

Illiacc IV History

- First massively parallel computer
 - SIMD (duplicate the PE, not the CU)
 - First large system with semiconductor-based primary memory
- Three earlier designs (vacuum tubes and transistors) culminating in the Illiac IV design, all at the University of Illinois
 - Logical organization similar to the Solomon (prototyped by Westinghouse)
 - Sponsored by DARPA, built by various companies, assembled by Burroughs
 - Plan was for 256 PEs, in 4 quadrants of 64 PEs, but only one quadrant was built
 - Used at NASA Ames Research Center in mid-1970s

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Illiacc IV Architectural Overview

- One CU (control unit), 64 64-bit PEs (processing elements), each PE has a PEM (PE memory)
- CU operates on scalars, PEs on vector-aligned arrays
 - All PEs execute the instruction broadcast by the CU, if they are in active mode
 - Each PE can perform various arithmetic and logical instructions
 - Each PE has a memory with 2048 64-bit words, accessed in less than 188 ns
 - PEs can operate on data in 64-bit, 32-bit, and 8-bit formats
- Data routed between PEs various ways
- I/O is handled by a separate Burroughs B6500 computer (stack architecture)

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Programming Issues

- Consider the following FORTRAN code:

```
DO 10 I = 1, 64
10  A(I) = B(I) + C(I)
```

 - Put A(1), B(1), C(1) on PU 1, etc.
 - Each PE loads RGA from base+1, adds base+2, stores into base, where "base" is base of data in PEM
 - Each PE does this simultaneously, giving a speedup of 64
 - For less than 64 array elements, some processors will sit idle
 - For more than 64 array elements, some processors might have to do more work
- For some algorithms, it may be desirable to turn off PEs
 - 64 PEs compute, then one half passes data to other half, then 32 PEs compute, etc.

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The Illiac IV Array

- Illiac IV Array = CU + PE array
- CU (Control Unit)
 - Controls the 64 PEs (vector operations)
 - Can also execute instructions (scalar ops)
 - 64 64-bit scratchpad registers
 - 4 64-bit accumulators
- PE (Processing Element)
 - 64 PEs, numbered 0 through 63
 - RGA = accumulator
 - RGB = for second operand
 - RGR = routing register, for communication
 - RGS = temporary storage
 - RGX = index register for instruction addr.
 - RGD = indicates active or inactive state

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The Illiac IV Array (cont.)

- PEM (PE Memory)
 - Each PE has a 2048-word 64-bit local random-access memory
 - PE 0 can only access PEM 0, etc.
- PU (Processing Unit) = PE + PEM
- Data paths
 - CU bus — 8 words of instructions or data can be fetched from a PEM and sent to the CU (instructions distributed in PEMs)
 - CDB (Common Data Bus) — broadcasts information from CU to all PEs
 - Routing network — PE i is connected to PE $i-1$, PE $i+1$, PE $i-8$, and PE $i+8$
 - Wraps around, data may require multiple transfers to reach its destination
 - Mode bit line — single line from RGD of each PE to the CU

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Illiac IV I/O System

- I/O system = I/O subsystem, DFS, and a Burroughs B6500 control computer
- I/O subsystem
 - CDC (Control Descriptor Controller) — interrupts the Burroughs B6500 upon request by the CU, loads programs and data from the DFS into the PEM array
 - BIOM (Buffer I/O Memory) — buffers (much faster) data from DFS to CPU
 - IOS (I/O Switch) — selects input from DFS vs. real-time data
- DFS (Disk File System)
 - 1 Gb, 128 heads (one per track)
 - 2 channels, each of which can transmit or receive data at 0.5 Gb/s over a 256-bit bus (1 Gb/s using both channels)

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Illiac IV I/O System (cont.)

- Burroughs B6500 control computer
 - CPU, memory, peripherals (card reader, card punch, line printer, 4 magnetic tape units, 2 disk files, console printer, and keyboard)
 - Manages requests for system resources
 - OS, compilers, and assemblers
 - Laser memory
 - 1 Tb write-once read-only laser memory
 - Thin film of metal on a polyester sheet, on a rotating drum
 - 5 seconds to access random data
 - ARPA network link
 - High-speed network (50 Kbps)
 - Illiac IV system was a network resource available to other members of the ARPA network

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Illiac IV Software

- Illiac IV delivered to NASA Ames Research Center in 1972, operational sometime (?) after mid -1975
 - Eventually operated M–F, 60-80 hours of uptime, 44 hours of maintenance / downtime
- No real OS, no shared use of Illiac IV, one user at a time
 - An OS and two languages (TRANQUIL & GLYPNIR) were written at Illinois
 - At NASA Ames, since PDP-10 and PDP-11 computers were used in place of the B6500, new software was needed, and a new language called CFD was written for solving differential equations