

Why Threads Are A Bad Idea (for most purposes)

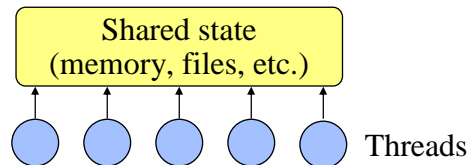
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Introduction

- ∪ **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.

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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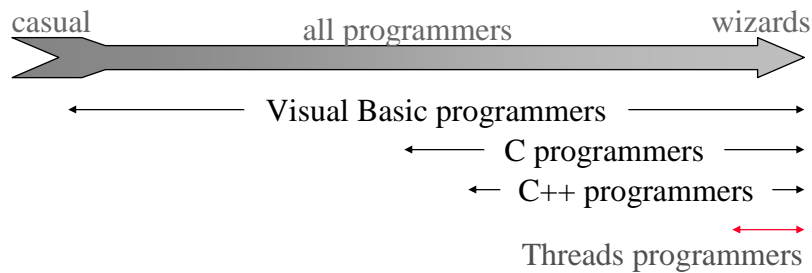
What Are Threads Used For?

- ∪ **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?



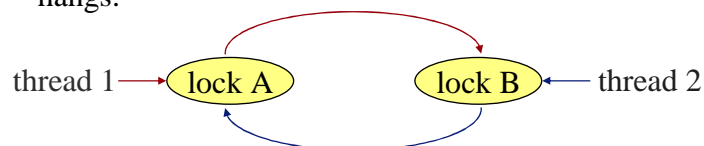
- ∪ **Too hard for most programmers to use.**
- ∪ **Even for experts, development is painful.**

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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.

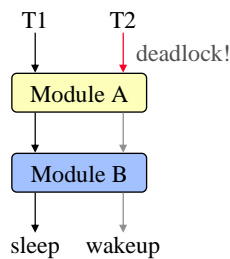


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Why Threads Are Hard, cont'd

- ∪ **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

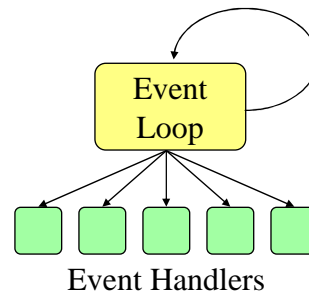
- ∪ **Achieving good performance is hard:**
 - Simple locking (e.g. monitors) yields low concurrency.
 - Fine-grain locking increases complexity, reduces performance in normal case.
 - OSes limit performance (scheduling, context switches).
- ∪ **Threads not well supported:**
 - Hard to port threaded 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

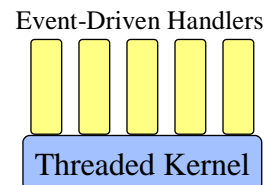
- ∪ **Events faster than threads on single CPU:**
 - No locking overheads.
 - No context switching.
- ∪ **Events more portable than threads.**
- ∪ **Threads provide true concurrency:**
 - Can have long-running stateful handlers without freezes.
 - Scalable performance on multiple CPUs.

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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.**