Mediation Chain Generation in Pervasive Environments

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Agenda

- Introduction
- State of the Art
- Problematic Challenges and Related Work
- Background: Creating Pervasive Applications
- Proposition
- Implementation
- Validation
- Conclusion and Future Work

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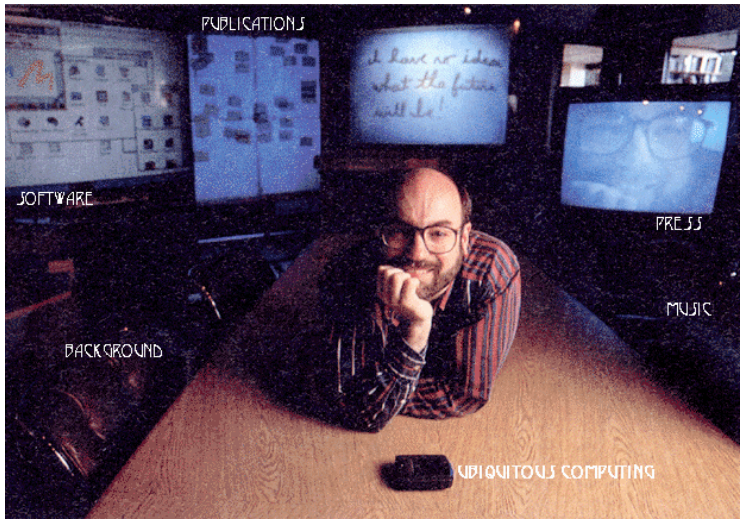
Pervasive (ubiquitous) Computing

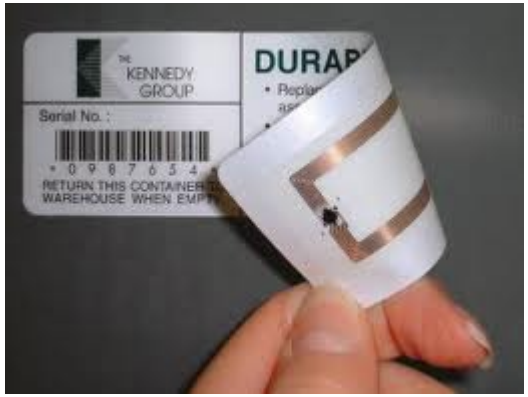
„Ubiquitous computing names the third wave in computing, just now beginning. First were mainframes, each shared by lots of people. Now we are in the personal computing era, person and machine staring uneasily at each other across the desktop. Next comes ubiquitous computing, or the age of calm technology, when technology recedes into the background of our lives.“



Mark Weiser (1952-1999)

Pervasive (ubiquitous) Computing

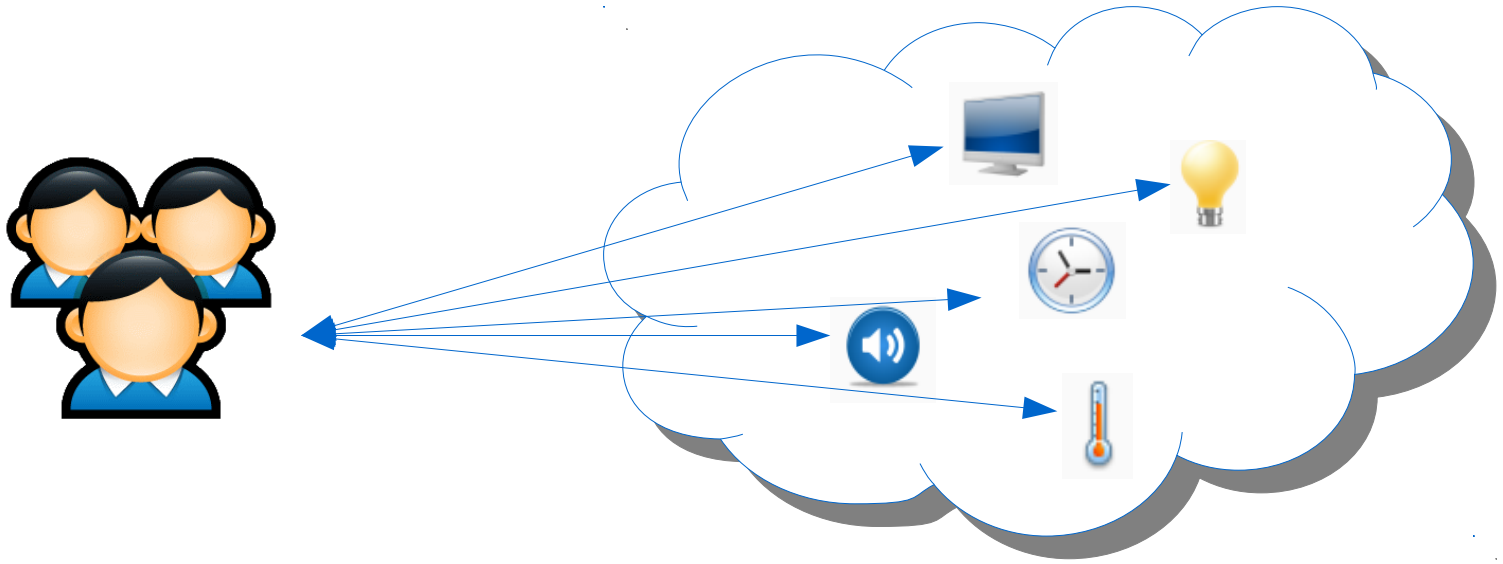
Thre are three main categories of devices: small, hand-size and large



Pervasive Environment

Pervasive Environment consists of computing devices integrated into everyday objects

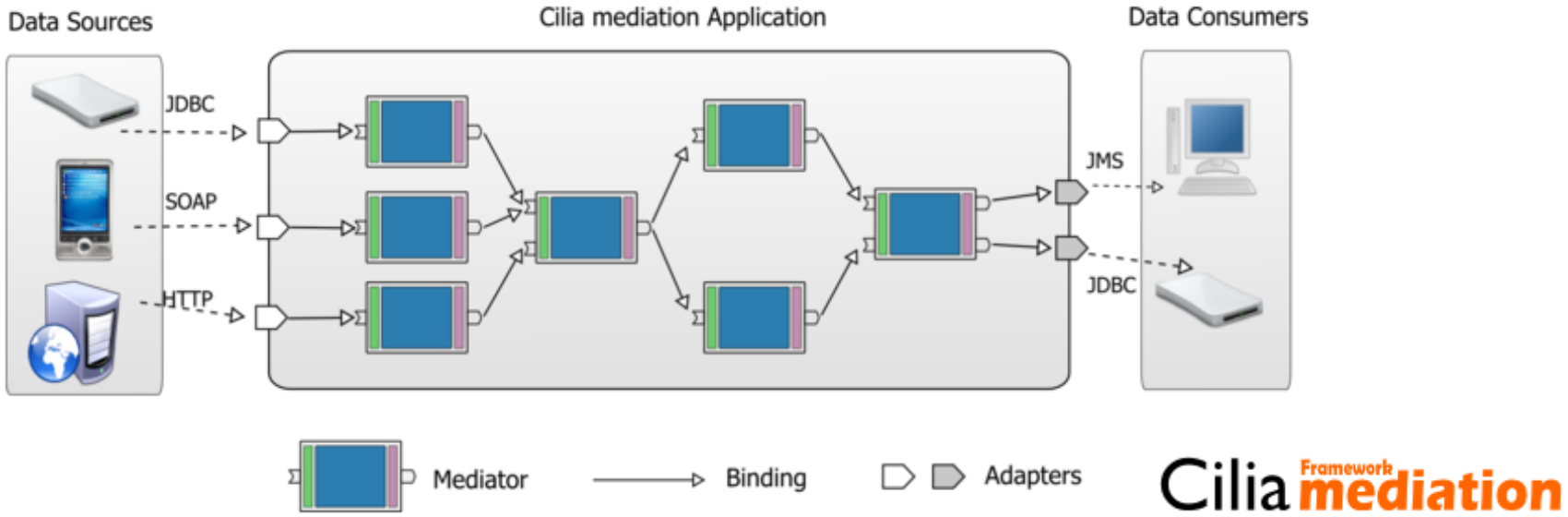
Freely shared, multi-purpose devices integrated into everyday objects used by users in different contexts.



Mediation & Mediation Chain

Mediation consists of

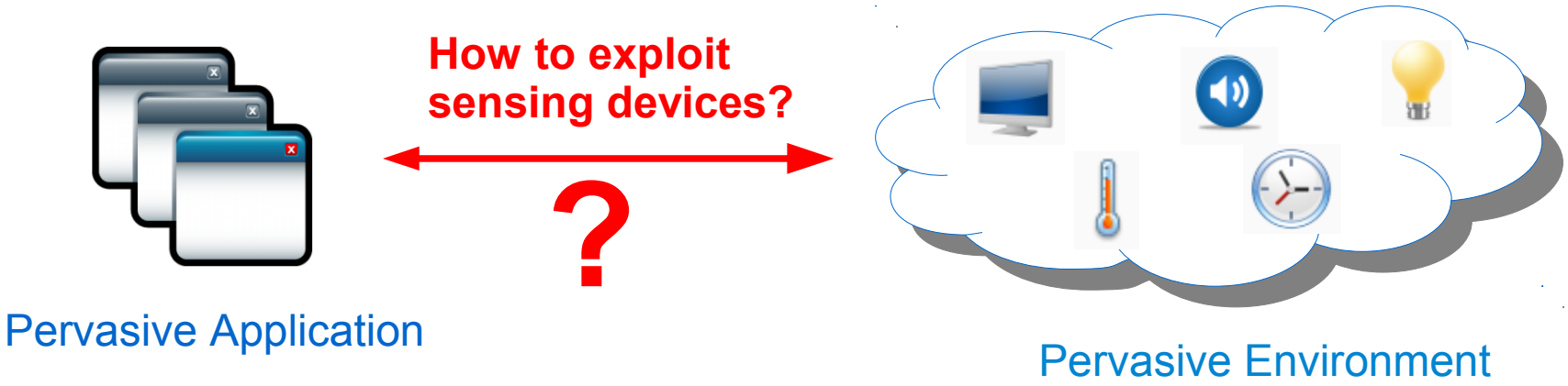
- Data Collecting
- Synchronization
- Mediation Logic Execution (i.e. data transformations)
- Routing and Delivery via Mediation Chain



Motivation

When building pervasive applications, it is necessary to exploit sensing devices in pervasive environment, but:

- Sensing devices have heterogeneous interfaces
- Devices often produce different data (different unit, time interval, format, ...)



As a result, an integration solution is needed

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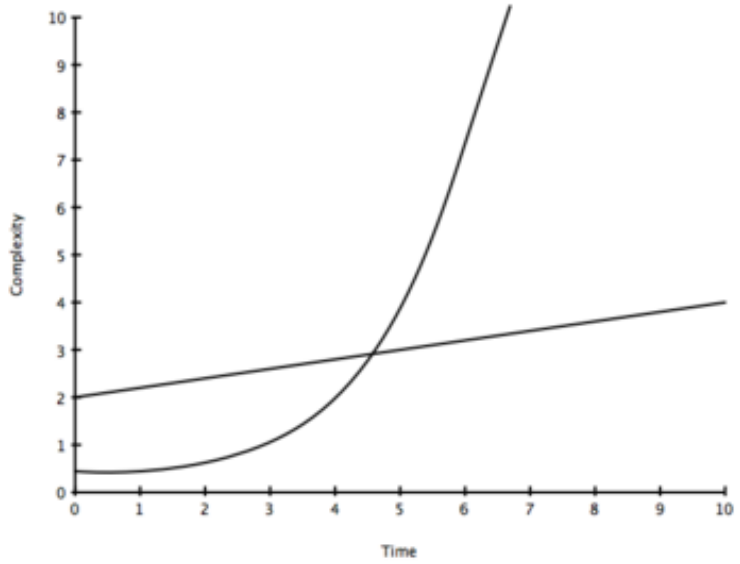
State of the Art

New challenges...

- Complexity
- Dynamism
- Heterogenity

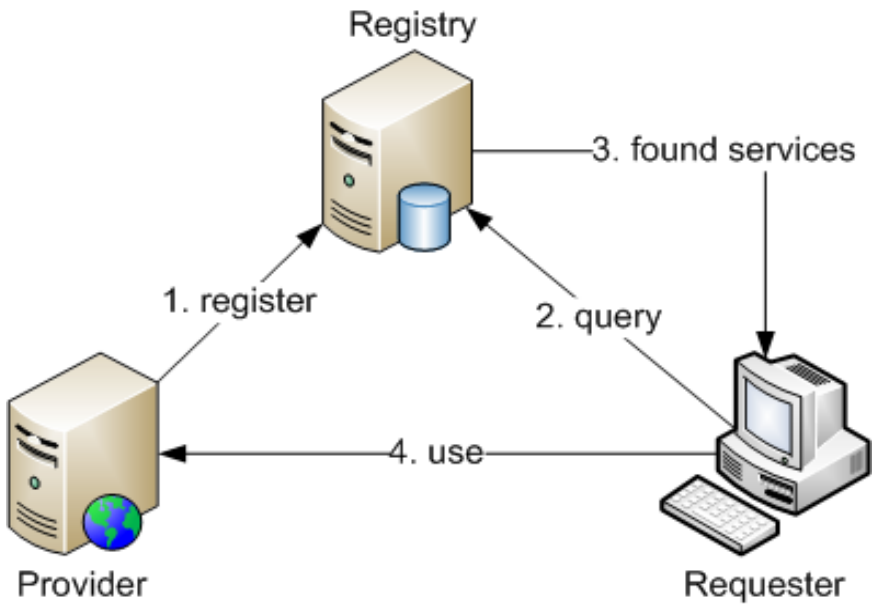


… bring new solutions:

- Component-Based Software Engineering
- Service-Oriented Computing
- Mediation

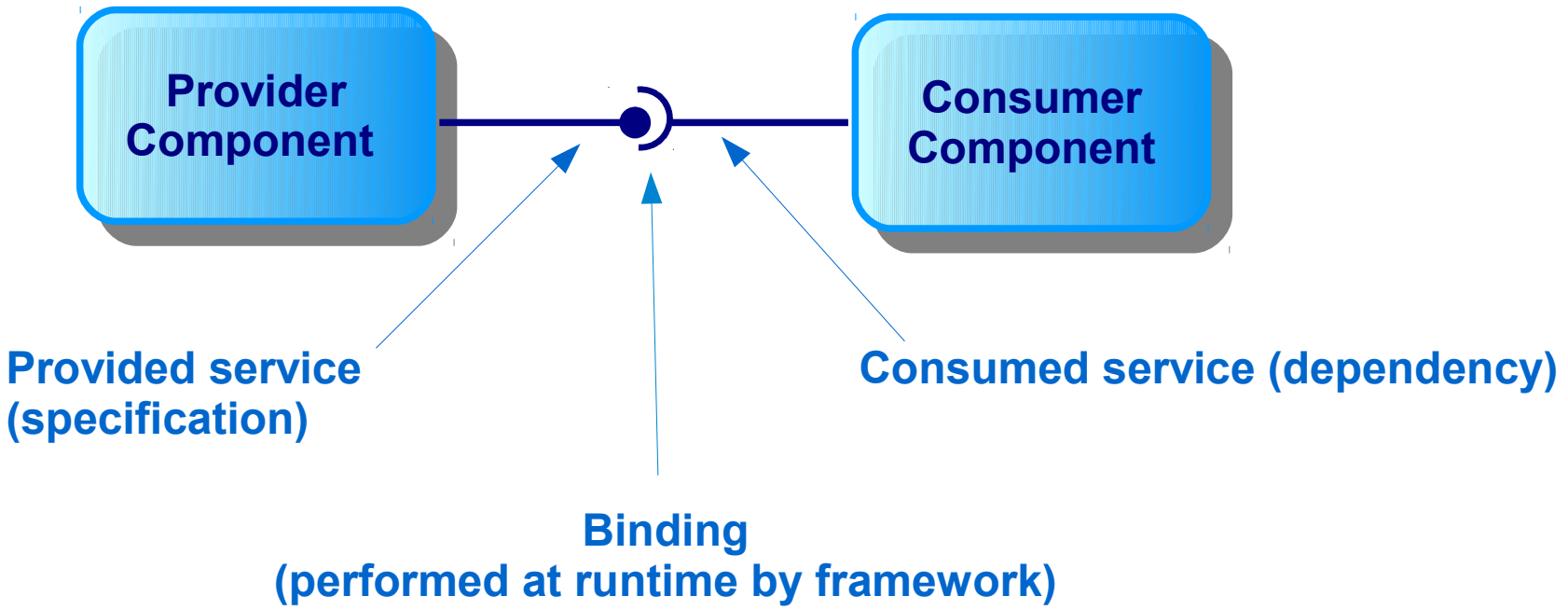
Service-Oriented Computing

- Schema



- Advantages
  - Loose-coupling: only service contract is shared
  - Late-binding: on-demand binding
  - Evolution: a provider can be replaced

Service-Oriented Components

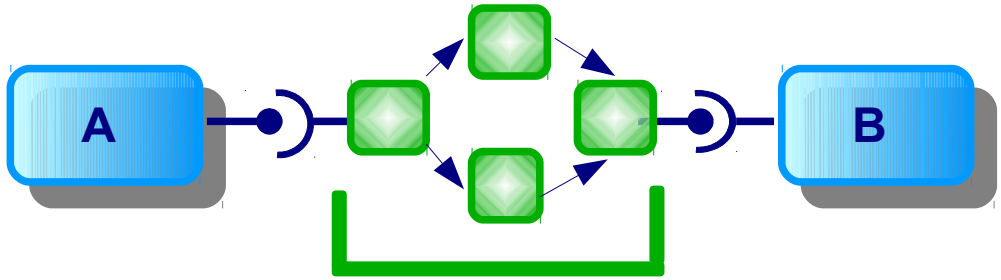


Integration

- Proxy based integration

- Advantages
  - Separation of concerns
- Disadvantages
  - Lack of modularity
  - Lack of composition

- Platform-based integration



- Advantages
  - Composition of transformations
  - Modular
- Disadvantages
  - Complex, hard to introspect

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Problematic Challenges

Integration issues of devices in pervasive environment:

- Data Representation (i.e. different units)
- Dynamism (devices may appear or disappear anytime)
- Configuration (amount of manual configuration)
- Timing aspects (data aggregation, sync vs async)

Related Work

PervML

- Generation of code from several models
- Doesn't address heterogeneity

SStream

- Considers data from sensors as tuples
- Interpretation of data is delegated on the client

EEML

- Extensible Environment Markup Language
- Flexible scheme for representation of data from sensing devices
- Used in Cosm project

DynaMo

- Dynamic Multimodal Interface
- Integration based on proxies, semantic and type of data

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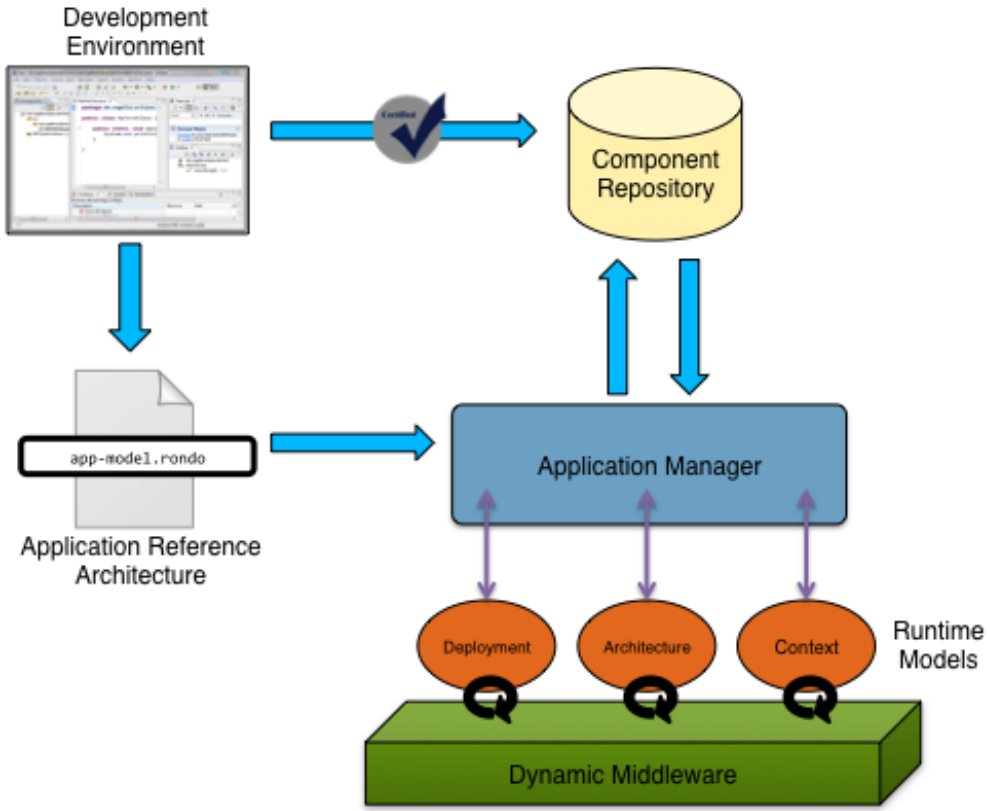
Rondo Framework

Global scheme: Model-Driven approach of Rondo



Framework for defining and dynamically assembling service-oriented components

Background: Creating Pervasive Applications

- Aspects of pervasive applications addressed by Rondo:
  - Discoverability
  - Context (i.e. User's location)
  - Dynamic Adaptability
  - Composability
- Rondo is essentially functional today
- Components need to express high-level dependencies to the data produced by devices.

Goal of this work

- Propose smarter integration of sensing devices in the Rondo approach by generating mediation flow from high-level description that:
  - Hides the complexity of heterogeneous devices
  - Provides unified access to underlying devices
  - Provides unified data
  - Provides additional capabilities (transformations)

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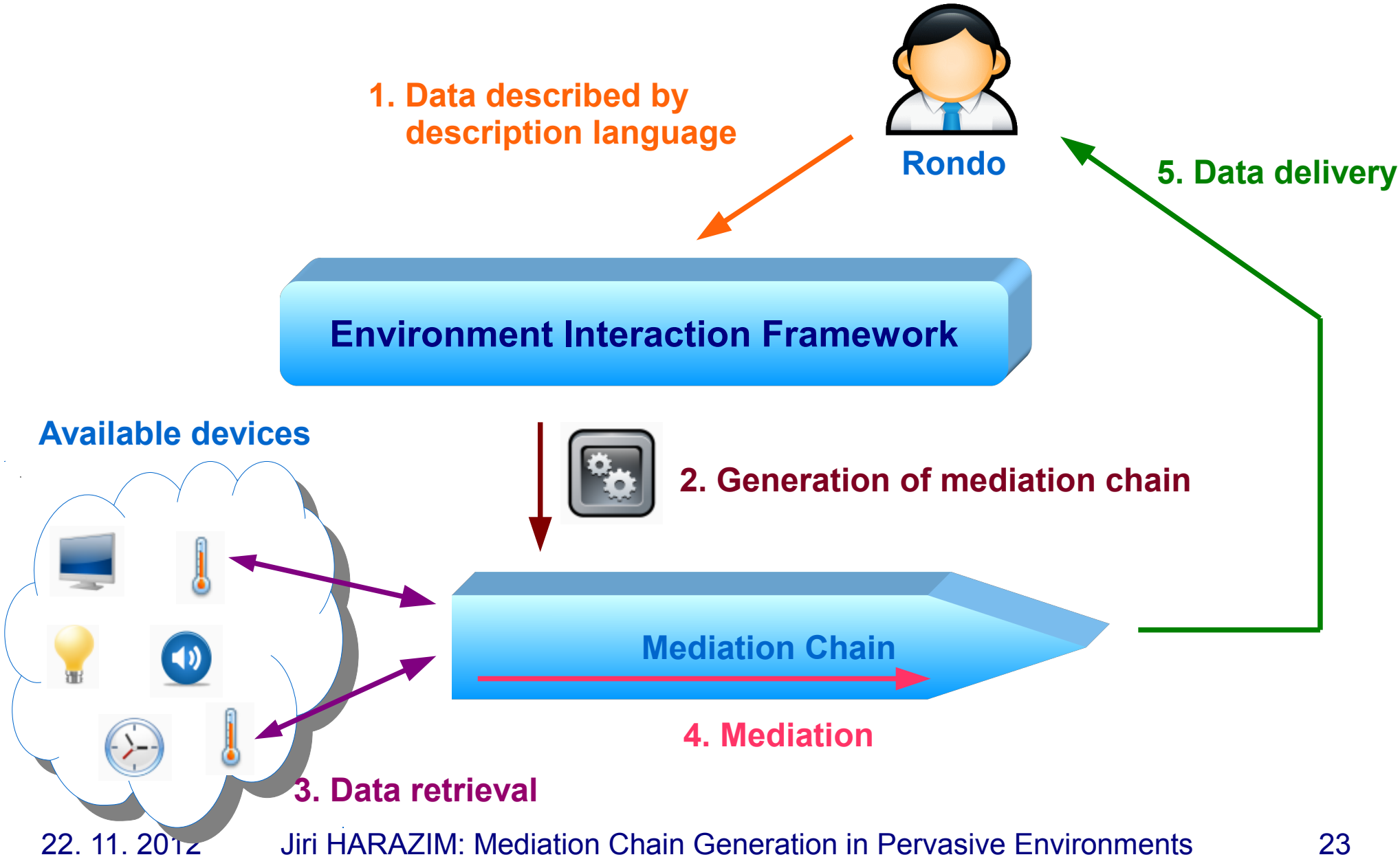
Proposal

- Incorporate concept of Semantic Tag
  - Human-understandable semantic expression associated with various devices: humidity, presence, temperature, illuminance etc.
- Extend the Rondo language by mediation concept
  - Uses expressive filter (RFC#1960) applicable on data
  - Contract of Mediator: tries to translate data before filtering (i.e. (location=livingroom) but device may produce location=living-room or room-04 although they denote the same location)
- Use Cilia as underlying component model in the generation phase
  - Enables dynamism, modularity, follows EAI patterns

Environment Interaction Framework



Description Language

- Consists of tag & filter
- Tag denotes the semantic meaning of data that is collected in environment.
  - Emphasis on semantic aspect instead of form of data
  - For example: ”temperature”, ”humidity”, ”illuminance”, ”sensed-presence-of-human” etc.
- Filter influences generation of mediation chain
  - Incorporates mediators to enable transformation
  - By chaining mediators it is possible to obtain quite complex behaviour

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Implementation

EIF

- Available as a service with simple and intuitive API
- 3 OSGi bundles (API, Controller and Cilia-Components)
- 20 Cilia components for additional transformations
- Independent from underlying technologies

Used technologies

- Cilia Mediation Framework
- Apache iPOJO
- Apache Maven
- JScience library

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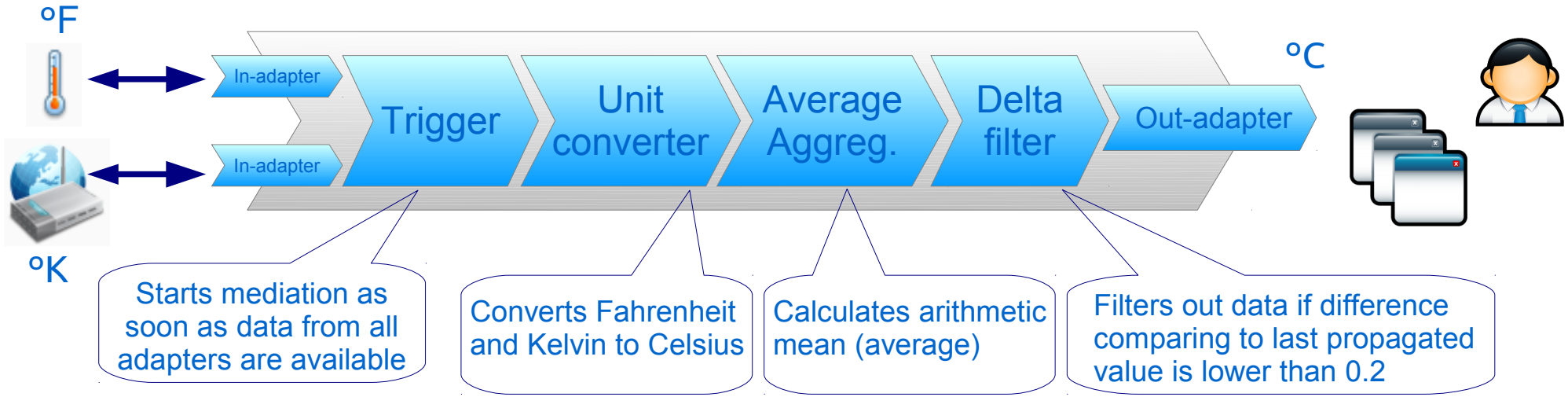
Validation

Validation

- Scenario based on real use-case brought by ADELE tested on iCASA: Digital House Simulator

Scenario

- Human's presence in the house triggers actions (switches on/off light, air-condition etc.) based on certain conditions that are retrieved from sensing devices via EIF (such as time, illuminance and temperature)



iCASA House Simulator

Devices for: Home (All)

Devices for Home (All)

Device Name	Location	Usable *	Fault	Details
Kitchen Thermometer Sensor	kitchen	deactivated	no	...
Bedroom Thermometer Sensor	bedroom	activated	no	...
Kitchen Lamp	kitchen	activated	no	...
Livingroom Hi-Fi	livingroom	activated	no	...
Bathroom Lamp	bathroom	activated	no	...
Livingroom Thermometer Sensor	livingroom	activated	no	...
Bedroom Thermometer Sensor	bathroom	activated	no	...
Livingroom Halogen Lamp	livingroom	activated	no	...
Bedroom Halogen Lamp	bedroom	deactivated	no	...

Applications

Simulated Users

Device List

Simulated Time & Date

Bedroom Halogen Lamp
Serial Number: Elektro-Halogen4000-985614-65891-78
Fault NO
State deactivated

Livingroom Thermometer Sensor
Serial Number: SekuSensor-AAA-20119915-F
Temperature 296.15
Fault NO
State activated

Livingroom Halogen Lamp
Serial Number: Elektro-Halogen4000-453147-08234-88
Fault NO
State activated

Validation

Validation in practice

- Verified against validation scenario
- Tested with various combinations of mediators
- Exploited advanced features such as unit conversions
- Full integration with all sensing devices in iCASA such as thermometers, presence sensors, noise sensors, illuminance sensors and power-consumption sensors

iCASA: Digital House Simulator

Conclusion and Future Work

Conclusion

- Generates mediation chain and provides additional transformations of sensed data
- Simplifies the development of pervasive applications (the simplest mediation chain can be created and started in only 2 lines of code)
- EIF will be integrated in Rondo Framework

Future Work

- Integration into Domain-Specific Language in Rondo
- Extend description language and enable hierarchical data
- Two-way interaction with environment
- More components (triggers & mediators)

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Questions?

The End

Thank you for your attention!

Implemented Transformations

- Implemented Cilia components for mediation can be combined and chained to obtain desired behaviour.
- 3 triggers
- 10 processors (aggregators, statistical ops., converter ..):

  Average Aggregator, Delta filter, Forward processor, Max Aggregator, Min Aggregator, Min filter, Max filter, OlderThanFilter, Sum Aggregator filter, Unit converter
- 6 + 1 adapters

Sources

Pics:

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