

## Why Threads Are A Bad Idea (for most purposes)

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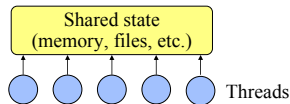
## Introduction

- ◆ **Threads:**
  - Grew up in OS world (processes).
  - Evolved into user-level tool.
  - Proposed as solution for a variety of problems.
  - Every programmer should be a threads programmer?
- ◆ **Problem: threads are very hard to program.**
- ◆ **Alternative: events.**
- ◆ **Claims:**
  - For most purposes proposed for threads, events are better.
  - Threads should be used only when true CPU concurrency is needed.

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## What Are Threads?



- ◆ **General-purpose solution for managing concurrency.**
- ◆ **Multiple independent execution streams.**
- ◆ **Shared state.**
- ◆ **Pre-emptive scheduling.**
- ◆ **Synchronization (e.g. locks, conditions).**

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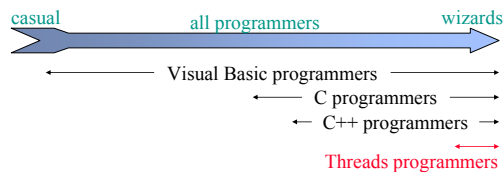
## What Are Threads Used For?

- ◆ **Operating systems: one kernel thread for each user process.**
- ◆ **Scientific applications: one thread per CPU (solve problems more quickly).**
- ◆ **Distributed systems: process requests concurrently (overlap I/Os).**
- ◆ **GUIs:**
  - Threads correspond to user actions; can service display during long-running computations.
  - Multimedia, animations.

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## What's Wrong With Threads?



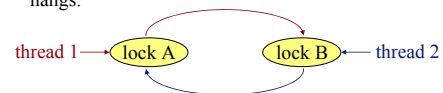
- ◆ **Too hard for most programmers to use.**
- ◆ **Even for experts, development is painful.**

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## Why Threads Are Hard

- ◆ **Synchronization:**
  - Must coordinate access to shared data with locks.
  - Forget a lock? Corrupted data.
- ◆ **Deadlock:**
  - Circular dependencies among locks.
  - Each process waits for some other process: system hangs.

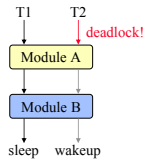


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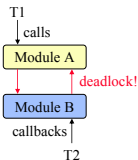
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## Why Threads Are Hard, cont'd

- ◆ **Hard to debug:** data dependencies, timing dependencies.
- ◆ **Threads break abstraction:** can't design modules independently.
- ◆ **Callbacks don't work with locks.**



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## Why Threads Are Hard, cont'd

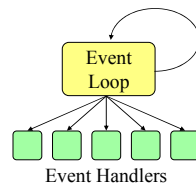
- ◆ **Achieving good performance is hard:**
  - Simple locking (e.g. monitors) yields low concurrency.
  - Fine-grain locking increases complexity, reduces performance in normal case.
  - OSES limit performance (scheduling, context switches).
- ◆ **Threads not well supported:**
  - Hard to port threaded code (PCs? Macs?).
  - Standard libraries not thread-safe.
  - Kernel calls, window systems not multi-threaded.
  - Few debugging tools (LockLint, debuggers?).
- ◆ **Often don't want concurrency anyway (e.g. window events).**

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## Event-Driven Programming

- ◆ **One execution stream: no CPU concurrency.**
- ◆ **Register interest in events (callbacks).**
- ◆ **Event loop waits for events, invokes handlers.**
- ◆ **No preemption of event handlers.**
- ◆ **Handlers generally short-lived.**



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## What Are Events Used For?

- ◆ **Mostly GUIs:**
  - One handler for each event (press button, invoke menu entry, etc.).
  - Handler implements behavior (undo, delete file, etc.).
- ◆ **Distributed systems:**
  - One handler for each source of input (socket, etc.).
  - Handler processes incoming request, sends response.
  - Event-driven I/O for I/O overlap.

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## Problems With Events

- ◆ **Long-running handlers make application non-responsive.**
  - Fork off subprocesses for long-running things (e.g. multimedia), use events to find out when done.
  - Break up handlers (e.g. event-driven I/O).
  - Periodically call event loop in handler (reentrancy adds complexity).
- ◆ **Can't maintain local state across events (handler must return).**
- ◆ **No CPU concurrency (not suitable for scientific apps).**
- ◆ **Event-driven I/O not always well supported (e.g. poor write buffering).**

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## Events vs. Threads

- ◆ **Events avoid concurrency as much as possible, threads embrace:**
  - Easy to get started with events: no concurrency, no preemption, no synchronization, no deadlock.
  - Use complicated techniques only for unusual cases.
  - With threads, even the simplest application faces the full complexity.
- ◆ **Debugging easier with events:**
  - Timing dependencies only related to events, not to internal scheduling.
  - Problems easier to track down: slow response to button vs. corrupted memory.

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## Events vs. Threads, cont'd

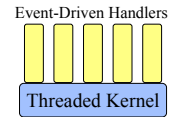
- ◆ **Events faster than threads on single CPU:**
  - No locking overheads.
  - No context switching.
- ◆ **Events more portable than threads.**
- ◆ **Threads provide true concurrency:**
  - Can have long-running stateful handlers without freezes.
  - Scalable performance on multiple CPUs.

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## Should You Abandon Threads?

- ◆ **No: important for high-end servers (e.g. databases).**
- ◆ **But, avoid threads wherever possible:**
  - Use events, not threads, for GUIs, distributed systems, low-end servers.
  - Only use threads where true CPU concurrency is needed.
  - Where threads needed, isolate usage in threaded application kernel: keep most of code single-threaded.



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## Conclusions

- ◆ **Concurrency is fundamentally hard; avoid whenever possible.**
- ◆ **Threads more powerful than events, but power is rarely needed.**
- ◆ **Threads much harder to program than events; for experts only.**
- ◆ **Use events as primary development tool (both GUIs and distributed systems).**
- ◆ **Use threads only for performance-critical kernels.**

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