

### 1.6.1 C++ Class *Thread* for Win32

Listing 1.5 shows C++ classes *Runnable* and *Thread* for Win32:

- Method *run()* can return a value.
- A call to *T.join()* blocks the caller until thread T's *run()* method completes. Method *join()* returns the value that was returned by *run()*.
- Class *Runnable* simulates Java's *Runnable* interface.
- C++ *Threads* can be created on the heap or on the stack. (Java *Thread* objects, like other Java objects, are never created on the stack.)
- Java has a built-in *join()* operation that is useful in Java when one thread needs to make sure that other threads have completed before, say, accessing their results. Java's *run()* method cannot return a value so results must be obtained some other way.

The program in Listing 1.6 illustrates the use of C++ classes *Thread* and *Runnable*. It is designed to look like the Java programs in Listings 1-1 and 1-2.

```

class Runnable {
public:
    virtual void* run() = 0;
    virtual ~Runnable() = 0;
};

```

Runnable::~~Runnable() {} // function body required for pure virtual destructors

```

class Thread {
public:
    Thread(std::auto_ptr<Runnable> runnable_);
    Thread();
    virtual ~Thread();
    void start();           // starts a suspended thread
    void* join();          // wait for thread to complete
private:
    HANDLE hThread;
    unsigned winThreadID; // Win32 thread ID
    std::auto_ptr<Runnable> runnable;
    Thread(const Thread&);
    const Thread& operator=(const Thread&);
    void setCompleted(); // called when run() completes
    void* result;         // stores value returned by run()
    virtual void* run() {return 0;}
    static unsigned WINAPI startThreadRunnable(LPVOID pVoid);
    static unsigned WINAPI startThread(LPVOID pVoid);
    void PrintError(LPTSTR lpszFunction,LPSTR fileName, int lineNumber);
};

```

Listing 1.5 C++/Win32 classes *Runnable* and *Thread* (header files).

```

class simpleRunnable: public Runnable {
public:
    simpleRunnable(int ID) : myID(ID) {}
    virtual void* run() {
        std::cout << "Thread " << myID << " is running" << std::endl;
        return reinterpret_cast<void*>(myID);
    }
private:
    int myID;
};

class simpleThread: public Thread {
public:
    simpleThread (int ID) : myID(ID) {}
    virtual void* run() {
        std::cout << "Thread " << myID << " is running" << std::endl;
        return reinterpret_cast<void*>(myID);
    }
private:
    int myID;
};

int main() {
    std::auto_ptr<Runnable> r(new simpleRunnable(1));
    std::auto_ptr<Thread> thread1(new Thread(r));
    thread1->start();
    std::auto_ptr<simpleThread> thread2(new simpleThread(2));
    thread2->start();
    simpleThread thread3(3);
    thread3.start();
    // thread1 and thread2 are created on the heap; thread3 is created on the stack

    int result1 = reinterpret_cast<int>(thread1->join()); // wait for the threads to finish
    int result2 = reinterpret_cast<int>(thread2->join());
    int result3 = reinterpret_cast<int>(thread3.join());

    std::cout << result1 << ' ' << result2 << ' ' << result3 << std::endl;
    return 0;
    // the destructors for thread1 and thread2 will automatically delete the
    // pointed-at thread objects
}

```

Listing 1.6 Using C++ classes *Runnable* and *Thread*.

```

Thread::Thread(std::auto_ptr<Runnable> runnable_) : runnable(runnable_) {
    if (runnable.get() == NULL) PrintError( ... );
    hThread = (HANDLE)_beginthreadex(NULL,0,Thread::startThreadRunnable,
    (LPVOID)this, CREATE_SUSPENDED, &winThreadID );
    if (!hThread) PrintError("_beginthreadex failed at ",__FILE__,__LINE__);
}
Thread::Thread(): runnable(NULL) {
    hThread = (HANDLE)_beginthreadex(NULL,0,Thread::startThread,
    (LPVOID)this, CREATE_SUSPENDED, &winThreadID );
    if (!hThread) PrintError (...);
}
unsigned WINAPI Thread::startThreadRunnable(LPVOID pVoid){
    Thread* runnableThread = static_cast<Thread*> (pVoid);
    runnableThread->result = runnableThread->runnable->run();
    runnableThread->setCompleted();
    return reinterpret_cast<unsigned>(runnableThread->result);
}
unsigned WINAPI Thread::startThread(LPVOID pVoid) {
    Thread* aThread = static_cast<Thread*> (pVoid);
    aThread->result = aThread->run(); aThread->setCompleted();
    return reinterpret_cast<unsigned>(aThread->result);
}
Thread::~Thread() {
    if (winThreadID != GetCurrentThreadId()) {
        DWORD rc = CloseHandle(hThread);
        if (!rc) PrintError( ... );
    } // note that the runnable object (if any) is automatically deleted by auto_ptr.
}
void Thread::start() {
    assert(hThread != NULL);
    DWORD rc = ResumeThread(hThread);
    // thread was created in suspended state so this starts it running
    if (!rc) PrintError("ResumeThread failed at ",__FILE__,__LINE__);
}
void* Thread::join() {
    /* a thread calling T.join() waits until thread T completes; see section 3.7.4.*/
    return result; // return the void* value that was returned by method run()
}
void Thread::setCompleted() {
    /* notify any threads that are waiting in join(); see section 3.7.4. */
}
void Thread::PrintError(LPTSTR lpszFunction,LPSTR fileName, int lineNumber)
{ /* see Listing 1.4 */}

```

Listing 1.5 (continued).

When a C++ *Thread* is created, the corresponding *Thread* constructor calls function *\_beginthreadex()* with the following arguments:

- **NULL**: This is the default value for security attributes.
- **0**: This is the default value for stack size.
- The third argument is either *Thread::startThread()* or *Thread::startThreadRunnable()*. Method *startThread()* is the startup method for threads created by inheriting from class *Thread*. Method *startThreadRunnable()* is the startup method for threads created from *Runnable* objects.
- **(LPVOID) this**: The fourth argument is a pointer to this *Thread* object, which is passed through to method *startThread()* or *startThreadRunnable()*. Thus, all threads execute one of the startup methods, but the startup methods receive a different *Thread* pointer each time they are executed.
- **CREATE\_SUSPENDED**: A Win32 thread is created to execute the startup method, but this thread is created in suspended mode, so the startup method does not begin executing until method *start()* is called on the thread.

Since the Win32 thread is created in suspended mode, the thread is not actually started until method *Thread::start()* is called.

- Method *Thread::start()* calls Win32 function *ResumeThread()*, which allows the thread to be scheduled and the startup method to begin execution.
- The startup method is either *startThread()* or *startThreadRunnable()*, depending on which *Thread* constructor was used to create the *Thread* object.

Method *startThread()* casts its `void*` pointer parameter to *Thread\** and then calls the *run()* method of its *Thread\** parameter.

- When the *run()* method returns, *startThread()* calls *setCompleted()* to set the thread's status to completed and to notify any threads waiting in *join()* that the thread has completed.
- The return value of the *run()* method is saved so that it can be retrieved in method *join()*.

Static method *startThreadRunnable()* performs similar steps when threads are created from *Runnable* objects. Method *startThreadRunnable()* calls the *run()* method of the *Runnable* object held by its *Thread\** parameter and then calls *setCompleted()*.

In Listing 1.6, we use *auto\_ptr<>* objects to manage the destruction of two of the threads and the *Runnable* object *r*.

- When *auto\_ptr<>* objects *thread1* and *thread2* are automatically destroyed at the end of the program, their destructors will automatically invoke *delete* on the pointers with which they were initialized.
- This is true no matter whether the *main* function exits normally or by means of an exception.

Note that startup functions *startThreadRunnable()* and *startThread()* are static member functions.