Context-Aware Service Selection Using Graph Matching

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Outline

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- Motivating scenario
- Problem statement
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- Describing context-aware services
- Graph-based matching algorithm
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What is the MUSIC Project?

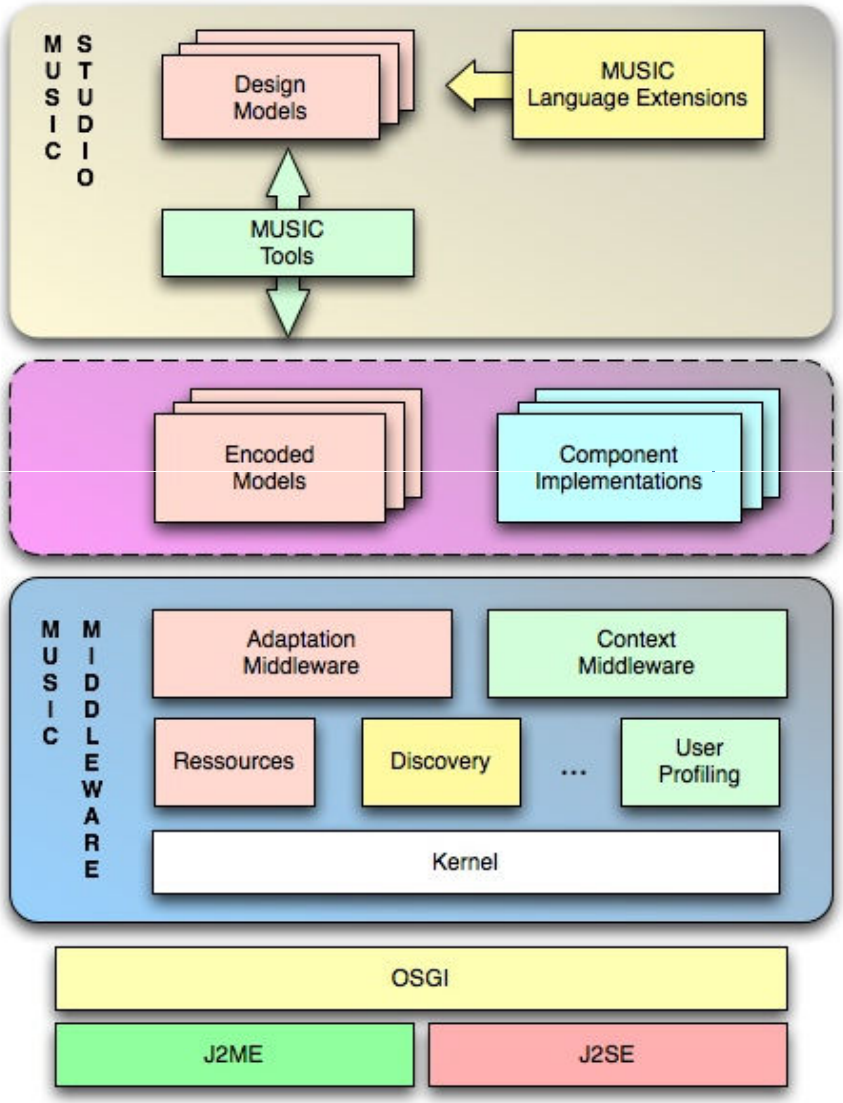
- IST-MUSIC
  - ➢ www.ist-music.eu
- *MUSIC: Self-adapting applications for **M**obile **Us**ers **I**n ubiquitous **C**omputing environment*
- Focus on the development of context-aware and self-adapting applications
  - Software systems capable of being adapted to highly dynamic user and execution context

6th Framework programme

Information Society Technologies

MUSIC Project

- Variability support at design and runtime
- Exploiting variability and non-functional properties of context-aware services
  - Several implementations with the same functional capabilities
  - Different non-functional context-related properties



Motivating scenario

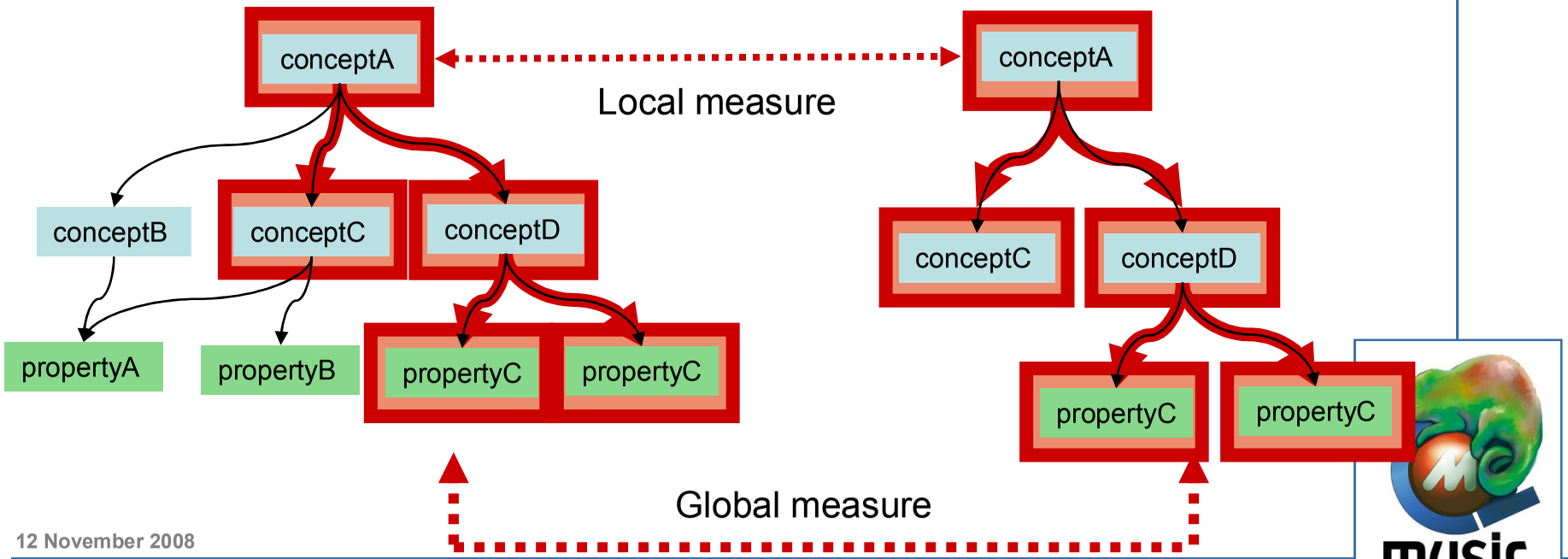
- Mobile content sharing platform
  - Sharing content scattered on mobile devices
- Context-aware services dynamically proposed
  - Different versions of a service
    - Each version indicates appropriate contextual conditions
  - Context-related non-functional properties
  - Variations of photo sharing service
    - for client devices with high *resolution* and *memory* capacities
    - for a given location (*e.g. a conference hall*)
    - for a particular user profile (*e.g. adult users)*

Problem statement

- Several context-aware services available
  - Several services matching functional requirements
  - Different context-related non-functional properties and conditions
- Execution context detected by the client
  - Context information can be incomplete
    - Sensors failures leading to missing information
- Mismatching risks
  - How to perform matching if context information is missing?
- Focus on non-functional properties

Proposal overview

- Graph-based matching of non-functional properties of context-aware services and current execution context
  - Service properties and execution context as graphs
  - Matching using similarity measures



Describing context-aware services

- Service descriptions in OWL-S
- Service profile enriched with contextual properties
  - New element "context"
  - External file containing context information
  - Service state and conditions
  - Easy update of context-related information
- MUSIC Context Model
  - Context element referring to an entity and a scope, considering a given representation

Graph-based matching algorithm

- Goal: rank available services based on contextual non-functional properties
- Describing a graph : $G = <\underbrace{\text{Context Elements}}_{\text{nodes}}, \underbrace{\text{Relations}}_{\text{edges}}>$
- Comparing graphs from :
  - Context description of the services
  - Current execution context on the client
- Two-phase matching
  - Comparing nodes locally: local measures
  - Comparing graph globally: global measures

Local measures

- Comparing two context elements
  - $Sim_l\ (C_{Ei}, C_{Ej}) = x \in [0, 1]$
- Local measure depends on the context scope
  - Comparing only compatible scopes
  - Considering supported representations
- MUSIC middleware keeps a library of Sim_l measures
- Only best-ranked nodes are considered for global measure

Global measures

- Comparing overall composition of two graphs
  - $Sim_g\ (G_{Sk}, G_C) = x \in [0, 1]$
    - G_{Sk} : graph from context description of a service *k*
    - G_C : graph from current execution context
- Several measures are possible
  - Graph isomorphism, subgraphing…
- MUSIC Middleware
  - Considering results from local measures
  - Considering nodes and edges
  - Measure based on proportion between best ranked local measures and total number of graph elements

Global measures

Considering that:

$$\text{if } \mathbf{G_{S_k}} = \langle \mathbf{N}, \mathbf{E} \rangle, \text{ where } \begin{matrix} \mathbf{N} = \{\mathbf{C_{E_i}}\}_{1 \le i \le n} \text{ and} \\ \mathbf{E} = \{\langle \mathbf{C_{E_i}}, \mathbf{C_{E_j}} \rangle_k\}_{0 \le k \le m} \end{matrix} \quad then \; |G_{S_k}| = n + m$$

And considering two edges E_i and E_j that:

$$Sim_l(E_i, E_j) = \frac{Sim_l(l_i, l_j) + \sum_1^p Sim_l(C_{E_i}, C_{E_j})}{(p+1)}, where \begin{matrix} l_i \text{ and } l_j \text{are the edges labels, and} \\ C_{E_i} \text{ and } C_{E_j} \text{are edges extremeties} \end{matrix}$$

$Thus, Sim_g(G_{S_k}, G_C)$ *can be defined as:*

$$Sim_g(G_{S_k}, G_C) = \frac{\sum max\left(Sim_l(C_{E_i}, C'_{E_i})\right) + \sum max\left(Sim_l(E_j, E'_j)\right)}{|G_{S_k}|}$$

Conclusions & Perspectives

- Incompleteness of context information handled through similarity measures
  - Missing context information does not stop the matching process
  - Best ranked services (variations) are chosen
- Focus on non-functional aspects
  - Selection among services that match functional aspects
- Evaluation
  - On going with MUSIC Middleware

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Thanks !!

Questions?

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