ICSOFT 2012
7th International Conference on Software Paradigm Trends
Rome, Italy
24 - 27 July, 2012

Data, Context, Situation

On the Usefulness of Semantic Layers for Designing Context-aware Systems

Prof. Dr. Daniela Nicklas

Department für Informatik
Juniorprofessur Datenbank- und Internettechnologien
Carl von Ossietzky Unversität Oldenburg

CARL VON OSSIETZKY universität OLDENBURG

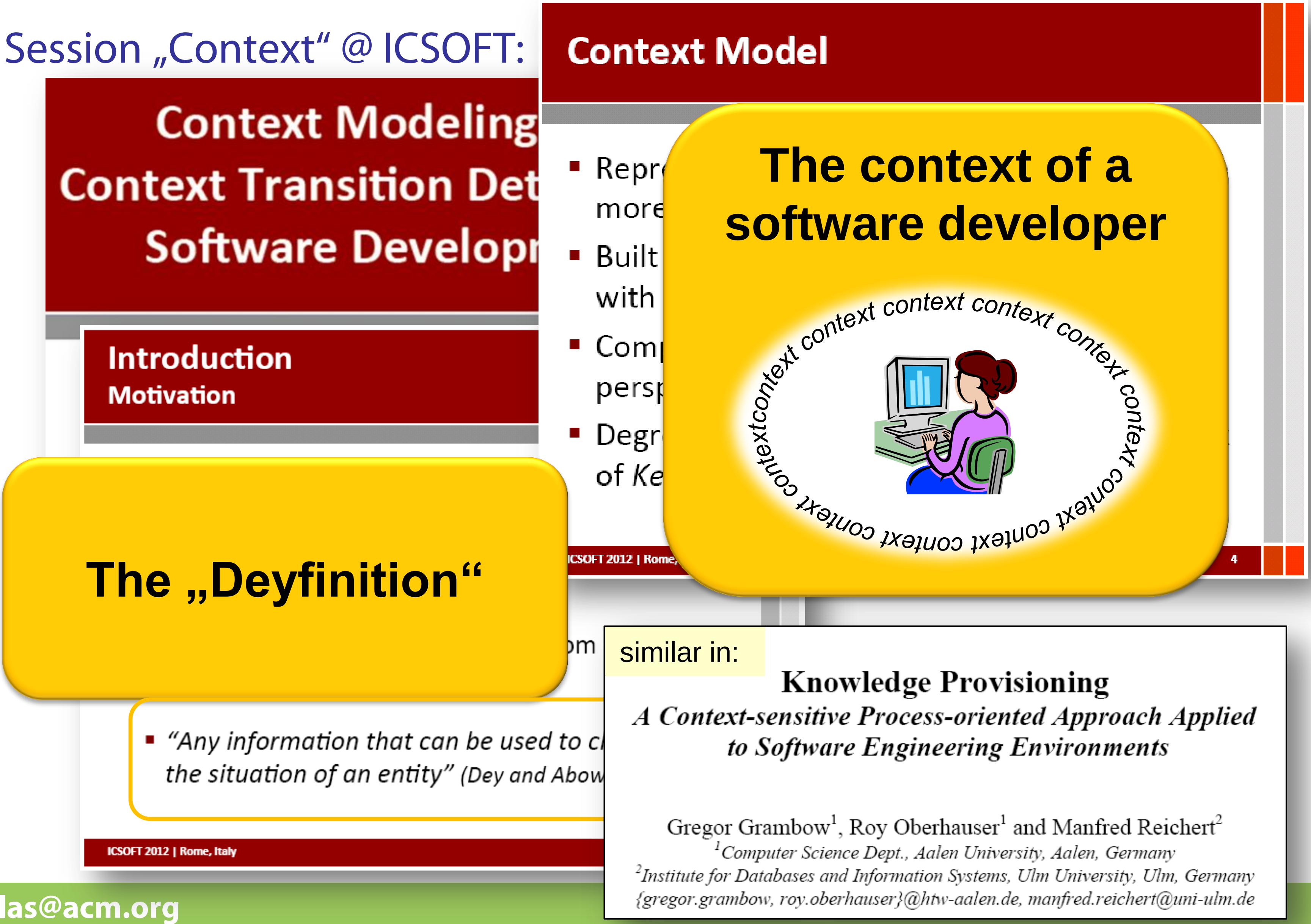
D&itB

dnicklas@acm.org

Context

What is Context?

- Session „Context“ @ ICSOFT:



Context Modeling

Context Transition Det

Software Developr

Introduction

Motivation

The „Deyfinition“

pm

- “Any information that can be used to c

the situation of an entity” (Dey and Abow

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Context Model

- Repr

more

- Built

with

- Comp

persp

- Degr

of Ke

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4

The context of a software developer

context context context context context context context context context context context context

similar in:

Knowledge Provisioning

A Context-sensitive Process-oriented Approach Applied to Software Engineering Environments

Gregor Grambow[1], Roy Oberhauser[1] and Manfred Reichert[2]

[1] *Computer Science Dept., Aalen University, Aalen, Germany*

[2] *Institute for Databases and Information Systems, Ulm University, Ulm, Germany*

{gregor.grambow, roy.oberhauser}@htw-aalen.de, manfred.reichert@uni-ulm.de

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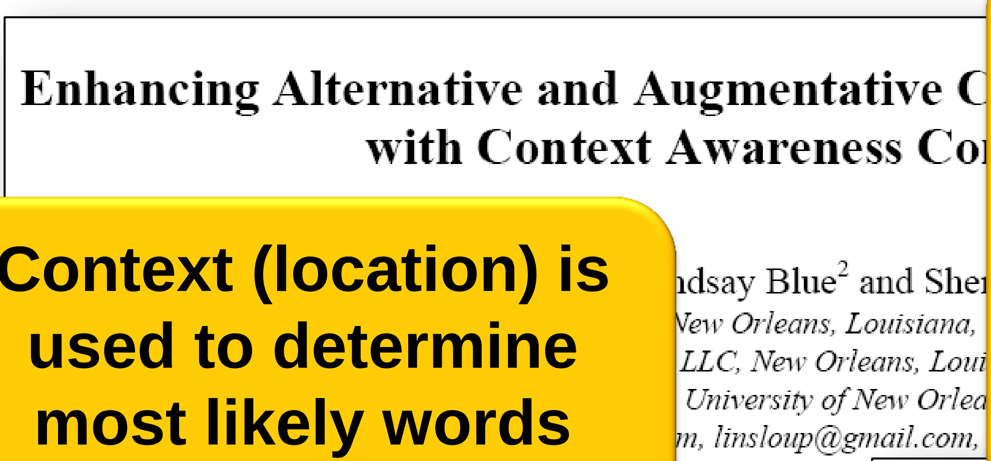


Enhancing Alternative and Augmentative C
with Context Awareness Co

ndsay Blue[2] and Sher
New Orleans, Louisiana,
LLC, New Orleans, Loui
University of New Orlea
m, linsloup@gmail.com,

Context (location) is used to determine most likely words (by categories)

The context of an user

context context context context context context context context context context context context

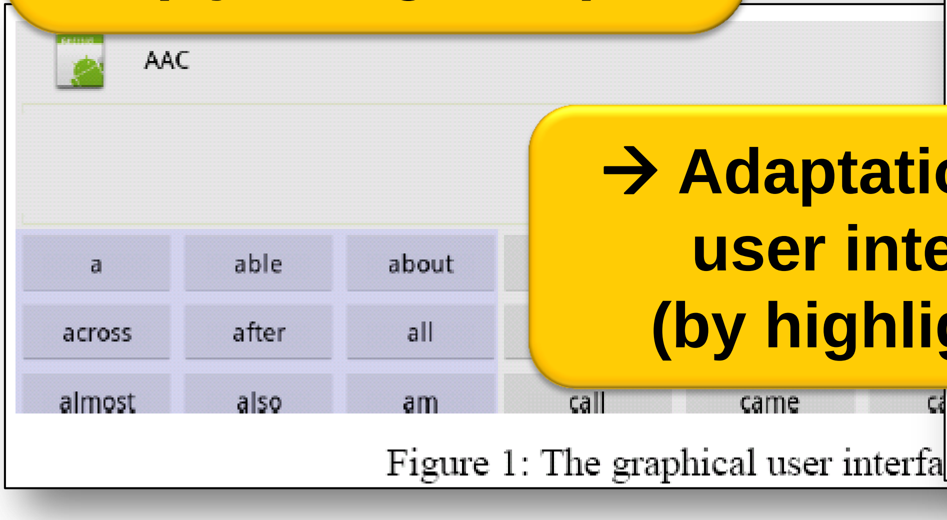


Figure 1: The graphical user interfa

→ Adaptation of the user interface (by highlighting)

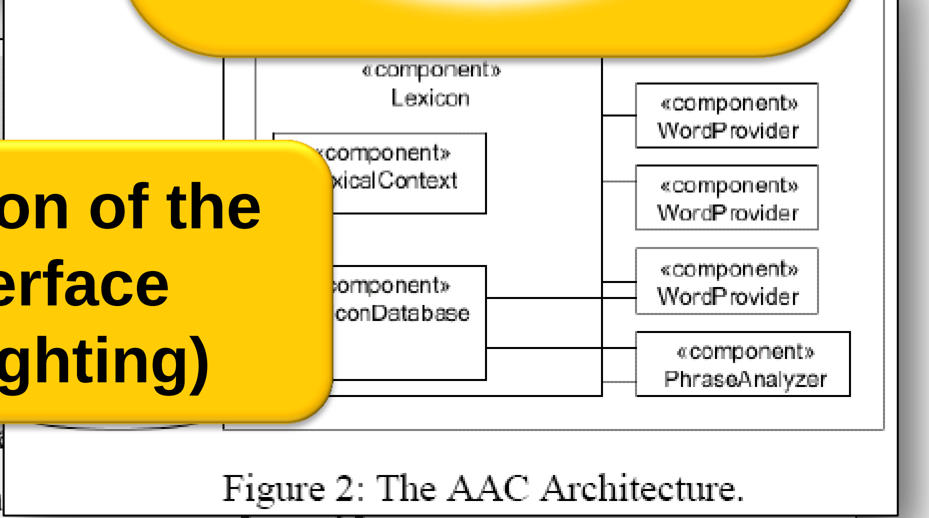


Figure 2: The AAC Architecture.

What is Context?

from Wikipedia:

- Context (computing):
  - task context - „the minimal set of data used by this task that must be saved to allow a task interruption at a given date, and a continuation of this task at the point it has been interrupted and at an arbitrary future date"

- Context awareness
  - "deal with linking changes in the environment with computer systems, which are otherwise static"

The context of an application

context context context context context context context context context context context context

The "Deyfinition"

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

An entity is a **person**, **place**, or **object** that is considered **relevant to the interaction** between a user and an application, **including the user and applications** themselves.

A system is context-aware
if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user‘s task.

A. K. Dey. Understanding and using context. Personal and Ubiquitous Computing, 5(1):4–7, 2001.

Why should I care?

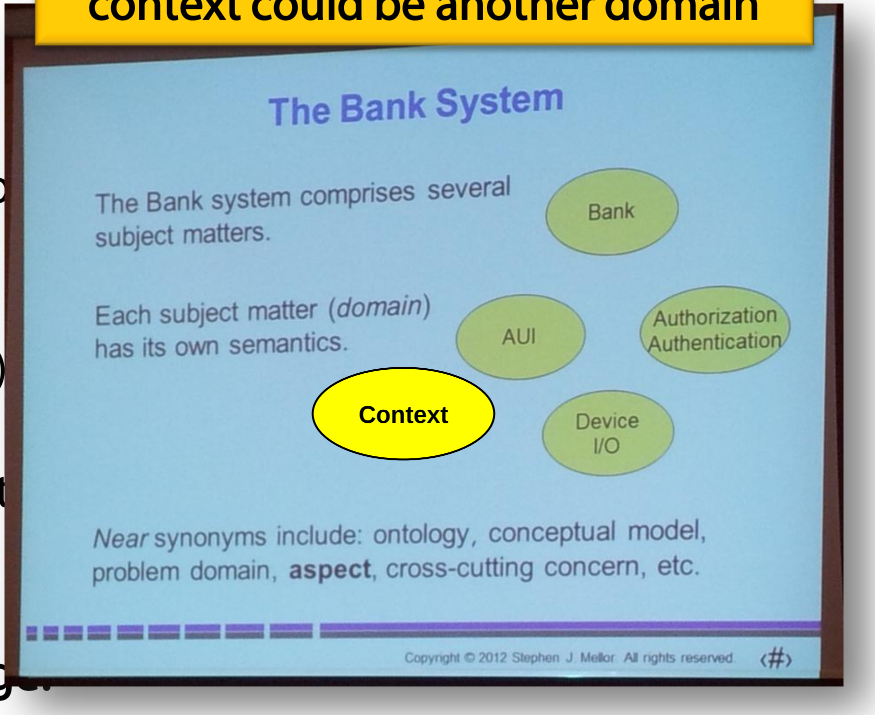
- **Context in requirements engineering:**
  during development time …
  - find out where your software is going to be used
  - find out whether it interacts with its context (does it have to be context-aware?)
  - derive additional requirements

- **Developing context-aware systems:**
  during run time …
  - software finds out what the current co
  - software adapts to context changes:
    - presentation
    - selection (of information/services)
    - action (do other things)
    - tagging (annotate information wit

→ **needs context management**

…and this is a real challeng

if you've seen Stephen's keynote: context could be another domain



The Bank System

The Bank system comprises several subject matters.

Each subject matter (*domain*) has its own semantics.

Near synonyms include: ontology, conceptual model, problem domain, **aspect**, cross-cutting concern, etc.

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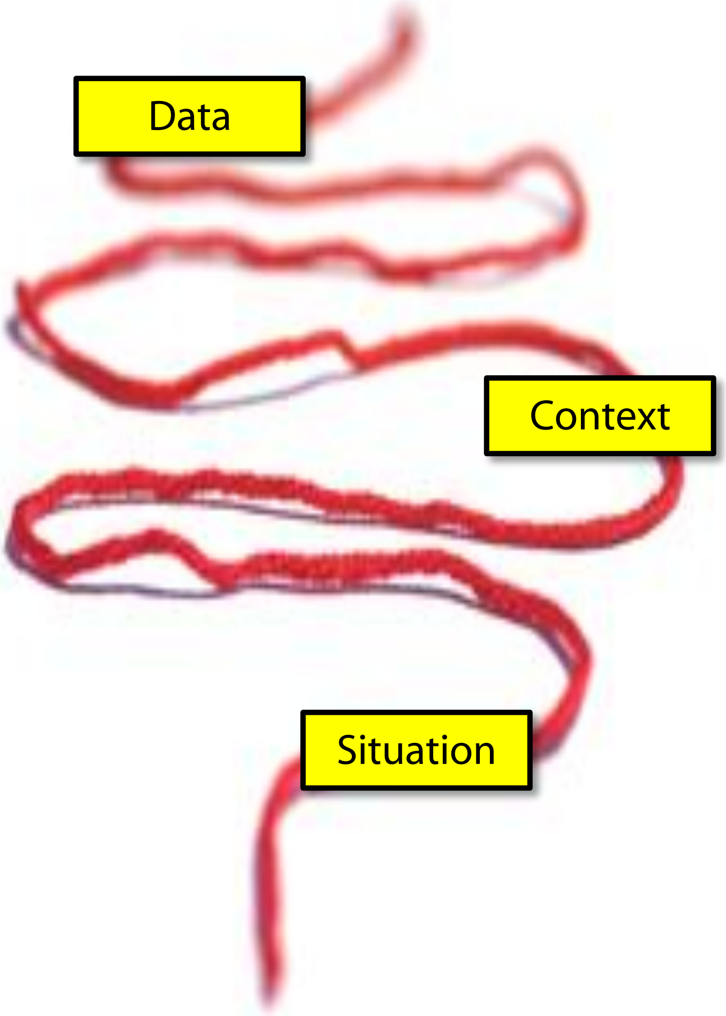
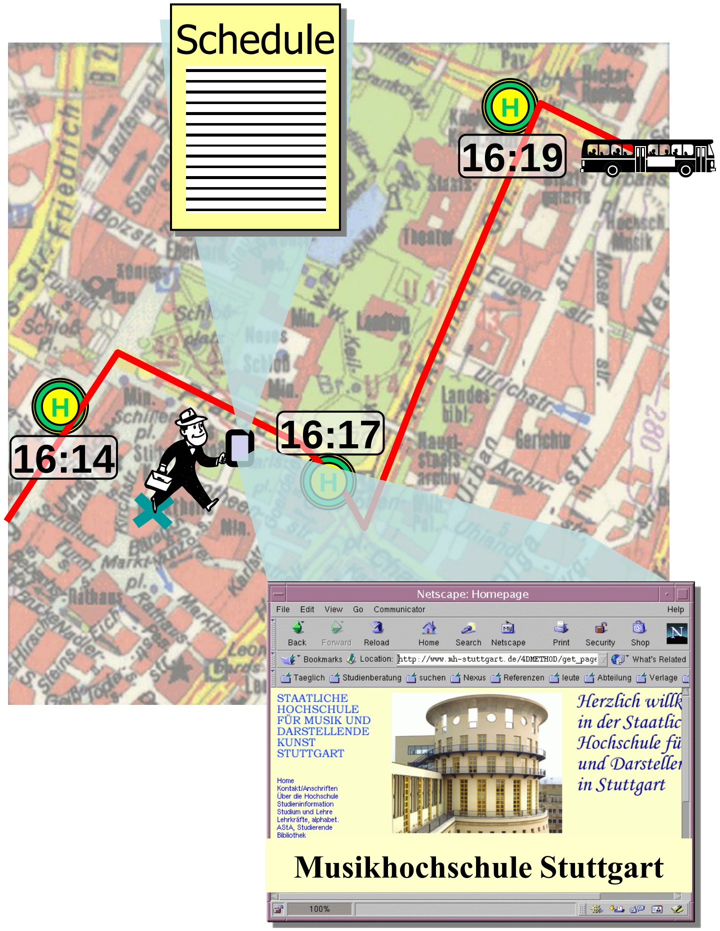
Overview

- Introduction
- Context Management
  - Characteristics of context
  - Anatomy of context-aware applications
  - Context management approaches
- Conclusion

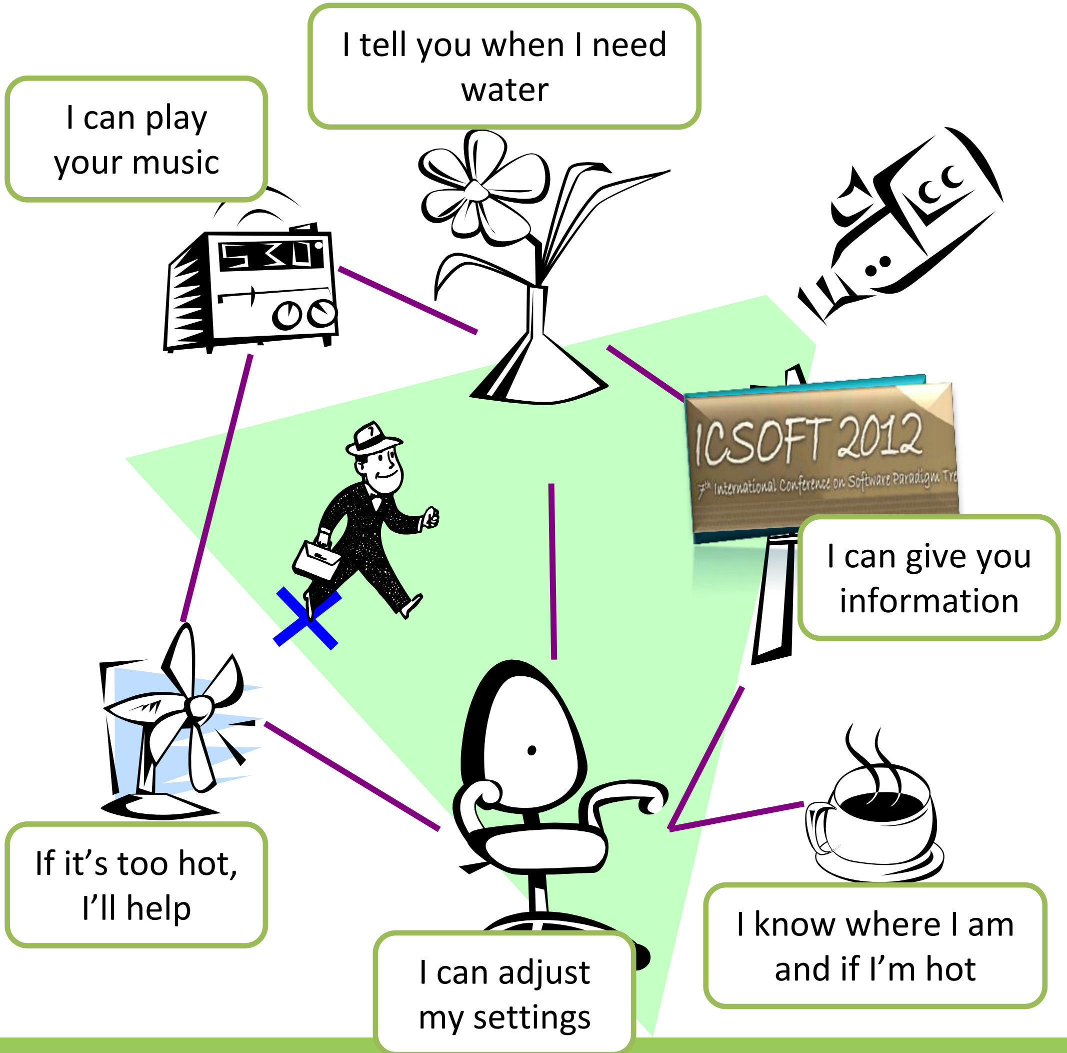


Typical Context-Aware Systems

mobile computing


Schedule
16:19
16:14
16:17
H
Netscape: Homepage
File Edit View Go Communicator Help
Back Forward Reload Home Search Netscape Print Security Shop
Bookmarks Location: http://www.mh-stuttgart.de/4DMETHOD/get_page What's Related
Taeglich Studienberatung suchen Nexus Referenzen leute Abteilung Verlage
STAATLICHE HOCHSCHULE FÜR MUSIK UND DARSTELLENDE KUNST STUTTGART
Home
Kontakt/Anschriften
Über die Hochschule
Studieninformation
Studium und Lehre
Lehrkräfte, alphabet.
AStA, Studierende
Bibliothek
Herzlich willk in der Staatlic Hochschule fü und Darsteller in Stuttgart
Musikhochschule Stuttgart
100%

"smart" environments (AKA Internet of Things)



I tell you when I need water

I can play your music

I can give you information

If it's too hot, I'll help

I can adjust my settings

I know where I am and if I'm hot

More examples … (of my current interest)

Crew

Congestion

Snow

Pedestrians

Wind

Goods

Cargo

Processes

Trucks

Safe Off-shore Operations

Traffic monitoring

Logistics

Parcels

Sea

Ships

Obstacles

Application Areas

Vessel Traffic Management

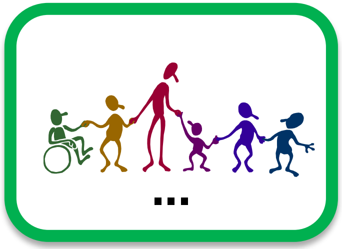
Driver assistant systems

Ground

Lanes

Products

Smart Factory



… and many more!

Cars

Workers

Machines

Roads

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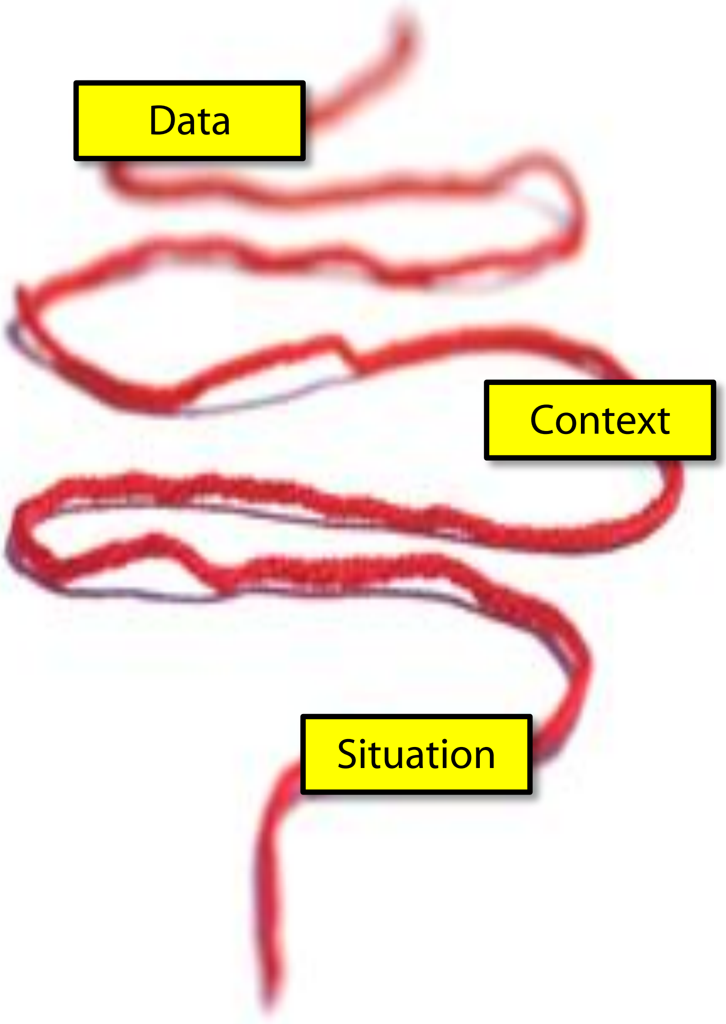
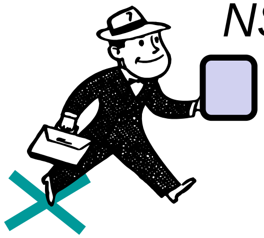
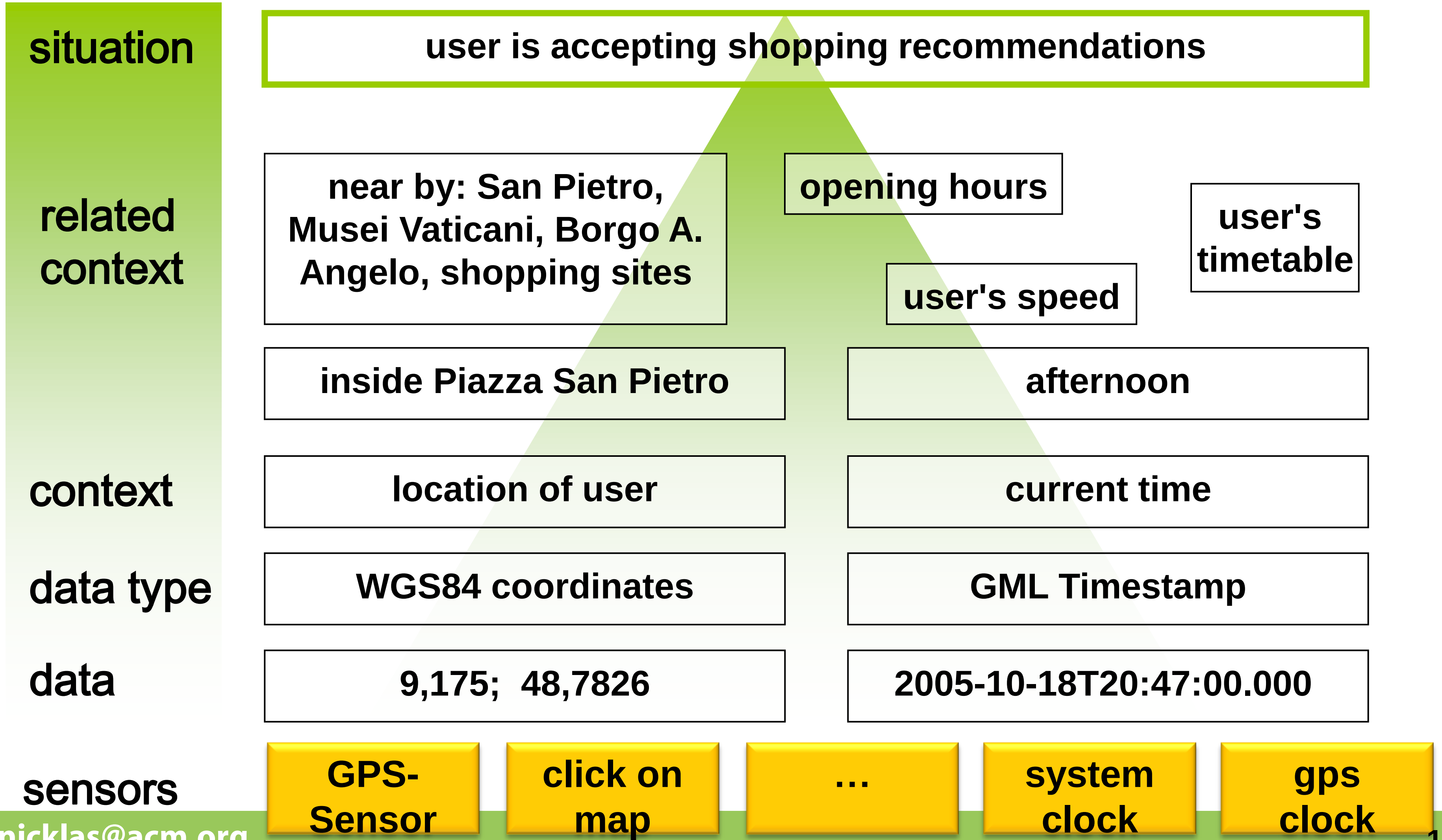


Context Management

How to get the context?



NSASG – not so annoying shopping guide



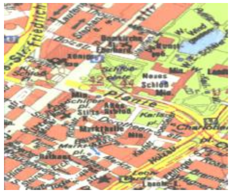
situation	user is accepting shopping recommendations	
related context	near by: San Pietro, Musei Vaticani, Borgo A. Angelo, shopping sites	opening hours user's speed user's timetable
	inside Piazza San Pietro	afternoon
context	location of user	current time
data type	WGS84 coordinates	GML Timestamp
data	9,175; 48,7826	2005-10-18T20:47:00.000

sensors

- GPS-Sensor
- click on map
- …
- system clock
- gps clock

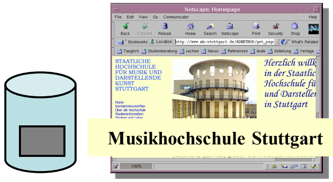
Context types

- Geographic context: map data
  - Streets, buildings, land marks, points of interest, ...
  - Data source: geographic information systems (GIS)
  - Stationary objects, rarely changing

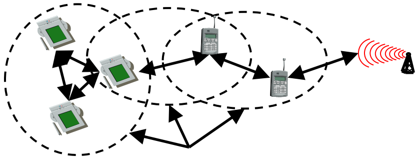


- Dynamic context: movement and change
  - Persons, vehicles,traffic situation, weather, ...
  - Data source: sensors

- Information context: digital world, "cyberspace"
  - web sites, documents, game objects, ...


Netscape: Homepage
STAATLICHE HOCHSCHULE FÜR MUSIK UND DARSTELLENDE KUNST STUTTGART
Herzlich willk in der Staatlic Hochschule fü und Darsteller in Stuttgart
Musikhochschule Stuttgart

- Technical context: infrastructure
  - access networks, topology, services (printer, projector, ...)

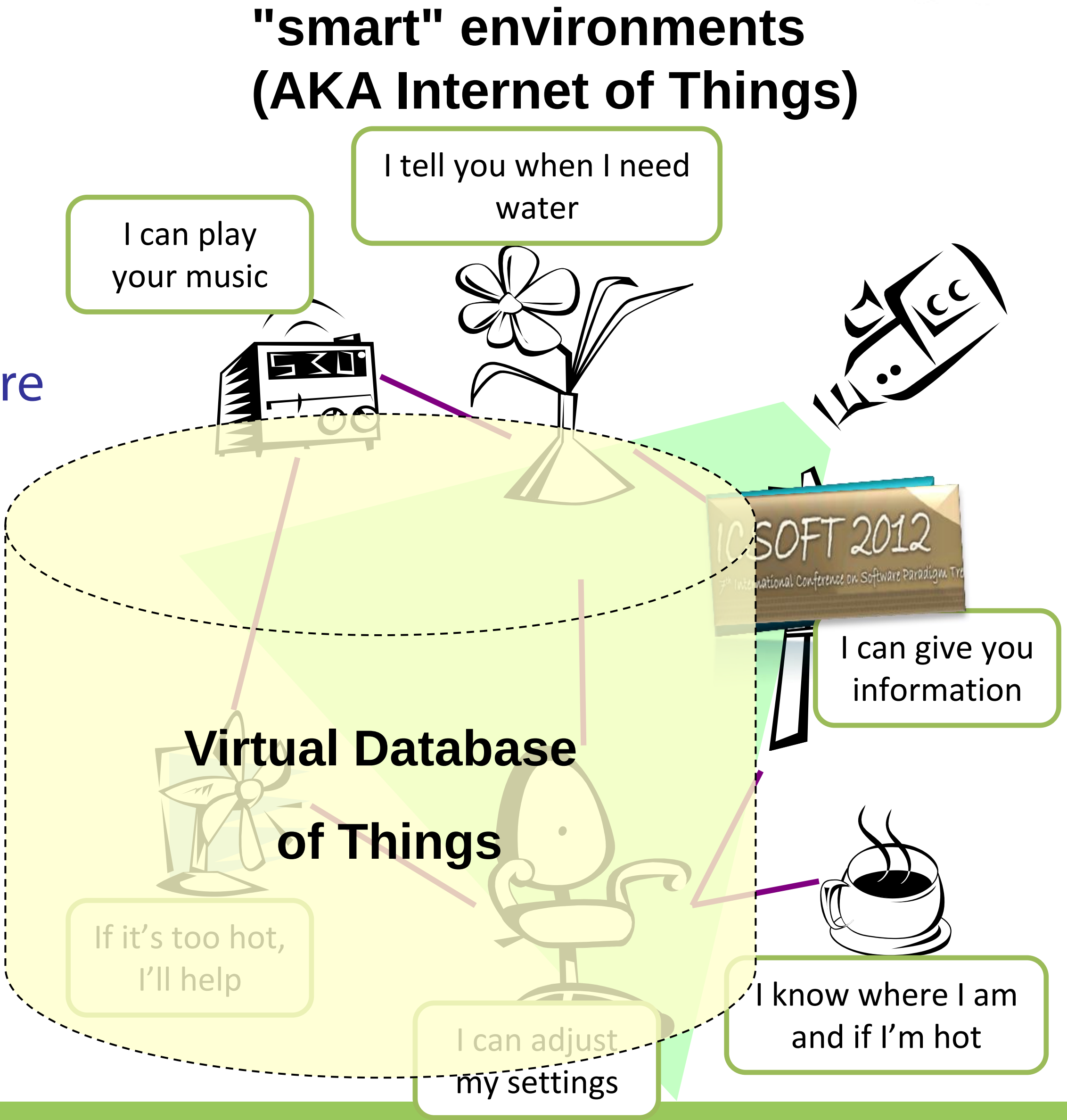


- User context
  - activities, plans, preferences
  - highly sensitive!

Context models in smart environments

Technical context:

- service discovery
- object positioning
- object identification
- integration of new hardware
- remote control of entities
- context events


"smart" environments
(AKA Internet of Things)
I tell you when I need water
I can play your music
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I can give you information
Virtual Database of Things
If it's too hot, I'll help
I can adjust my settings
I know where I am and if I'm hot

Context characteristics

- Context information is heterogeneous
  - discrete / continuous
  - multi-dimensional
  - multi-media
  - spatial
  - sensed / static / profiled / derived

- Context information differ in
  - type
  - information quality
  - temporal characteristics

Context characteristics

- Sensed Context: Low persistence
  - may be inaccurate, unknown, or stale
  - source of errors
  - sensor failures
  - network disconnections
  - delays (in communication or processing)

- Context information may differ in quality; may be
  - unknown
  - ambiguous
  - imprecise
  - erroneous

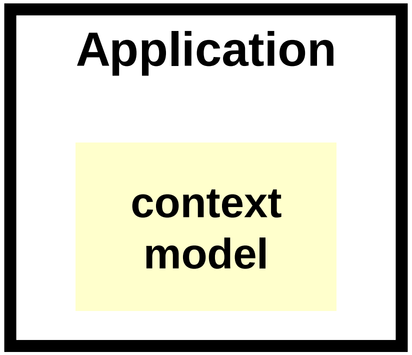
Context characteristics

- Context information needs temporal meta data
  - past state (history)
  - current state
  - future state
  - changes in state over time

- Context has various dependencies
  - physical laws
  - ownership
    - who owns devices
    - which computers have a license to run
  - particular software
  - derivation rules for derived context

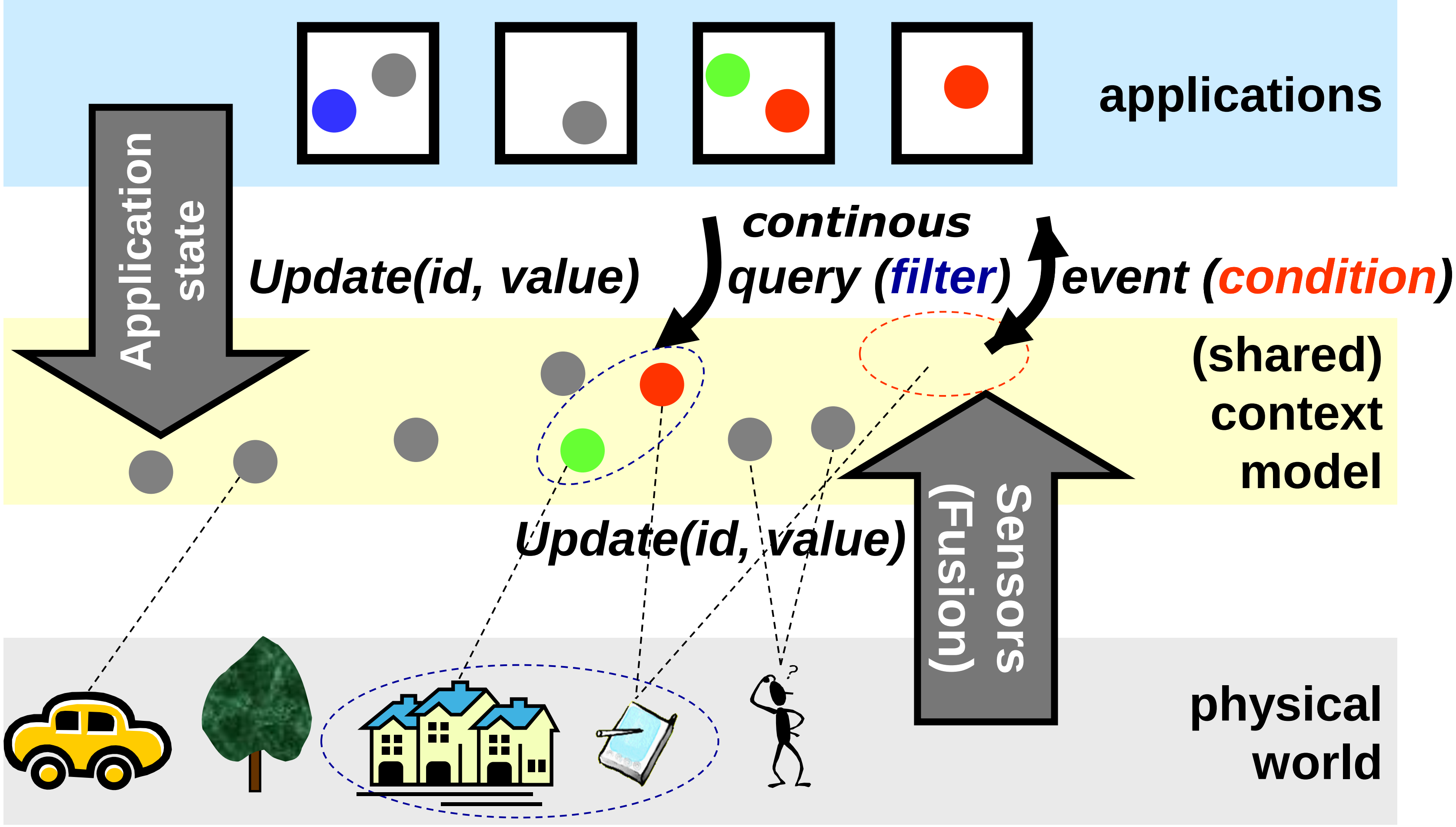
Local context model or shared

- Local context model:
  - context management for just one application
  - design of components up to the software developer, but it‘s a good idea to seperate concerns:
    - from sensors to data
    - from data to context
    - from context to situation



- Shared context model:
  - common context management for several applications
  - design of components depends on „sharability“
  - can save tremendous amount of development time if several applications work in similar/overlapping (by space / by content) contexts

Abstraction: Shared Context Model



Anatomy of a context-aware application

and „sharability“ of context information

Application-specific

Standards for aggregation methods

Easy to share

Enable domain-specific standards

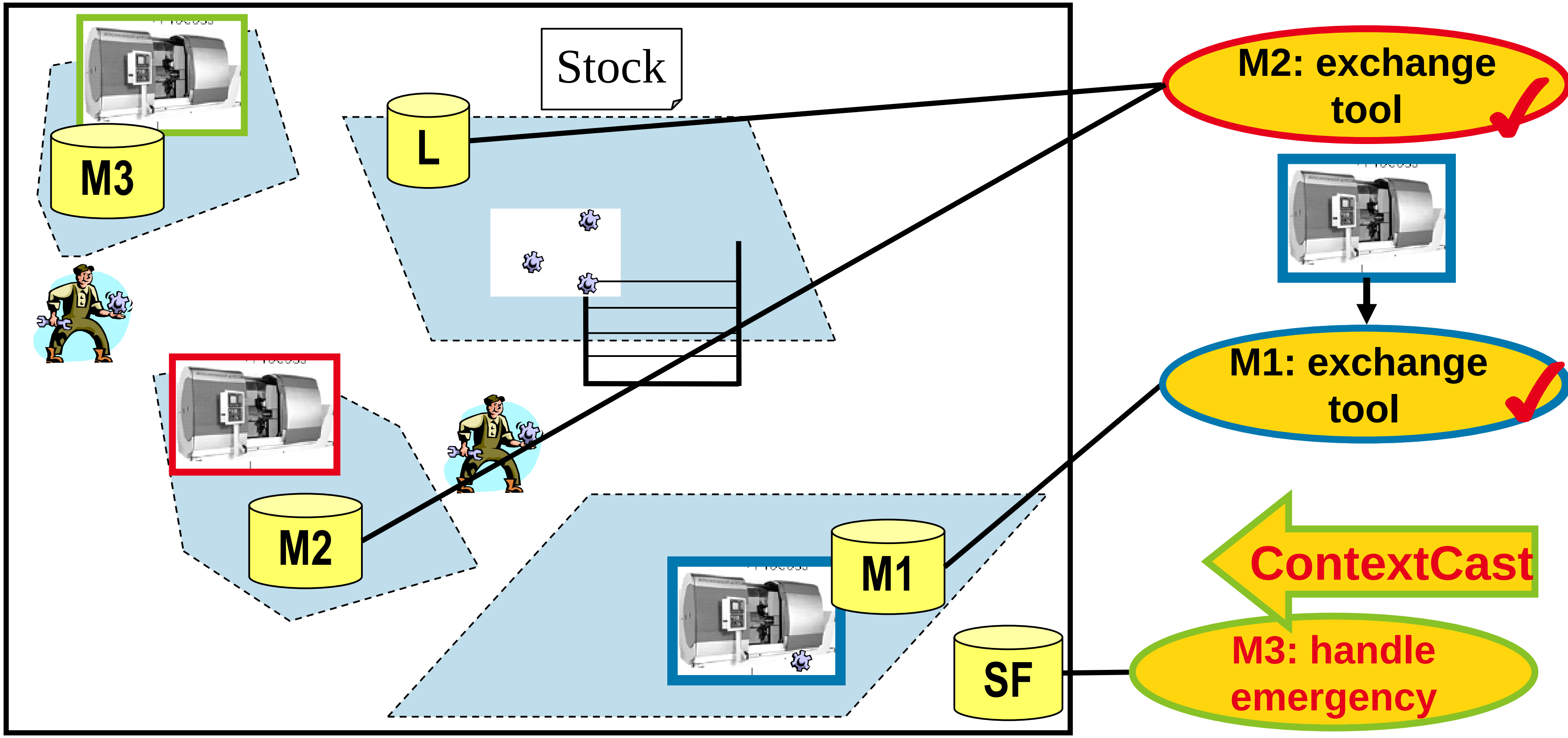
Application	what the user / **other systems / the world** see
Adaptation	how the application's behaviour changes
Situation	in what cases does adaption happen
Context	any information that can be used to characterize the situation of an entity ["Deyfinition"]
Data	data (e.g., from sensors, content) used by the system to determine context information

Example: Smart Factory

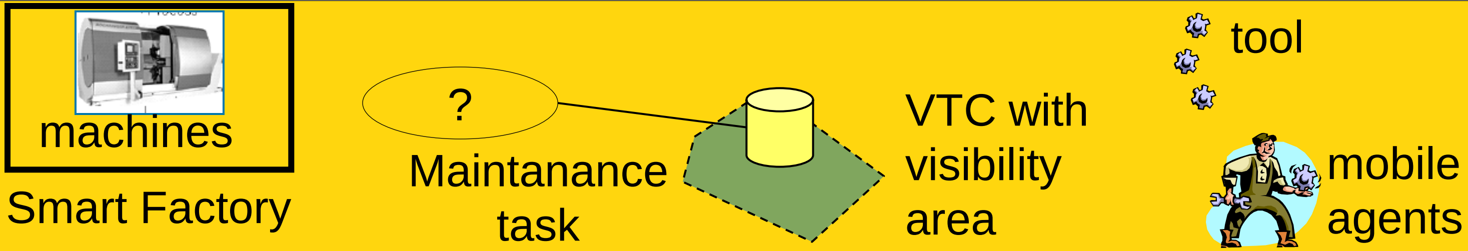
- Context-awareness in production environment
- Detailed model of Smart Factory:
  - Locations of objects:
    - machines, installations, tools, work pieces, fixtures, etc.
  - State of objects:
    - e.g., mechanical wear of tools

Westkaemper, E.; Jendoubi, L.; Eissele, M.; Ertl, T.: Smart Factory - Bridging the gap between digital planning and reality. In: Proceedings of the 38th CIRP International Seminar on Manufacturing Systems, 2005

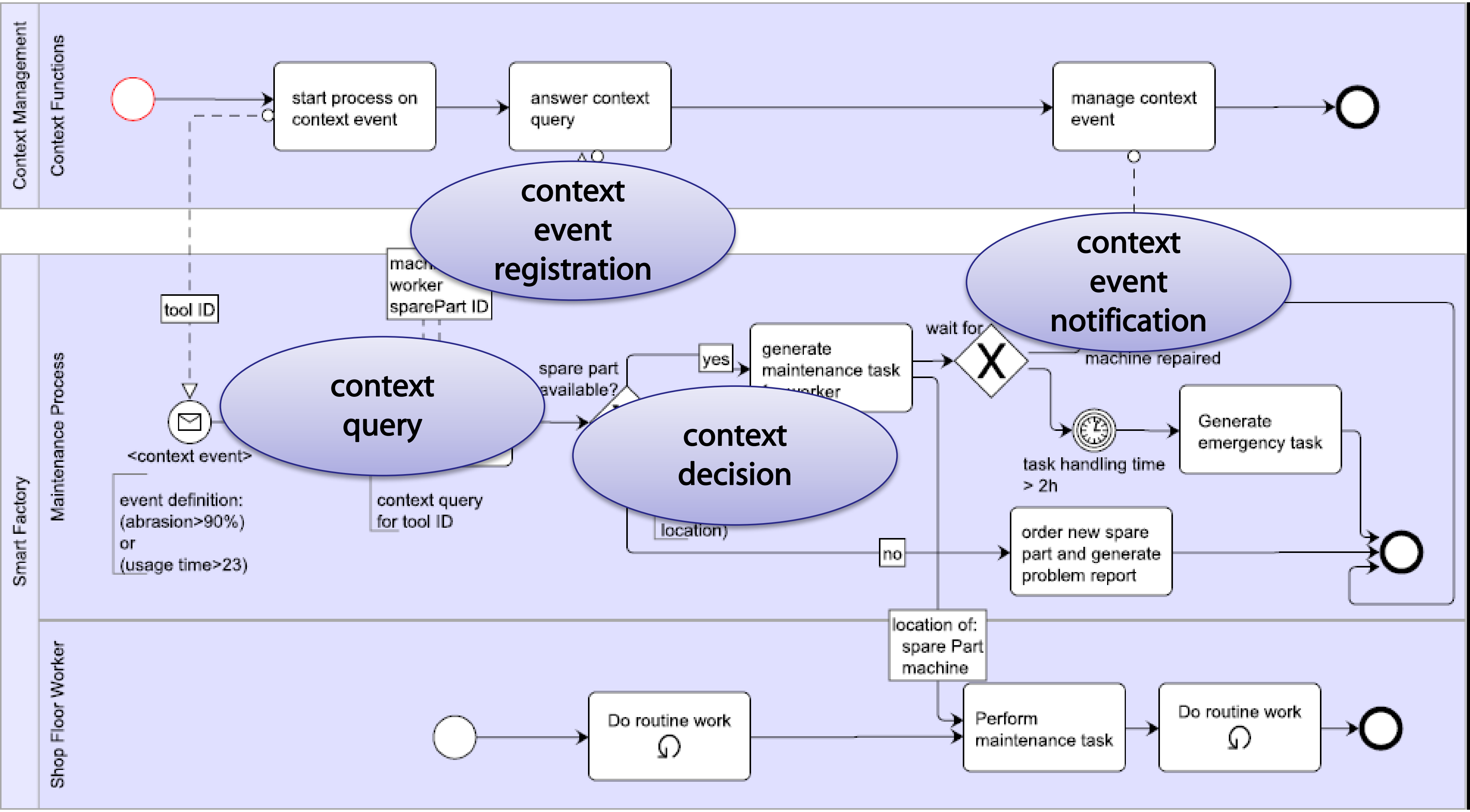
Example Smart Factory: Maintenance Process



Objects in context model



Smart Factory – Machine Maintenance Processes



context event registration

context event notification

context query

context decision

Anatomy of the Smart Factory Applications

Tasks (offered/assigend)	Application	what the user / **other systems / the world** see
Modeled in BPMN (with context extensions)	Adaptation	how the application's behaviour changes
Context events (task notifications, task state)	Situation	in what cases does adaption happen
Live digital factory	Context	any information that can be used to characterize the situation of an entity ["Deyfinition"]
Shop floor layout, locations, …	Data	data (e.g., from sensors, content) used by the system to determine context information

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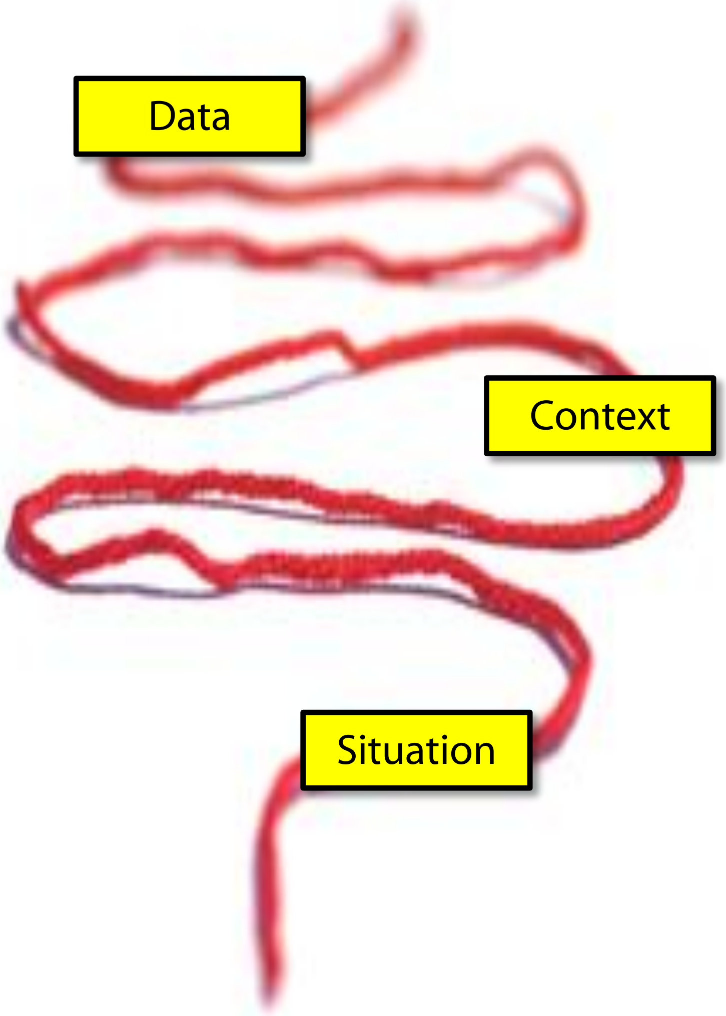


Context Modeling Approaches

- Key-Value Models
- Markup Scheme Models
- Graphical Models
- Object Oriented Models
- Logic Based Models
- Ontology Based Models
- Relational Models
- Hybrid Models

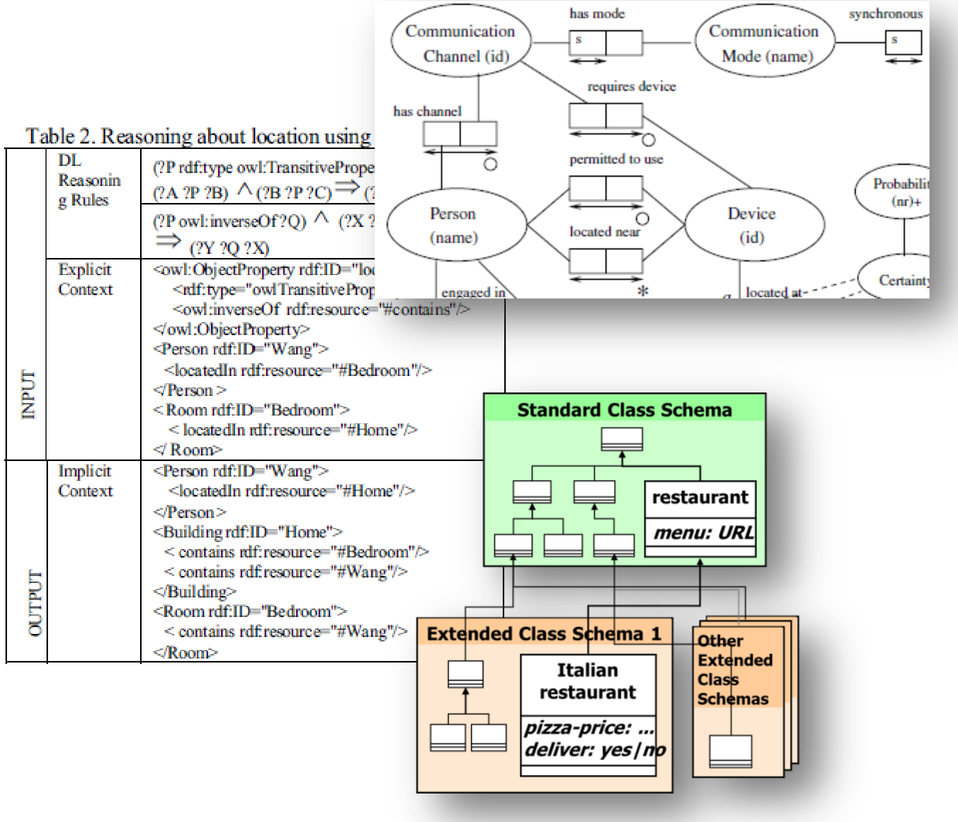


Table 2. Reasoning about location using

INPUT	DL Reasoning Rules	(?P rdf:type owl:TransitivePrope (?A ?P ?B) ∧ (?B ?P ?C) ⇒ (?
		(?P owl:inverseOf ?Q) ∧ (?X ? ⇒ (?Y ?Q ?X)
	Explicit Context	<owl:ObjectProperty rdf:ID="loc <rdf:type="owl:TransitiveProp <owl:inverseOf rdf:resource="#contains"/> </owl:ObjectProperty> <Person rdf:ID="Wang"> <locatedIn rdf:resource="#Bedroom"/> </Person > < Room rdf:ID="Bedroom"> < locatedIn rdf:resource="#Home"/> </ Room>
OUTPUT	Implicit Context	<Person rdf:ID="Wang"> <locatedIn rdf:resource="#Home"/> </Person> <Building rdf:ID="Home"> < contains rdf:resource="#Bedroom"/> < contains rdf:resource="#Wang"/> </Building> <Room rdf:ID="Bedroom"> < contains rdf:resource="#Wang"/> </Room>

… result in different management architectures

C. Bettini, O. Brdiczka, K. Henricksen, J. Indulska, D. Nicklas, A. Ranganathan, und D. Riboni, “A survey of context modelling and reasoning techniques,” *Pervasive and Mobile Computing*,

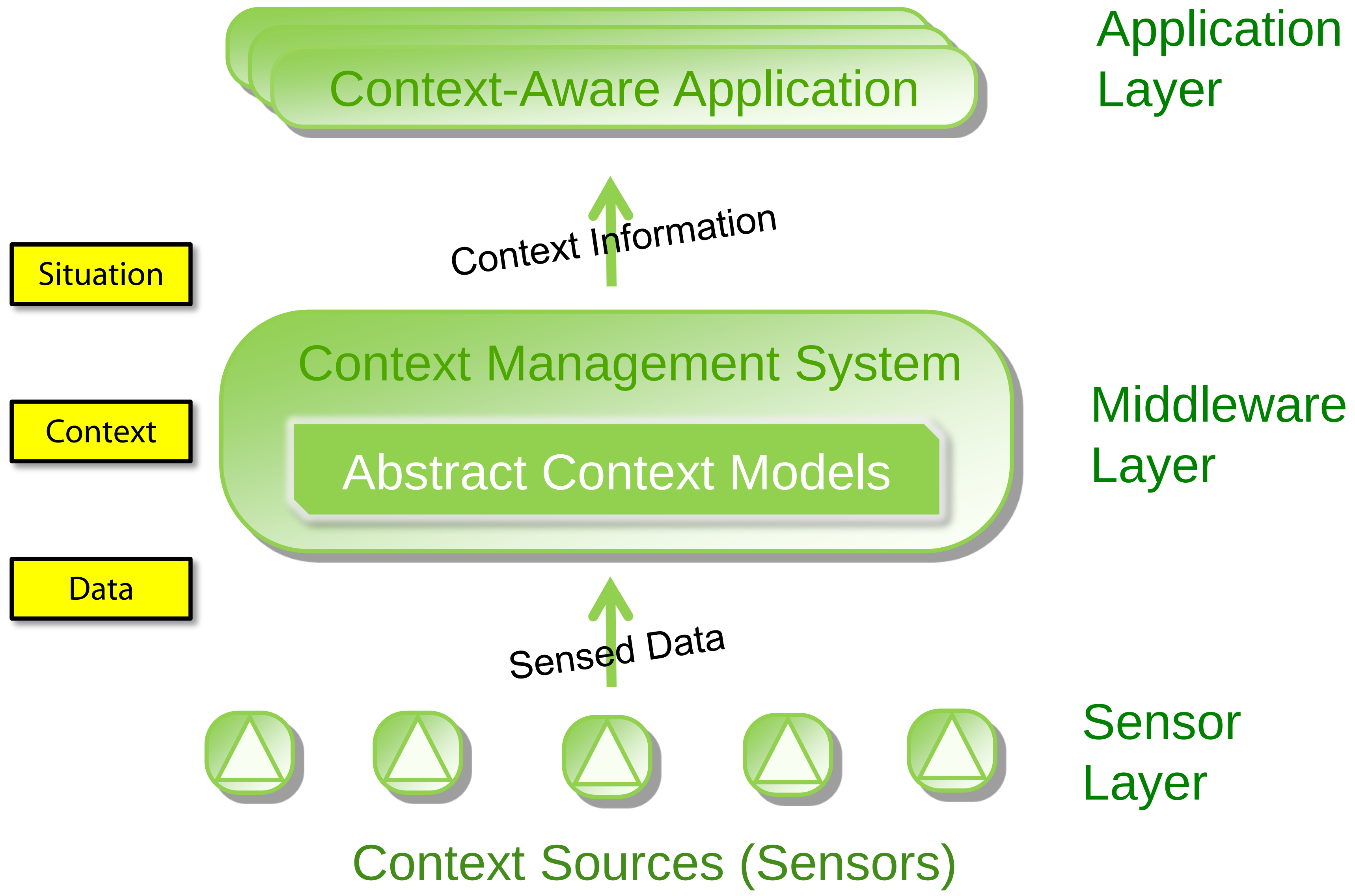
A quick round of typical Context Management Architectures

- CML (University of Queensland)
- Mileo (ISST Dortmund)
- CARE (University of Milan)
- Nexus (University of Stuttgart)

Context Management: the CML approach

- Jadwiga Indulska et al., University of Queensland / NICTA

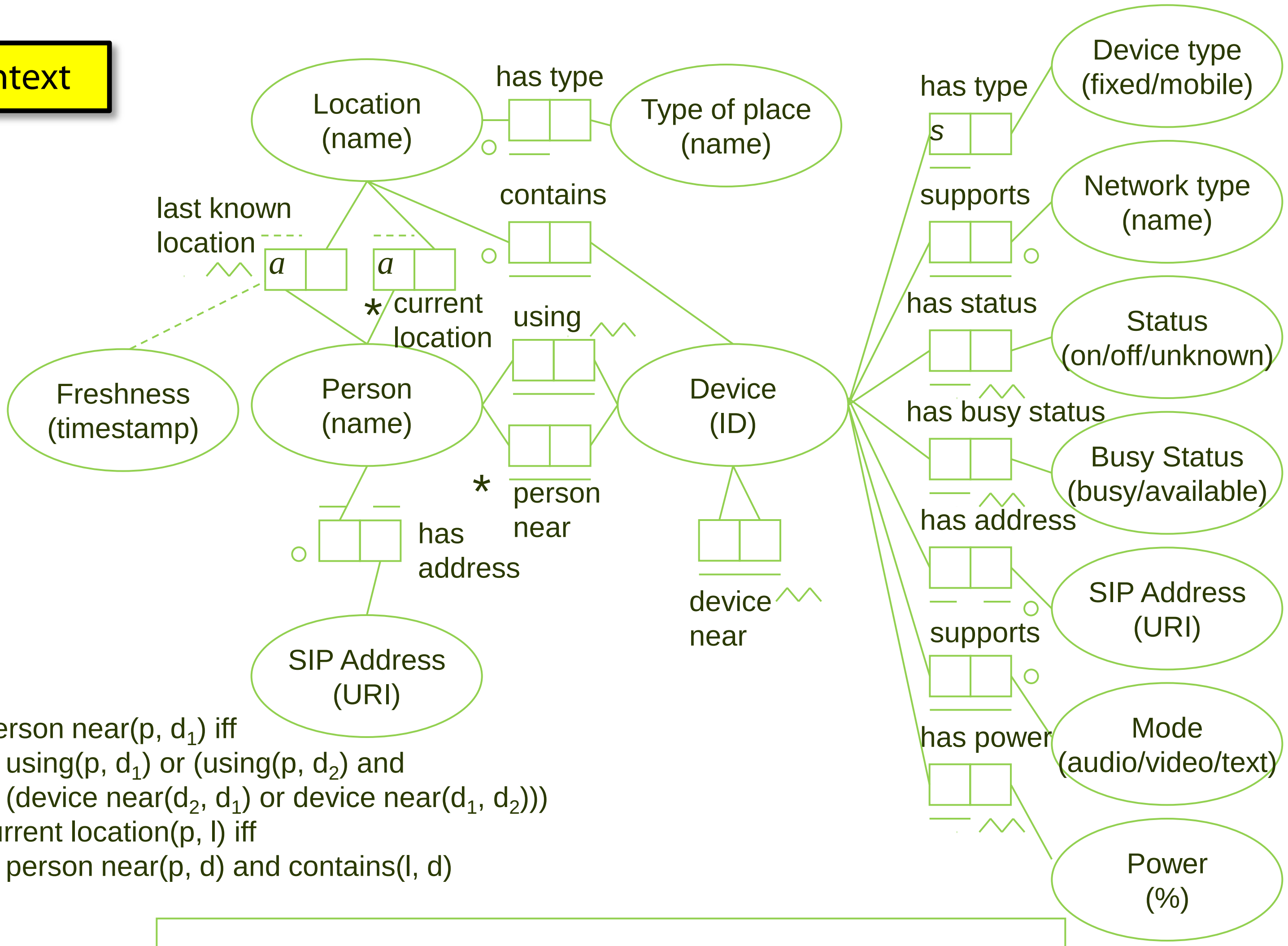
Model-Based Context-Aware Applications



Fact Modelling: Example application model

NICTA

Context

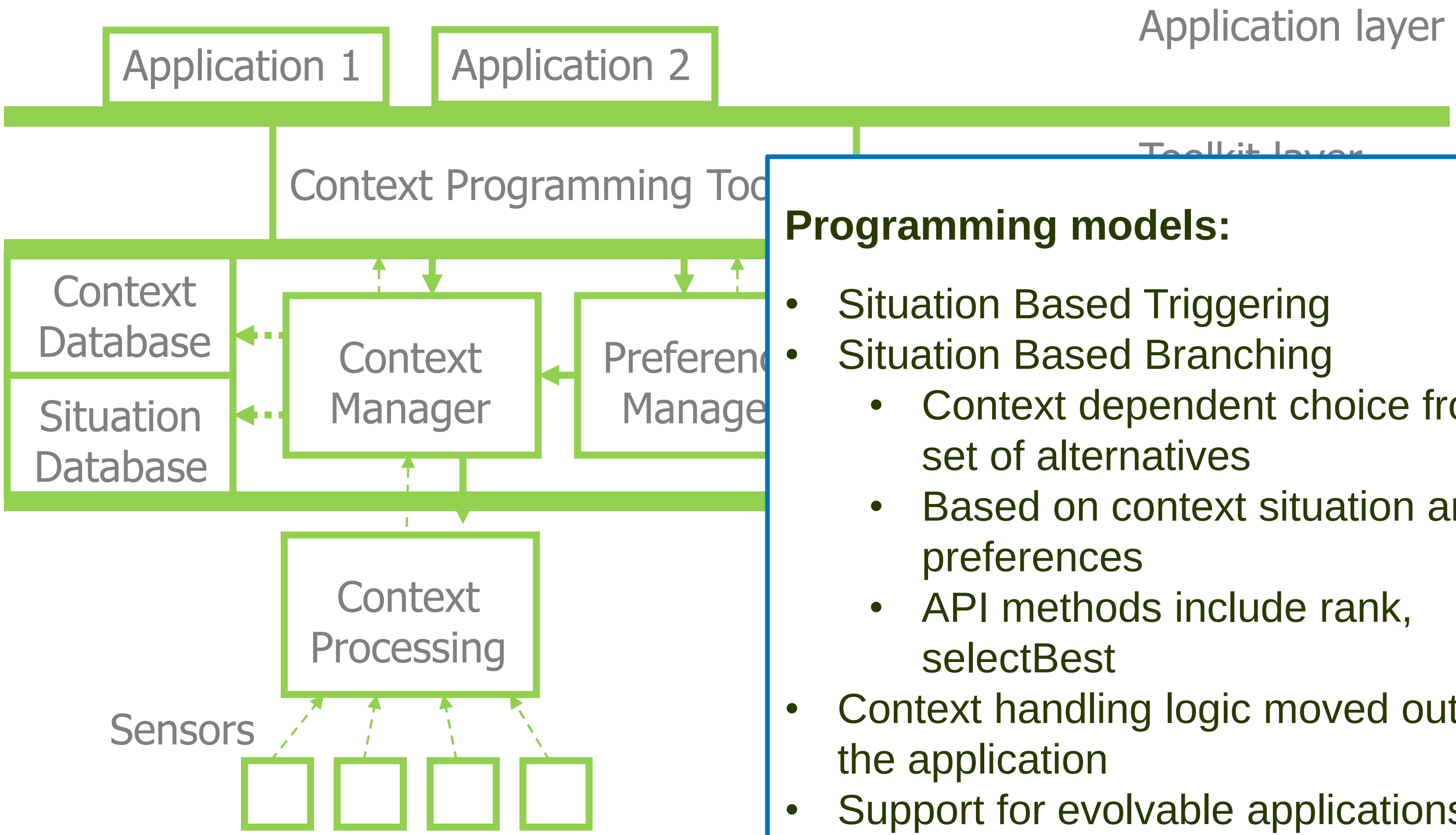


* person near(p, d_1) iff
using(p, d_1) or (using(p, d_2) and
(device near(d_2, d_1) or device near(d_1, d_2)))
current location(p, l) iff
person near(p, d) and contains(l, d)

Legend

○ Profiled information
* Derived information
⌃⌃ Sensed information
s Static information
— Uniqueness/key constraint
- - - Alternative uniqueness constraint
a Alternative fact type
- - ⬭ Quality annotation

System architecture for CML based approach



Programming models:

- Situation Based Triggering
- Situation Based Branching
  - Context dependent choice from set of alternatives
  - Based on context situation and preferences
  - API methods include rank, selectBest
- Context handling logic moved out of the application
- Support for evolvable applications

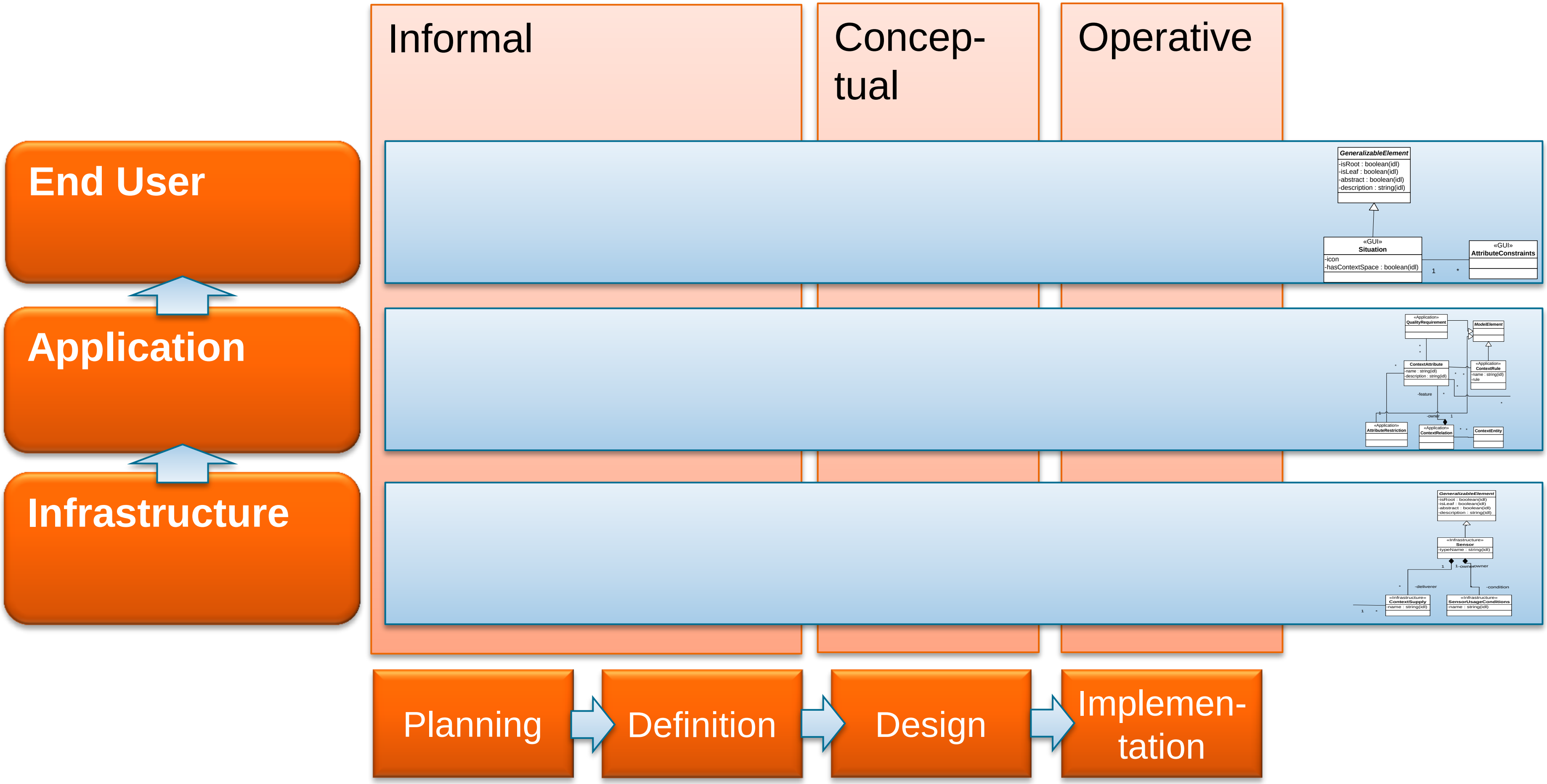
Context Management Examples: the MILEO –Context Server

Manfred Wojciechowski, Markus Wiedeler

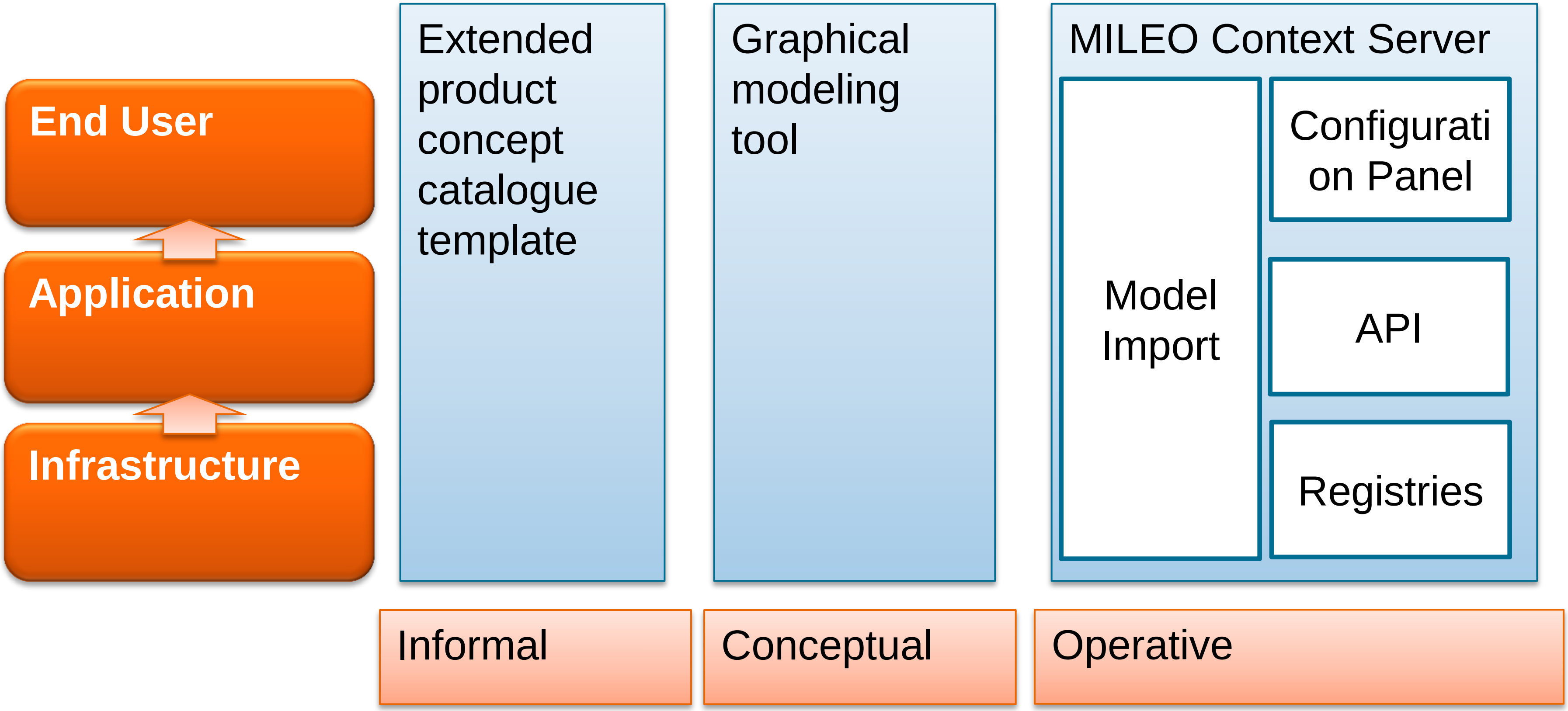
Fraunhofer Institute for Software and Systems Engineering

Approach

Context Meta-Model



Approach
Tools



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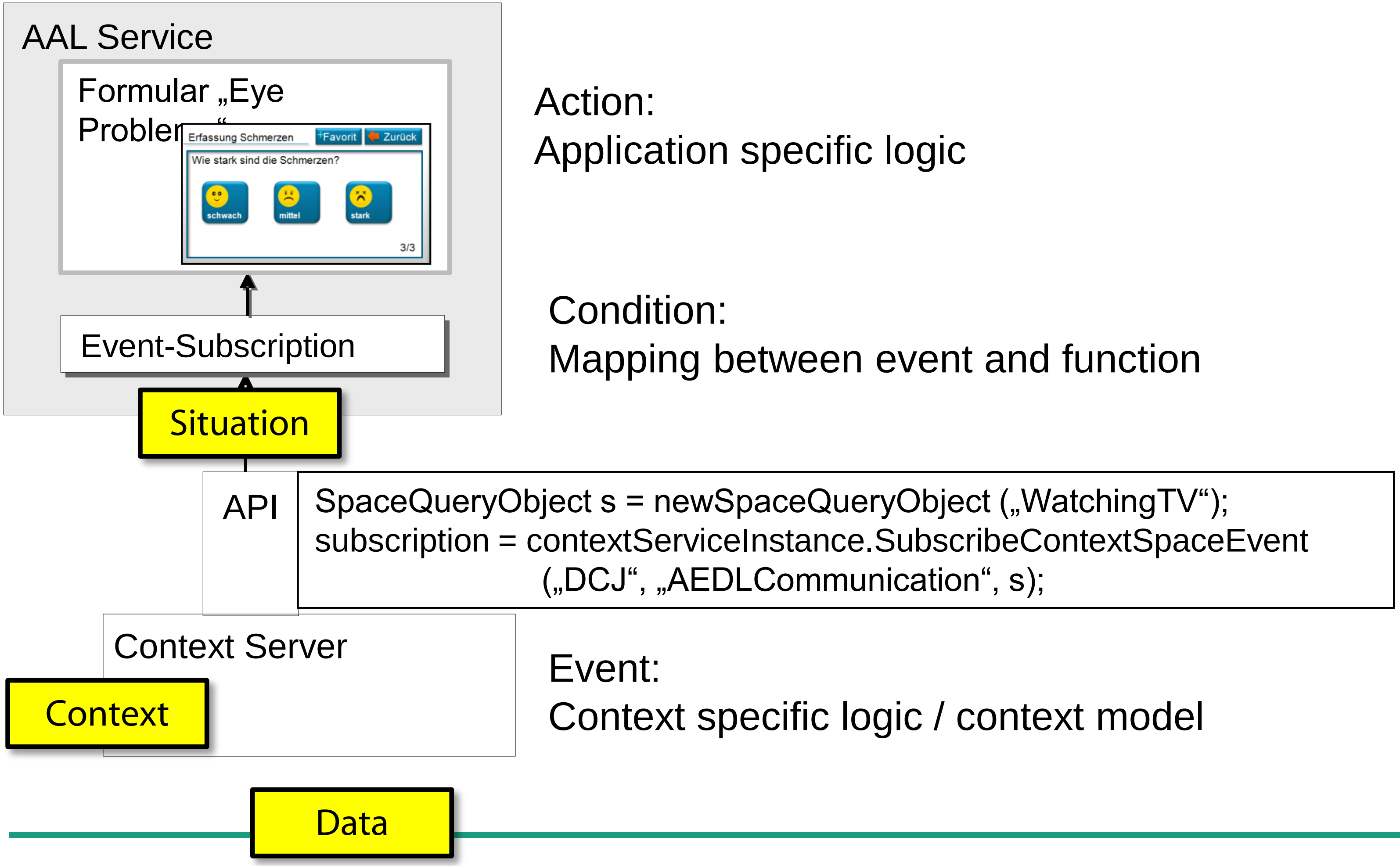
Application Example
Project ‚Daily Care Journal‘



AAL Service

Formular „Eye Problem“

Event-Subscription

Situation

API

SpaceQueryObject s = newSpaceQueryObject („WatchingTV“);
subscription = contextServiceInstance.SubscribeContextSpaceEvent
(„DCJ“, „AEDLCommunication“, s);

Context Server

Context

Data

Action:
Application specific logic

Condition:
Mapping between event and function

Event:
Context specific logic / context model

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Context Management Examples: the CARE platform

A. Agostini, C. Bettini, D. Riboni

Data, Knowledge, and Web Engineering Laboratory
University of Milan, Italy

Modeling Non-Shallow Profile Data

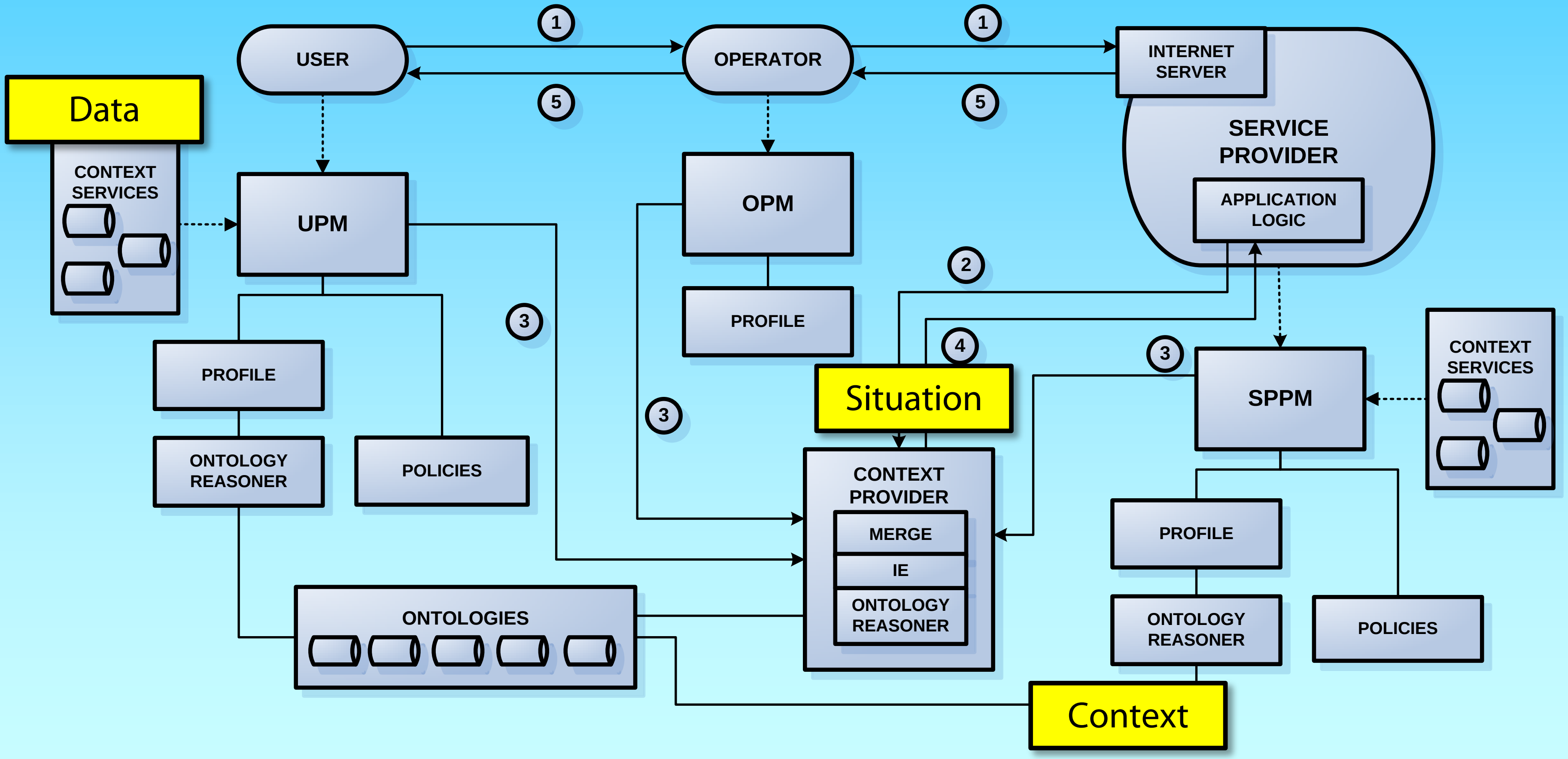
- We represent “complex” data by means of OWL-DL ontologies, to allow:
  - Knowledge sharing among involved entities
  - Consistency checking of contextual data instances
  - Reasoning to derive additional contextual data (e.g., specific activity of the user)
- Profile data are mapped into CC/PP attributes

Context

Situation

Data

Architecture overview



Context Management Example: the Nexus Platform

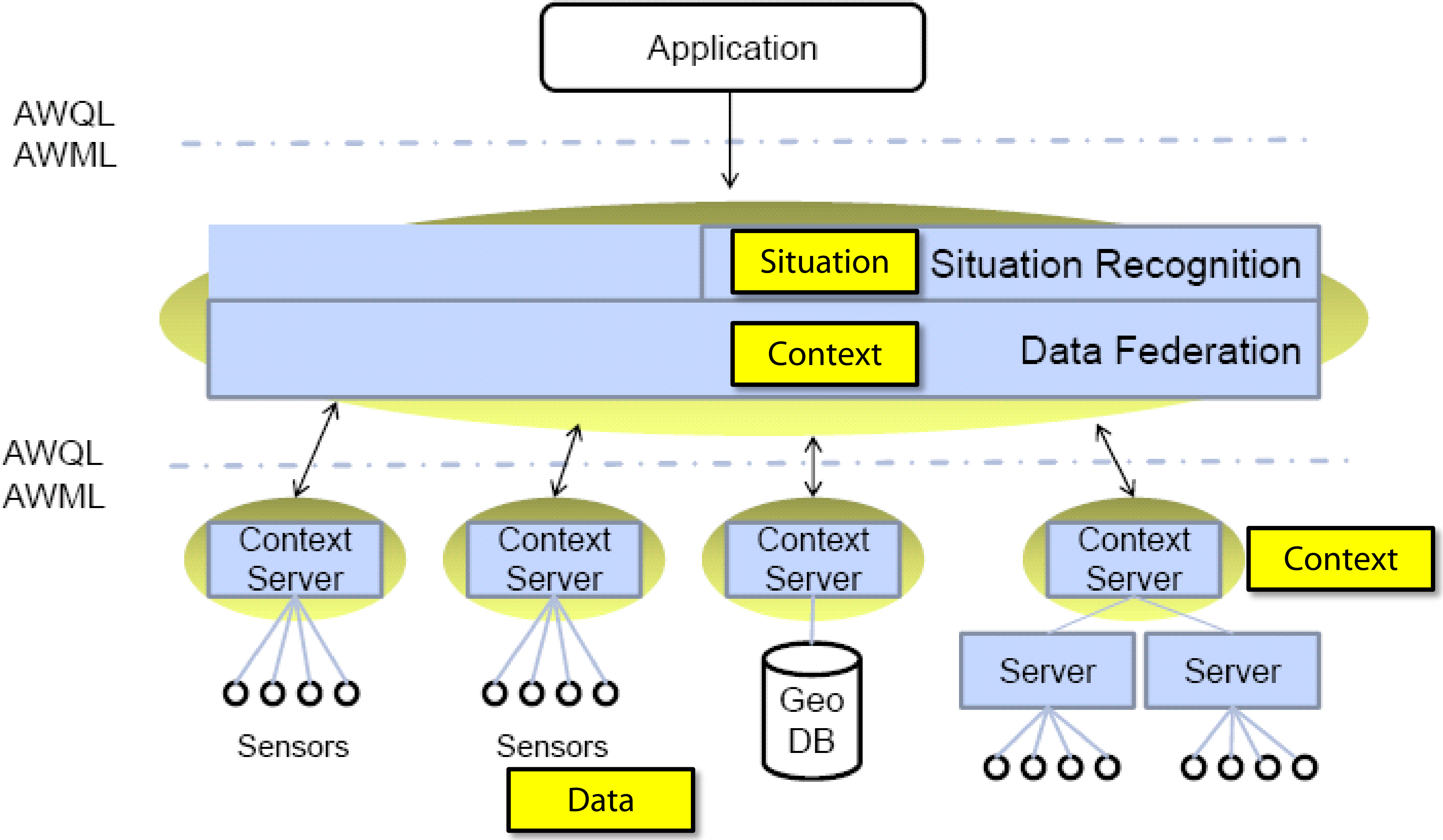
- Kurt Rothermel et al, University of Stuttgart

Context Management by Nexus

A global federation over …

- Specialized context servers:
  - For static data: spatial databases (Spatial Model Server)
  - For dynamic data: sensor platforms, main memory services, ... (ContextCube)
  - For mobile data: Location Service (copes with high update rates)
- Integrate legacy data / servers
  - Wrappers for existing context mangement (AHSS)
  - Discovery, e.g. web robots (DCbot)
- For updates: specialized event services
  - registration of spatial events
  - distributed observation
- For streamed, distributed context information: NexusDS
  - data stream management system with flexible operators

Nexus Architecture: Global Federation of Context Models



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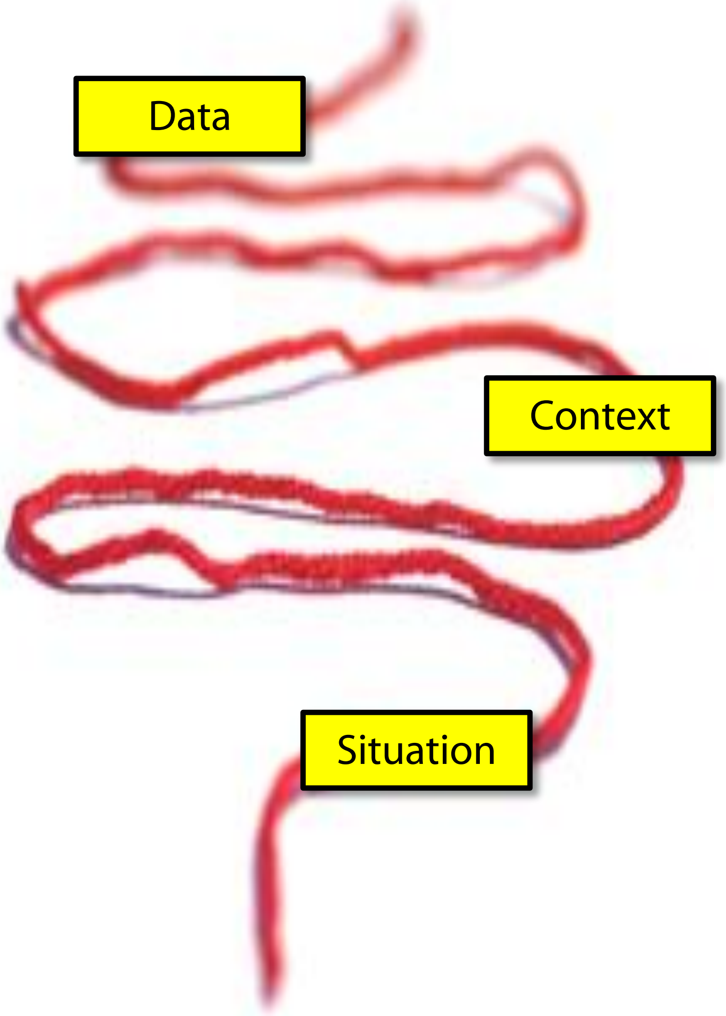

Conclusion

- To develop context-aware application, context modeling and management has to be solved first

- There has been many research in the pervasive computing community
  - however, less approaches for comprehensive software engineering approaches (see Indulska or Wojciechowski)

- The layers of data, context, and situation can help to cope with the complexity
  - develop applications that deal with (defined, named) *situations*
  - let the context management do the derivation of situations out of *context*
  - decouple from the derivation out of raw *data*

http://nexus.informatik.uni-stuttgart.de/COMOREA

CoMoRea 2013: 10th IEEE Workshop on Context Modeling and Reasoning

San Diego, California, March 18-22, 2013

Thank you!

textcontext context context context context context context
context context context context

and also thanks to …

Bruno Antunes, Jadwiga Indulska, Daniele Riboni, Matthias Wieland, Manfred Wojciechowski for ideas and slides