A Hybrid Approach to QoS Evaluation

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Motivation of the work

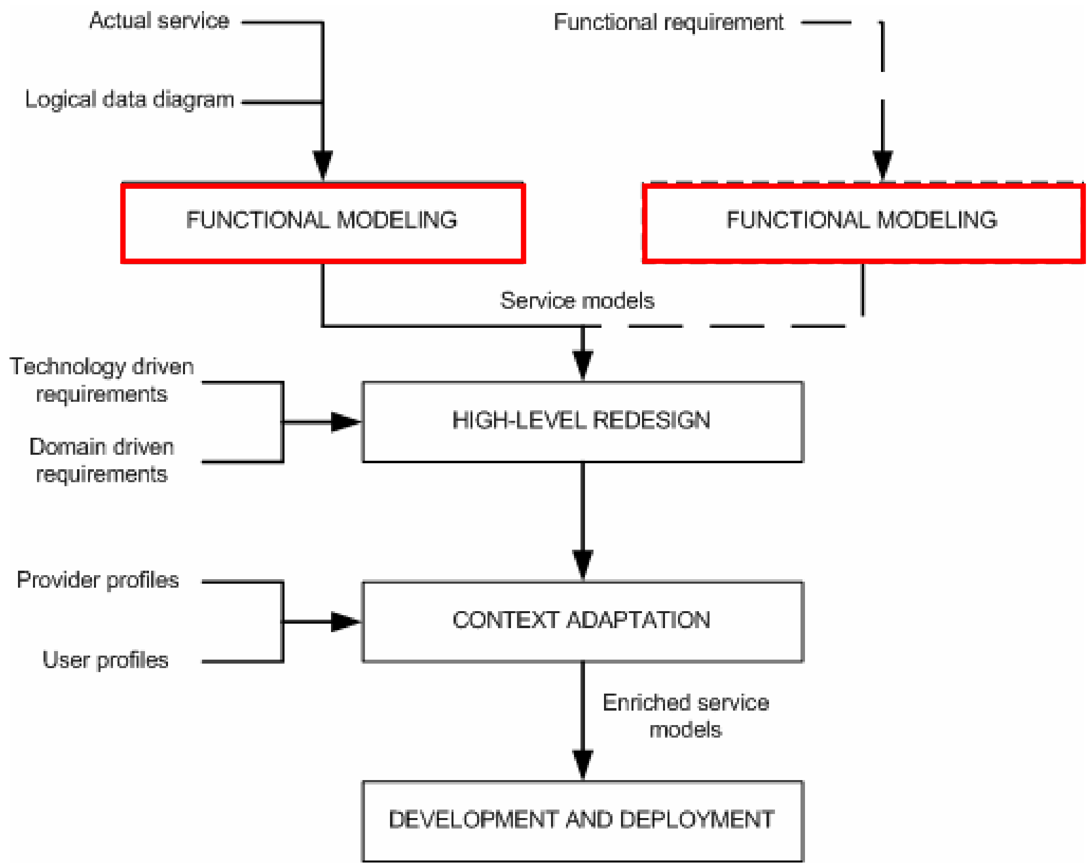
- Usually, the process of development of services available as web applications considers only functional requirements
- New kinds of communication channels and devices, the design process must be revised by considering new aspects:
  - quality of service **(**QoS**)**
  - user profiles
  - technical characteristics of channels
- Definition of a methodology that provides a rational to formalize the redesign process of existing services to support multi-channel access
- Quantitative evaluation of QoS
- Multichannel Adaptive Information Systems (MAIS) project

The Reference Methodology

- Goals:
  - Service design
  - Service redesign
- Support the selection of services technical characteristics such that QoS requirements are satisfied
- QoS is represented by an ontology. QoS dependencies are represented by quality trees

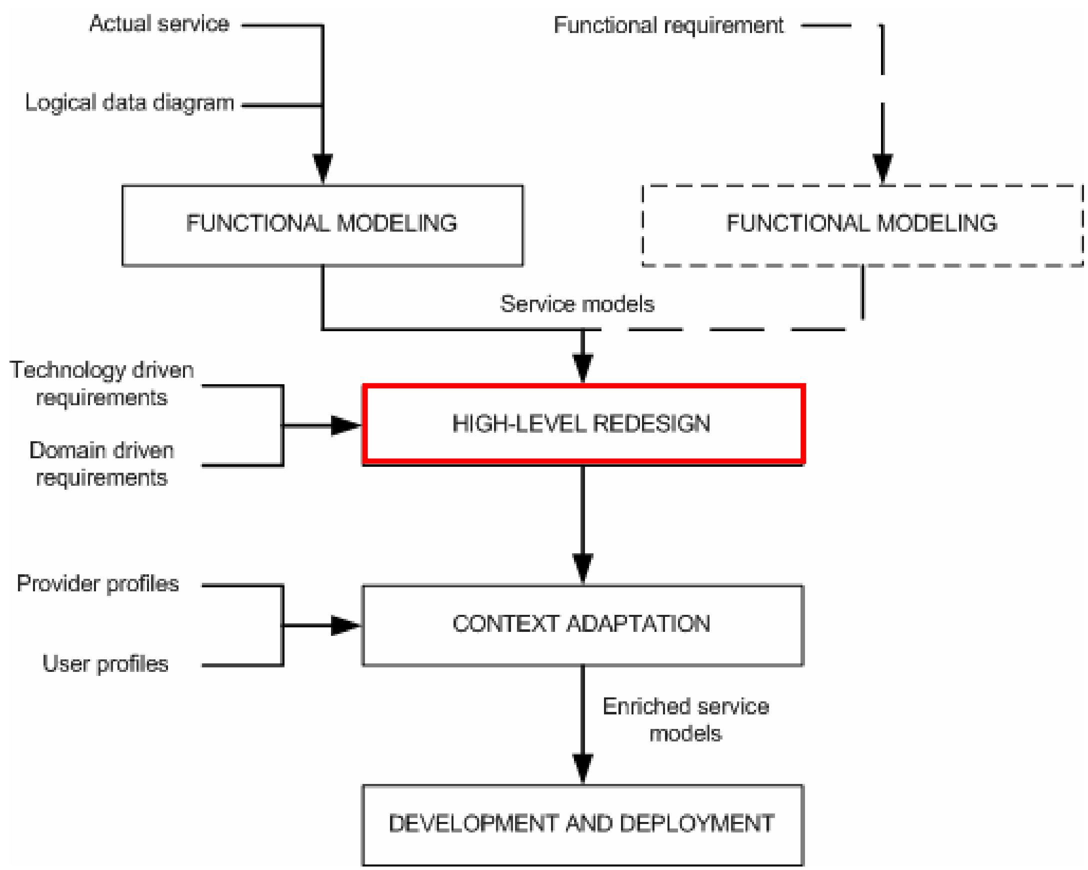
The phases of the Methodology

Functional modeling: deliver a set of UML diagrams that highlights the logical structure of the service



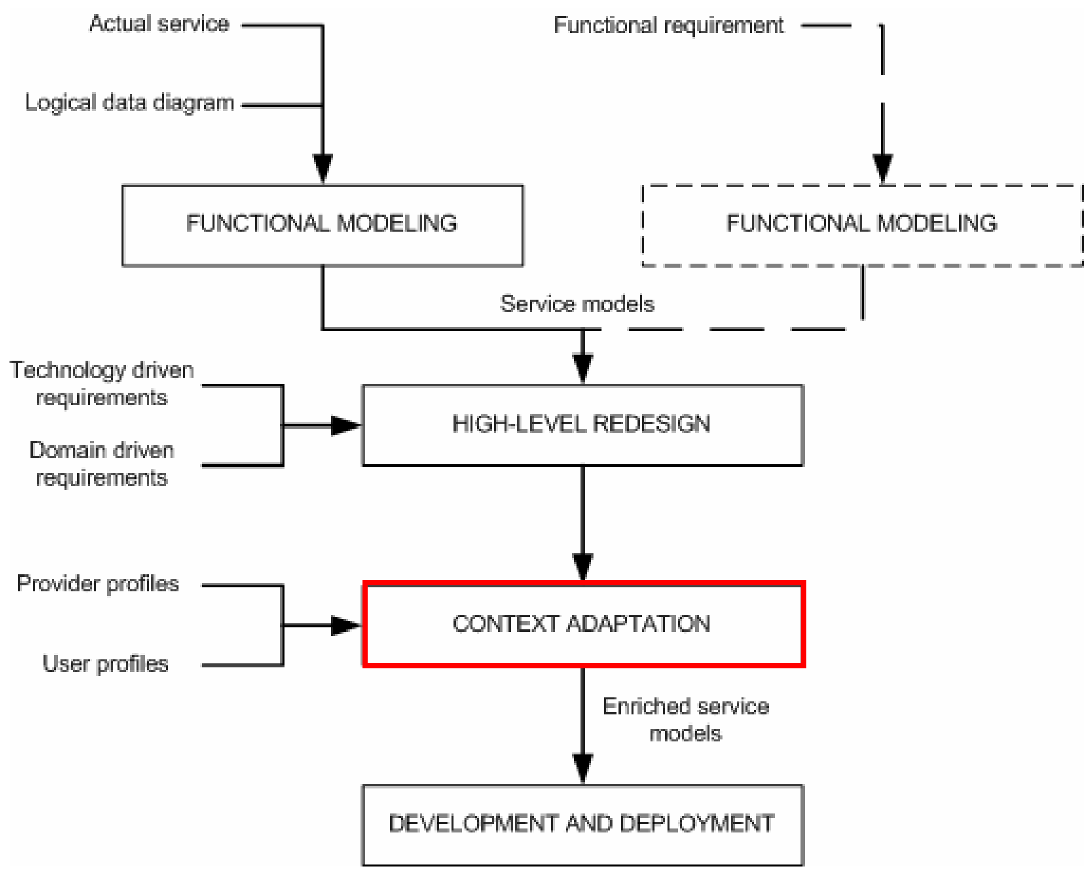
The phases of the Methodology

High level redesign: redesign the service taking into account new requirements promoted by new channels and domains



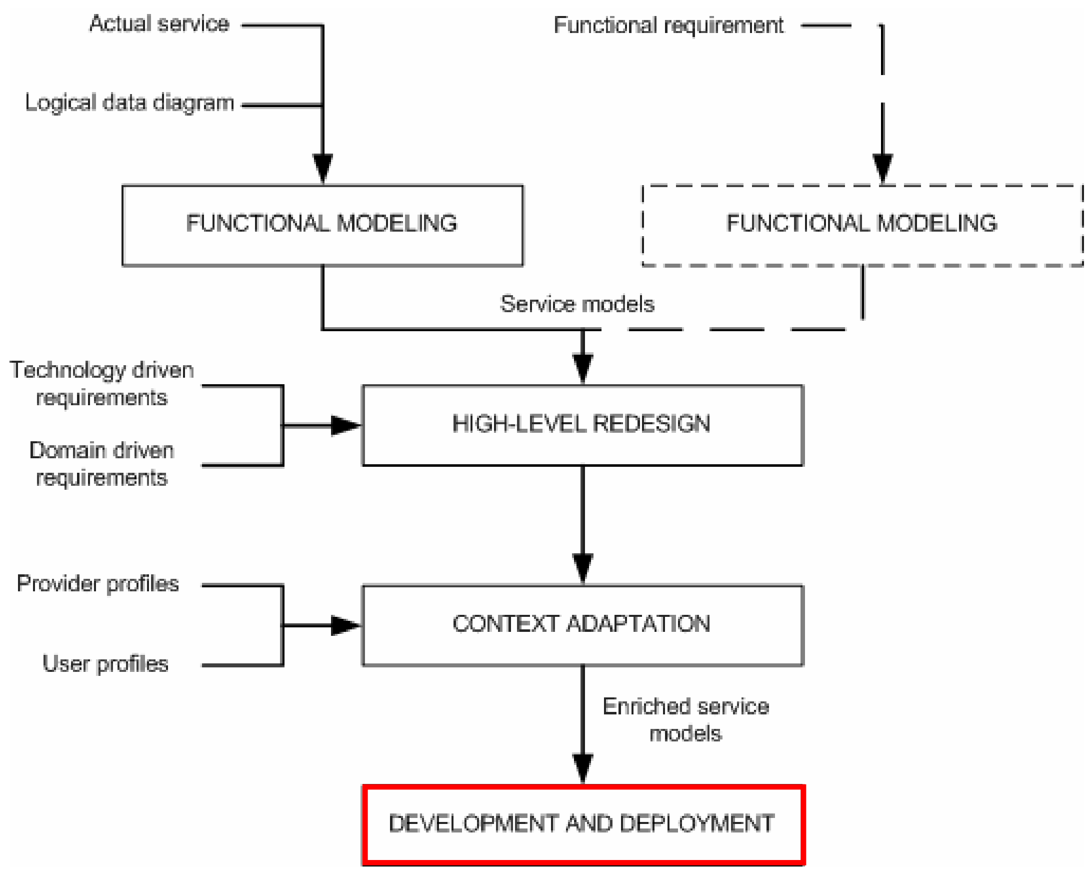
The phases of the Methodology

Context adaptation: considers actual deployment environment to evaluate and adapt the abstract assumptions with respect to actual technical characteristics of channels and user profiles

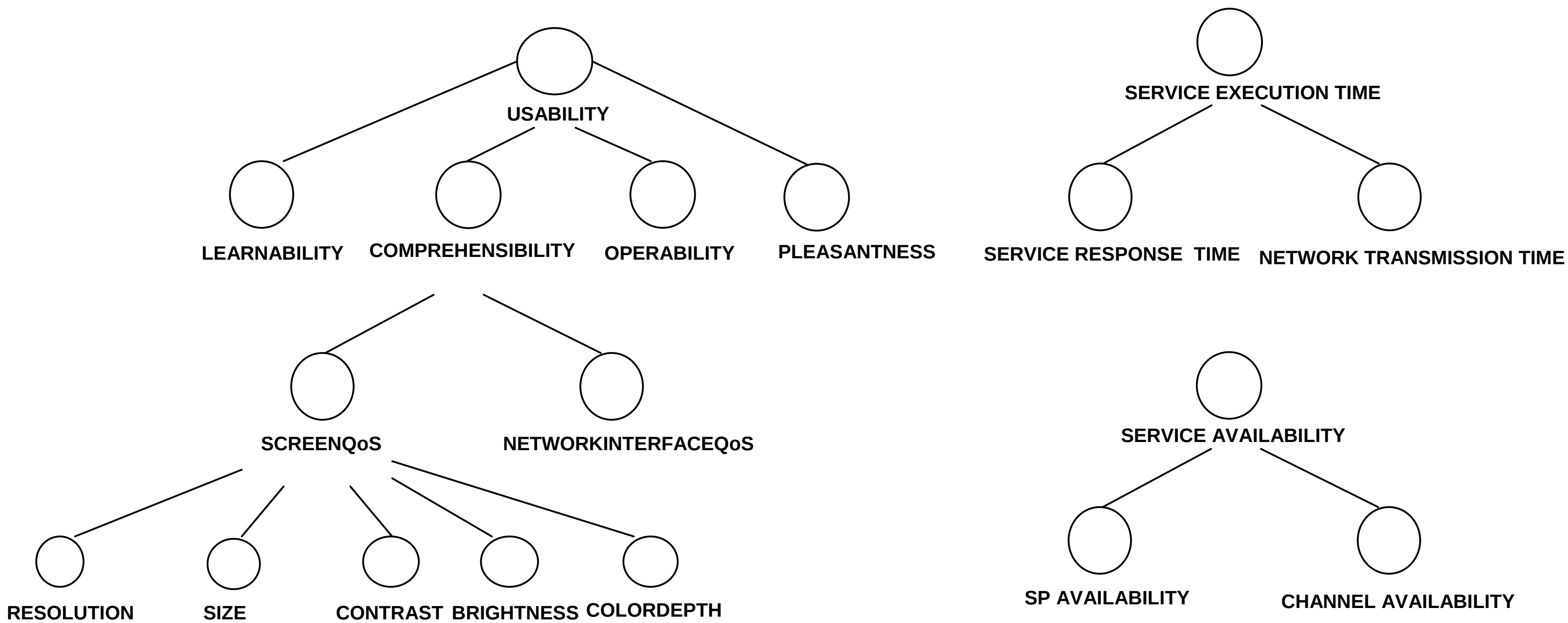


The phases of the Methodology

Enriched service models: a set of UML diagrams that models the multi-channel service along with its quality characteristics

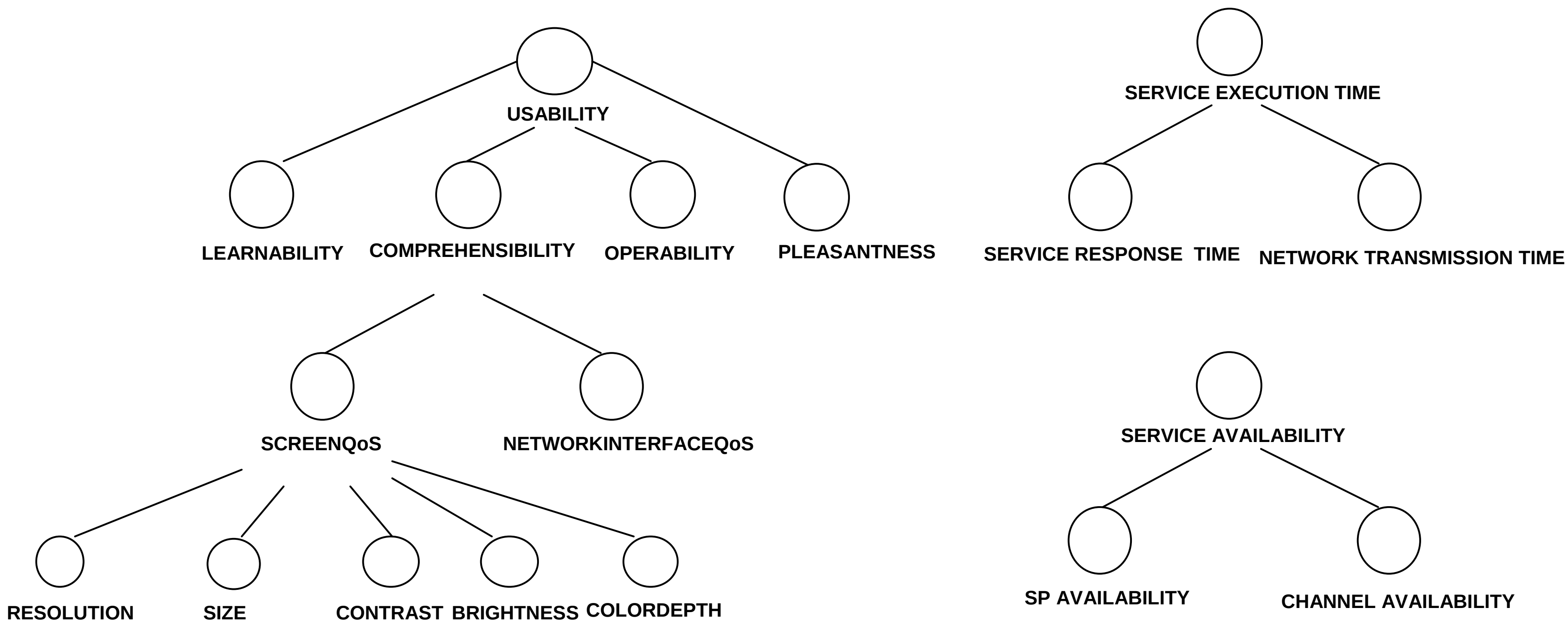


Quality of Service Evaluation



Dependencies could be linear, non-linear or expressed in tabular form

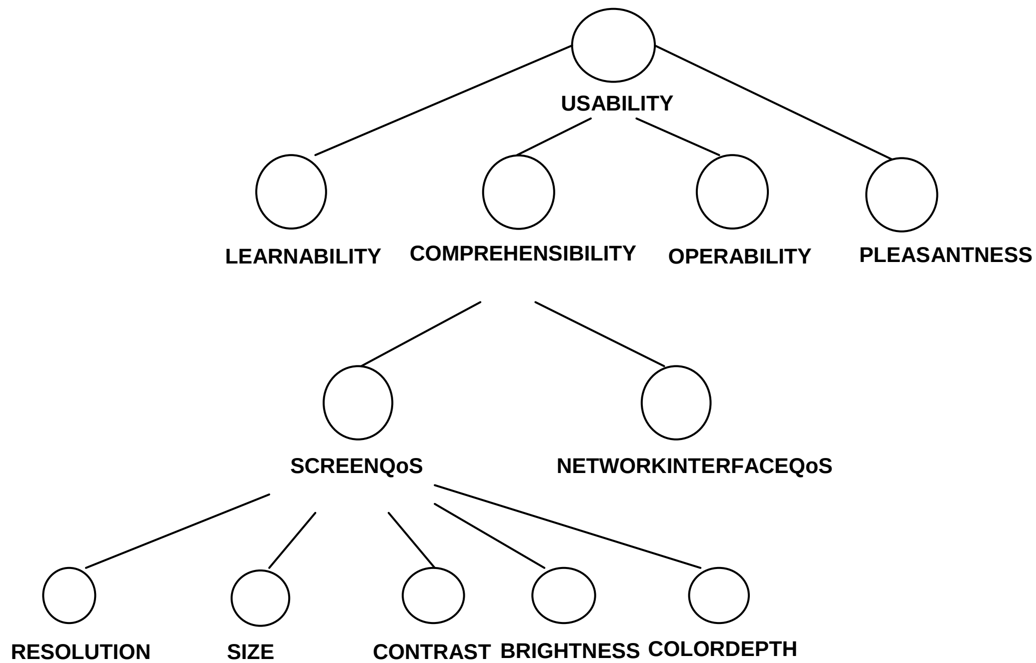
Quality of Service Evaluation



321 QoS dimensions, 203 dependencies, explicit formulation in 8% of total cases, while 50% can be evaluated by running simulations

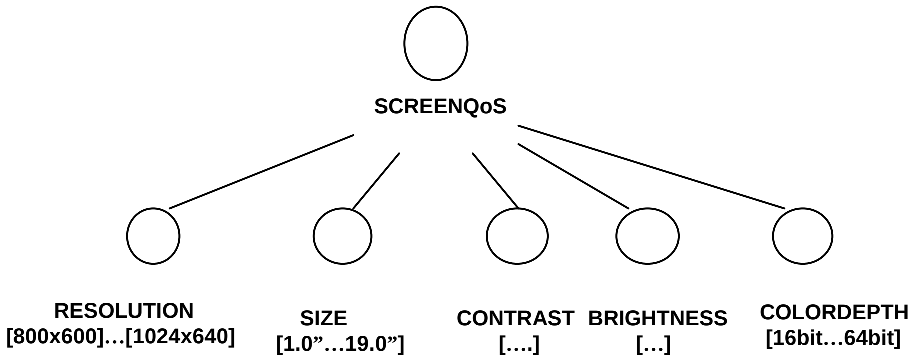
QoS Evaluation

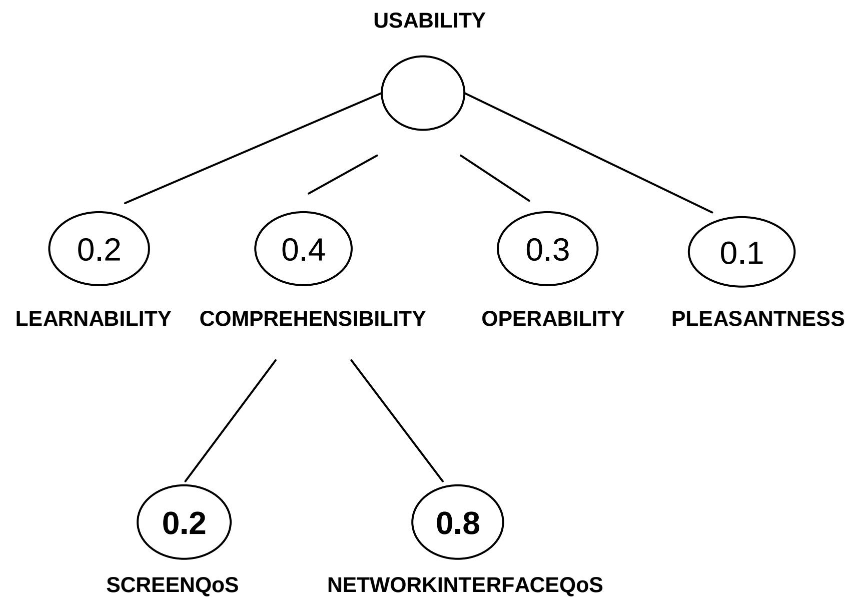
- The dependency among quality dimensions could also be qualitative



- In order to evaluate quantitatively the value of usability, the Simple Additive Weighting **(**SAW**)** technique is adopted
- The SAW method is one of the most widely used techniques to obtain a *score* from a set of dimensions having different units of measure

SAW Method





T_1= <1024x640, 19.0”, …, 64 bit>

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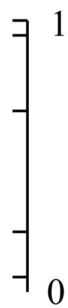
T_n = <800x600, 1.0” , …, 32 bit>



T_k, value 0.7 T_j, value 0.3

v(T)

v(T,UP) if the mapping depends on the user profile

COMPREHENSIBILITY=0.2*0.7+0.8+0.3=0.38

USABILITY=0.2*LEARNABILITY+0.4*0.38+….

Assumptions Evaluation

- The quality evaluation technique allows verifying design hypotheses
- If the technical characteristics are fixed, then the relevant quality values can be determined
- A design hypothesis is verified if the technical characteristics provide quality values greater or equal to given threshold B_k (e.g. availability≥99%, usability≥0.7)
- Quality thresholds can be fixed a priori as a desired characteristic of the service but could also be determined by end user profiles (a set of characteristics of the users that can be exploited for further customization of services)

UP/QoS Matrix (step 1)

UP \ QoS	Comprehensibility	Learnability	Operability	Pleasantness
Is_ltf_pref.	X			X
Is_ltf_skills		X	X	
ICF_rel_capab.			X	
ICF_body_funct.	X	X	X	
Expertise	X	X	X	
Delivery pref.	X	X	X	X

User profile attributes are values in the range [0,1]

UP/QoS Matrix (step 2)

QoS / UP	Comprehensibility	Learnability	Operability	Pleasantness
Is_ltf_pref.	0.1			0.5
Is_ltf_skills		0.2	0.2	
ICF_rel_capab.			0.2	
ICF_body_funct.	0.4	0.5	0.2	
Expertise	0.3	0.2	0.1	
Delivery pref.	0.2	0.1	0.3	0.5

COMPREHENSIBILITY=0.1*IS_ITL_pref+0.4*IS_ICF_BODY_FUNCT+0.3*EXPERTISE+
+0.2*DELIVERY PREF=0.1*0.2+0.4*1+0.3*0.8+0.2*0.8=0.82

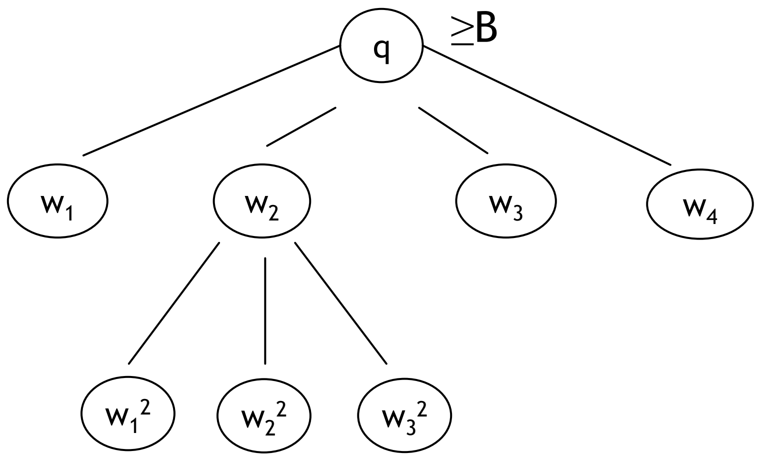
Quantitative approach

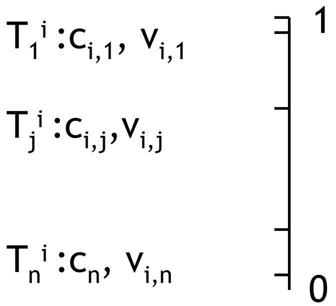
- Lower bound to be provided by each leaf:
  - From *0.2*ScreenQoS+0.8*0.3>=0.82*, we have ScreenQoS ≥ 2.9 **(**impossible the value attributed to every node can be at most 1)
  - If NetworkInterfaceQoS ≥0.85, then the design hypothesis is verified
- If, vice versa, design hypotheses are verified, in the same way we can determine for each leaf the range such that constraints are satisfied

Revising design Hypotheses

- The service design/re-design can be modeled as an optimization problem:
  - Identify the set of choices for the technical characteristics relevant for the end users and for the service requirements which minimizes design costs
- The problem is NP-complete, local search approach

NP-completeness – Proof





I: set of technical choices
$v_{i,j}$: the quality value for alternative j
$c_{i,j}$: the cost associated with alternative j
$x_{i,j}$: the binary decision variable which is equal to 1 if the j alternative for the technical choice i is selected and 0 otherwise

P1)
$$\min \sum_{i \in I} \sum_{j=1}^{n} c_{i,j} x_{i,j}$$

$$\sum_j x_{i,j} = 1; \qquad \forall i \in I \qquad (1)$$

$$\sum_k w_k \sum_l w_l^k v_{i,j} x_{i,j} \geq B \qquad (2)$$

$$x_{i,j} \in \{0, 1\}$$

By relaxing constraint (1) P1) becomes a knapsack problem

The Overall Problem

- In real projects, the design/re-design methodology faces several quality trees and non linear dependencies among quality variables
- Local search approach which is based on the following steps:
  - if the design hypothesis is violated, find a feasible solution by focusing iteratively on the most violated constraint
  - the feasible solution obtained in the first step **(**or the solution which corresponds to the design hypothesis if it is verified**)** is improved by exploring the current solution neighborhood in order to to find a quasi-optimum solution
  - the optimization technique implements a quality tree partitioning, in order to solve with integer linear programming tools, problems for qualitative dependencies
- We are developing an hybrid optimization approach which interleaves the solution of linear integer programming problems with non-linear problems

Conclusions and Future Work

- Methodology to support design/redesign of multi-channel services
- Consider different classes of end user with different ideal user profiles
- Develop a semi-automatic tool which supports the designer in the assumption revision process
- Support the design of composite services

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