

*Il numero 1 al mondo (dal 2002 al 2004):  
ES (Earth Simulator), Yokohama (JP)*

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## **Hardware**

The ES is based on:

- 5,120 (640 8-way nodes) 500 MHz NEC CPUs
- 8 GFLOPS per CPU (41 TFLOPS total)
- 2 GB (4 512 MB FPLRAM modules) per CPU (10 TB total)
- shared memory inside the node
- $640 \times 640$  crossbar switch between the nodes
- 16 GB/s inter-node bandwidth
- 20 kVA power consumption per node

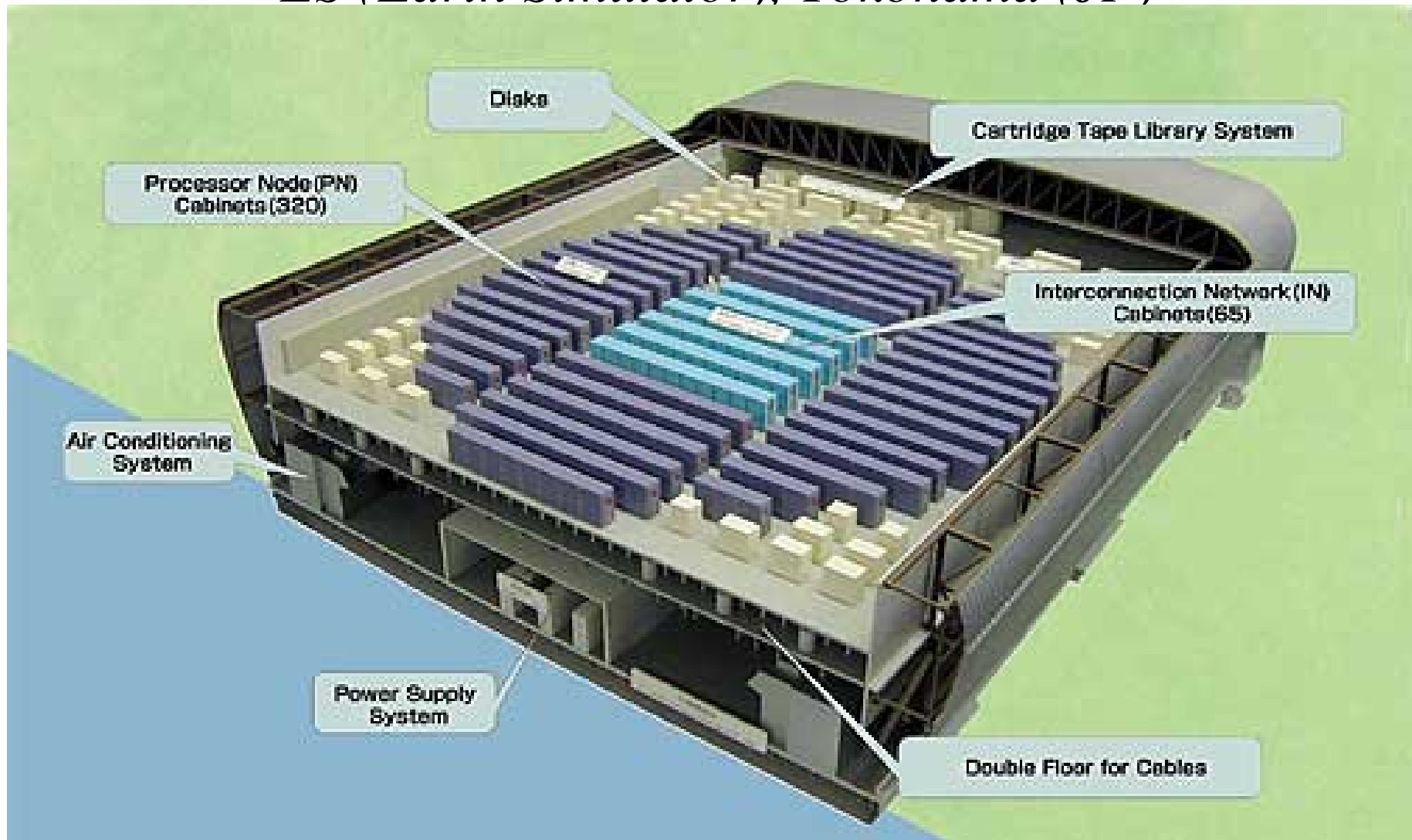
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## **Physical**

The CPUs are housed in 320 cabinets, 2 8-CPU nodes per cabinet. The cabinets (blue) are organized in a ring around the interconnect, which is housed in another 65 cabinets (green). Another layer of the circle is formed by disk array cabinets (white). The whole thing occupies a building 65 m long and 50 m wide. Activity on the nodes is signalled by a bright green beacon at the top of the cabinet, and if a fault occurs, a similar red light turns on. Switch cabinets also have green and red signaling lights for various types of communication events.

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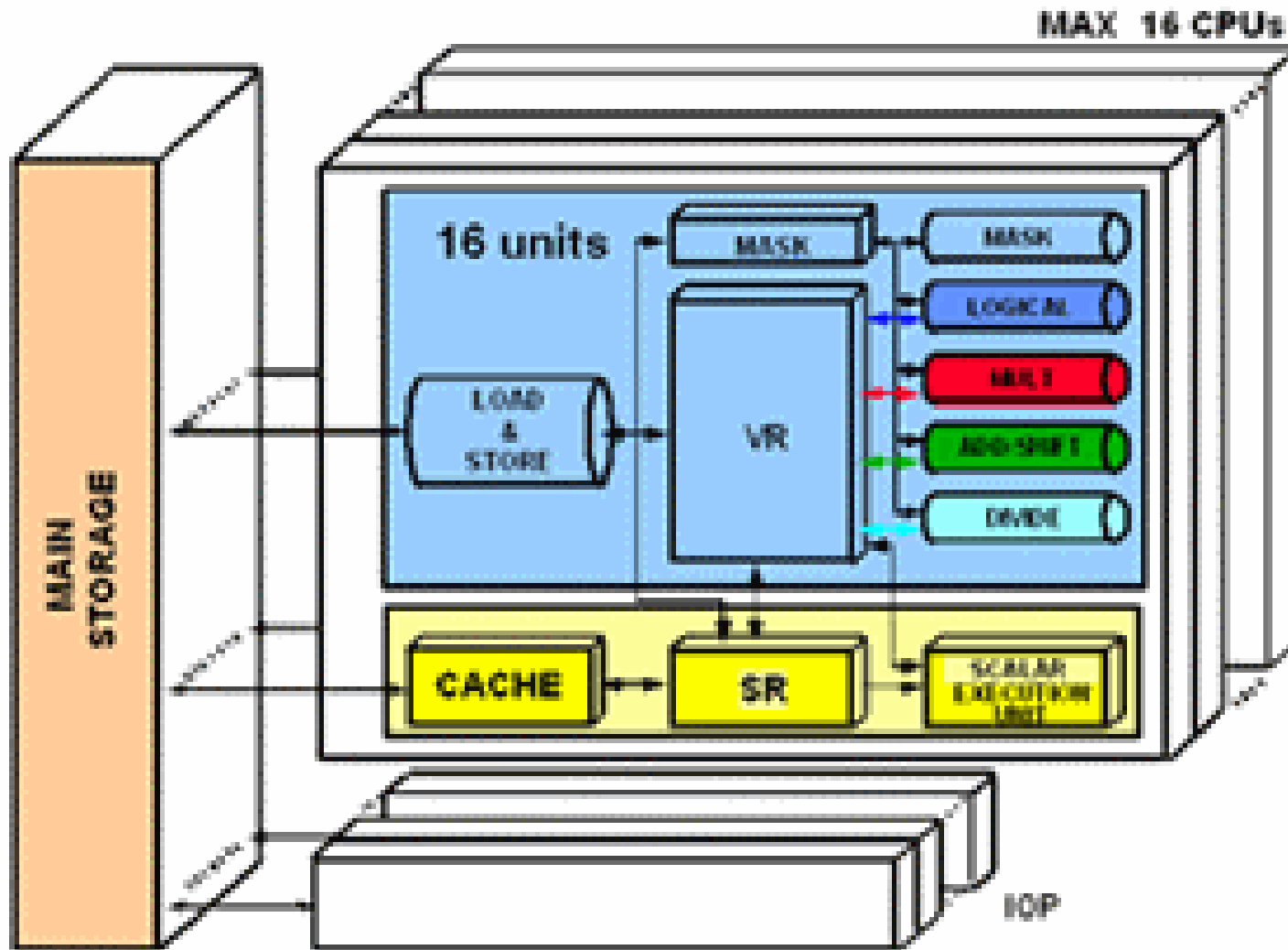
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The vector CPU is made using 0.15  $\mu\text{m}$  CMOS process, and is a descendant (same speed, smaller process) of the [NEC SX-5](#) CPU. The machine runs a version of the Super-UX UNIX-based OS. OpenMP parallel directives are used within a node, and MPI-2 or HPF must be used across multiple nodes, necessitating a *dual-level parallel implementation*. In fact this can be considered a three-level parallel system, if single-CPU vectorization is taken into account; however, vectorization is largely automatic. Still, an optimized code will need to employ MPI-2 at the subdomain level, OpenMP at the loop level, and vectorization directives at the instruction level all at once.

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