Smart Sensing and Sensor Data Collection on the move for Modelling Intelligent Environments

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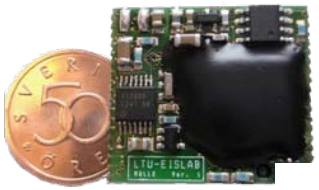

Presented by

Arkady Zaslavsky

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Agenda

- Introduction
- Sensor Data Collection – Related Work
- Motivation, Overview
- Smart Sensing
  - CAM-*R* Architecture
- Context Spaces - Overview
- Modelling a Virtual Environment - Context Spaces Extension
- Prototype Implementation
- Simulation and Results
- Conclusion

Introduction

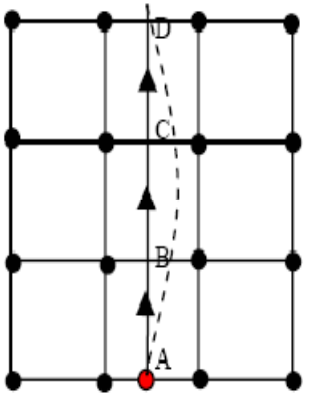
- Sensor Networks
  - Tiny low powered sensing devices
  - Use radio for communication
  - Ad Hoc Infrastructure
- Propose Smart Sensing and Cost efficient Data collection
  - Context Aware Approach
  - Mobile object based Approach
  - Virtual Modeling of Physical environment based on sensor sources (Smart Sensing)

Sensor Data Collection – Related Work

- Distributed data sources
- Valuable producer of contextual data
- Two Broad Categories of Data Collection
  - Direct Diffusion, Multi hop based
  - Mobile object based

Related Work Cont.

- Mobility based data collection
  - Increase the lifetime of the network
  - Existing Approaches
    - Random
    - Predictable
    - Controlled
- Existing Approach
  - Lacks context awareness
  - Not efficient data collection techniques
  - Lacks adapting sensor behavior

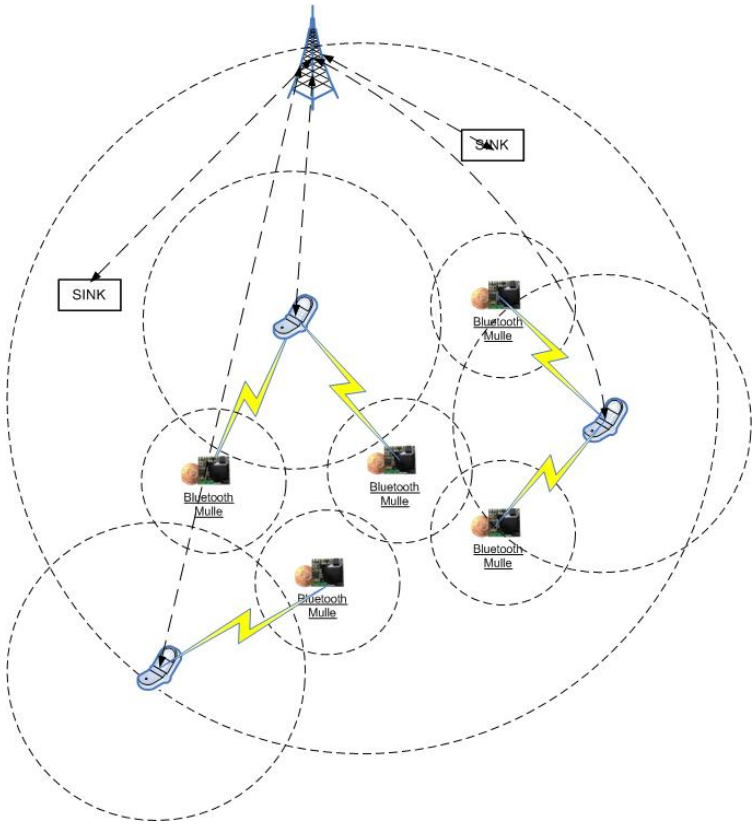


Motivation

- Advances in Pervasive Computing Environments
- Acceptance of sensor networks
- >2 billion Bluetooth enabled mobile device
- Context Aware research advances
- Abundance of mobile devices with huge potential to form a distributed mobile access network

System Overview

- Context Aware Mobile Objects
- Underlying Sensor Network Infrastructure
- Massive amount of sensor data
- Approach for Smart Discovery and Sensing
- Efficient Data Collection Approach
- Context Aware Sensor Adaptation



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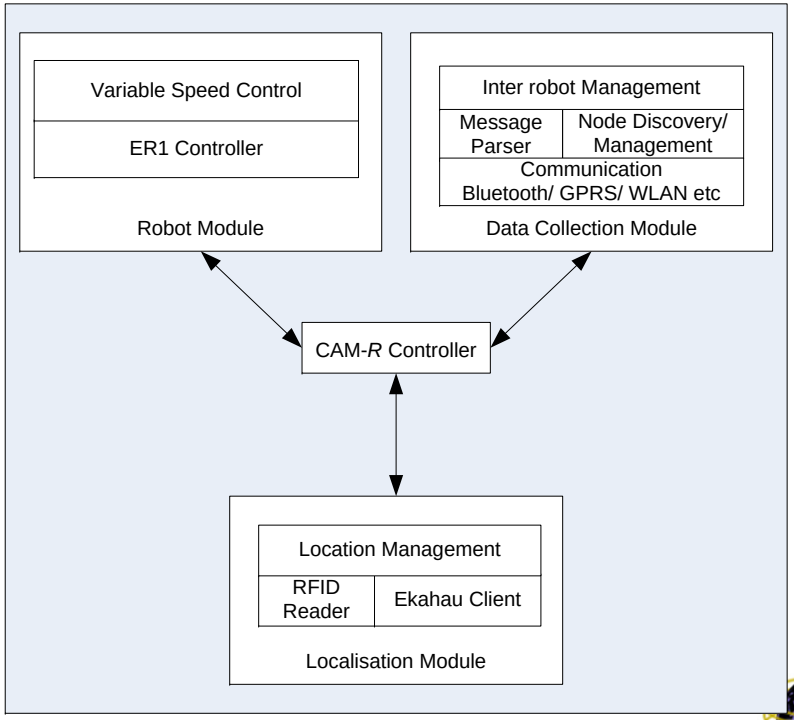
Smart Sensing

- Discovery Context at Runtime
- Using context aware mobile objects in the environment
- Mobile object responsible for intelligently sensing the environment for new sensor sources
- Update the context model (The virtual model of the physical environment) with new sensor sources
- Our Virtual Model is a multidimensional representation of context attributes

CAM-*R* Architecture

- Smart Sensing using mobile robots
- A robot built on off-the-shelf hardware



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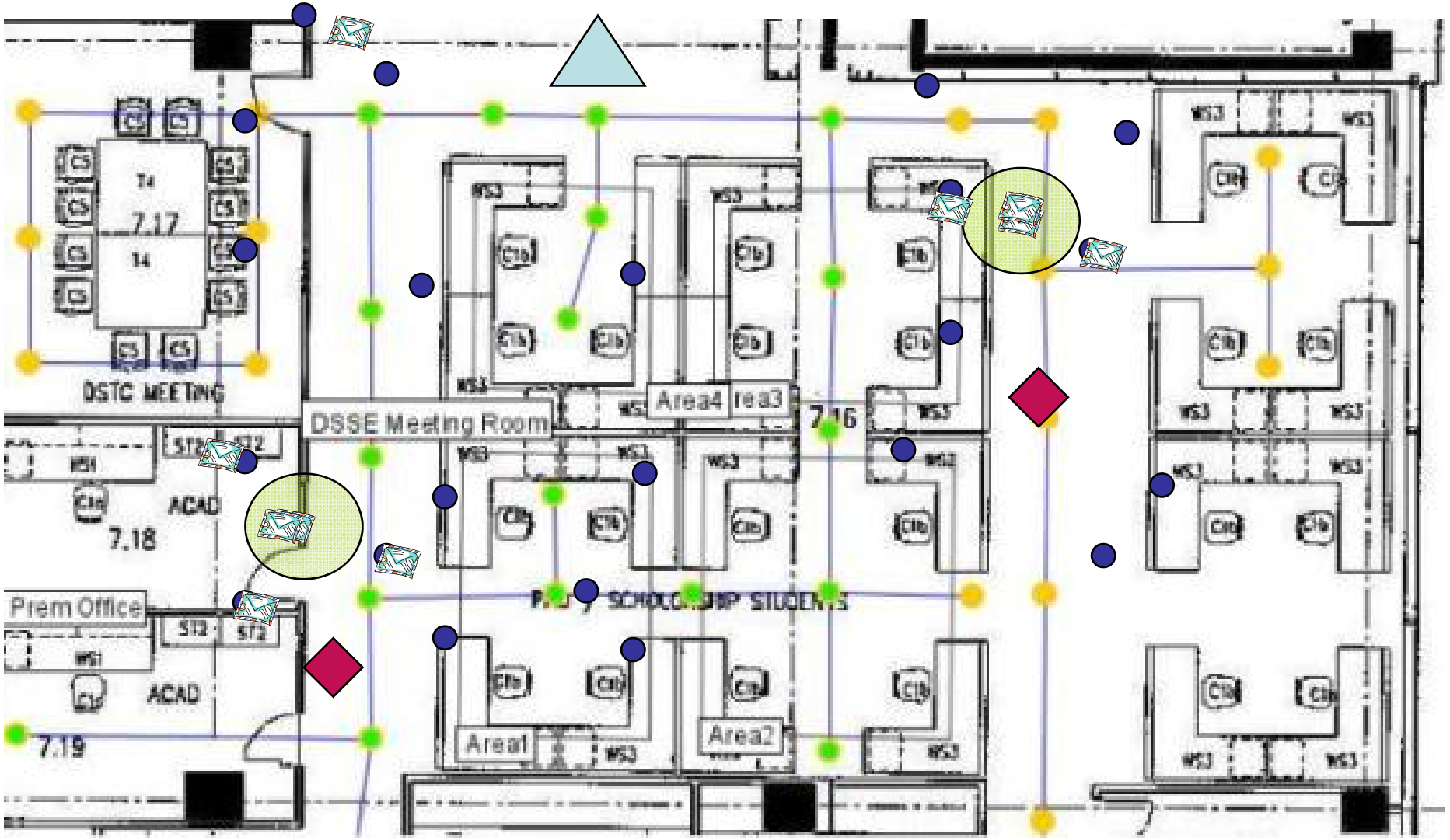


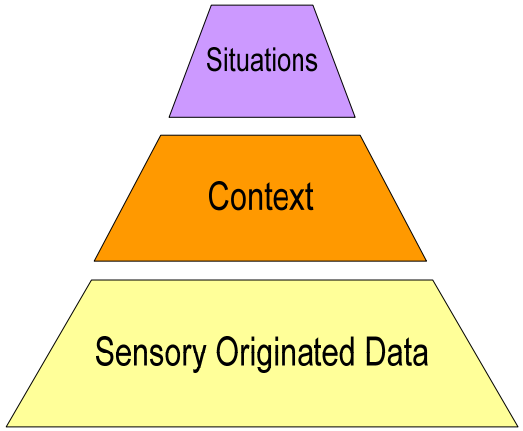
Mobile Robot
(CAM- *R*)

Mulle Sensor Node

Sink

Context Spaces - Overview

- Context Spaces
  - Multidimensional context representation
  - Definition
    - Application Space
    - Context Attribute
    - Context State
    - Situation State
  - Probabilistic reasoning approach

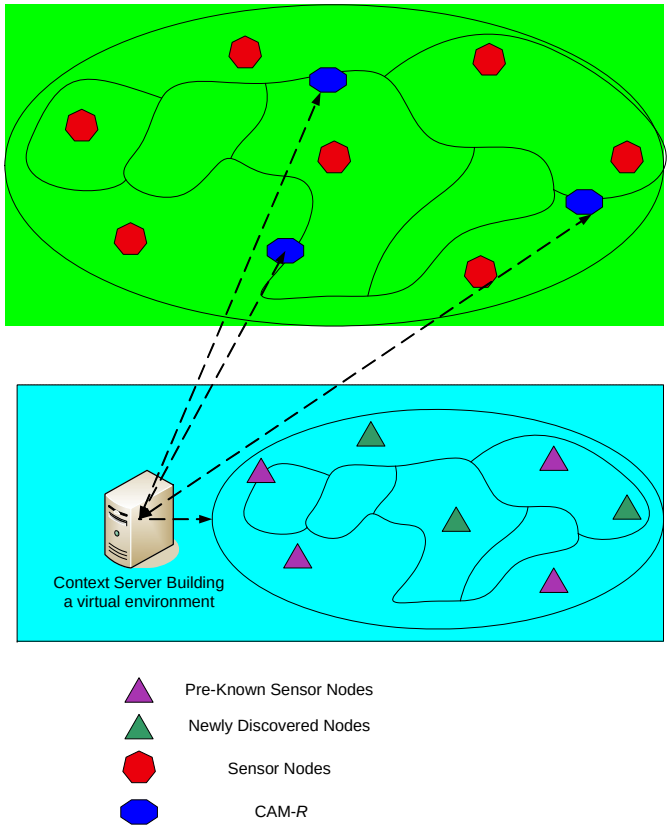


Virtual Environment Modeling

- Modeling the physical world into a virtual context model
- Each new parameters is a new attribute in the dynamic context model
- Built on top of underlying Context Spaces theory
- CAM-*R* based smart sensing of new sensor sources

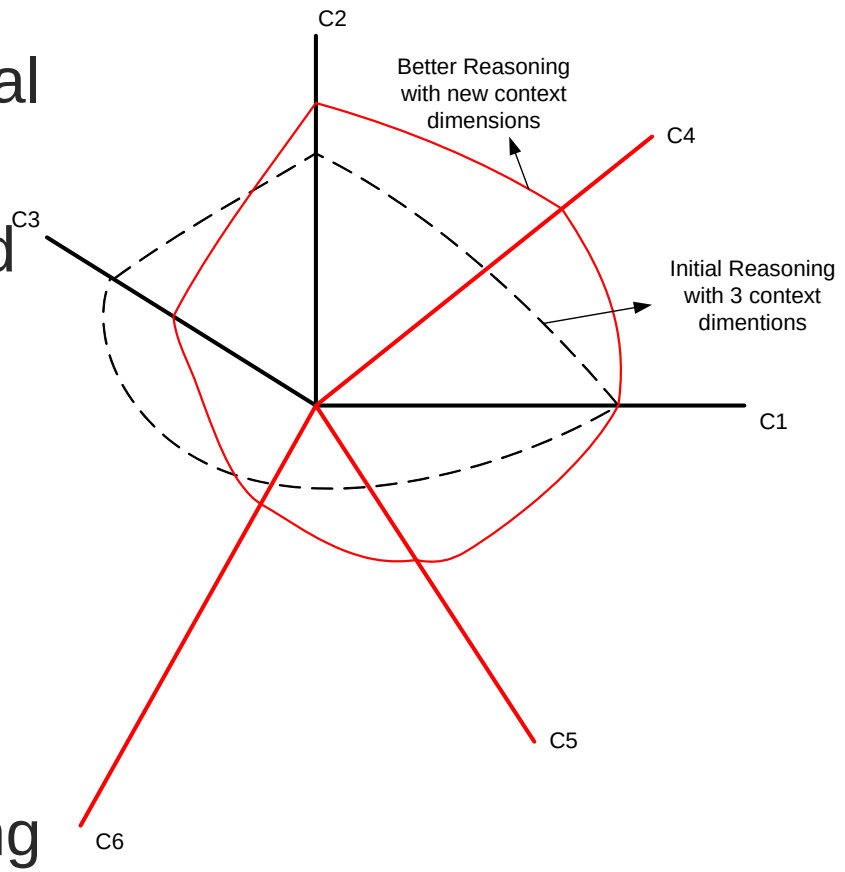
Virtual Environment Modeling - Overview

- Smart Sensing – CAM-*R* Approach
  - Discovery
  - Negotiation
  - Collection
- Update Context Server
  - Update Existing Model
  - Add new sources with its attributes
  - Re-compute the virtual context model on the fly



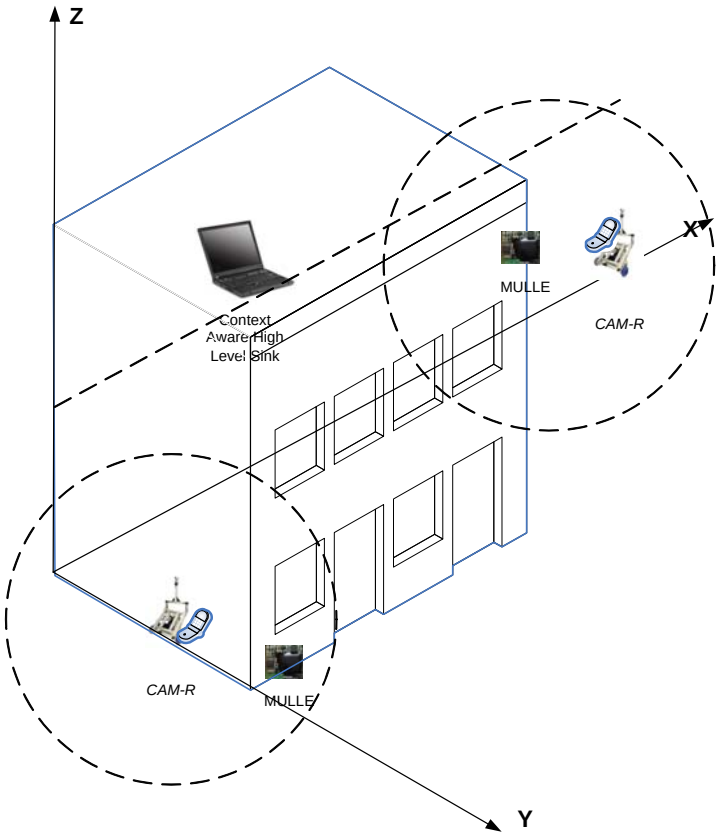
Virtual Environment Modeling - Cont

- Update Existing Virtual Model
- Include Newly sensed sensor sources
- New context Dimensions
- Re-evaluate parameters
- New confidence values while reasoning situations



Prototype Implementation Scenario

- A building scenario
- Bluetooth based sensor network spread across the building - Mulle
- CAM-*R* a part of the infrastructure
- Smart Sensing and Data Collection
- Implemented with 3 Mulle and 1 CAM-*R*



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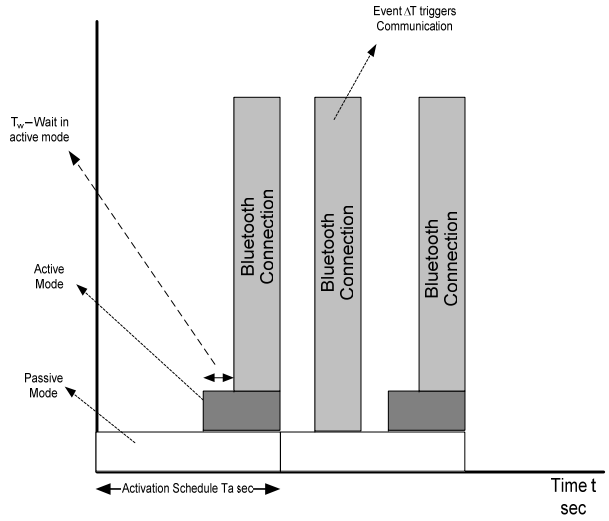
Mulle

- EISLAB, Lulea University of Technology
- Bluetooth based Sensor Node
- Operating Voltage 3.7 V
- Standardized protocols and stack
- TCP/IP and Bluetooth
- Event Based Operation
- XML for activation schedule
  - Download
  - Upload



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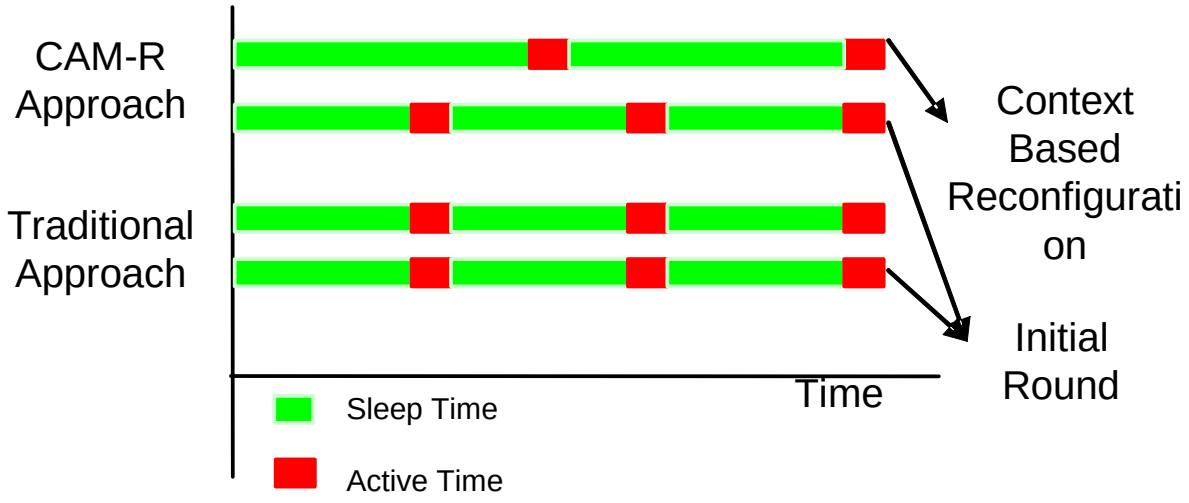
Context Aware - Sensor Adaptation

- Adapt Sensor Sleep/ Wake Interval
- Context Aware – Determined by CAM-*R* on the fly
- Enables extending sensor life time
- Allows efficient data collection



Simulation

- Simulate a Bluetooth based sensor network
- Simulate CAM-*R*
  - To obtain better results with more sensors
- Test CAM-*R* speed control algorithm for efficient data Collection
- Dynamically Adapt Sensor based on Context
- Use cost function to Compute Energy Spent
- Compare our approach with Traditional direct hop approach

Simulation - Cont

- Bluetooth Mulle sensor node
- Simulation developed using VisualStudio.net
- Activation Schedule
  - Sleep / Wake Interval
  - Altered using Context
- Simulation
  - A 2200 mAh Li-ion (7.4 Watt power)
  - Use Mulle power consumption values
  - Data transmission interval of 5 mins

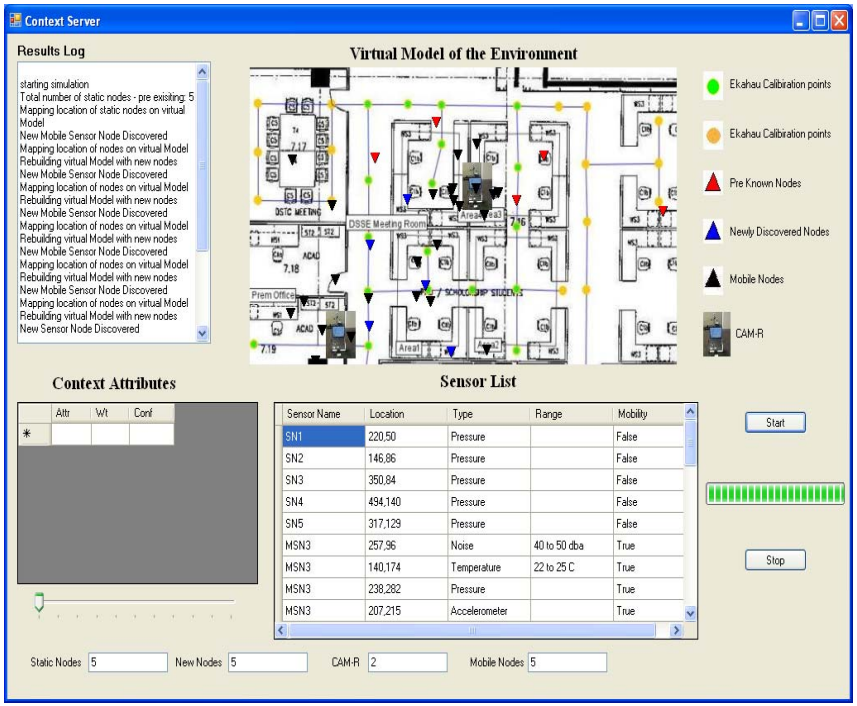
Mode	Power
MCU 10.0 MHz, BT off	25.1 mW
MCU sleep, BT active	132.9 mW
MCU sleep, BT sniff (210 slots)	27.8 mW

Mulle Power Consumption

Simulation Results

$$T_{Energy} = E_f(Send\,\mathrm{Re}cv(X_{bits}), d) + E_{con} * N_R + E_{cpu}$$
$$+ C_f(Activation_S, Power_{\mathrm{mod}e}) * w_i$$

Cost Formula Used to Compute Energy Spend by the Mulle



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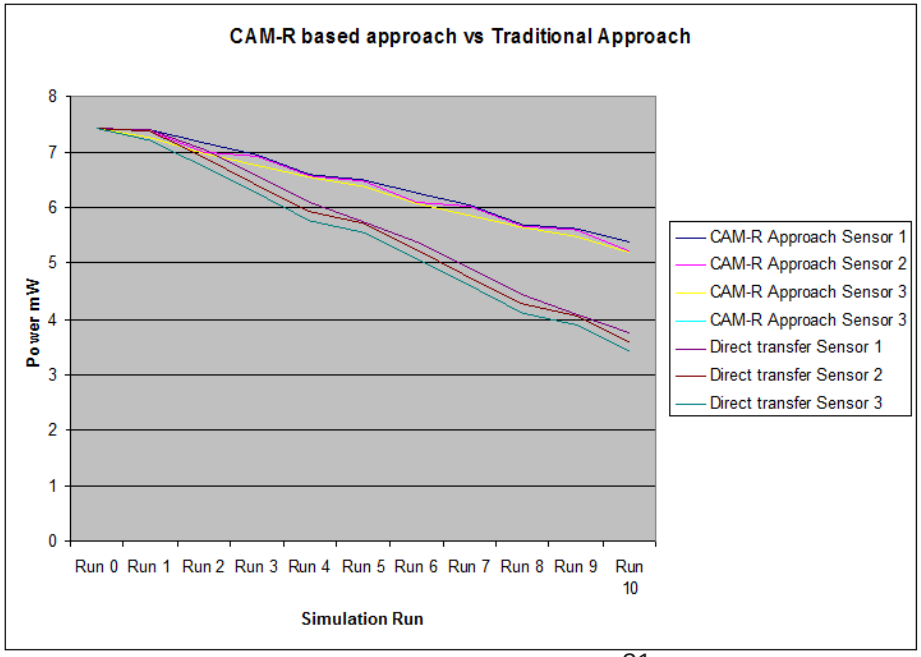
Simulation Results

- Traditional Approach
  - Direct Communication with sink
  - Bluetooth based
  - No Context incorporated



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Conclusion

- Context aware Mobile Robot (CAM-*R*) based data collection
- Smart Sensing Approach to discover new sensor sources
- Context Aware Sensor adaptation for efficient data collection
- Context Spaces Extension
- Virtual Modeling of the environment using discovered sensor sources

Conclusion and Future Work

- Prototype Implementation
- Simulation
  - Simulated Mulle
  - Simulated CAM-*R*
- Efficient Data Collection – Cost efficient proposed approach
- Future Work
  - Intelligent Environmental Sharing Algorithm
  - Exchange Sensed Context among CAM-*R* for much dynamic decisions