

It's not enough for a CPU to fail, of course; other CPUs have to find out that it has failed. The solution here is a watchdog. Each CPU broadcasts a message, the so-called "I'm alive" message, over both buses every 1.2 seconds. If a CPU misses two consecutive "I'm alive" messages from another CPU, it assumes that that CPU had failed. If the CPUs share resources (processes or I/O), the CPU that detects the failure then takes over the resources.

Repair

It's not enough to take a defective component offline; to maintain both fault tolerance and performance, it needs to be brought back online ("up") as quickly as possible, and of course without taking any other components offline ("down").

How this happens depends on the component and the nature of the failure. If the operating system has crashed in one CPU (possibly deliberately), it can be rebooted ("reloaded") online. The standard way to boot a system is to first boot one processor from disk and then boot all other processors across the IPB. Failed processors are also rebooted via the IPB.

If, on the other hand, the hardware is defective, it needs to be replaced. All system components are *hot-pluggable*: they can be removed and replaced in a running system with power up. If a CPU fails because of a hardware problem, the appropriate board is replaced, and then the CPU is rebooted across the bus as before.

Mechanical Layout

The system is designed to have as few boards as possible, so all boards are very large, about 50 cm square. All boards use low power Schottky TTL logic.

The CPU consists of two boards, the processor and the MEMPPU. The MEMPPU contains the interface to memory, including virtual memory logic, and the interface to the I/O bus. The T/16 can have up to 512 kW (1 MB) of semiconductor memory or 256 kW of core memory. Memory boards come in three sizes: 32 kW core, and 96 kW and 192 kW semiconductor memory. This means that there is no way of getting exactly 1 MB of semiconductor memory with fully populated boards. Core memory has word parity protection, whereas semiconductor memory has ECC protection, which can correct a single-bit error and detect a double-bit error.

Processor cabinets are about 6 feet high and house four CPUs with semiconductor memory or four CPUs with core memory. The processors are located at the top of the cabinet, with the I/O controllers located in a second rack directly below. Below that are fans, and at the bottom of the cabinet there are batteries to maintain memory contents during power failures.

Most configurations have a second cabinet with a tape drive. The disk drives are freestanding 14-inch units. There is also a system console, a DEC LA-36 printing terminal.