

## **Effective Virtual-Classroom: Evidence-Based Procedures for Adaptive Learning**

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**Abstract:** *Real-time virtual classrooms therefore play an important role in distance learning. In this type of tele-education, multimedia communication systems let teachers and students in different locations participate in the class synchronously. The model we proposed helps to remove the boundaries between tele-education and physical classroom activities in terms of the teacher's experience and seamlessly integrates these two currently separate educational practices. More specifically, we replace the legacy desktop based tele education system. Hence the teachers are not opting to mouse and keyboards than marker and whiteboard. In the proposed model, teachers can use multiple traditional approaches while interacting with students who are available on virtual class.*

**Keywords:** *Virtual-Class, Remote Student, Computer-Vision, Component Technologies*

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### **1. INTRODUCTION**

Now a days, rather than physical class room education, craze and necessity for distance education is under rapid growth. The time of the students is better handled in this type because they can even have lessons from teachers of other nations and saves their travelling time. This helps them to study working for their lives.

All this distance education need is the environment of a smart class room. It simply integrates tasks like voice-recognition, computer-vision and other technologies which aid for the environment of a physical classroom. The best used technique is the Tele-education. To make all this possible, any organization makes use of a computer and an internet connection to it.

There are 2 types again in this Tele-education. One is that material of textbook converted into html being presented to the students. He can access it by following the hyperlinks provided. By this may not attract the students more because it does not create the experience of a real class room and a teacher. So, both teacher and the student should be in front of the system and should contact each other by teacher explaining and the student asking doubts if any. But it is awkward for teachers to be in front of the systems all the time.

The problem can be overcome by imparting smart spacing technologies in the physical classroom. This reduces the difference between the Tele-education and traditional education. In this

Classroom teacher instead of taking a system and interacting only with one student, he can rather interact with many local students, moving here and there coding many examples with objects as if the remote student who is accessing the lesson also feels as if he is in the class. All this facility is imparted in the Tele-education software. The example smart class can be:

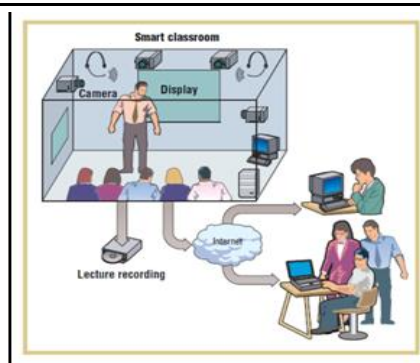


Fig1. Example Smart virtual classroom

## 2. VIRTUAL-CLASSROOM

### 2.1. Class Room Setup

The size and how the objects of the class like teacher, local and remote students are seen to the software are so important. All this is called the class room's setup. Usually the size of the class room is 3.2 \* 7.6- meters. Further, it has some divisions where the main part is used as the class room and the other covered by curtains filled with computers to support the smart class system. In addition to this the room has a front and side projector screens to cover all the views of the class. The board used by the faculty is touch-sensitive so that any teachings on the board by teacher are clearly seen by remote user. The presence of a source where the teacher and local students can also interact visually to remote students is quite important. This is possible by Student boards where the remote students can be seen by the teacher in the classroom.

This smart class room is quite effective do to the presence of movements of the teacher explaining the things visually. This is possible only by presence of lots of cameras. Some for capturing teacher's actions and some other for absorbing the signals of the teacher and convert them into the format which the Tele-education software can understand and eventually in to the format which the remote student can access. Also some others present the video of the class room as it is to the remote user. The teacher should use the microphone as that he may be audible to the remote students. As we are presented with different cameras, we do have many modules for better communication and also boards. The front board on which the teacher is writing is for teaching purpose which can be accessed both by local and remote students and the side board for the teacher to see and interact with remote students.

### 2.2. Component Technologies

The smart-class room to be adopted, has to follow some technologies called component technologies developed by many organizations in which IBM China Research lab is the pioneer. Some of them are discussed in fallowing sections.

### 2.3. Remote Student Tele-Presence

We already know that the smart class access to the remote student is by invoking client side program. This program intern invokes all the cameras on clients system so that the client is clearly visible on student's board in the classroom. But this obviously improves burden on network and CPU. To reduce this, instead of providing the whole remote student's view, each student is given a fixed space to display. Even this display is possible for those students who had requested the floor. Even this process is difficult with very remote area students who cannot be captured. So, the ultimate problem is to limit the number of people to be displayed on the board even thought they have requested the floor. This can be achieved by making all the students to be visualized to sit in a big hall so that the space gradually reduces as the seating arrangement goes far from the teacher, finally reducing the space and accommodating more people.

### 2.4. Pen Based User Interface

Unlike traditional way of teaching with chalks on boards, Tele-education involves the use of wall-size touch-sensitive smart boards for display purpose. It inbuilt has many mouse functions like moving from one page to another, erasing the text etc just by touching on the icons. All the

explanation part of the teacher like drawing figures etc can be done with digital pens and erasers. All this is from teacher's perspective. A student in turn can also do the same actions like writing on the board with the help of real-time multimedia communication software.

### 2.5. Laser Pointers As Interaction Tools

In traditional teaching methods, a teacher point outs the student either by name or so. If any important text arises, he may point it with stick. But in this smart class room, this can be done using a laser light. Even the students who should come under the floor are also decided by this laser light which is a thin red pointed light. The teacher aims the light on the remote student's image choosing an interested area, circling it and giving him the floor so that he can freely interact with teacher and local students. Along with this any important point in the lesson can be pointed by this laser light so that both local and remote students can have a good view of the point.

To make all these possible for the system, its adaptability must be increased and it should be made to accustom to the new environments. This can be achieved by both training process and by studying the color segmentation and motion detection thresholds respectively. Later to this job is employing Kalman filter to smooth the spot's trajectory and to use a finite state machine to track the laser spot and its behavior.

The best use of laser light shown in the figure is that:

A teacher can point out the student board by a laser light and made them interact with the class.

Conducting several tests on this laser detection yielded satisfactory results about selecting objects as with mouse but many sounded the difficulty in clicking process. That difficulty can be overcome using the next spotted technique called Speech capable virtual assistant.

### 2.6. Speech- Capable Virtual Assistant

Speech recognition is one of the best application used every in the smart class room. By this a teacher can easily instruct something which cannot be accomplished by laser pointing. But these voice instructions must be limited. If not the usual teaching words can be mismatched with voice instructions.

Voice instructions are not only to the student but also a student can use these instructions for a teacher. By the use of text-to-speech module5, a remote student under the floor can inform the teacher about his doubts and answers. The client program then in turn indicates the teacher about these sounds.

Every class room has a virtual assistant to handle and take over the class. He has the physical presence with the class having facial features, lip movements synchronized with the voice coming from the actual teacher. The actual teacher interacts and is synchronized with this virtual assistant in classes.

### 2.7. Biometrics- Based Login

For a teacher to take over a class in the smart class system, he has to login first. This is done by making use of biometric techniques like face recognition and voice recognition. The teacher stands in front of a machine and synchronizes his face with the image. Then goes for voice recognition. If both sounds positive, then the virtual assistant responds with some welcome messages and adjusts itself to the voice of the teacher if it is already trained in that aspect. Then a teacher can write, show an object or just interact with remote students.

The student can access the works by concentrating on that the teacher tells like while showing the model concentrating on the model, while writing the formula concentration on the formula etc. That is only a portion of the entire class can be accessed at once and can be enlarged by some expensive human means.

Even if a human camera operator positions the camera angle for a better perspective of live camera, but it may lead to inconvenience to the students and includes more cost (since, high payment to the camera man). Smart Cameraman is a better alternative to this as it has a decision block along with an array of cameras. Due to the presence of a sequence of cameras, it can view

the classroom from different perspectives and captures different actions going on in the class. Thus, it can select the best perspective with the help of decision block. Some kinds of circumstances in this block are as follows:

1. *Instructor writing on Media Board:* Here, the block decides to choose the close up perspective i.e. the area of writing on the board (as in fig 6a). It is known by following the mouse movements of the mouse over the board.
2. *Instructor depicting a model:* The smart camera helps in showing the model more clearly by zooming it in (as in fig 6b). It is known by the computer-vision hand-gesture-recognition block. (It can be precisely known if we define only a certain area to the instructor while depicting a model).
3. *Remote student talking:* The live video of a remote student is sent to the other remote students as well as it is presented on the student board. It is known through the floor controlled actions.
4. *Other:* In remaining cases, decision block decides to select the overview of the class (as in fig 6c).

The smart class is modelled with a finite state machine to capture all the state transitions. It avoids any kind of misrecognitions by maintaining a threshold steady time.

### 2.8. Software Infrastructure

Software infrastructure has a keen role in smart classes, as in it different modules are interconnected and work in synchronization. Runtime environment and some primary operations to different blocks are serviced. Along with it, enhancing interface to the building blocks is provided. All these services are embedded into the system. There are various applications to the smart platform<sup>10</sup> apart from the smart class (for reference, visit [p://media.cs.tsinghua.edu.cn/~pervasive](http://media.cs.tsinghua.edu.cn/~pervasive)). Some of the issues related to smart space project and some other applications are:

There may not be any synchronization among the components designed. Hence to integrate them includes high-level abstraction and synchronization.

Most of the blocks follow stream oriented communication i.e. transmission of the data at a regular interval. For e.g. Laser2Cursor block needs to send the position of the cursor at a regular interval i.e. 10times/sec. Here, the major issue is communication latency.

Perceptual interfaces are very much exposed to errors, especially during joint debugging. This leads to regular restart of the system degrading its performance. Thus, a loosely coupled system is needed to provide resistance against those errors and to provide system development.

Smart space attributes technology need to have a simple structure having an elaborated development interface. Thus it doesn't need to have distributed computing experts.

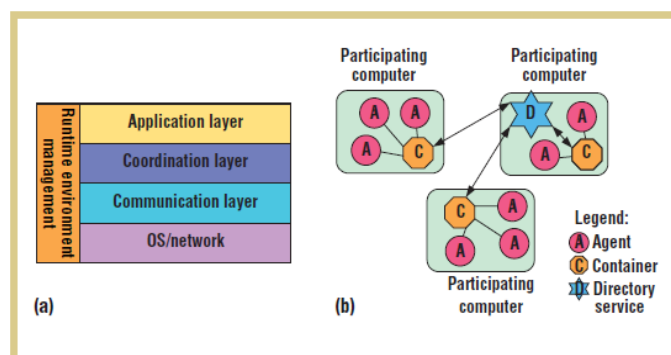


Fig2. The Virtual-Classroom

1. The platform organization has four horizontal layers and a vertical runtime environment management mechanism

2. The two-tier runtime structure secures against network failures and requires no configuration.

### **3. ARCHITECTURE AND RUNTIME STRUCTURE**

Here, every block saves its relating information like its state, nature and the logic needed to initiate it within an agent. Hence, it is modelled as agent having its target. It communicates with other blocks through an inter-agent language at a peek level (known as intention level). This set up plays a vital role in Smart class having heterogeneous technologies.

In figure 7a, there are 4 layers in smart platform organization. In it, communication layer improves the QOS (quality of service) of the network layer, the coordination layer acts as an interface among agents for their synchronization. Other two layers include application layer and OS/network layer. The runtime environment management methodology helps in managing various acts as agent enrolment and life cycle etc...

In figure 7b, the runtime organization of the smart platform is shown with its two components. This two tier system has 2 advantages, such as, resistance to the temporary network failures and zero system configurations. After recovering from the temporary failures, the container negotiation technique, in automatic directory service, frees users and developers.

Of those two tiers, various agents are provided local runtime environment by the container component. This local container helps the agents to connect to the local socket. Whereas, agent enrolment, message transmission and system management are carried on by the directory service component. The container and directory service create a connection between themselves through IP multicast. IP multicast is a procedure in which the

Directory server listens for any multicast address. If a container wants to establish connection with it, it sends a request message like "hello". The directory service in return replies it with an acknowledgement such as "helloack" along with the IP address and port number of the area of connection.

#### **3.1. Inter-Agent Communication**

The communication among the agents occurs through publish- and-subscribe model. In this message-group relied model, an agent can either "publish" message or can "subscribe" to any message group. If the subscribing group doesn't exist, the system opens a new group, thus providing flexibility. This system provides the facility to send the message to all the members of the group by initiating "call back" function at the receiver.

There are two types of message groups. They are:

1. *Message oriented:* In this group, there are no strict temporary constraints. Here, the directory service provides transportation and duplication. The messages, hence, travel along agent-container-directory Service-container-agent-path.
2. *Stream oriented:* It is preferred when the transmitting data is volatile to transaction latency. Here, each group is allotted a multicast IP address by the directory service. The system uses RTP (Real time Transport Protocol) for the transactions using the IP address. As it interacts directly with the particular agent, it minimizes the transaction latency to a huge extent.

Thus, this model provides certain characteristics of a loosely coupled system. They are as follows:

1. Directory service takes the responsibility to direct the messages to the respective agents and hence avoids agents to keep track of every agent's description in the group.
2. The agents constrain the expansion of error/exceptions by interacting with each other in a non-coordinated manner and also provide catching those exceptions in case of failures.

Various features used have their own significance, as RTP minimizes the changes in delivery delay whereas, IP multicast restrict the messages to the particular group.

The messages follow the XML standard format at agent as well as protocol. XML provide flexibility to include extra attributes to the messages without affecting the already existing ones. It also provides interaction with other agents.

### **3.2. Runtime environment management and debugging support**

Smart platform provides an “agent dependency-management technique” and a “centralized system-monitoring and debugging technique”. These techniques avoid the overhead of moving to each system to initiate the agents and to track their status.

To utilize those services, each agent must enroll to the directory service by providing its OfferedSvcs and ReliedSvcs. Here OfferedSvcs refers to the services which the agent will provide whereas; ReliedSvcs refers to the services based on which it works. These arguments are used to know the inter-dependencies among various agents. This will be used to initiate the agent needed by the currently working agent from same location. Hence, it helps to initiate a cluster of agents with one stroke.

The monitor is used to access various embedded control operations and system states of containers and directory service. The system allows users to remotely create or destroy an agent. It also provides the facility to analyze the format of messages or to transmit own messages. The user interface has topology followed during dependencies, IP address and hostname of all the agents within runtime, the agents under execution and their updates.

### **3.3. Agent development interface**

An interface is just a skeleton code which can be configured according to the requirement. In case of Java, it can be achieved through abstract classes, whereas, in case of Visual C++, customAppWizard is used. Apart from it, it also provides services to install dynamically the attributes needed for new systems. It is mostly used when agent needs to provide only 5 arguments: Register, Subscribe, OnMsgNotify, Publish and Quit.

A training session was created by the developers of smart classroom over the usage of the Smart platform to seven members having various research backgrounds. In was found in the survey that most of them understood its usage and started using SDK within an hour. Half of them installed the platform and initiated agents on their PCs. Also the platform received great response from the instructors of our own university, especially for it interactive sessions with remote pupils.

## **4. IMPLEMENTATION OF TEST-BED AND RESULTS**

The effectiveness of the proposed smart classroom model called virtual class has been validated by developing a sample web environment model in java technologies. In the virtual class, teachers can instruct and interact with remote students just like in an ordinary classroom. The involved technologies and modules consist of human and hand tracking, face recognition, speaker recognition, speech recognition, language translation and so on. They are encapsulated in about eleven agents running on proposed gadget platform. We also made an informal usability study of gadget Platform as training other members of Virtual-Class to use it. About seven selective students involved and accepted training at virtual-class. According to our observation, all of the students could understand the principle of Virtual-Class and grasped the usage in less than one hour. Half of them could deploy Virtual-Class on their own computer and start participating in Virtual-Class Sessions.

We carried out a performance evaluation on Virtual-Class to evaluate its throughput and delivery latency. The experiment is conducted on computers (dual-core 2.6G/256 RAM) connected under network. The Round- Trip Time (RTT) of the system collected by sending and bouncing probing messages. The length of the probing message is a uniform distribution on [0, 1000] bytes. All other computers are used to run agents that publish messages in a rate according to Poisson process to simulate the background load. We observed the RTT in different system loads. The result is illustrated in following Fig

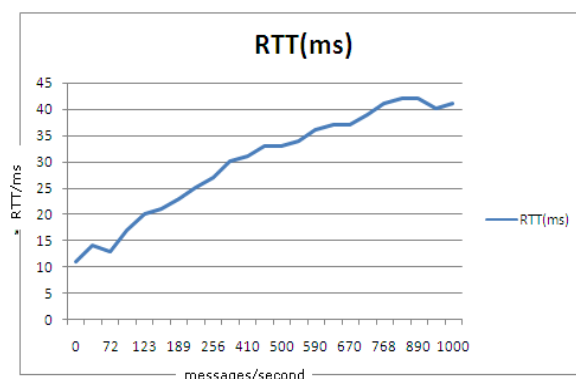


Fig3. RTT/ms of the proposed Virtual-Classroom

## 5. CONCLUSION

We proposed an off-the-shelf gadgets integration platform based virtual class for remote students. Our work aimed to retain the traditional class room activities while providing services to remote students. Due to the system capabilities and smart off-the-shelf gadgets the RTT is stable during student and class room interaction at Virtual-Class platform. In future this work can be extended by considering the mobility at student side infrastructure.

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