# Adaptation of Shared Traces in e-learning Environment

Karim Sehaba
Université de Lyon, CNRS
Université Lyon 2, LIRIS, UMR5205
F-69676, France
karim.sehaba@liris.cnrs.fr

***Abstract*— In the context of e-learning, this work focuses on sharing experiences between users (learners, tutors or designers). This article focuses particularly on the transformation process to adapt the shared traces according to the profile of their target users. The trace is defined as history of user actions collected in real time from his/her interactions with the computer environment. Thus, we propose models for representing trace, user profile and adaptation knowledge. In order to bring flexibility and adaptability to our approach, we propose a model of knowledge extraction from a Trace-Based Management System (TBMS) representing the activity traces of several users.**

***Keywords: E-learning; Traces; Sharing experiences; Interaction modality; Adaptation***

## I. INTRODUCTION

Our work aims to develop a system that adapts the shared traces according to the target user profile. Formally, a trace is a set of *observed elements* temporally located [1][4]. Each observed element represents the user action on computer environment such as opening a file, clicking on a hyperlink, posting a message on the forum, etc.

The objective of our research is to propose models and tools for transforming the traces shared by a user $u_1$ in order to be adapted to the target users $u_2$. For this, the system should have *adaptation knowledge* and *user profiles* that allow it to transform the traces of $u_1$ according to the properties of user $u_2$ stored in his/her profile. The main areas of these adaptations are: *Content adaptation, Presentation adaptation* and *Adaptation of interaction modalities*. This paper focuses on the adaptation of modalities. In particular, it addresses two issues:

- How to adapt the traces? It consists in transforming the trace of a source user $u_1$ in order to be adapted to the target user $u_2$, particularly concerning the interaction modalities of the shared traces. For this, we have proposed representation models (for traces, profile and adaptation knowledge) and transformation process (adaptation of traces taking into account the profile of the target users).
- How extract adaptation knowledge from traces? This is to propose a method that can analyze the traces of several users, stored in TBMS, in order to deduce generalizations on the adaptation rules. For this, we propose to represent modalities in the interaction traces and analyze these traces with a process of knowledge extraction.

The article is organized as follows: Section 2 and section 3 describe our models for representation and transformation of traces. Section 4 presents the application context of our work that concerns the VCIel training.

## II. FORMALIZATION

### A. Trace

A trace T is a sequence of user actions, and the modalities used, to achieve a given task. Indeed, to perform a task (e.g. printing a file or compiling a .tex file), the user performs actions on one or several medias using a language of interaction (e.g. command line or via a GUI). Formally,

$$T=<u, task, (O_1, O_2, \ldots O_n)>$$

- $u$ : the traced user,
- *task* : the description of the user task,
- $O_i$: observed element, each $O_i$ is a couple $(A_i, M_i)$.

$A_i$ is the user action, knowing that each action $A_i$ has a type, noted $\overline{A_i}$, which defines its structure. The type $\overline{A_i}$ defines the attributes of the action ($a_1$, $a_2$,…, $a_n$), where each attribute $a_j$ has a definition domain $D_j$. Examples of actions:

- $\overline{move\_file}$ (file, folder), *move_file* (file.tex, Doc)
- $\overline{write\_date}$ (dd, mm, yyyy), *write_date* (1/1/2011)

$M_i$ is the interaction modality. The notion of "*modality*" has different meanings and it is therefore difficult to find a definition that is accepted unanimously by researchers. In our approach, we retain the definition of [2] that defines the modality by information structure exchanged, in connection with the physical device used for presentation. Formally $M_i = <d, L>$ where:

- $d$ interaction device: one or more media that allow the acquisition or diffusion of information, and
- $L$ interaction language: a set of well-formed and meaningful expression for the computer system.

### B. Profile

The profile has an important role in the adaptation process. Indeed, based on the properties of the profile, the adaptation process will transform the shared trace in order to be conform to the target user. The profile is also involved in the knowledge extraction process. It determines the conditions under which a given modality may be used to perform a given action. Formally, the user profile P is a set of properties that characterize the user:

$$P = <P_1=v_1, P_2=v_2, \ldots, P_n=v_n>$$

- $P_i$: the property name. Each property belongs to one of the following components: skills (eg, Linux commands, programming language, etc.), physical

and cognitive abilities (eg, visual, auditory, etc.), and preferences (eg, learning style, colors, etc.).

- $v_i$: the value of the property, with $v_i \in [0,1]$. The value 0 indicates the absence of the property and value 1 indicates the maximum value of the property. For example, the visual capacity of a blind user is $P_{visual} = 0$, and the visual capacity of a user without visual impairment is $P_{visual} = 1$.

### C. Adaptation Knowledge

Knowledge adaptation allows the system to choose, for each action of the trace, the adequate modality based on the user profile. The principle is to associate for each action type $\overline{A_i}$ one or more facets where each *facet* is defined by a *mode* and a *modality*. The mode defines the conditions under which the modality can be used. These conditions are related to the user profile. The modality defines the media and the interaction language to achieve the action.

Formally, adaptation knowledge of action type $\overline{A_i}$ is defined as follows:

$\overline{A_i}$ {
  $\underline{Facet_1}$:
  $Mode_1$: < ($m^1_1 \in I^1_1, w^1_1$), ..., ($m^1_{k1} \in I^1_{k1}, w^1_{k1}$)>
  $Modality_1$: < $media_1$, $interaction\ language_1$>
  $\underline{Facet_2}$:
  $Mode_2$: < ($m^2_1 \in I^2_1, w^2_1$), ..., ($m^2_{k2} \in I^2_{k2}, w^2_{k2}$)>
  $Modality_2$: < $media_2$, $interaction\ language_2$>
  ...
}

For each *facet j*:

- $m^j_1$: profile property / $m^j_1 \in P$
- $I^j_1$: interval of values / $I^j_1 \subseteq [0, 1]$
- $w^j_1$: weight of property $m^j_1$ in the mode of the facet j.

The mode expresses constraints on the profile properties where each constraint specifies the interval within which must belong the property value and the weight of property in the mode.

## III. Reasonning

### A. Adaptation process

The adaptation of traces is a transformation process that generates, from a trace shared by a user $u_1$, another trace with appropriate modalities to the target user $u_2$. The principle of transformation is to associate each action of the trace of $u_1$ the modality that maximizes the similarity between its mode and the profile of $u_2$. Several similarity functions that can be used, for example:

$$\phi(mode, u_2) = \frac{\sum_{i=1}^{n} w_i * \varphi(p_i = v_i, m_i \in I_i)}{\sum_{i=1}^{n} w_i}$$

$P_i$: profile property, $m_i$: mode property, $I_i \subseteq [0, 1]$: interval of values, $w_i$: weight of property in mode, $n$: cardinality properties of the mode, $\varphi$: similarity between $P_i$ and $m_i$.

The aim of the adaptation process here is not to automatically run the adapted traces but to allow the user to know how it should proceed to carry out its tasks. For the execution of the adapted traces, in addition to the profiles other criteria must be taken into account, such as: media available, consistency between the interaction language and the software available in the computer environment, etc.

### B. Extraction of Adaptation knowledge

The aim is to extract adaptation knowledge concerning the modalities of an action type from traces stored in TBMS. The principle is to:

- Search in the TBMS all users who have performed an action of type $\overline{A_i}$ with the modality $M_i$,
- Determinate, in the profiles of those users, properties with similar or identical values,
- Assign these properties to the mode $mode_i$ associated with the modality $M_i$ of $\overline{A_i}$, then
- Add the facet $(Mode_i, M_i)$ to the knowledge of $\overline{A_i}$,
- Repeat the same reasoning for all modalities associated with actions of type $\overline{A_i}$

Formally, for each action $A_k$ associated with a modality $M_k$ in the TBMS, we define the matrix of size $m*n$, where $m$ is the number of the users used the action of type $\overline{A_k}$ with the modality $M_k$, and $n$ is the number of the properties in the user profile. We have developed a classification algorithm to determine, from the matrix, the similar properties. These will be assigned to mode of the modality in question.

## IV. First Results : Application VCIel

Our work is applied to the training device VCIel[1] [13]. This is a Master (Bac + 5) fully-online learning environment that aims to train professionals in Computer Science and Multimedia Information. Each year, this training trains twenty students from several different countries. Some students are in continuous training (i.e. they already exercise an occupation) and others are in initial training. This geographic and institutional diversity requires a transformation of shared traces between learners in order to adapt them to the specificities of each student (context, skills, preferences, capacities, etc.). The adaptations in this area concern the assistance to use the SPIRAL[2] platform and the use of some computer software.

## References


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[1] Website : http://vciel.univ-lyon2.fr/

[2] http://spiralconnect.univ-lyon1.fr/