Sensing as a Service - Architectures for Closed-loop Sensor Network Virtualization

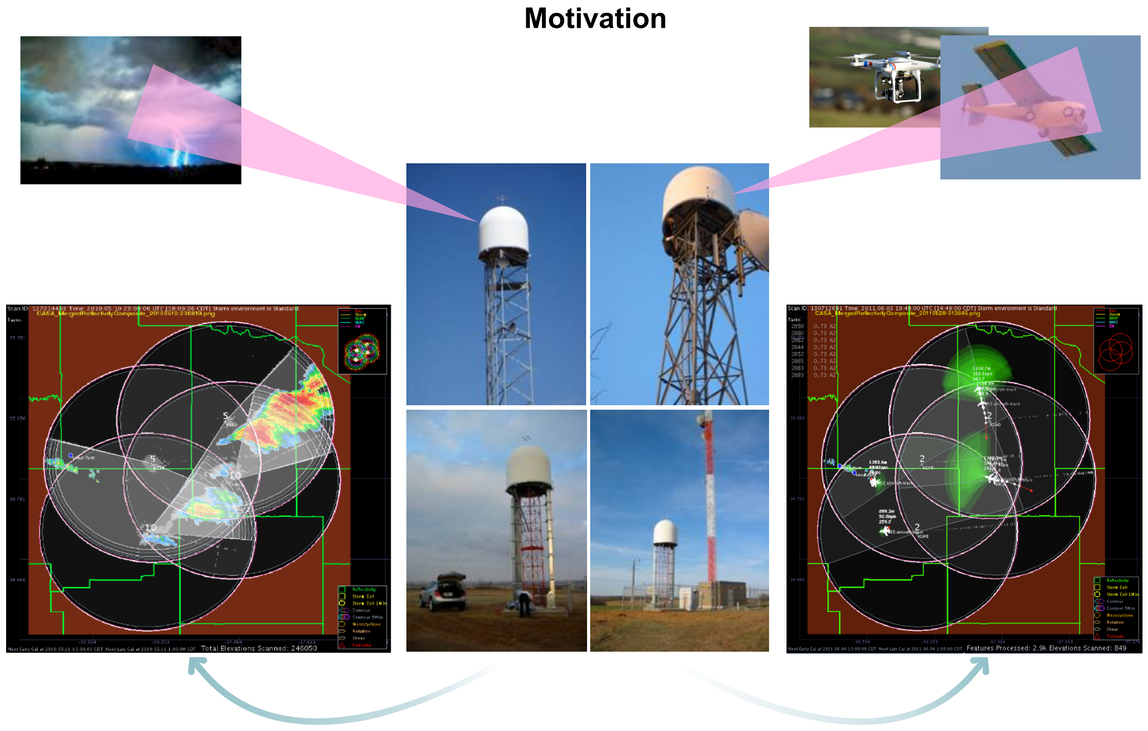
Priyanka Dattatri, Rajvardhan Deshmukh, Divyashri Bhat, Michael Zink
University of Massachusetts, Amherst

Abstract

The goal of this project is to demonstrate that new cyber-physical architectures will enable closed-loop sensor networks to be shared among multiple applications and to dynamically allocate sensing and computing resources necessary to analyze sensor data and perform sensor actuation. The sharing of sensor network infrastructures will make the provision of data (e.g., weather information) more cost efficient and will create cyber infrastructures, which will result in a dramatic increase in the number of sensor networks available for use. The proposed architectures will introduce a new paradigm, which we call *Sensing as a Service*, in which users can obtain sensing, networking, and computational resources to generate the required data for their sensing applications.

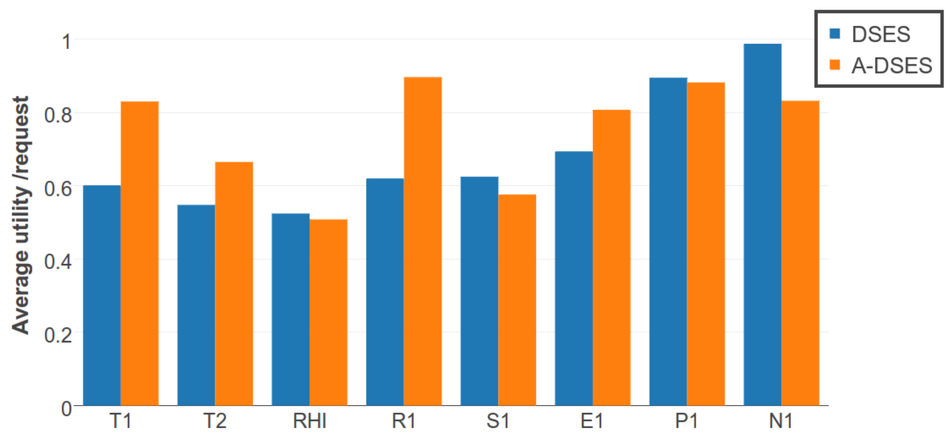
In this poster, we give a motivation for this approach, introduce the overall system architecture, and demonstrate the benefits of our approach by presenting evaluation results from trace-based simulations. The traces used to drive these simulations are based on data from an actual closed-loop sensor network.

Motivation

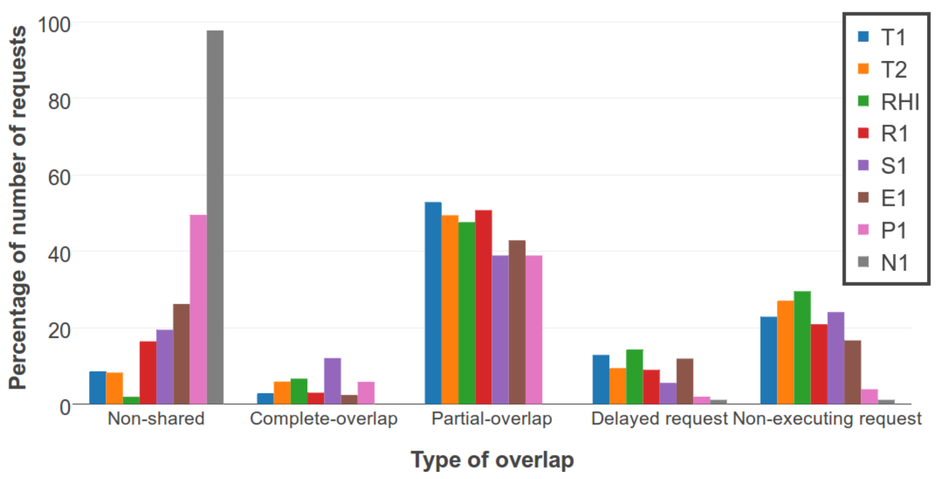


Progress and Results

- Analysis of sensor/actuator virtualization based on data from actual sensor network (4-node CASA testbed, 22-hour event, 10949 tasks generated, 1335 heartbeats).
- Initial analysis of TDMA-based approaches.
- Analysis of a scheduling approach that allows data to be shared between incoming requests based on the data overlap (DSES).
- A-DSES: requests are reordered to maximize the number of overlaps
- The average utility of across most of the applications sharing a network is higher in A-DSES compared to DSES.



Average Utility for all applications under DSES and A-DSES scheduling

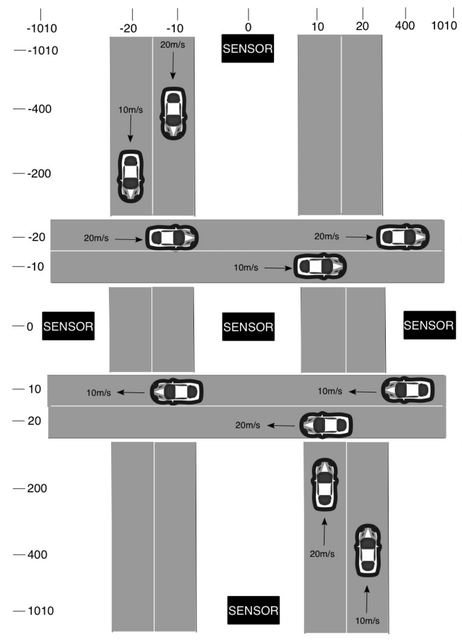


Analysis of overlapping requests

Research Objectives

The goal of this project is to create architectures for virtual private sensor networks (VPSNs) that will revolutionize the use of closed-loop sensor networks by creating new cyber infrastructures. These architectures will be based on the following three components:

- a sensor/actuator virtualization layer containing a class of utility-driven scheduling algorithms that will enable multiplexing of different applications on to a single sensor network at a given point of time.
- a computation virtualization layer that will allow the allocation of computational resources for data intensive applications which is closely tied to the sensor virtualization layer.
- a virtualization toolkit that will support application developers in their efforts to build applications for virtualized, closed-loop sensor networks.



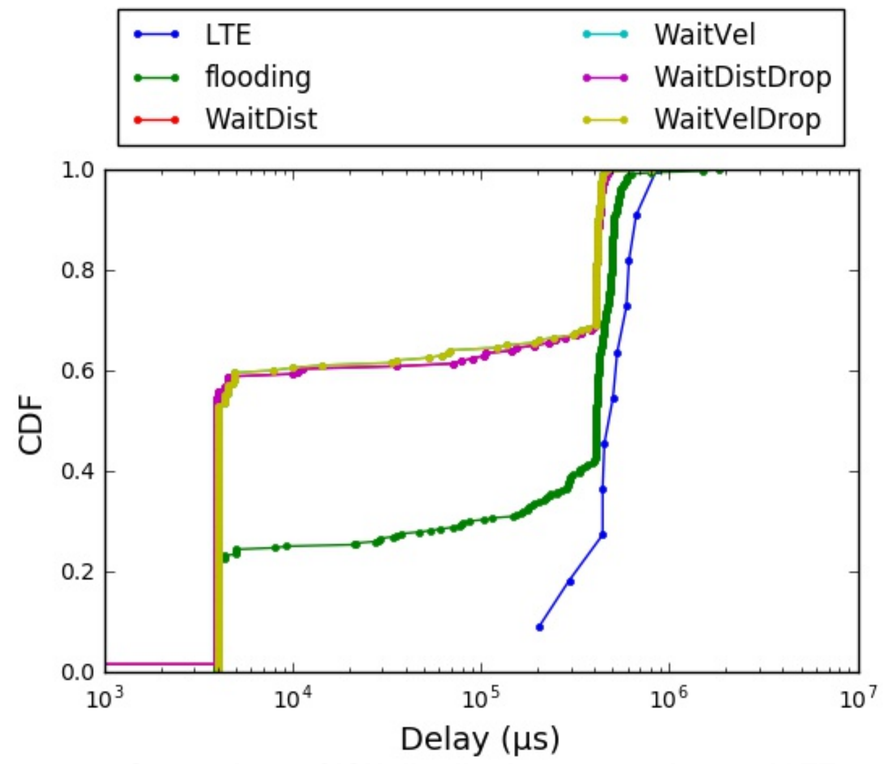
Communication in Disasters

The particular problem with (even smaller, localized) flooding events in urbanized areas in the US is the fact that vehicles are driven into hazardous flood waters. To prevent such incidents, more and more underpasses (and other flood prone road sections) are outfitted with gauges that can measure water depth and flow.

- Disasters that cause flooding often impair communication infrastructure.
- Evaluate the performance of an ICN-based road assistance approach that alerts drivers in the case of flooding related road hazards.
- Approach enables direct communication between sensors and cars.
- Evaluate the performance of different routing approaches in the ICN-based scenario.

Evaluation

Our simulation-based evaluation results, in which we investigate a typical traffic scenario involving an underpass, show that the ICN-based approaches outperform a traditional, infrastructure-based approach if node densities stay below a certain level. Our results show that the timer based approaches outperforms the pure flooding technique in at least 70% of the cases. In the case of an infrastructure based approach with LTE the ICN-based approach outperforms it in low-density cases while performing equally in high-density cases.



Comparison of ICN distribution approaches and LTE

Publications

- "Virtualizing Closed-loop Sensor Networks: A Case Study", Priyanka Kedalagudde and Michael Zink. In Proceedings of SENSORNETS 2017, Porto, Portugal, 19-21 February 2017.
- "ROC GENI: The CASA On Demand Radar Operations Center", Eric Lyons, Michael Zink, Divyashri Bhat, Priyanka Datattri, and Cong Wang, Presentation at the 97th Annual Meeting of the American Meteorological Society, 22-26 January 2017.
- "Efficient Data Processing with ExoGENI for the CASA Urban Testbed", Eric Lyons, Michael Zink, Brenda Philips. Presentation at IGARSS 2017, Fort Worth, TX, July 2017.
- "An Information Centric Approach for Sensor to Vehicular Network Communication in Disasters", Rajvardhan Deshmukh and Michael Zink. In Proceedings of the IEEE WiMob 2017 – 4th Workshop on Emergency Networks for Public Protection and Disaster Relief, Rome, Italy, October 2017.
- "Efficient Crowd Sensing Task Distribution Through Context-aware NDN-based Geocast", The An Binh Nguyen, Pratyush Agnihotri, Christian Meurisch, Manisha Luthra, Rahul Dwarakanath, Jeremias Blendin, Doreen Böhnstedt, Michael Zink, Ralf Steinmetz, In Proceedings of the IEEE Conference on Local Computer Networks (LCN), Oct. 2017, Singapore

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