

- **Service process**—A process that is similar to a background process but is performing an activity that is apparent to the user (such as streaming music)
- **Background process**—A process that may be performing an activity but is not apparent to the user.
- **Empty process**—A process that holds no active components associated with any application

If system resources must be reclaimed, Android will first terminate empty processes, followed by background processes, and so forth. Processes are assigned an importance ranking, and Android attempts to assign a process as high a ranking as possible. For example, if a process is providing a service and is also visible, it will be assigned the more-important visible classification.

Furthermore, Android development practices suggest following the guidelines of the process life cycle. When these guidelines are followed, the state of a process will be saved prior to termination and resumed at its saved state if the user navigates back to the application.

## 3.4 Interprocess Communication

Processes executing concurrently in the operating system may be either independent processes or cooperating processes. A process is *independent* if it does not share data with any other processes executing in the system. A process is *cooperating* if it can affect or be affected by the other processes executing in the system. Clearly, any process that shares data with other processes is a cooperating process.

There are several reasons for providing an environment that allows process cooperation:

- **Information sharing.** Since several applications may be interested in the same piece of information (for instance, copying and pasting), we must provide an environment to allow concurrent access to such information.
- **Computation speedup.** If we want a particular task to run faster, we must break it into subtasks, each of which will be executing in parallel with the others. Notice that such a speedup can be achieved only if the computer has multiple processing cores.
- **Modularity.** We may want to construct the system in a modular fashion, dividing the system functions into separate processes or threads, as we discussed in Chapter 2.

Cooperating processes require an **interprocess communication (IPC)** mechanism that will allow them to exchange data—that is, send data to and receive data from each other. There are two fundamental models of interprocess communication: **shared memory** and **message passing**. In the shared-memory model, a region of memory that is shared by the cooperating processes is established. Processes can then exchange information by reading and writing data to the shared region. In the message-passing model,

### MULTIPROCESS ARCHITECTURE—CHROME BROWSER

Many websites contain active content, such as JavaScript, Flash, and HTML5 to provide a rich and dynamic web-browsing experience. Unfortunately, these web applications may also contain software bugs, which can result in sluggish response times and can even cause the web browser to crash. This isn't a big problem in a web browser that displays content from only one website. But most contemporary web browsers provide tabbed browsing, which allows a single instance of a web browser application to open several websites at the same time, with each site in a separate tab. To switch between the different sites, a user need only click on the appropriate tab. This arrangement is illustrated below:



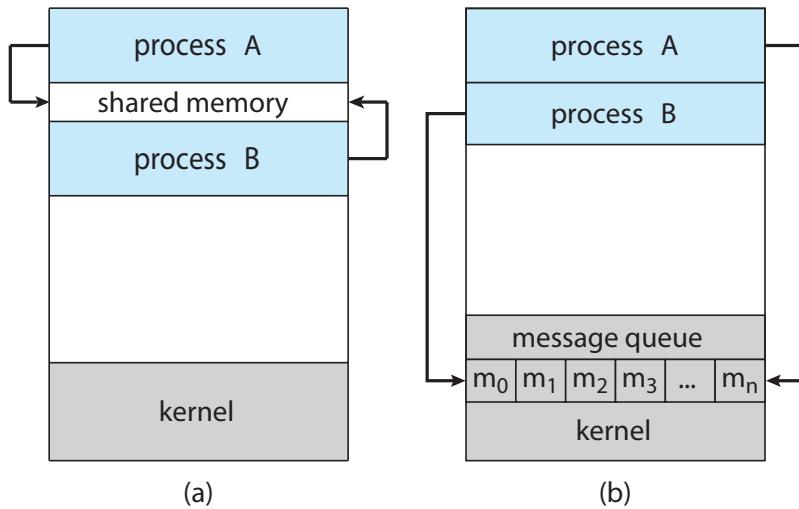
A problem with this approach is that if a web application in any tab crashes, the entire process—including all other tabs displaying additional websites—crashes as well.

Google's Chrome web browser was designed to address this issue by using a multiprocess architecture. Chrome identifies three different types of processes: browser, renderers, and plug-ins.

- The **browser** process is responsible for managing the user interface as well as disk and network I/O. A new browser process is created when Chrome is started. Only one browser process is created.
- **Renderer** processes contain logic for rendering web pages. Thus, they contain the logic for handling HTML, Javascript, images, and so forth. As a general rule, a new renderer process is created for each website opened in a new tab, and so several renderer processes may be active at the same time.
- A **plug-in** process is created for each type of plug-in (such as Flash or QuickTime) in use. Plug-in processes contain the code for the plug-in as well as additional code that enables the plug-in to communicate with associated renderer processes and the browser process.

The advantage of the multiprocess approach is that websites run in isolation from one another. If one website crashes, only its renderer process is affected; all other processes remain unharmed. Furthermore, renderer processes run in a **sandbox**, which means that access to disk and network I/O is restricted, minimizing the effects of any security exploits.

communication takes place by means of messages exchanged between the cooperating processes. The two communications models are contrasted in Figure 3.11.



**Figure 3.11** Communications models. (a) Shared memory. (b) Message passing.

Both of the models just mentioned are common in operating systems, and many systems implement both. Message passing is useful for exchanging smaller amounts of data, because no conflicts need be avoided. Message passing is also easier to implement in a distributed system than shared memory. (Although there are systems that provide distributed shared memory, we do not consider them in this text.) Shared memory can be faster than message passing, since message-passing systems are typically implemented using system calls and thus require the more time-consuming task of kernel intervention. In shared-memory systems, system calls are required only to establish shared-memory regions. Once shared memory is established, all accesses are treated as routine memory accesses, and no assistance from the kernel is required.

In Section 3.5 and Section 3.6 we explore shared-memory and message-passing systems in more detail.

## 3.5 IPC in Shared-Memory Systems

Interprocess communication using shared memory requires communicating processes to establish a region of shared memory. Typically, a shared-memory region resides in the address space of the process creating the shared-memory segment. Other processes that wish to communicate using this shared-memory segment must attach it to their address space. Recall that, normally, the operating system tries to prevent one process from accessing another process's memory. Shared memory requires that two or more processes agree to remove this restriction. They can then exchange information by reading and writing data in the shared areas. The form of the data and the location are determined by these processes and are not under the operating system's control. The processes are also responsible for ensuring that they are not writing to the same location simultaneously.