5.8   EXPERIENCES TOWARDS ADVANCED WEATHER RESEARCH AND TRAINING

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1.   INTRODUCTION

The Warning Decision Training Branch (WDTB), as part of National Oceanic and Atmospheric Administration (NOAA), National Weather Service (NWS) Training Division, was tasked to provide the Advanced Warning Operations Course (AWOC) starting in the fall of 2004 to every NWS forecaster. WDTB instructors designed a comprehensive blended-delivery AWOC course that includes facilitation workshops. In order to effectively administer these workshops, WDTB designed and built a new in house computer lab, the WDTB Research and Training (WRAT) lab. The WRAT lab houses 25 triple-display, dual 2.4 GHz Xeon processor Linux workstations (Fig. 1). The WRAT lab has been performing an important role in enhancing the interactive learning in workshops, such as the NOAA's NWS AWOC and the Distance Learning Operations Course (DLOC).

The WRAT lab team has installed and developed many flexible computer application tools and techniques that fully support various training strategies, functions and objectives, as well as different simulation types. While the lab can be used in a traditional server-client manner, with the servers processing data and serving it to the workstations, it can also be configured to group workstations together, running the server processes on one of the workstations in the group. This gives the ability to run several weather scenarios at once.   These capabilities allow participants to practice inter- and intra-office coordination and cooperation, respond to changing weather conditions by restructuring workload, and deliver realistic forecasts and warnings all within a relatively short training period.

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When training workshops are not in session, the WRAT lab also provides an opportunity for applied research where newly designed techniques and tools can be used in a simulated operational environment and subsequently transferred to the NWS community. The WRAT lab will provide the Norman Weather Community an operationally representative environment for demonstrations, as well.

Fig. 1: The WRAT lab. One AWOC workshop was in session.

This preprint will start with a brief description of the WRAT lab hardware, system settings and configurations (section 2), continue with the data which are and will be available in the lab including archived cases and real time data (section 3), move to training strategies and relative lab configurations (section 4) and application tools (section 5), and finish with future training and research plans (section 6) and the summary (section 7).

2.   LAB SETTINGS AND CONFIGURATIONS

The WRAT lab includes 2 servers and 25 3-headed workstations. Each server consists of 2 Intel Xeon processors operating at 2.8 Gigahertz, 4 Gigabytes of RAM, an internal SCSI RAID with 100 Gigabytes storage capacity and 2 Broadcom gigabit ethernet adapters. One internal DVD±RW and an external Terabyte RAID offers plenty of strorage for data cases. The workstations each have 2 Intel Xeon processors operating at 2.4 Gigahertz, 2 Gigabytes of RAM, 36 Gigabytes of Ultra 320 SCSI storage space, a Broadcom gigabit ethernet adapter, one Matrox G400 dual output AGP video card, one Nvidia GeForce2MX PCI

video card and three Samsung 19-inch LCD monitors.

The systems have been configured to simplify the management of a large number of machines. Keeping all of the workstations identical allows the use of imaging technology. This allows the flexibility to change the entire lab overnight, rebuilding all of the workstations over the network from a previously built and tested image. Use of the ssh-agent allows us to build scripts on the server that can push a command to each of the workstations to perform the same task on all of the machines at once. The wake-on-lan feature allows the booting of all workstations with a single command from the server, and when combined with auto-login and special user-level X configuration files, the machines can boot all the way to a semi-kiosk mode, running a predefined set of applications, while managing access to the rest of the system.

3. DATA

All data, including localizations, archived cases and real time data, are stored on servers and a RAID.

3.1 *Localizations and customizations*

In order for AWIPS to display real time data and cases over the US, we built localizations and customizations for all County Warning Areas (CWAs). The shared data set is consistent with the version of AWIPS, which is convenient to maintain or update, and also efficient for storage.

3.2 *Archived Cases*

Each archived case data set is a completed data set for a specific weather event, which is used for training and research. It includes satellite data, radar data, model data and point data in AWIPS format. The normal size of one case data is around 6 GB. The localizations of each case are linked respectively to the site-specific shared localization data set.

3.3 *Real Time Data*

The WRAT lab can get real time data via the WDTB real time system, which involves AWIPS, Local Data Manager (LDM) and FTP. With the LDM and FTP, various real time data, such as satellite data, radar data, model grid data, point data (including METAR, upper air, profiler, lightning) and Bufr profiles are fed into the real

time system. Most of these data are the AWIPS input data, which are handled further by the AWIPS processes including the decoding process and the notification process.

The WDTB real time system collects lots of station specific local data, such as radar data from all over the country. The Local Analysis and Prediction System (LAPS) is also executed at about 10 different local sites. In the future, with the WRAT lab resource, we might be able to run storm scale model at the local areas of interest. Unlike the local radar data having a unique name, the local LAPS data and Model data have to be handled with a special technique to let the multiple local data be viewable by AWIPS. We create a group of generic directory trees, such as /data/fxa1, /data/fxa2, etc. Under each of these local directories, excluding LAPS data, which is stored in Grid/FSL/netCDF/LAPS_Grid/LAPS, all entries are links, which link these entries with relative entries under /data/fxa. Therefore, it provides great opportunities for training and research. Instructors can conveniently look at the interesting events cross the county and archive them as training cases for future use.

4. TRAINING STRATEGES AND CONFI-TIONS

It has been extensively demonstrated that it is a powerful training method to provide trainees or forecasters the ability to replay weather events in either displaced real-time or case study mode (Ferree et al. 2002). Depending on the time available for training, the needs of the trainee, and the focus of the training, a simulation can be conducted as a simple simulation, such that the trainees are required mainly to view the data and practice using the WarnGen application process of the AWIPS, or as a more involved simulation, in which the simulation may be paused for several times to discuss warning decisions and the impacts of data on these decisions.

Some training strategies have been performed for the simulation training, such as the real time simulation, interval based simulation and situation awareness simulation (NWS Warning Decision Training Branch, 2002). These strategies can also be classified as non-stop simulations and with-stop (pause) simulations. There are also requirements to configure the lab in various geometries to support running simulations on all lab machines, several separated small groups of machines, or simply on each individual computer. These capabilities allow participants to practice inter- and intra-office coordination and collaboration, respond to changing weather

conditions by restructuring workload, and deliver realistic forecasts and warnings all within a relative short training period.

To fully support various training strategies, functions and objectives, as well as different simulation types, some computer application techniques and tools have been developed. With these techniques, the configuration of the WRAT lab can be very flexible. It can be used in a traditional server-client manner, with the servers processing data and serving it to the workstations. In this way, the whole lab may be conducted with one event simulation. It can also be configured to group workstations together, running the server processes on one of the workstations in the group. This gives the ability to run several weather scenarios at once. The simulation events may be different, or the same but with different CWA. The detailed tools and techniques will be introduced in the next section.

5. TRAINING SOFTWARE AND TOOLS

The WRAT lab's training software and tools are composed with the AWIPS, Open System Radar Product Generation (ORPG), and the WDTB developed tools, including customized lab version of the Weather Event Simulator (WES), Weather Event Simulator Scripting Language (WESSL), Weather Case Browser, and the WRAT Lab ToolKit.

5.1 *AWIPS*

Developed by Forecast Systems Laboratory, NOAA, AWIPS is an interactive computer system that integrates all meteorological, hydrological, satellite, and radar data into one computer workstation. AWIPS Display in 2-Dimensions (D2D) allows forecasters the interactive capability to view, analyze, combine, and manipulate large amounts of graphical and alphanumeric weather data. AWIPS provides an efficient and effective means for forecasters to prepare and issue timely, accurate forecasts and warnings. AWIPS has been the key interface of our training.

5.2 *ORPG*

The NEXRAD ORPG gives forecasters higher resolution radar images, higher quality data and the ability to scan storms in new ways. This tool can generate new radar products with the old archived case base radar data. Therefore, training for some new functions and products can be still fulfilled with archived cases.

5.3 *WES*

Scenarios of simulations have been demonstrated as a very effective way to gain experience with software, hardware, data set interpretation, applied science and the integration of these with the people in control (Ferree et al. 2002). The Weather Event Simulator is one of the major pieces of software used for such tasks.

To perform a simulation using AWIPS where data is processing as if in real time, all the file names are first made invisible to AWIPS by the WES. To do so, the file names are renamed with an "a" in front of the file names. Symbolic links with a "b" in front of the file names are also created to assist processing files at the correct time. During the simulation, the simulator makes these files visible by creating symbolic links that point to the data at appropriate times (Magsig et al. 2002).

The WES was primarily designed to work at one single workstation, where the AWIPS, WES and case data are all in the same machine. To run the WES in the WRAT lab setting in the server-clients fashion, it needs a special configuration and other tools to do things like synchronize, etc. If more complicated configurations and functions are required, such as running multiple WESs separately in multiple groups or running a simulation for a case event whose duration was more than several hours, for winter weather maybe even several days, more tools are needed and the WES needs to be modified, as well. The tools will be introduced in section 5.6.

Since all case data are stored in servers and a RAID Disk Array, if to run the WES other than on the server, data preparation and simulation processes are separated to improve the efficiency and performance of the WES.

5.4 *WESSL*

The WES Scripting Language (WESSL) is a training and evaluation tool. The WESSL was developed to allow timed events to occur during a WES simulation. Builder is an interface used to enter the events that will appear at the specified times. Builder (Fig. 2.1) accepts dates and times corresponding to events as well as a wide range of event styles. These styles include, but are not limited to, text messages, map generation, image and response boxes. Combinations of the styles may be created to make a unique event, such as the text and map commands (Fig. 2.2). Another example of a very useful combination is the image

and text commands to provide the participant with Storm Prediction Center product data (Fig. 2.3).

The WESSL commands currently under development and testing are the slider bar, question, video, and audio commands. The slider bar is intended to allow the user to answer a question quickly and allows a large range of values as well as text options, both chosen in Builder. One example of the slider bar is to gauge the importance of an event or report as high to low (Fig. 2.4).
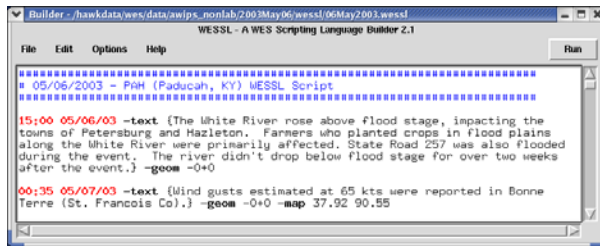

Fig. 2.1: Builder is an interface which accepts WESSL events based on their date and time.
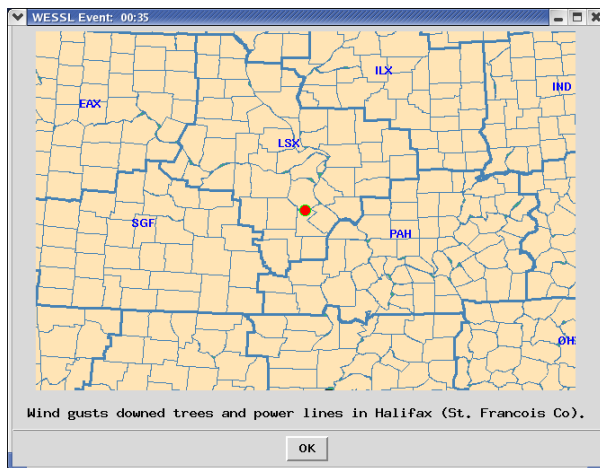
Fig. 2.2: Text and map commands are combined to create a more specific event.
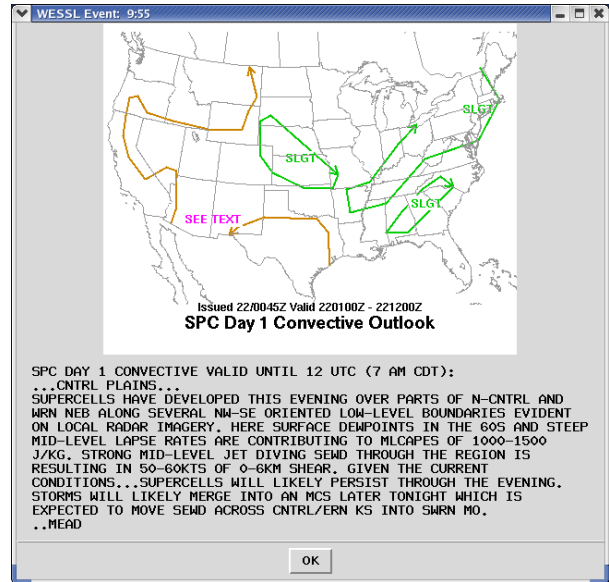

Fig. 2.3: A combination of the image and text commands provide the participant with SPC product data.
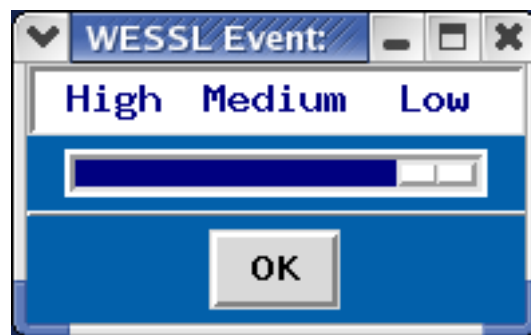

Fig. 2.4: One slider bar configuration to gauge importance of an event or situation as high to low.
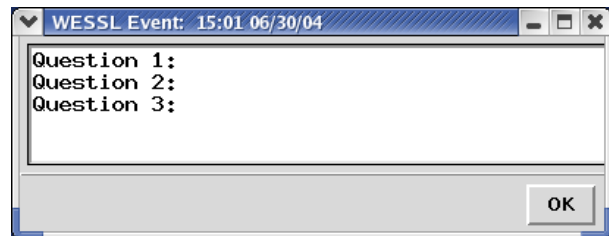

Fig. 2.5: The question command allows for multiple questions and responses in one event.
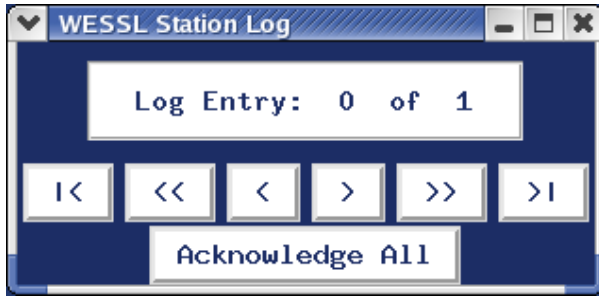
Fig. 2.6: The new station log eases the event review process as well as clearing the screen quickly of many events.

The question command is an enhancement on the existing response box command. It allows text to be entered in Builder which will show up when the response box is initiated. A response may still be entered after the text, making this an alternative to the combination of the text and response commands allowing multiple questions and answers in one event (Fig. 2.5).

Along with new commands the future releases of WESSL will employ a new station log. The new station log allows the user to acknowledge all the reports on the screen at one time, as well as page through them not only one by one, but also in leaps of five and simply by jumping to the beginning or end of the logged reports (Fig. 2.6).

Other evaluation tools under development are a sorting executable and the Threat Assessment Log. The sorting tool sorts warnings by time/date or type (SVR, TOR, etc.). The Threat Assessment Log was designed to allow the facilitator to gain a large amount of information about what data the forecaster is using to make decisions (Magsig et al. 2004).

5.5 *Weather Case Browser*

To use the AWIPS to display AWIPS data, the user needs to determine AWIPS environment variables such as the FXA_DATA and FXA_LOCAL_SITE for the data path of a selected case data and the CWA. It is simple if there is only one or a few CWAs with real time data or few cases. However, it becomes challenging for the WDTB instructors who deal with all CWAs and dozens of archived cases.

The Weather Case Browser is a Graphical User Interface (GUI), written in Tcl/Tk (Fig. 3.1). The three buttons, "Data", "Localization" and "CWA" are used for the selections of data path or location, AWIPS localization and the CWA. The selected results will appear on the relative entries.
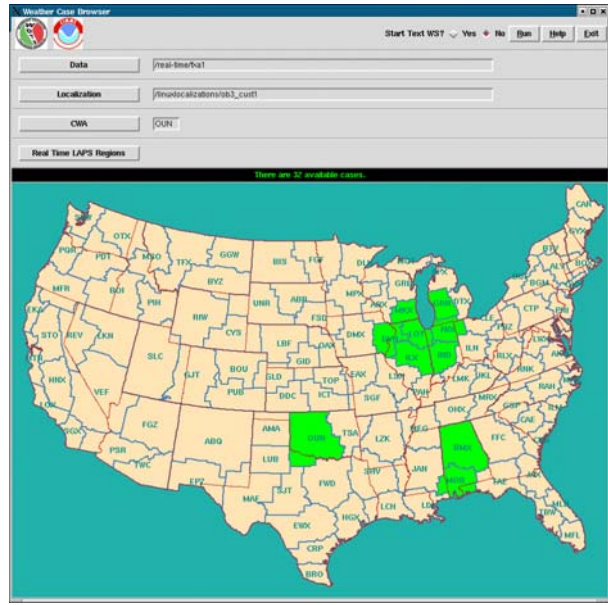

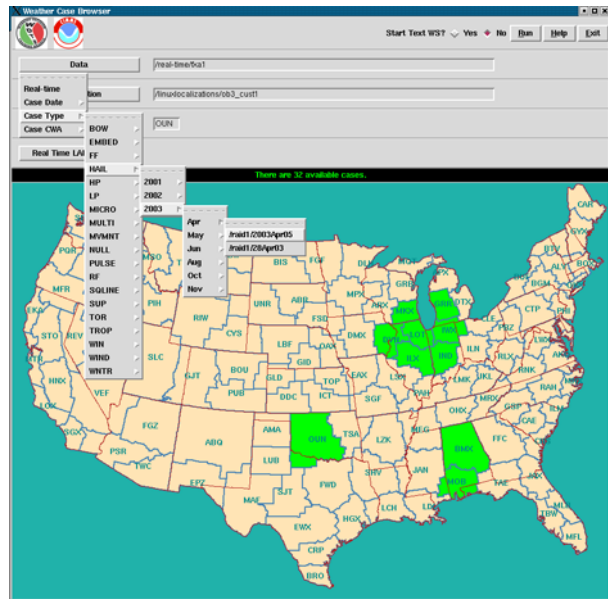Fig. 3.1: The Weather Case Browser

Fig. 3.2: The selection of a case from the pull down menubutton of the Data.

There are two types of data: real time data and archived case data. The default path for FXA_DATA is set for real time data. Since there are local radar data available over the country, you can click on the CWA of interest to view the current weather in D2D. Some locations with special local data, for example LAPS data, will appear on the map in a green color. For archived cases, we designed three searching categories to help the users to find what they want. The first

category is the case date. A user, if knowing when the case occurred, can select the case by the year, and then by the month to find the case. The second category is the case type, which includes tornado, hail, wind, squall line, super-cells, etc (Fig. 3.2). Many cases have multiple threat types and thus are listed under each type list. The last category is the case location. This category helps users to focus on weather in a certain geography area, either their own local area or other remote areas.

Another advantage of this tool is that it allows users to view the case data with different versions of the AWIPS and different customizations by selecting different localization datasets from the menu button of "Localization". For instance, if a user made two customizations for OB4, etc., OB4_cust1 and OB4_cust2, the user can choose one of them by selecting it from the dropdown menu button, titled "Localization" (Fig. 3.3). After these selections, clicking the Run button will start the D2D.

Fig. 3.3: The sub-menu buttons of the Localization button.

5.6 *WRAT Lab ToolKit*

In order to set up the WRAT Lab for various purposes of training and research, appropriate configurations, reconstructions and supporting tools need to be developed. The WRAT Lab Control Panel is one element of this toolkit (Fig. 4.1)
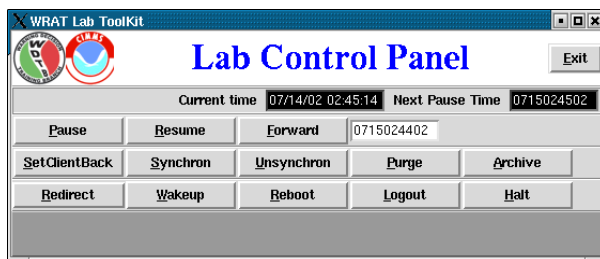

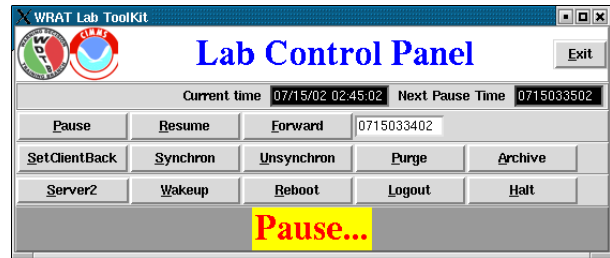Fig. 4.1: The WRAT Lab Control Panel

Fig. 4.2: The WRAT Lab Control Panel with configuration of the Server2 as the current server and at a pause status.

There are approximately three types of lab operations: system commands and configuration, lab managing and computer time control. Since there are 25 workstations, in order to effectively administer these workshops, scripts were built on the server that leverage the ssh-agent and public key authentication to push a command to each of the workstations to perform the same task on all of the machines at once without requiring password authentication. To make passwordless login work, public key authentication is used. After logging in to the server, a passphrase is supplied to the ssh-agent. When an ssh connection is attempted, the ssh-agent will pass the public key to the ssh deamon on the workstation which will compare it to the key stored in a local file. Then as long as the agent is running, you can login to any machine that has the authorized key in file.

a. System commands and configuration

1) *Wakeup and Reboot*

We use the wake-on-lan feature to start all of the workstations with a single command from the server. When combined with auto-login and special user-level X configuration files, the machines can boot all the way to a semi-kiosk mode, not requiring user login, running a predefined set of applications, without a desktop manager (Gnome or KDE), while managing access to the rest of the system. For example, three D2D sessions may be automatically started with a selected case, or three Weather Case Browser sessions for the user to browse either real time data or archived cases or a combination on the three heads.

In some situations, the workstations need to be rebooted. Clicking the "Reboot" button, on the Lab Control Panel, will reboot all the machines.

2) *Logout and Halt*

The Lab Control Panel also has a "Logout" button and "Halt" button, which allow logging out or halting of all the workstations.

3) *Redirect*

Two file systems, server1 and server2, are mounted on each workstation, while /data/awips, as a default server link, is only pointed to one of them at a time. Clicking the "Redirect" menu button will reconfigure the lab server-clients settings by switching from server1 to server2, or vice versa. After switching servers, the current shared server name will be displayed on the button (Fig. 4.2).

b. Lab Managing

1) *Purge*

This process will purge all local data created during a previous simulation, such as issued WarnGen files. The purging process should be executed each time before the simulation is started.

2) *Archive*

The archive function allows the manager to archive the WarnGen text files issued by the trainees during a simulation to a shared archived directory for future evaluation. Usually, this process should be run right after the simulation.

c. Lab Computer Time Control

Computer time setting and controlling are the fundamental part of a simulation, since lots of functions, such as warning generation and procedures, of the AWIPS are based on the system time. To run a simulation on a single workstation, the machine time must be set back to the selected case time and the machine time must be returned to current time after the simulation. To run a simulation on a server and view D2D on clients, for a non-stop simulation, it is relatively simple and the clients' time is set to be consistent with their server once. However, if there are server pauses during the simulation, continuous synchronization is required between each client and its server. It is much more complicated to group workstations together, and run the server processes on one of the workstations in the group.

We use the ntpdate and date commands to perform the synchronization every ten seconds. The date command is used before the ntpdate command for adjusting significant time difference. Then ntpdate is used to adjust any tiny difference.

There is a high potential of machine lockup when setting machine time back, especially for RedHat 7.2 and older versions. To avoid such a situation from happening, a couple of techniques can be applied. One is to set the machine time back before login. Another is to set the machine time way back to a safe date, and then set time forward to the case starting time. One safe date used is Jan. 1, 1997 for case dates after this date. The last technique is that to adjust the time back with a small step, for example, less than one minute, which was used in our new pause function.

The original WES pause function worked by pausing simulation processes while the machine time continued going. When resuming the simulation, the machine time needed to be set back to the pause time. With this there is a high risk that the machine will not respond. Another disadvantage is that if the machine time keeps going, the WESSL products will keep popping up and show "future" data to the trainee.

In the Lab Control Panel, a new pause function was designed to set the computer time back to the pause time every 3 seconds. Therefore, the machine time seems stopped. Whenever the "Resume" button is clicked, the machine time will start advancing again.

Another new unique function is the forward function, which can forward computer time to a desired time. This function can enhance traditional case mode training by changing it to simulation mode. Even though the event may extend more than one day, we can jump into any interesting time period and focus on specific training objectives efficiently.

For each specific case, according to the training objectives, a set of pause times and forward times for a specific case can be created in setting files. During the simulation, the machine will automatically pause at the designed time and remind the trainer of the pause time by flashing and beeping (Fig. 4.2).

In the timing control buttons, the "Pause", "Resume" and "Forward" are working on the server, while the others are working on the clients. Timing control buttons and their function are as follows:

1) *Pause*

The simulation can be paused at any time by clicking the "Pause" button. It can be also paused automatically at any pre-determined time in a setting file. When an automatic pause time is reached, the next pre-determined pause time will appear in the entry box. These two ways of the pause function are very useful and convenient for pre-briefing and interval based simulation.

2) *Resume*

The "Resume" button is for restarting the simulation and the clock.

3) *Forward*

The "Forward" button is to set the machine time forwarding to a pre-determined time or other input time with the same format. After the click, the next forward time for a selected case will show on the entry.   Generally, after forwarding the machine time, it takes a couple of minutes for the simulation to have available data up to the current time.

4) *SetClientBack*

If there are some users already logged into the workstations, to avoid potential machines lock up potentially, click the "SetClientBack" button can safely set these machines' time back to Jan. 1, 1997.

5) *Synchron and Unsynchron*

After the server time setting is ready, clicking the "Synchron" button will start the synchronization of the workstations with their server. Clicking the "Unsynchron" button, the synchronization will be stopped.

6. FUTURE PLANS

We will continue working on developing and exploring advanced training tools, which can be used in a simulated operational environment and subsequently transferred to the NWS community. The training tools will be available and distributed to the field through the WDTB web site and by the CD-ROM.

The next important project is the 2006 Winter Weather AWOC.   Major efforts will work on collaborations of multiple simulations with different CWAs. Enhancemet to the WESSL, including its map function, will have high priority as well.

When the training development of the WRAT lab is mature, more research studies will be conducted.   The WRAT lab will provide an interactive venue for education and collaborative efforts within the Norman weather community.

6.1 *Training*

As introduced previously, in the DLOC, there will be multiple simulations in several groups with 2-3 workstations. These simulations are different cases. While in the Winter Weather AWOC, these groups will run the same case simulation, with different CWAs. We will develop tools to support the collaboration among the groups. Each group is able to view other group's warning generations.

This concept to communicate among groups during a simulation can be further extended for multiple remote simulations.   This technique will be very helpful for simulation training in the field. For example, one trainer will be able to conduct the simulation training for several trainees either in his local office or in several different offices.

WDTB is developing new features for WESSL as well as other evaluation tools to improve the simulation environment.   One major task is to enhance the WESSL map functions. These new map functions include county or zone plotting switch map; zoom command to change map scale in the builder; multiple dot plotting and a Local Storm Report (LSR) input converter to WESSL script.

6.2 *Research*

To support the warning decision making process, storm-scale modeling using the WRF will be conducted by clustering the lab machines. We plan to work on a weather event database supported by pattern recognition, data mining and visualization as well.

6.3 *Education and Collaboration*

When training workshops are not in session, the lab can be used for real-time viewing or briefing, case studying and introduction to AWIPS for students of Oklahoma University.

7. SUMMARY

The WRAT lab was built recently for the NOAA's NWS AWOC workshops, DLOC workshops and other interactive learning

workshops. The lab's settings, configurations and newly developed tools were introduced. These new techniques and tools strongly support advanced training strategies, functions and objectives. These capabilities allow participants to practice inter- and intra-office coordination and cooperation, respond to changing weather conditions by restructuring workload, and deliver realistic forecasts and warnings all within a short training period. Some on going and future training tools, research and education collaboration plans were also introduced.

8. ACKNOWLEDGEMENTS

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