Context Modeling

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Peratham Wiriyathammabhum
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Fig. 1. Five Fundamental Categories for Context Information
A Data-oriented Survey of Context Models

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In brief

• A comparison of context models with respect to a given target application - metric
  • With the stress on analysis of features
  • 2 folds
    • General framework analysis
    • Up-to-date comparison
A Data-oriented Survey of Context Models

- **Introduction**
  - Context definition and context-aware applications
  - AI and context modeling
  - High-level architecture of a context-aware system
  - Context-based data tailoring

- **The Analysis Framework**
  - Model aspect
  - Representation features
  - Context management and usage

- **The Context Models**
1. Introduction

• Context definition and context-aware applications
• AI and context modeling
• High-level architecture of a context-aware system
• Context-based data tailoring
Context definition and context-aware applications

• Context
  • Not just a profile but an active process dealing with the way humans weave their experience within their whole environment, to give it meaning.
  • Not just a state but part of a process where users are involved.

• General context models support context-aware applications
  • Adapt interfaces
  • Tailor the set of application-relevant data
  • Increase the precision of information retrieval
  • Discover services
  • Make the user interaction implicit
  • Build smart environments
Ex. Automated support for a natural history museums visitors

- Adapting the UI to the **different abilities of the visitor**
  - Low-sighted people to a very young children

- Providing different information contents based on the **different interests/profiles of the visitor** and on **the room the visitor is currently in**

- Learning from the **visitor previous choice**. Try to predict which room the visitor is likely to visit next

- Providing the visitor with **appropriate services**
  - Purchase a ticket for a temporary exhibition to reserve a seat for the next in-door show

- Deriving **location information** from sensors which monitor the user environment

- Provide **active features** within the various areas of the museum, which **alert visitors with hints and stimuli on what is going on** in each particular ambient.
AI and context modeling

- AI goal – context reasoning
  - Propositional logic
  - MultiContext System/Local Models Semantics
    - Linking multimodal knowledge sources
  - Semantic Web
- Require a different approach
High-level architecture of a context-aware system

Modelling the elements that affect the knowledge/service/actions that have to be made available to the user at run-time when a context become available.

Context = Input/Output Switch

What portion of the entire information is relevant wrt. The ambient condition

Figure 1: A context-aware system architecture
Context-based data tailoring

• Defining **data views** based on
  • the **identification of the various contexts** the application user is going to experience in the envisaged scenario
  • The **design of a set of data views** for each of the identified contexts.

• Filter the **relevant portion of data** in order to
  • provide the user with the **appropriately tailored set of data**
  • match devices’ **physical constraints**
  • operate on a **manageable amount of data** (for improving query processing efficiency)
  • provide the user with **time- and location-relevant data** (mobile applications).
2. The Analysis Framework

• Define a set of **objectives** for comparison of which context model will be best suited with the goal
  • Model aspect
  • Representation features
  • Context management and usage

• Assume that the system designer follows 2 steps
  • **Identification of the key issues or features** for the application being developed – data tailoring (section 2)
  • **Select the best model** from the classification of the existing context models with respect to each feature based on step 1 (section 3)
Model aspect

- The set of context dimensions managed by the model.
  - Space
    - Location
  - Time
    - Temporal
  - Absolute/relative space and time
    - +? GMT, last month, near ?
  - Context history
    - Context depends on the previous context or just the current snapshot
  - Subject
    - The user itself
  - User profile
    - Preference, profile, role
Representation features

• General characteristics of the model itself.
  • Type of formalism
    • Key-value, XML, logic, graph, ontology
  • Level of formality
    • Definition formalize the intuition
  • Flexibility
    • Adapt to different contexts, not application bounded
• Variable Context Granularity
  • Different levels of details
• Valid Context Constraints
  • Semantic constraints specific to the application
Context management and usage

• The way the context is built, managed and exploited.
  • Context construction
    • Context description: design time/runtime
  • Context reasoning
    • Inference
  • Context information quality monitoring
    • E.g. sensors
  • Ambiguity and incompleteness management
    • Disambiguation
  • Automatic Learning Features
    • Learn user preference
  • Multi-Context Modeling
    • One model, all context
5 classes of uses / features grouping

• Context as a matter of
  • channel-device-presentation
  • location and environment
  • user activity
  • agreement and sharing (among groups of peers)
  • selecting relevant data, functionalities and services (data or functionality tailoring).
3. The Context Models

• Systems and supported features
  • See the table in the next slide ➔
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Conclusion

• Still no ‘one context model system for all’
• The solution is based on application, no common solution
• define context | task → create data views
Modeling context in pervasive computing systems

Karen Henricksen, Jadwiga Indulska, and Andry Rakotonirainy
In brief

- The development of appropriate context modeling concepts for pervasive computing, which can form the basis for such a context management infrastructure - concepts
  - Overcomes problems associated with previous context models, including their lack of formality and generality, and also tackles issues such as wide variations in information quality, the existence of complex relationships amongst context information and temporal aspects of context.
Modeling Context Information in Pervasive Computing Systems

• Motivation
• Defining Context
• Related Work
• Modeling Context Information
1. Motivation

• Pervasive computing
  • Cheap, interconnected computing devices are ubiquitous
  • Supporting users in a range of tasks

• The system should be capable of operating in
  • Highly dynamic environments
  • Placing fewer demands on user attention
  • OR sensitive on context

• How to program a context-aware application?
  • Common tasks: context modeling and management
2. Defining context

• 2.1 Case study : communication applications
  • Bob has finished reviewing a paper for Alice and would like to share his comments.
  • Bob instructs his communication agent to initiate a discussion with Alice.
  • Alice is in a meeting with a student, so her agent determines on her behalf that she should not be interrupted.
  • The agent recommends that Bob either contact Alice by email or meet with her in half an hour.
  • Bob’s agent consults his schedule, and, realizing that he is not available at the time suggested by Alice’s agent, prompts Bob to compose an email on the workstation he is currently using, and then dispatches it according to the instructions of Alice’s agent.
2. Defining context

• 2.1 Case study: communication applications
  • A few minutes later, Alice’s supervisor, Charles, wants to know whether the report he has requested is ready. Alice’s agent decides that the query needs to be answered immediately, and suggests that Charles telephone her on her office number. Charles’ agent establishes the call using the mobile phone that Charles is carrying with him.
2.1 Case study : communication applications

• Agents are relied upon the informations of...
  • The participants
    • Knowledge about the participant’s activities
    • Relationships between peoples - X supervised Y
  • The communication devices
    • Owned devices and availability of them
    • Channels and devices to use

• These information can be collected from...
  • Explicit inputs by users - diary
  • Sensors – location sensor
2.2 Characteristics of context Information

• Context Information Exhibits a Range of Temporal Characteristics
  • Pervasive systems are characterized by frequent changes (dynamics) - sensors
    • Duration varies - colleagues (months), location (minutes)
  • Reasonable to acquire static informations from user input – birthday

• Context Information is Imperfect
  • may be incorrect or ambiguous –
    • sensors fault
    • out-of-date information from a highly dynamic nature
    • disconnections/failures
2.2 Characteristics of context Information

- Context Has **Many Alternative Representations**
  - sensor output like GPS to app level knowledge like CSIC 2107
  - Many levels of abstractions

- Context Information is **Highly Interrelated**
  - Relationships between people, devices and channels
  - Derivations – derive current activity by past locations and past activities
    - The **quality** of the derived information depends on the source information to be derived
2.3 Context Modeling and Management for Pervasive Systems: Requirements

• How to represent and manage context information?
  • Neither DBMS nor Object-oriented programming language are appropriate
  • When the authors try to model the ‘case’ in section 2.1 with ER or UML,
    • Difficulties in distinguishing between different classes of context information – static/dynamic, sensor/input
    • UML is better than ER but still cumbersome
  • The authors suggest using a special construct design with context characteristics in mind
3. Related work

• 2 types of frameworks
  • Support the abstraction of context information from sensors
  • High-level models of context information that can be queried by apps

• Short comings
  • Lack the formal basis to capture the context in an unambiguous way and support reasoning
  • Restricted to narrow class of context, only sensed information and derivatives, no temporal or context histories
  • Does not address context quality
4. Modeling context information

- Core Modeling Concepts
- Classifying Associations
- Structural Constraints on Associations
- Modeling Dependencies
- Modeling Context Quality
4.1 Core modeling concepts

- **Nodes**
  - ○ entities – person, communication channel
  - ○ attributes – name, identifier of communication channel

- **Directed edges**
  - → associations – linking entities/attributes
  - A own B = A → B
4.2 Classifying associations

• Static = the relations are fixed for the lifetime of the entities
  • Relationship over devices, channels

• Dynamic = ~static
  • Can be further classified based on source
    • GPS
    • Near?
    • Works with X

• Help reasoning
4.3 Structural Constraints on Associations

- Simple, atomic facts to complex histories
- Simple = entity participates 1 time or less
- Composite = ~simple
  - Collective – one entity to many entities/attributes
  - Alternative – one entity to one of many entities/attributes
  - Temporal – one entity to X in time interval
4.4 Modeling Dependencies

• Association A depends on Association B
  • Correlate – B changes → A changes (by some potential)
    • Battery life → Bandwidth
    • Location of person → Location of device

• Help improve stability
  • Can detect out-of-date context information
4.5 Modeling Context Quality

• Context information are not perfect
  • Have to judge the reliability

• Tag the relations by ‘quality indicators’
  • Some parameters that are relevant as a probability estimation
  • Location:
    • Accuracy: standard error
    • Freshness: timestamp and lifetime associated
Conclusion

• Generic abstract concepts $\rightarrow$ implementation models $\rightarrow$ queried by apps
  • Show by case study

• Future work on privacy and distribution of context information