

directly contribute to fault tolerance—in fact, a couple detract from it! So prepare for a voyage into the past, back to about 1980, starting with one of Tandem’s marketing slogans.

Tandem/16: Some Day All Computers Will Be Built Like This

Tandem describes the machines as single computers with multiple processors, but from the perspective of the 21st century, they’re more like a network of computers operating as a single machine. In particular, each processor works almost completely independently from the others, and the system can recover from the failure of any single component, including processors. The biggest difference from conventional networked processors is that the entire system runs from a single kernel image.

Hardware

Tandem’s hardware is designed to have no potential for a “single point of failure”: any one component of the system, hardware *or* software, can fail without causing the entire system to fail. Beyond this, it is designed for *graceful degradation*. In most cases, the system as a whole can continue running despite multiple failures, though this depends greatly on the nature of the individual failure.

The first implication of this architecture is that there must be at least two of each component in case one should fail. In particular, this means that the system requires at least two CPUs.

But how should the CPUs be connected? The traditional method, then as now, is for the CPUs to communicate via shared memory. At Tandem we call this *tightly coupled multiprocessors*. But if the processors share memory, that memory could be a single point of failure.

Theoretically, it is possible to duplicate memory (a later Tandem architecture actually did that), but it’s very expensive, and it creates significant timing problems. Instead, at the hardware level, Tandem chose a pair of high-speed parallel buses, the “interprocessor bus” or *IPB*, sometimes also referred to as *Dynabus*, which transfer data between the individual CPUs. This architecture is sometimes called *loosely coupled multiprocessors*.

There’s more to a computer than the CPU, of course. In particular, the I/O system and data storage are of great importance. The basic approach here is also duplication of hardware; we’ll look at it further down.

The resultant architecture looks something like Figure 8-1, the so-called *Mackie diagram*, named after Dave Mackie, a vice president of Tandem.