# Term Paper

## – Context-Aware Applications in Smart Buildings –

Max Kister

Institute of Operating Systems and Computer Networks
Technische Universität Braunschweig

July 13, 2007

# Outline

# Outline

# Context

Context is any information that can be used to characterize the situation for an entity.

- an entity is a person, place or object that is considered relevant to the interaction between a user and an application
- examples of context information are:
  - identity
  - environmental information (light level, temperature, ...)
  - temporal information (time, date, ...)
  - activity (walking, talking, lying, ...)

# Context-Awareness

Context-awareness means that one is able to use context information.

- context can be used to interpret explicit operations
- a context-aware system should be able
  - to extract context information
  - to interpret context information
  - to use context information
- aim is to adapt the functionality of a system to the current situation

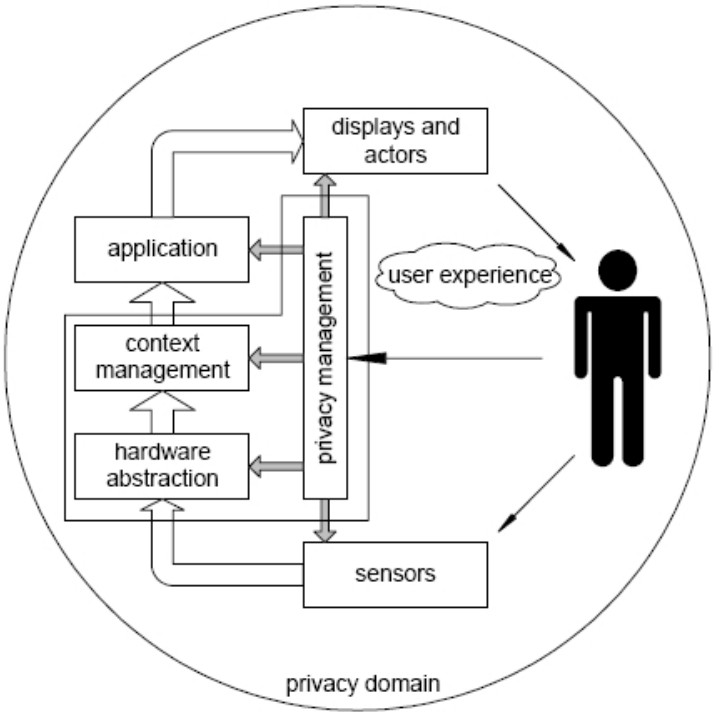
# Outline

# Issues of context-aware applications

- context is often indirect deducible
- applications have to be aware of user intentions
- applications must communicate with sensors
- applications should be reusable
- two possibilities for handling context:
  - connect sensor drivers directly into applications
  - use services to hide sensor details

# Use of design models

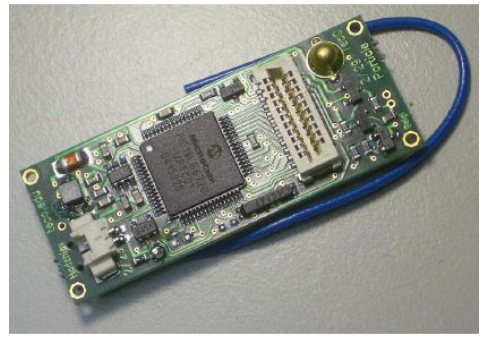
- to make context-aware applications more reusable in different environments, design models were elaborated
- design model consists of:
  - sensors
  - middleware (hardware abstraction, context and privacy management)
  - applications
  - displays and actuators



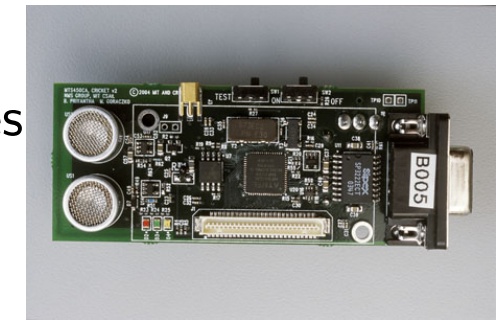
# Sensors

- sensors are the senses of a context-aware application
- ideally should reflect the 'real world' situation
- combination of multiple sensors for more meaningful information
- should have small size and be cheap
- should be wirelessly interconnected
- should have enough energy for a long time period

# Sensors - examples



- 'Smart-Its' from the TecO in Karlsruhe, cPart as an example:
  - 8 bit microprocessor
  - operation of multiple sensors
  - wireless communication unit
  - different power modes
- the Cricket Indoor Location System from MIT
  - combination of RF and ultrasound technologies
  - beacons (see picture) send ultrasonic pulse
  - mobile receivers can determine their positions



# Middleware - hardware abstraction, context and privacy management (1)

- middleware should simplify the design of new context-aware applications
- hides details of how context-information was derived
- provides an interface for new applications

Middleware consists of:

- hardware abstraction layer
  - decouples the higher level software from the actual sensor hardware
  - has the task of communicating with different types of sensors
  - builds up a highly dynamic environment with sensors and networks changing constantly

# Middleware - hardware abstraction, context and privacy management (2)

Middleware consists of:

- context manager
  - derives basic context information from raw sensor data
  - interprets the context
  - builds up an overview about the entity (modeling and evaluation)
- privacy manager
  - creates a privacy domain
  - affords a user the possibility to explicitly adjust the domain
  - seals the privacy domain off the whole world

# Displays and Actuators


- interfaces should be manageable by the average user without any computing knowledge
- no cognitive overload
- fix or mobile interfaces
- speech and gestures as interactions possible
  - but hard to use for novices
  - GUI is easier to understand

# Outline

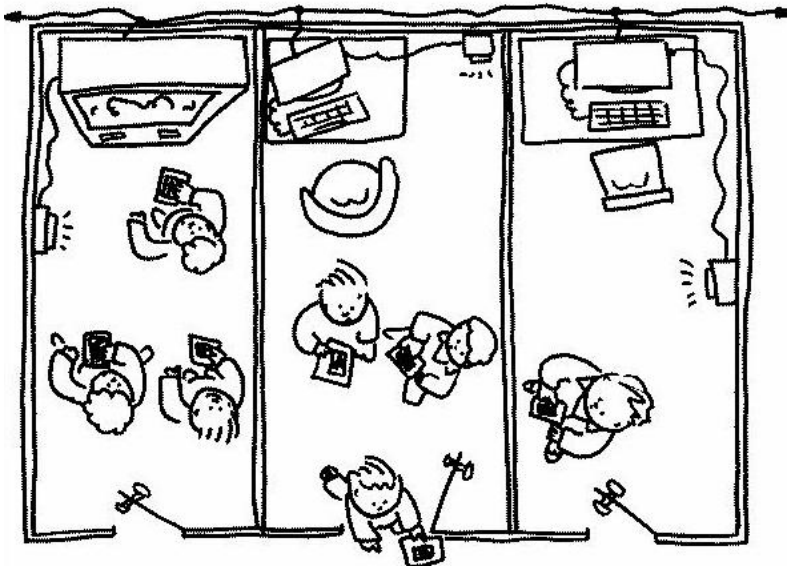
# Smart Buildings - Overview (1)

Smart Environment is a small world where network-enabled devices work continuously and collaboratively to make lives of inhabitants more comfortable.

- interconnects sensors, middleware and context-aware applications
- is able to autonomously acquire and apply knowledge about the environment
- adapts to current situation

# Smart Buildings - Overview (2)

- first applications for offices in the beginning of the 90's
  - Active Badge system (1990)
  - ParcTab system (1993)
- first smart house in 1993
- houses differ in design concepts
  - reactive environments
  - teaching homes
  - programmable pervasive spaces



# Reactive Environments (1)

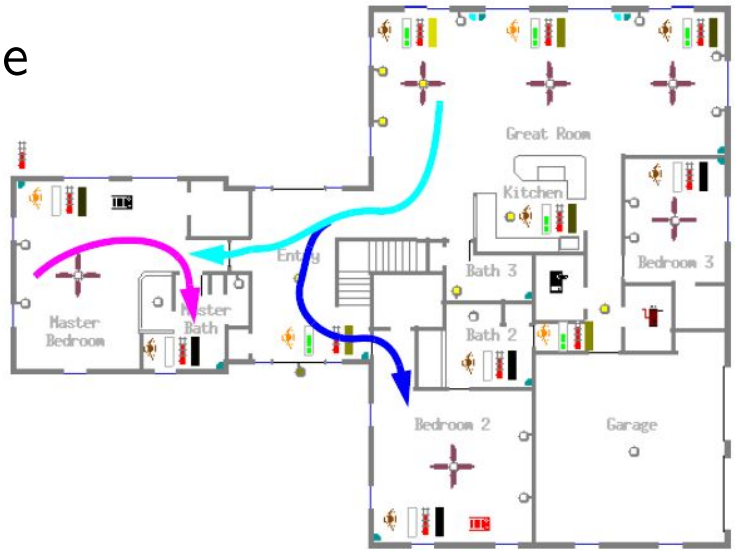
The Adaptive Home (University of Colorado)

- smart house which can react to its environment
- has no user interfaces beyond the sort of controls offered by an ordinary home
- focus on home comfort systems
  - air and water temperature regulation
  - ventilation
  - lighting
- programs itself by observing the inhabitants

# Reactive Environments (2)

ACHE - middleware of the Adaptive Home

- acronym for Adaptive Control of Home Environments
- centralized on several servers
- direct control of 75 sensors
- transparent for the inhabitants

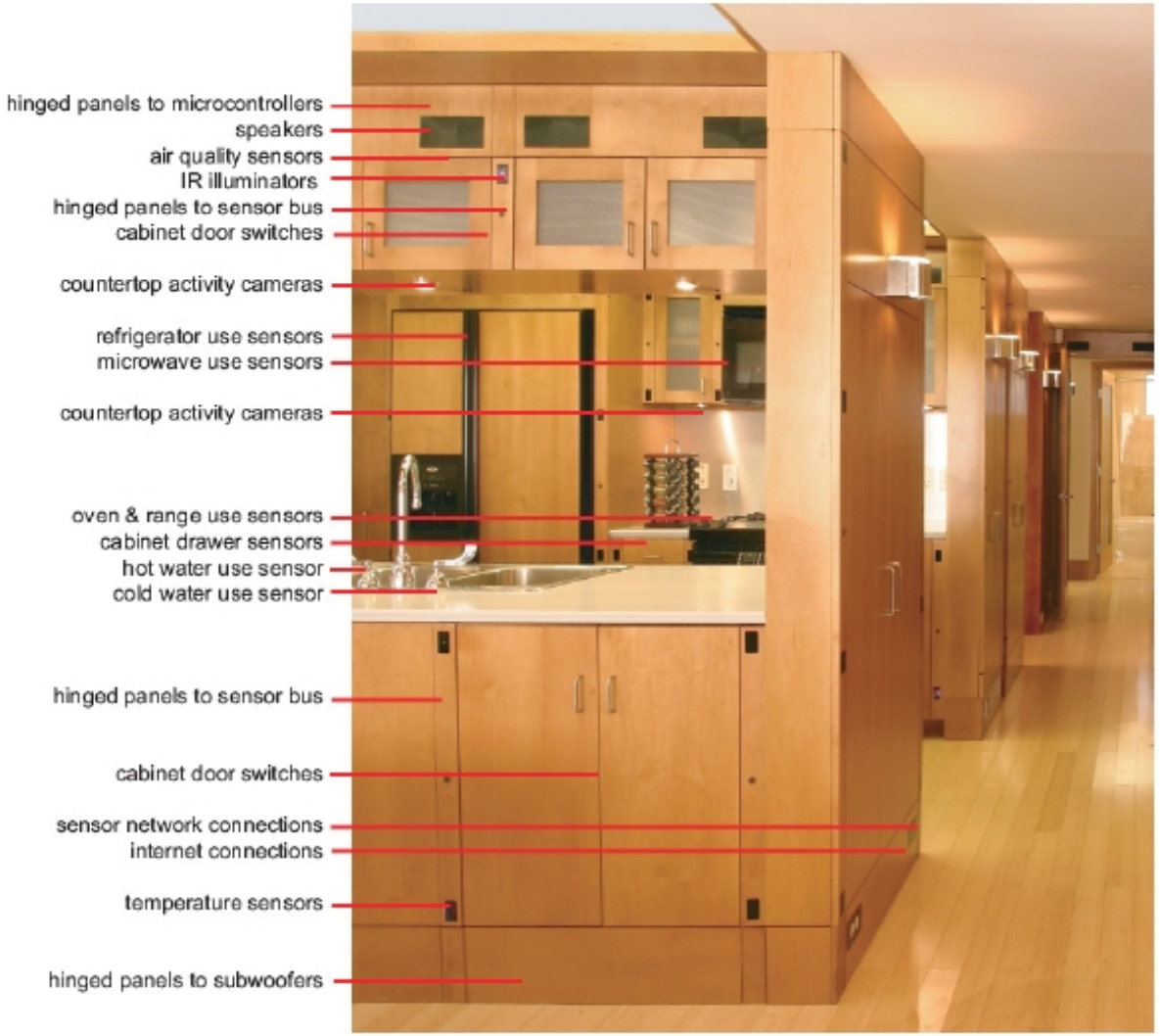


# Teaching Homes (1)

House_n (Massachusetts Institute of Technology)

- no controlling home, but a home which is supportive
- living laboratory MIT-TIAX PlaceLab
- uses a cabinet-based integrated interior infill system
  - Dallas Semiconductor TINI networked microcontroller
  - up to 30 sensors per cabinet
  - capture a complete record of audio-visual activity
  - Java virtual machine for sensor communication
- further sensors shared in the rooms

# Teaching Homes (2)

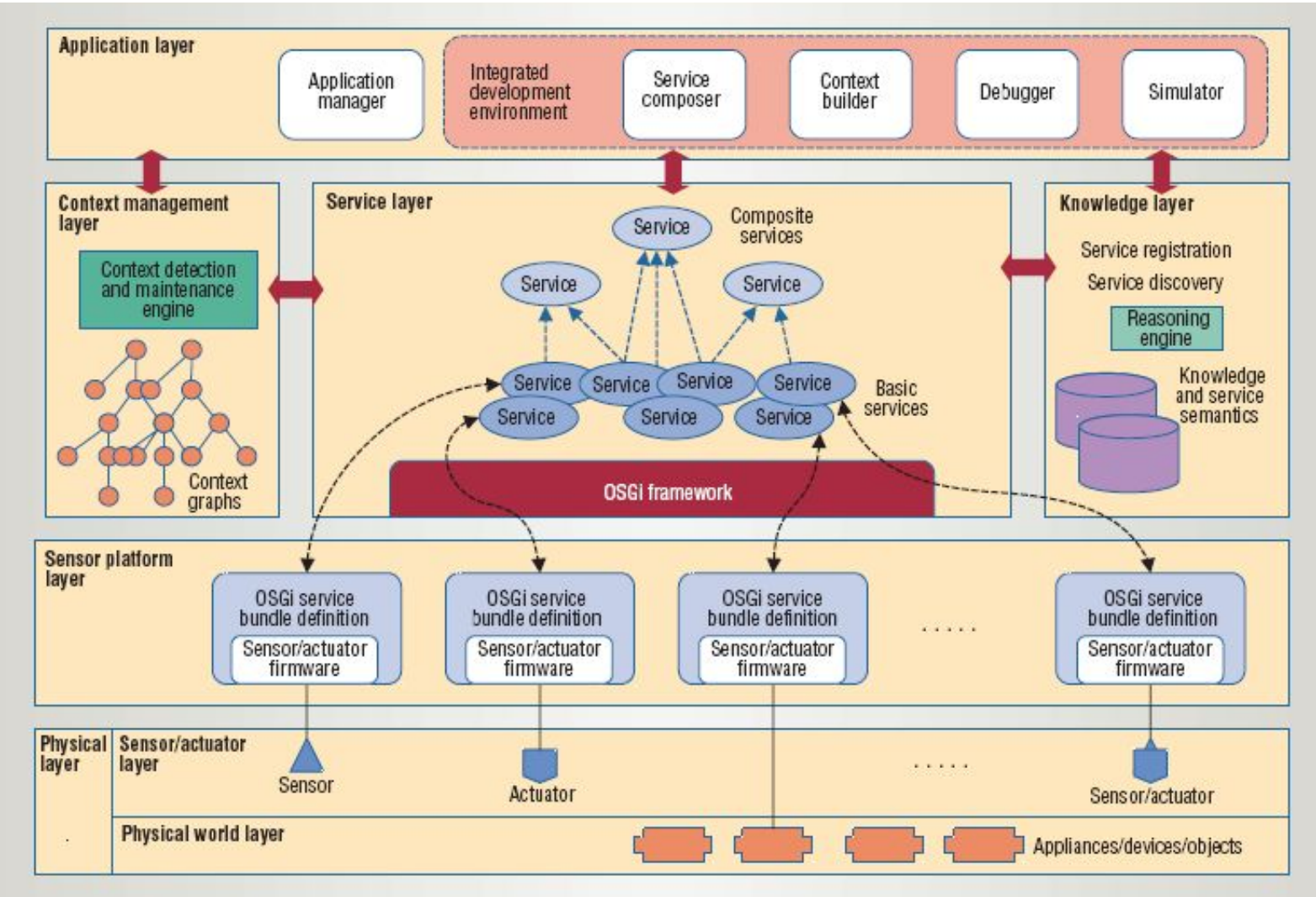



# Programmable pervasive spaces (1)

Gator Tech Smart House (University of Florida)

- assistive environment which is easy to monitor by an average user
- Open Services Gateway Initiative framework
  - middleware based on Java
  - sensors represented as OSGi service bundles
  - applications use services in order to obtain context information

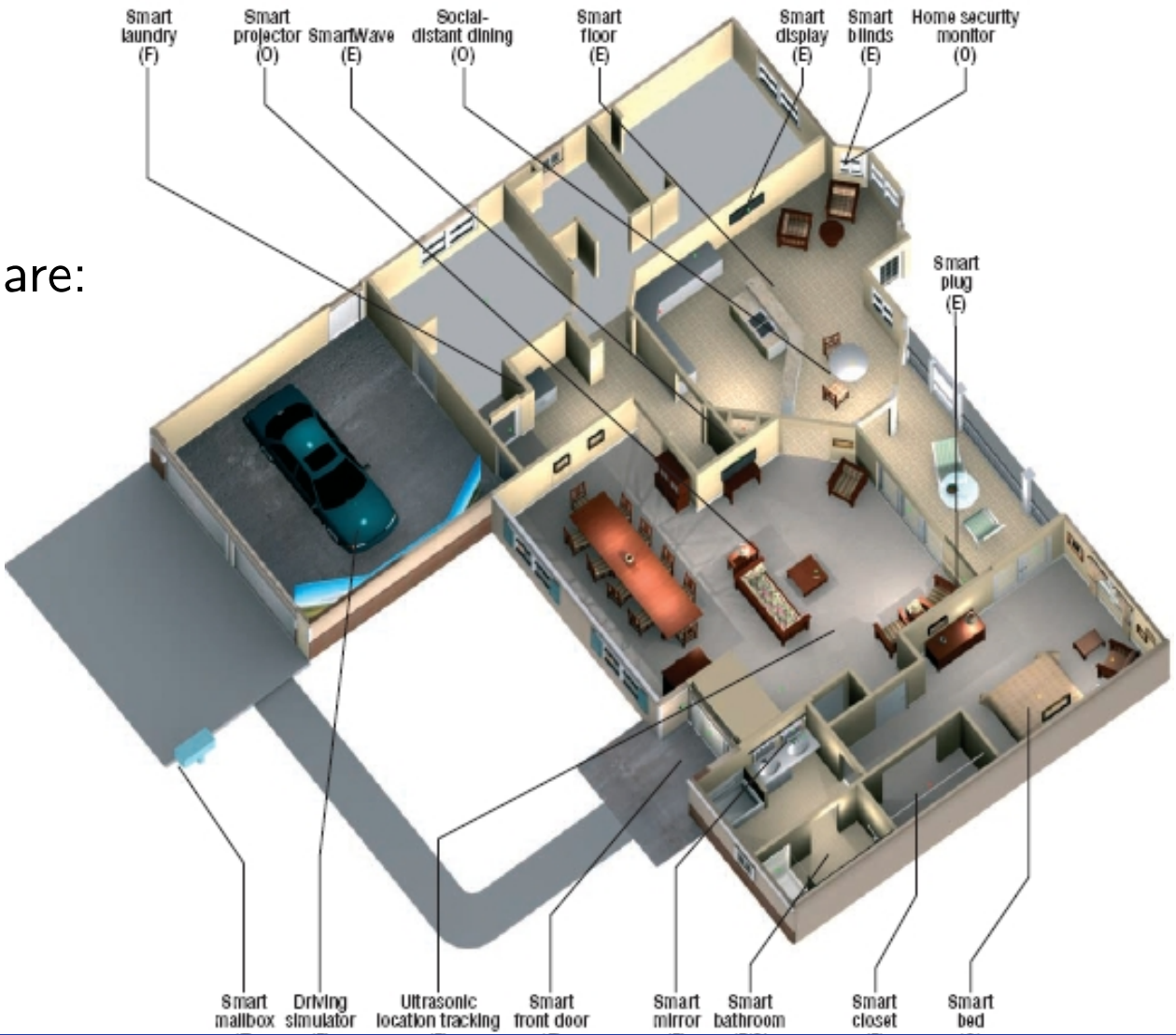
# Programmable pervasive spaces (2) - middleware



# Programmable pervasive spaces (3)

existing applications are:

- smart mailbox
- smart front door
- smart mirror
- smart displays



# Outline

# Conclusions

- all systems disclose a potential in helping inhabitants at home
- easy usable user interfaces are a precondition
- modular architectures which can be easily expanded
- technology becomes cheaper

# Thank you!

# Term Paper

## – Context-Aware Applications in Smart Buildings –

Max Kister

Institute of Operating Systems and Computer Networks
Technische Universität Braunschweig

July 13, 2007