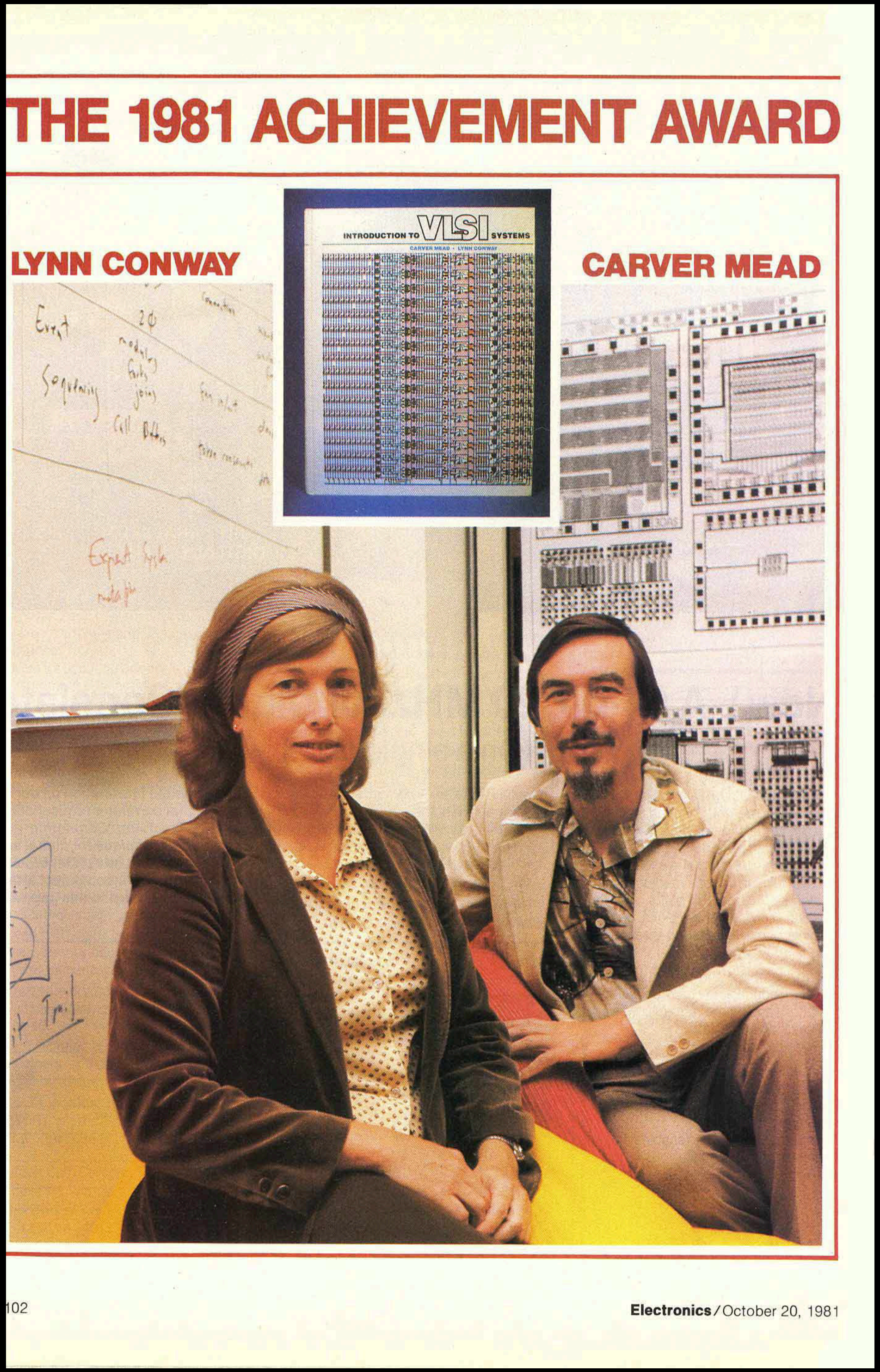
There is no hardware - Lynn Conway and the Mead-Conway Revolution.



Electronics October 20, 1981 S. 102

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DFG Project: Assistiv Media

There Is No Software

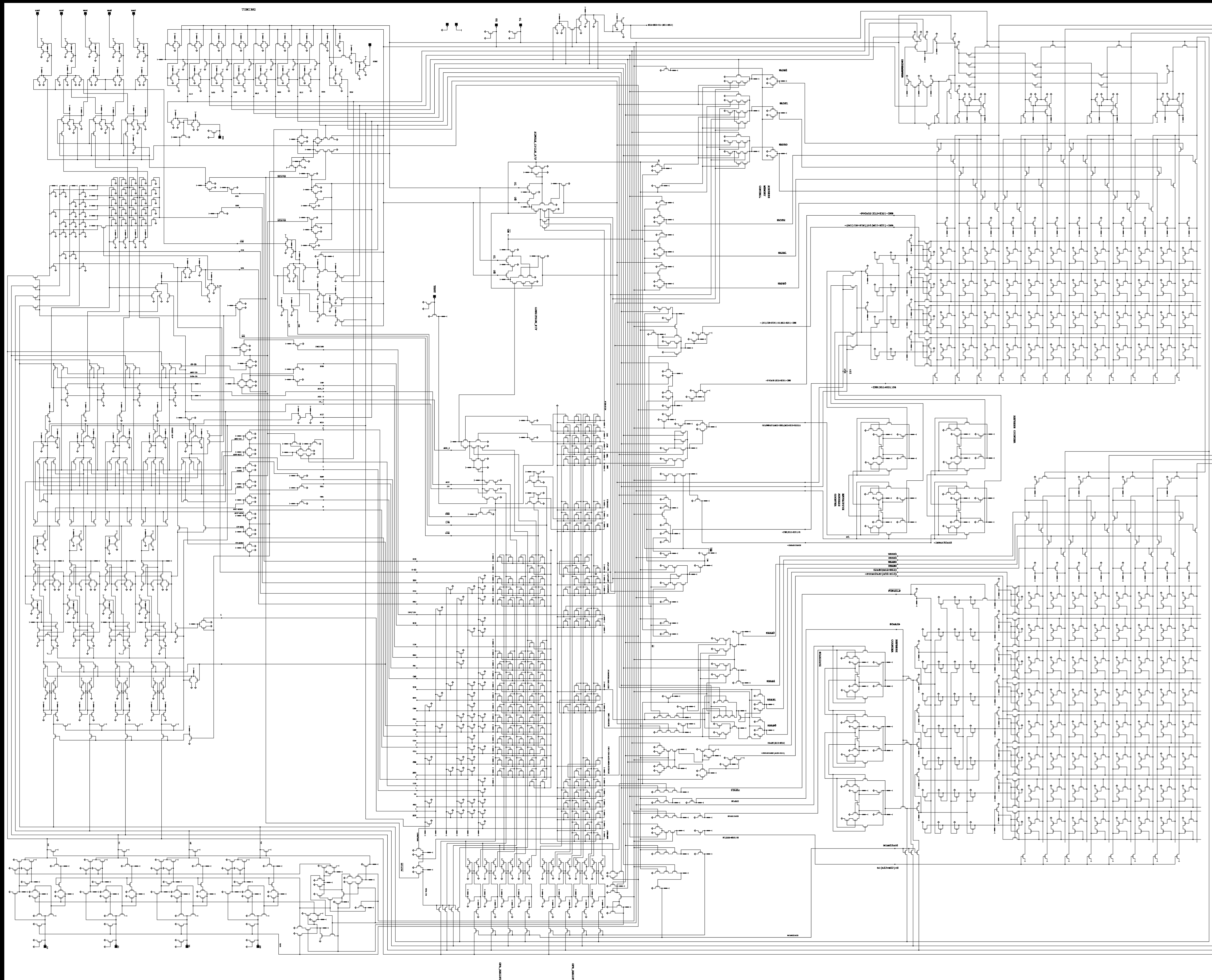
The present explosion of the signifying scene, which, as we know from Barry McGuire and A. F. N. Dahran, coincides with the so-called Western world, is instead an implosion. The bulk of written texts—including the paper I am actually reading to you—no longer exist in perceivable time and space, but in a computer memory's transistor cells. And since these cells, in the last three decades of Silicon Valley exploits, have shrunk to spatial extensions of less than one micrometer, our writing scene may well be defined by a self-similarity of letters over some six orders of decimal magnitude. This state of affairs does not only make a difference to history, in which, at its alphabetical beginning, a camel and its hebraic letter gamel were just two and a half orders of decimal magnitude apart. It also seems to hide the very act of writing.

As one knows without saying, we do not write anymore. The crazy kind of software engineering that was writing suffered from an incurable *confusion between use and mention*. Up to Hölderlin's time, a mere mention of lightning seems to have been sufficient evidence of its possible poetic use. Nowadays, after this lightning's metamorphosis into electricity, manmade writing passes instead through microscopically written inscriptions, which, in contrast to all historical writing tools, are able to read and write by themselves. The last historical act of writing may well have been the moment when, in the early seventies, the Intel engineers laid out some dozen square meters of blueprint paper (64 square meters in the case of the later 8086) in order to design the hardware architecture of their first integrated microprocessor. This manual layout of two thousand transistors and their interconnections was then miniaturized to the size of an actual chip and, by electro-optical machines, written into silicon layers. Finally, this 4004-microprocessor found its place in the new desk calculators of Intel's Japanese customer,[1] and our postmodern writing scene could begin. Actually, the hardware complexity of microprocessors simply discards such manual design techniques. In order to lay out the next computer generation, the engineers, instead of filling countless meters of blueprint paper, have recourse to Computer Aided Design, that is, to the geometrical or autorouting powers of the actual generation.

In constructing the first integrated microprocessor, however, Intel's Marcian E. Hoff had given an almost perfect demonstration of a Turing machine. After 1937, computing, whether done by men or by machines, can be formalized as a countable set of instructions operating on an infinitely long paper band and the discrete signs thereon. Turing's concept of such a paper machine,[2] whose operations consist only of writing and reading, proceeding and receding, has proven to be the mathematical equivalent of any computable function. Universal Turing machines, when fed the instructions of any other machine, can imitate it effectively. Thus, precisely because eventual differences between hardware implementations do not count anymore, the so-called Church-Turing hypothesis in its strongest or physical form is tantamount to declaring nature itself a universal Turing machine.

This claim in itself has had the effect of duplicating the implosion of hardware by an explosion of software. Programming languages have eroded the monopoly of ordinary language and grown into a new hierarchy of their own. This postmodern Tower of Babel reaches from simple operation codes whose linguistic extension is still a hardware configuration, passing through an assembler whose extension is this very opcode, up to high-level programming languages whose extension is that very assembler. In consequence, far-reaching chains of self-similarities in the sense defined by fractal theory organize the software as well as the hardware of every writing. What remains a problem is only recognizing these layers which, like modern media technologies in general, have been explicitly contrived to evade perception. We simply do not know what our writing does.

To wordprocess a text, that is, to become oneself a paper machine working on an IBM AT under Microsoft DOS, one must

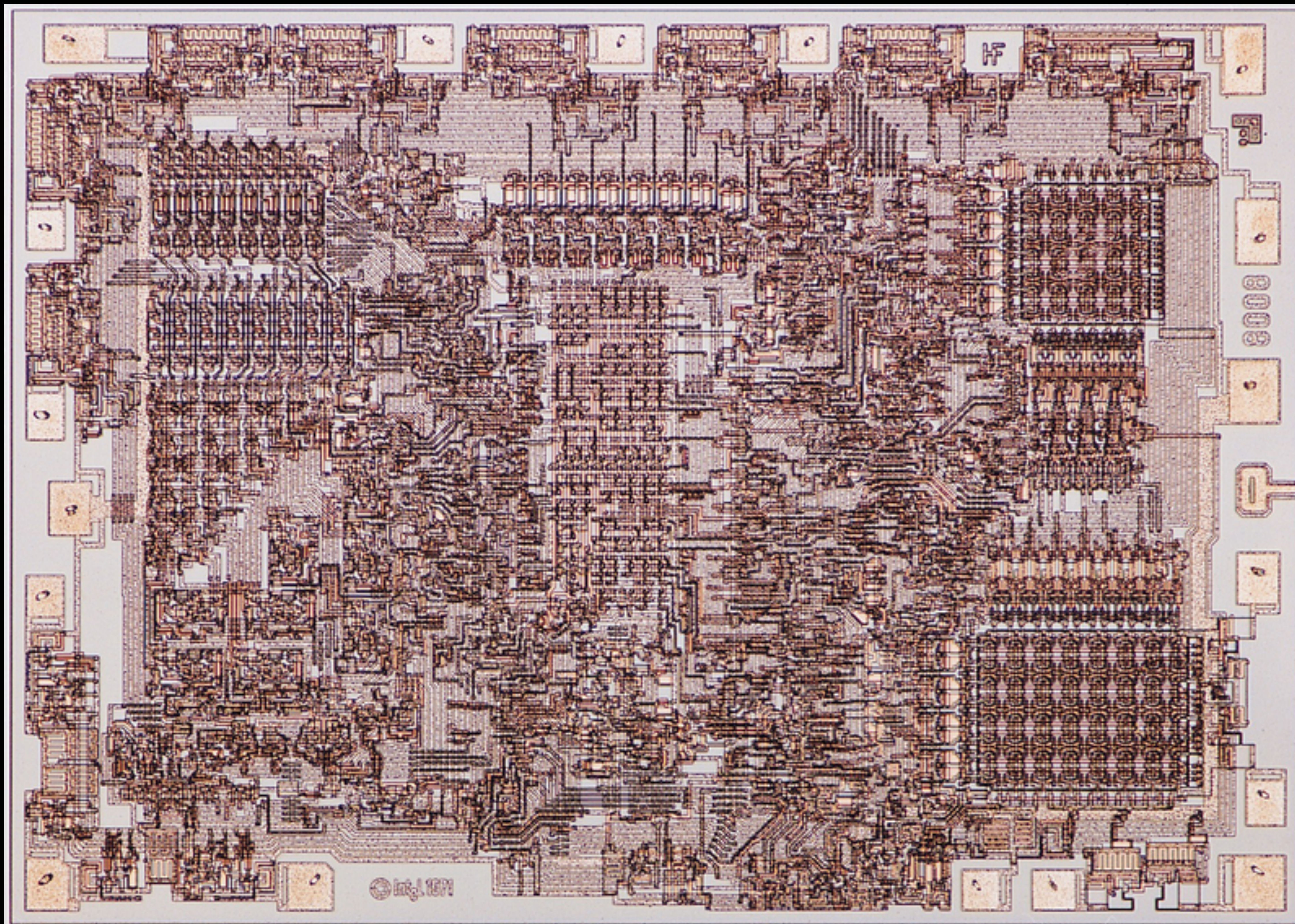


http://www.4004.com/assets/4004-lajos-schematics.gif

Name	Signification	Number of Transistors
SSI	Small-Scale Integration	1 to 10
MSI	Medium-Scale Integration	10 to 500
LSI	Large-Scale Integration	500 to 20,000
VLSI	Very Large-Scale Integration	20,000 to 1,000,000
ULSI	Ultra Large-Scale Integration	more than 1,000,000

Generations of Integrated Circuits

https://www.robotshop.com/community/tutorials/show/electronics-done-quick-6-integrated-circuits-ics



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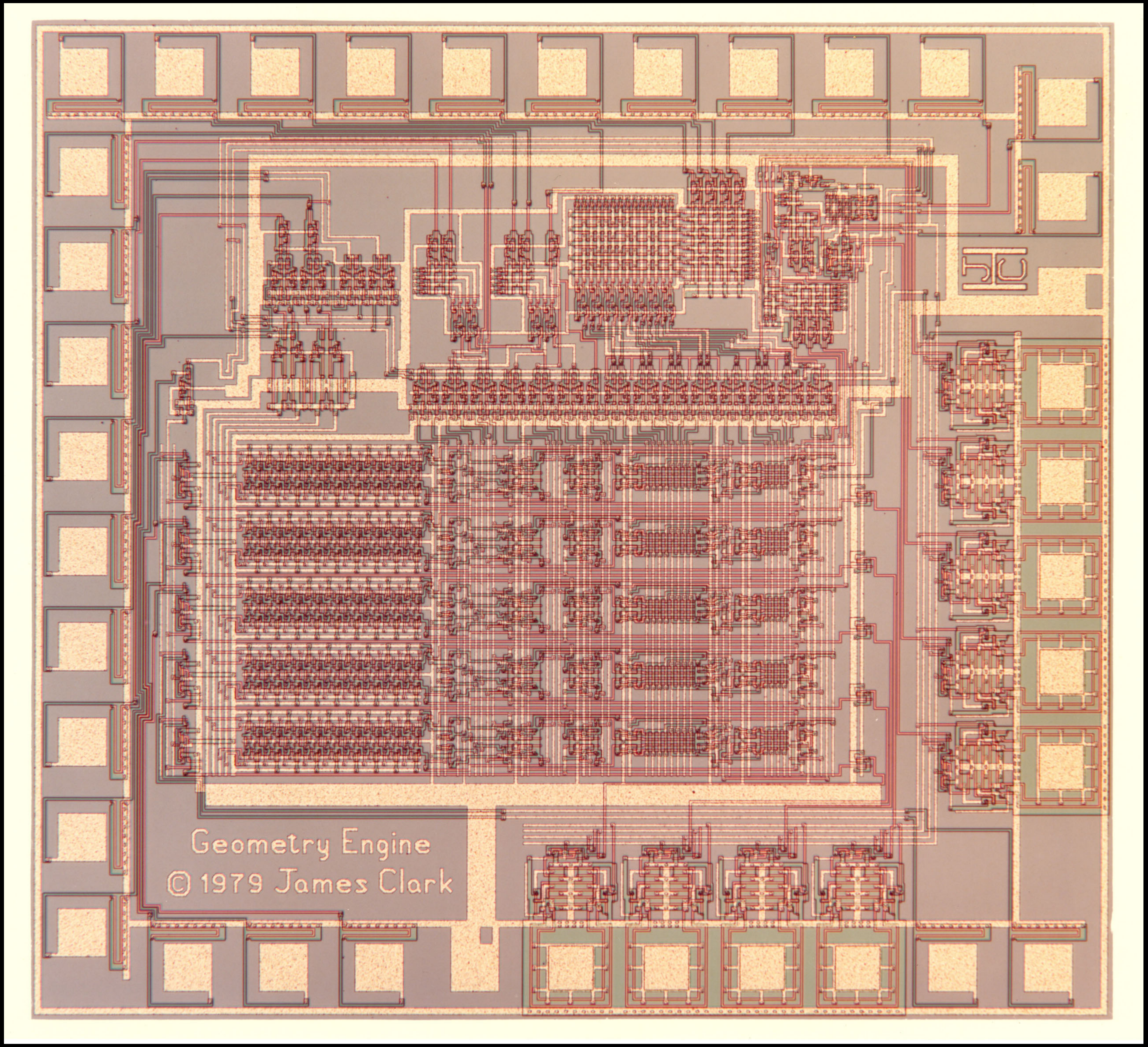

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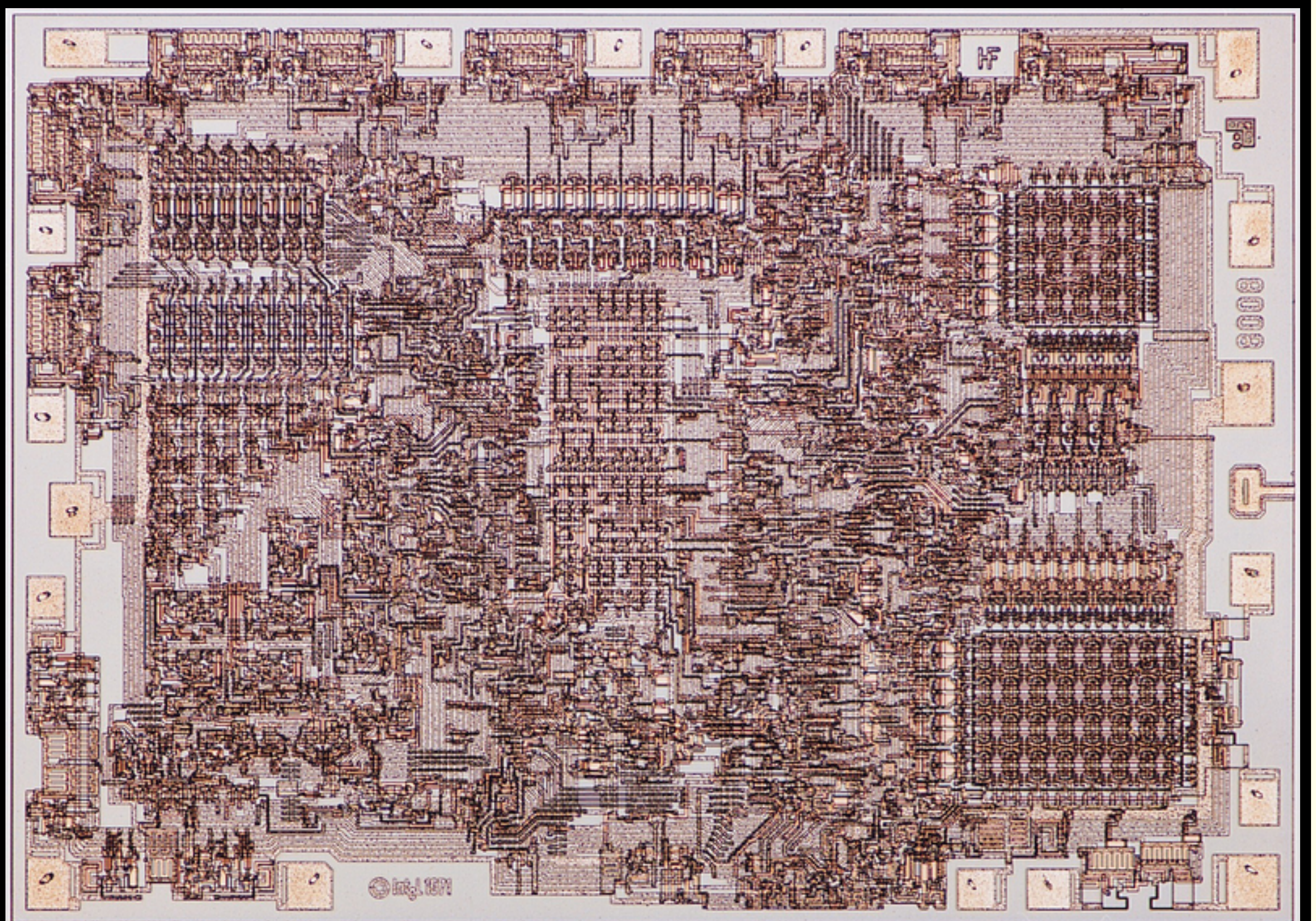

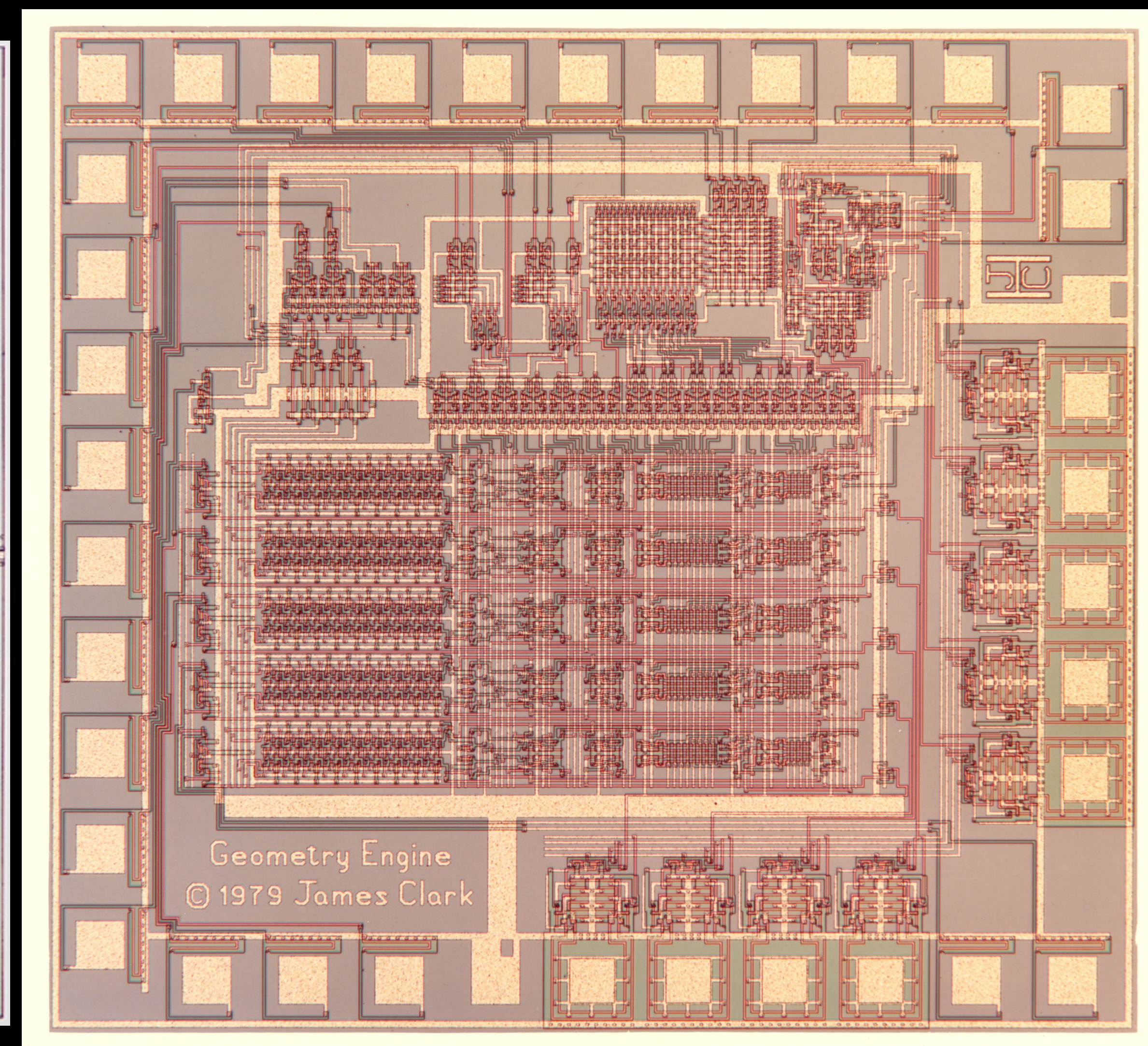
Geometry Engine
© 1979 James Clark

ARPA ORDER NO.: 189-1
7P10 Information Processing

R-1956-ARPA
November 1976

Basic Limitations in Microcircuit Fabrication Technology

Ivan E. Sutherland, Carver A. Mead, and Thomas E. Everhart

A Report prepared for

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

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JAN 2? 197?

The Problem: How to build digital electronic circuits from now to 1985.

Background: Integrated circuit electronics has reached the stage where the cost and performance of systems which use customized integrated circuits are irresistably attractive. But because customized integrated circuits require customized masks, the first copy of any circuit is inordinately expensive.

Needed: An understanding of digital integrated circuit design. There are two facets to this understanding as I see it. First, we need to understand the fundamental strengths and weaknesses of the medium. What kinds of circuits are appropriate for implementation in integrated circuits? Since the cost of a design is mainly the cost of the wires involved, we need new understanding of the topological, geometric and signal transmission implications of large wiring nets. All of the circuit optimization theory now available minimizes gates; for integrated circuits that theory is irelevant.

Second, we need systems which enable us to take our design ideas through prototyping at reasonable cost. A designer can do the conceptual design of an integrated circuit quite easily. He should be able to describe that design to a computer in terms corresponding to his conception, have the design simulated to see if its performance is what he expects, obtain computer help in executing the layout, and have the masks prepared automatically. The conception, functional check, layout, and layout check are all made possible by the same hierarchical structure.

Proposal: I believe that substantial progress in understanding the proper strategies for making integrated circuits and building appropriate tools for doing so can be made with relatively modest resources. Unlike the task of actually building circuits which requires a large capital investment and a lot of labor, the tasks I have in mind are more conceptual and intellectual; I want to set about learning how to "program" integrated circuits.

I would like to ~~xxxxxxxxx xxxxxxxxx~~ lead a research group of 6-10 profesionals undertaking this activity. I believe that the skills required in the group include: programming, topology, maze solving, systems engineering, computer graphics, and a little electronics. The kinds of people involved are very similar to those already at PARC. Association with PARC will be helpful both ways: the computer facilities and capability of PARC is an important base on which to build, and the understanding and tools I propose to produce should be important to PARC and Xerox in simplifying the process of obtaining integrated circuits.

Close association both with PARC and with the Xerox prototype circuit line here in L.A. are important. The designs we make should actually be fabricated and tested; feedback from the fabrication process is essential to tuning up the design tools and conceptual ideas.

I see the products of this activity coming out in three forms. First, there will be a series of actual designs. The members of the group will have to learn what it takes to

https://reuther.wayne.edu/node/1512

3-8-76

Bert,

Thanks for letting me read this. Ivan's proposed project is an <u>excellent</u> idea. Hope I can be of assistance in getting it started.

Lynn

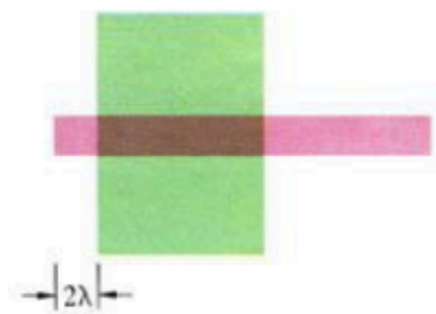
(a) $W_d/\lambda \geqslant 2$.

(b) $S_{dd}/\lambda \geqslant 3$.

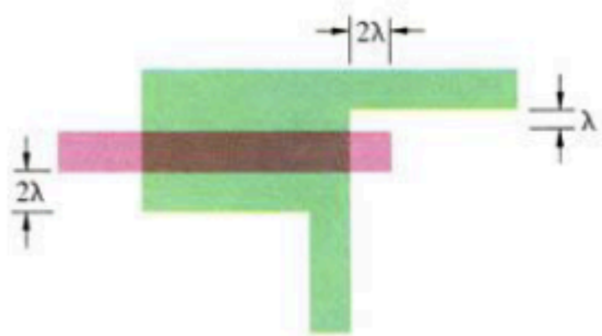
(c) $W_p/\lambda \geqslant 2$.

(d) $S_{pp}/\lambda \geqslant 2$.

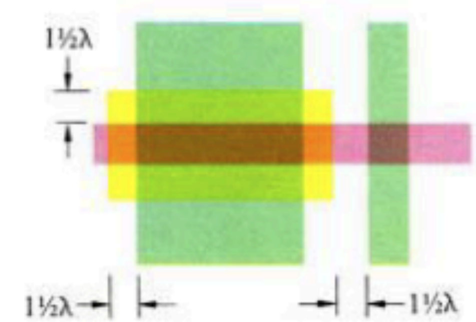
(e) $S_{pd}/\lambda \geqslant 1$.



(f) $E_{pd}/\lambda \geqslant 2$.



(g) Example of several rules.

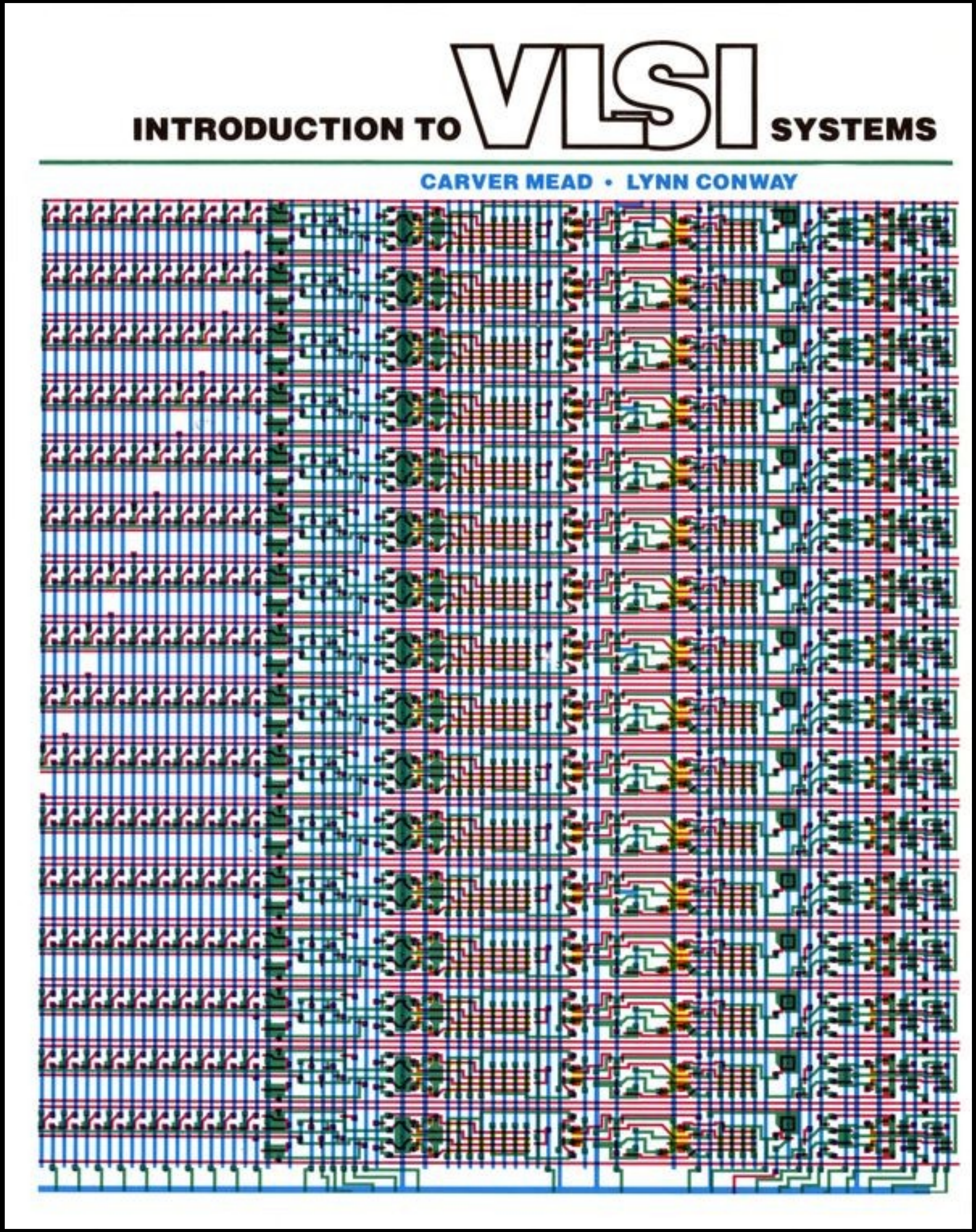


(h) $S_{ig}/\lambda \geqslant 1\frac{1}{2}$; $E_{ig}/\lambda \geqslant 1\frac{1}{2}$.

PLATE 2 *n*MOS design rules

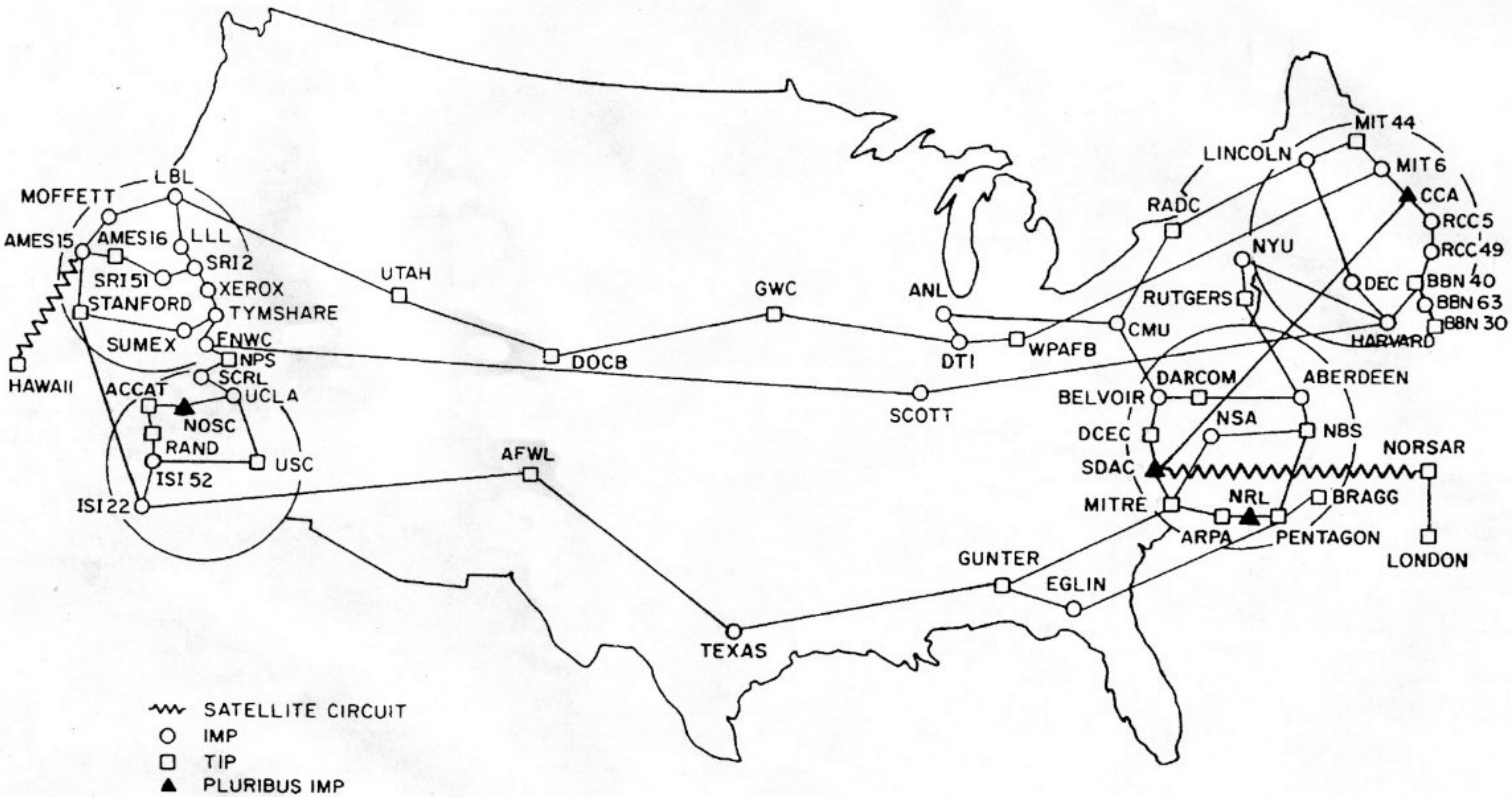
http://worrydream.com/refs/Conway%20-%20Reminiscences%20of%20the%20VLSI%20Revolution.pdf

https://pbs.twimg.com/media/DDC9SaRUAAEBQ_S.jpg:large



https://www.computerhistory.org/revolution/digital-logic/12/287/1613

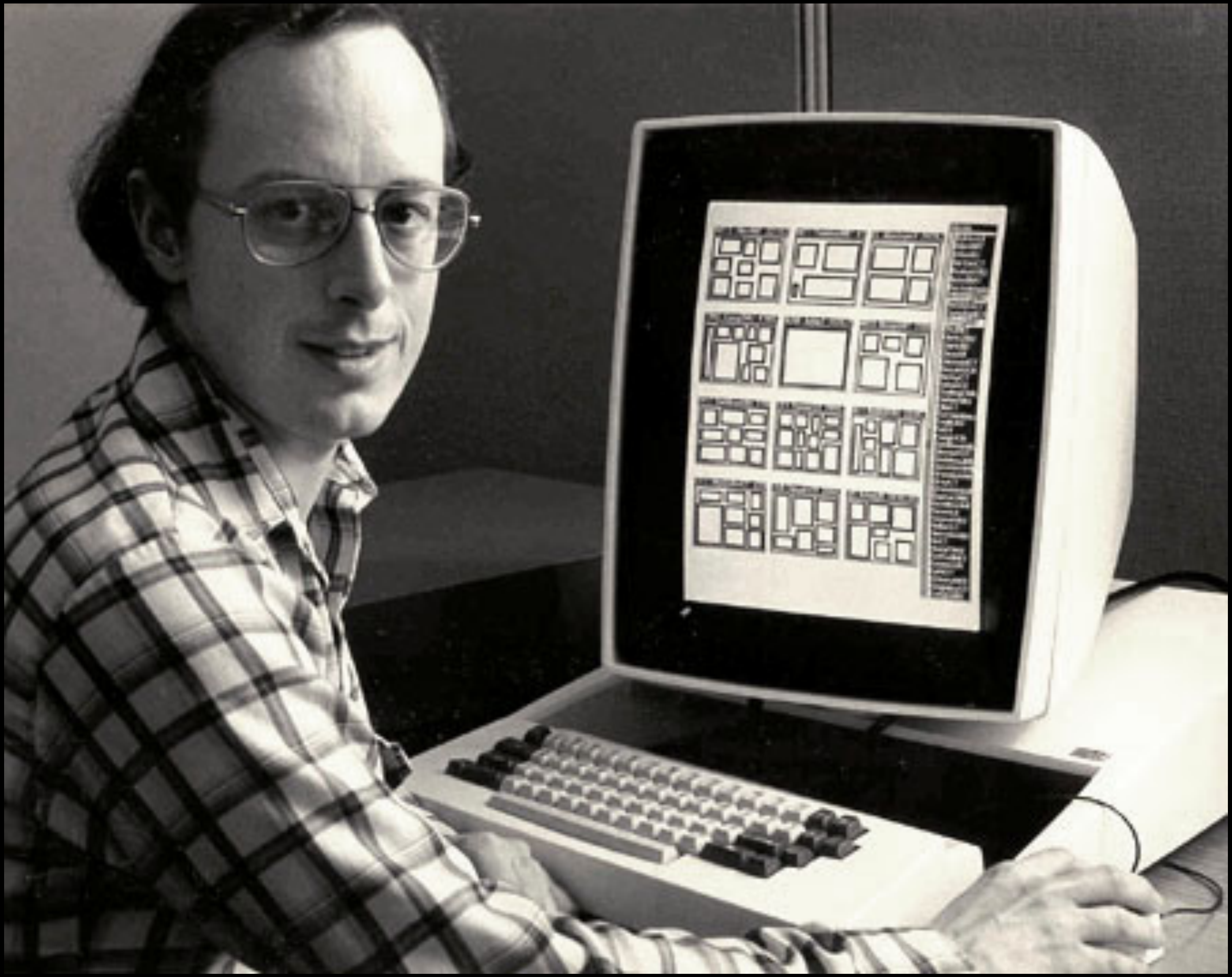
ARPANET GEOGRAPHIC MAP, NOVEMBER 1978



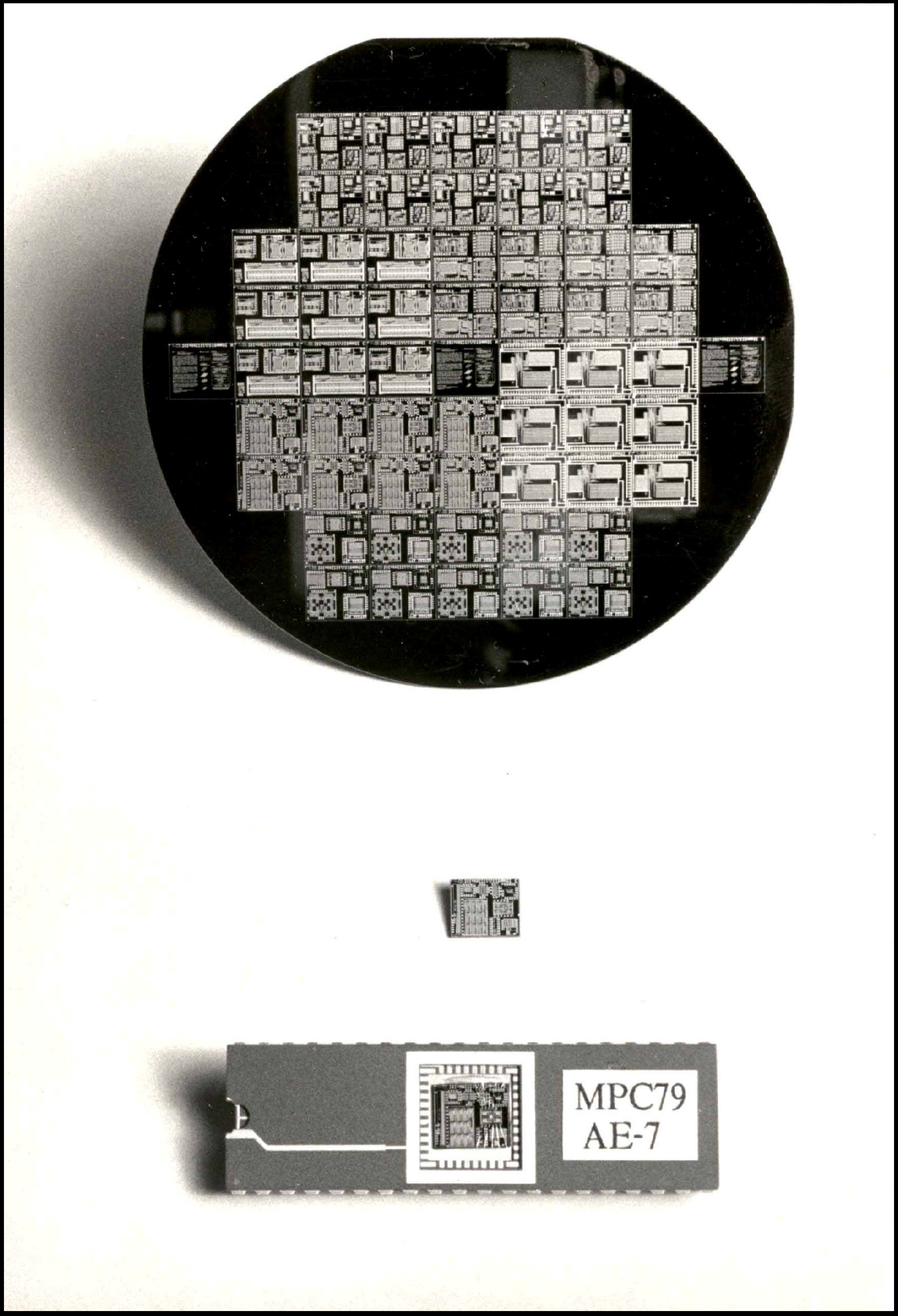
(NOTE: THIS MAP DOES NOT SHOW ARPA'S EXPERIMENTAL SATELLITE CONNECTIONS)

NAMES SHOWN ARE IMP NAMES, NOT (NECESSARILY) HOST NAMES

http://mercury.lcs.mit.edu/~jnc/tech/jpg/ARPANet/G78Nov.jpg



Alan Bell using the Implementation System to merge the MPC79 projects


MPC79
AE-7

MPC79: The demonstration of a prototype remote-entry, fast-turnaround, VLSI Implementation System

During the fall of 1979, the LSI Systems Area of Xerox PARC/SSL conducted the demonstration-operation of a prototype information management system, designed by Alan Bell and Martin Newell, for enabling the remote-entry, fast-turnaround implementation of large numbers of VLSI system designs. The user community for this demonstration was composed of EE/CS students taking courses in VLSI design at a number of universities, and university faculty and research staff members undertaking research prototype designs. MPC79 contains ~75 designs submitted by ~100 designers from many different universities.

The purposes of this effort were (i) to support the new university VLSI design courses by providing the implementation of student-project designs, (ii) to demonstrate the feasibility and general capabilities of such VLSI implementation systems to a wide technical community, and (iii) to refine our ideas about how to architect, design, and operate such systems by running a major operational test of a prototype system.

Several other organizations collaborated with us in conducting this demonstration: Data Communications (electronic messages and design file transfers) were supported by use of the ARPANET; Maskmaking was done by Micro Mask, Inc., using an electron-beam mask-making system; Wafer fabrication was done by Hewlett-Packard's Integrated Circuit Processing Laboratory.

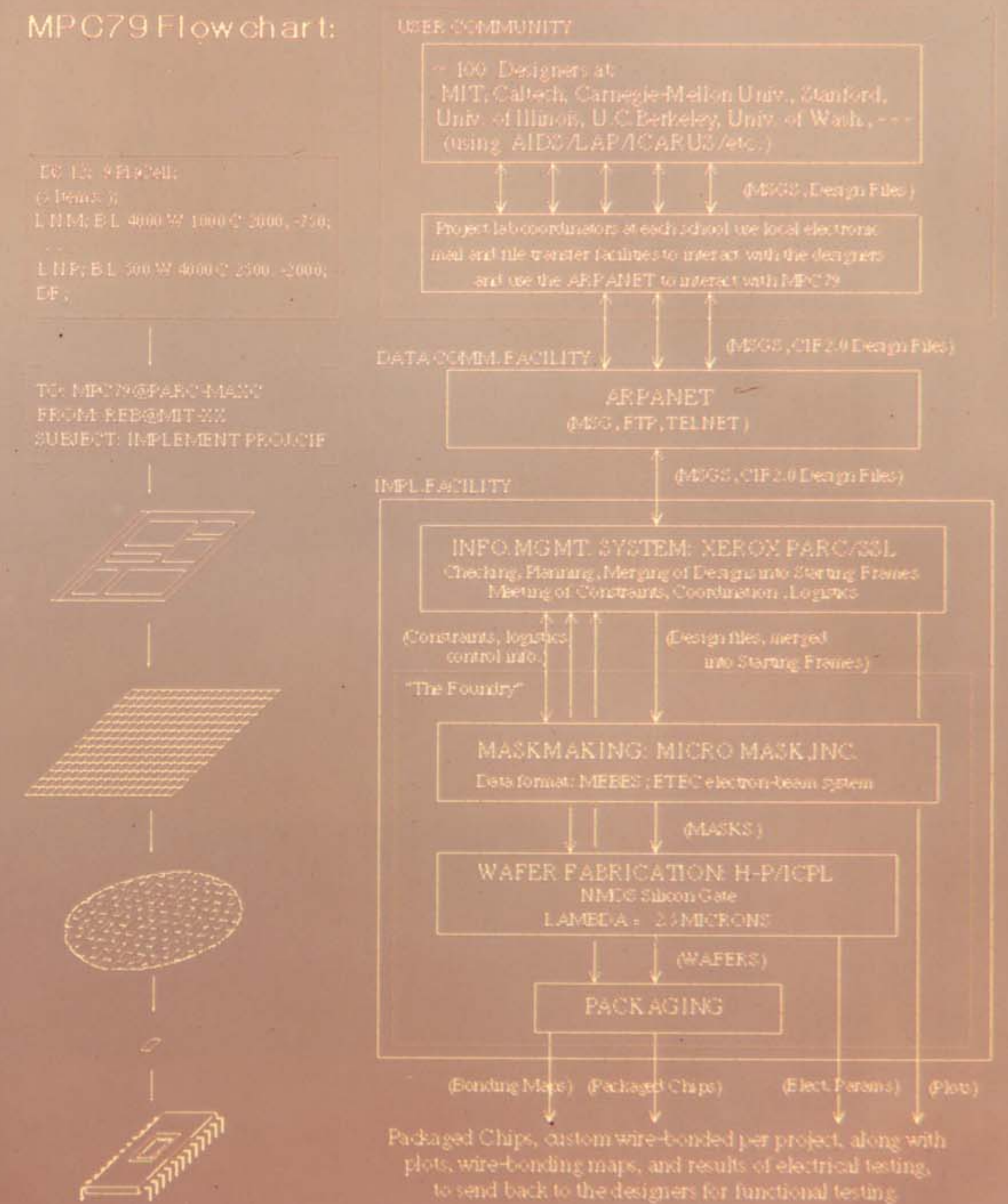
The VLSI design techniques used in the university courses are described in the textbook *Introduction to VLSI Systems*, by C.Mead and L.Conway, Addison-Wesley Publishing Co., 1980.

The background and context of the MPC79 effort, the structure of the MPC79 system, and the final results of the effort will be described in a Xerox PARC/SSL Report by L.Conway, A.Bell, and M.Newell entitled *The Implementation of VLSI Systems*.

The MPC79 Organizers:

Lynn Conway, Alan Bell, Martin Newell, Richard Lyon
LSI Systems Area, Xerox PARC/SSL
4 December 1979

MPC79 Flowchart:



Students and faculty observers, MIT'78 VLSI design course

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Thank you for attention