Wireless Sensor Networks for information provisioning for facilities management

Apostolos Malatras, Hamid Asgari & Timothy Baugé

1st International Conference on Industrialised, Integrated, Intelligent Construction
Outline

- Introduction
- Motivation
- Wireless sensor networks (WSN)
- Related work
- Proposed WSN architecture
- Architecture specification
- Conclusion
Introduction

- Shift towards architectures that allow for integrated Building Management Systems (BMS) and support building automation and control under a unifying framework
  - Enable the building manager to have a single point of interaction to control facilities in an integrated manner

- Integration is the key to the effective operation of intelligent buildings

- Need for broader perspective
  - Open and extensible architecture
  - Dynamic integration of new BS and existing ones
  - Flexibility, scalability, interoperability support
Motivation

- One of the most important parameters regarding facilities management is accurate monitoring of the building system and its surroundings
  - Sensors located inside and outside of the building
  - Existing building systems are tightly coupled with their sensors
- Service oriented architecture (SOA) to enable dynamic, coordinated, integrated and distributed facilities management
- Wireless sensor networks (WSN) considered within this scope as information service providers
  - Cost efficient, flexible deployment
BS architecture reference model

Service bus

Service registry

Service access control

Legacy systems services

Building application services

Enterprise level services

Legacy system wrapper

Existing conventional BMS

BMS

Building assessment tools

IT systems

WSN

Ambient UI

IT systems
Elements of wireless sensor motes
- Processor
- Battery
- Sensor
- Storage
- Peripherals
The synergy of building systems, services and data communications reduces operational costs and creates new service opportunities [Brambley et al, 2005]

Provides BMS and building automation and control systems with access to additional information that enable the building to be used more effectively

Information collected from a variety of sensors [Ming et al, 2006]

- physically sensed data (structural, environmental, physiological, etc.)
- electronic records (building maintenance records and schedules, personnel profiles and calendars, etc.)
Traditional view of sensors as static resources, has shifted to satisfy a service-oriented perspective [OpenGIS, 2006][King et al, 2006][Moodley et al, 2006]

- WSN regarded as service providers, i.e. information monitoring and reporting services
- Advanced, dynamic, reusable and extensible applications and operations

The SWE (Sensor Web Enablement) activity [OpenGIS, 2006] views sensors as service providers in a generalized SOA

- Benefits: underlying WSN complexity is hidden from higher-layer applications, reusability is ensured, scalability, abstraction, extensibility and interoperability are promoted
Proposed architecture

- Context model
- Enterprise middleware
- Service registry
- Tasking middleware
- WSN
- BMS
- Assessment tool
- Service consumer

Data flow:
- Context model → Enterprise middleware
- Tasking middleware → WSN
- BMS → Assessment tool

Service provider:
- WSN
- Tasking middleware
WSN exposed in the SOA

Gateway's communication network (Ethernet, 802.11 etc.)

Gateways' communication network

Zone 1
WSN (802.11.15)

Zone 2
WSN (802.11.15)

Zone 3
WSN (802.11.15)

Gateways

Virtual gateway

REST-based WSN WS Interface

Enterprise Service Bus

queries

information

BIM

BMS

WSN (802.11.15)
Sensor nodes

Sensor boards

Sensor node: sensor board + wireless module

Indicative size (mm) : 58 x 32 x 7 Excluding battery pack
Functional WSN architecture

Wireless sensor network

Sensor Node
- Tasking middleware
- Network services
- Node services
- Security
- Reprogrammability

Gateway
- Enterprise middleware
- Tasking middleware
- Gateway coordination
- Network services
- Node services
- Security
- Reprogrammability
WSN seen as a collection of resources

- REST-based style SOA to integrate WSN with enterprise services

WSN WS accessed by clients through URI

- `http://{hostname}/REST/{version}/`
- GET, POST, PUT, DELETE HTTP method support
- Implemented as servlets in Web Server

Tasking middleware performs backend core WSN functionality, such as tasking of sensor nodes and collecting data
REST resources

- DomainTask
- DomainTaskResult
- SensorTask
- SensorTaskResult
- Sensor
- SensorResult
- Space
- ContextInfo
REST resources associations

- ContextInfo
  - associated to DomainTask
  - used at decomposition
  - decomposed into SensorTask
  - yields SensorTaskResult

- SensorTaskResult
  - yields SensorTask
  - yields SensorTaskResult
  - mapped to Sensor

- SensorTask
  - yields SensorTaskResult
  - mapped to Sensor

- SensorResult
  - yields Sensor
  - located within Space

- Sensor
  - yields SensorResult

Thales Research & Technology (UK) Ltd.
Architecture specification (Sensor node)

- **Task Scheduler**
  1) Keep a schedule of running tasks.
  2) Generate an event when task is due.

- **Task Processor**
  1) Processes sensor tasks.
  2) Handles task cancellations.

- **Zigbee Network Handler**
  Sends/receives Zigbee packets.

- **Task Data Manager**
  1) Samples hardware sensors.
  2) Generates data or alarm reports depending on sensor task, and sends to gateway.

- **Task DB**
  1) Storage of sensor tasks.

- **Data DB**
  1) Storage of sensor data.
Architecture specification (Gateway node)

- **Query Manager**: Processes queries and cancellations from clients.
- **Query Decomposer**: 1) Decompose a query into sensor tasks. 2) Resolve domain semantics to WSN location semantics.
- **Response Manager**: 1) Handle sensor task reports. 2) Generate appropriate client responses by matching task reports to client queries.
- **Sensor Task Manager**: Processes and generates sensor tasks that were derived from queries.
- **Sensor Task DB**: Stores sensor tasks.
- **Zigbee Network Handler**: Masks underlying connectivity to Zigbee network and sends/receives Zigbee messages.
- **Task Filter**: Filter redundant sensor tasks.
- **Data Query DB**: Stores clients’ queries and maps data query to sensor tasks.
- **Node DB**:
- **Building Information Model**:
- **Enterprise Network Handler**:

21/05/2008
Conclusions

- Architectural framework to enable integration of WSN in an overall facilities management enterprise architecture
  - Reductions in cost, flexibility and agility to respond to dynamic conditions
- Provided functional architecture and specification
  - SOA to expose WSN-related information to the overall enterprise architecture
  - Tasking middleware for data collection and processing.
- Future work will evaluate the proposed WSN architecture in our experimental WSN testbed
  - Case-study: building assessment tool for energy efficiency