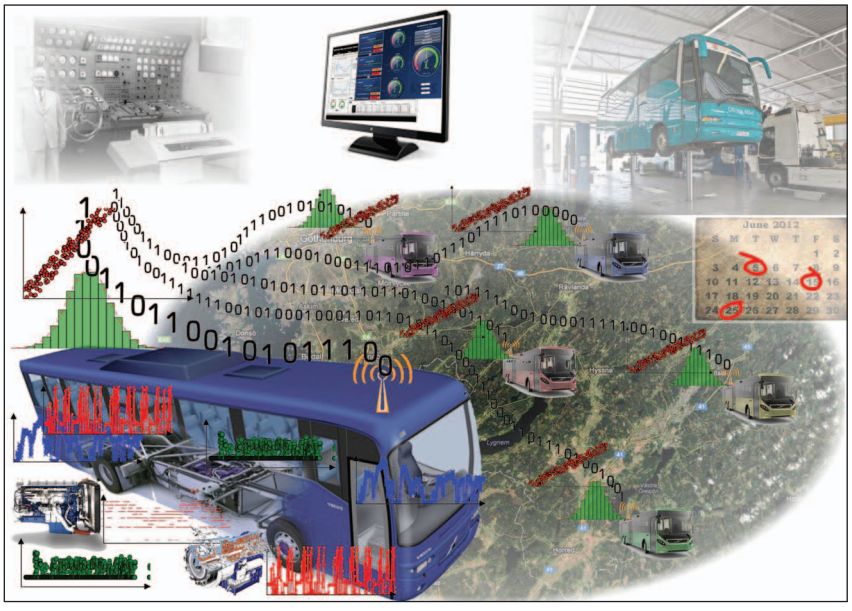

FIGURE 12 Using telematics and on-board data, self-aware buses can predict maintenance and receive remote diagnostics. (Figure courtesy of Slawomir Nowaczyk.)

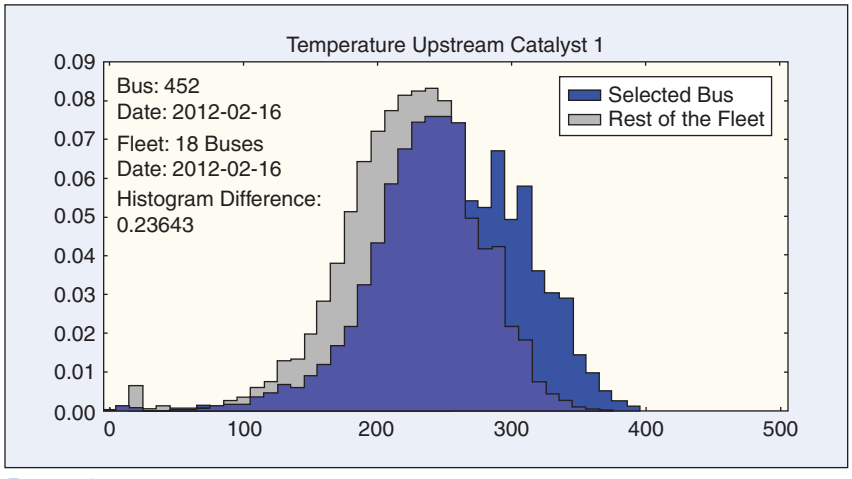

FIGURE 13 Self-aware buses monitor their own operation and compare their behavior against fleets of similar vehicles. (Figure courtesy of Slawomir Nowaczyk.)

Calendar of Events

Conferences of Interest

IEEE VTS-sponsored conferences are marked "✓." Note that the submissions date and other conference details are subject to change. Check the conference Web sites for full details.

2013

Globecom 2013
IEEE Global Communications Conference
9–13 December 2013
Atlanta, Georgia, USA

2014

✓ VTC 2014-Spring
79th IEEE Vehicular Technology Conference
18–21 May 2014
Seoul, Korea

✓ VTC 2014-Fall
80th IEEE Vehicular Technology Conference
14–17 September 2014
Vancouver, British Columbia, Canada

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Society News

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Keerthi Nagalapur from Chalmers University of Technology gave an overview of the research project Chase V2X—Antenna Systems for V2X Communication. In the Chase V2X project, the design and placement of antennas for reliable communications is being studied. The project is also looking at exploiting multiple antenna technologies for increasing the reliability of communications. In long term, the project aims to obtain knowledge and methodologies about designing wireless vehicular communication systems that meet diverse application requirements while considering the vehicle manufacturing constraints.

Annette Böhm from Halmstad University talked about the coexistence of periodic position update messages and hazard warnings in platooning applications. Specifically, she considered how the performance of one message type can be improved while causing minimum performance loss to the other type of message. As an example, she showed how to reduce the dissemination delay of hazard warning messages in platooning applications, while still maintaining a relatively high update rate for periodic exchange of position messages.

Magnus Jonsson from Halmstad University gave a presentation titled "Increasing the Probability of Timely and Correct Message Delivery in Road Side Unit Based Vehicular Communications." He proposed a framework supporting scheduling and real-time analysis of both ordinary transmissions as well as retransmissions, leading to increased reliability for delay-sensitive V2X applications.

Finally, Slawomir Nowaczyk from Halmstad University talked about some of the solutions that wireless technology and connectivity will enable in the future. In the project Remote Diagnostic Tools and Services (ReDi2Service), the goal is to develop new fault detection, predictive maintenance, and remote diagnostics algorithms. Self-aware trucks and buses use telematics and onboard data to monitor their own operation and to compare their behavior against fleets of similar vehicles. Using distributed machine learning in data streams, deviating individuals are detected and matched against available expert knowledge, in the form of service records and usage information databases.

The presentations are available at http://www.hh.se/wwvc2012. VT