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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 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

design for this medium and will produce their own designs. Users from elsewhere in Xerox will also be encouraged to come and implement designs, thus providing a source of design problems for the group. These designs will often result in actual chips produced on the prototype circuit line.

Second, the group will produce a series of design tools for use in integrated circuit prototyping. Most of these tools will be software systems suitable for assisting a designer in his tasks. With access to the advanced software thinking of PARC, I believe that we can make tools of considerable power with a group of the size I have indicated. Initially I see these tools operating in place in my group, but subsequently I see them as an exportable product in their own right. The graphics capability of the XGP will be a major asset in understanding the geometric and topological situations in the designs. I have in mind that the raster scan graphics technology can make important contributions to layout, layout checking, and mask making.

Third, the group will produce a design philosophy. The fundamental limitations to computing power are in transmission of information. Wires occupy space, and communication cannot exceed the speed of light. We need to learn how to colocate computing and memory so as to avoid moving the information around. We need to learn how to design circuit modules which fit together easily into a variety of configurations. We need to learn how to describe the complexity of different designs. I believe that the creative activity required here will be stimulated by the practical work of the other two tasks.

Resources required: The tasks I have outlined will require a small research group. I personally wish to remain in the L.A. area at least until my son finishes high school in 1979. I believe that close physical ties with the prototype production line are appropriate, and combined with close intellectual and administrative ties with PARC might be quite effective in providing a communication bridge between northern and southern California. An interactive computing facility with graphics capability will be required; I anticipate that this would be built around the Alto terminals. A precision artwork maker should be included - I believe that a design based on commercially available drum facsimile equipment is possible and more economic than the Calcomp or D.W.Mann designs.

TiMescale: Initial chip designs and some initial design tools can be expected during the first year. By the end of the second year their should be a substantial design capability and regular design activity taking place. During the third year delivery of software systems can be expected. Conceptual progress in building a design philosophy for integrated circuit technology will no doubt occur sporadically - by the end of the second year I believe a "school of thought" will have developed which can begin to have effect through personnel transfer to other parts of Xerox.

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Bert,

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

Lynn