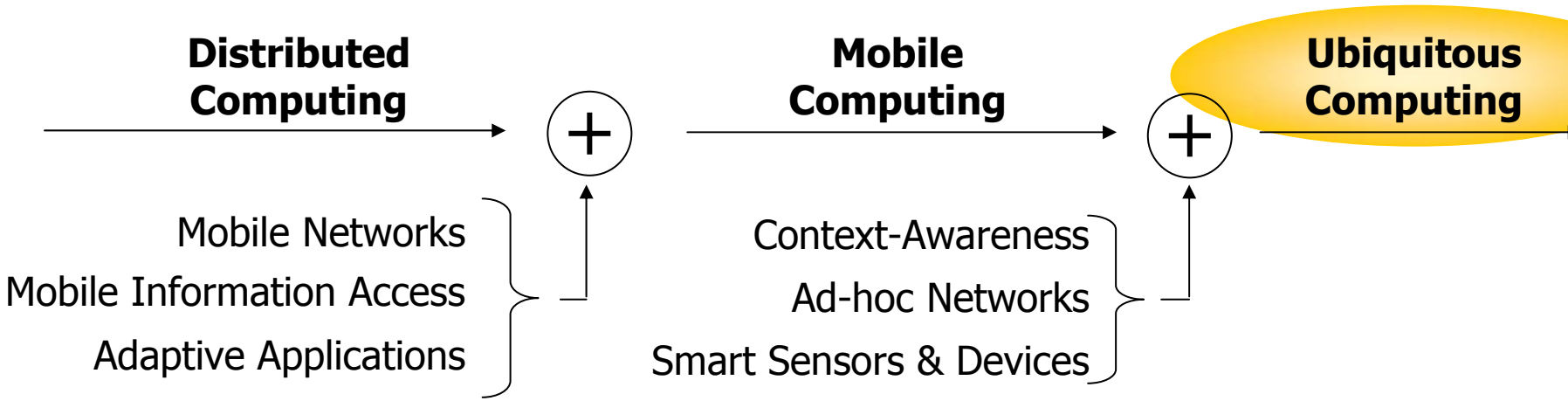
A Context Modeling Survey

Thomas Strang <thomas.strang@dlr.de>
Claudia Linnhoff-Popien <linnhoff@ifi.lmu.de>

UbiComp Evolution Chain

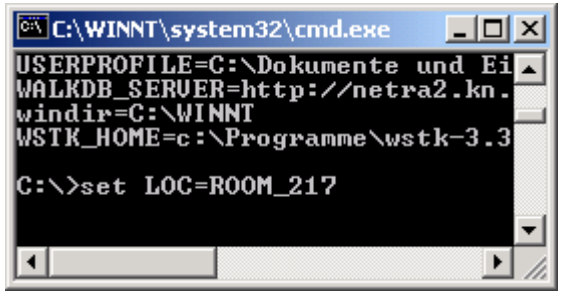


Context

- Two main benefits from Context-Awareness for Mobile Services:
  - **Adaptation to changes in environment without user interaction**
  - **Effective information filter (typical mobile devices have limited UI!)**
- *Location-Awareness* is special kind of Context-Awareness.
- Typical Context Modeling & Integration Requirements for UbiComp:
  - high level of formality
  - distributed composition
  - partial validation
  - incompleteness
  - quality of information
  - applicability to existing service frameworks

Context Modeling Approaches (1/3)

- Key-Value-Pairs Models
  - most simple category of models
  - not very efficient for more sophisticated structuring purposes
  - exact matching, no inheritance



Environment Variables: Key-Value-Pairs

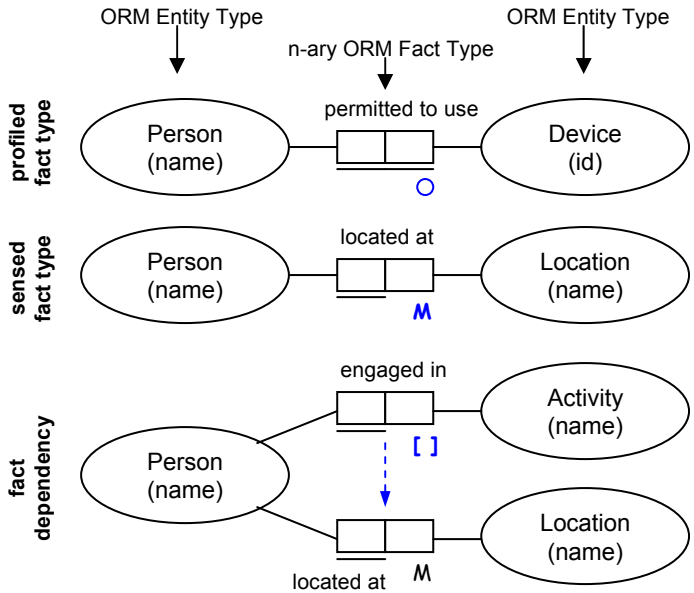
- Markup Scheme Models
  - scheme implements model
  - typical representatives: *profiles*
  - Examples:
    - Extensions of
      - Composite Capabilities/Preference Profile (CC/PP)
      - User Agent Profile (UAProf)
    - Comprehensive Structured Context Profiles (CSCP)
    - Pervasive Profile Description Language (PPDL)
    - Centaurus Capability Markup Language (CCML)

```
<?xml version="1.0"?>
<rdf:RDF
  xmlns:rdf = "http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:cscp  = "http://example.org/CSCPProfileSyntax#"
  xmlns = "http://example.org/SessionProfileSyntax#"
  xmlns:dev = "http://example.org/DeviceProfileSyntax#"
  xmlns:net = "http://example.org/NetworkProfileSyntax#">
  <SessionProfile rdf:ID="Session">
    <cscp:defaults rdf:resource=
      "http://localSessionContext/CSCPProfile/previous#Session"/>
    <device><dev:DeviceProfile>
      <dev:hardware><dev:Hardware>
        <dev:memory>9216</dev:memory>
      </dev:Hardware></dev:hardware>
    </dev:DeviceProfile></device>
  </SessionProfile>
</rdf:RDF>
```

CSCP Instance based on RDF

Context Modeling Approaches (2/3)

- Graphical Models
  - particularly useful for structuring, but usually not used on instance level
  - Examples:
    - Well known: *UML*
    - *Contextual Extended ORM*



Contextual Extended ORM

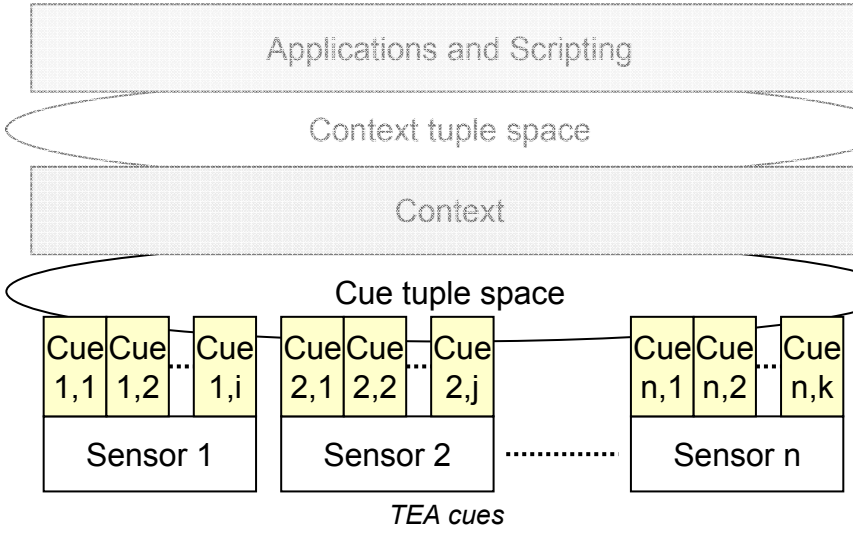
- Logic Based Models
  - Logic defines conditions on which a concluding expression or fact may be derived from a set of other expressions or facts (reasoning)
    → context is defined as facts, expressions and rules
  - High degree of formality
  - Examples:
    - McCarthy's *Formalizing Context*
    - Akman&Surav's *Extended Situation Theory*

$$S_1 = [\dot{s} \mid \dot{s} \models\!\!\ll bird, \dot{a}, 1 \gg]$$
$$S_2 = [\dot{s} \mid \dot{s} \models\!\!\ll flies, \dot{a}, 1 \gg]$$
$$B \models\!\!\ll present, air, 1 \gg \wedge \ll penguin, \dot{a}, 0 \gg \wedge \ldots$$
$$C = S_1 \Rightarrow S_2 \mid B$$

Context Expression from Extended Situation Theory

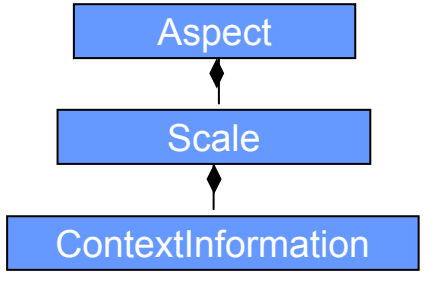
Context Modeling Approaches (3/3)

- Object Oriented Models
  - Intention behind object orientation is (as always) encapsulation and reusability
  - Examples:
    - *Cues* (TEA project)
    - *Active Object Model* (GUIDE project)



TEA cues

- Ontology Based Models
  - Ontology used as explicit specification of a shared conceptualization
    → strong in the field of normalization and formaliy
  - Context is modelled as concepts and facts
  - Examples:
    - CoBrA system
    - ASC model of Context Ontology Language (CoOL)
    - CONON ontology



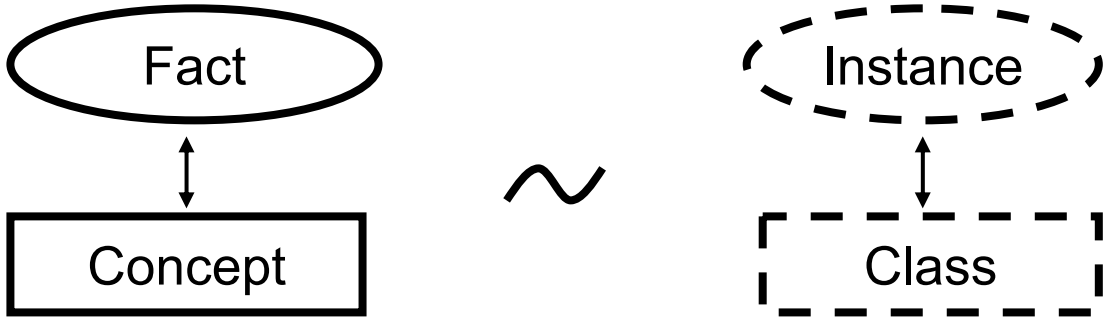
ASC Model of CoOL

Context Retrieval

Modeling Approach	Standard Retrieval Method
Key-Value-Pairs Models	Linear Search
Markup Scheme Models	Markup Query Language
Graphical Models	Transformation
Logic Based Models	Inferencing
Object Oriented Models	Algorithm
Ontology Based Models	Reasoning

Excursion: Ontologies & Uncertainty (1/2)

"An ontology is a hierarchically structured set of terms for describing a domain that can be used as a skeletal foundation for a knowledge base."
by Swartout, Patil, Knight and Russ, 1996



Important distinguishing feature: Ontologies are **property oriented**.

Father/son conversation:

„Dad, is a ferrari a red car with a little horse on it?"
„That's correct, son, why?"
„I think it is passing us just now!"

Excursion: Ontologies & Uncertainty (2/2)

Property orientation allows for „fuzzy“ context reasoning!

Summary & Conclusion

- Several different context modeling approaches exist
  - different characteristics for different requirements
- Classification by scheme of data structure is sometimes ambiguous
  - assignment in this overview according relevance for UbiComp
  - may help to identify appropriate approach for UbiComp apps
- This list of context modeling approaches is comprehensive, but - as in all surveys - incomplete

Thank you!