Overview on Engineering Issues in Ubiquitous Web Applications

THE UWA APPROACH TO CUSTOMIZATION

Mag. Dr. Wieland Schwinger, MSc
wieland.schwinger@jku.at
http://www.tk.uni-linz.ac.at/people/schwinger/
+43 (0)70 / 3343-843
+43 (0)70 / 3343-888

Outline of the Module 2/2

Modeling of Ubiquitous Web applications
- Motivation
- Customization
- Excursus: Supporting person with disabilities
- Excursus: Linzer Mobile Guide
- Design space of Customization

The UWA Approach to Customization
- Customization Architecture
- Context Models
- Customization Rules
- Customization Example
- Tool Support
Motivation

Demand for Ubiquitous Web Applications
- additionally to the criteria of "traditional Web applications" allow for ubiquitous access to services anytime / anywhere / anymedia

Development Goals
- accessibility despite of restrictions = semantic equivalence
- best quality of service = semantic enhancement

Motivation

Ubiquitous Web Applications:
- have to be "aware" of their context - "Situation of Use"
  - Context is not what is explicitly provided but which comes aside
  - e.g.: device, network, user, location, time
- have to adapt accordingly
  - changing the "standard" Web application

Customisation = Adaptation to Context

Modelling is important but existing modelling approaches fall short in considering all aspects of UWAs

Currently
- disregarding full potential of ubiquity

"Excuse me ... could you tell my car's navigational system how to get to Bucknell and Smith Road?"
Objectives and Approach

EU-funded Fifth Framework Program project (IST-2000-25131)

Objectives:
- Define a set of methodologies, notations, and tools to support the design and fast prototyping of complex ubiquitous web applications
- Propose a set of notations based, along with a set of heuristics and guidelines to help developers
- Provide tool support to make the design activity more efficient

Approach:
- Explicit requirement elicitation, hypermedia modelling, transaction support and ubiquity modelling
- UML profile for UWA-specific concepts
- Dynamic rules as a means to deal with ubiquity
- Extension of existing UML tool to facilitate an integrated development process

http://www.uwaproject.org

UWA Approach To Customization Modeling

- **Goal:** regarding all requirements of customization
- **Designed from the start** to take the ubiquitous nature into account
- **Customization as the uniform mechanism** to enable ubiquity
  - by adapting towards a particular context which reflects the environment
- **Holistic view** on the development
- **process by introducing**
  - customization as additional
  - design dimension
  - effecting all dimension of traditional web application modeling
- **Levels**
  - Presentation
  - Hyperbase
  - Content
  - Analysis
  - Design
  - Implemetation
  - Customization

W. Schwenger - Model-Driven Development of Ubiquitous Web Applications
Customisation Modelling
Customisation Architecture

- Reification of the environment in terms of an explicit
  - physical context model: information sensed from the environment
  - logical context model: high-level descriptions of the situation of use

- Separation of the core functionality of a web application (stable part) from its context-dependent part (variable part)

- Adaptation of all aspects of navigation, operation, transaction

- Specification of dynamic customisation in terms of event-condition-action rules to reflect dynamicity

- Development of a UML profile for customisation modelling

- Extension of Rational Rose to facilitate an integrated development process
Outline of the Module 2/2

Modeling of Ubiquitous Web applications
- Motivation
- Customization
- Excursus: Supporting people with disabilities
- Excursus: Linzer Mobile Guide
- Design space of Customization

The UWA Approach to Customization
- Customization Architecture
  - Context Models
  - Customization Rules
  - Customization Example
  - Tool Support
Customisation Modelling
Physical Context Model

- **Manageable description of the environment** and the Web application itself
- At a **very low level of abstraction** (e.g. what is provided by sensors)
- **Open and extensible** to include new properties (e.g. temperature, altitude, battery level) in the sense of an object-oriented framework
- **Updates outside the scope** of the Web application
Logical context represents **more stable, abstracted information**

- Can be provided simply by means of **profiles** or by using **abstraction mechanisms** such as aggregation and inference
- Needed to **enrich the physical context**, e.g. to derive the street name from a sensed X/Y-position
- Modelled as profiles and **organized in UML packages**
- **Open and extensible** to include new profile information and abstractions
Logical Context Model

User Agent Profile

- **DeviceProfile**
  - **Hardware**
    - displaySize
    - colorSupport
    - memory
    - cpu
    - avgBandwidth
    - maxBandwidth
  - **Software**
    - type
    - name
    - version
    - vendor

- **DeviceCategoryHierarchy**
  - **DeviceCategoryComponent**
    - **DeviceType**
      - name
    - isOfCategory
      - name
    - **DeviceCategory**
      - isPartOf
      - e.g. Nokia 6120
      - WAP-enabled mobile, WAP

- **OperatingSystem**
- **Browser**

- **MIMEType**
- **MarkupLanguage**
  - type
  - version

Logical Context Model

User Profile

- **GenericUserProfile**
  - **User**
    - login
    - password
    - phone
    - number
    - currentRole
  - **Role**
    - currentRole
    - **ActorRole**
    - **ExpertiseRole**
      - Novice
      - Expert

- **ApplicationSpecificUserProfile**
  - **DeviceProfile**
    - **DeviceCategory**
    - **ColorSchema**
      - name
      - backColor
      - textColor
      - linkColor
      - headingColor
      - highlightColor
  - **PersonalPreferences**
    - name
    - eMail
    - preferredLanguage
  - **MobilePreferences**
    - simNumber
    - prefersSMS
  - **HotelPreferences**
    - category
    - maxPrice
  - **ConferencePreferences**
    - subscribedInfos
    - downloadPapers
    - getSubscribedTracks
  - **BirdsOfAFeather**
    - conferenceFee
    - hasRegistered
    - hasPaidConferenceFee
    - hasPaidTutorialFee
  - **PCChair**
    - author
    - staff
  - **PCMember**
    - conference
    - hasRegistered
    - hasPaidConference
    - hasPaidTutorial
  - **Subject**
    - name
  - **Participant**
    - conferenceFee
    - hasRegistered
    - hasPaidConferenceFee
    - hasPaidTutorialFee

Department of Telecooperation
Modeling Adaptation

- Adaptation activates the variable part of the Web application
- Generic adaptation operations
  - more than 70 generic adaptation operations have been defined for hypermedia and transaction modelling elements
  - e.g.: any collections can apply a filter operation to its extension
- Application-specific adaptation operations
  - the designer is enabled to introduce arbitrary adaptation operations

Outline of the Module 2/2

Modeling of Ubiquitous Web applications
  - Motivation
  - Customization
  - Excuse: Supporting person with disabilities
  - Excuse: Linzer Mobile Guide
  - Design space of Customization

The UWA Approach to Customization
  - Customization Architecture
  - Context Models
    - Customization Rules
    - Customization Example
    - Tool Support
Customisation Rules are:
- formulated in terms of **event/condition/action-rules**
- allow declarative specification of dynamic customisation

**Event:**
- identifies the **potential need** for customisation
- predefined in a **generic Event Model**
- extensible by additional primitive events and composite events

**Condition:**
- identifies if customisation is actually **needed**
- very often reasons about the **context** specified in **OCL**

**Action:**
- activates a certain adaptation operation

---

**Event Model**

- **Event**
  - **EventOperator**
    - **CompositeEvent**
    - **PrimitiveEvent**
      - **ChangeOfPhysicalContext**
        - **ChangeOfDevice**
        - **ChangeOfNetwork**
        - **ChangeOfTime**
          - **ChangeOfUser**
          - **ChangeOfBrowser**
          - **ChangeOfLocation**
          - **ChangeOfApplicationState**
Modeling Adaptation

- Adaptation hooks
  - Allow customisation rules to adapt the Web application
  - Support micro and macro adaptation
  - Resemble object-oriented framework idea

- Micro Adaptation (a single model element is adapted)

- Macro Adaptation: (more than one) model element

Action Model
Customisation Rule Modeling (cont.)

Example 1/3 - Requirements

**Context:** Device used is not graphics enabled

**Adaptation:** Change the description to text mode

---

Example 1/3

**Context:** Device used is not graphics enabled  
**Event:** changeOfDevice  
**Condition:**

```
session.history[current].context.userAgent.deviceType = profile.device.type AND
profile.device.graphicEnabled = 'FALSE'
```

**Adaptation:** Change the description to text mode  
**Action:**

```
textMode {
    description.switchTo('text')
}
```
Customisation Rule Modeling (cont.)

Example 2/3

**Context:** Moved more than 5 km

**Adaptation:** Recompute the route description

W. Schwenger - Model-Driven Development of Ubiquitous Web Applications

Customisation Rule Modeling (cont.)

Example 2/3

**Context:** Moved more than 5 km

**Event:** changeOfLocation

**Condition:**
- `session.history[current].context.location.
  distance(session.history['StartTime'].context.location) >= '5 km'

**Adaptation:** Recompute the route description

**Action:**
```java
recomputeRoute {
    routeDescription.compute(context.location);
}
```
Customisation Rule Modeling (cont.)

Example 3/3

**Context:** Bandwidth fallen below 10kb

**Adaptation:** Adapt the graphics accordingly

---

Customisation Rule Modeling (cont.)

Example 3/3

**Context:** Bandwidth fallen below 10kb

**Event:** changeOfBandwidth

**Condition:**
```
session.history[current].context.bandwidth <= '10 KB'
```

**Adaptation:** Adapt the graphics accordingly

**Action:**
```
resizeGraphics {
    overviewMap.resize(context.bandwidth);
    detailMap.resize(context.bandwidth);
}
```
Macros and Rule Patterns

- We introduce the notation of **macros and rule patterns** to:
  - increase expressiveness
  - ease the task of the customisation designer
  - support reusability
- **Macros** represent pre-defined parts of customisation rules in terms of condition and action (currently 67 macros are supported)
- **Rule patterns** are **templates** abstracting customisation rules as a whole
- Both can contain **parameterised components**

Customisation Macros

- **Specification of a** non-parameterised macro
  
  \[
  \text{CURRENT\_CONTEXT} = (\text{Session.History})\rightarrow\text{last()}
  \]

- **Usage**
  
  ```
  \ldots
  E: \ldots
  C: \text{CURRENT\_CONTEXT}.User.eMail = "sysadmin@uwaproject.org"
  A: \ldots
  ```
Customisation Macros

- **Specification of a** parameterised macro

  ```plaintext
  CERTAIN_CONTEXT(Time t) = (Session.History)->certain(t)
  ```

- **Usage**

  ```plaintext
  ...
  E: ...
  C: CERTAIN_CONTEXT("2001/NOV/22 11:00").User.eMail
      ="sysadmin@uwaproject.org"
  A: ...
  ```

Outline of the Module 2/2

**Modeling of Ubiquitous Web applications**
- Motivation
- Customization
- Excursus: Supporting person with disabilities
- Excursus: Linzer Mobile Guide
- Design space of Customization

**The UWA Approach to Customization**
- Customization Architecture
- Context Models
- Customization Rules
  - Customization Example
  - Tool Support
Customization Example 1

"If a device of type PDA is used then the Artist Highlight should and the link to that node should not be available"

Detects that now another device is used

Checks whether the currently used device is of type "PDA", uses a macro specifying: DeviceCategory=DeviceCategory(CURRENT_DEVICE, <devCat>)

Activates the three adaptation operations disableLink() and disableNode() for the model elements HB_ArtistHighlight, ArtistOICDTour, and the link to HB_ArtistHighlight in between

Customization Example 2

"CustomisationRule"

Name: FilterPapers

Requ: Only the papers currently presented in the current room's track should be available

E: ChangeOLocation OR ChangeOfTime

C: CURRENT_LOGICAL_LOCATION_ISA("InLectureRoom")

"If a device of type PDA is used than the node "Full Description" and the link to that node should not be available."

Web application model in W2000

«CustomisationRule»
Name: ReducePC_MemberForNavigation
Requ:Maximise Usability
E: ChangeOfDevice
C: DEVICECATEGORY.ISA("PDA")
A: Index_FullDescription→disableLink();
    FullDescription→disableNode()

detects that now another device is used
checks whether the currently used device is of type "PDA", uses a macro specifying:
    DeviceCategory→isaCategoryCURRENT_DEVICE,<devCat>
activates the two adaptation operations disableLink() and disableNode() for the model elements
    FullDescription and Index_FullDescription, respectively
Customization Example 4

"On basis of the users current role select the according design"

```
<CustomisationRule>
  Name: ChooseDesign
  Requ: The appropriate design should be choosen according to the user's current role
  E: ChangeOfUser
  C: CURRENT_USER.currentRole != PREVIOUS_USER.currentRole
  A: DesignSwitcher.switchDesignTo("DesignFor__"+CURRENT_USER_ROLENAME)
</CustomisationRule>
```

Customization Example 5

```
<<customizationRule>>
Name: SMSConfirmation
E: CommitTransaction
C: CommitTransaction.name='Booking' AND
   userAgentProfile.getType('Session,History',CURRENT,UserAgentContext.get(),UserAgentContext.get())='MobilePhone'
A: BookingConfirmation.sendSMS()

<<customizationRule>>
Name: WebConfirmation
E: CommitTransaction
C: CommitTransaction.name='Booking' AND
   userAgentProfile.getType('Session,History',CURRENT,UserAgentContext.get(),UserAgentContext.get())='PC'
A: BookingConfirmation.sendEMail(); BookingConfirmation.showConfirmationWebPage();
```

As soon as the user commits booking, construct an appropriate booking confirmation according to the characteristics of the device used.
Outline of the Module 2/2

Modeling of Ubiquitous Web applications

- Motivation
- Customization
- Excursus: Supporting person with disabilities
- Excursus: Linzer Mobile Guide
- Design space of Customization

The UWA Approach to Customization

- Customization Architecture
- Context Models
- Customization Rules
- Customization Example
  - Tool Support

Tool Support

- Modeling supported by customization modeling tool
- Extension of commercial UML modeling tool Rational Rose
- UWA tool framework comprises:
  - UML profile including e.g.: stereotype definition
  - Generic models, e.g.: event model, logical context models
  - Plug-ins - providing functionality
    - Wizard supporting customization rule creation
    - Model checking
    - Lookup

- Currently available as prototype
Customisation rules and their constituents are modelled in terms of stereotyped UML classes.

- aCompositeEvent
- aPrimitiveEvent
- aCondition
- anAction

Customisation rules are attached to:
- those hypermedia or transaction modelling elements being subject to adaptation using an association stereotyped «adapts» and to
- those requirements which are realised using an association stereotyped «realises»

Customisation Rule Example With Rational Rose Tool

ReviewerProfile

ShortDescription

Index

FullDescription

<<customises>>

<<customises>>

ReducePC_MemberF

(Removed <<customises>>)

W. Schwenger - Model-Driven Development of Ubiquitous Web Applications
Customisation Rule Example
With Rational Rose Tool

Action of ReducePC_Member For Navigation

Condition of ReducePC_Member For Navigation

Change of Device

<<performs>>
<<evaluates>>
<<triggers>>
<<implments>>
<<UWARequirement>>
Maximise Usability
(from aRequirementsModel)
Customisation Rule Example
With Rational Rose Tool

Summary

- Modeling of Ubiquitous Web Applications is important but Software Engineering methods can not be directly applied
- Design space of Web Applications comprises:
  - Levels: content, hyperbase, presentation
  - Aspects: structure and behavior
  - Phases: from analysis to implementation
- Customization (adaptation to content) as uniform mechanism to address the requirements of ubiquity
- Customization modeling comprises:
  - context modeling in terms of physical and logical context models
  - adaptation modeling: adaptation operations and adaptation hooks
  - customization rules: in terms of ECA-rules
Benefits of that Approach

- Enabling new types of applications like **personalised services, location-aware services** and **device-optimised services** using customisation as **uniform mechanism**
- Ensuring a systematic development of high-quality **UWAs** by conceptual modelling of customisation
- Respecting the **highly dynamic nature of UWAs** by employing customisation rules
- Reducing maintenance efforts and **increasing reusability** by separation of context-dependent and independent parts of UWAs and by providing pre-defined macros and pattern libraries
- Coping with **technology evolution** and **changing requirements** by allowing to extend context models and adaptation possibilities
- Going in line with **current software engineering standards** using UML as basic formalism
- Facilitating an **integrated development process** by proper tool support

Issues of that Approach

- What belongs to content and what belongs to context is sometimes blurred
- Very "fine grained" - concernd may be too much with the details of formulating constraints
- Notation hard to understand and to communicate to the user
- Way of annotating clutters the customization model
  - e.g. what if I want to see all personalization
- No "semantics" of how the context is actually filled
- Event-driven approach might not be "feasible" way of thinking for often changing context
- Static adaptation realization quite artificial
Lessons Learned

- Let it be said in the words of the user
- Notation matters - need for easy to understand icons and graphic representation
- Understandability prevails detailed semantics
- Need to see customization as cross-cutting concern
- Modeling can be either
  - full specification prior to implementation
  - pragmatic approach to communicate to the user

Outlook
Final End
- Model-Driven Development of Ubiquitous Web applications

Open Issues
- make customization modeling more handy
- extensible customization run-time environment
- realizing ubiquitous web applications

Current Work
- Explore capabilities of aspect-orientation of representing customization as cross-cutting concern
- Run-time customization framework
- Elaborate on the methods, techniques, and tools for model-driven development

Where does Customisation take place?

External (proxy-based) Customisation
- most approaches, e.g., IBM Transcoding Publisher, Oracle Wireless Edition

Intra-Level Customisation
- e.g., OOHDM, WUML

Inter-Level Customisation
- e.g., WebML

Is the application customisation-aware or not?

HTTP-Request
Customization Run-Time Framework

1. request
2. use pre-cached version if available
3. select corresponding original source
4. retrieve from source
5. receive original version
6. run through adaptation server
7. respond to client

Context and content sometimes blend

Take Home Message

1. Physical Context is the reification of the environment extended by logical context (profiles)
2. Context and content sometimes blend
3. Separation of the stable and the adaption by means of adaptation hooks
4. Approach provides dynamic customization by means of customization rules (ECA-rules)
5. Semantics of adaptations on the Web applications problematic
6. Users need to be able to express customization at a suitable level of abstraction
7. Modelling is fine but also a suitable run-time platform is needed
Thank you for your attention!

Annex
Selected Publications


References 1/3


References 2/3


W. Schwenger - Model Driven Development of Ubiquitous Web Applications 65

References 3/3


