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Trade-Off Study and Selection  
Of The N.mPc Simulation Package

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Trade-Off Study and Selection  
Of The N.mPc Simulation Package

In Partial Fulfillment of Contract No. OER82-05067  
Sponsored by the Communication Research Centre

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Approved By: Dr. S.A. Mahmoud

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Department of Communications

DOC CONTRACTOR REPORT

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DEPARTMENT OF COMMUNICATIONS - OTTAWA - CANADA

SPACE PROGRAM

TITLE: Trade-Off Study and Selection Of The N.mPc Simulation Package

AUTHOR(S): Dr. C. Laferriere

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ISSUED BY CONTRACTOR AS REPORT NO:

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DATE: August 24, 1982

## 1. Introduction

The second phase of the work on design methodologies for multi-processor systems calls for actual experimentation with computer aided design tools. The purpose of the experimentation is to simulate multi-processor systems and to obtain indications as to the performance and the correctness of various designs. The tools required to carry out such experimentation should provide facilities to define multi-processor systems, to program individual processors and to monitor simulated processor execution. Computer aided design tools corresponding to that description are not very numerous; section 2 briefly describes three such tools. Each of those tools require a special environment to work properly. Section 3 lists various candidate operating systems for the tool chosen in the previous section.

## 2. Multi-processor Simulation Tool

Three computer aided simulation tools for multi-processor systems were examined for possible procurement. The three contenders were:

1. AIDE [ELLE81]
2. SABLE [HILL79a], [HILL79b].
3. N.mPc [PARK79a], [PARK79b], [ROSE79], [ORDY79]

Each of these systems makes use of the fact that computer systems can be decomposed in terms of Behaviour and Structure at any given design level. At a high level design for example, the designer can conceive the system as being a collection of algorithms expressed in pseudo-code (or high level flow chart), with each of these algorithms being executed by a processor or sharing a processor with other algorithms. The required set of processors will have a given interconnection which is the structure part of the Behaviour/Structure description. The structure of the interconnection is an important factor in determining the eventual performance of the overall system.

Similarly at a low level design, the behaviour of a processor can be some portion of microcode. The structure will then be the interconnection of the various registers and busses which form the processor on which the microcode is to run. These concepts are explained in greater details in [MAHM82].

As mentioned before, all three systems surveyed support the behaviour/structure view of computer systems. Consequently, the selection criteria will be concerned with factors such as ease of use, flexibility and range of design levels covered.

### 2.1 AIDE

AIDE is a multi-processor simulation tool designed and

implemented at the BELL Laboratory. It consists of three main parts which are:

1. A language environment,
2. A runtime environment and
3. A user interface.

The language environment includes the Behaviour Description Language (BDL) which is used to describe the algorithmic behaviour of the proposed system. Also included in AIDE is the Interconnection Description Language (IDL) which is used to describe the interconnection of the various elements supporting the behaviour algorithms.

Typically, a system would be described in terms of its functionality in BDL. BDL is in fact an extension of the C Programming language. IDL would then be used to create a virtual computer system to support the functions described in BDL. The Runtime Environment is used to set up the simulation of the system that has been defined using BDL and IDL. The runtime environment includes a scheduler, a memory monitor, a performance monitor and a command interpreter. All these runtime facilities are supplemented by a user interface to allow ease of control over the simulation.

It is interesting to note that the runtime environment is the facility through which the host computer is made to look like and perform like the simulated system. The memory monitor for example determines the amount of memory that will be required by each simulated processor and performs the allocation of physical host memory. Each simulated processor is therefore represented by a partition of host memory and by a program which represents its (the simulated processor's) functionality.

The AIDE package is the most versatile among all those surveyed in the literature and, having been developed at Bell Labs, is the property of Western Electric. Intellitech tried to obtain the AIDE package but was unsuccessful because it is not the policy of Western Electric to divulge information of that kind. Names and addresses of persons contacted at Bell Labs are to be found in Appendix A.

## 2.2 SABLE/ADLIB simulation tool

The SABLE/ADLIB system was designed to support multi level simulations of multi-processor systems. The behaviour of the system to be simulated is described using ADLIB which is a language derived from Pascal. The structure of the simulated system is specified using SDL which allows specification of components and their interconnection.

The SABLE component is the simulation environment as well as the runtime package. As such, SABLE takes the output of the

ADLIB precompiler and that of the SDL compiler. It also provides interpretation of users' commands during the simulation.

SABLE/ADLIB is written mostly in Pascal and runs on a Digital Equipment Corporation System 20, under the TOPS Operating System. The system was developed at Stanford University and has been transferred to Silvar-Lisco, a California based commercial company. Silvar-Lisco plans to release a stand alone designer work station based on the SABLE/ADLIB simulation tool in the last quarter of 1982. This work station would be based on the Motorola 68000 microprocessor. In the first quarter of 1983, it also plans to release a version of SABLE/ADLIB to run on the Digital Equipment Corporation VAX-11 under the VMS or UNIX operating system. SABLE/ADLIB was therefore not considered for the current work because of its unavailability in the short term (i.e. 6 to 12 months). Appendix A contains further details on Silvar-Lisco and some of the designers of SABLE/ADLIB.

### 2.3 N.mPc Simulation Tool

N.mPc which stands for a network of multi-processor systems has been developed at Case Western Reserve University. The system consists of a Meta-micro-assembler, a linking/loader, an ISP compiler, an ecologist, a simulated memory processor and a runtime package.

The meta-micro-assembler is used to define instruction sets of new processors and also to assemble assembly language programs to be executed by those newly defined processors. Those programs are then linked and loaded by the linking/loader provided by the system. The hardware structure of the target system is defined and is then compiled into a machine executable form by the ISP compiler. This compiler supports multi-processing. The ecologist takes care of the topology of the system and fulfills a role akin to that of the linking/loader with respect to the meta-micro-assembler.

The simulation having been defined in terms of both behaviour and structure, it can then be set up using the simulated memory processor and supervised by the runtime package. N.mPc addresses only the Processor-Memory level and the register transfer level. Its scope is more limited than the previous two systems (2.1 and 2.2) but it is the only such system currently available commercially. Appendix A contains a list of names and addresses connected with N.mPc. Incidentally, N.mPc runs under the UNIX operating system on a PDP11.

### 2.4 Preferred System

The choice was limited by the availability of the surveyed systems. N.mPc, the least versatile for our purpose, was the only one available off the shelf. It should be emphasized that N.mPc is a very versatile system at the Processor-Memory level for which it was designed. The other systems would have exhibited a greater flexibility in handling the higher level simulation work

which may be attempted within the framework of this contract. Appendix B contains a price list from DICAR as well as a copy of the Lease Agreement.

### 3. Operating System Support

N.mPc having been chosen as the simulation package on which multi-processor simulation work will be done, it became necessary to acquire a UNIX or UNIX-compatible system. This selection of a UNIX system is the topic of this section.

Four UNIX systems were under consideration and are listed below: (General details are in Appendix C).

1. Western Electric UNIX provided by DICAR Corporation, the vendor of N.mPc. This UNIX is either version 6 or version 7. The cost of such system was deemed very high in comparison with others and was not considered further.
2. XENIX operating system which is a UNIX compatible system designed by Microsoft Corporation and marketed in Canada by Human Computing Resources of Toronto. XENIX is aimed primarily at microprocessors such as the INTEL 8086, the Motorola 68000, etc.. The cost of XENIX is \$4795.00 for a two-user system.
3. UNITY is a UNIX compatible system offered by Human Computing Resources of Toronto, Canada. UNITY is based on System 3 of AT&T and is the newest UNIX system available. It is competitively priced at \$3995.00 (US) for a 2-16 user system. The UNITY system also offers the advantage of being serviced and maintained by HCR which is based in Toronto and thus of easy access. UNITY was therefore selected as the UNIX compatible system to be purchased.
4. VENIX, another UNIX compatible system, was also at one time considered. It was to be distributed by A. Lewinson Corporation of Ottawa under an agreement with VenturCom Inc. of Cambridge, Massachusetts, U.S.A. Unfortunately, A. Lewinson Corporation is still not in a position to distribute VENIX at the time of the writing of this report.

### 4. Summary and Direction for Further Work

The procurement choices that were made are as follows:

- a) The multi-processor system simulation package N.mPc was chosen primarily because of its availability. It was deemed that N.mPc will be quite versatile for simulation work at the Processor-Memory level. Later on, software tools may be designed to bridge some gaps between high level description of system functionality and low level hardware architecture

details.

- b) Unity, a Unix compatible system, was chosen as the operating system to work with N.mPc. Being distributed and serviced by a canadian company was a very strong point in its favour, as well as its very competitive price.

With Unity and N.mPc installed and running on Intellitech's LSI 11/23, real experimentation and research work can begin. The installation procedure for both packages will be documented in the next progress report, together with a preliminary description of N.mPc in actual use.

Unity and N.mPc have been ordered already and delivery is expected to be at the end of August 1982.



APPENDIX A

Multi-Processor Simulation Tools

- 1) AIDE was developed by Dr. D.J. Ellenberger and Dr. Y.W. Ng of:

Bell Laboratories,  
1100 East Warrentonville Road,  
Naperville, Illinois 600566  
U.S.A.  
(Telephone: (312)-979-200, main number)

AIDE is written in the C language and runs on the Unix system either on a PDP-11 or a VAX-11. Western Electric will not release any information on AIDE other than what is available in the open literature.

- 2) SABLE/ADLIB/SDL is a system developed by the centre for Integrated System, Department of Electrical Engineering and Computing Sciences, Stanford University, by Dr. W.M. vanCleemput, Dr. W.E. Cory and others. The system is now being packaged for sale by a California based company specializing in design automation. This company is:

Silvar-Lisco  
3172 Porter Drive,  
Palo Alto, California,  
U.S.A. 94304  
(Telephone: (415)-856-2525)

Mr. David Kwelo of Silvar-Lisco informed Intellitech of the following:

- a) Plans to introduce a design workstation based on the Motorola 68000 and featuring ADLIB/SABLE. Availability of such system was to be around the latter part of 1982.
- b) Plans to introduce ADLIB/SABLE for the VAX-11 around the first quarter of 1983.
3. N.mPc is a multi-processor simulation tool developed at Case Western Reserve University by Dr. C.W. Rose, Dr. F.I. Parke, Mr. G.M. Ordly and others. It is being distributed by:

DICAR CORPORATION  
10900 Euclid Avenue,  
Crawford Hall, Room 511,  
Cleveland, Ohio,  
U.S.A. 44106  
(Telephone: (216)-368-2800, Dr. Charles W. Rose)

This system is the only one of its kind currently available.

APPENDIX B

This Appendix contains:

1. A schedule of charges as of the 20th of May 1981 for the N.mPc system. All the prices quoted are in U.S. currency. Please note the second footnote regarding mandatory maintenance.
2. A copy of the Lease Agreement for the N.mPc system.

## N.mPc/Binary UNIX\* License

## SCHEDULE OF CHARGES

20 May 1981

## N.mPc License (1)

Includes sources, documentation,  
installation and 2 days training \$ 20,000

## N.mPc Maintenance (2)

Includes bug fixes, enhancements and  
additional library entries \$ 2,000/year

## UNIX Binary License V6

Includes UNIX Version 6 binaries, documentation,  
installation and 2 days training \$ 11,400

## UNIX Binary License V7

Includes UNIX Version 7 binaries, documentation,  
installation and 2 days training \$ 14,700

## UNIX Binary Maintenance

Includes bug fixes, problem solving \$ 2,000/year

## UNIX Binary Demonstration

Includes configuration and 2 day on site  
demonstration. (The \$2,000 is applied  
against the binary license fee if the  
same version license is purchased within  
60 days of the demonstration) \$ 2,000

## Consulting and Training

UNIX System Course 2.5 days \$ 1,500 plus first class  
travel expenses

UNIX User Course 2.5 days \$ 1,500 plus first class  
travel expenses

N.mPc User Course 2.5 days \$ 1,500 plus first class  
travel expenses

Consulting not included in \$ 300/day plus first class  
installation or maintenance services travel expenses

\* UNIX is a trademark of Bell Laboratories

(1) Requires UNIX license (source or binary V6 or V7)

(2) First two years maintenance required

LEASE AGREEMENT

THIS AGREEMENT, made and entered into as of the 20th day of August, 1982, by and between DICAR Corporation (hereinafter referred to as "LESSOR") and INTELLITECH CANADA LIMITED (hereinafter referred to as "LESSEE").

WITNESSETH:

That for and in consideration of the mutual covenants hereinafter contained, the parties hereto agree as follows:

1. The computer program which is the subject of this Lease Agreement is described in Exhibit A which is attached hereto and made a part hereof.
2. Subject to the terms and conditions set forth herein, LESSEE agrees to acquire and LESSOR agrees to grant to LESSEE a lease with the right to use LESSOR's computer program described in Exhibit A which is attached hereto. This Lease Agreement shall be for a term of ninety-nine (99) years from the date hereof. LESSEE agrees not to sublease, sell or disclose to others LESSOR's computer system without the written consent of LESSOR.
3. In consideration for the rights herein granted, LESSEE agrees to pay LESSOR as follows:
  - a) The sum of Twenty Thousand Dollars (\$20,000), payable within forty-five (45) days after the effective date of this Agreement, for the use of the concerned computer program at or in connection with its Ottawa, Canada facility, and
  - b) an additional sum of Ten Thousand Dollars (\$10,000) for each additional facility of LESSEE which uses the concerned computer program, with said additional sum being due within forty-five (45) days after the concerned additional use.
4. LESSOR shall furnish those personnel which it deems are reasonably necessary to perform certain installation services. Such services shall be hereinafter referred to as "Installation Services" and shall include:
  - a) As appropriate, a two (2) day review and orientation session as to the features, documentation and operation of the program described in Exhibit A. Any review and orientation session exceeding two (2) working days must be requested by the LESSEE and may be provided at LESSOR's sole discretion at a daily rate of Three Hundred Dollars (\$300) plus first class travel and living expenses.

- b) In addition to the services set out in paragraph 4(a) above, at LESSEE's request LESSOR agrees to consider providing additional assistance concerning the use of the leased computer program at a daily rate to be agreed upon by the parties hereto, plus first class travel and living expenses. Such additional assistance shall be made available at the sole discretion of LESSOR.
5. For a period of two (2) years from the effective date of this Agreement, LESSOR shall provide LESSEE with solutions to any known errors in or improvements to the leased computer program which it is free to disclose to others in consideration for such information LESSEE shall pay to LESSOR the sum of Two Thousand Dollars (\$2,000) per year, payment for the first year being due one hundred and twenty (120) days following the execution of this Agreement, the second, on the anniversary date of this Agreement.
6. For a period of two (2) years from the date of this Lease Agreement, LESSEE shall make known to LESSOR any errors or omissions found in the concerned computer system and any improvements or modifications relating thereto and LESSOR shall have the right to use the same free of charge as it sees fit of itself, of others, e.g., such as including the same in any new or old version of the concerned computer program.
7. With regard to the herein leased computer program, LESSOR makes no warranties, either expressed or implied, as to its merchantability or fitness for a particular purpose. LESSEE agrees that LESSOR shall not be liable in breach of contract or otherwise, and LESSEE expressly waives any claims against LESSOR for loss, injury or damage of any kind directly or indirectly resulting from LESSEE'S use of the leased computer program or from any defect therein.
8. LESSEE accepts LESSOR's representation that LESSOR has expended significant funds in creating the leased computer program and has developed proprietary rights therein. LESSEE represents that he will not sublease, sell or loan said computer program to others and that LESSOR will have no adequate remedy in money or damages and accordingly shall be entitled to an injunction against such breach. However, no recitation in this Lease Agreement of a specific legal or equitable remedy shall be construed as a waiver or prohibition against the pursuing of other legal or equitable remedies in the event of the breach of any provision of this Lease Agreement. The representations and warranties contained in this paragraph shall survive the consummation of this transaction and the delivery of any documents hereunder.
9. This Lease Agreement and the obligations hereunder will be transferred to the Government of Canada (Communications

Research Centre, Ottawa, Canada); the transfer may take place at any time after the effective date of this Agreement. The LESSEE shall inform the LESSOR of such transfer in writing within thirty days of the effective date of the transfer.

10. The computer program described in Exhibit A is made to run on a Digital Equipment Corporation PDP-11 computer under the UNIX operating system. It is agreed that the LESSEE has the option of acquiring the license to a similar program which would run on a Digital Equipment Corporation VAX-11 computer under the VMS operating system. If the LESSEE chooses to exercise the above option, the LESSEE shall pay the LESSOR the difference between the cost of the N.mPc System license for the VAX-11 and the cost of the N.mPc System license for the PDP-11. The maintenance shall be transferred accordingly at no charge other than those already mentioned. It is also understood that the LESSEE will relinquish all rights to the PDP-11 version of the computer program in the event of such a change.
11. Each paragraph and provision of this Agreement is severable from the entire Agreement, and if one provision is declared invalid, the remaining provisions shall nevertheless remain in effect.
12. This Lease Agreement supersedes all prior agreements and understandings between the parties and may not be changed or terminated orally, and no change, termination or attempted waiver of any of the provisions hereof shall be binding unless in writing and signed by the party against whom the same is sought to be enforced.
13. Any payment, notice or other communication required or permitted to be made by either party hereunder shall be sufficiently made or given on the date of mailing if sent by first class mail to such party at its address given below, or at such other address as it shall hereafter designate in writing as follows:

LESSOR: DICAR Corporation  
Attention: Charles W. Rose  
10900 Euclid Avenue,  
Crawford Hall, Room 511,  
Cleveland, Ohio, U.S.A. 44106

LESSEE: INTELLITECH CANADA LIMITED  
Attention: Samy A. Mahmoud  
352 MacLaren Street,  
Ottawa, Ontario, Canada K2P 0M6

14. This Lease Agreement shall be construed according to the laws of the State of Ohio.

IN WITNESS WHEREOF This Lease Agreement has been duly executed by authorized representatives of the parties hereto and in effect as of the date first hereinabove set forth.

DICAR CORPORATION

Signature:

Title:

INTELLITECH CANADA LIMITED

Signature:

Title: Dr. S.A. Mahmoud, Vice-President

## EXHIBIT A

### The N.mPc System

Department of Computer Engineering and Science  
Case Western Reserve University  
Cleveland, Ohio 44106

N.mPc, a design tool for multi-processor systems, consists of six major components which work together to produce functional register transfer level simulations of multiple processor, heterogeneous target systems. A meta assembler allows the user to specify the format, mnemonics, and associated bit patterns of bit strings and output in a machine independent control/memory allocation graph. A generalized linking loader resolves the machine dependent aspects of assembler output graphs, links, and allocates the resulting image to physical memory according to user specified strategies. A hardware description language, ISP<sup>h</sup>, compiler is used to translate processor and interconnection element descriptions into executable code. This code, the linking loader outputs, and a description of the target system topology are linked by an Ecologist and Simulated Memory Process-  
Runtime Package. The Runtime Package consists of a Command Interpreter, Kernel, and Simulated Memory Manager. The Kernel and Command Interpreter permit interactive control and monitoring of simulations. The Simulated Memory Manager supervises the simulated memory contents, available physical memory, and mass storage to optimize the performance of the simulation. N.mPc is implemented on a PDP-11 system under the UNIX operating system.

#### Programs in the N.mPc System

The executable programs of the N.mPc system are as follows. Included are source code for the programs, and design documentation.

CI	runtime command interpreter
LISTRTSYMS	utility program used by the ecologist
cater	Linking/Loader allocator
cmem	simulated memory creator
ec	ecologist and smp control program
ecologist	simulation builder
ic	ISP <sup>h</sup> compiler
inter	Linking/loader interpreter
isplist	ISP <sup>h</sup> compiler disassembler
kernel.a	runtime kernel archive
libisp.a	ISP <sup>h</sup> runtime library
libstart.o	module used in building simulations
listesym	utility program used by the ecologist



listnode	metaMic.
llp	format converter for Linking/Loader output
logic	graphic driver for post processor
mas	metaMicro and loader control program
mdump	dumper of loader memory images
micro	metaMicro assembler
pp	runtime data post processor
pp.msg	error message file for post processor
prom	prom programmer driver
sme	simulated memory editor
smm	simulated memory manager
smp	simulated memory processor

### User Documentation in the N.mPc System

All N.mPc executable programs have UNIX format manual pages, used for quick reference. In addition, the following users manuals are provided:

- metaMicro User's Manual
- Linking/Loader User's Manual
- metaMicro - Linking/Loader Utilities User's Manual
- ISP Compiler User's Manual
- Ecologist and SMP User's Manual
- N.mPc Runtime User's Manual
- N.mPc Post Processor User's Manual

APPENDIX C

Unix/Unix compatible Systems

1. Unix version 6 or version 7 sold by DICAR  
(see schedule of charges, Appendix B)
2. Xenix (Unix compatible), sold by:

Human Computing Resources Corporation (HCR)  
10 St. Mary Street,  
Toronto, Ontario,  
Canada M4Y 1P9  
(Telephone: (416)-922-1937)

The price of Xenix is \$4795 for a two-user system.

3. Unity (Unix compatible) sold by:  
HCR (see above)

The price of Unity is U.S. \$3995 for a 2-16 user system.

4. Venix (Unix compatible) sold by:

A. Lewinson Corporation,  
Computer Consultants,  
16 MacKinnon road,  
Ottawa, Ontario,  
Canada K1M 0G3  
(Telephone: (613)-234-1133, offices at 124 O'Connor)

Note: Price of Venix was not firm at time of buying and  
system was not yet available.

## REFERENCES

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