Imaging Services on the Grid as a Product Line: Requirements and Architecture

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Context: Services for the Grid

- **Grid**
  - *sharing* data, algorithms
  - computation power, data-intensive

- **Workflows for the e-Science Grid**
  - process chain, pipeline, data flow
  - reuse and compose (black) boxes

- **Implemented as Services**

![Diagram of workflow]

- **Preprocess**
  - Registration of IRM sequences
  - Intensity Correction
  - Segmentation
Requirements Overview

Functional
Format: DICOM
Acquisition Model: MRI
Anatomic Structure: Brain
Noise: Not significant

QoS
Accuracy: 80%
Security: None
Reliability: 50%
Execution time: Not specified

Services for image segmentation,
S1
S2

Functional
Format: DICOM
Acquisition Model: MRI
Structure Anatomique: Stomach
Bruit: Dedicated to noisy images

QoS
evaluation: Statistical
Accuracy: 90%
Reliability: 30%

Functional
Format: DICOM
Acquisition Model: MRI
Structure Anatomique: Brain
Bruit: Noise sensitive

QoS
evaluation: Statistical
Accuracy: 85%
Reliability: 50%
Composing Services on the Grid

- How to deploy Grid Services?
  - needs fine-grained information
- How to manage QoS (Quality of Service)?
  - such as execution time, availability, reliability, etc.
- To give information to ...
  - workflow engine, software architect, scheduler

- Our position: a variability problem!
From Service to Product Line (1)
From Service to Product Line (2)
Functional Variability

Magnetic Resonance Imaging

extract: inputs
Functional description: example

Acquisition Model
MRI = MRI T2

Resolution
Spatial Resolution
Dimension = 2D
color = B&W
Noise = none

Anatomic Structure = brain

Format = DICOM
QOS Variability

How to characterize
How to measure
How to compute

Time
Cost
Security
Accuracy
Reliability

Metric

QoS Property

Dimension

Value Type

Dynamic

Static

Input

Output

Operator

Conditions

<=

maximum

minimum

Measurable

Non Measurable

Unit

Comparable

Non Comparable
QoS description: example

**Metric**
- measurable = true
- unit = %
- comparable = true
- type = numeric

**Dimension**
- accuracy = high
- time = any
- ...

**Computation**
- dynamic = true
- rely_on = output
- accuracy = good

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**QoS Property**

**Metric**
- Measurable
  - Unit
    - %
  - Comparable
  - Value Type
    - Numeric
  - Accuracy
- Computation
  - Dynamic
    - accuracy
  - Output
    - good

**Output**
- <=
- Output
Segmentation: refining classification

QoS depends on application domain:
- goal of segmentation
- body region
- imaging protocol

“A particular segmentation may have high performance in determining the volume of a tumor in the brain on an MRI image,

... but may have low performance in segmenting a cancerous mass from a mammography scan of a breast”

Dimensions: time and space complexity, accuracy, robustness, precision, specificity, sensibility

Interdependency between QOS and Computation of QoS:
- costly but precise
- quick but uncertain
- evaluation has a QoS too
Towards SPL: big picture
Towards Service product line

- Service Product Line
- Service Product Line segmentation service
- Service Product Line registration service
- Behaviour + QOS + variability
- Service Metamodel
- QoS Metamodel
- Grid Metamodel
- Service Repository
- Grid workflow expert
- Medical imaging computation expert
- Workflow
- One Workflow
An MDE Approach

Equipping Service/Workflow with meta information
- A common core (QOS & service metamodels)
- Specific branches

Building the SPL
- Describing a generic Domain-Specific service / workflow
- Specifying composition protocol of one service
- allow to address different workflow
- includes also variability

Approach
- Model Driven Engineering (MDE)
- Platform independent, abstraction
- Model transformation and/or model composition
An MDE Approach

Model-Driven Engineering

Service Metamodel
QoS Metamodel
GRID Metamodel
SPL Metamodel

Model abstraction of services

Service Repository

Selection
Deployment

Workflow?
Service Composition

eHealth domain
Instance of the SPL

transformation

Platform dependent

GRID Engine

Model-Driven Engineering
On-going Work

- QoS multi-views
  - experts collaboration
  - from end users to services

- How to infer a SPL?

- Derivation process
  - who for the reasoning process?
  - heuristics needed

- From Service to workflow
From Service to Workflow

Behaviour + QOS
+ variability

Service Metamodel
QoS Metamodel

Service Repository

Medical imaging computation expert

Grid workflow expert
Questions?