Improving System Safety through Agent-Supported User/System Interfaces: Effects of Operator Behavior Model

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Introduction

The results of technology development :

- ✓ Higher degree of performance
- ✓ Higher degree of reliability (dependability)
- ✓ Higher responsibility on human operators
- ✓ Higher importance of the Human Interface

⇨ More than 70% of the failures which happen during the interaction between the operator and the system, are under the responsibility of the operator

In this context, the safety is one of the more important quality of the human/system interfaces

Human errors

The causes of human errors can be :

- ✓ Internal such as stress, tiredness, high cognitive loads or lack of knowledge
- ✓ External such as wrong aids and navigation systems

A wrongly designed user/system interface may lead to misinterpretations, causing decision making errors

User/System Interface adequacy becomes even more important and critical

The quality of the USI can reduce the incidence of the human errors

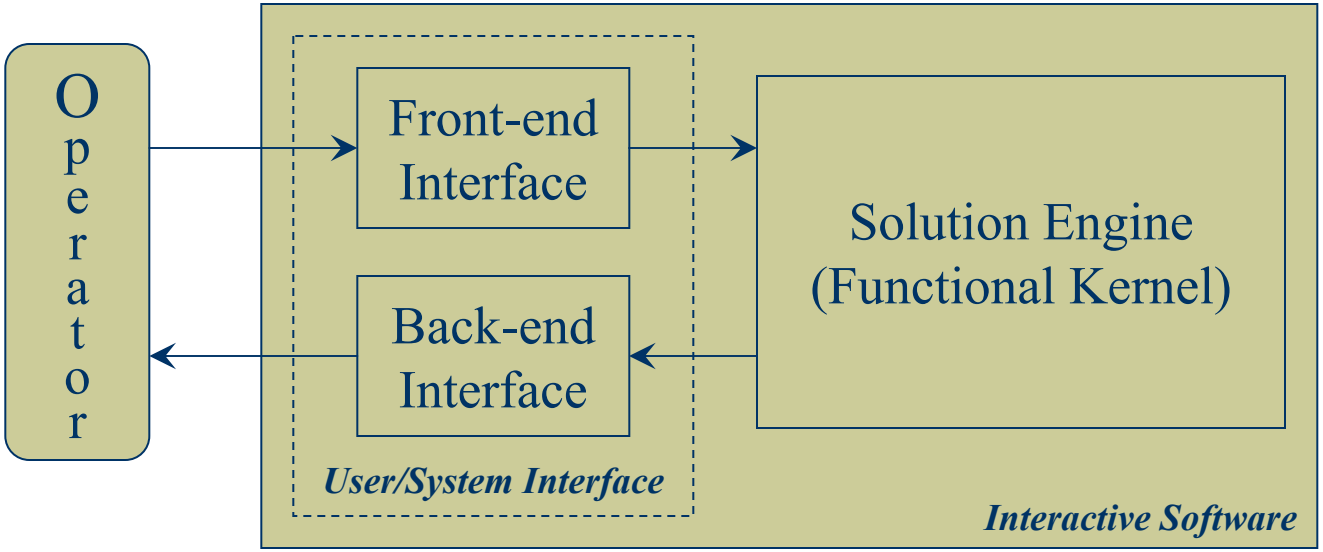
Quality principles

Quality principles make it possible to design as well as evaluate and compare the user/system interfaces. They are presented in four groups :

- ✓ The usability principles *related with users* or *problems*
- ✓ The communicativeness principles *related with users*, *formulation and solving of problems,* and *display*
- ✓ The reliability principles *related with users*, *usages* and *computerization*
- ✓ The evolvability principles *related with users* and *with software product*

Interactive software

Every interactive software consists in two parts :



Intelligent interfaces (including knowledge-based and agent-supported interfaces) add several types of cognitive abilities to both front-end and back-end interfaces

Objective

- To improve the quality of the user/system interactions through the conception of agent-supported interfaces, adaptive and more ergonomic in order to support interaction within critical situations

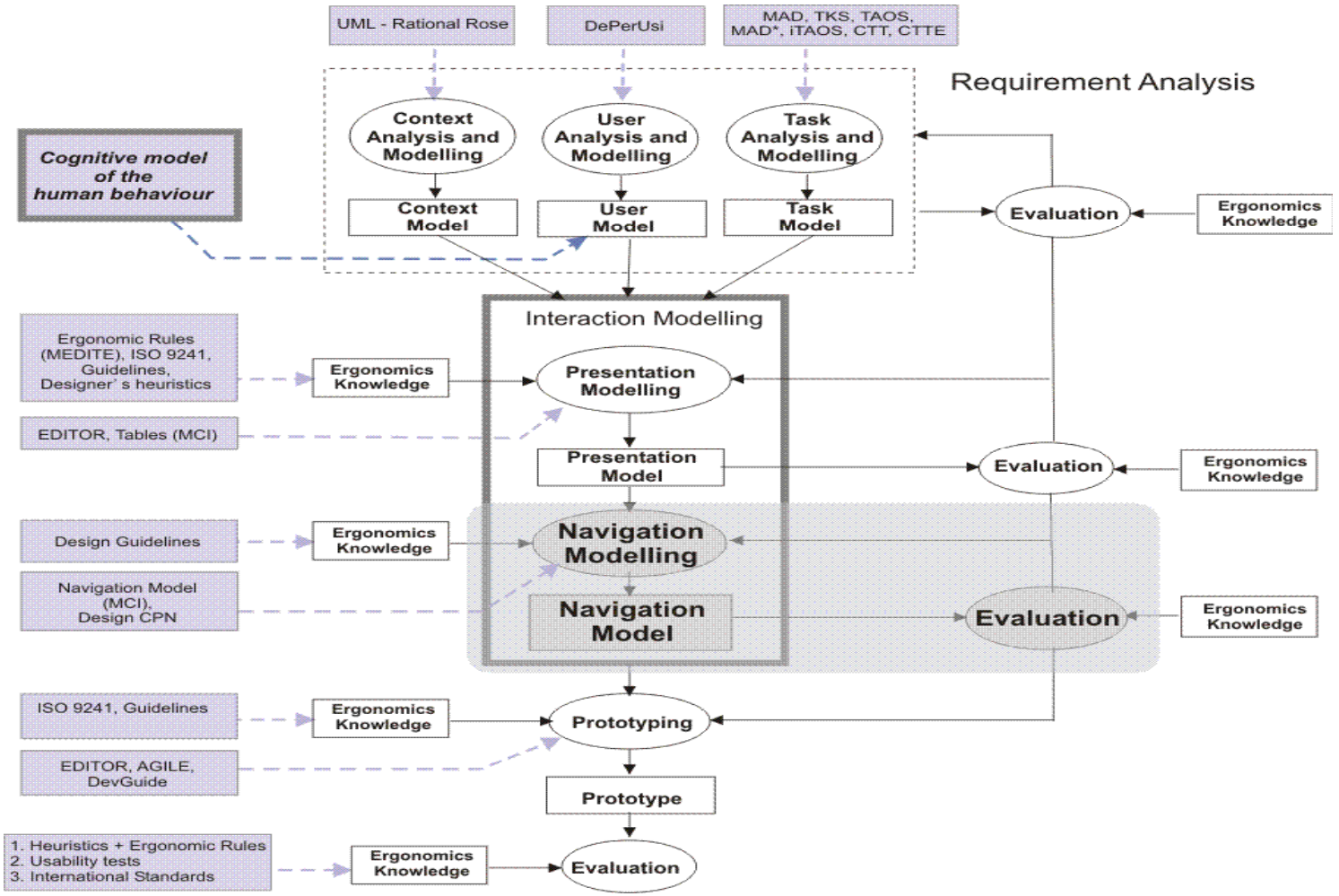
- To reach this objective, we propose :
  - ✓ To refine the interface design method MCIE
  - ✓ To define and integrate a behavior model of the operator when facing critical situations
  - ✓ To take into account the quality principles and the operator stereotypes into the human interface design process

MCIE (Method for the Conception of Ergonomic Interfaces)

MCIE is user centred and based on ergonomic principles incorporated as rules :

- ✓ The conception process is based on model building and evaluation
- ✓ It consists of three main phases: requirement analysis and specification, interaction abstract representation and prototype building and evaluation
- ✓ It adopts an iterative approach of interface design
- ✓ It formalizes its outcomes into an interaction model from which a prototype can be built.

MCIE method


UML - Rational Rose
DePerUsi
MAD, TKS, TAOS, MAD*, iTAOS, CTT, CTTE
Requirement Analysis
Context Analysis and Modelling
User Analysis and Modelling
Task Analysis and Modelling
Cognitive model of the human behaviour
Context Model
User Model
Task Model
Evaluation
Ergonomics Knowledge
Interaction Modelling
Ergonomic Rules (MEDITE), ISO 9241, Guidelines, Designer' s heuristics
Ergonomics Knowledge
Presentation Modelling
EDITOR, Tables (MCI)
Presentation Model
Evaluation
Ergonomics Knowledge
Design Guidelines
Ergonomics Knowledge
Navigation Modelling
Navigation Model (MCI), Design CPN
Navigation Model
Evaluation
Ergonomics Knowledge
ISO 9241, Guidelines
Ergonomics Knowledge
Prototyping
EDITOR, AGILE, DevGuide
Prototype
1. Heuristics + Ergonomic Rules
2. Usability tests
3. International Standards
Ergonomics Knowledge
Evaluation

The operator behavior model

The optimization of the navigation component
The taking into account of the operator behavior

More efficient task completion and overall increase of the quality of system's performance and operation safety

The model is based on the Object-Action Interface Model (OAI)

It is taken into account :

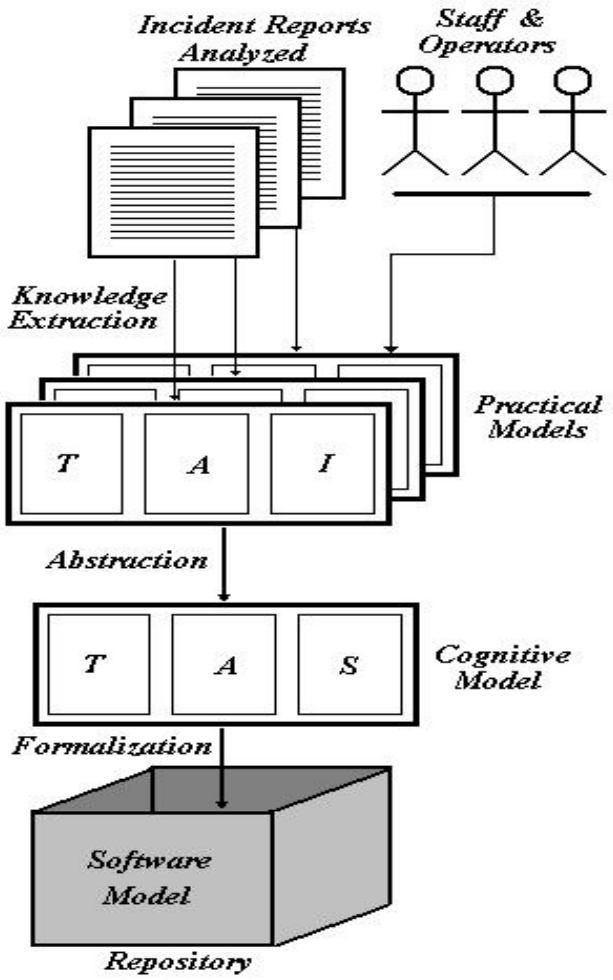
- ✓ the knowledge of the operator
- ✓ his stereotype depending of the way the tasks are performed

Analysis of the operator behavior

The method consists in seven steps :

- ✓ Development of a conceptual model of incident scenarios
- ✓ Construction of an incident scenario simulator
- ✓ Observation and recording of the behavior of this industry's operators
- ✓ Building of a cognitive model of the operators' behavior
- ✓ Validation of the cognitive model of the operators' behavior
- ✓ Integration of the cognitive model of behavior into MCIE
- ✓ Validation of the method MCIE

A conceptual model of incident scenarios



Corpus

Knowledge Acquisition:
<Taxèmes, Actèmes, Inferences>

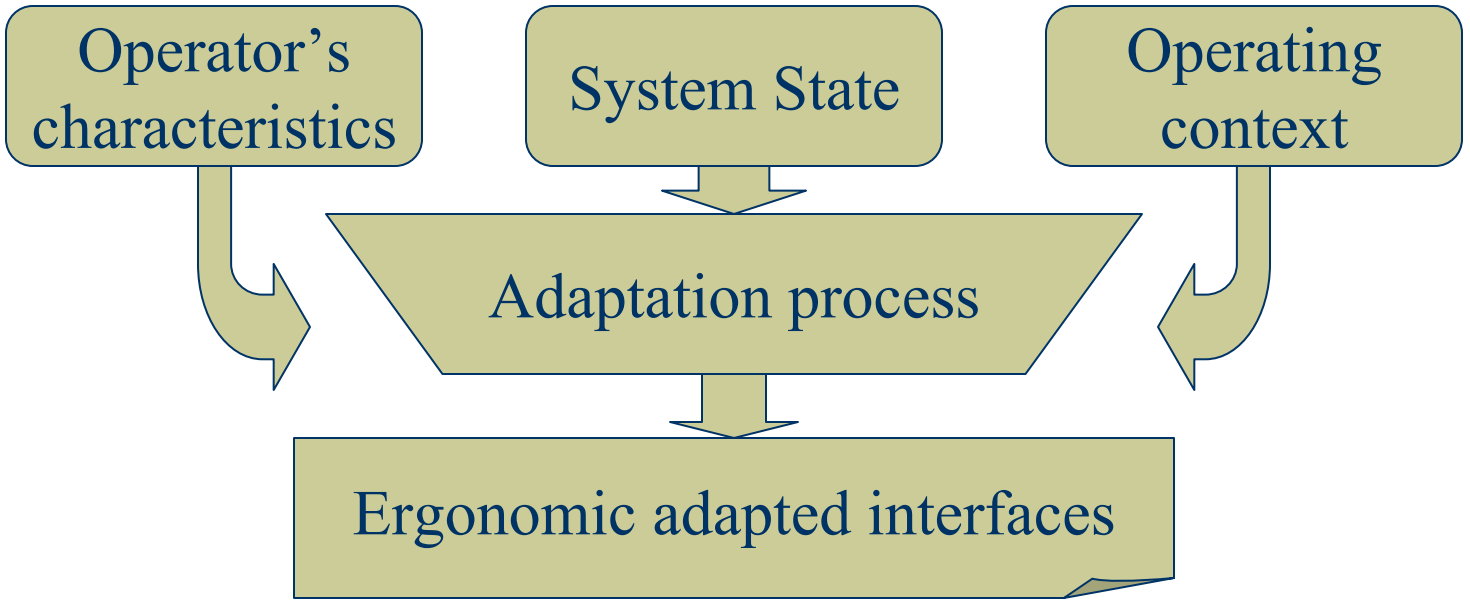
Abstraction of the practical models:
<Taxinomies, Actinomies, Reasoning Schemas>

Formalisation
<Objects, Methods, Rules>

Adaptive User/System Interface

Objective :

- ✓ To help the operator during critical situations
- ✓ To avoid critical situations due to wrong interactions



Adaptation process

- To choose the right interactive object according to both the performed task and the current operator.
  - The interactive objects can be:
    - ✓ Diagrams
    - ✓ Graphics
    - ✓ Forms…
- The choice of task representation depends on the operator's interaction achievements. They can be computed through the operator's actions during the task running.

Operator's stereotypes

Stereotype groups are define according to the operator interaction performance, from the following features : *Interaction frequency*, *Repetitiveness rate*, *Experience level, Task complexity*

Four stereotypes groups has been composed :

1. the *casual* operator
2. the *limited* operator
3. the *general* operator
4. the *expert* operator

The set of features, which allows to define the stereotype groups, has to be re-examined and expanded, according to the operator behavior study

Intelligence and agent-support in user/system interfaces

- The characteristics of intelligent interfaces are :
  - ✓ User adaptivity
  - ✓ User modeling
  - ✓ Natural language technology
  - ✓ Dialogue modeling
  - ✓ Explanation generation
- Agents may assist by decreasing task complexity, bringing expertise to the user or simply providing a more natural environment with which to interact

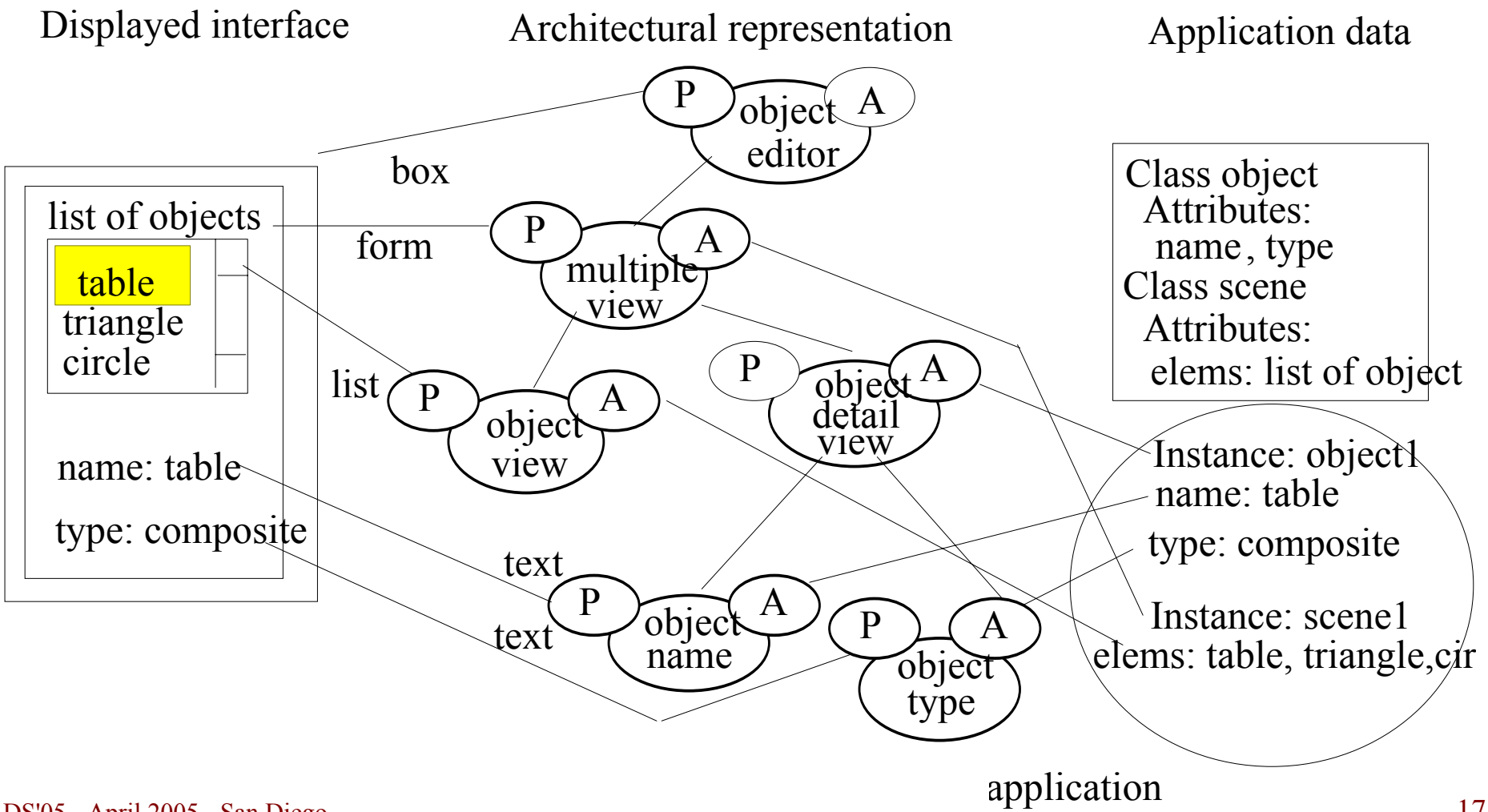
Agent architecture for USI

In order to implement the behavior model of the operator as well as the adaptation process, we propose to design the user/system architecture by using agent architecture

A PAC agent is composed of three facets :

- ✓ The presentation facet
- ✓ The Abstraction facet
- ✓ The control facet

Agent architecture example



Formal description

A formal description of the interface agents has been used to built the former hierarchy

⇨ The composition rules are specified by a context-free grammar :

<editor> ::= **box** <view>n *abstraction (where n=1: multiple_view)*

<view> ::= **form** {<form_control>} *abstraction* /
graphic {<graphic_control>}...

<form_control> ::= <interactive_list>/ <interactive_text>/
<interactive_menu> ...

<interactive_list> ::= **list** *abstraction*

Conclusion

The aim of our work is to provide an user/system interface with a high error tolerance to supervision operators in order to support them during interaction within critical situations

The quality of the user/system interactions is increased through the conception of adaptive and more ergonomic agent-supported interfaces, which take into account quality principles

We are now developing an incident scenario simulator in order to observe and record the behavior of operators facing critical incident before integrate the behavior model into MCIE method