

**A flexible and adaptable virtual class  
in a tele-teaching environment**

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**Abstract.** This paper describes a virtual class which is based on the principles of CSCW (Computer Supported Cooperative Work) and ICAL (Intelligent Computer Aided Learning) systems. The virtual class proposed allows to a group of learners to participate in training sessions of an adapted tele-teaching system or adapted virtual class, this system takes into account progression rhythm different inside a community of remote learners. The virtual class allows to adapt the teaching system in a flexible, individual, and collective way. This system allows also the implementation of a pedagogical method: the cooperative learning. This implementation is developed in a distance education context using a telematic network. An application of this system in a multi-site environment of teaching of the accounting domain is described. The development of this system has been realized as a distributed application, the system of development used is the RPC (Remote Procedure Calling) product and the C and C++ languages.

**Keywords:** Tele-teaching, ICAL system, collaborative learning, distributed system

## I Introduction

The principle of the architecture proposed for an adapted training service is to allow the adaptation of knowledge transmission from a teaching function managing a virtual group of learners by a communication system (figure 1). Teaching functionalities are distributed taking into account the participation of teachers, system, resources and learners in some cases (when a learner has the knowledge or experience necessary for playing the teacher's role).

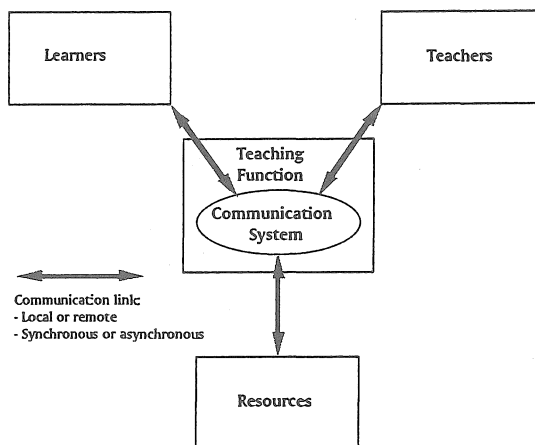
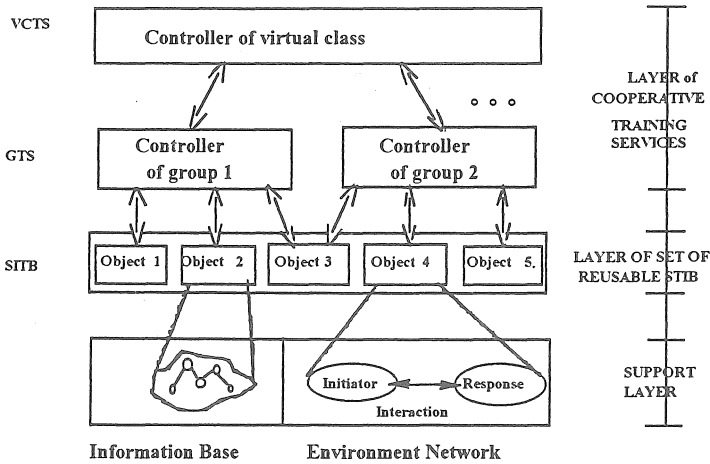


Figure 1: General architecture for each adapted training service.

The majority of learning telematic systems developed do not or rarely enable the system to control the teaching module. In general this function is controlled by the teachers, in the same way as traditional classrooms. In this paper, we propose for each adapted training service that the system controls the teaching functionality with the participation of teachers, learners and resources in a virtual class system.

## II General architecture

In the multi-site environment of tele-teaching (figure 15) [Hern, 95d], we propose that any training site must be represented according to the ARESFED (In french: "Architecture pour la Reutilisation et l'Exploitation des Services de Formation dans le contexte de l'Education à Distance"). This architecture is composed of three layers: support layer, layer of a set of reusable SITB (Service Independent Training Building Block) and a cooperative services layer [Hern, 94c], [Hern, 95c], [Hern, 95d] (figure 2).



SITB: Service Independent Training Building Block  
 GTS: Group Training Service

VCTS: Virtual Class Training Service

Figure 2: Training architecture of a virtual class.

In this way, the representation of each training site is simplified and standardized. Thus, we must specify only an architecture: the ARESFED.

II.1 Support layer

It represents a set of frameworks from which the training architecture is built:

*Information Space*, provides information management services relevant to the courseware developed (for example: an object-oriented database management system stocks all the reusable objects).

*Communication Space*, supplies services supporting a distributed system and network services.

II.2 Layer of a set of reusable SITB

This layer is represented by a set of functional, independent, and reusable components. These components will be shared and reused for creating a new service. We have identified with a participation of educationalists two kinds of resources: didactic and information resources:

- a) Didactic resources represent a set of teaching activities [Canu, 94], [Vinc, 94], these resources are constituted by a set of didactic “bricks” that can be teleloaded from each training center.
- b) Information resources represent a set of complementary information “bricks” of domain.

From reusing of these types of resources a training service can be specified as a dynamic training service. The criteria of reusing of didactic and information resources are determined by learner’s educational needs. The dynamic training service must diagnose an adequate resource that responds to learner’s educational needs. In this way a dynamic training service is considered as an adaptable service.

II.3 Cooperative service layer

This abstraction level represents the two kind of cooperative training services provided by this architecture. We consider two kind of adaptable services (figure 3):

- a) global level represents a virtual class composed of a set of remote learner groups and
- b) local level represents a particular learner group, each remote learner group is classified by a knowledge level.

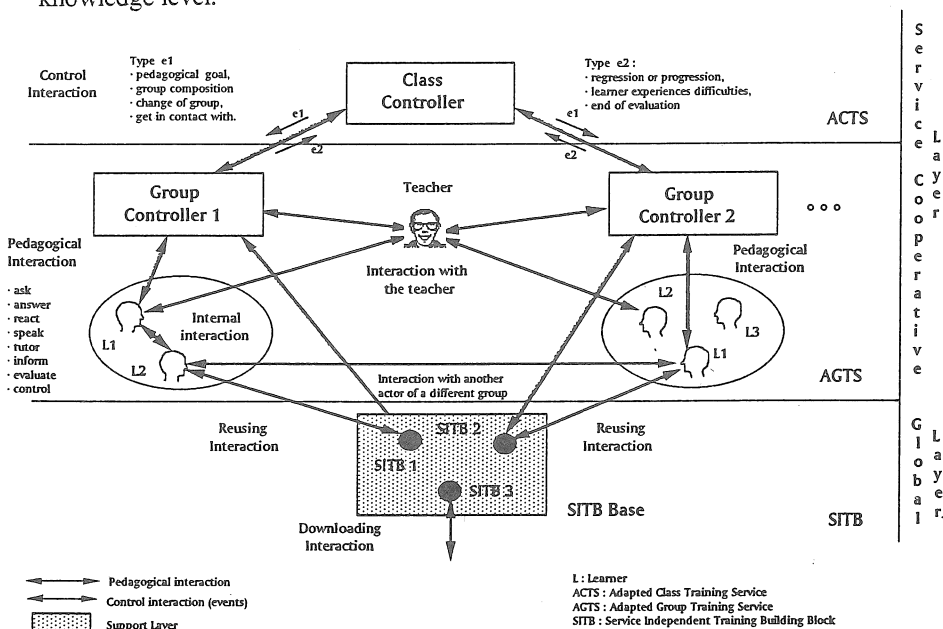


Figure 3: Interactions in the architecture of adapted virtual class.

These two classes of cooperative services must be adaptable to learner's behavior in a training session.

The composition criterion of virtual class takes into account a pedagogical context, this pedagogical context is based on the cooperative learning [Doyo, 91]. A virtual class will be composed of a set of heterogeneous groups, each group allows to a set of remote learners to participate to a training session. In a traditional class the homogeneity of knowledge level is not always assured. Some cases, this homogeneity of knowledge level becomes very superficial. For solving this problem, we consider a first level of adaptation to learner's educational needs, this first level correspond to take into account a composition of a virtual class from heterogeneous groups. These groups have a variable composition [Hern, 95d]. Each heterogeneous group corresponds to a different level of knowledge allowing to characterize a group of learners with the same level of knowledge about a particular domain. However, inside a group of learners is possible to find different behaviors of learners according to progression rhythm of each learner. The second level of adaptation is taken into account into a group of learners. A particular knowledge level associated to a group of learners may also become

superficial and not adapted. For preventing this problem, we propose to consider the behavior zones into a group of learners. In this case, it is necessary to allow and manage the change of behavior zone of a learner inside a group (*inter-group change*) for assuring an adapted knowledge level of learners inside a particular group (local view). For assuring an adapted virtual class (global view) is also necessary to allow and manage the change of group (*intra-group change*).

### II.3.1 The adapted training service of a virtual class

The adapted training service of a virtual class has as principal functionalities:

- a) the managing of progression of a set of remote learners,
- b) the controller of the VCTS (Virtual Class Training Service) takes into account a pedagogical, structural and adaptable control of a virtual class.

An initial composition allows to create a set of heterogeneous groups, this initial composition is based on a learner evaluation. However, for preventing that the initial distribution becomes static and not adapted during a training session, we must consider a *logical mobility of learners*. This logical mobility must respond to learner's educational needs according to behaviors detected of a group of learners during a training session. So, two levels of distribution of learners have been considered: *variables groups* corresponding to level of class and inside a group of learners, that is a set of *behavior zones* have been established (figure 4).

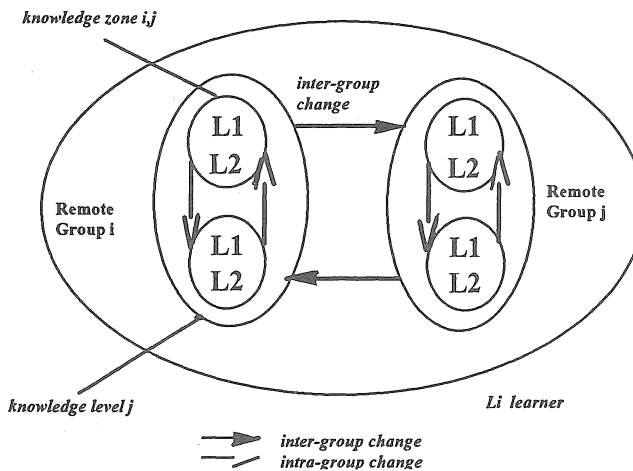


Figure 4: The distribution of learners in the virtual class.

### II.3.2 Group training service

A controller of a Group Training Service (GTS) must adapt a training session to learner's educational needs.

The actors considered in a virtual class are: remote learners, teacher and shared didactic resources (didactic and domain entities).

A didactic interaction is a teaching interaction of cooperative type based on the roles played by actors. A role may be played by several actors [Depa, 91].

A local didactic strategy is represented by activating didactic interaction. These didactic interactions are managed by the controller of a GTS.

The controller of an ATG must establish a dialogue with the controller of the virtual class. This dialogue allows to indicate either a learner may change of group or a learner has a problem or a learner send a request (when he wants to express a problem or point of view).

We established with educationalist team three behavior zones inside a group, these behavior zones represent three types of possible progressions: normal, intermediate and critical zones (figure 5).

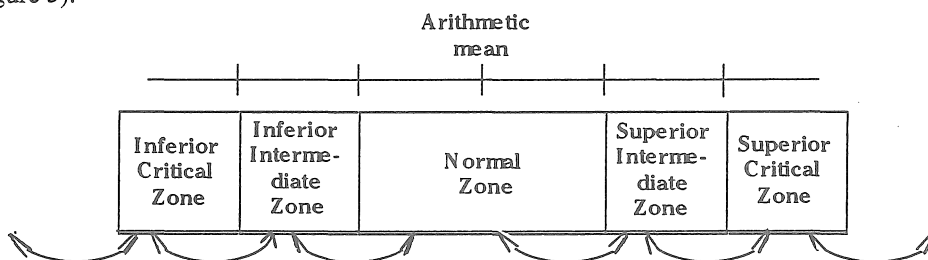


Figure 5: Behavior zones inside a group.

These behavior zones represent a *fine adaptation to knowledge level* and to learner's educational needs. The control of behavior zones requires a set of control rules to manage of mobility of learners. In this way, the control of mobility of learners allows to manage a dynamic and flexible composition of virtual class.

The execution of individual activities will allow to measure the learner progression by a learner profile. This learner profile is the element which allow to an ATG to detect a learner behavior. An ATG controller analyzes and decides a set of adequate didactic interactions according to knowledge level.

The analyze of a learner's profile allow to adjust the composition of a group by a control of mobility of learners inside the behavior zones.

### III Specification of the VCTS

The VCTS must assure the knowledge transmission of a domain to teach. The VCTS has to manage a training session of a virtual class which is composed of a set of remote learner groups. It must also supervise and adapt the execution of a pedagogical strategy in a flexible way.

#### III.1 Architecture of controller of the VCTS

The controller of the VCTS is composed of the following modules [Hern, 95d] (figure 6):

- a) managing module of communication (event manager) with each controller of a GTS. This module must analyze each event sent by a controller of a GTS.

- b) pedagogical module must manage a pedagogical strategy. The principal objectives of this module are: managing of pedagogical goals (knowledge transmission and knowledge evaluating), supervising of homogeneity of knowledge level associated to each group, and providing pedagogical aiding. This pedagogical aidings may be provided by different ways: using a didactic resource which is represented by a computer intervention, a teacher intervention is necessary for having similar functions as a traditional class (explanations, resolving doubts, providing advises, ...), and in the context of cooperative learning a learner intervention is also necessary.
- c) behavior managing module of a group of learners. The VCTS has a *global view* of a virtual class composed of a *set of groups*. The global view is represented by a *set of group profiles*. Each GTS has a *local view* which is represented by a *set of learner profiles*.

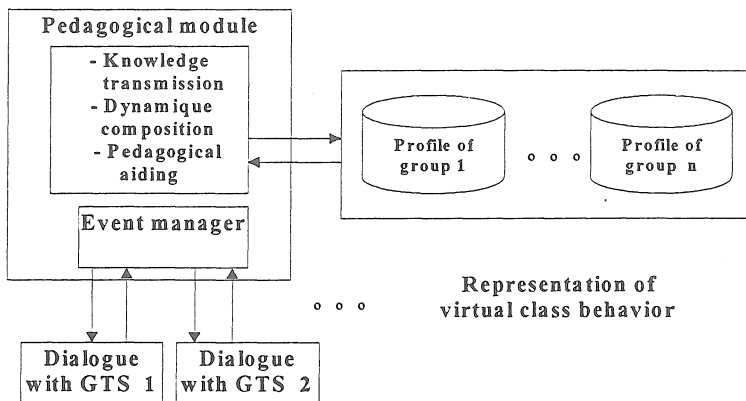


Figure 6: Architecture of controller of the virtual class (VCTS).

Now, we are going to develop the architecture of the VCTS.

### III.2 Managing module of communication

This module is represented as a module that manages all interaction with each controller of a GTS. These interactions between controllers are represented by events. An event is considered as a *client-server interaction* between controllers. The controller of VCTS must manage each event sent by a controller of GTS. The event is analyzed and an interaction must be established. The controller of VCTS gives a response by an event. This event may be a pedagogical goal, a change of group, and get in contact with a teacher or another learner. The processing of events is represented by a repetitive selection (figure 7).

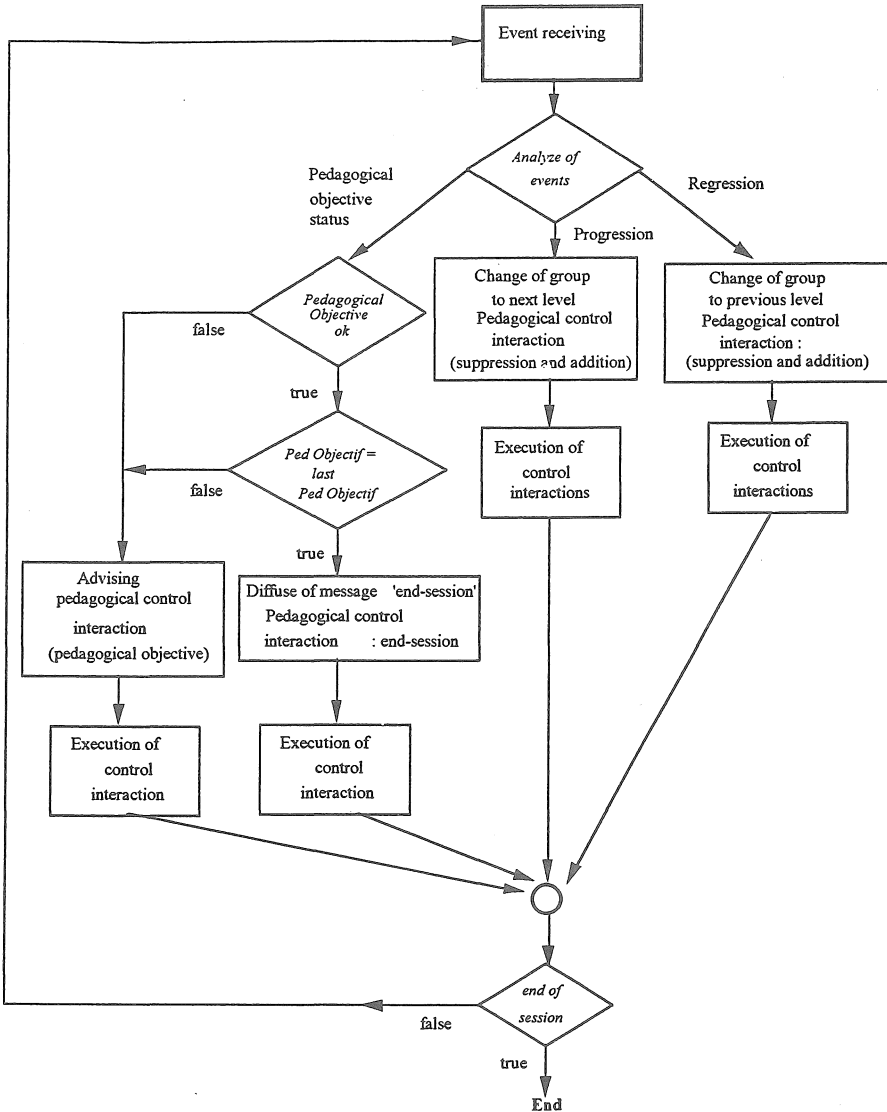


Figure 7: Control of Events in the Virtual Class.

All dialogue event between controllers is represented by a pedagogical control interaction according to an object-oriented approach [Hern, 95c]. The execution of an interaction correspond to execute a communication protocol [Hern, 95d].

### III.3 Pedagogical module

The ICAL system must adapt a pedagogical method according to learner’s educational needs [Canu, 90].

### *Knowledge transmission*

A principal postulate of an ICAL system is to consider a learner behavior as a key factor in all decision taken by the system. In this context, knowledge transmission takes into account a learner evaluating. Thus, an interactive evaluating of learner becomes essential.

In an analogous way to Wenger [Weng, 87], we consider a set of interactions as a means for managing knowledge transmission. The controller of VCTS has the following functions.

• Point of view: Structure

The controller of VCTS is based on the general architecture of an ICAL system [Hato, 92]:

- a expert module must be enabled to solve any problem asked to learners,
- a group profile characterizes a behavior of learner group (knowledge level),
- a tutor module must to manage:
  - knowledge transmission of a domain, that is, from pedagogical objectives aimed and knowledge of learner groups, this module by a teaching strategy must apply adequate learning situations (individual and collective),
  - the dynamic composition of learner group, this is controlled by a validation of inter-group changes indicated by controllers of GTSs,
  - information provided by a human intervention in the context of pedagogical aiding,
  - a dialogue module must assure the communication between controllers (VCTS and each GTS) and the interaction between controller of VCTS and learners.

• Point of view: Knowledge transmission

Pedagogical managing takes into account individual and collective behaviors. Thus, a pedagogical strategy uses an evaluating function.

A learner profile corresponds to an instance of learner profile class (figure 8) and a group profile corresponds to an instance of group profile class (figure 9).

Name
Global_Score
Score of error_1 ("diagnostic")
Score of error_2 ("compte")
Score of error_3 ("sense")
Score of error_4 ("valorisation")
Sum of right reponses
Sum of wrong reponses
Sum of empty reponses
Sum of exercises executed

Figure 8: Learner's profile.

Level of group
Number of learners
AM of Global score
AM of Score of error_1 ("diagnostic")
AM of Score of error_2 ("compte")
AM of Score of error_3 ("sense")
AM of Score of error_4 ("valorisation")
AM of right reponses
AM of wrong reponses
AM of empty reponses

AM: Arithmetic Mean

Figure 9: Profile of a group.



```

Type of interaction: "pedagogical objective"
Parameters: "next pedagogical objective"
Type of relation: "1..1"
Context of interaction
  Scope: string
  Actor_initiator: "id_GTS"
  Role_i: "client"
  Actor_answer: "controller of VCTS"
  Role_a: "server"

```

Figure 11: Representation of the pedagogical control interaction:  
next pedagogical objective.

*When status-pedagogical-objective*

*next pedagogical objective = pedagogical strategy  
(current pedagogical objective)*

*instantiation of next pedagogical control interaction  
execution of next pedagogical control interaction*

#### Dynamic composition

An initial composition is created from an initial evaluating. The results of this evaluating allows to identify the knowledge level of a set of remote learners.

The learner mobility in a virtual class is managed by a control of events sent by a GTS. The homogeneity of a group of learners could be called into question when a learner not progress to same rhythm. So, it is necessary to take into account possible inter-group regressions and progressions.

#### Progression

A learner which advances quickly inside his group, he is a candidate to change of group. So, a controller of a GTS send an event to indicate an inter-group progression. The processing of this event is characterized by a suppression of the origin level and an addition to next level. In this way, the controller of VCTS must establish and execute two pedagogical control interactions: "suppression" (figure 12) and "addition" (figure 13).

*When inter-group progression (learner\_id, knowledge\_level, profile)*

*If knowledge\_level < maximum\_level then*

*instantiation of pedagogical control interaction:*

*suppression (knowledge\_level, learner\_id)*

*execution of pedagogical control interaction*

*instantiation of pedagogical control interaction:*

*addition (knowledge\_level+1, learner\_id)*

*execution of pedagogical control interaction*

```

Type of interaction: "suppression"
Parameters: id_learner
Type of relation: "1..1"
Context of interaction
  Scope: string
Actor_initiator: "controller of VCTS"
Role_i: "client"
Actor_answer: id_GTS
Role_a: "server"

```

Figure 12: Representation of the pedagogical control interaction: suppression.

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Type of interaction: "addition"
Parameters: "id_learner"
Type of relation: "1..1"
Context of interaction
  Scope: string
Actor_initiator: "controller of VCTS"
Role_i: "client"
Actor_answer: "id_GTS"
Role_a: "server"

```

Figure 13: Representation of the pedagogical control interaction: addition

### Regression

A learner which is “very late in his progression” of a training session, he is a candidate to change of group. So, a controller of a GTS send an event to indicate an inter-group regression. The processing of this event is characterized by a suppression of the origin level and an addition to previous level.

*When inter-group regression (learner\_id, knowledge\_level, profile)*

*If knowledge\_level > minimum\_level then*

*instantiation of pedagogical control interaction:*

*suppression (knowledge\_level, learner\_id)*

*execution of pedagogical control interaction*

*instantiation of pedagogical control interaction:*

*addition (knowledge\_level-1, learner\_id, profile)*

*execution of pedagogical control interaction*

The representation of regression interactions are analogous to progression interactions (figures 12 and 13).

### Pedagogical Aiding

A pedagogical aiding may be necessary when the system detects a problem or when a learner wants to express a problem (misunderstood concept, doubt, complementary information). In the last case the human intervention is necessary, especially for resolving any doubt or giving a complementary information.

A decision of type of intervention (system or human intervention) is controlled by a pedagogical strategy. The system proposes a type of intervention and the learner decides the intervention wished.

In the context of human intervention, we have identified two cases:

#### Case 1

When a measure of an error type exceeds to intervention limit, a human intervention is very important to explain again a concept (figure 14).

*If Group i.M-Score\_error i >= intervention\_limit then  
instantiation of pedagogical control interaction:  
get in contact (teacher/learner\_id, Group i)  
execution of pedagogical control interaction*

Type of interaction:	"get in contact"
Parameters:	"id_actor1, id_actor2, profile_actor1"
Type of relation:	"1..1"
Context of interaction	
Scope:	string
Actor_initiator:	"controller of VCTS"
Role_i:	"client"
Actor_answer:	"id_GTS"
Role_a:	"server"

Figure 14: Representation of the pedagogical control interaction: get in contact

#### Case 2

When a inter-group regression has been indicated and the knowledge level considered is smaller than other levels, in this case the human intervention is necessary for aiding to learner.

*When inter-group regression (learner\_id, knowledge\_level)  
if knowledge\_level = minimum\_level then  
instantiation of pedagogical control interaction:  
get in contact (teacher, learner\_id)  
execution of pedagogical control interaction*

The representation of get in contact interaction is the same to case 1 (figure 14).

#### IV Implementation of an adapted virtual class

An example of a virtual class in the context of SEMIEC (In french: Service Evolutif Multimédia de Enseignement de la Comptabilité) has been developed at IPST (French institute for professional training) [Hern,93b]. The SEMIEC environment is based on a distributed configuration. Two kind of sites have been characterized (figure 15):

- The central site which provides a set of reusable SITB from a server.
- The decentralized sites which allow to learners to participate in an adapted training class.

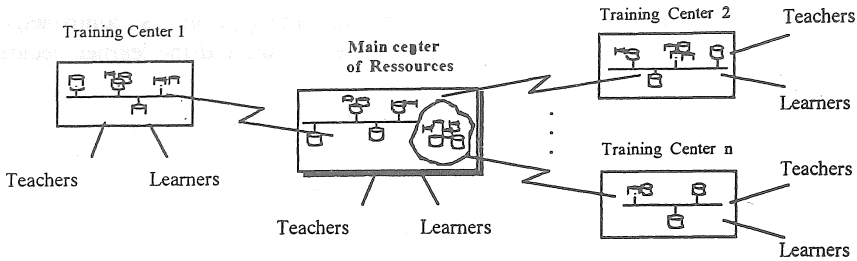


Figure 15: The multi-site configuration of SEMIEC.

The public aimed has been represented by students of first cycle of management at CNAM (in french: "Le Conservatoire National des Arts et Métiers"). The class taken into account had an "initiation" level, this level characterized to learners which are partially or completely novices. Thus, two knowledge levels were considered: "novice" and "intermediate". Each knowledge level was managed by a GTS controller and a class was associated to level "initiation" which was managed by a VCTS controller.

Now, we are going to describe the system used to implement an adapted virtual class.

#### IV.1 Remote Procedure Calling (RPC)

The product RPC (ONC RPC 4.0 developed by Sun Microsystems) [Bloo, 92] allows to develop distributed systems. RPC allows to a program (client) to execute a procedure placed on a remote computer (server). A remote server listen a network detecting when an event has been sent by a client. The RPC library uses the Internet protocols (UDP and TCP). These protocols are the transport protocols more used on Unix.

#### IV.2 The architecture with RPC

The architecture used is based on reusing of reusable SITB. The pedagogical control is distributed between: the controller of virtual class (VCTS), the manager of SITB server, and the controller of group of learners (GTS).

Several RPC servers have been developed allowing to manage the events (figure 16). We have specified a server associated to each learner, a server is associated to the teacher, a server is also associated to controller of VCTS for managing the communication with a controller of an GTS, and a server of reusable SITB is implemented to manage the reusing interactions..

This architecture allows a distributed processing of pedagogical control. The programming of this application has been realized using of language C for managing the communication channels and the language C++ for implementing the cooperative interactions according to an object-oriented approach.

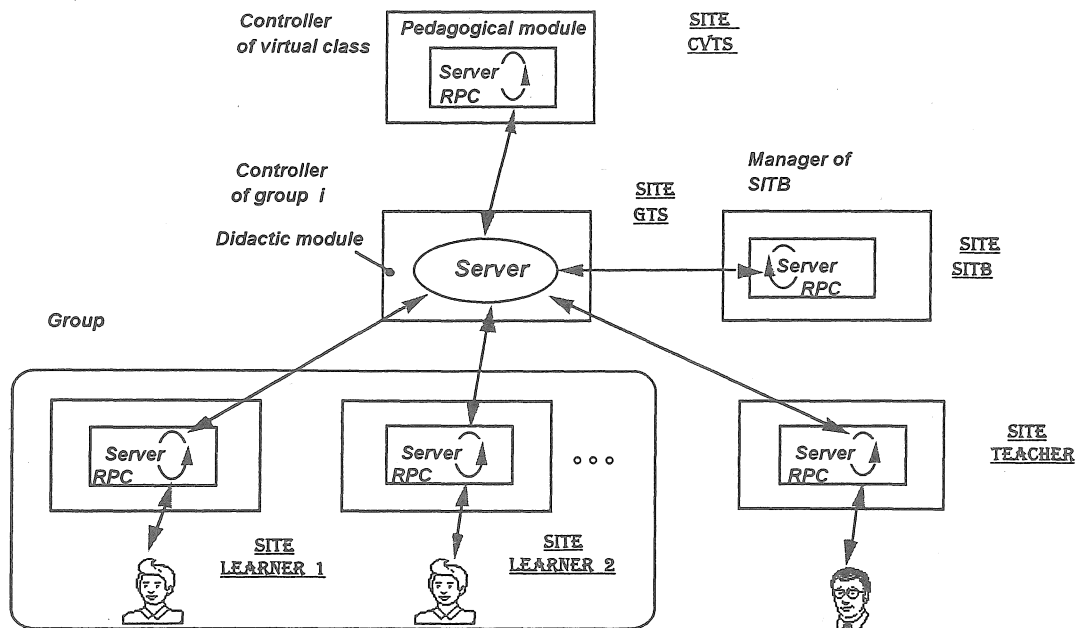


Figure 16: Architecture on RPC.

## V Conclusion

The architecture of the virtual class proposed is a response to traditional virtual classes which are not adapted. The virtual class proposed takes into account different types of learner progressions (behaviors). The virtual class considered is adapted allowing and controlling the learner mobility. This logical mobility may be inside a learner group (intra-group or change of zone) and outside a learner group (inter-group or change of group). This system provides a teaching function distributed between different actors: learners, teacher and resources. This teaching function allows: to use of cooperative learning, to give remote pedagogical aidings, and to apply remote tutor functions.

Works are in progress for implementing a server of reusable SITB in the programming methodology domain. This server will be implemented using of Internet, the access to server will be analogous to a learning environment. The same server will be also used for reusing a set of reusable SITBs and adapting them in a virtual class by Internet.

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