*Can You Imagine . . .*

. . . a new and fundamentally more expressive "language" for designing digital electronics.

# PARADIGM SHIFT IN DIGITAL CIRCUIT DESIGN ELIMINATES THE CLOCK

Widely accepted as the fundamental design paradigm in the computer industry today, Boolean logic has serious shortfalls in how it provides and moves information through digital circuits. Its circuit topology (the layout of transistors and their connection) is specifically designed for data processing, inherently preventing data movement from one processing step to the next. Therefore, "clocks" must regulate the movement of information packets.

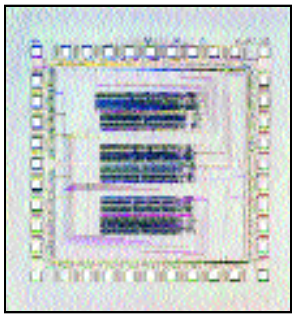
Not only is this design approach inefficient (the need for and use of input and output data may not match a particular clock cycle), but clocks account for up to 50 percent of the design cost, up to 25 percent of the manufacturing cost, and 40 percent of the power consumed in operation. More important, clocks present a potentially intractable barrier to faster, denser chip design. Denser circuit designs place more features on a chip, making the design and distribution of clock signals increasingly difficult.

To overcome this problem, Theseus Research, Inc. (Minneapolis, MN), formed Theseus Logic, Inc. (St. Paul, MN), to develop a patented chip technology called NULL Convention Logic™ (NCL). Representing a fundamental paradigm shift in the computer industry, this technology eliminates the need for clocks, allowing faster, more efficient, and better integrated internal computer systems. Fully compatible with existing fabrication processes and with existing clocked systems, NCL yields clockless circuits and systems that are straightforward to design and easy to test. Multichip integration is essentially "plug and play" as chips in a system inherently coordinate themselves regardless of their varying throughput rates.

TO ACCELERATE PRODUCT DEVELOPMENT, THESEUS IS FORMING STRATEGIC ALLIANCES WITH MAJOR ELECTRONICS CORPORATIONS.

Supporting the company's business strategy of licensing NCL throughout the industry, Theseus recently signed a five-year deal with Sanders, a Lockheed Martin Company. This strategic alliance provides Theseus with an established partner that can help insert the technology into system applications. As part of this alliance, Sanders and Theseus have started working on a $2.3 million Defense Advanced Research Projects Agency program, with an additional investment from Lockheed. The program aims to develop NCL-based Digital Signal Processors for system validation in the F-22 Advanced Tactical Fighter test bed.

In 1996, Theseus raised $1.9 million in a private stock offering, and the company is preparing another stock offering in 1997 to augment ongoing development funding from government agencies and private corporations.



■ Pictured above is a layout of one of Theseus' prototype chips. It contains no detailed timing analysis.

## ABOUT THE TECHNOLOGY

All-digital electronic operations are based on two data values, usually represented as binary mathematics employing the digits 0 and 1. NCL employs a third value, the null, which indicates that no input or output value is present. Using the null value, NCL circuits can perform binary data processing functions without needing a clock circuit to synchronize data inputs and outputs. Each combinatorial circuit inherently "knows" when it has completed processing a data set, when it is reset, and when it is ready to process another data set. All communication is local and asynchronous.

NCL allows high-performance asynchronous chips without any detailed timing analysis. In a BMDO SBIR project, Theseus developed seven proof-of-concept asynchronous chips. In tests, these chips "worked perfectly on the first pass" said Ken Wagner, president of Theseus Logic. Tests also showed that the chips can operate at extremely wide temperature and voltage levels. Theseus demonstrated that input supply voltage on NCL-based chips can be varied during run time from as low as 0.5 volts to over 9 volts, allowing smooth control of speed and power consumption.