BEARS | SinBerBEST

Sensing, Data Mining, and Modeling

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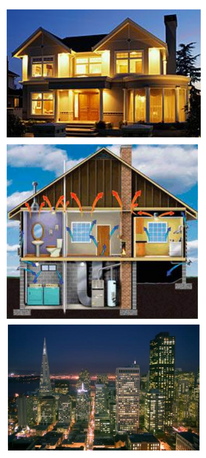
Supported by:

Funded by: National Research Foundation

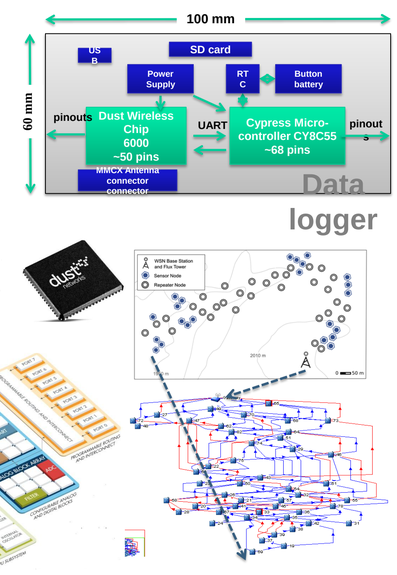
MOTIVATION

- Human activity is a significant cause for rapid increase in Green House Gas (GHG).
- Human tendency to waste resources everywhere: homes, offices, outdoors, etc.
- This is the major cause of global warming and the rapid depletion of natural resources.
- To realistically estimate total resource consumption, we need to know the contribution of each of us to the GHG at the finest possible granularity.
- Need to collect resource consumption data and building environment parameters on a per-individual, per-device, per building unit basis.



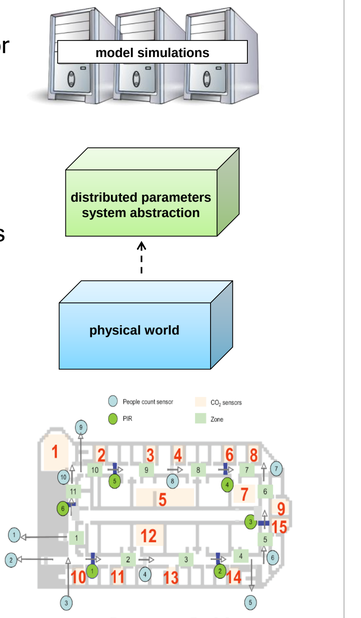
PROTOTYPING, TESTING OF HARDWARE

- Wireless backbone built from a 2-chip solution combining
  - transceiving
  - power control
  - 32-bit computation
  - full analog signal conditioning for any analog and digital sensor
  - sensors are IPv6
- Form multi-layer network of networks
- Integrate any sensor of interest, but will concentrate on micro-fabricated devices for size and power consumption concerns, e.g.
  - environmental mold, CO_2
  - occupant location, structural displacement, current flow
- Multiple deployment modalities
- 75/floor, 5 floors; 50~100 badges; 50 exterior nodes
- Validate system response against statistically meaningful conventional measurements



DATA DRIVEN MODELING APPROACHES

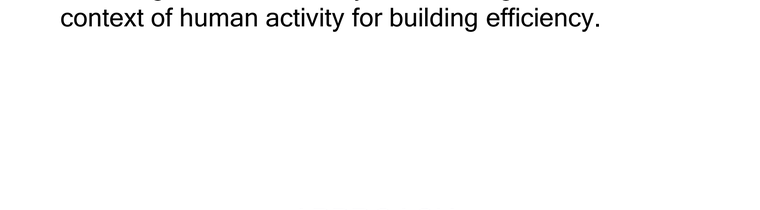
- Tunable environment models
- Data driven approach for modeling indoor micro-environments
- Usual building state parameters (temperature, humidity, light/HVAC use, air quality).
- Human activity, occupancy models
- Predictive occupancy and activity models
- Model of the interaction between the building and its occupants
  - Aggregate traffic flow models (mass balance based)
  - Model calibration (based on one-time dedicated infrastructure based measurements)
  - Statistical models (graphical models)
  - Learning algorithms for graphical models



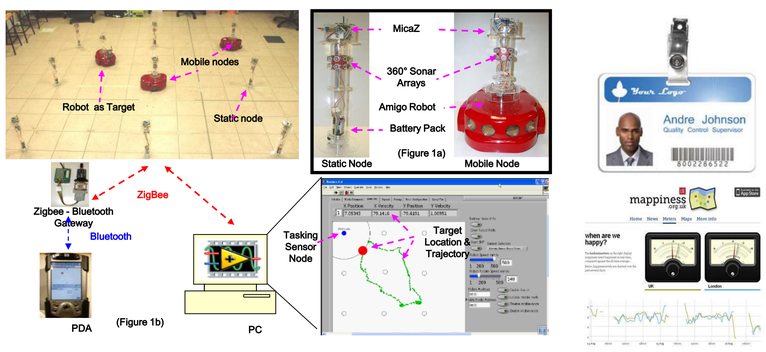
Source: S. Meyn

THRUST ORGANIZATION

Thrust 1 is organized in 6 categories working synergistically in order to fully achieve the main objectives of reducing energy inefficiencies by tactfully collect key parameters data, involving awareness of the user, fully optimize middleware, a comprehensive forecasting, thus determining a high performance building in tropical climate

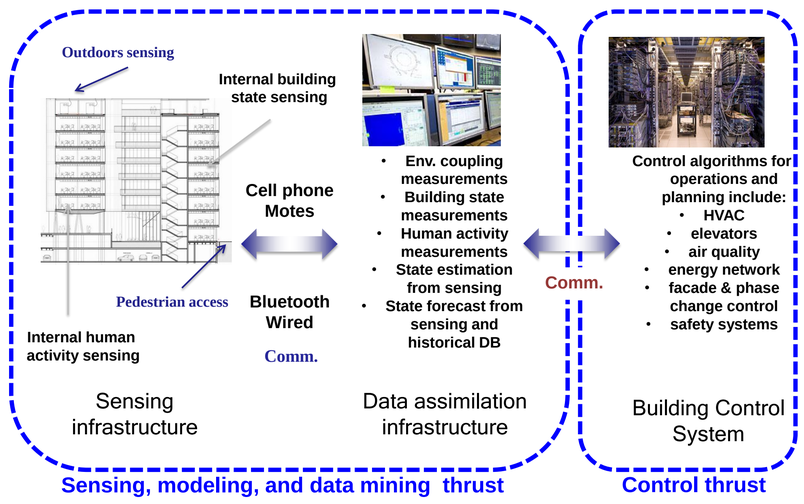


PARTICIPATORY SENSING AND DATA FUSION



- Development of innovative participatory sensing techniques for improving building full state awareness: sensing human activity.
- Deployment of smartdust motes on people (in badges): voluntary disclosure of activity
- Smartphone based sensing (special client for indoor activity)
- Web based app disclosure (comfort, feedback, access to calendars).

SYSTEM ARCHITECTURE

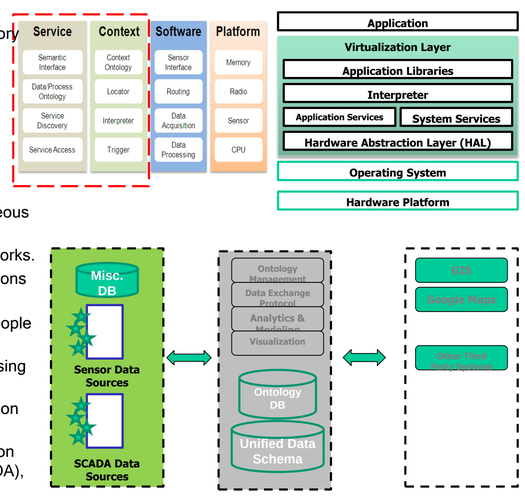


CHALLENGES

- Interconnecting geographically distributed smart spaces (smart rooms, smart homes, smart buildings, transportation systems, etc).
- Real-time data exchange between various WSNs embedded within smart spaces.
- In-network context-aware computing.
- Sensor node hardware and platform heterogeneity across different smart spaces.
- Data collection, data assimilation, and data mining via participatory sensing techniques using smartphones and mobile devices.
- Modeling of human activity and building state in the context of human activity for building efficiency.

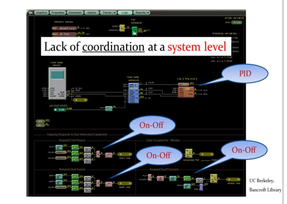
MIDDLEWARE SERVICE

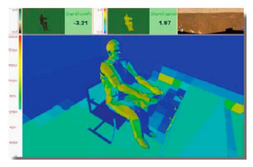
- Middleware framework to support embedded sensing and participatory sensing
  - Sensor data collection.
  - Sensor node control and management.
  - In-network context aware processing.
- Sensor network virtualization
  - Interoperability of heterogeneous sensor nodes.
  - Interfacing with building networks.
- Middleware services and applications
  - Accurate and practical 3D localization techniques for people within buildings.
  - Participatory and mobile sensing support.
  - Scalable and robust data fusion techniques
- Smart Cyberinfrastructure based on Service-Oriented Architecture (SOA), Semantic Networks, Unified Data Exchange Protocols, Knowledgebase, High-Performance Backend (Grid/Cloud).



INTEGRATION WITH OTHER THRUST

- Integrative: develop infrastructure to support collaboration with other related research efforts in Singapore (SMART CENSAM, ETH Future Cities Lab) by facilitating data exchange and workflow.
- Outreach to community of engineers/scientists working in building sensing and inverse modeling.
- Organize a workshop to be held in Singapore in the third year of the project
- Special issue of Networks and Heterogeneous Media (or relevant IEEE journals to publish articles based on the work).
- Work with other communities / projects to perform outreach (publications, entrepreneurial venues, IP development).





APPROACH

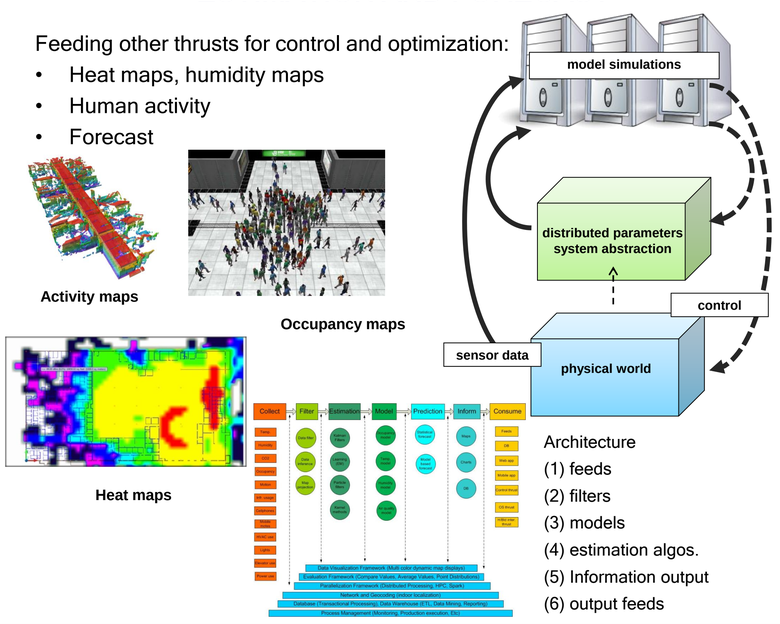
Wireless Sensor Networks and mobile devices + Pervasive Middleware Technologies + High Performance Computing powered data assimilation = Cyberinfrastructure for Smart Buildings

- A new cyberinfrastructure to support smart buildings.
- WSNs and mobile devices provide the means to monitor the physical world in an unobtrusive manner.
- Pervasive middleware technologies provides mechanisms for interpreting who is consuming what resource.
- High Performance Computing techniques such as Grid and Cloud Computing provide the infrastructure for data management, processing (assimilation), mining, analysis, visualization, and sharing.

ESTIMATION AND FORECAST

Feeding other thrusts for control and optimization:

- Heat maps, humidity maps
- Human activity
- Forecast



Architecture
(1) feeds
(2) filters
(3) models
(4) estimation algos.
(5) Information output
(6) output feeds

SUMMARY

- Prototyping, testing and deployment of new hardware
- Development of innovative participatory sensing techniques
- Design and implementation of middleware services
- Prototyping and testing of backend HPC/cloud cyber infrastructure
- Data driven approaches for modeling indoor environments
- Data mining, state estimation, data assimilation