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NETWORK II.5, LANNET II.5 AND COMNET II.5

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ABSTRACT

This tutorial will acquaint the reader with a powerful modelling tool which can dramatically reduce the amount of time it takes to simulate a computer system. The NETWORK II.5 world view and the class of problems it addresses will be discussed. A summary of NETWORK II.5 capabilities will be presented. To tie the tutorial concepts together, an example of using NETWORK II.5 is included.

1 BACKGROUND

Simulation languages ease the burden of programming simulation problems. However, in certain application areas higher level facilities can be designed to speed the simulation analysis. While this higher level facility would probably be written in a simulation language, it would require no programming on the part of the user. Instead, the user is interactively guided in building a description of the system to be simulated. The higher level facility would then run the model. This allows someone to dive into a simulation problem without the delay inherent in becoming fluent in a simulation language and coding up a model. NETWORK II.5 is such a higher level facility for modeling computers and communication networks.

2 NETWORK II.5 WORLD VIEW

There are two concepts at the heart of the design of NETWORK II.5. First, items to be simulated are viewed strictly based on their function. Second, timing is the most important consideration in the simulation. There are four main functions in the computer and communications world. They are processing, transfer, storage and control. NETWORK II.5 has a separate general purpose building block to model each of these functions. NETWORK's processing, transfer and storage building blocks are used to model hardware. NETWORK's module building block models both the software and control functions that may be in either hardware, firmware or software. Every device is described in terms of the function it provides to the system to be simulated. Many real world devices require more than one NETWORK II.5 building block to be fully described because they embody more than one function. For example, a personal computer might require two processing elements (main processor and coprocessor), three transfer devices (internal bus, serial port and parallel port) and two storage devices (disk and main memory).

By concentrating on providing a few powerful function oriented building blocks, the explosive progress of technology will never outpace NETWORK II.5. Whether data is being moved via a bus, satellite link, fiber optics or some advanced technology not yet discovered, the function is the same. Information is transferred. In addition, the limited number of building blocks makes NETWORK II.5 a very easy tool to learn to use.

NETWORK II.5 simulates a system based on timing. Instructions that run on a processing element are not executed in the sense that at the end of an add instruction, the result is 4 and the overflow bit is reset. Instead, the effect of the instruction on system operation is modeled. If the instruction sent a message, a transfer device will be tied up for the amount of time it took to send the message. If a fetch from memory is required, at the proper time and for the proper duration, a transfer device and a storage device will be utilized. NETWORK II.5's timing orientation facilitates measurement of such system considerations as response time, conflicts, device utilization, etc.

3 APPLICATION DOMAIN

NETWORK II.5 is designed to simulate systems in which devices are requesting, manipulating and distributing information and/or making decisions based on the system state. Local area networks, telephone networks, distributed database systems, automotive electronic systems, military communication systems and automated factories are just a few of the current applications of NETWORK II.5.

NETWORK II.5 is extremely flexible, allowing the portions of a computer system of special interest to be modeled at a finely detailed level while the rest of the system is modeled at a courser level. There is no arbitrary limit to the number of processing, transfer, storage and module building blocks which may be used to describe a system. In addition, any device interconnection scheme is allowed.

4 WITHOUT PROGRAMMING

You do not need to learn (or own) any computer language to run NETWORK II.5.

NETWORK II.5 speaks your language! You describe the system being simulated using terms like Processing Element, Instruction and Protocol = Collision. All errors are expressed in terms easy to understand. "PE 5 does not connect to TD 2" is much easier to understand than "Subscript out of range."

NETWORK II.5 has a graphical interactive front end called NETGIN that uses a mouse and keyboard dialog to quickly build, modify and display a system description. NETGIN will also interactively diagnose logic errors in a user's model description, allowing quick corrections. It also can produce diagrams of both the hardware and software which the user has described. When the system description is complete, NETWORK will run the simulation using an interactive dialog to set up the simulation parameters. If desired, the user can interactively follow the simulation's progress by requesting a narrative trace of the simulation. At the end of a NETWORK II.5 simulation, the user may request a post processed report called NETPLOT. By analyzing a log file produced during the simulation run, NETPLOT produces both timeline diagrams of simulation activity and utilization graphs.

NETANIMATION allows a user to draw the computer system simulated and watch the simulation graphically represented as the simulation progresses. A wide variety of styles and colors are available to represent objects in the simulated system. Zooming and panning allow very large systems to be displayed. Simulations may run automatically or single stepped. Descriptive trace messages may be displayed concurrent with the animation to explain the details of the simulation activity. Figures 1 and 2 show output from NETPLOT and NETANIMATION.

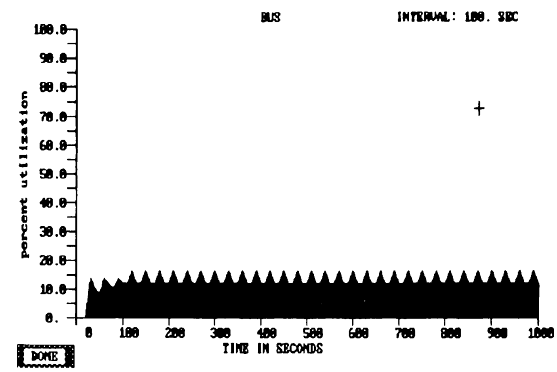

Figure 1: NETPLOT Utilization Graph

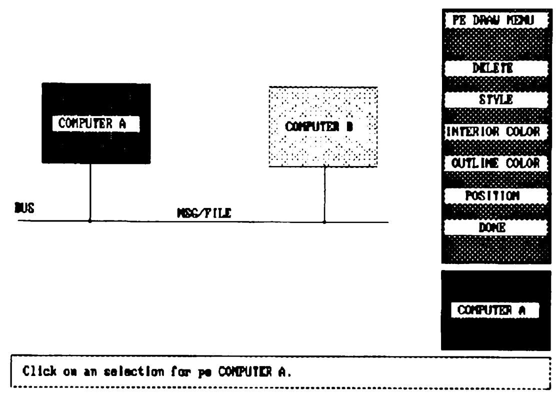

Figure 2: NETANIMATION Screen

5 NETWORK II.5 AVAILABILITY

NETWORK II.5 is currently available on IBM (CMS and TSO), VAX/VMS, VAXstation, PC-DOS, OS/2, SUN/3, SUN/4, SUN SPARCstation, HP 9000/800, HP 9000/300, Apollo, IBM RISC/6000 and DECstation machines. Versions for other machines will be added as required. All versions work identically, so that models can be moved from one manufacturer's machine to another without any changes.

6 NETWORK II.5 REPORTS

There are eleven basic reports provided by NETWORK II.5. The tabular reports include Module Summary, Processing Element, Transfer Device, Storage Device, Semaphore and Message Statistic reports. NETWORK II.5 also offers a Narrative Trace, a Snapshot Report, a Hardware diagram and a Software Diagram report.

The tabular reports are produced both at the end of the simulation and any other user specified times. The Narrative Trace report is produced interactively upon demand and chronicles the progress of the simulation event by event as they occur. This report interacts with the user to allow the user to stop the simulation or produce additional reports if things are going wrong. The Snapshot report lists the current status of every hardware device, module, semaphore and message in the simulation. It is produced both as a part of the end of tabular reports and interactively during a simulation run in response to a user request. The Timeline and Utilization reports are post processed reports that act upon a database produced during a simulation run to show the status of every hardware device and every semaphore in the simulation. The time span plotted on these reports is user specified so that a user can go back and expand the time scale of a period of interest several times until the needed information is obtained.

7 LAN SIMULATION WITH LANNET II.5

LANNET II.5 is a local area network tool that lets you experiment on a computer-based model before you incur the risk and cost of committing to a proposed LAN. LANNET II.5 is a subset of NETWORK II.5 that has been streamlined for easy modelling of LAN configurations.

The basic LANNET II.5 building blocks are LANs, Stations, Gateways and Routes. Traffic is generated by specifications made during the definition of each Station building block. Standard LAN protocols such as Ethernet, Token Ring, and Token Bus are built-in, others can be modeled.

7.1 LANNET II.5 Building Blocks

The LAN is the backbone that supports the Stations and Gateways that use it. For each LAN, you specify the protocol, the connections to the LAN, the LAN speed, and any overhead associated with the system.

Stations represent any type of LAN user: PC's, workstations, file servers, printers, etc. Users with common configurations can be combined into a Station Group, and modeled collectively. Each Station has a Station Activity list, which defines the actions that the Station performs while connected to the LAN. Each Activity has a unique name, generation method, length and destination attached to it.

Gateways are used to model the link a LAN has with other LANs or with the "outside world." Gateways, Bridges, Routers, and Repeaters can be modeled using the Gateway construct.

Routes are used to send messages between Stations via Gateways. A Route is composed of a list of Gateways followed by a destination Station.

A graphical interface allows you to easily build the LAN model using these building blocks. The LAN is drawn automatically and you see an animated picture of LAN usage as the simulation proceeds.

7.2 LANNET II.5 Summary Reports

To analyze the LAN usage after the simulation is finished, LANNET II.5 provides summary reports of LAN statistics, Station statistics, Gateway statistics, activity statistics and message statistics. These reports provide statistics such as the number of collision episodes, number of successful LAN transfers, percentage of time busy, number of LAN requests granted, utilization statistics and much more. Both graphical plots and text-based reports are available.

LANNET II.5 can greatly enhance the analyst's ability to make the right decisions in LAN planning.

8 COMMUNICATION NETWORK SIMULATION WITH COMNET II.5

COMNET II.5 is a capacity planning and performance prediction tool used in the design and ongoing management of LAN, WAN, voice, and data communication networks. Based on a description of the network topology, access protocols, traffic and routing algorithms, COMNET II.5 simulates the operation of the network, providing measures of network performance such as response times, network throughput, node, link and LAN utilization, end-to-end blocking probabilities and other traffic statistics.

Because of its generalized approach, you can use COMNET II.5 to analyze virtually any data, voice, or integrated services network. X.25, ISDN, SS7, DECnet, SNA, TCP/IP, CSMA/CD, token passing, polling, radio and satellite networks are all easily modeled in COMNET II.5. Like NETWORK II.5 and LANNET II.5, it does not require any programming. You simply describe the network you wish to model using a graphical interface.

As the simulation runs, you see animation of the network in operation. The model pinpoints bottlenecks and allows you to compare different network configurations.

8.1 COMNET II.5 Building Blocks

A network description in COMNET II.5 consists of three major categories of data: the Network Topology, Network Traffic and the Network Operation.

The network topology is defined by the nodes of the network and the link groups connecting the nodes. Nodes represent sources and destinations for network traffic. In addition, nodes may perform circuit switching, packet switching, or both. A link (or circuit) is a transmission facility connecting two or more nodes. A link group is composed of one or more identical links. Voice, data, and other types of traffic can be routed over the same link. Multiple link groups can connect the same nodes. Depending on the access protocol, a link group can represent a point-to-point channel, a polled mutipoint line, a CSMA/CD or token passing LAN, or a random access radio channel. Each link group has additional attributes that depend on the access protocol.

LAN attributes include slot times, contention intervals, collision windows, jam times, retry distributions, token-passing times, polling times, NAK times and others, depending on the LAN under study.

There are three kinds of traffic that can be defined in a COMNET II.5 model: circuit-switched calls, data messages (which can be circuit-switched or packet-switched), and virutal-circuit calls. For a typical network, there are many categories of calls or messages. Each category is defined by an origin node, a destination node, and a class of service.

The class of service distinguishes between traffic which may have the same origin and destination, but with other characteristics which may vary. Packet priority levels, bandwidth requirements, retry intervals, and maximum packet size can all be specified in the service class.

The attributes of many of the traffic categories are random variables with some probability distribution. An extensive list of distributions is available in COMNET II.5 for modelling both discrete and continous random variables. In addition, users can define their own probability distributions to generate the traffic load on the network. For cases where actual or historical traffic data are available, it is possible to drive the simulation with files of user-provided traffic data, rather than relying on the generation of traffic data based on probability distributions.

Network operation parameters include a description of the network's routing strategies. The routing strategies determine how the network traffic moves through the network topology from origin to destination. COMNET II.5 includes both static and adaptive routing. With static routing, routing tables are predetermined; with adaptive routing, routing tables are updated dynamically so that traffic is routed along the shortest path to the destination node. What is meant by shortest is specified by the distance metric for the link groups.

8.2 User Interface and Results

The network is described using a graphical interface that produces a realistic "picture" of the network. As the simulation proceeds, you see animation of the network processes. The animation is very helpful for seeing routing choices, bottlenecks, and to ensure that the simulation model accurately represents the network. Figure 3 show animation of a COMNET II.5 network.

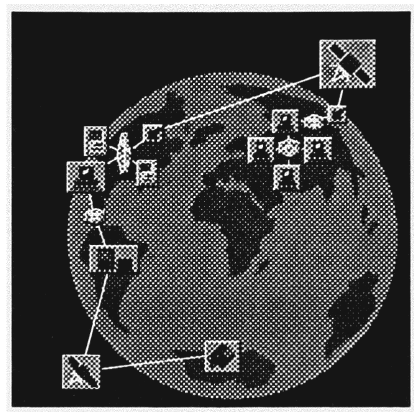

Figure 3: COMNET II.5 Network Animation

COMNET II.5 automatically produces reports summarizing network utilization and service. Reports give statistics on circuit group failures, busy circuits, bandwidth, calls attempted, calls blocked, average call length, number of packets transmitted, number of collision episodes, access delay, utilization percentage, and many other statistics that characterize the network. Utilization is also shown graphically as a function of time.

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AUTHOR BIOGRAPHY

WILLIAM J. GARRISON is an Executive Associate in the CACI Products Company. He led the development of NETWORK II.5, a computer and communications network simulator, and LANNET II.5, a Local Area Network analysis tool. Currently, he is involved in the development of future versions of both NETWORK II.5 and LANNET II.5. In addition, he teaches courses and consults on the use of both NETWORK II.5 and LANNET II.5.

William Garrison received the B.S. degree in Electrical Engineering from the University of Pennsylvania in 1975. He received a M.S. degree in Computer Science from the University of Pennsylvania in 1980. He is a lifetime member of the engineering honor society Tau Beta Pi and a member of the IEEE Computer Society.