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Distributed Problem Solving: Adaptive Networks with a Computer Intermediary Resource

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for

Contracting Officer's Representative
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This report presents an overview and instructions for administering a dynamic control skill task on the Macintosh. The acquisition of distributed dynamic control skills can be assessed through the programs that accompany the overview.

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Distributed Problem Solving: Adaptive Networks with a Computer Intermediary Resource

The Man-Machine-Environment Engineering Laboratory

The Acquisition of Distributed Dynamic Control Skills*

Overview and General Instructions

There are two separate programs that are divided among four Macintosh Pluses. The four computers are designated thus:

> Mac0: The Experimenters station--uses program <u>WaterMacZero</u>.
>
> Mac1: Subject A's station--uses program <u>Water</u>.
>
> Mac2: Subject B's station--uses program <u>Water</u>.
>
> Mac3: Subject C's station--uses program <u>Water</u>.

The four computers must be connected on an AppleTalk Network. The programs read the Chooser Name of their computer. Therefore, before running any of the programs, the Chooser DA must be selected and the name must be entered which corresponds to that computer's station: The Chooser Names are Mac0, Mac1, Mac2, or Mac3.

Make sure all four computers have started their programs before attempting to send anything between them. At start-up, each programs registers itself on the network. When a program sends its first message, it checks who is on the network and makes a table of names. Each program only does this once, so if one of the other computers is not registered when the table is made, it will not be recognized in later communications.

When each of the three subject stations have booted up the program (Water), the Debug window first comes up with some programmer information, then the Welcome Screen comes up:

Welcome to the Distributed Problem Solving Experiments

Figure 1. Welcome Screen.

At this point the experimenter (or trained subject) presses the mouse key once and the Group Number Dialog Box appears. The experimenter enters the appropriate number and clicks on 'Finished'. The group number is stored in each computer and is not sent to Mac0.
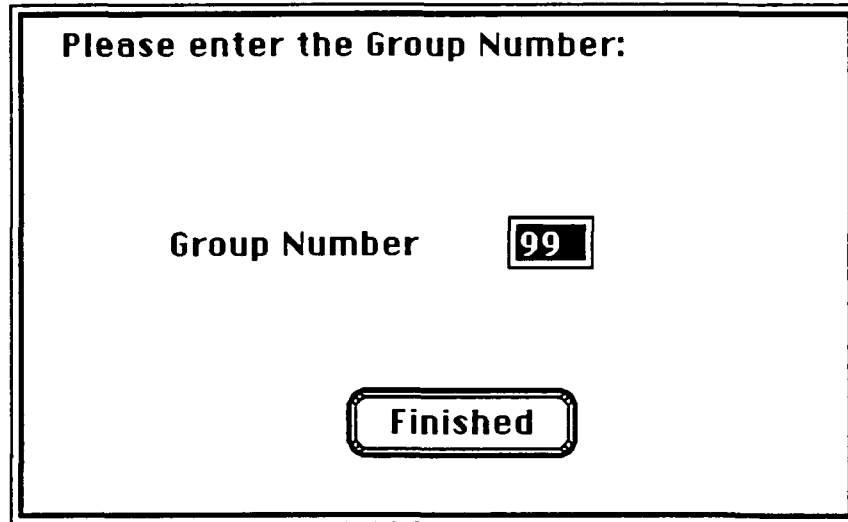
```
┌─────────────────────────────────────────────┐
│  Please enter the Group Number:               │
│                                               │
│                                               │
│     Group Number        [99█]                 │
│                                               │
│                                               │
│                  ⎛ Finished ⎞                 │
│                  ⎝          ⎠                 │
│                                               │
└─────────────────────────────────────────────┘
```

Figure 2. Group Number Dialog Box.

At the same time at the experimenter's station, the program (WaterMacZero) has been

booted up and has reached the Welcome Screen. The experimenter presses the mouse key once

and then the Task Parameter Dialog Box appears. The experimenter selects the appropriate

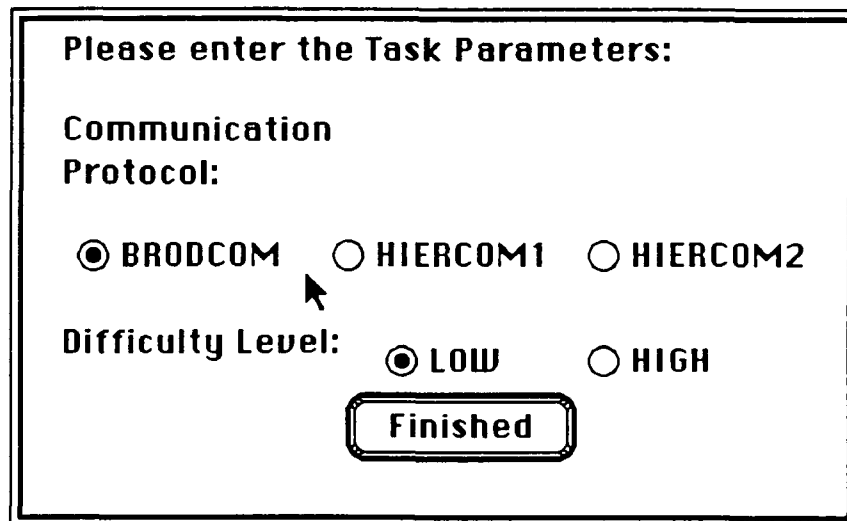parameters for the current scenario and clicks on 'Finished'.

```
┌─────────────────────────────────────────────┐
│  Please enter the Task Parameters:            │
│                                               │
│  Communication                                │
│  Protocol:                                    │
│                                               │
│  ◉ BRODCOM    ○ HIERCOM1    ○ HIERCOM2        │
│                 ▶                             │
│  Difficulty Level:  ◉ LOW      ○ HIGH         │
│                  ⎛ Finished ⎞                 │
│                  ⎝          ⎠                 │
└─────────────────────────────────────────────┘
```

Figure 3. Task Parameter Dialog Box.

The task parameters are then sent to each of the three subject stations.

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When the task parameters have been received by the subject stations it triggers a series of Instruction Screens that the subjects read. There is a 'Next' button at the bottom of each screen that the subject clicks on after he or she is done reading that screen. The experimenter is also explaining the scenario and answering any questions at this time.

The last screen asks the subjects if they are ready and they click on the 'Ready' button when they are. When they press the 'Ready' button their station sends a message to Mac0 that they are ready. When Mac0 has received a ready message from all three of the subjects, Mac0 sends a message to each of the subject stations to begin the scenario.
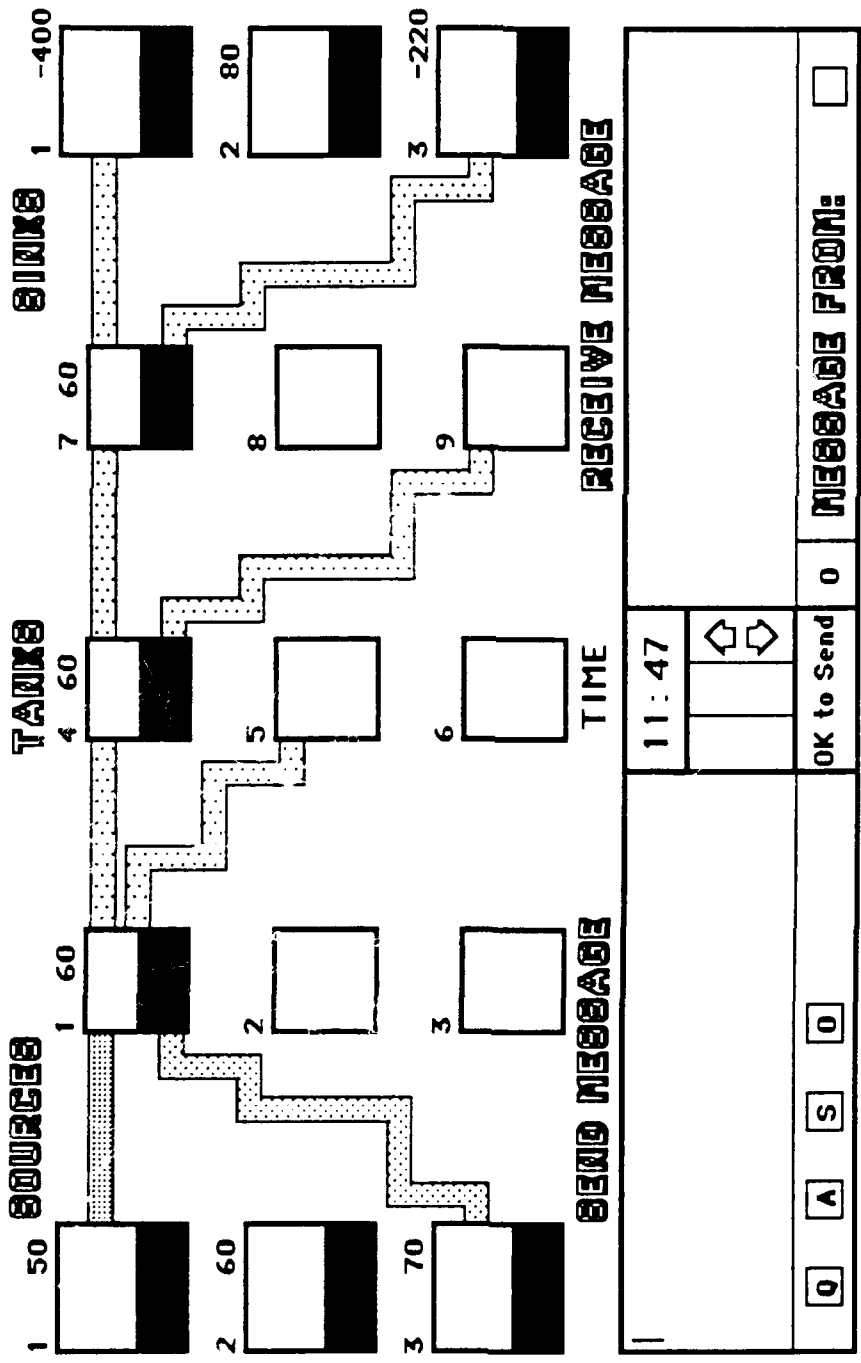
The scenario begins:

The scenario screen is made up of many elements, some of which are under the control of the subjects and some are not. The menu bar is used in the program but there are three

Figure 4. Scenario Screen.

Command Keys available (mostly for programming and debugging). ⌘D brings the Debug Window forward which displays the writeln messages inserted by the programmer. ⌘E ends the scenario early (used by the programmer). ⌘Q quits the program.

There are three source tanks, numbered 1, 2, and 3 down the column, with an infinite supply of water. The temperature of the source water is displayed above each source. There are nine finite tanks arranged in three columns of three. The temperature of the tanks may or may not be displayed above each tank. The current volume of the tanks is indicated by the level of the shading (in black) of each tank.
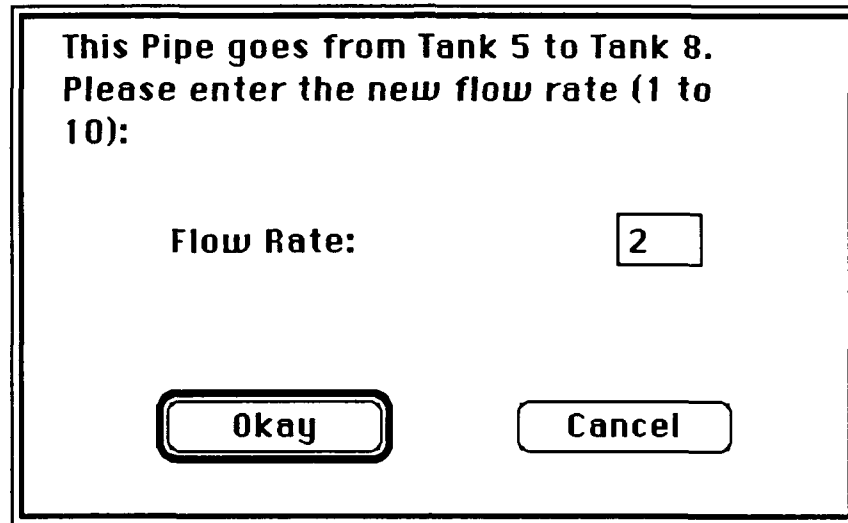
The sources supply water to the tank system via the first column of tanks. The rate of flow from the sources is indicated by the density of the shading of the pipes between the sources and the first column of tanks. Subjects do not control the rate of flow from the sources.

The first column of tanks supplies the second column of tanks which supplies the third column of tanks. The third column of tanks supplies three infinite sinks. The energy input into the sinks is displayed above the sinks. The subjects' goal is to drive all the energy inputs into the sinks to zero.

To achieve their goal the subjects can control the flow rates from the nine tanks. An individual subject, however, has control of only a subset of the total scenario. Figure 4 displays the view that Subject A has in the low level, broadcast scenario. Subject A does not have information about or control of tanks 2, 3, 5, 6, 8, or 9 although these tanks are active in the scenario. What each subject sees and has control over is determined by the task parameters.

If a subject can see a flow pipe from a tank, then that subject can change the flow rate by clicking the mouse on the pipe. After clicking on the pipe a Dialog Box appears, such as the one in Figure 5, which informs the subject the source and destination of the the pipe and its current flow rate. If the subject wishes to change the rate he or she presses the appropriate

number (1 is a slow rate, 10 is a fast rate) and clicks on 'Okay' (or hits return). Changing the flow rate into a sink will change the energy input into that sink.

```
This Pipe goes from Tank 5 to Tank 8.
Please enter the new flow rate (1 to
10):

        Flow Rate:                  2

          Okay                  Cancel
```

Figure 5. Change Flow Rate Dialog.

Because each subject only sees a subset of the scenario, communication between subjects is an important factor for the group to achieve its goal. The content of the messages generally will consist of informing the other subjects what that subject has control of, what actions he or she has taken, or requests for information or actions from the other subjects.

When a subject begins typing the message is displayed in the 'Send Message' box. To send the message, the subject must click in one of the four boxes below the message. Each box has a letter within it that indicates the type of message that is going to be sent. Thus, the subject categorizes and sends the message at the same time. In the Broadcast scenario the four types of messages are 'Q'uestion, 'A'nswer, 'S'uggestion, and 'O'bservation. In the two Hierarchical scenarios the four types of messages are 'Q'uestion, 'A'nswer, 'R'eport, and 'O'rder. Also in the two Hierarchical scenarios, Subject B has to choose between sending to Subject A or Subject B. There are two additional boxes next to the four send boxes with the

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letter of the appropriate subject. Subject B has to click on one of the two subject boxes to send to before clicking on one of the send boxes.
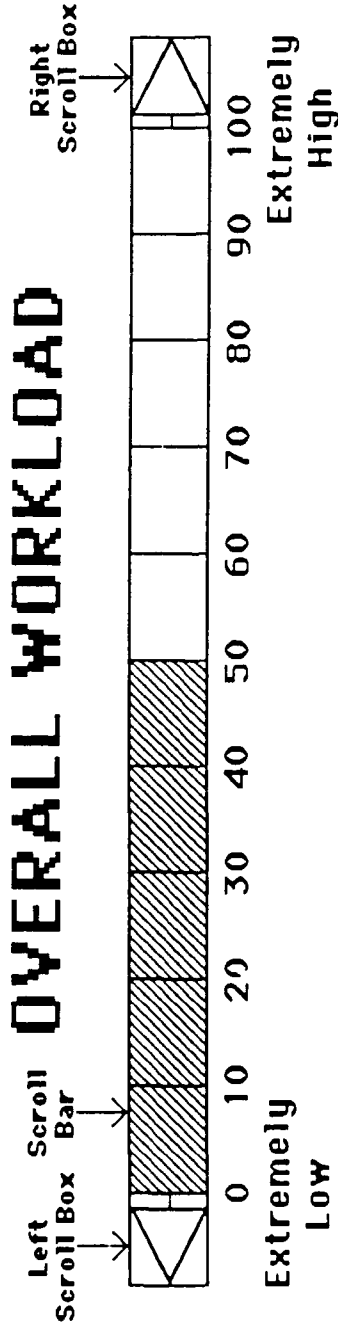
While a message or a change in the flow rate of a pipe is in the process of being sent, the 'OK to Send' box is filled in and all input is ignored so that an attempt at sending another message is not possible. When the 'OK to Send' is cleared then new input will be accepted and another message or flow rate change can be sent.

Messages arriving at a subject station will be displayed in the 'Receive Message' box. The first message will be displayed and subsequent messages stored in a list. In the box just to the right of the 'OK to Send' box the number of messages that have been received will be displayed. In the box just above the 'OK to Send' box and just to the right of the up and down arrows the number, in the list, of the message currently shown will be displayed. To change the message being shown, the subject clicks on the down-pointing arrow (above the 'OK to Send' box) to move down the list and see more recent messages. By clicking on the up-pointing arrow, the subject can move up the list to review older messages. A maximum of 15 messages are kept in the list at one time. The first message in will be the first message out when the 16th message is received.

When the scenario is over the subject is informed and then the Workload Assessment Section of the experiment begins. The first screen includes the instructions of how the subjects are to enter their workload assessments.

Please complete the following rating scales. Base your ratings on the Water Flow task you have just completed.

You can perform the ratings in either of two ways. First, by positioning the cursor arrow in either of the scroll box triangles and clicking the mouse button, you can move the scroll bar left or right. Or second, position the cursor arrow at the end of the scroll bar, hold the mouse button down and drag the the bar left or right. Release the mouse button when you are done.

OVERALL WORKLOAD

Left Scroll Box · Scroll Bar · Right Scroll Box

0   10   20   30   40   50   60   70   80   90   100

Extremely Low   Extremely High

If there are any questions, please ask the experimenter at this moment. If you are ready to begin rating, please click on the CONTINUE box.

CONTINUE

Figure 6. Workload Assessment Instructions.

There are nine scales that range of 0 to 100. The nine scales, which the subjects are to rate to they felt during the task, are: Overall Workload, Task Difficulty, Time Pressure, Performance, Mental and Sensory Effort, Physical Effort, Frustration Level, Stress Level, and

Fatigue. The subjects can adjust the rating scales (each scale starts at 50) either by clicking the mouse in one of the two directional arrows at each end of the scale or by clicking on the edge of the shaded rating box and dragging the edge forward or backward.

Upon completion of the nine Workload Rating Scales the subjects are done with the scenario (they generally perform several scenarios in an experimental session). The Thank You Screen is then presented.

Thank you for Participating in the Distributed Problem Solving Experiment

Figure 7. Thank You Screen.

At this point the Experimenter presses ⌘Q to quit the program and two 'Save this Document' Dialog Boxes will appear so that the data accumulated in the scenario can be stored. The two data files include all the actions of sending messages and data to the other subjects and also the performance data as pertains to their goal of setting the output to the Sinks to zero.
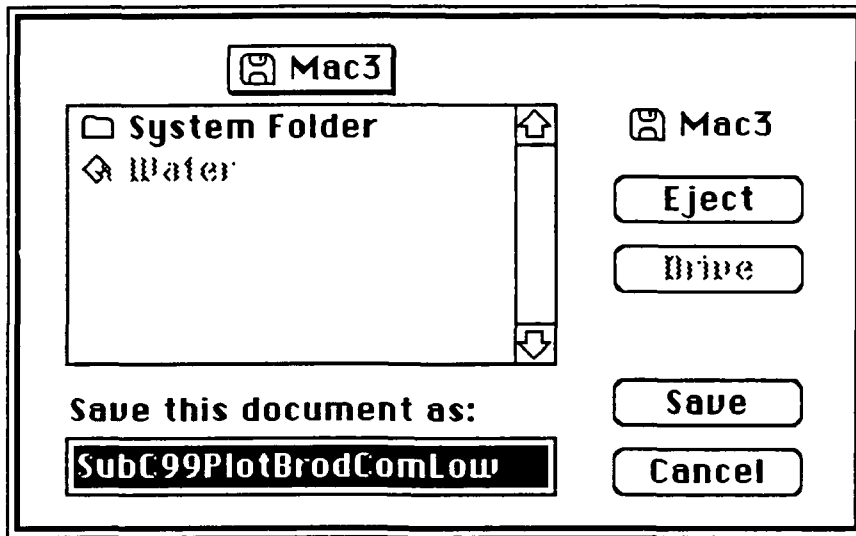
Figure 8. Save Data Dialog Box.