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

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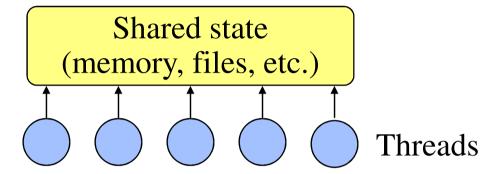
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## Introduction

#### **♦** 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?

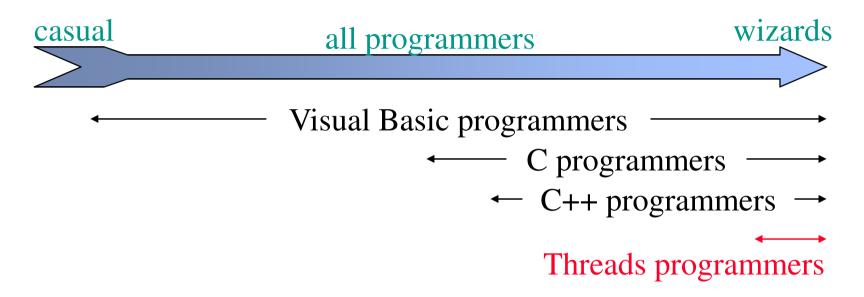


- General-purpose solution for managing concurrency.
- Multiple independent execution streams.
- Shared state.
- Pre-emptive scheduling.
- Synchronization (e.g. locks, conditions).

## 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.

# What's Wrong With Threads?



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

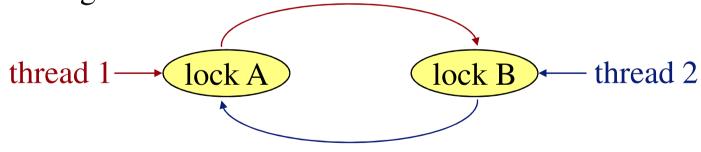
# Why Threads Are Hard

### Synchronization:

- Must coordinate access to shared data with locks.
- Forget a lock? Corrupted data.

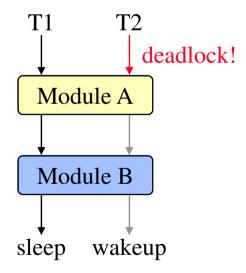
#### Deadlock:

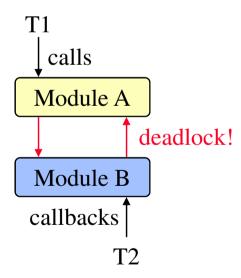
- Circular dependencies among locks.
- Each process waits for some other process: system hangs.



# 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.





# Why Threads Are Hard, cont'd

### Achieving good performance is hard:

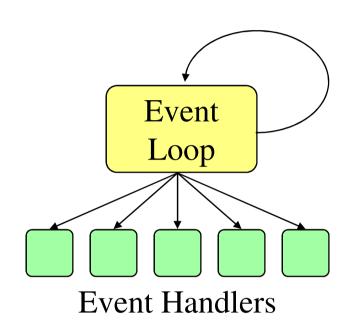
- Simple locking (e.g. monitors) yields low concurrency.
- Fine-grain locking increases complexity, reduces performance in normal case.
- OSes limit performance (scheduling, context switches).

## 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).

# **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.



## 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.

## **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).

## **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:

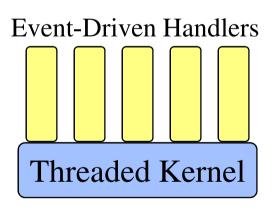
- Timing dependencies only related to events, not to internal scheduling.
- Problems easier to track down: slow response to button vs. corrupted memory.

# 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.

# **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.



## **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.