

CIMBLE: Distributed Team Training via HLA

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CADETT is researching the use of advanced and emerging technologies in adult and workplace training. CIMBLE is the current result of that research. It provides a distributed and collaborative virtual environment for conducting team training. This paper describes the technology and application of CIMBLE and how HLA was used in its implementation.

Keywords: Distributed simulation, HLA, team training, communications, decision-making, VRML, CIMBLE, CADETT

1. Introduction

The Consortium for Advanced Education and Training Technologies (CADETT), managed by The Franklin Institute in Philadelphia, was sponsored by the Defense Advanced Research Projects Agency (DARPA) and the Defense Modeling and Simulation Office (DMSO) to research the use of advanced and emerging technologies in adult and workplace training. The initial research, funded by DARPA, produced CIMBLE (CADETT Interactive Multi-user Business Learning Environment). CIMBLE provides a distributed and collaborative virtual environment for conducting team training. It was initially developed with a client-server architecture. In the current version, funded by DMSO, CIMBLE is being redesigned to be HLA-compliant for improved performance and usability. This paper describes the technology and application of CIMBLE and how HLA is being used in its revision.

2. The CIMBLE Concept

CIMBLE is based on the principle that teams are built through coordination and cooperative problem solving, and that these activities can be accomplished remotely if the system that integrates participants is engaging, robust and believable. Specifically at issue are

the learning and practice of soft skills, such as communications and decision-making. CIMBLE is designed to bring six potential team members from six remote locations to work on common problems. A seventh participant, an online facilitator, keeps the process moving forward and has the capability to manipulate the level of challenge to the team.

CIMBLE's technology brings virtual participants together using virtual interactions—team members work with one another using workstations and the Internet. Each team member is represented by an avatar, a computer representation of himself. The avatars move, turn their heads, and gesture in response to commands from the team members. On their workstation screens, team members see their environment and avatars representing other team members, but they only see what their own avatar would see based on where they are standing. CIMBLE is designed to allow participants to talk to other team members through microphones and speakers on their workstations.

A sample team building exercise was developed to enable evaluation of the CIMBLE technology template for learning. It tasks six participants from StarBridge Corporation and a facilitator to journey to a distant construction site and resolve issues that have prevented the completion of a bridge. Participants must use communication and decision-making skills to accomplish this task. The exercise consists of three segments: a formation stage at corporate headquarters where the team is given its mission and decides how it will operate; a journey stage where the team drives to the construction site and deals with difficulties along the way; and a resolution stage at the bridge construction site, where the team must absorb conflicting data and determine a collective proposal for resolving the problem. The elements of the exercise are as follows:

- A participant begins her experience by entering into the Avatar Gallery. Here she chooses an avatar to represent herself in the virtual world and practices movement and gestures with her workstation controls.
- When she is ready, the participant moves to the headquarters, a facility closely resembling The Franklin Institute. She can explore at will and is greeted at the reception desk by a "bot" receptionist, an automated avatar with no human controller.
- When all of the members of the team are present in the headquarters, the facilitator begins the exercise by prompting the software to advance all six avatars into the conference room so they can seat themselves around a conference table.
- Next, the president of the company introduces the team's mission to everyone, and independent vice-presidents give separate instructions to each participant via embedded video. These instructions

produce some of the conflict to be dealt with later in the exercise.

- After discussing the options, participants select objects represented by icons that identify the responsibilities of each team member. For example, a debit card icon signals budgetary responsibility and a car key icon indicates the person with the authority to drive.
- When all of the responsibilities have been determined and necessary decisions made, the team begins its journey by car to the bridge construction site. During the journey, the team encounters several different situations that require communication and decision-making. Sometimes all members are informed (the driver has been stopped for speeding); other times only one participant is informed, based on that person's role (only the person with the debit card can pay bills or fines; only the person with the cell phone can make calls). How the participants respond to the situations, as well as what the driver does, determines which succeeding events occur.
- When the team reaches the bridge site, members navigate to trailers containing the bridge construction stakeholders (government people, protesters, construction people, engineers) to gather information. The team must decide whether to visit the areas as a group or split up to hear the concerns of the stakeholders.
- The team reassembles to discuss the situation and determine a solution. They inform the site manager of their solution and watch as the bridge is completed as a result of their recommendations.
- Finally, the team participates in an online debriefing led by the facilitator. The discussion includes a review of the team success, examination of data and participation, and the development of an action plan for integrating improved communications into the workday.

3. CIMBLE Technology

To implement the activities described in the CIMBLE Concept, several fundamental technologies were employed.

VRML. The CIMBLE virtual environment utilizes Virtual Reality Markup Language (VRML) to present scenes. The VRML environment permits participants to navigate inside a virtual world without direct involvement of central controlling software, yet permits the central software to arbitrarily alter a participant's virtual environment. Playback of canned video and audio for individual participants is a part of VRML capabilities. Java programs handle distribution and sequencing of events. The fully distributed system operates over the Internet or can operate within a corporate intranet.

HLA. CIMBLE technology is divided along functional lines into federates. Fifteen federates participate in a CIMBLE exercise.

- Six Participant federates control what the participants do and see. The software is identical for all of these federates, varying only when a participant begins execution and acquires a virtual personality.
- The Facilitator federate is similar to Participant federates but with more capability.
- The Logger federate collects HLA data for post-exercise evaluation.
- The Interaction Object federate controls objects that are shared throughout the federation.
- The HQ Story, Map Story, and Bridge Story federates control the action in each of the phases of the exercise.
- The HQ VRML and Bridge VRML federates control the variable portion of the VRML world in the first and third phases, and the Map World federate controls the map in the second phase.

Robust Participants. Participant federates were designed and constructed to retain significant control and capability in the participant workstation. The workstation contains both the Participant federate and all graphical information. This approach saves bandwidth and processing time by localizing the large data files. When the Participant federate software or environment

is updated, the new information is downloaded to the workstation before the session is scheduled to begin.

The Facilitator plays a key role in CIMBLE. Initially, the Facilitator manages most of the activity and movement through the simulation. As the exercise progresses, the Facilitator manages less of the simulation and focuses more on team performance. The Facilitator has the ability to intervene should the situation require it. This includes communicating with individuals or the team as a whole, moving team members' avatars, redistributing objects, and even pausing the exercise to deal with issues. The Facilitator can also remove barriers if the team is not performing well, or add barriers if the team is moving too smoothly.

The environment presented to the participants is shown in Figure 1. It was developed in VRML and Java. The information and controls presented on the screen surrounding the virtual world were specially designed to enable successful participation within the exercise. The surrounding area includes photos, names and inventories of all participants, movement controls, gesture buttons, and transport buttons to "jump" to another location within the segment in which the team is working.

Audio communication in CIMBLE is primarily voice using an open audio channel over the Internet. All other interactions are managed via the mouse, so the keyboard is not required for any portion of the simulation.

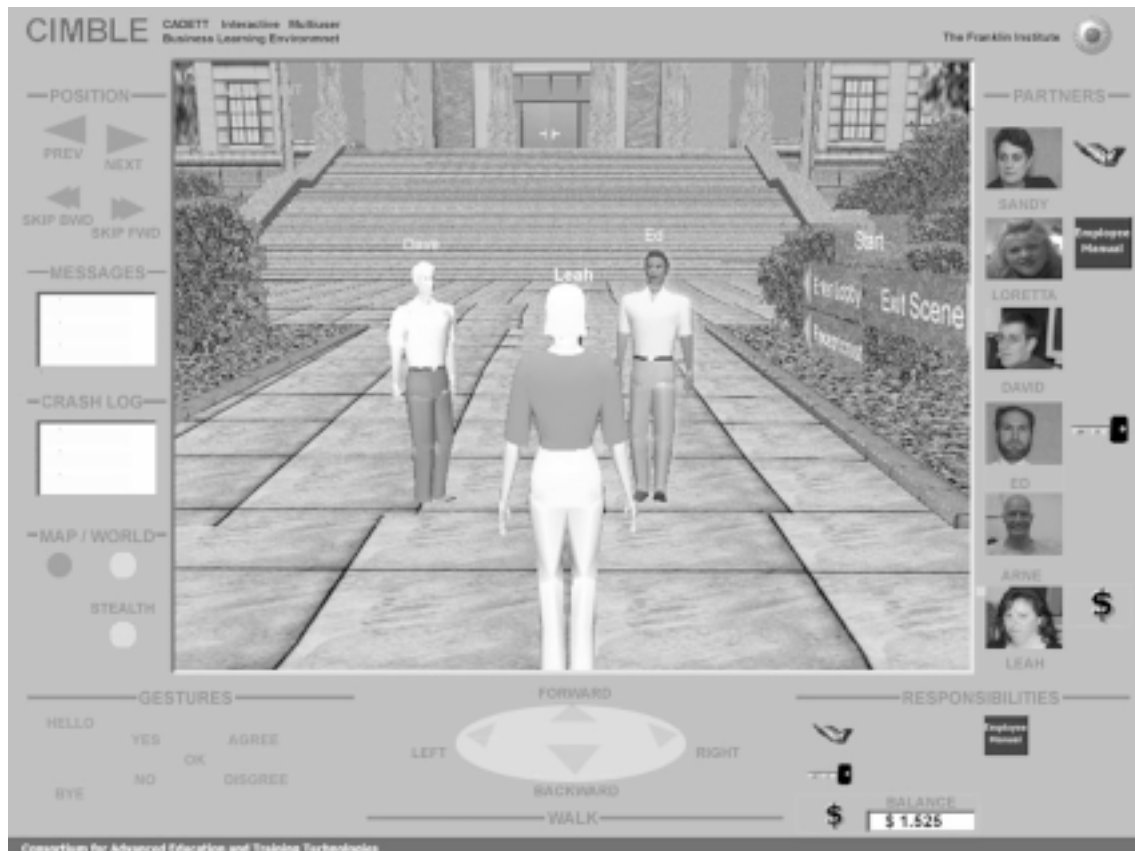


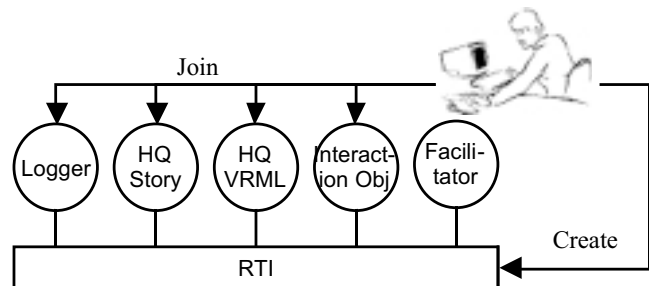
Figure 1. A CIMBLE screen showing the virtual world surrounded by information and controls

4. CIMBLE Technology Execution

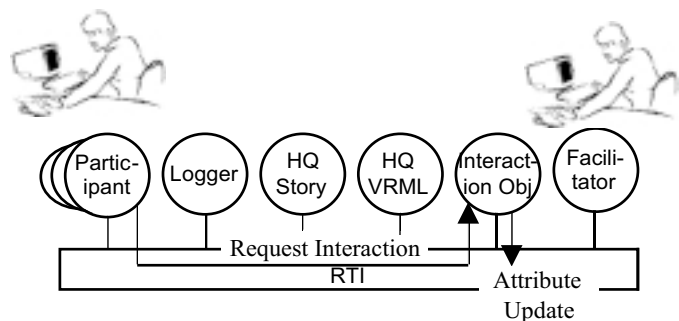
The CIMBLE Concept above described the activities of a training event from the viewpoint of a training participant. The paragraphs that follow describe the

same activities from the viewpoint of the component federates that comprise CIMBLE. In each case, the paragraph is mirrored by a graphic showing the activities in the federation.

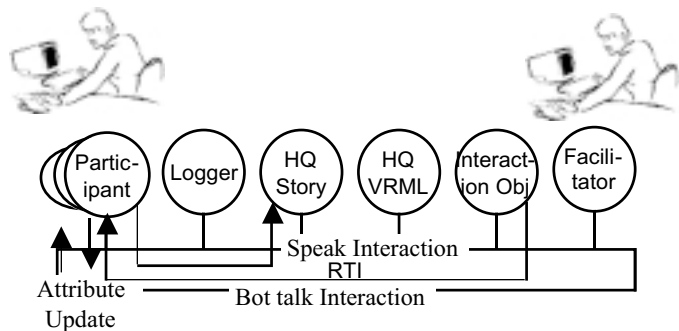
- The facilitator begins a training event by creating an HLA federation and causing the Interaction Object, HQ VRML, HQ Story and Logger federates to join the federation.



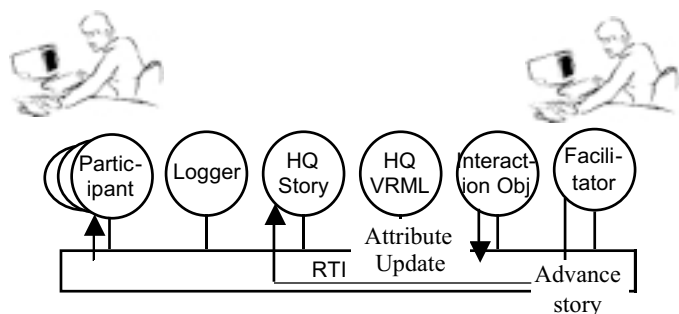
- When the participant joins the federation, the HQ VRML federate creates a 3D world and permits the participant's avatar to move around the environment. The participant chooses an avatar by sending a request interaction to the Object Interaction federate; it replies with an attribute update to change the participant's avatar.



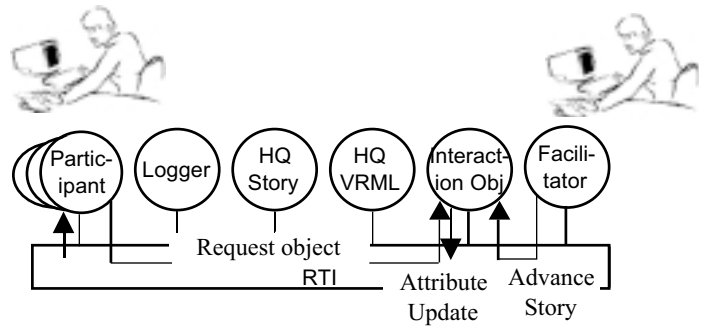
- Participant federates report all control actions (moving, gesturing to other avatars, and using transport buttons to "jump" to another area of the VRML environment) to the other Participant federates via attribute updates, and the participants see the resulting changes to avatars. Participants "speak" to bots (the receptionist, for example) by sending an interaction to the Object Interaction federate which, in turn, activates the correct response from the bot.



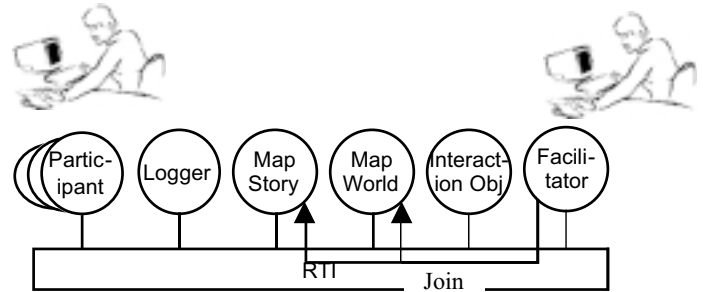
- The facilitator begins the session by sending an interaction to the HQ Story federate. That federate replies with an update to an attribute of the story object. Thus the sequence of events in the training exercise is controlled by the Story federate—whether it be in the headquarters, on the journey, or at the construction site. This assignment of responsibility makes it possible to incorporate any story federate into a CIMBLE template.



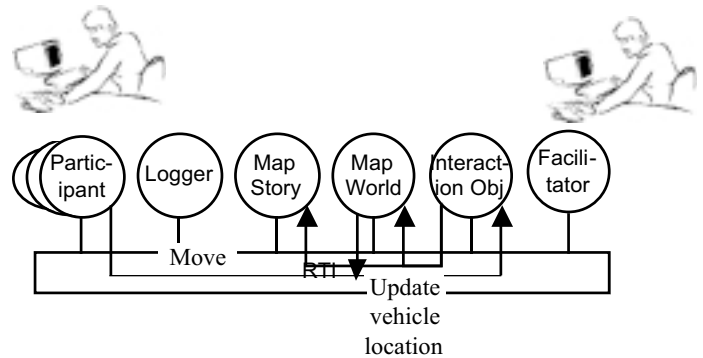
- The facilitator advances the HQ Story federate through a series of interactions that alerts the Interaction Object federate to present the icons. Participants select the items by sending interactions to the Interaction Object federate. The item icons appear in the inventory box for that participant.



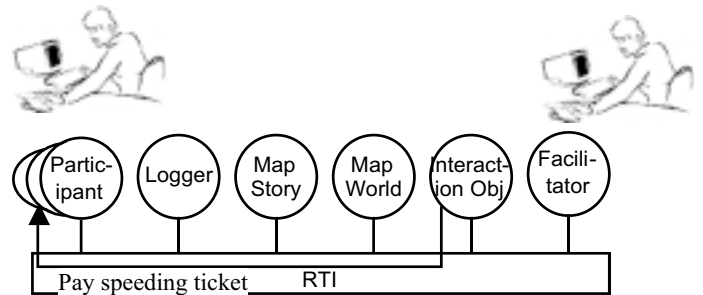
- When all of the segments in the HQ Story federate have been completed, the Facilitator federate sends an interaction to the HQ Story federate, which causes the next environment federate and Story federate to join the federation.



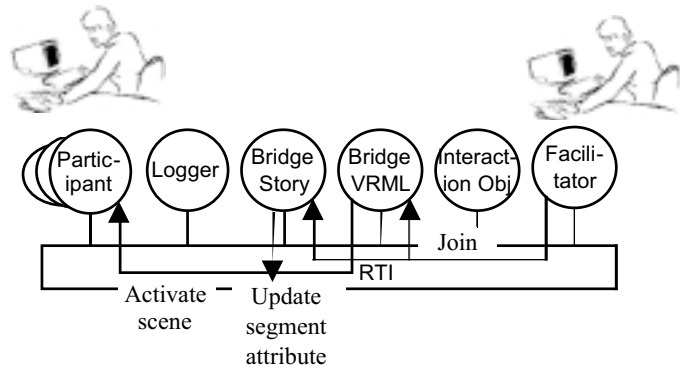
- Progress through this phase moves in the same manner as above. An interaction is sent to the Interaction Object federate, which sends an interaction to the Map World and Map Story federates. The Map World federate sends an attribute update to indicate the new location for the vehicle, and the Map Story federate activates the messages for the next vehicle position segment.



- Some messages are sent to all the Participant federates, while others are sent only to selected Participant federates. The latter sequence depends on the properties of items in the Interaction Object federate (for example, a message to pay a speeding ticket would only be received by the Participant federate owning the debit card, since that participant must pay and approve all financial transactions). Messages sent to federates depend both on which segment of the Map Story federate the team is in and actions taken by participants (for example, continued speeding triggers a speeding ticket message).



- When the vehicle reaches the destination node, the Map World federate sends an interaction to cause the Bridge VRML and Bridge Story federates to join the Federation, and the Map World and Map Story federates to resign. The Bridge VRML federate activates the 3D Bridge scene on each participant's screen, while the Bridge Story federate activates the first segment of the final portion of the simulation.



5. Aspects of the HLA Implementation

The version of CIMBLE developed prior to The Franklin Institute's involvement with HLA used a client-server architecture. It used a conventional Web browser at the client side and a commercial VRML application at the server side. One of the goals of the implementation of the HLA version of CIMBLE was to identify and overcome shortcomings and limitations of the client-server implementation. These limitations identified are listed below, together with how they were overcome in the HLA version of CIMBLE.

Performance

- The client-server architecture required reliance on Internet speed to transmit large amounts of data. Although the VRML world and pre-recorded videos were downloaded to the client machine prior to beginning the exercise, the network was still utilized frequently. Much of the network activity was determined by the commercial VRML server and outside of CIMBLE control.
- The HLA implementation reduces this data flow by locating the large data files on the client workstations, by determining which message traffic is needed, and by limiting data transmissions to low-volume state-change and event transactions.

User Interface

- The use of a commercial VRML server application in conjunction with a conventional Web browser limited the developer's ability to customize interfaces to user requirements.
- The HLA implementation replaces the VRML controller and browser with a Java 3D browser. The new screen window, created in Java, allows the designers to better manage the screen space by eliminating the limitations of current Web browsers.

Data Control

- With the VRML client-server architecture, only one data path existed between the clients and the server and only one format existed for data representation.

- With the HLA peer-to-peer communication architecture, data transmission format is customized for each transmission. In addition, transmissions are focused to specific uses, among federates appropriate to that use, with data appropriate to the use. Unnecessary network traffic is eliminated.

Development Process

- The client-server implementation encouraged fewer processes, each serving multiple purposes.
- The Federation Development and Execution Process Model [1] recommends a structured approach to development where distinct functional areas are isolated in their own process (federate). This has led to a more structured and better specified implementation.

Versatility

- CIMBLE training exercises are divided into scenes; the current exercise has three: team formation, team journey, and resolution. It is likely that new scenes will be developed that address a new set of training needs. With the client-server architecture, all the functionality and application were more integrated than is ideal.
- With HLA, CIMBLE represents each scene by two separate federates: the events and story line of a segment translate into a Story Object federate, and the virtual environment of that segment translates into a VRML world federate. Therefore, with this architecture it will be easy to replace or add new segments to change the exercise and application.

6. Conclusions

The CIMBLE technology is proving useful in investigating distributed team training. Shortfalls in the initial client-server implementation of that technology have been overcome by a second peer-to-peer implementation using HLA. The HLA development processes and implementation tools have facilitated the second implementation.

7. References

- [1] *Federation Development and Execution Process (FEDEP) Model, Version 1.4*, DMSO, Alexandria, VA, 1999.



David W. Seidel is Associate Manager for the Software and Information Architecture Technical Area at the MITRE Corporation. He supports DMSO in the development and refinement of HLA concepts, specifications, and implementations, as well as in facilitating the development of new HLA federations. Previously, Mr. Seidel supported the JSIMS Program Office, the STOW program, and the ALSP project. He has developed Navy, Army, Air Force, and Joint war games and Navy command and control systems. Mr. Seidel holds a BS from Illinois Institute of Technology and an MBA from Bryant College.



Sandra Testani is Director of the Consortium for Advanced Education and Training Technologies at The Franklin Institute in Philadelphia. Prior to her work with the Institute, she was Director of Strategic Programs at the NYNEX Venture Company, responsible for new lines of business. She came to that position from a management consulting role. Earlier, she worked as a speech therapist and program placement specialist for handicapped children. Ms. Testani holds a BA from Queens College and an MA from The American University.



Ed Wagner is the Training Programs Director for the CADETT program at The Franklin Institute. He is managing the development of the HLA-compliant implementation of CIMBLE. Previously, Mr. Wagner had worked on the development team of the client-server version of CIMBLE. In addition, he is managing the SkillPlace research project, an online collaborative workspace for work-based learning programs. Mr. Wagner holds BS and MS degrees from Drexel University.