Scaling Smart Spaces: Concept and Exploration

SinBerBest AGM 2013
Motivation

- Building energy monitoring/optimization is active area of research
  - Dynamic building-occupant interaction
  - New materials/systems verification testing

- It is promising to link multiple physical smart spaces in real-time.
  - Acquire and apply the knowledge to design, monitor, and manage smart spaces.
  - Improve building design, environmental modeling, energy resource optimization, and building control.
Main Objectives

- To interconnect geographically distributed smart spaces (smart homes and offices, buildings, etc.) in real time.

- To implement data exchange and information delivery in smart spaces embedded with heterogeneous Wireless Sensor Networks (WSNs).

- To analyse the collected data and optimize the sensor network deployments in smart spaces via context-aware modelling and computing.
The Problem

- Difficult to maintain same density of sensor deployment
- Scaling cannot be done strictly using geo-spatial expansion
- Heterogeneous environment with different sensor node platforms deployed across different smart spaces.
- Data management and analytics for large-scale WSNs
- Flexibility required to test different BAS profiles
Wireless sensor networks provide the means to monitor the physical world in an unobtrusive manner.

Pervasive middleware technologies provide mechanisms for interpreting spatial variability thus enabling classification.

High performance computing technologies such as grid and cloud computing provide the infrastructure for data management, processing and analysis.

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**EcoSense: Cyberinfrastructure to Support Smart Spaces**

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**Our Solution - Ecosense**

- Wireless Sensor Networks
- Pervasive Middleware Technologies
- High Performance Computing

= Cyberinfrastructure for Smart Buildings
Testbedding

- Heterogeneous sensor networks
  - Micaz with Tiny OS
  - TelosB with Contiki OS
  - iMotes
  - IRIS
Context Modeling

- Based on the observations from an intensively instrumented smart space, to model and identify the areas with different environmental variability, which are referred to as context zones.

- Two dimensions in identifying environmental variability:
  - *Temporal variability*: the changing of the monitored characteristics over time (e.g. different temperatures at a specific location over time).
  - *Spatial variability*: the difference of the monitored characteristics over space (e.g. different temperatures in different locations at the same time).
Linking

H = high env. variation
L = low env. variation

Ecosense

H
L

H

L

H
Context Zones

- Based on temperature variability, identified locations requiring greater sensor density and vice versa

- Able to reduce sensors deployed

<table>
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<tr>
<th>Smart Space</th>
<th>Node</th>
<th>Near airbox/vent</th>
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</thead>
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</tbody>
</table>
Sampling Rate Optimization

- Adjust sampling rate based on temporal variation
- Significant power reduction

![Graph showing adaptive and fixed sampling rates](image-url)
The data transmitted by adaptive sampling is only 0.36% of fixed sampling.
Future Work

- Implement real-time VO-to-VO control schemes to optimize energy efficiency.

- Design cyber-physical actuation systems to enable real-time operation of smart spaces.

- Facilitate the development, simulation, and validation of new building technologies through the FLEX [1] testbeds to be built by BCA.