

1.3.3 Clustered Systems

Another type of multiprocessor system is a **clustered system**, which gathers together multiple CPUs. Clustered systems differ from the multiprocessor systems described in Section 1.3.2 in that they are composed of two or more individual systems—or nodes—joined together. Such systems are considered **loosely coupled**. Each node may be a single processor system or a multicore system. We should note that the definition of *clustered* is not concrete; many commercial packages wrestle to define a clustered system and why one form is better than another. The generally accepted definition is that clustered computers share storage and are closely linked via a local-area network LAN (as described in Chapter 17) or a faster interconnect, such as InfiniBand.

Clustering is usually used to provide **high-availability** service—that is, service will continue even if one or more systems in the cluster fail. Generally, we obtain high availability by adding a level of redundancy in the system. A layer of cluster software runs on the cluster nodes. Each node can monitor one or more of the others (over the LAN). If the monitored machine fails, the monitoring machine can take ownership of its storage and restart the applications that were running on the failed machine. The users and clients of the applications see only a brief interruption of service.

Clustering can be structured asymmetrically or symmetrically. In **asymmetric clustering**, one machine is in **hot-standby mode** while the other is running the applications. The hot-standby host machine does nothing but monitor the active server. If that server fails, the hot-standby host becomes the active server. In **symmetric clustering**, two or more hosts are running applications and are monitoring each other. This structure is obviously more efficient, as it uses all of the available hardware. However it does require that more than one application be available to run.

Since a cluster consists of several computer systems connected via a network, clusters can also be used to provide **high-performance computing environments**. Such systems can supply significantly greater computational power than single-processor or even SMP systems because they can run an application concurrently on all computers in the cluster. The application must have been written specifically to take advantage of the cluster, however. This involves a technique known as **parallelization**, which divides a program into separate components that run in parallel in individual computers in the cluster. Typically, these applications are designed so that once each computing node in the cluster has solved its portion of the problem, the results from all the nodes are combined into a final solution.

Other forms of clusters include parallel clusters and clustering over a wide-area network (WAN) (as described in Chapter 17). **Parallel clusters allow multiple hosts to access the same data on shared storage**. Because most operating systems lack support for simultaneous data access by multiple hosts, parallel clusters usually require the use of special versions of software and special releases of applications. For example, Oracle Real Application Cluster is a version of Oracle's database that has been designed to run on a parallel cluster. Each machine runs Oracle, and a layer of software tracks access to the shared disk. Each machine has full access to all data in the database. **To provide this shared access, the system must also supply access control and locking to**