Situation Specification and Realisation in Rule-Based Context-Aware Applications

TTT presentation
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Background

- Collaboration on architectural support for context-aware applications
  - PhD thesis of Patrícia Dockhorn Costa
  - 15+ scientific papers
- Involvement of several people
  - Patrícia Dockhorn Costa
  - João Paulo Andrade Almeida
  - Luís Ferreira Pires
  - Marten van Sinderen
- Embedded in the AWARENESS and A-MUSE projects

Main contributions

- Architectural patterns for context-aware services infrastructures
- Context modelling based on an ontological foundation
- ☞ Situation modelling
- Situation realization using a rule-based approach
- Domain-specific language for specifying context-aware reactivity

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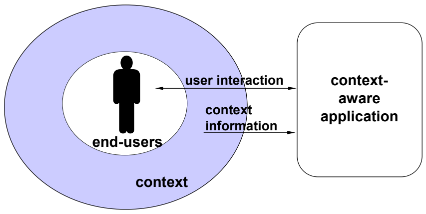
Motivation

- Context-aware applications are capable of reacting intelligently upon changes in their users' context
- Too expensive to build each application (for each user) from scratch
  → need for a 'platform' with reusable building blocks and facilities to accelerate application development and deployment
- We applied the Event-Control-Action (ECA) architectural pattern to design a context-aware services platform
  - Lower-level patterns: Context Sources and Managers Hierarchy pattern, Actions pattern

Motivation (cont'd)

- ECA pattern has been filled in with components to handle context changes (Events), components that perform the application logic (Control), and components to handle service calls (Actions)
- We developed a language to describe the application logic (ECA-DL) meant for application designers
- We investigated the implementation of the controller component using rule engines (particularly Jess)

Context-aware applications



Context

- ‘the set of possibly interrelated conditions in which an entity exists’

CA application development

In order to support context-aware applications one needs amongst others (meta)models that represent

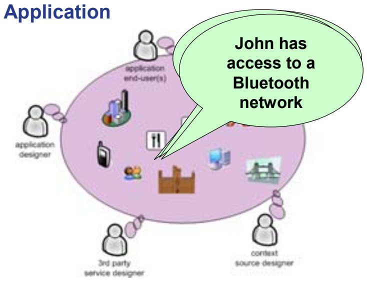
- context types and their relationships
- the ‘imperfection’ of context information (Quality of context)

Presentation concentrates on first topic
→ conceptual model for context

Goal: common understanding (unambiguous representation)

Universe of discourse and state-of-affairs

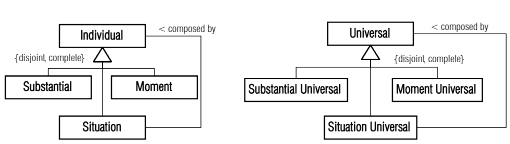
Tourist Application



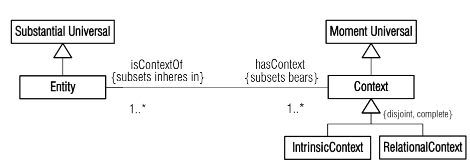
Context modelling goals

- We aim at providing basic conceptual foundations for context modelling, which allow designers to represent
  - (i) relevant elements of a context-aware application’s universe of discourse and
  - (ii) particular state-of-affairs of interest
- We consider results from foundational ontologies to support our conceptual context modeling approaches
- We focus on situation specification and realisation

Foundational ontologies



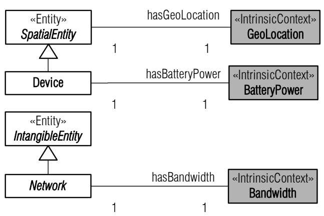
Foundational context concepts



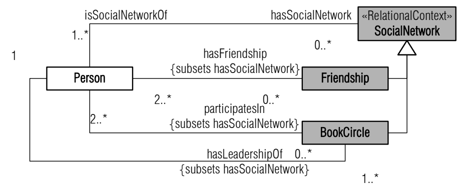
Context

- the set of possibly interrelated conditions in which an entity exists

Intrinsic context



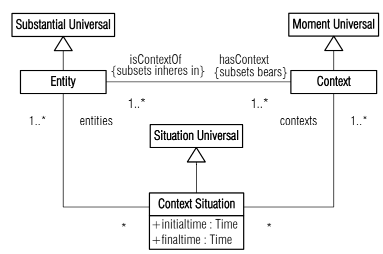
Relational context



Context situations

- Context models presented so far give a static view of context
- Context-aware applications should be able to react on Situations → specific configurations of entities and context conditions
- We have applied the ontological notion of Situation for that
  → particular state-of-affairs

Foundational context concepts: situations



Context situation specification

Standard UML 2.0 class diagrams using OCL 2.0 for constraints

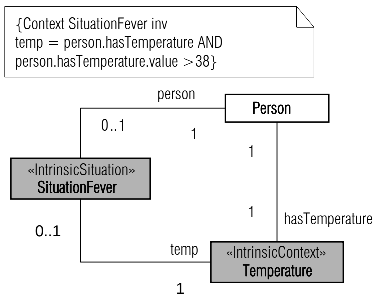
- OCL constraints define the conditions under which context situations of a certain type exist
- an invariant defines a predicate that must hold for all instances of the target class

Mature technology for a model-driven approach

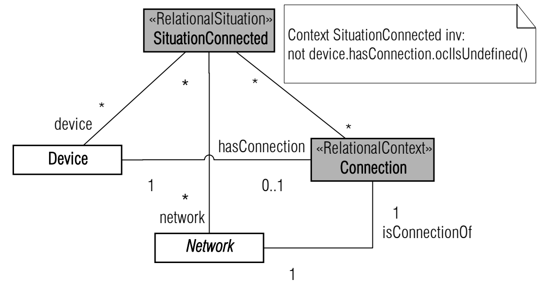
Context situation types

- Intrinsic Situation
- Relational Situation
- Formal Relation Situation
- Situation of Situations
- Combined Situations

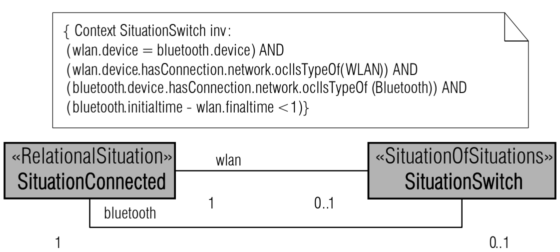
Situation Fever



Situation Connected



Situation Switch



Foundational Context Concepts (UML profile)

Artifacts for specification

- Context profile: <<Entity>>, <<RelationalContext>>, <<IntrinsicContext>>, …
- Situation profile: <<IntrinsicSituation>>, <<FormalRelationSituation, <<RelationalSituation>>, …

Products of specification

- Context Models: Person, Temperature, GeoLocation, GeoLocationCoordinate, Device, etc.
- Situation Models: SituationFever, SituationConnected, SituationPresentation, etc.

Situation realisation

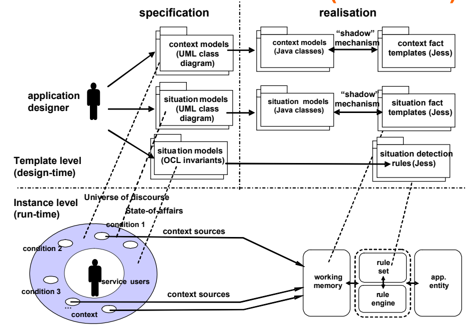
Rule-based approach

- Fits nicely the nature of situation detection
- Rules (OCL invariants) are repeatedly applied to a collection of facts (context information)

Jess

- Shadow facts
- Main components: working memory and rule-base

Situation Realization (overview)



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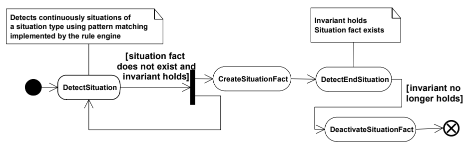
Situation Lifecycle



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Situation Detection

Creation Rule	Deactivation Rule

`(situation type invariant)`
`(not (situation exists))`
`=>`
`create (situation)`
`[RaiseEvent()]`
	`(not (situation type invariant))`
	`(situation exists)`
	`=>`
	`deactivate (situation)`
	`[RaiseEvent()]`

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Context models to Java

Octopus (www.klasse.nl/octopus/index.html)

Generates Java code from UML classes, and statically checks OCL constraints

UML classes to Java classes

Associations to class attributes

- One-to-one (one attribute in each class)
- One-to-many (one of the attributes is a collection)
- Many-to-many (both attributes are collections)

Subsets association

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Situation models to Java + Jess

OCL language	Jess language
object	(ObjectType (OBJECT ?object))
object.pdatatype	(ObjectType (OBJECT ?object) (pdatatype ?pdatatype))
object^1.object^2	(ObjectType^1 (OBJECT ?object^1) (object^2 ?object^2))
object^1.object^2.object^3	(ObjectType^1 (OBJECT ?object^1) (object^2 ?object^2)) (ObjectType^2 (OBJECT ?object^2) (object^3 ?object^3)) (ObjectType^3 (OBJECT ?object^3))
object^1.datatype	(ObjectType^1 (OBJECT ?object^1) (datatype ?pdatatype))
object^1.datatype.pdatatype	(ObjectType^1 (OBJECT ?object^1) (datatype ?datatype)) (DataType (OBJECT ? datatype) (pdatatype ?pdatatype))
object^1.object^2. datatype. pdatatype	(ObjectType^1 (OBJECT ?object^1) (object^2 ?object^2)) (ObjectType^2 (OBJECT ?object^2) (datatype ?datatype)) (DataType (OBJECT ?datatype) (pdatatype ?pdatatype))
Object->collection	(ObjectType (OBJECT ?object) (collection ?collection)

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Distribution

Service-oriented approach

- Components encapsulate Jess engines, and situation information is exchanged by means of the component services

DJess

- Separate engines virtually share working memory
- Rule engines running on different nodes can apply rules on shared facts

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Conclusions

- Context models help understanding context concepts and how they relate to each other
- Context models are static
- Situations allow one to define state-of-affairs of concern for context-aware applications
- Behaviours can be defined in terms of how the system evolves from situation to situation!
- Situations can be used to define conditions that trigger a rule system, as, e.g., in ECA rules
- Situations can be composed of situations themselves → modularization of the situation models, improving organization and reuse of situation specifications

Conclusions

- Rule-based situation realisation allows attentive situation detection as opposed to query-based solutions
- Model-driven approach
  - Specification elements are systematically mapped to realization elements
  - UML (including OCL!) is mature technology for model-driven developments