GAPSS
(GRAPHICAL ANALYSIS PROCEDURES FOR SYSTEM SIMULATION)

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SUMMARY

Two types of computer-graphic displays are discussed for analysis of simulation data subsequent to simulation runs. A display showing values over time was found to be superior to a display sequentially presenting individual states of a system.

A project has been underway at the RAND Corporation to develop Graphical Analysis Procedures for System Simulation. The goal is to learn how computer-graphics can aid people in their analyses of simulated systems. This paper reports interim progress on graphically displaying the results of simulations done in the GPSS language.

Our procedure has been to run a simulation and store period-by-period results on disk. As a second step we analyze the resultant data graphically. This sequence allows viewing the data in many ways with out waiting for repeat simulations.

To illustrate the graphical analysis procedures, we will use a simple simulation of a Health Center. It has the usual stream of sick patients entering it, with additional emergency patients coming through an emergency entrance. There are a number of doctors, but only one will be observed in detail. He uses two examining rooms; a patient is examined in one room while the other room is cleaned. Patients wait for an examining room in the waiting room if all examining rooms are full.

This simulation was run and the data stored on disk. It was then analyzed using graphical analysis procedures making use of the IBM 360/40, the IBM 2250 Graphical Display Unit, and the RAND Tablet as shown in Figure 1. The RAND Tablet is used for all human inputs to control the display. A person writes on the Tablet, and the position of the pen appears on the screen. To control the display, one prints in characters on the RAND Tablet, the characters are recognized by software, and standard characters replace them.

The first display (Figure 2) shows the state of four system variables at any one point in simulated time. In this

Figure 1—Graphic Display Station

case the person has requested information about a Facility by printing an F for the TYPE in the upper left graph. The particular Facility is number 41 -- the doctor. The bottom graphs give the states of the two examining rooms. If a Facility is idle, its value is zero; if in normal use, the value is one; if in emergency use, the value will be two. The upper right graph reports the length of the Queue (Q21) of patients waiting for an

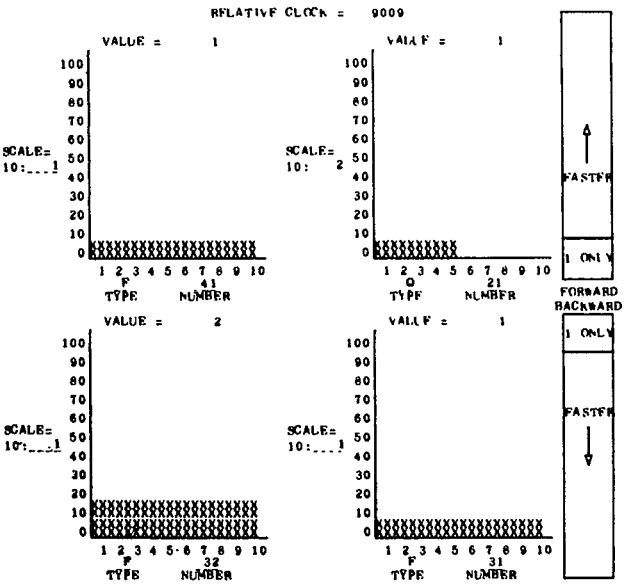

Figure 2—Display Sequentially Showing Individual States of System

examining room. A scaling factor has been printed in for each graph; it gives the ratio of the displayed value to the actual value. The "graphs" are essentially vertical bar charts with heights indicating the absolute magnitudes of the variables. If a scaled value is not an even multiple of 10, the remainder after division by 10 is indicated on the horizontal scale.

The relative clock time appears at the top of the display. In Figure 2 the relative clock happens to be 9009. Time can be advanced backward or forward one state at a time by pressing the pen in the ONE ONLY box. Time can also be continuously advanced at various speeds by pressing in the ONE ONLY box.

Unfortunately, people have great difficulty using this display. It requires the analyst to remember past data in order to detect changes, and changes are usually very important. Human memory is not adequate for the task, so much of system performance remains undetected. Because many of the simulated system's characteristics seemed hidden by this display, we tried another method.

The new display, a hybrid, is shown in Figure 3. At the bottom is a Gantt Chart, named for its creator, Henry Gantt. At the top is a simple graph of a variable over time. The operator can change the limits of time to be displayed by printing them on the RAND Tablet. In Figure 3 the limits have been set to display the system starting 1 1/2 hours into the day and ending 2 hours later. Since a second is the smallest time increment in the system, this means limits of 5400 and 12600 seconds. On the top portion Q21 is to be examined. The maximum value to be displayed is 10, and the minimum value is 0. Time is the independent variable with queue length plotted vertically. This graph presents the same data as the previous display, but gives a profile of use over time.

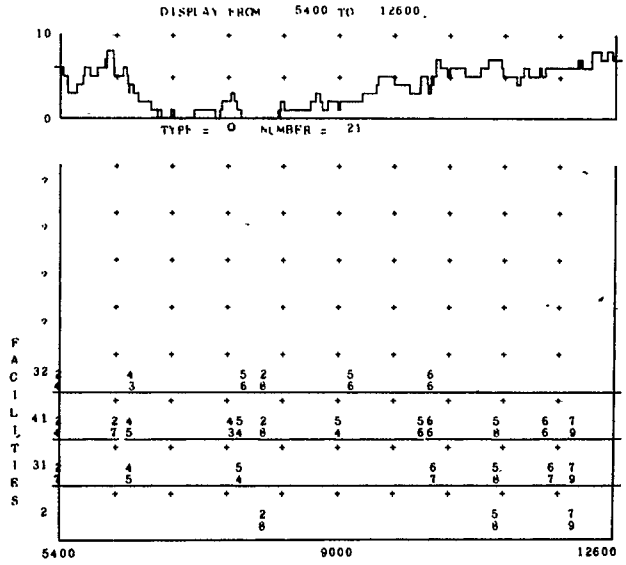

Figure 3—Hybrid Display

It would also be useful to know which patient is using which facility. This information is presented on the lower part of the display in the Gantt Chart. In this Chart a bar is drawn indicating the time a patient is using a facility, and the patient number is given above the bar. For example, information about the emergency entrance, Facility 2, is given at the bottom of the Chart. Patient 21 has passed through the emergency entrance rapidly, entering at about time 8000 as an emergency. This emergency case could be examined in more detail by changing the time limits of the display to magnify the relevant period.

The two display types seem to differ greatly in power, and a study was performed to test usefulness. In addition to knowledge about usefulness of the two displays, more general lessons were also learned from the study. Four of the most important points are:

1. An analyst almost never finds the right way to view simulation data on the first try.
2. Computer-graphics helps an analyst identify relationships obscured by summary statistics.
3. The first display (Figure 2) is less useful than the second display (Figure 3) in solving simulation problems.
4. Computer-graphics displays should be tested by the people for whom they are designed; intuitive feelings are often wrong about what display would be most useful.