

A Physical Mobile Interactions Framework based on Semantic Descriptions

Sven Siorpaes, Diploma Thesis

Duration: 01.01.2006 – 30.06.2006

Supervisors: Dipl.-Inf. Enrico Rukzio,
Massimo Paolucci (NTT DoCoMo Euro-Labs),
John Hamard NTT DoCoMo Euro-Labs)

Responsible Lecturer: Dr. Albrecht Schmidt

Responsible Professor: Prof. Dr. Heinrich Hußmann



Mobile Interaction with Real World Services

Gregor Broll, Diploma Thesis

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- Introduction, Challenge and Approach
- Selected Issues of Related Work
- Use-Case Scenarios and Paper Prototyping
- Framework Architecture
- System Descriptions Supporting the Interaction Process
- Focus: User Interface Generation Process
- Prototype Client Implementation
- User Study and Prototype Evaluation
- Conclusion and Future Work

Introduction, Challenge and Approach



- Increasing interest in Physical Mobile Interaction
- Facilitates mobile interaction with digital services through the interaction with physical objects
- Powerful mobile devices for information access, collection, processing and interaction
- (Augmented) physical objects become recognizable
- Techniques: pointing, touching, scanning, location, ...
- Technologies: visual marker and pattern recognition, wireless RFID / NFC tags, laser pointer, Bluetooth, GPS, ...
- Objects get digital identities (\Rightarrow Internet of things) and can be associated with information and services





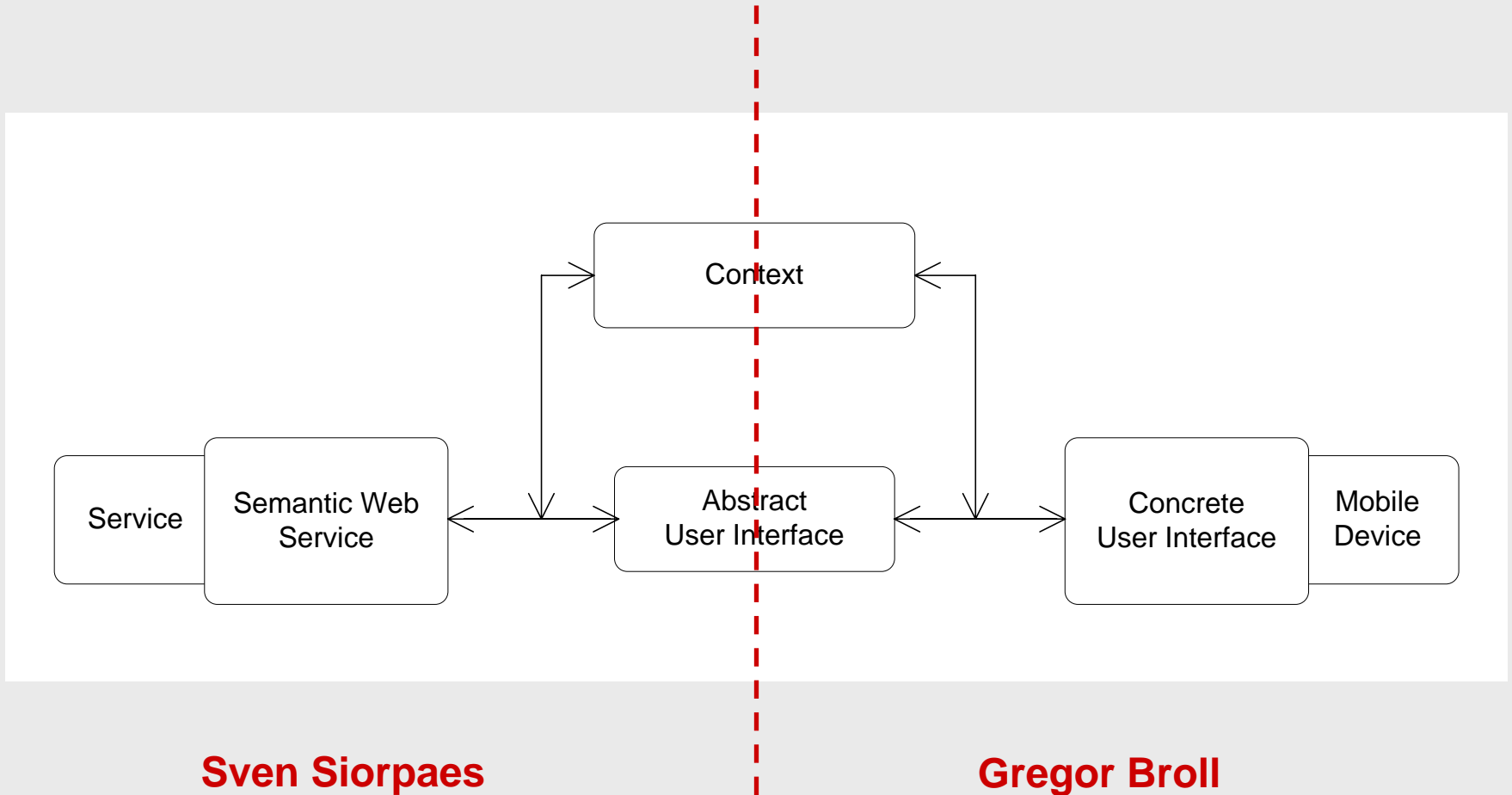
- Current implementations of Physical Mobile Interactions mostly simple and proprietary prototypes
- Limited scope of application and mostly single interaction techniques
- Little tool- and framework-support
- Support more complex Physical Mobile Interactions e.g. represent a sequence of interactions
- Shift focus of interaction from mobile devices onto physical objects (e.g. from the Internet of Things)
- Transfer the familiarity of interacting with physical objects and exploit it for more intuitive interaction with associated services
- Provide an independent service infrastructure that is reusable across different services and interactions
- Automatic user interface generation required that abstracts from specific target platform





- Perci project (PERvasive ServiCe Interaction), a collaboration between LMU and DoCoMo Eurolabs
- Goal: Combination of Physical Mobile Interaction and Semantic Web Services for their mutual benefit
- Generic framework to exploit the expressiveness, flexibility and interoperability of Semantic Web Services for richer Physical Mobile Interactions
- Use extended Web Service descriptions for the automatic generation of adapted interfaces that support and facilitate Physical Mobile Interaction





Sven Siorpaes

Gregor Broll



Selected Issues of Related Work



Web Services

- Standardized Web Service Description Language (WSDL) to specify service invocation interface
- Interoperation between heterogeneous platforms, e.g. hardware or software platforms
- Well established standard in industry and academia, extending existing Web Services like Amazon or Ebay

Semantic Web Services

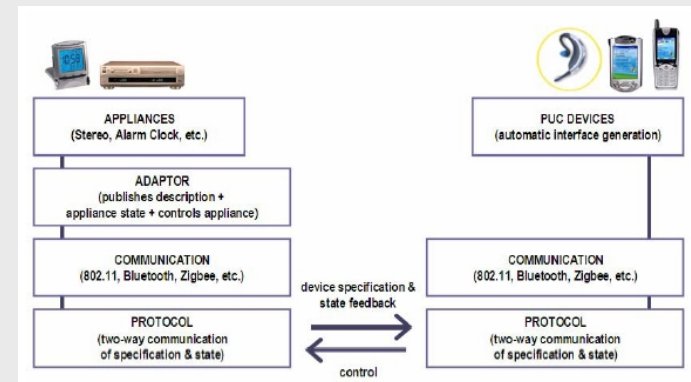
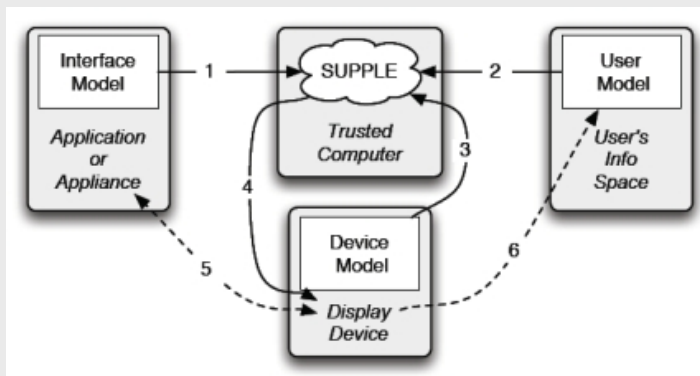
- Standardized service description ontology OWL-S
- Connect atomic WSDL operations to complex processes, e.g. sequence
- Provides semantic expressiveness by adding an abstract type system to the syntactic WSDL message formats



- UIDLs are the first step for the automatic generation of interfaces
- Facilitate development of application interfaces for different platforms; reusable, easy to learn, more effective prototyping, ...
- Scope of Perci: first step of the transition from Semantic Web Service descriptions to interfaces for Physical Mobile Interaction
- Evaluation of different abstract and concrete UIDLs: UIML, XUL, USIXML, XAML, WSXL, markup languages (XHTML, WML, cHTML)
- Mostly not suitable for the Perci approach: too inflexible or not generic enough (UIML), too concrete and heavyweight (XUL, XAML) or too general (USIXML), not enough support for mobile interfaces, no connection to Web Services
- Evaluated UIDLs only as drafts for the creation of an own abstract user interface description language

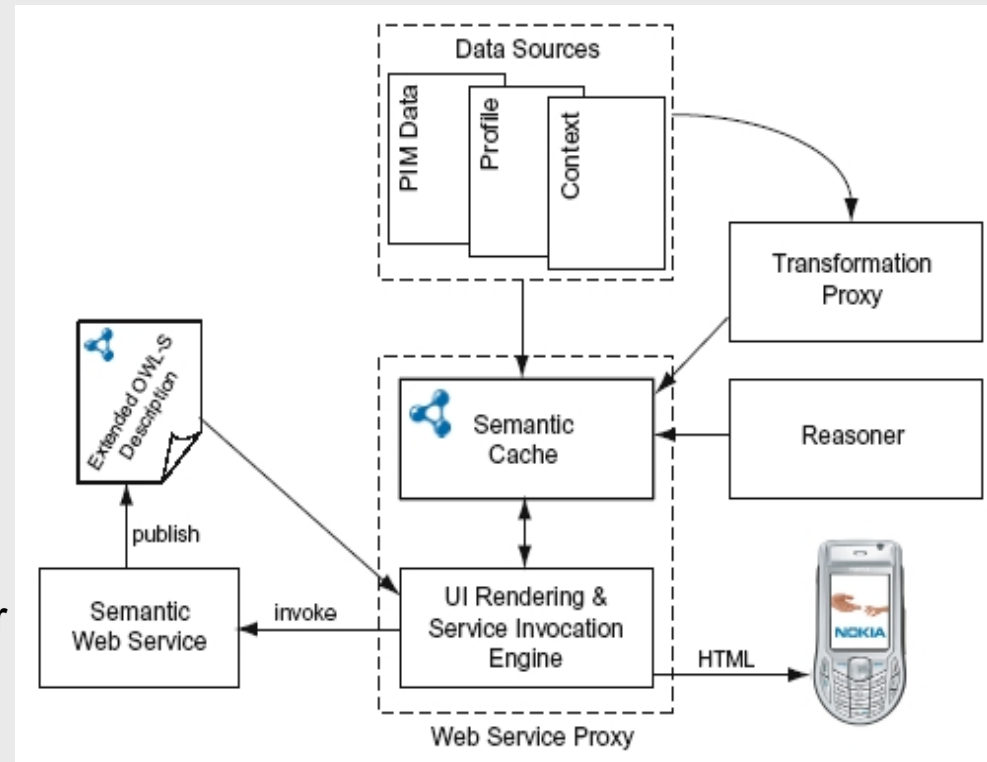


- Intermediates between SWS interface descriptions and Physical Mobile Interaction on mobile devices
- SUPPLE: Framework for automatic generation of UIs
 - Based on models for devices, users and abstract functional interface specification
 - Algorithm maps widgets to suitable UI elements based on efficiency constraints
- Pebbles: using mobile devices for controlling electronic appliances
 - Interface generation based on abstract descriptions of appliances and their functions
 - support for different modalities, device constraints and user preferences
 - 2-way communication for sending messages using device adaptors





- D. Khushraj and O. Lassila: Architecture for the automatic creation and personalisation of dynamic UI forms from *OWL-S Profile* and *Process Model* of Semantic Web Services
- OWL-S ontology to describe UIModel for SWS
- Extension of this ontology with *user interface annotations* (e.g. display labels)
- Exploiting relationship between WS input and association with info about a user from Semantic Cache for personalisation
- Role model for own framework for Physical Mobile Interactions





- Industrial effort to wirelessly tag and identify physical objects, e.g. using RFID
- Everyday objects get individual digital identities and references
- Objects can be presented, identified and linked with each other by means of a network infrastructure => “Internet of Things”
- Increasing importance in industry; automatic recognition, identification, tracking and monitoring of products
- Standardization of framework for identification and description driven by EPCGlobal and Auto-ID Labs.
- Infrastructure components: RFID-tags, Electronic Product Code (EPC) for unique identification, Object Naming Service (ONS) for matching EPC and PML and Physical Markup Language (PML) for describing object properties

Sicher im Blick! Hier können Sie jederzeit den aktuellen Sendungsstatus Ihrer Sendung erfahren.

Bitte geben Sie für die Statusprüfung Ihres Paketes den Sendungscode und die Postleitzahl des Empfängers ein. Bitte verwenden Sie keine Leerzeichen.

PLZ

Sendungscode

Der Sendungscode (12-stellige Nummer oder bis zu 39-stelliger License Plate) befindet sich unterhalb des Barcodes auf dem Paketlabel.

► Suchen



Use-Case Scenarios and Paper Prototyping



PERCI Movie Tickets

Choose a Cinema

- Maxx
- Mathäser
- Marmor Haus
- Leopold

Choose # of Persons

- 1
- 2
- 3
- 4
- 5

Choose a Movie

Choose a Timeslot

- 13:00
- 15:00
- 17:00
- 20:00
- 23:00

Choose Transportation

- S-Bahn/ U-Bahn Straßen Karte
- S-Bahn/ U-Bahn Einzel Fahrkarte
- S-Bahn/ U-Bahn Tages Karte

Order a Taxi

PERCI Transportation Tickets

Touch Stations to assemble your Route

Tickets

- Streifen Karte
- Single Tages Karte
- Partner Tages Karte
- Grüne Karte
- Isar Card
- Isar 60
- Ausbild. Tarif 1
- Ausbild. Tarif 2
- Kombi Ticket
- Airport

Persons

- 1
- 1...5
- Child
- Bicycle

Duration

- 1 Hour
- 1 Day
- 3 Hours
- 1 Week
- 4 Hours
- 1 Month

Touch here to activate



- Simple user study with 10 participants (mostly students)
- Complete 2 scenarios with the posters and the paper prototypes (buying a movie ticket and a transportation ticket)
- Questions about the system before and after the scenarios





- 70% of the users think that the proposed system is useful
- Initial effort to understand the system but then easy and intuitive to use, if users are already familiar with a mobile phone
- Useful where poster replaces another automat, but in some cases users could prefer a human contact for feedback (e. g. ticket counter)
- + Fast, low-cost, can be used anywhere, easy to replace
- + Less complicated menus, easy physical interaction, less faults
- + Added value: payment could be included into mobile phone
- NFC widely unknown, needs to be established
- Not enough feedback, only from mobile; actions not reversible
- Posters need to be put up and actualized



- Added support for visual marker recognition and direct input
- Incorporated the suggestions from the user study
- Added more hints and instructions on how to use the posters
- Definition of action/task-tags and parameter/option tags in order to make the poster's functionality more modular and extendible
- Transportation poster will use a new model for choosing stations more efficiently

PERCI Movie Tickets

Please follow the steps below in order to use this poster. To select a task or an option , take a picture of its visual marker  or touch its NFC-symbol  with your NFC-enabled mobile phone. You can also type in service-URLs and option names directly.

- 1) Open the PERCI client on your mobile phone.
- 2) On the poster, select the task you want to accomplish.
- 3) Follow the instructions on your mobile phone.
- 4) Select the options on the poster that are appropriate for your task.

Select a Cinema

Maxx 

Mathias 

Leopold 

Marmorhaus 

Gloria 

Select a Movie



Select a Task

Order Movie Ticket 

View Movie Details 

Select a Timeslot

13:00 

15:00 

17:00 

20:00 

23:00 



PERCI Transportation Tickets

Please follow the steps below in order to use this poster. To select a task or an option , take a picture of its visual marker or touch its NFC-symbol with your NFC-enabled mobile phone. You can also type in service-URLs and option names directly.

- 1) Open the PERCI client on your mobile phone.
- 2) On the poster, select the task you want to accomplish.
- 3) Follow the instructions on your mobile phone.
- 4) Select the options on the poster that are appropriate for your task.

Assemble Ticket
(Date, time, from, to)

Select Ticket directly
(only type of ticket)

Select the Duration of your Journey

1 Hour 3 Hours 4 Hours 1 Day 1 Week 1 Month

Select the Number of Passengers

1 2 Child Bicycle

Define Origin and Destination of your Journey by selecting the Areas, in which the appropriate Stations are

Select the Type of your Ticket

Single Ticket Day Ticket Family Day Ticket Schooling Ticket 1 Schooling Ticket 2 Senior Card Tickets

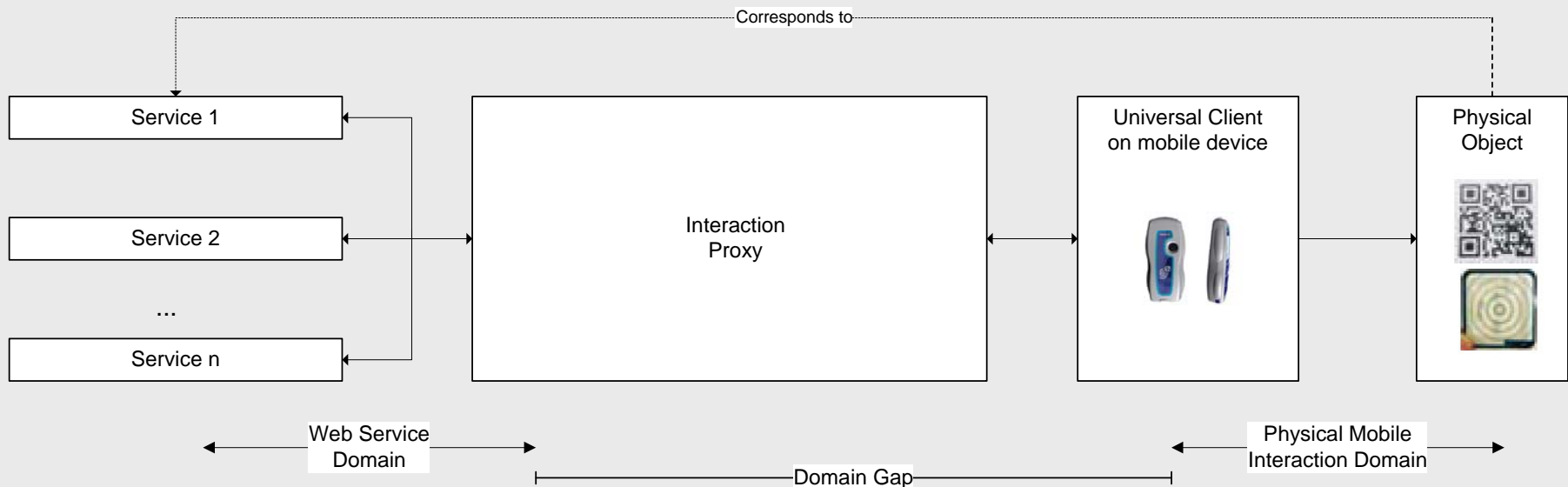
Define Origin and Destination of your Journey by selecting the Areas, in which the appropriate Stations are



Framework Architecture

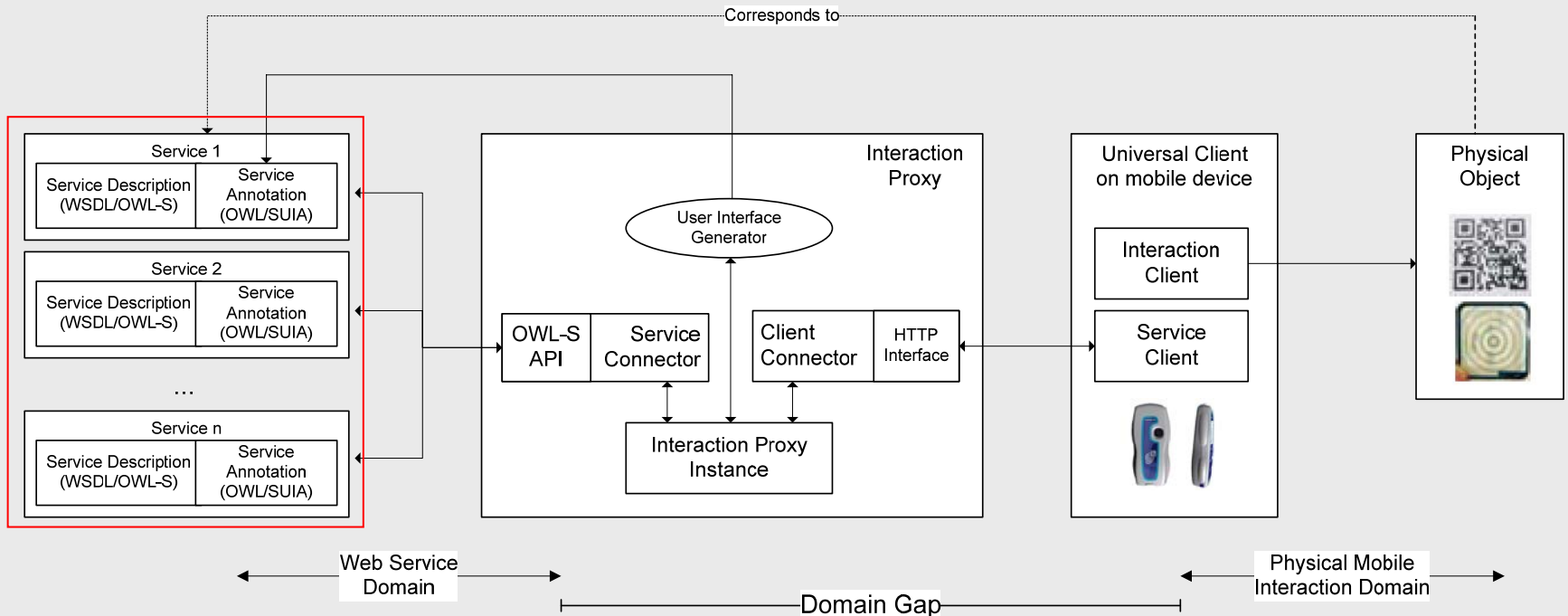


- Architecture bridging the gap between the *Web Service Domain* and the *Physical Mobile Interaction Domain*
- A *Universal Client* running on a mobile device is interacting with *Physical Objects* and providing a technical connection to services
- Component *Interaction Proxy* (IAProxy) that mediates between the two domains



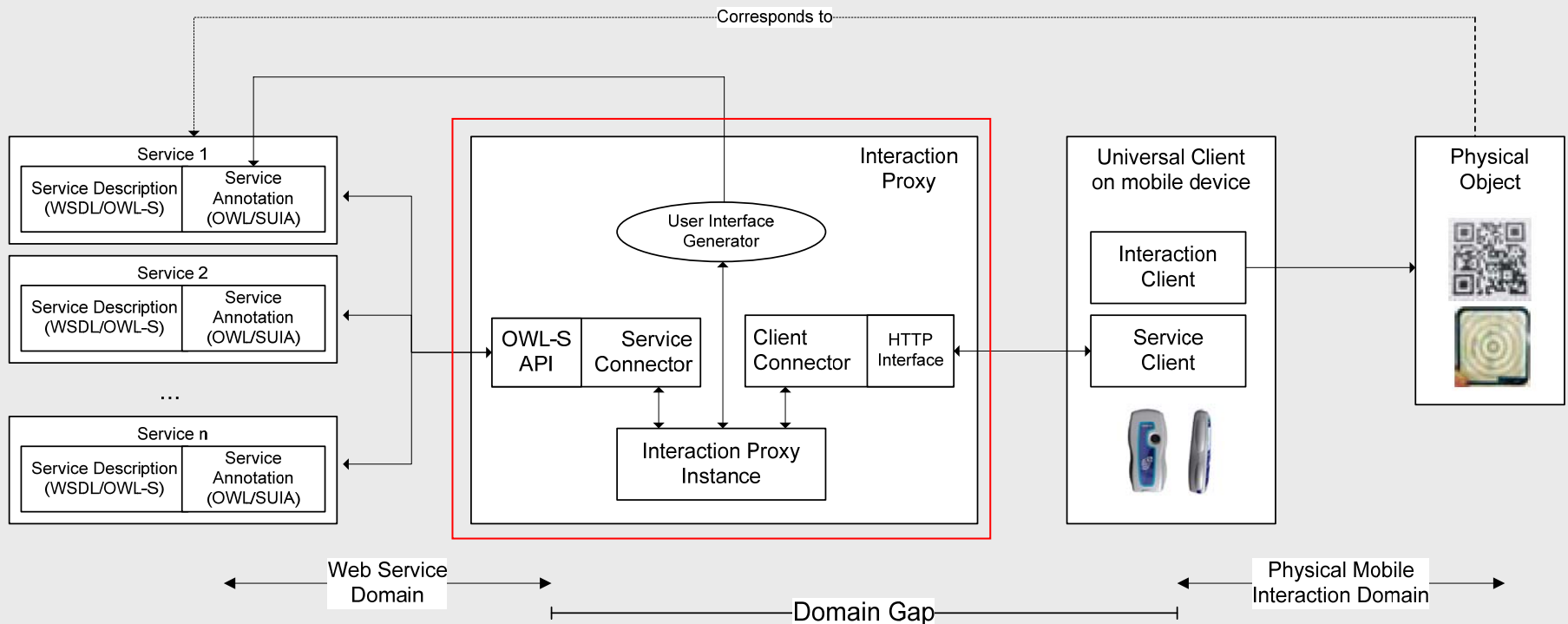


- *Services* provide different descriptions to allow controlling the interaction flow and the automatic user interface generation:
 - **Functional behaviour** and **abstract parameter types** of the service, defined as *Service Description* standards *WSDL* and *OWL-S*
 - Own user interface relevant *Service Annotations* based on *OWL*



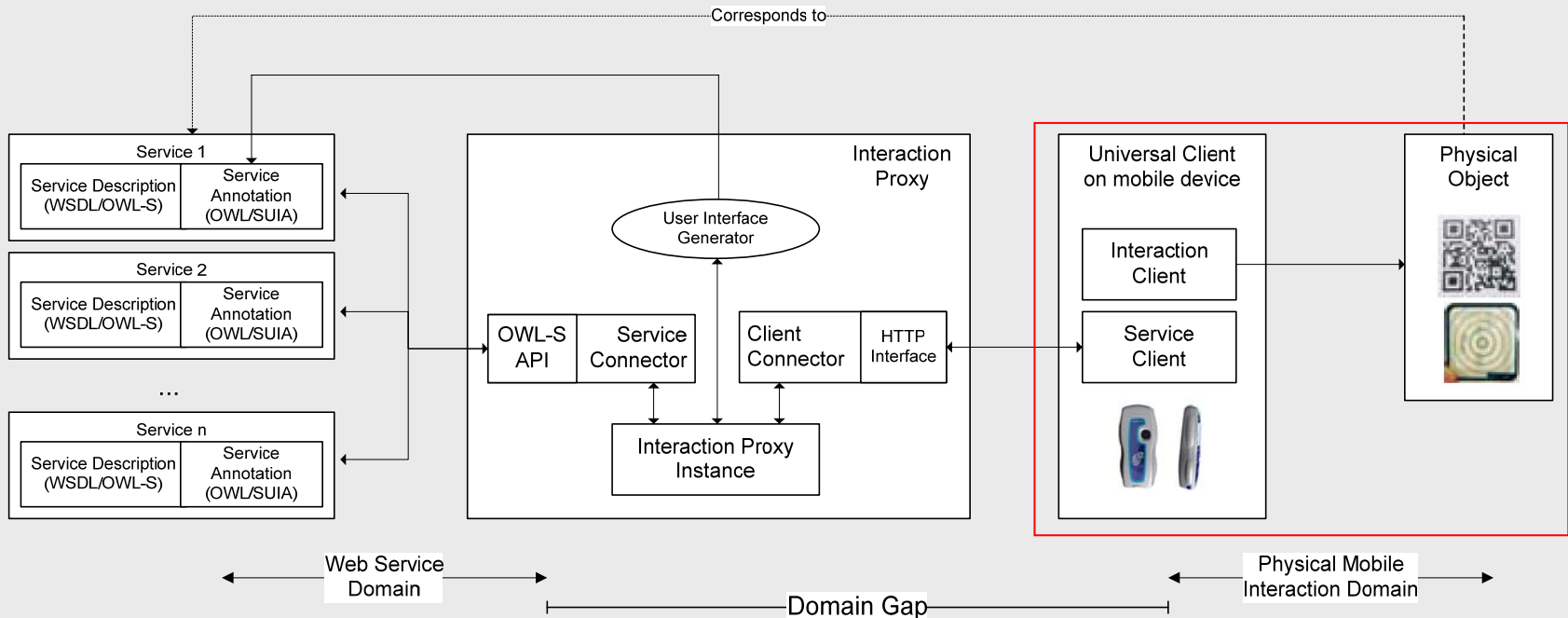


- Interaction Proxy responsibilities and components:
 - Interaction management (*Service Connector*)
 - Automatic user interface generation (*UI Generator*)
 - Interface provision for the Universal Client (*Client Connector*)

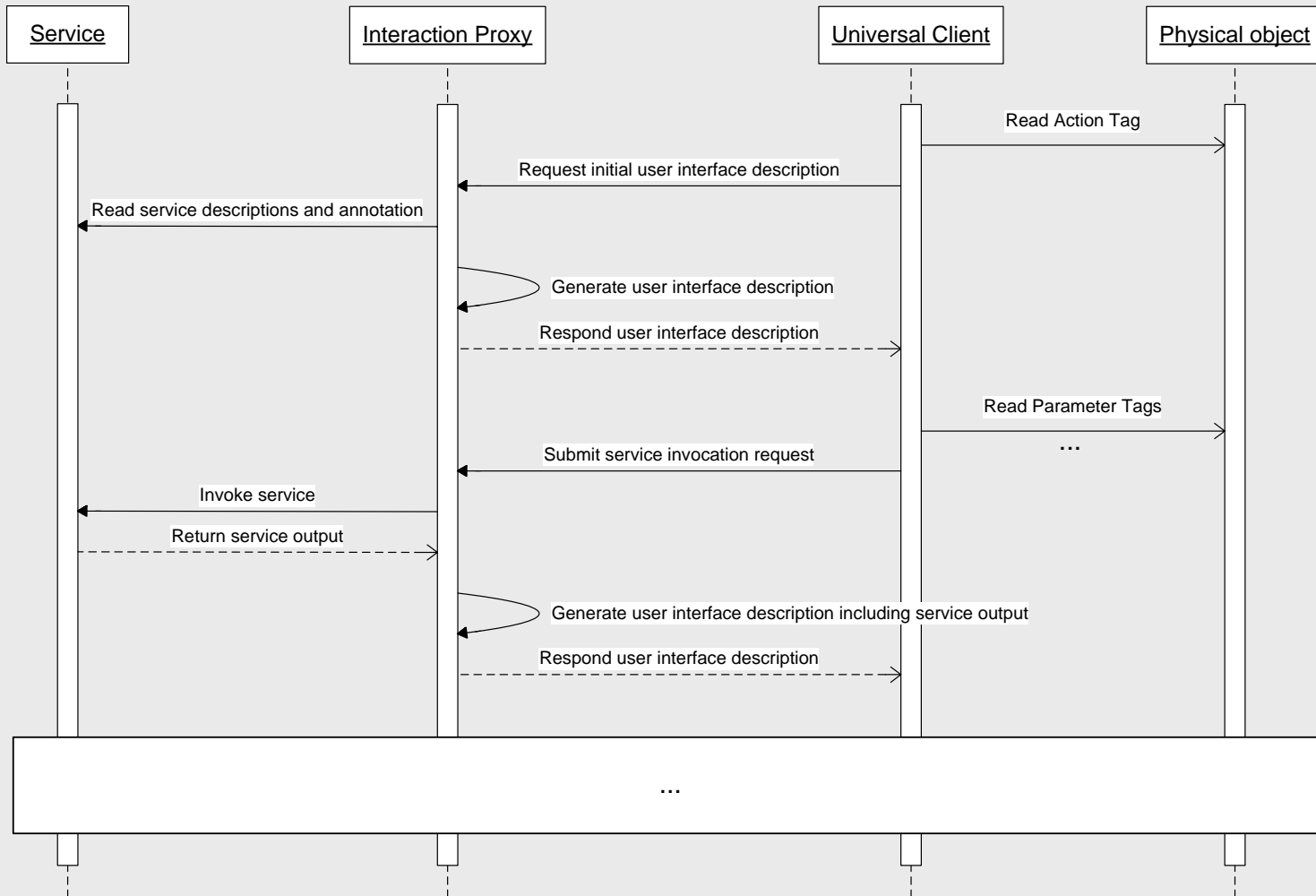




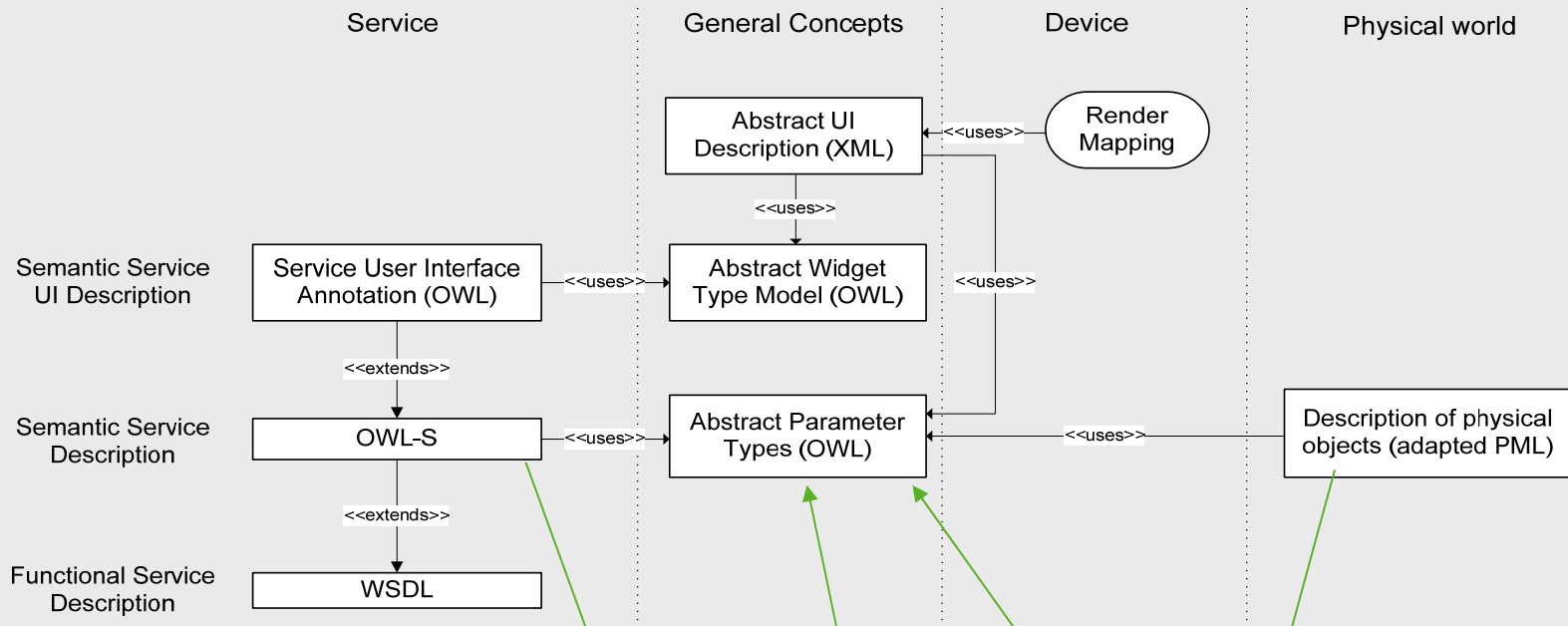
- *Universal Client*:
 - *Service Client* for a bidirect communication with IAProxy
 - *Interaction Client* reads data from *Physical Objects*
- *Physical Objects* store a type and value corresponding to the service



Interaction Sequence



System Descriptions Supporting the Interaction Process



OWL-S:

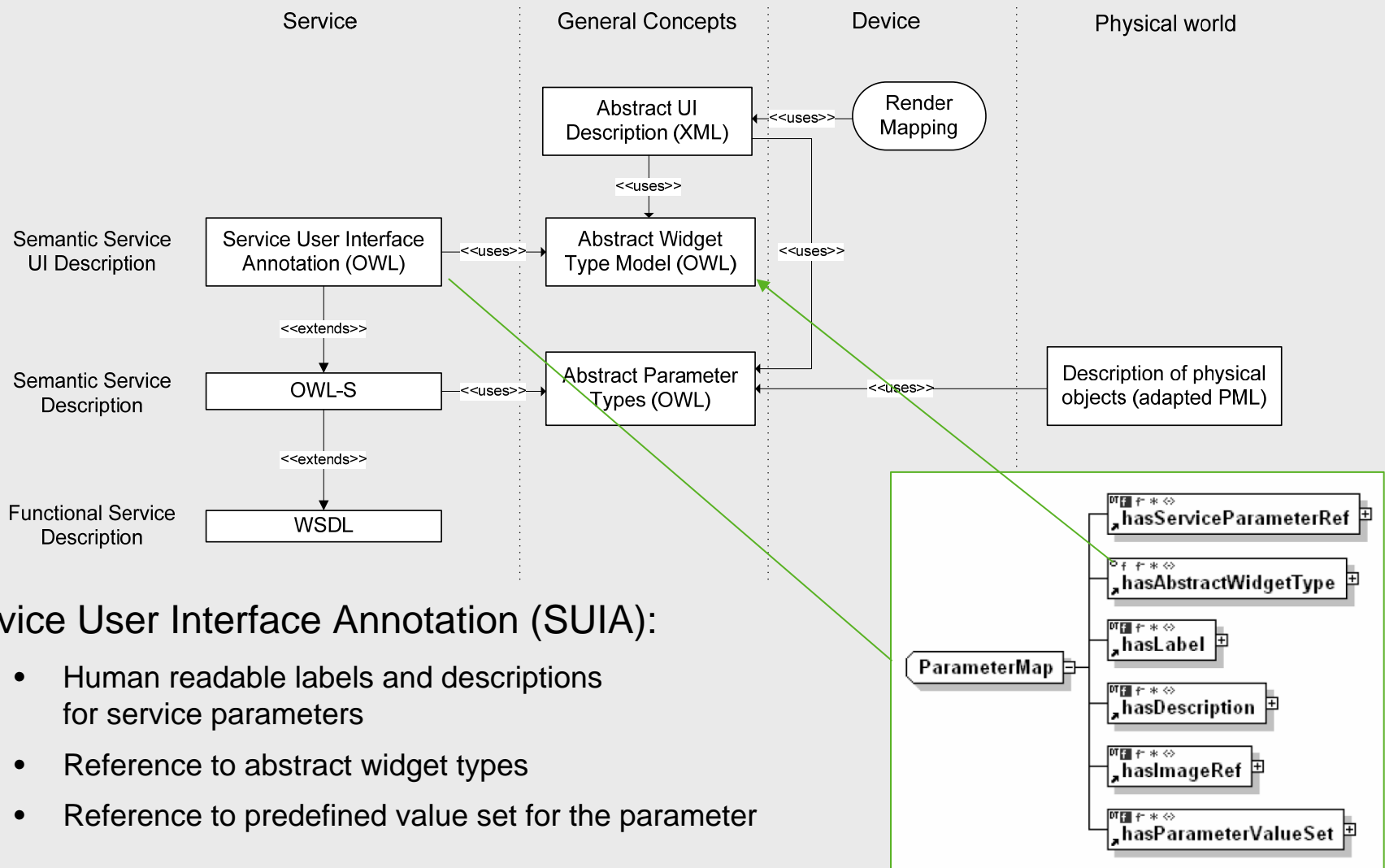
- Models complex interactions
- Not sufficient for UI generation

```

1 <process:AtomicProcess
  rdf:ID="PublicTransportProcess">
  ...
2 <process:hasInput>
3 <process:Input rdf:ID="TicketToBuy">
4 <process:parameterType
  rdf:datatype="&xsd:anyURI">
5 &publicTransportConcepts;#TicketType
6 </process:parameterType>
7 </process:Input>
8 </process:hasInput>
  ...
9 </process:AtomicProcess>
  
```

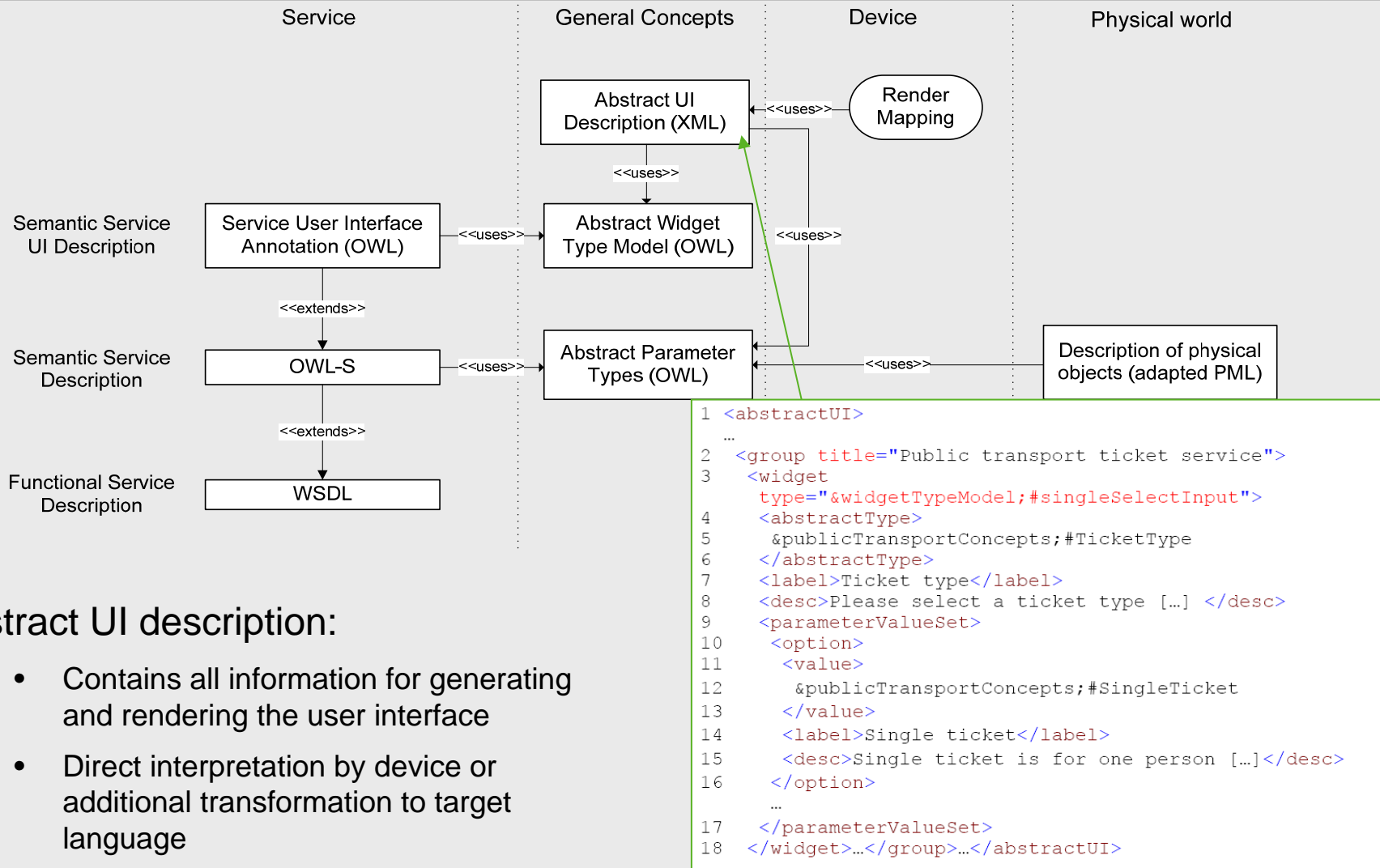
```

1 <tag type="parameter">
2 <abstractType>
  &publicTransportConcepts;#TicketType
</abstractType>
3 <value>
  &publicTransportConcepts;#SingleTicket
</value>
  ...
4 </tag>
  
```



Service User Interface Annotation (SUIA):

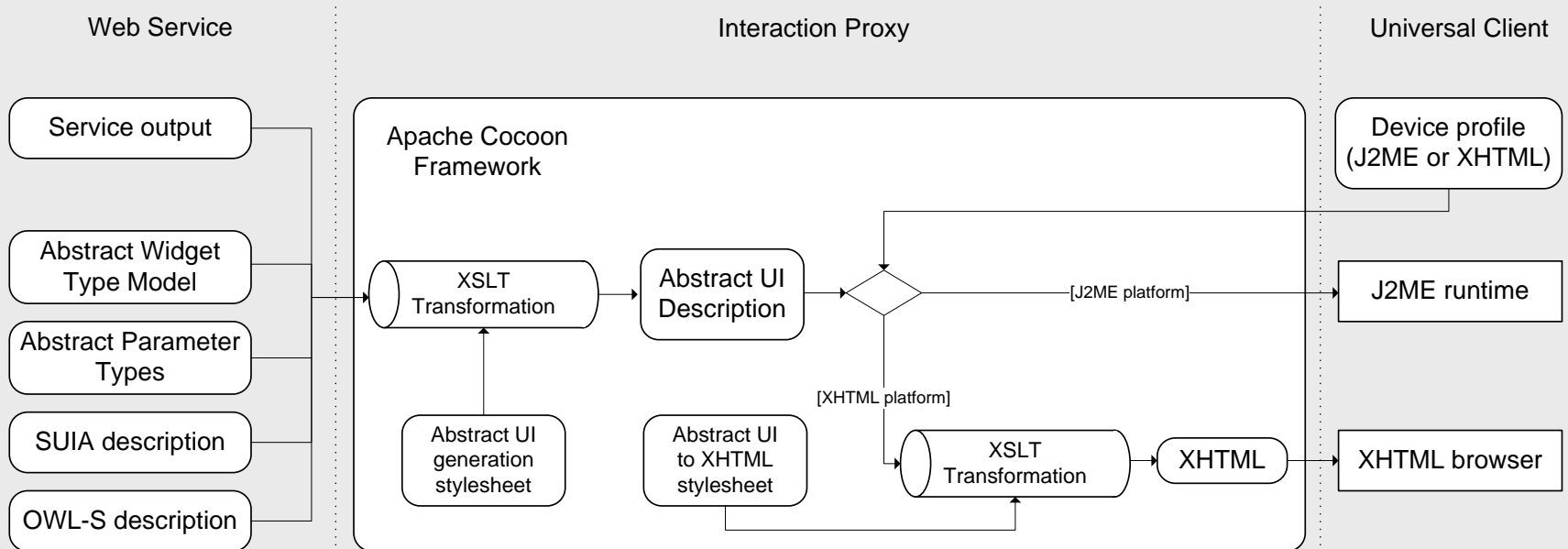
- Human readable labels and descriptions for service parameters
- Reference to abstract widget types
- Reference to predefined value set for the parameter



Abstract UI description:

- Contains all information for generating and rendering the user interface
- Direct interpretation by device or additional transformation to target language

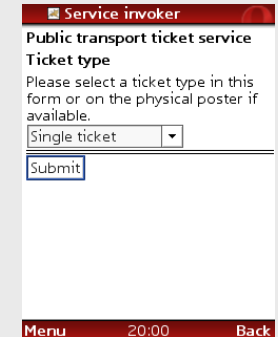
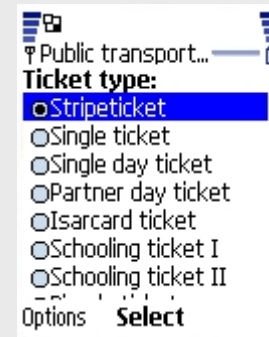
Focus: User Interface Generation Process



XSLT Transformation of different description sources to composed *Abstract UI Description*

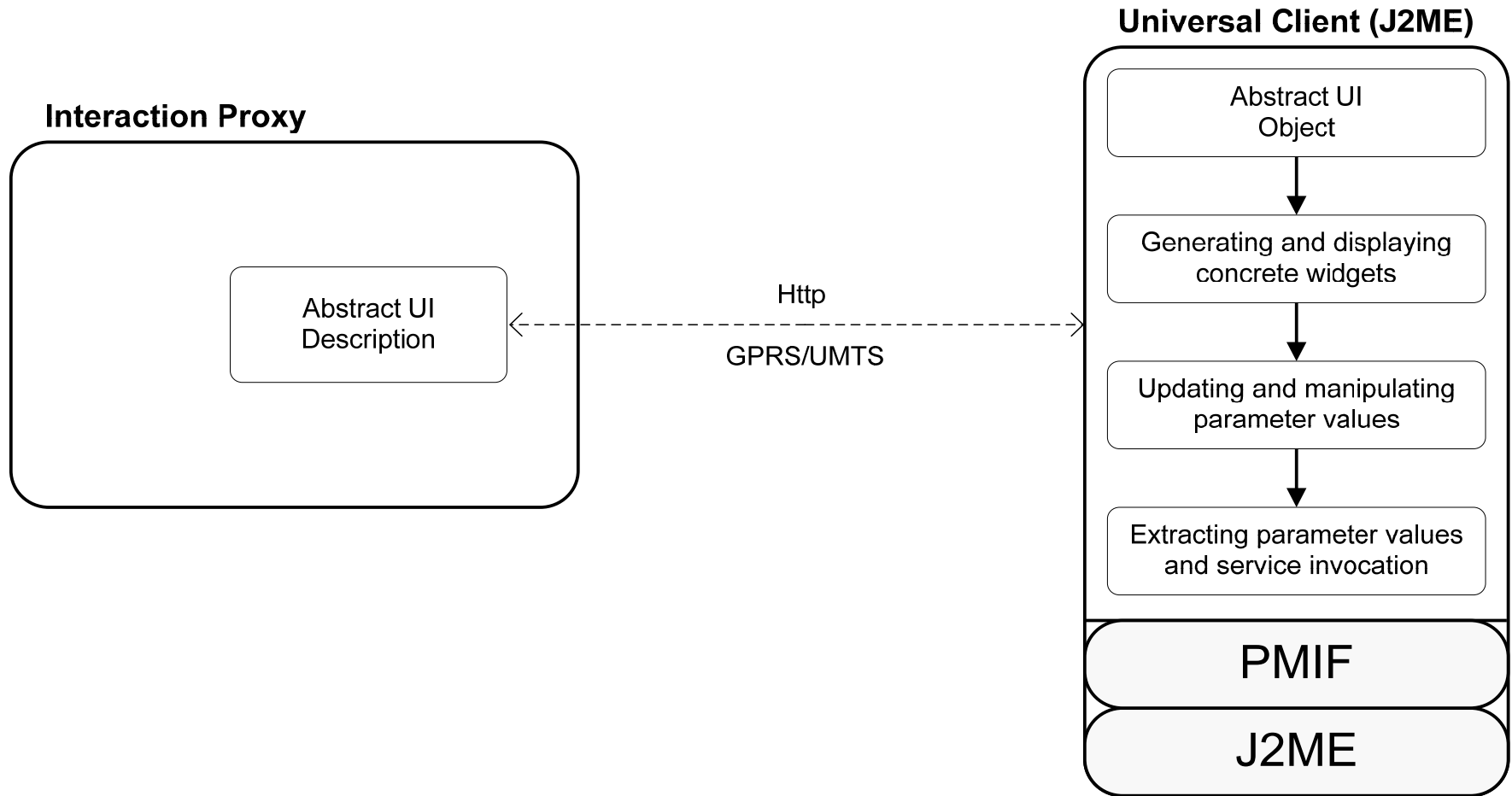
Two target platforms depending on the *Device profile*:

- Direct interpretation on J2ME runtime
- Additional transformation to create a representation for an XHTML browser



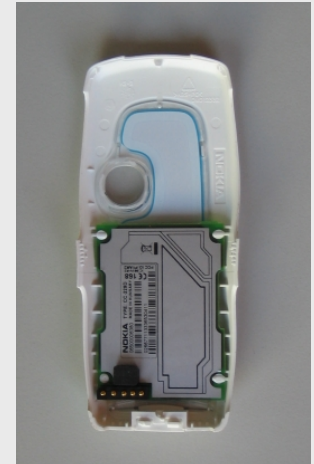


Prototype Client Implementation





- Prototype implemented with J2ME (CLDC 1.0/1.1 and MIDP 2.0), the Nokia RFID & NFC SDK 1.0 and kXML
- Uses NFC and visual marker recognition through PMIF (Physical Mobile Interaction Framework)
- No mobile device with technical outfit to support all technologies at the same time
- Development and testing with Nokia 3220 (plus NFC shell) and 6630 mobile phones
- Posters were augmented with NFC-tags and visual markers from www.visualcode.org



Supported Interaction Techniques



Touching



Direct Input

PERCI Movie Tickets

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- 2) On the poster, select the task you want to accomplish.
- 3) Follow the instructions on your mobile phone.
- 4) Select the options on the poster that are appropriate for your task.

Select a Cinema

- Max
- Mathäser
- Marmorhaus
- Gloria

Select Number of Persons

- 1
- 2
- 3
- 4
- 5



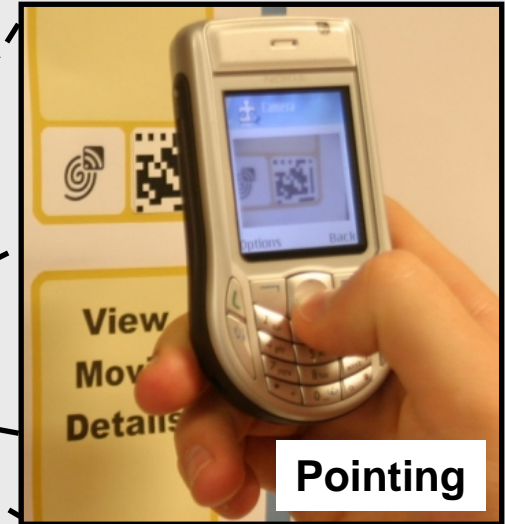
Select a Movie

Select a Task

- Order Movie Ticket
- View Movie Details

Select a Timeslot

- 13:00
- 15:00
- 17:00
- 20:00
- 23:00

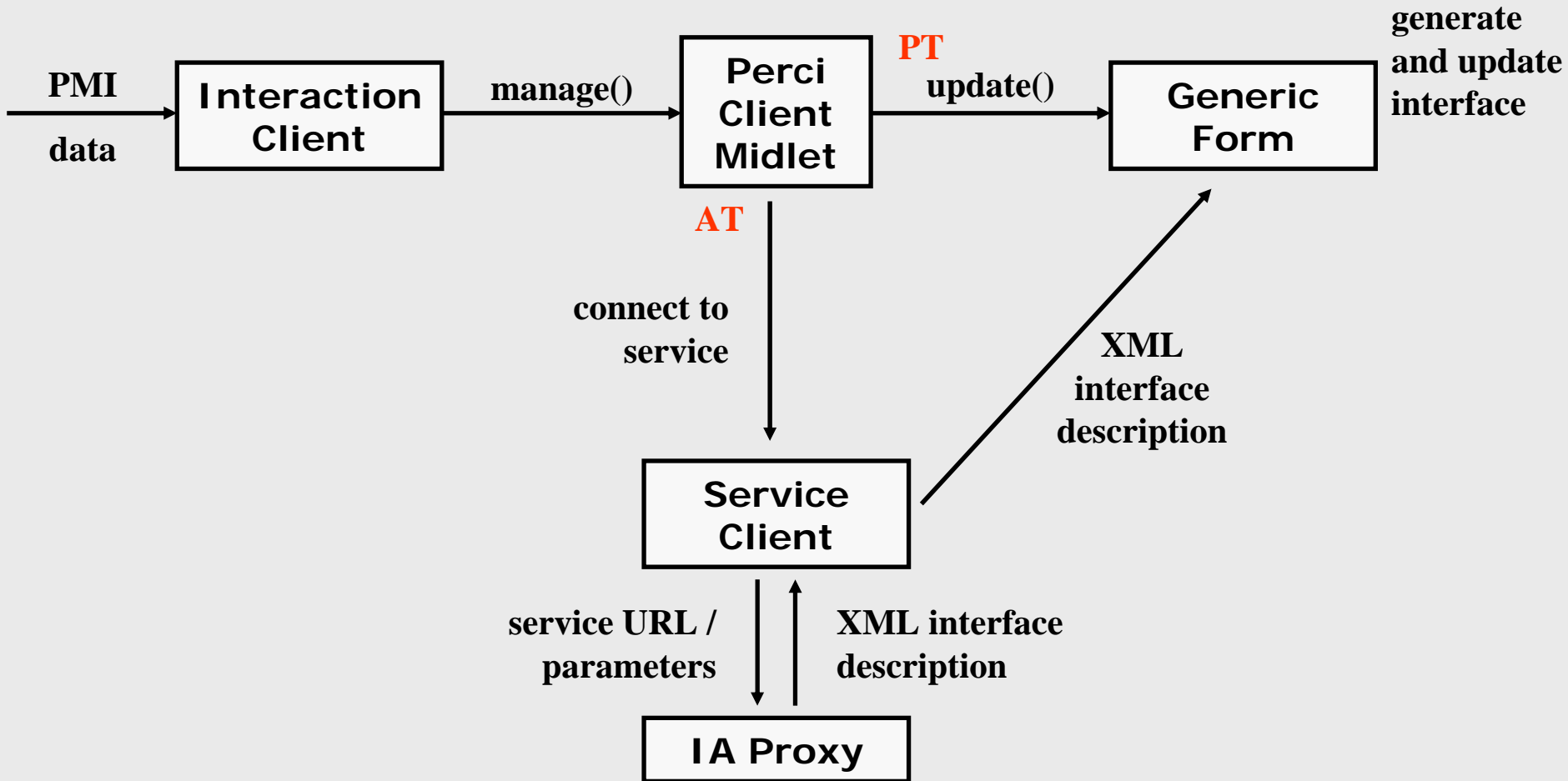


Pointing



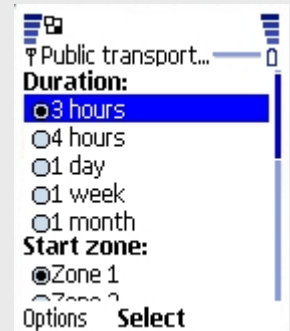
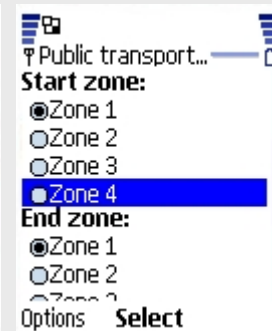
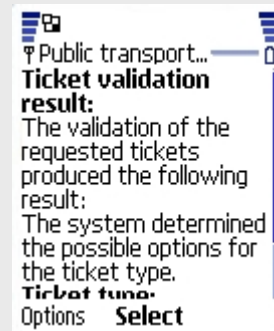
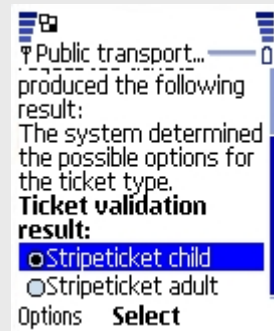
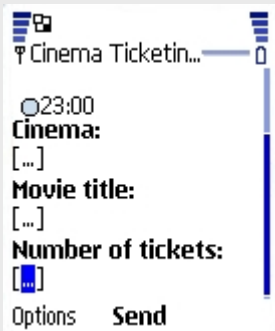
- **InteractionClient:**
Encapsulates and manages different PMIF interaction technologies and techniques that provide interpretation of marker based data
- **PerciClientMidlet:**
Manages the application logic through an update mechanism that handles information acquired through Physical Mobile Interaction
- **ServiceClient:**
Manages connection to the Interaction Proxy and the retrieval of interface descriptions according to user/device context
- **GenericForm:**
Interface container; generates concrete widgets from AbstractUIDescriptions, manages the interaction with them and updates them upon Physical Mobile Interaction







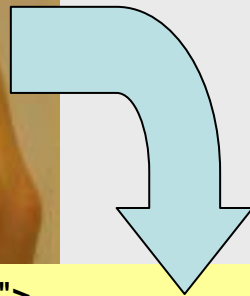
- AbstractUIDescription is parsed into an UIObject as the basis for the interface generation
- The Abstract Widget Type Model is used to map different widget-descriptions to concrete J2ME widgets
- Mapping is decided by the client and its context (e.g. support for different interaction techniques or user preferences)
- Widgets are created anonymously and have to be stored and registered for future reference (e.g. for updating widgets or reading their values for service invocation)





```

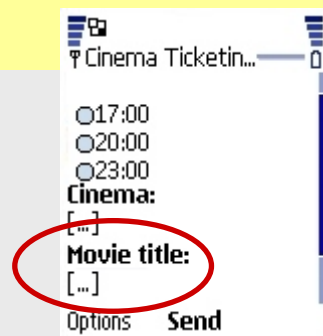
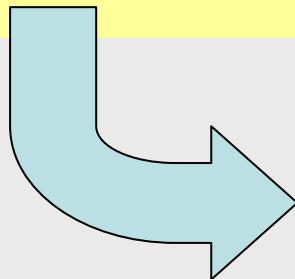
- <abstractUI>
- <group title="Cinema Ticketing Service">
- <widget type="http://perci.medien.ifi.lmu.de:8080/axis/ui/ParameterTypeModel.owl#singleSelectInputParameterType">
  <abstractType> http://perci.medien.ifi.lmu.de:8080/axis/domain/cinema/cinema.owl#Time </abstractType>
  <label>Timeslot</label>
  <desc> Please select the timeslot in this form or on the physical poster if available. </desc>
  <image> http://perci.medien.ifi.lmu.de:8080/axis/serviceDescription/extendedCinema/image4.jpg </image>
  <parameterValueType>http://www.w3.org/2001/XMLSchema#string</parameterValueType>
- <parameterValueSet>
- <option>
  <value>14:00</value>
  <label>14:00</label>
  <desc>N/A</desc>
  </option>
+ <option></option>
</parameterValueSet>
</widget>
+ <widget type="http://perci.medien.ifi.lmu.de:8080/axis/ui/ParameterTypeModel.owl#singleSelectInputParameterType">
  <group>
</abstractUI>
  
```

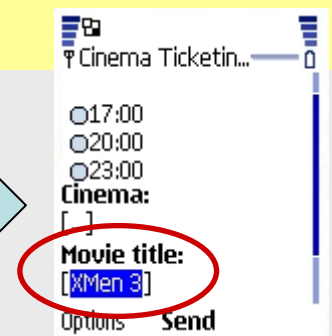
```

<tag type="parameter">
  <abstractType>http://perci.medien.ifi.lmu.de:8080/axis/domain/cinema/cinema.owl#MovieTitle</abstractType>
  <value>XMen 3</value>
  <label>XMen 3</label>
  <desc>The X-Men make a last stand in the war between humans and mutants.</desc>
</tag>

```



**Matching Abstract
Parameter Types**

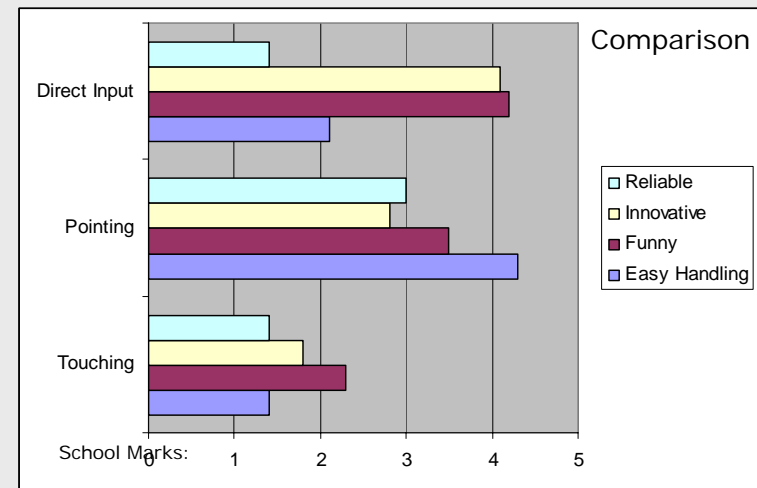
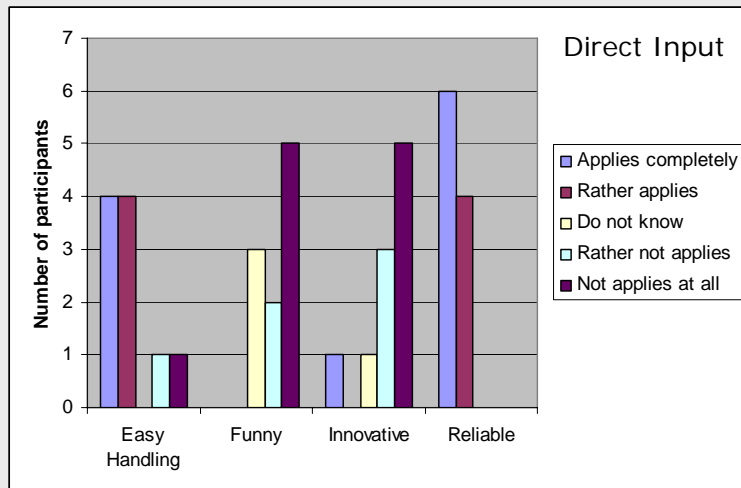
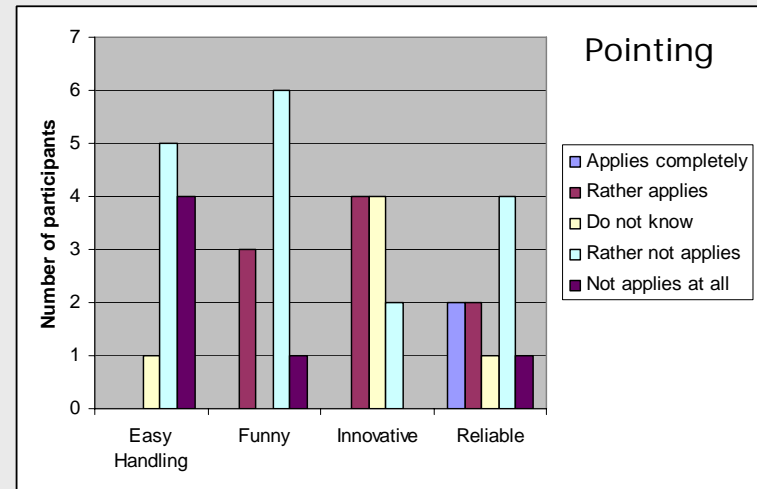
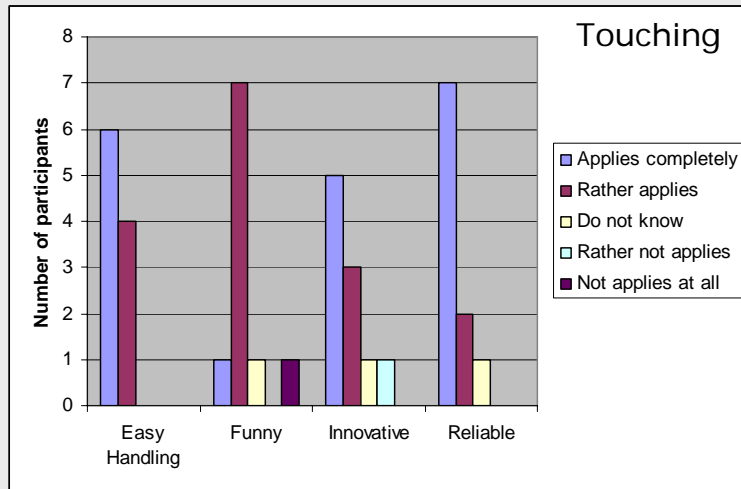


User Study and Prototype Evaluation



- 10 participants, aged from 23 to 46 (average 30.7), 8 participants with technical background
- Process
 - User-Experiment: Accomplish to buy cinema tickets for given properties. Use all interaction techniques (Touching, Pointing, Direct Input).
 - Post-Survey: Quantitative rating of interaction techniques
- User experiment results:
 - Good acceptance of the prototype in general, but strongly depending on the used interaction technique
 - Initial problems with the workflow of the interaction (Action and Parameter tag configuration, no attention to description)
 - Uncertainty about interaction order on the poster
 - Many participants wanted to use the interface directly for inputs although having been advised to use Touching or Pointing







Conclusion and Future Work



- Generic approach and architecture for a framework enabling Physical Mobile Interactions with the Internet of Things:
 - Support for the complete Physical Mobile Interaction workflow
 - Adaptation of SWS to model complex interactions, e.g. interaction sequence
 - Flexible abstract type system to link physical objects with service parameters
 - Automatic user interface generation from service descriptions and annotations
 - Abstract UI widget model independent from specific platforms
- UI adaptation to J2ME runtime and XHTML browser
- J2ME client prototype supporting the interaction techniques Touching, Pointing and Direct Input



Framework

- Assumptions are made regarding the message format of the service => Flexible interpretation of Web Services necessary to extend existing Web Services, e.g. Ebay Web Service
- Extend use of context information
- Extend the Abstract Widget Type Model to other widgets and modalities

Mobile Client

- Solve issues identified in the second high-fidelity user study
- Implementation of other interaction techniques

Physical Mobile Interaction (Posters)

- Cross-poster interactions; parameter-tags could be used with other posters
- General tag could describe poster and its tags => input for generic service search

Authoring

- Tedious and error-prone creation of service description and service annotation, only partially automated
- Desired: Fully automated creation of descriptions => Project Thesis of Christian Braun



Questions?

Thank You!