

Multithreading

A Process

- A Process is a running application
- A Process is composed of Threads
 - e.g. a process may have:
 - A GUI thread
 - Several computational threads
 - A file I/O thread
 - A print thread
- A Thread is the basic unit to which the Operating System allocates processor time
 - A dispatchable unit of code

Multithreading

- Thread
 - The fundamental unit of execution
 - Processes can be subdivided into threads
 - Threads run concurrently and share the cpu(s)
 - OS manages running threads with scheduling algorithms
 - Switches processor time between threads
 - Done so fast and efficiently that it appears all threads are running simultaneously
 - A managed application begins as a single thread
 - Can spawn additional threads to partition its tasks
 - On multi-cpu system, apps can run faster since different threads can run on different processors

Asynchronous Execution

- Threads run asynchronously with respect to each other
 - So independent units of work can be performed in parallel
- Example: a GUI app that enters into a long computational loop
 - Running as a single thread:
 - While app's single thread is computing, messages on the message queue are ignored
 - So the app's user interface is frozen until computation finishes
 - Running as two threads:
 - Relegate the computational work to a background thread
 - Now primary thread is free so service the message queue
 - App is now responsive to user input while computation is occurring

Multithreading Complexities

- Multithreaded apps are hard to write and debug
- Parallelism of concurrently running threads adds an extra layer of complexity
 - e.g., threads reading and writing to a data structure
 - Threads need to be synchronized
 - If not data could be corrupted
 - Also bugs are very dependent on timing
 - Very difficult to reproduce
 - Almost impossible to be sure that a multithreaded program is free of bugs

Threads in .NET

- Threading classes are in namespace: System.Threading
 - Most important class: Thread
 - Represents a thread of execution
 - Implements properties and methods that allow programmer to launch and manipulate concurrently-running threads

Some Thread Class Properties

- bool IsBackground
 - false (default) means thread runs in foreground
 - An app doesn't end until all its foreground threads have finished
- string Name
 - Retrieve/change a thread's name
- Thread CurrentThread
 - Static property returning a reference to the calling thread
 - Use result to get or change properties of a thread
- ThreadPriority Priority
 - ThreadPriority is an enumeration:
 - Highest, AboveNormal, Normal (default), BelowNormal, Lowest
 - Determines relative amount of processor time allotted to the thread
 - Can be changed:

```
Thread myThread = Thread.CurrentThread;  
myThread.Priority = ThreadPriority.AboveNormal;
```
- bool IsAlive

Starting Threads

- Instantiate a Thread object
 - Give constructor a new "thread method"
 - This is the method the thread executes when it starts
 - Must be "wrapped" in the ThreadStart delegate
- Then use the thread's Start() method
- Example:

```
Thread myThread = new Thread (new ThreadStart (myThreadMethod) );  
myThread.Start();
```

 - Starts the thread and causes myThreadMethod() to run
 - Your app must implement this method:

```
void myThreadMethod() { // code to run };
```
 - Thread is now "alive" and remains alive until it terminates
 - When the "thread method" returns, the thread ends

Threads-One & Threads-Two Example Programs

- Form has a "Toggle Background Color" & "Start Computation" buttons and a label
 - First button toggles background between red and green
 - Second button starts a long, nested-loop computation
 - When computation is done, label control is turned blue and displays an "All Done" message
- Running as a single thread (as usual):
 - After "Start Computation" button is clicked
 - Program does not respond to "Toggle Background Color" button until computation is done (seems to be dead)
- Running in two threads:
 - Foreground thread starts a background thread to do the computation when user clicks the "Start Computation" button
 - Now the program responds to the "Change Background Color" button while the computation is being done

Suspending & Resuming Threads

- Suspend() method temporarily suspends a running thread
 - Any thread can call Suspend() on any other thread
- Resume() method starts it running again
 - If a thread suspends itself, some other thread must call Resume() on it to start it again
- Static method Sleep(int iMilliseconds)
 - Suspend for specified number of milliseconds
 - A thread can only call Sleep() on itself

Terminating a Thread

- Abort() method terminates a running thread

```
myThread.Abort(); //terminates myThread
```

 - Always works for managed thread, but may not if app contains unmanaged code
- Many times a thread should pause until the thread it is trying to abort terminates
 - Join() method does that

```
otherThread.Abort(); // ask the other thread to finish  
otherThread.Join(); // "joins" the other thread and  
pauses until it finishes
```

Other Thread Complexities

- Starting and stopping threads is easy
- Making them work cooperatively is not
- Thread synchronization is very difficult
- Some ways of synchronizing threads:
 - Use System.Threading.Interlocked class
 - Use Monitors (System.Threading.Monitor class)
 - Use "locks" so that only one thread can access data at a time
 - Enter() acquires a lock
 - Exit() releases the lock
 - Use Mutexes (name comes from "mutually exclusive")
 - System.Threading.Mutex class)
- All of these are beyond the scope of this course
 - See Chapter 11 of the Deitel text book

Starting Processes on the System

- A Process component provides access to processes (executables) that are running or can run on the system
 - In System.Diagnostics namespace
- To run a process:
 - Instantiate a new Process object
 - Set its StartInfo.FileName property to the name of the executable file
 - Invoke its Start() method

```
Process myProc = new Process();
myProc.StartInfo.FileName = "c:\\Windows\\Notepad.exe";
myProc.Start();
```
- StartProcess example program
 - Allows user to start any application program on the system