Issues in Managing Variability of Medical Imaging

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MICCAI Grid
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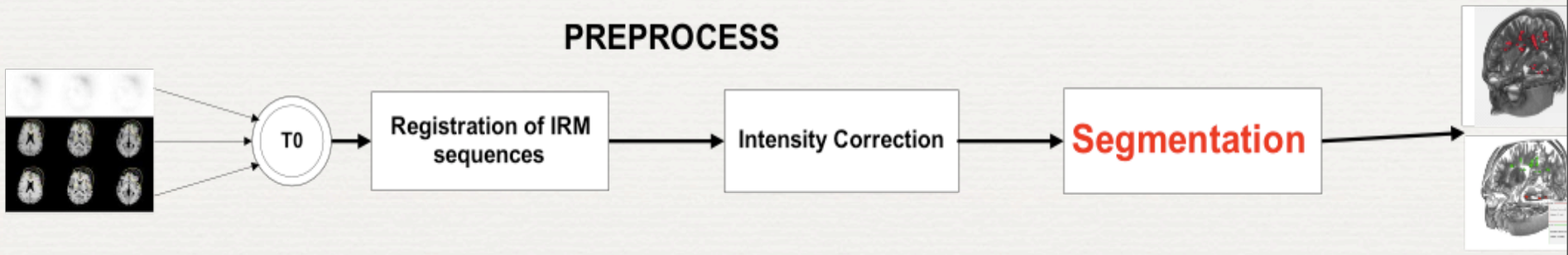
Université Nice SOPHIA ANTIPOLIS
CNRS CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE
i3S sophia antipolis
RAINBOW

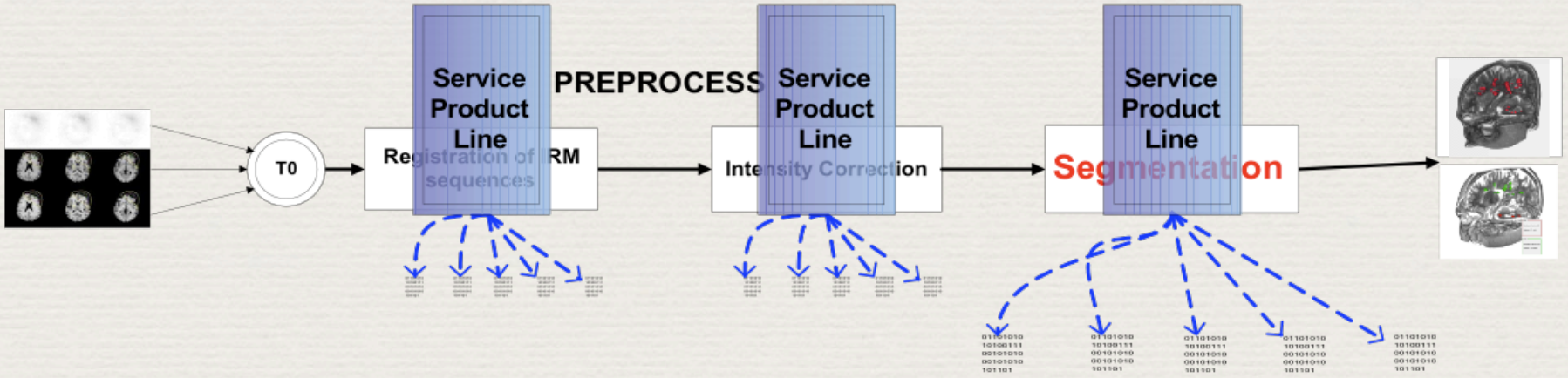


Variability

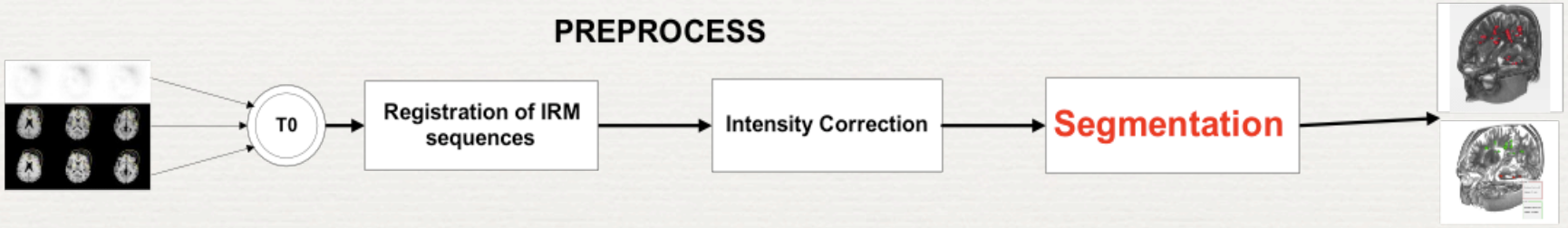
Functional

QoS description

QoS computation



Capturing commonality and variability ...

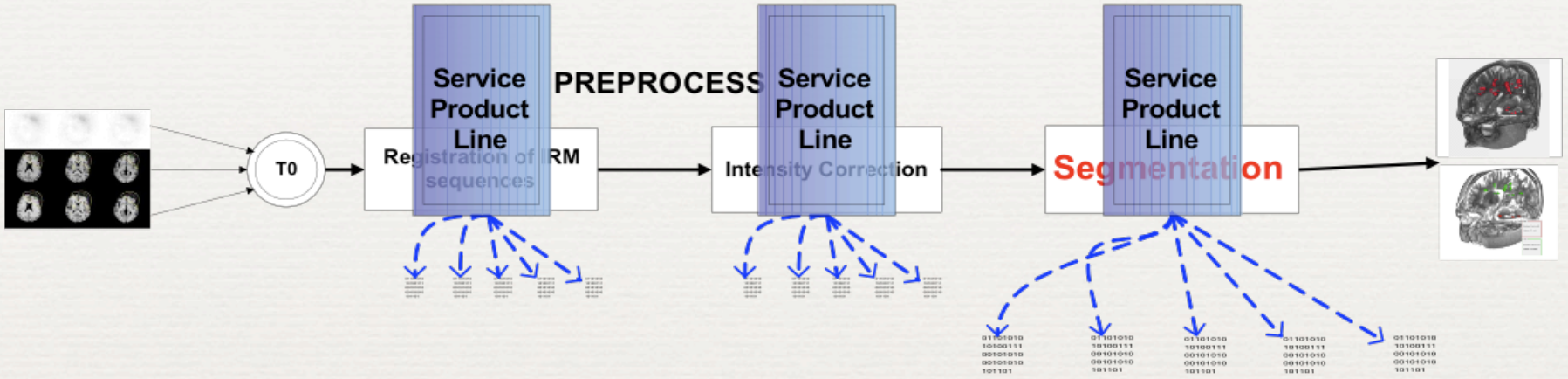


Capturing commonality and variability ...

Vehicle Navigation Systems
(# variants >> 10)

Driver Assistance Systems
(# variants >> 100)

Engine Control Systems
(# variants >> 1000)



Capturing commonality and variability ...

Vehicle Navigation Systems
(# variants >> 10)

Driver Assistance Systems
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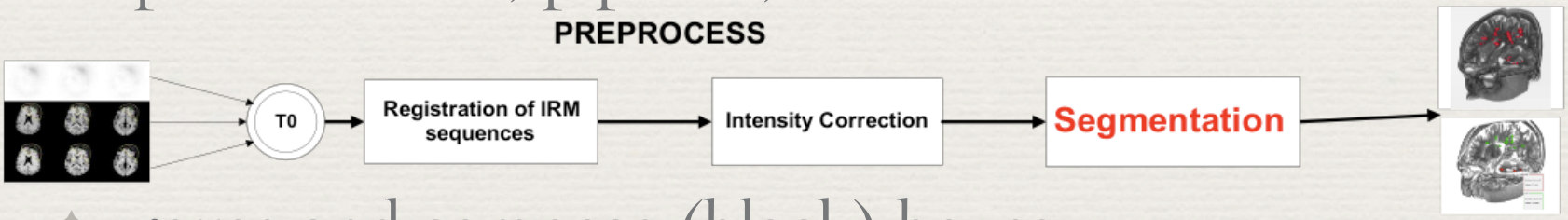
Engine Control Systems
(# variants >> 1000)

Services for the Grid

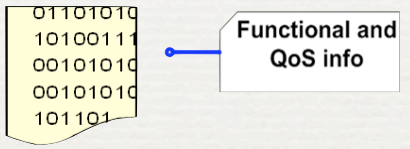
- Grid
  - sharing datas, algorithms
  - computation power, data-intensive
- Workflows for the e-Science Grid
  - process chain, pipeline, data flow



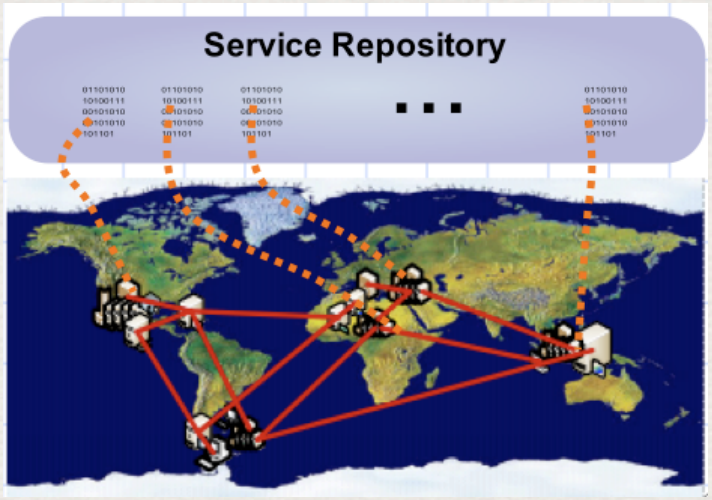
  - reuse and compose (black) boxes

Compose Services on the Grid : Requirements

- Easing the composition process
  - error-prone
  - functionnal / QoS / data / context / * **driven**



- How to manage QoS (Quality of Service) ?
  - 5 dimensions, 3 domains



- infrastructure
- distributed system
- business domain
- time, cost, fidelity, reliability, security

- Our position : a variability problem !

An analysis of variability in medical imaging

- Intuition : variability of the behaviour
  - different qualities and focus on QoS
- Segmentation as a running example
  - crucial and preliminary step in imaging analysis
  - a problem without general solution
- Standard quality measure requested [Zhang 2001]
  - analytical methods
  - goodness methods
  - discrepancy methods

Variability of QoS Segmentation

QoS depends on application domain [Udupa et al. 2006]

- 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"

QoS dimensions in our context

- Refine QoS characteristics in medical imaging [Jannin et al. 2002]
  - time and space complexity
  - accuracy, robustness
  - precision, specificity, sensibility [Popovic et al. 2007]
- Interdependancy between QoS
- Computation of QoS
  - costly but precise VS quick but uncertain

Handle Variability

- Introduce variability within services

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(# variants >> 10)

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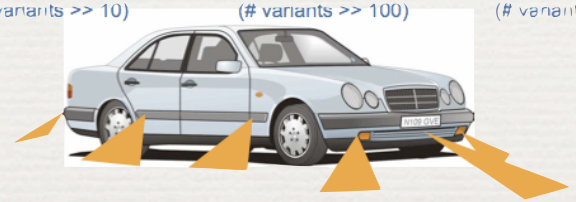
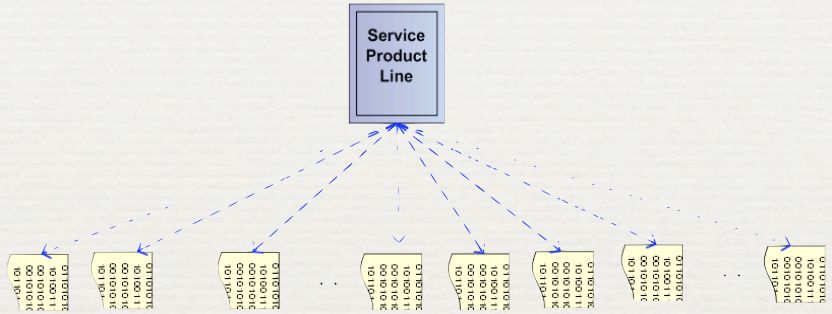
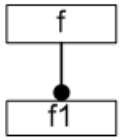
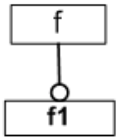




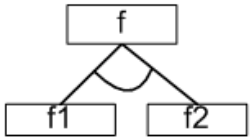
- Model Driven Engineering (MDE)
- Capture the domain knowledge
  - structure the information
- Platform independent
- Abstraction
- Transform models



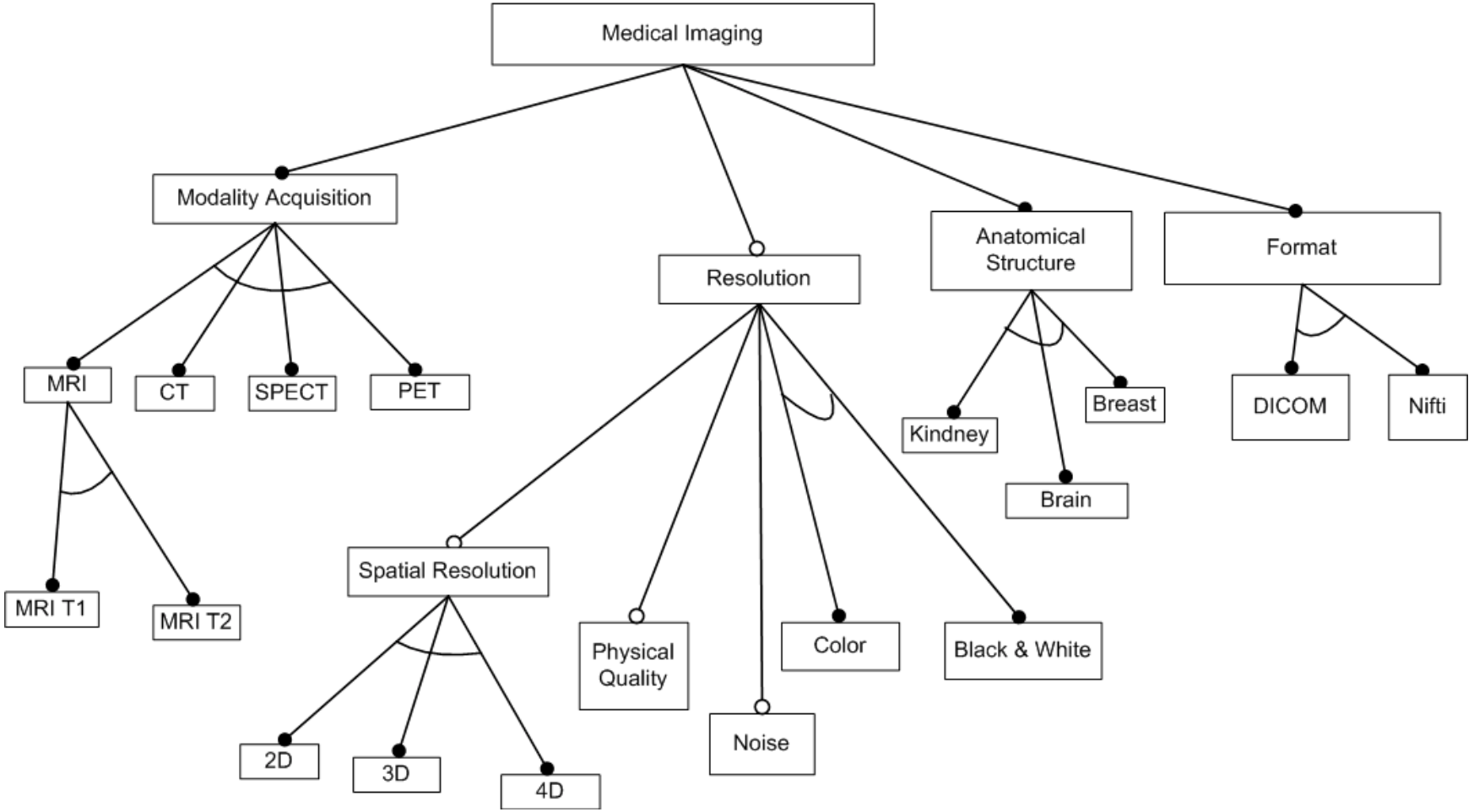
f1 is a mandatory subfeature of f



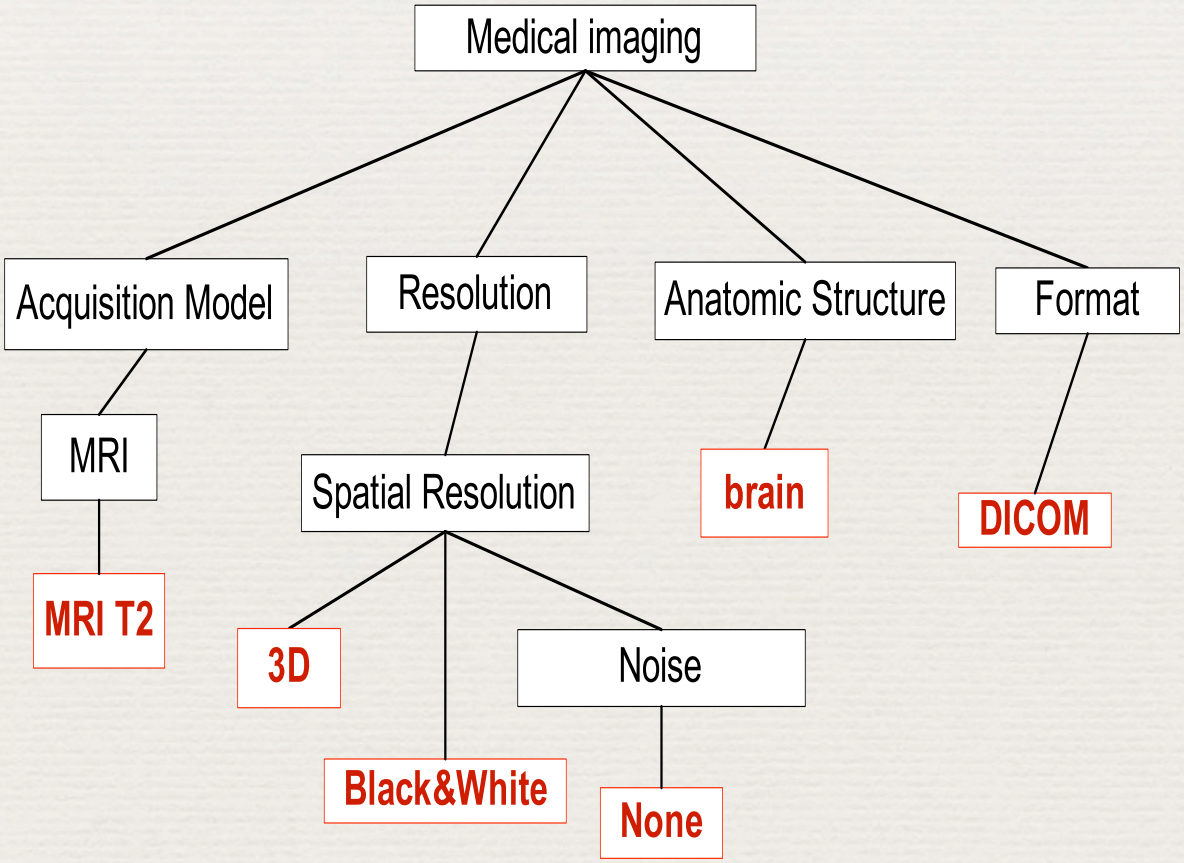
f1 is an optional subfeature of f



XOR group



Functional description : example



Acquisition Model

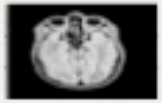
- MRI = *MRI T2*

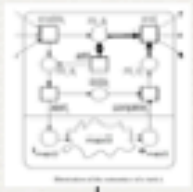
Resolution

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

Anatomic Structure = *brain*

Format = *DICOM*





Workflow

Service Repository

Reusable computation

Workflow

Variability description

Service Product Line (ex : segmentation service)

Functional and QoS info

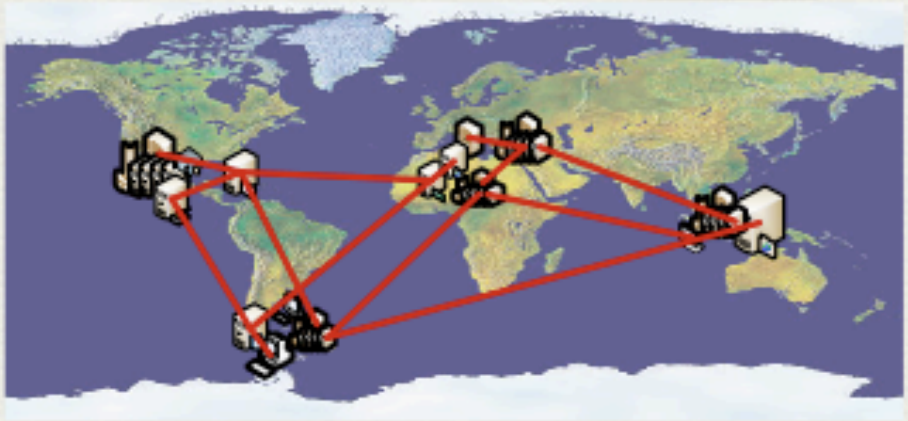
Service Repository

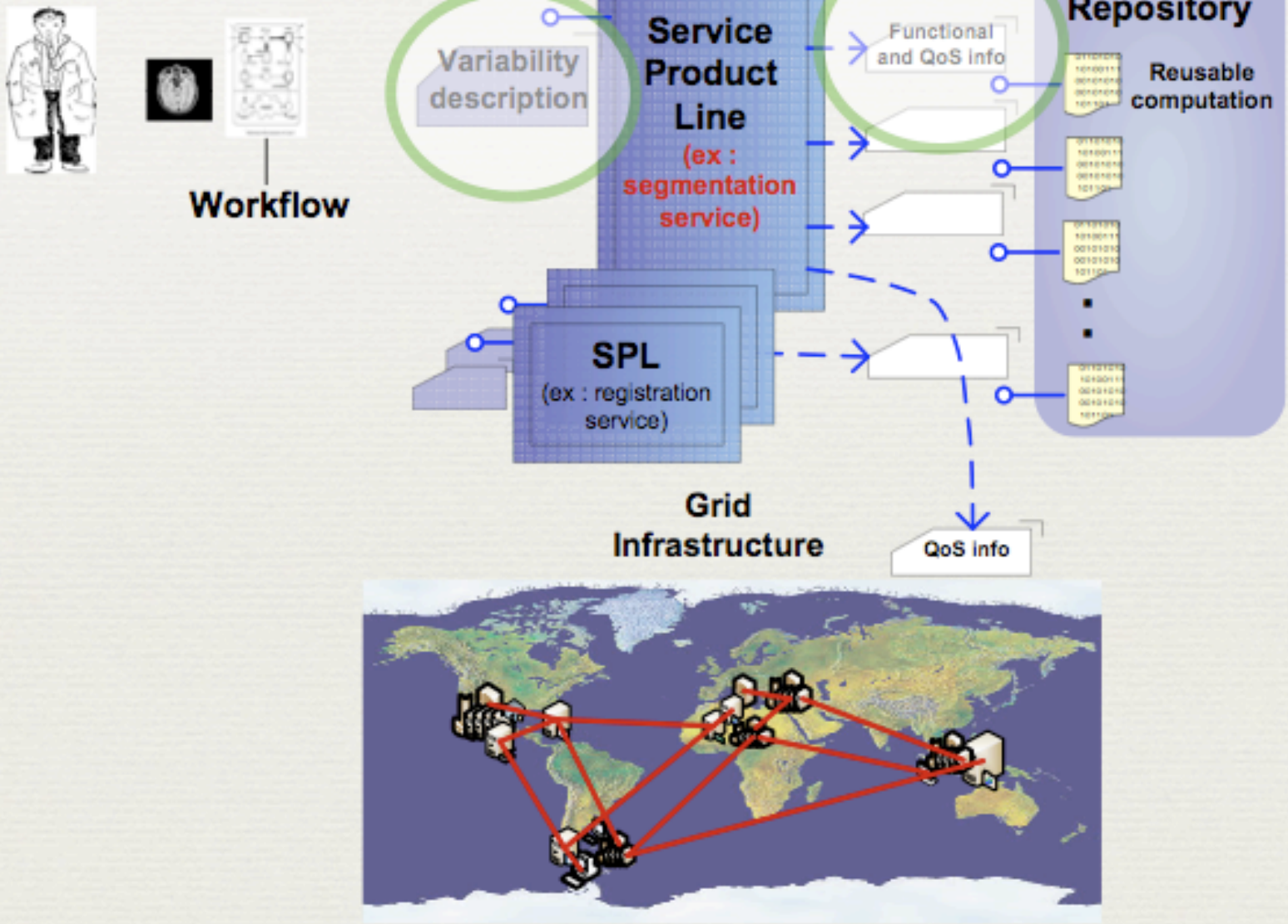
Reusable computation

SPL (ex : registration service)

Grid Infrastructure

QoS info

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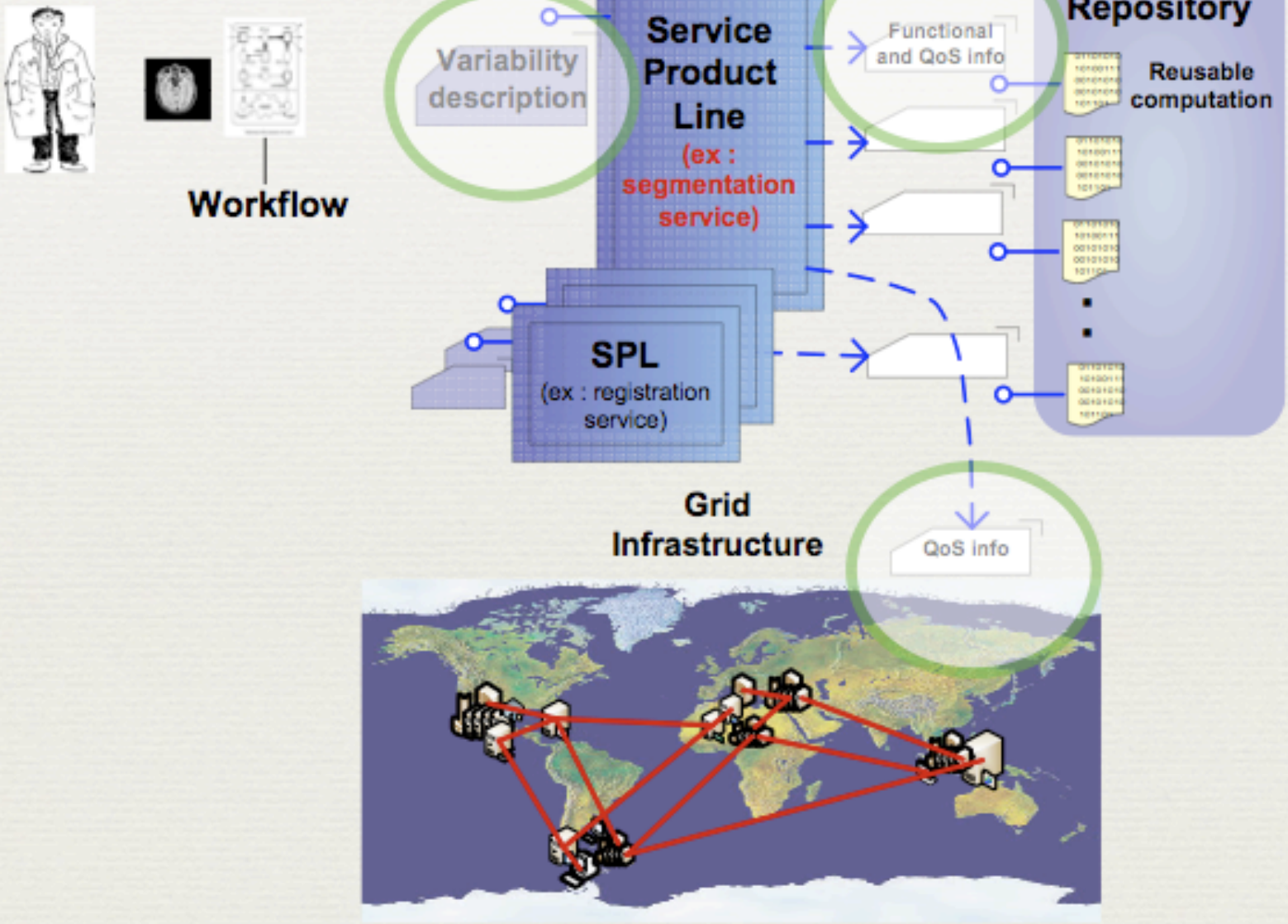
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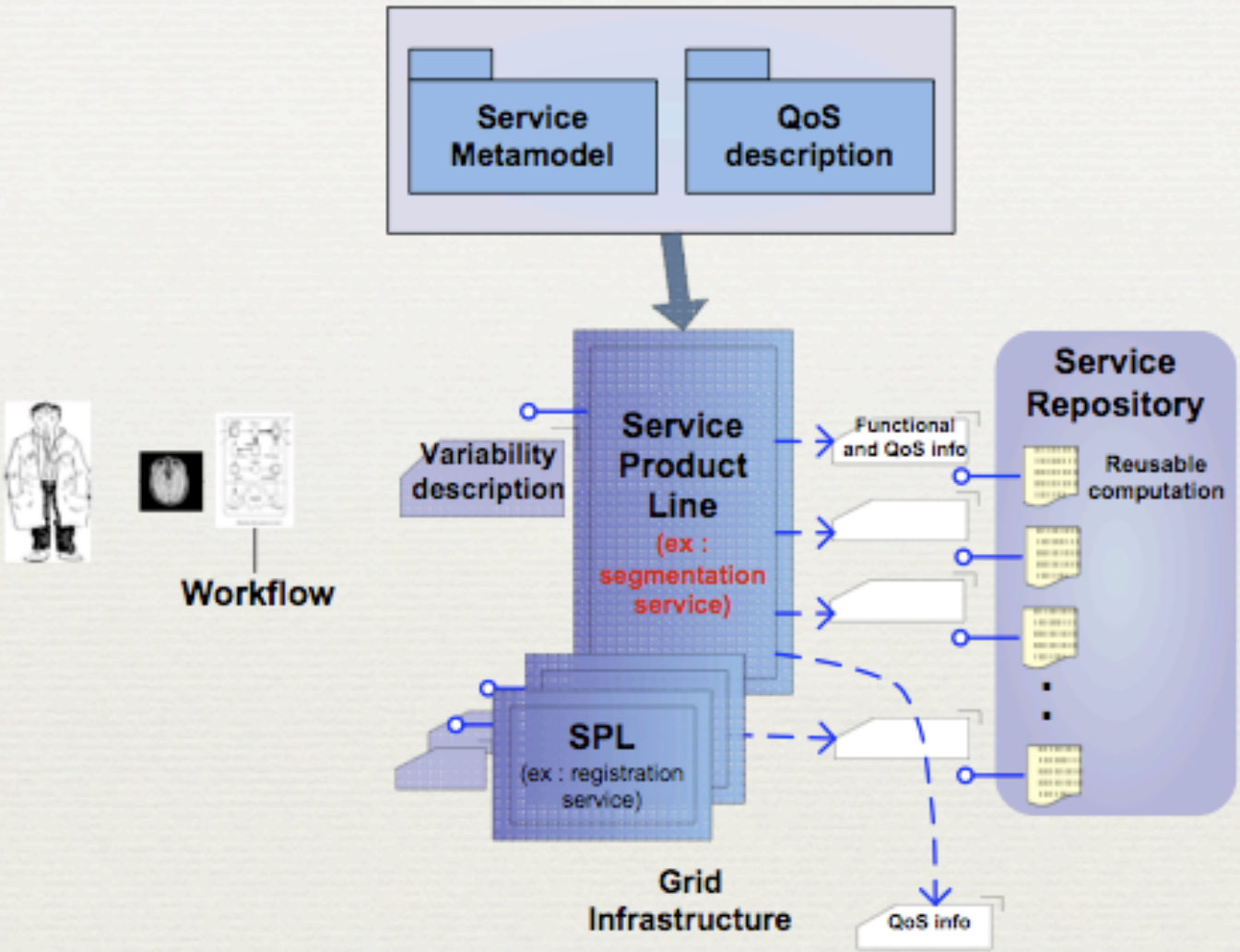
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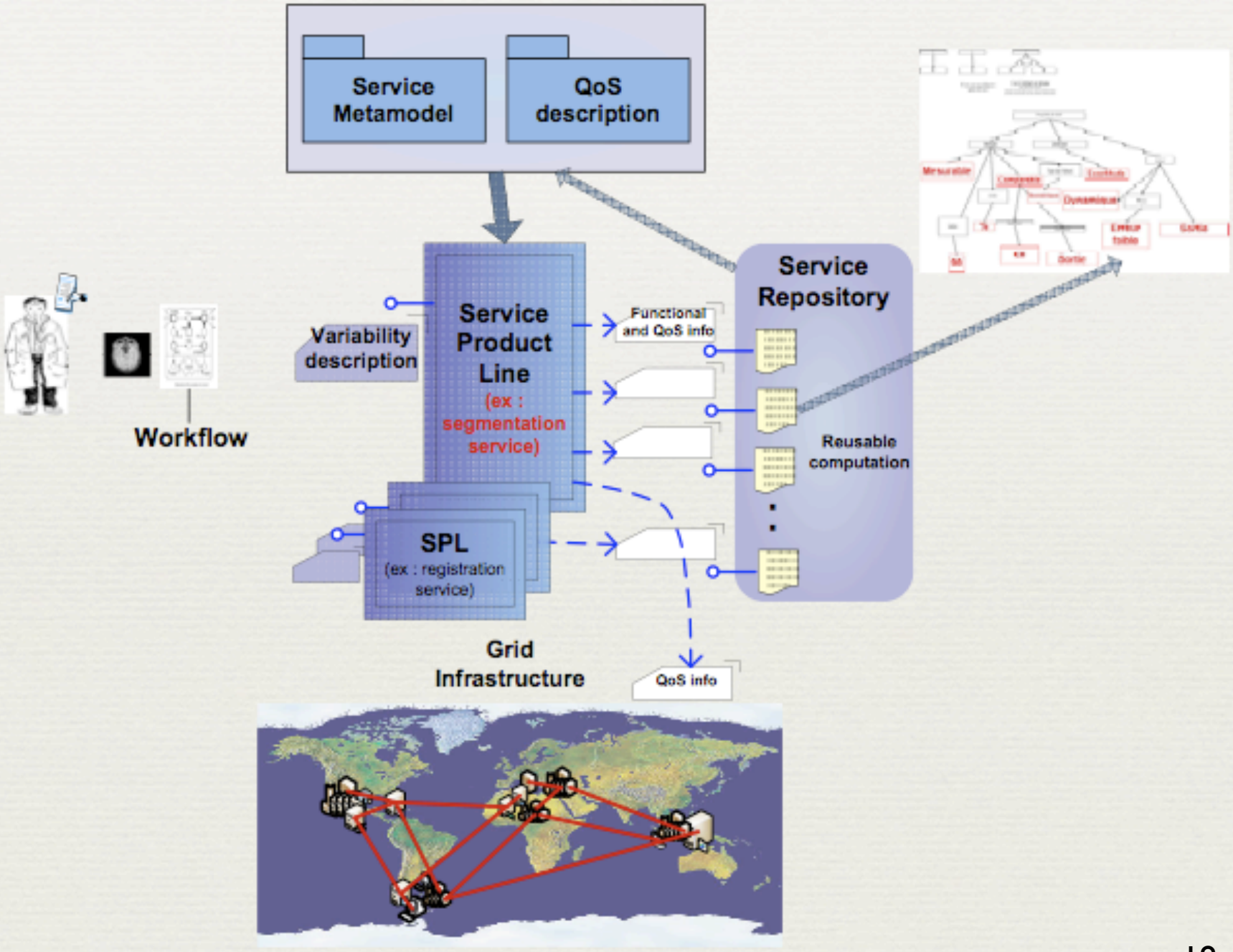
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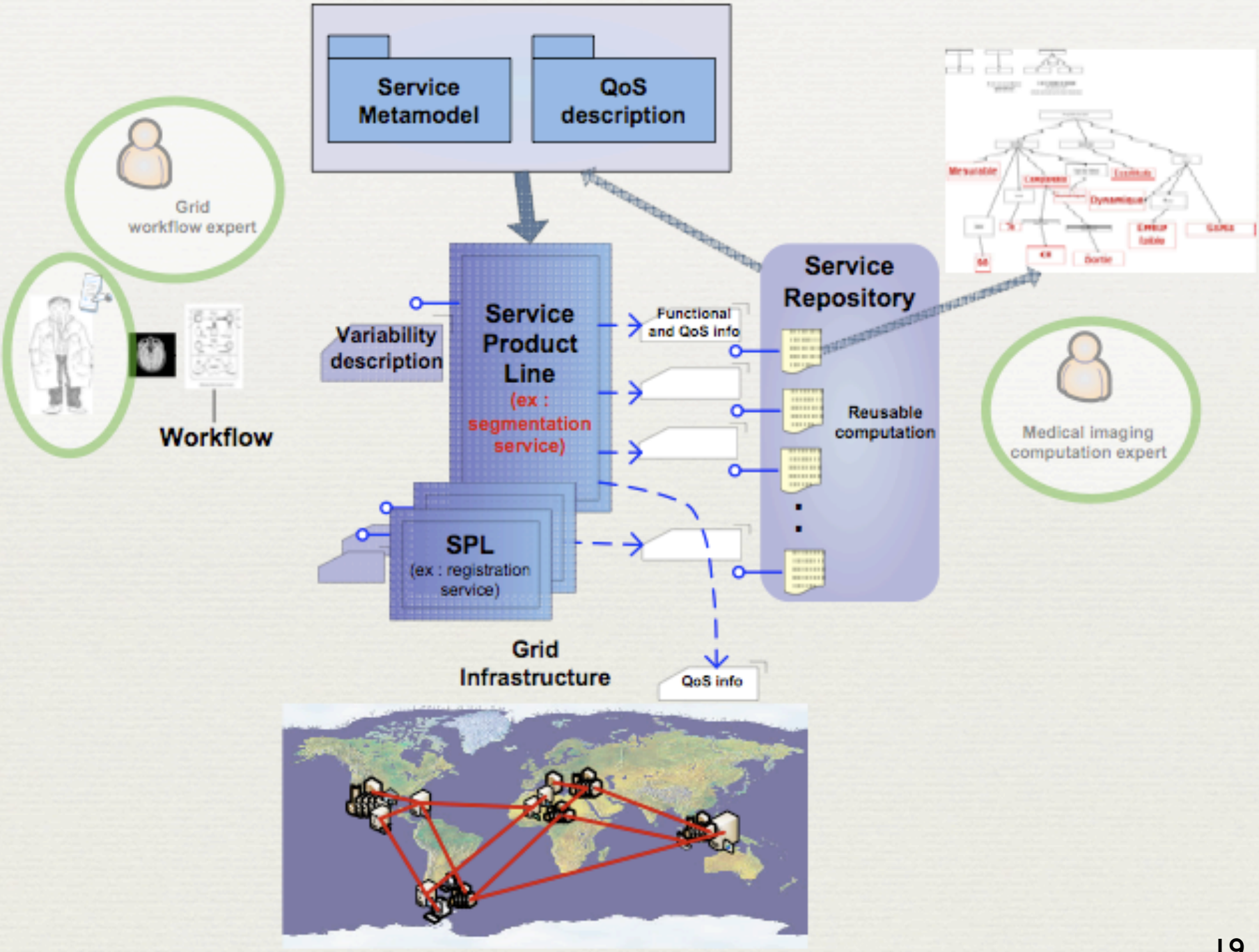
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QoS description
Grid workflow expert
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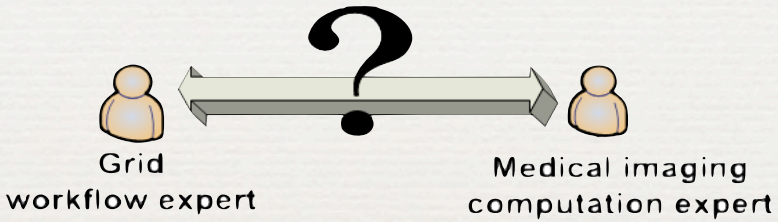
Medical imaging computation expert
Grid Infrastructure
QoS info

Open Issues

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



- Medical imaging needs
  - evaluation framework, algorithms validation
- Variability in workflow
- Derivation process
  - who for the reasoning process ?
  - multi-criteria : heuristics needed

SOA

Workflow

Segmentation

Medical Imaging

Questions ?

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QoS

Grid

MDE

SPL

- *Examining the Challenges of Scientific Workflows*
  - Yolanda Gil, Ewa Deelman et al., IEEE Computer 2007

- "Workflow end users frequently want to be able to specify quality of service requirements. These requirements then should be guaranteed—or at least maintained on a best effort basis—by the underlying runtime environment".
- "QoS parameters need to be extended beyond time-based criteria to cover other important aspects of workflow behavior such as responsiveness, fault tolerance, security, and costs".
- "This effort will require collaborative work on the definition of QoS parameters that can be widely accepted among scientists, so as to provide a basis for interoperable workflow environments or services."

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  - **Ivona Brandic, Rainer Schmidt, Gerhard Engelbrecht, and Siegfried Benkner.**
    - **Towards quality of service support for grid workflows. In Proceedings of the European Grid Conference 2005 (EGC2005), Amsterdam, The Netherlands, 2 2005.**
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  - **Marek Wieczorek, Andreas Hoheisel, and Radu Prodan.**
    - **Taxonomy of the multi-criteria grid workflow scheduling problem. In CoreGrid Workshop, 2007. [Yu and Buyya 2005]**
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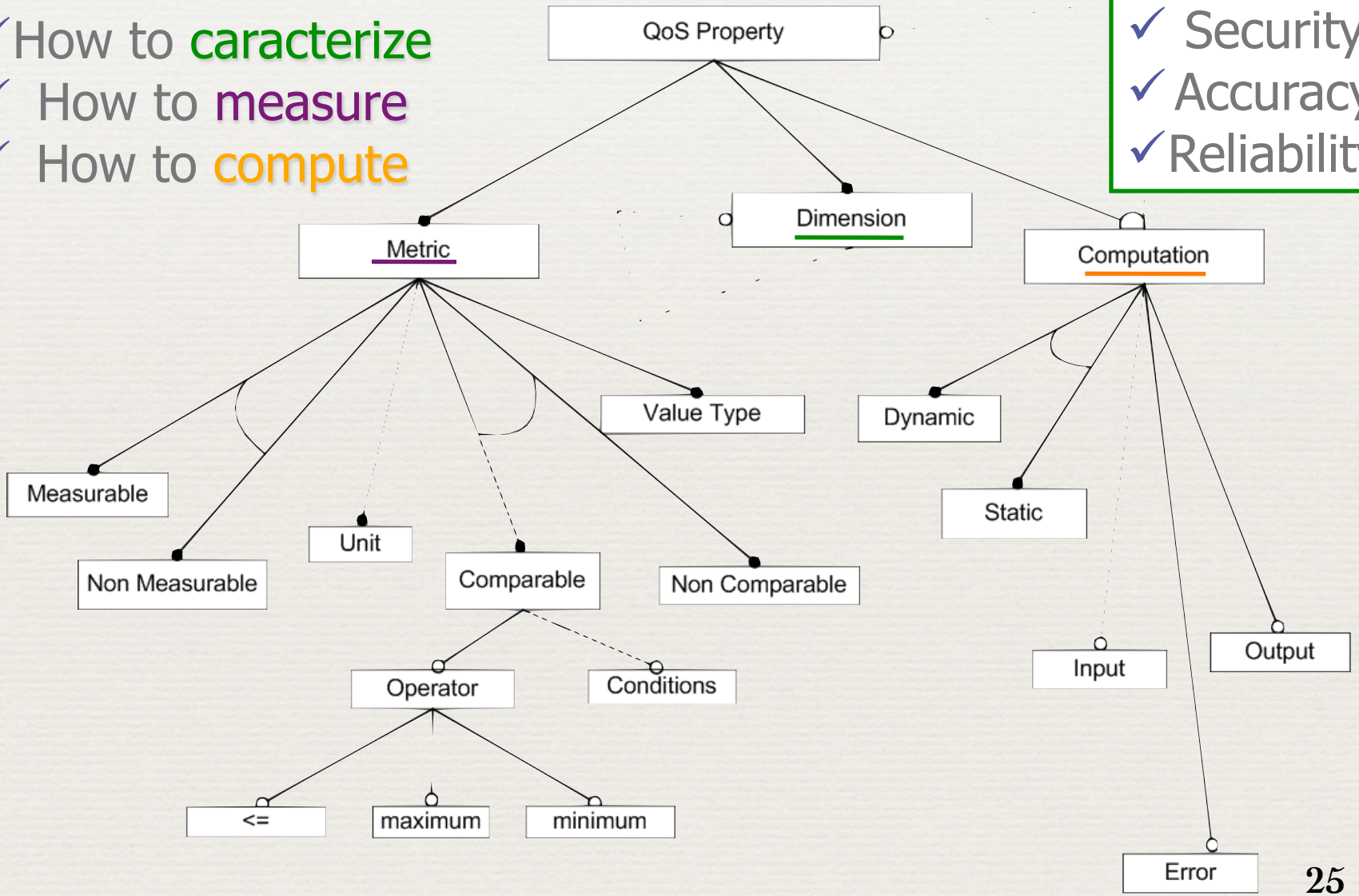
  - **A taxonomy of workflow management systems for grid computing, 2005.**

QoS Variability

- ✓ How to caracterize
- ✓ How to measure
- ✓ How to compute

- ✓ Time
- ✓ Cost
- ✓ Security
- ✓ Accuracy
- ✓ Reliability



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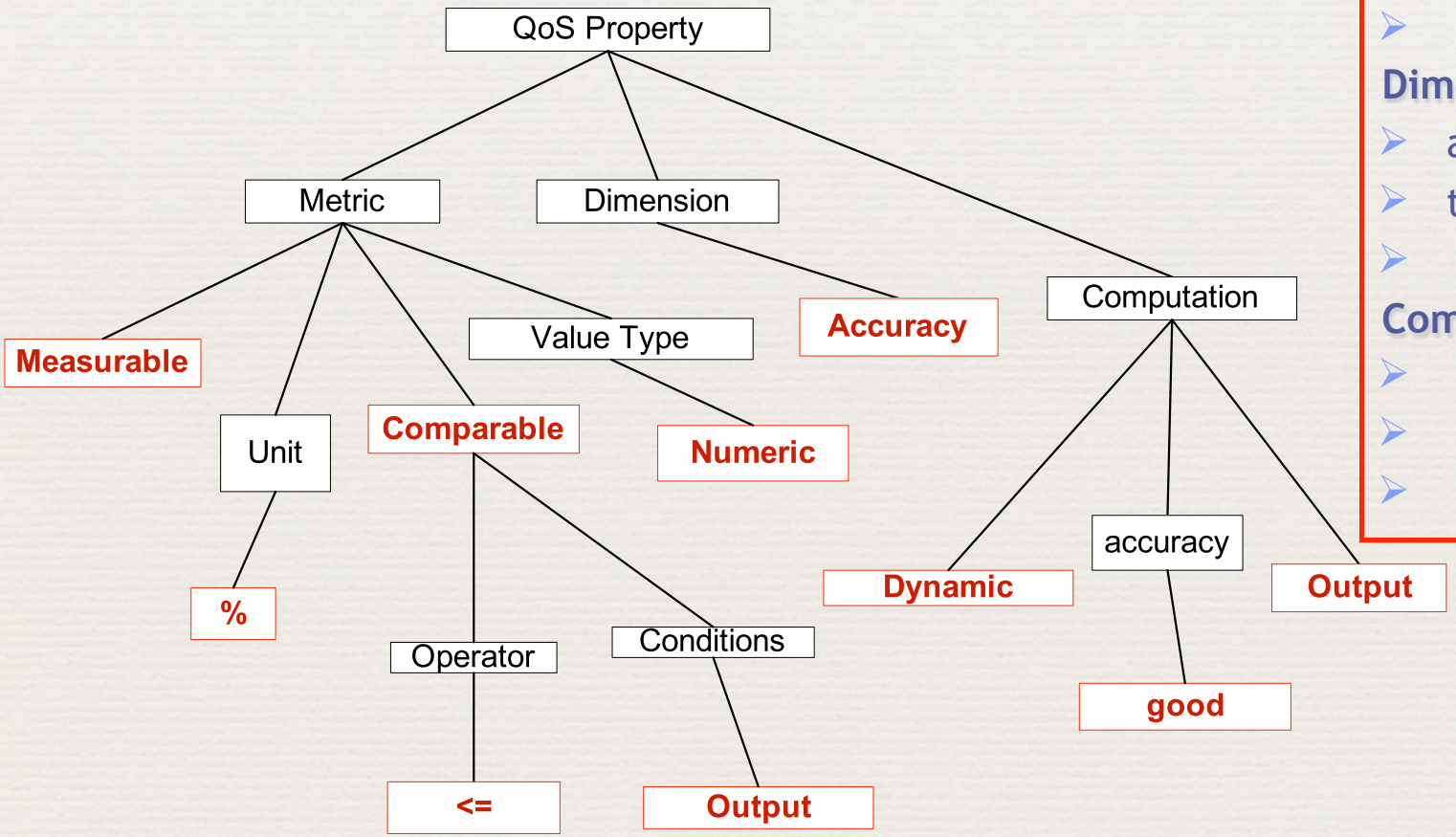


Metric

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

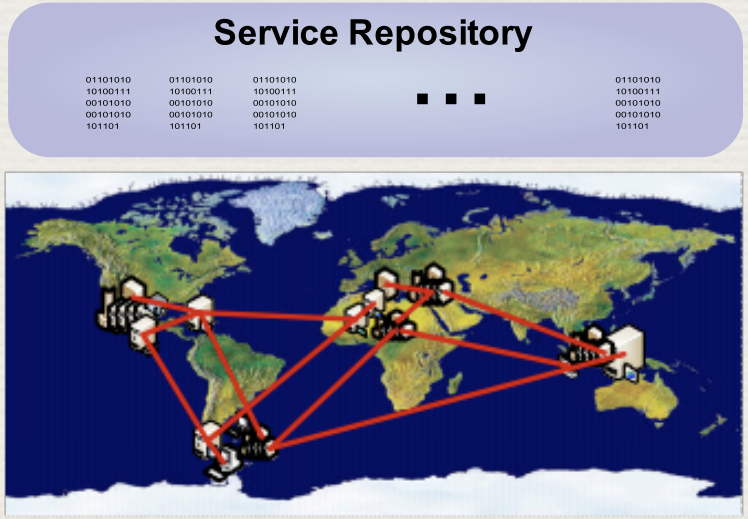
Dimension

- accuracy = *high*
- time = *any*
- …

Computation

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

Towards Service product line



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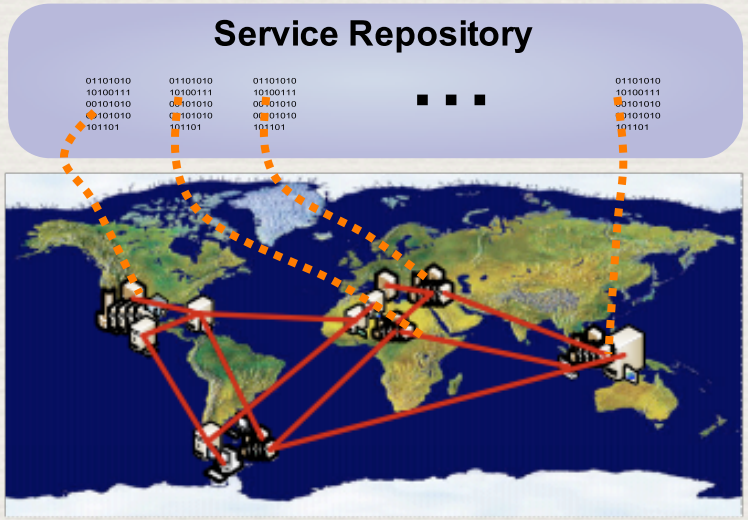

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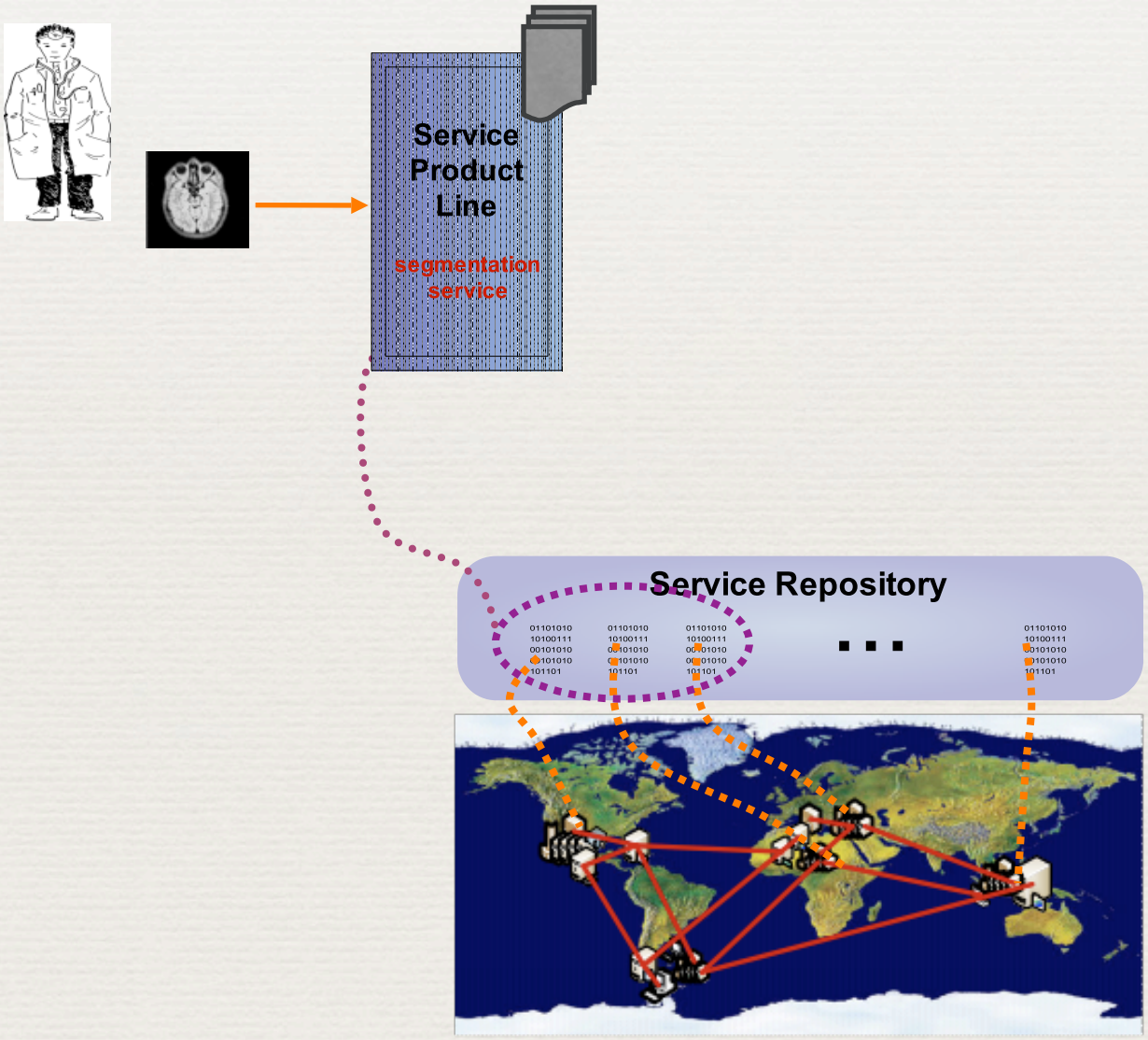

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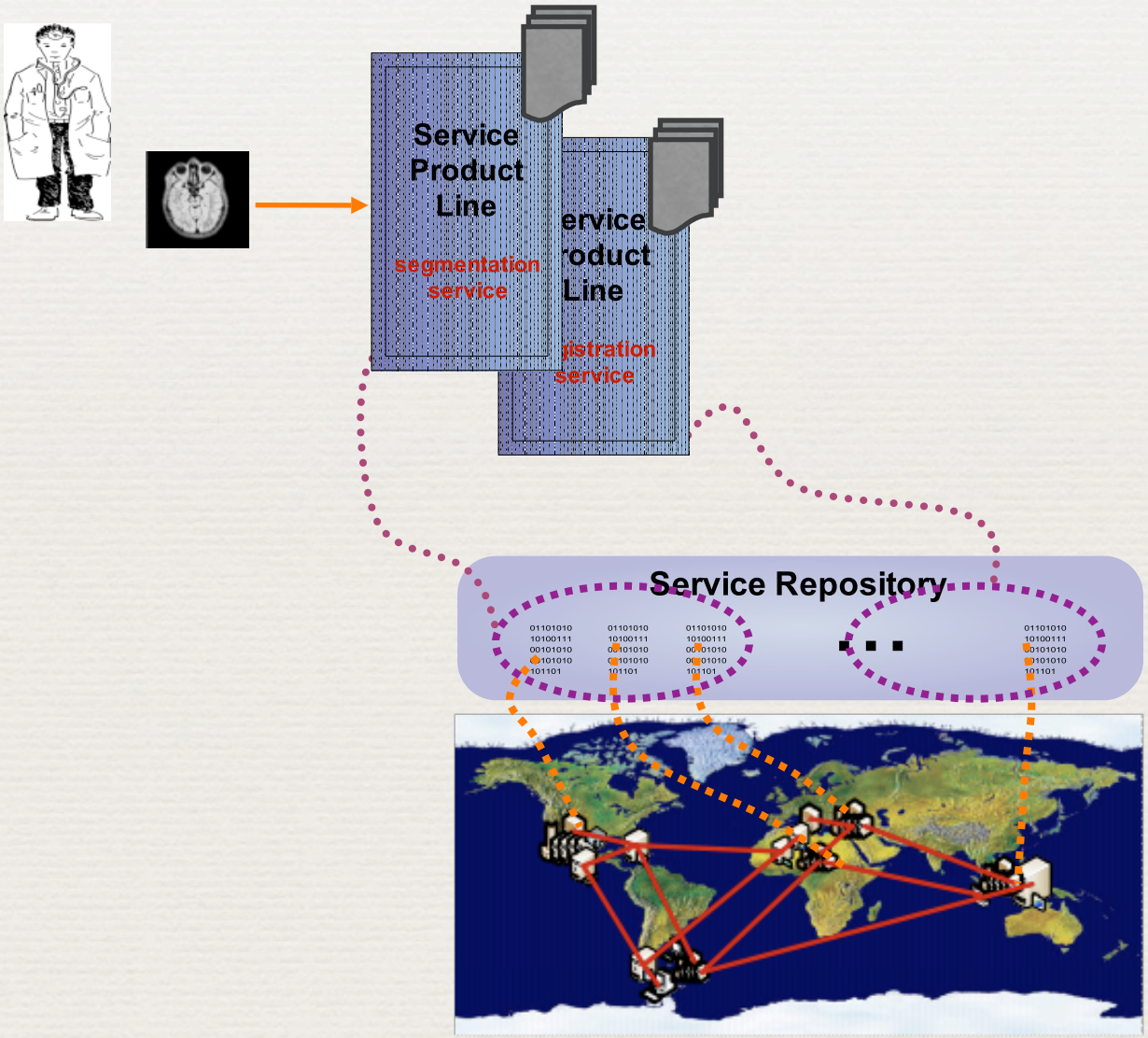

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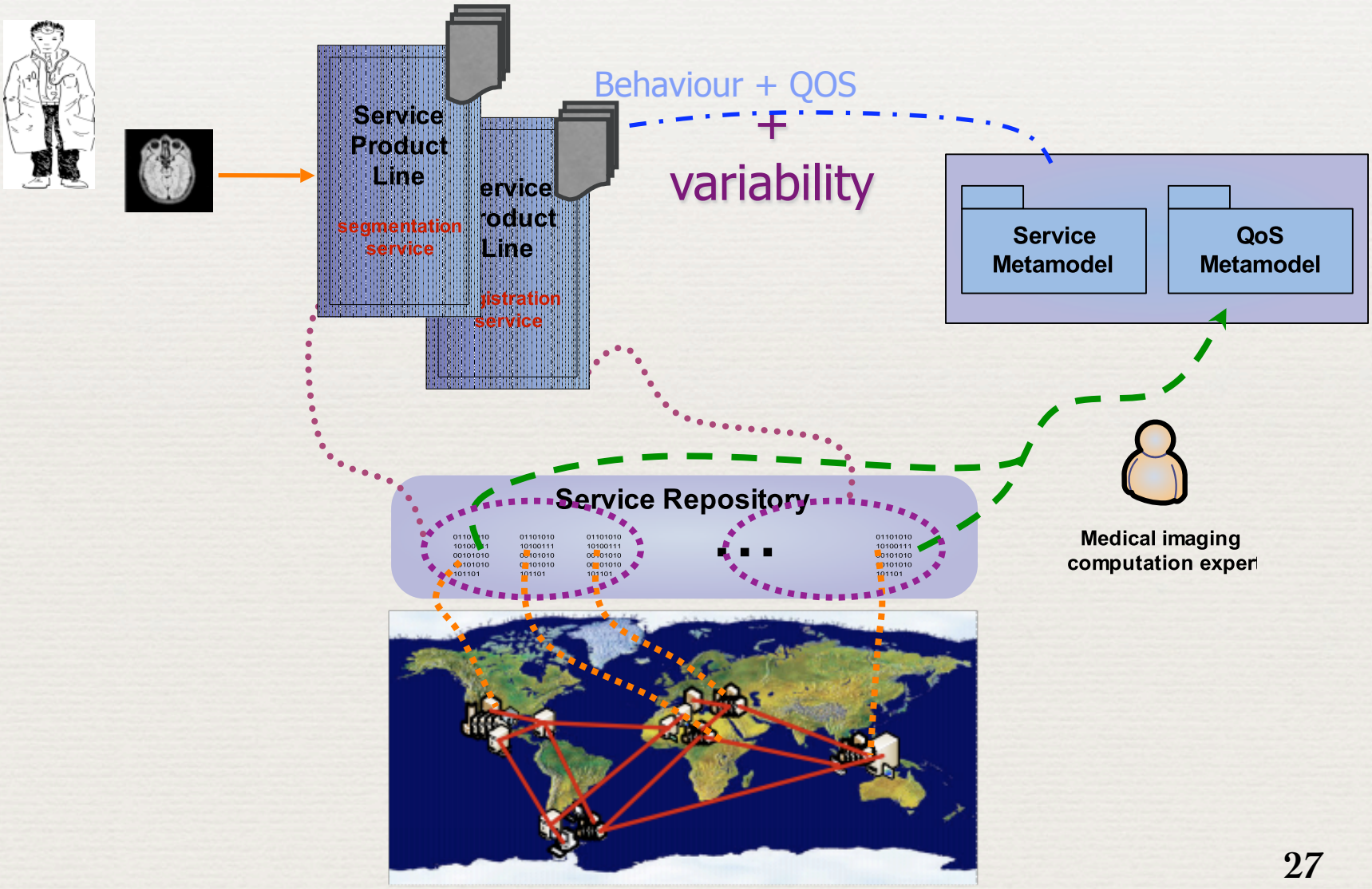

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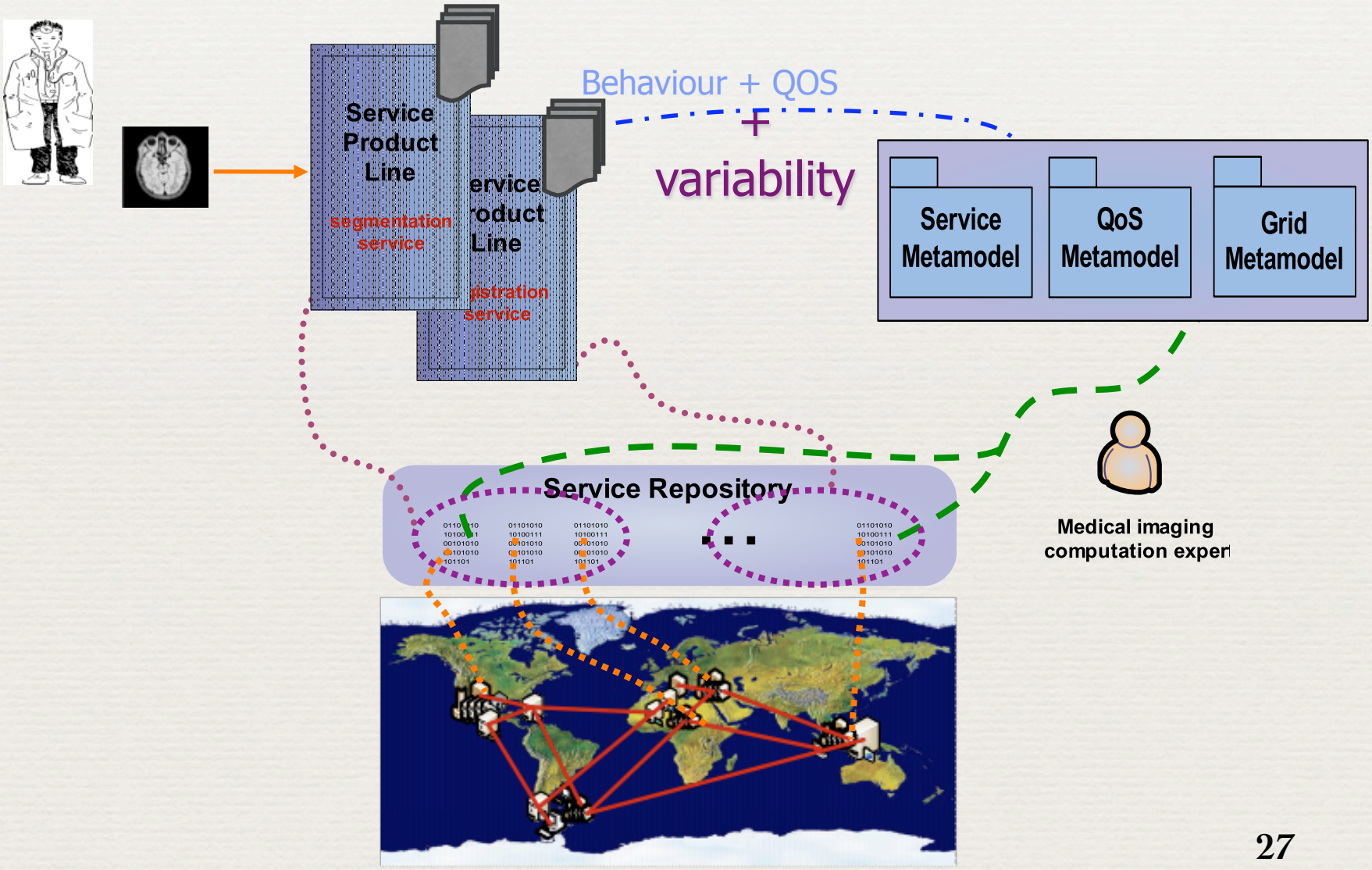

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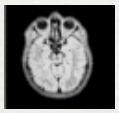


Service Product Line

segmentation service

ervice roduct Line

istration service

Behaviour + QOS

+

variability

Service Metamodel

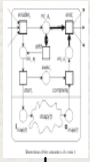
QoS Metamodel

Grid Metamodel

Grid workflow expert

Service Repository

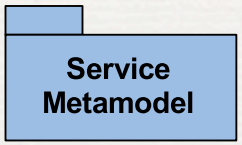
Medical imaging computation exper

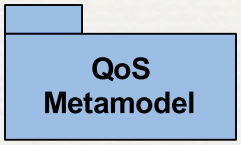


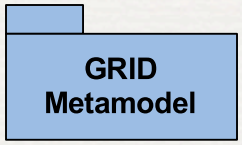
Workflow

Service Product Line

One Workflow

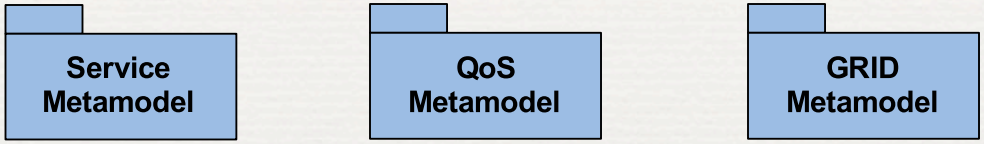


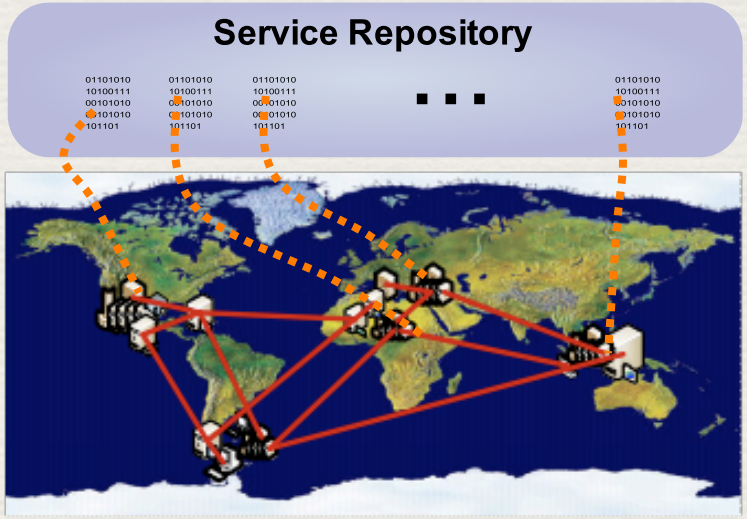




Platform dependent

Grid Engine

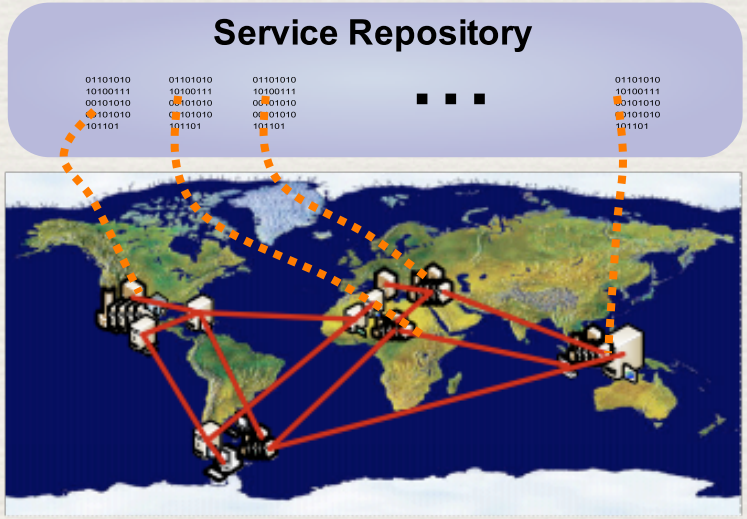




Platform dependent

Grid Engine

eHealth domain



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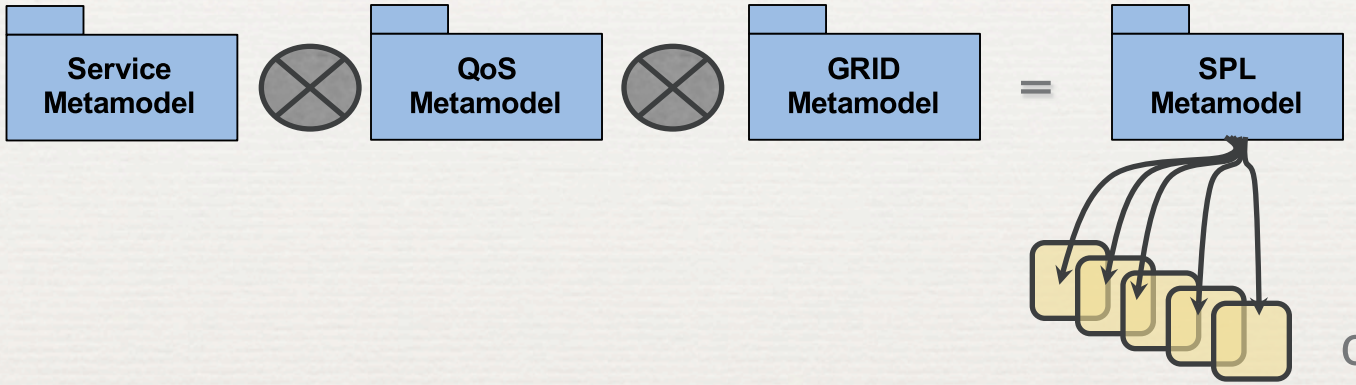
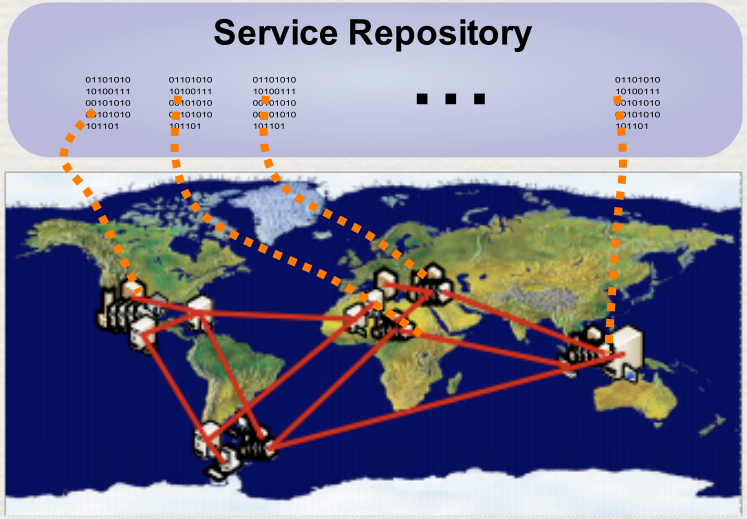


eHealth domain

Instance of the SPL



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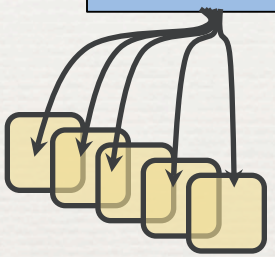

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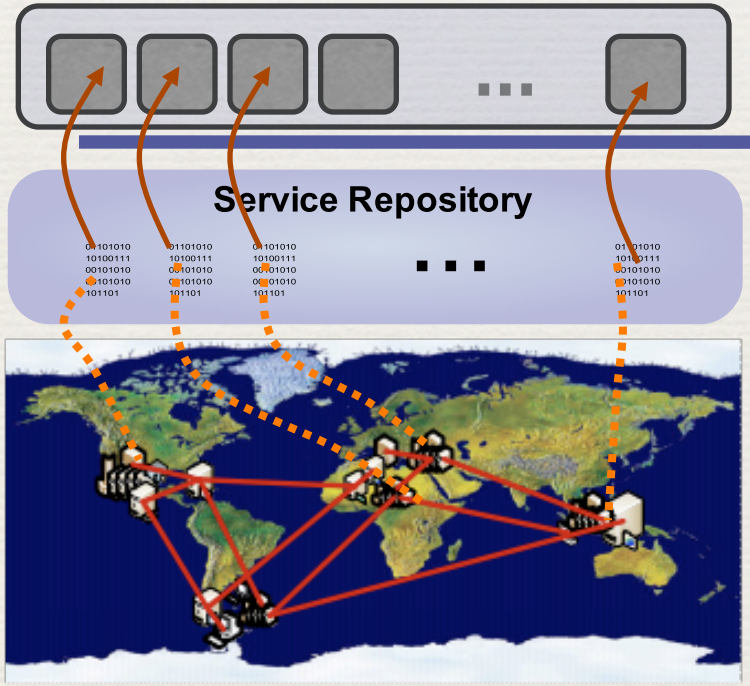
Model abstraction of services



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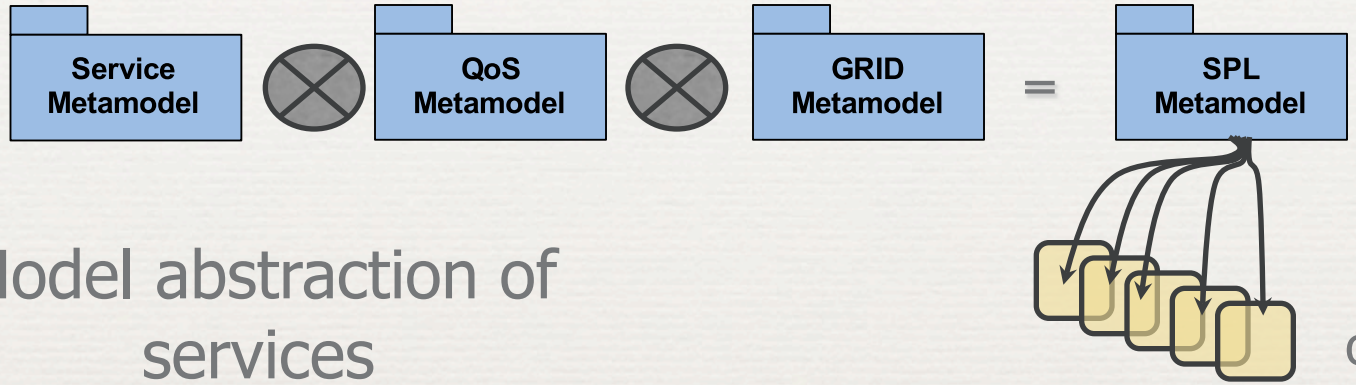

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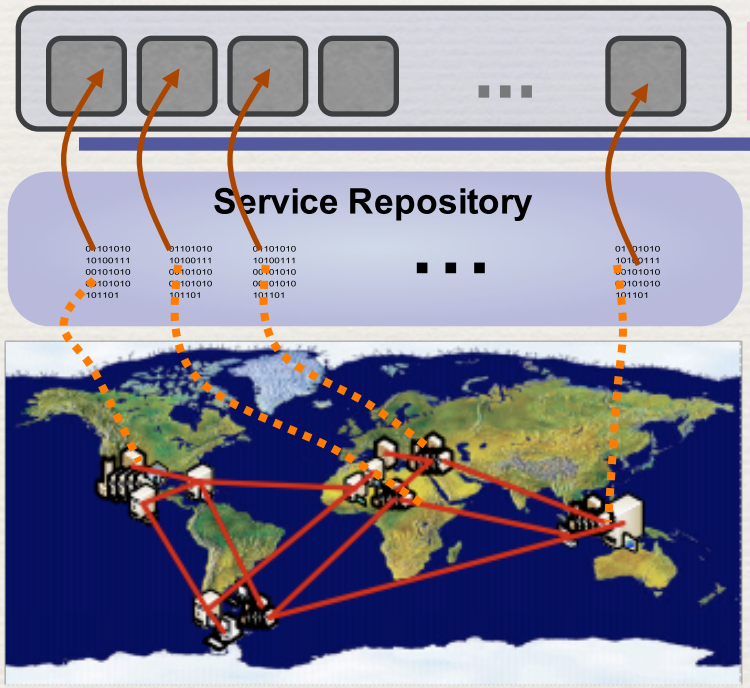
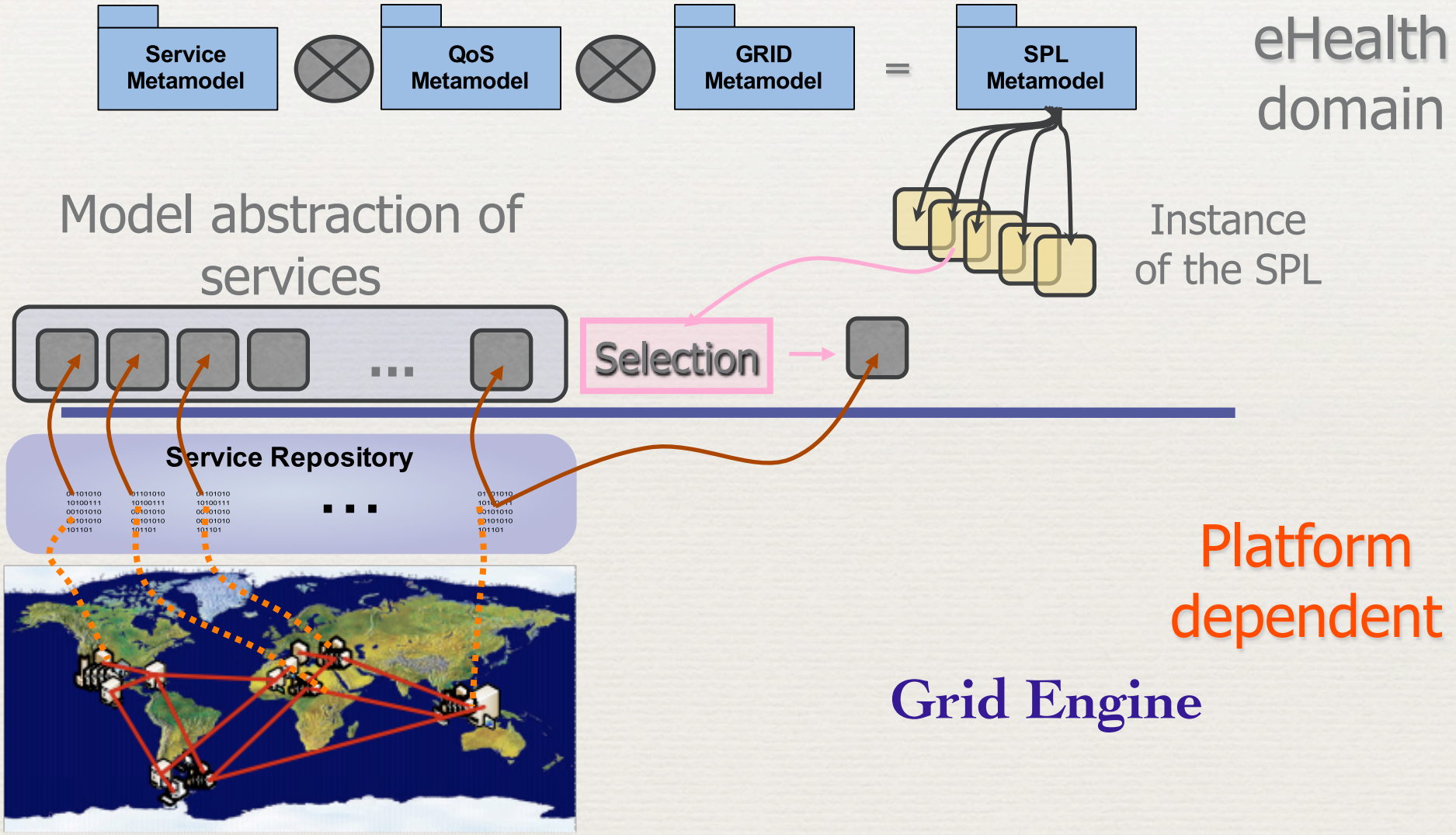
Model abstraction of services

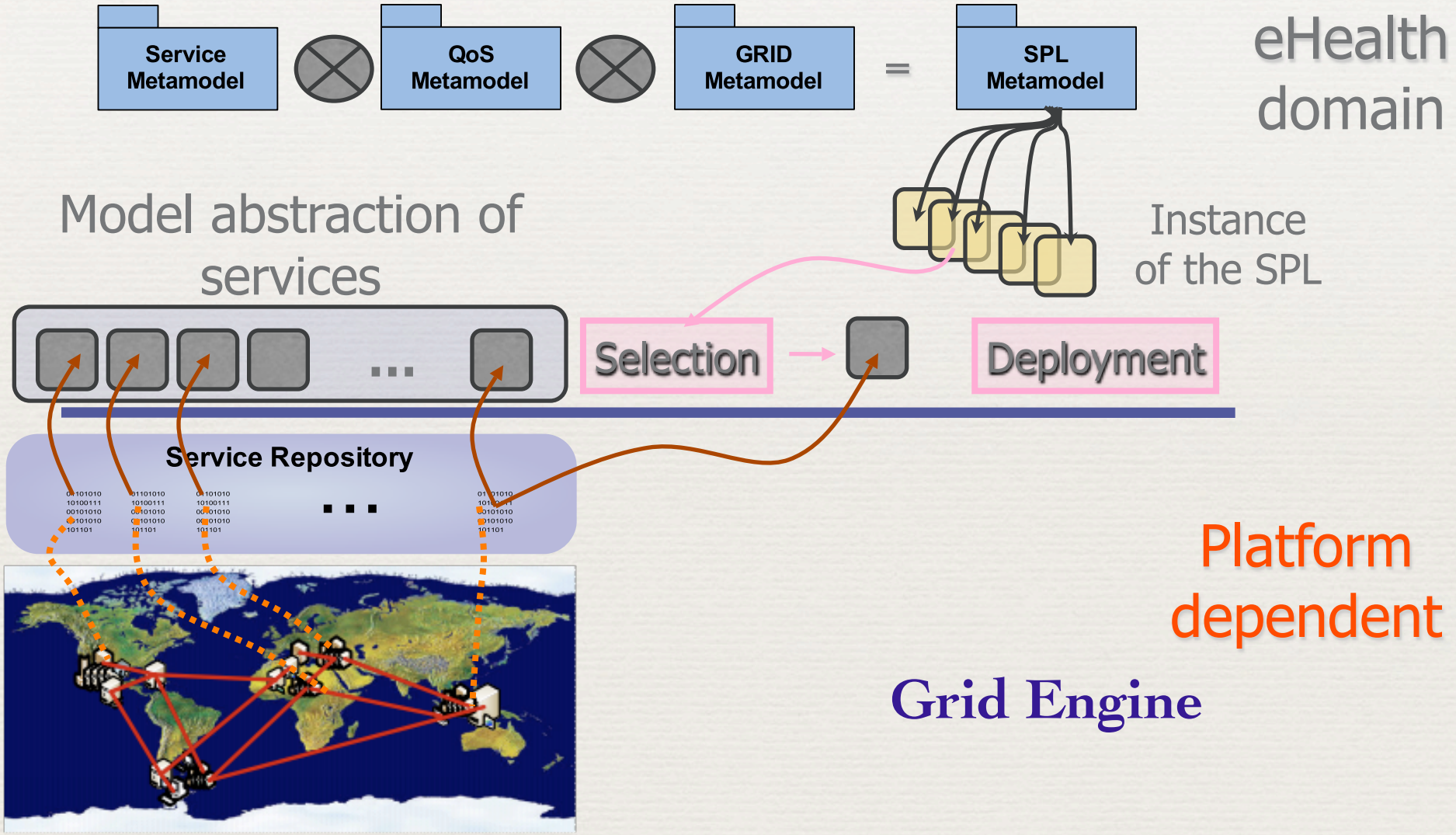
Instance of the SPL



Platform dependent

Grid Engine


Service Metamodel
QoS Metamodel
GRID Metamodel
=
SPL Metamodel
eHealth domain
Model abstraction of services
Instance of the SPL
Selection
Service Repository
Platform dependent
Grid Engine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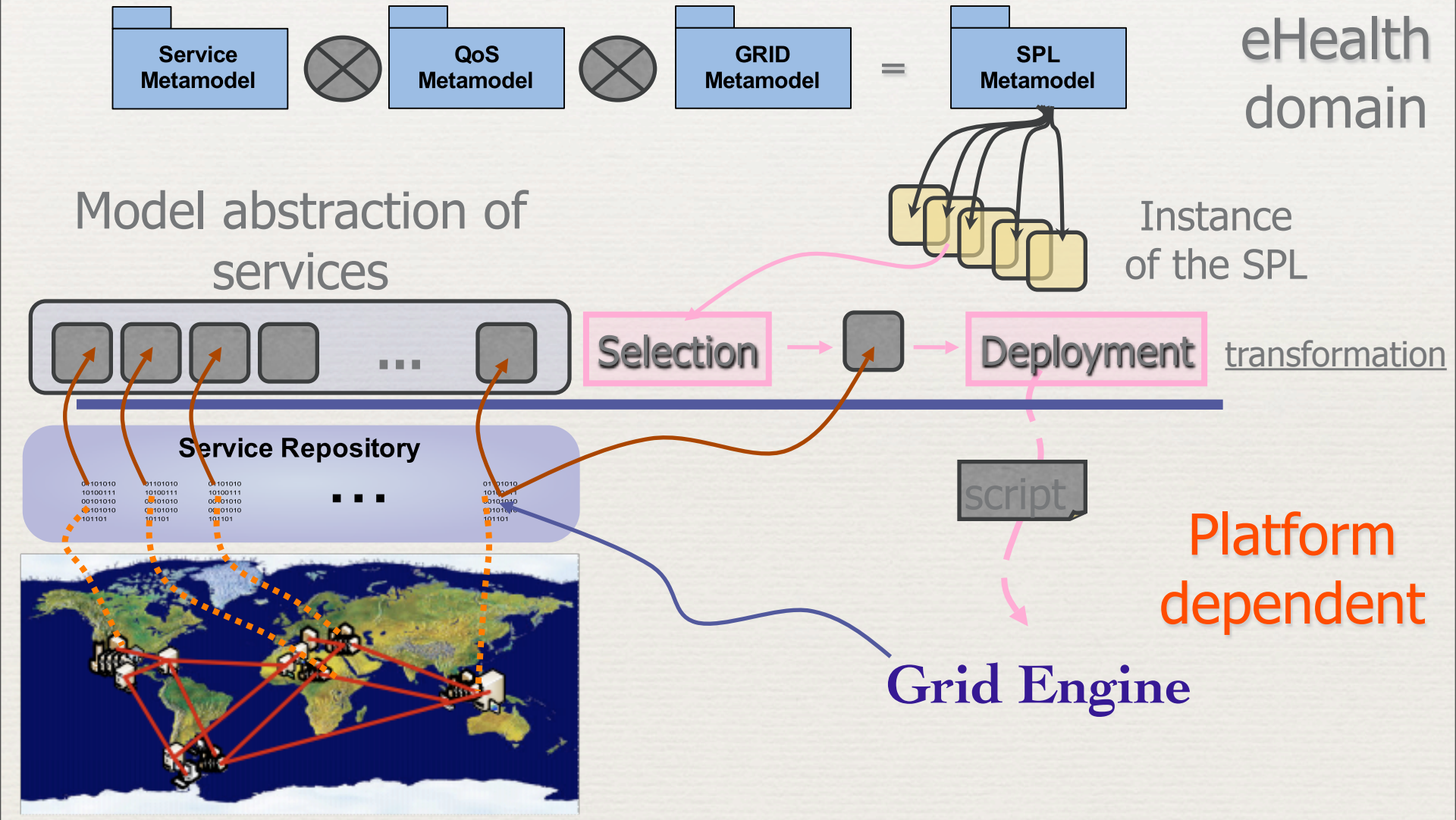
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