Graduate Operating Systems

Spring 2023

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Today's Papers

- **[13]** D. Stein and D. Shah, "Implementing Lightweight Threads", Proc. of USENIX, San Antonio, TX, June 1992.
- **[14]** John Ousterhout, "Why Threads are a Bad Idea (for most purposes)", talk given at USENIX Annual Conference, September 1995.

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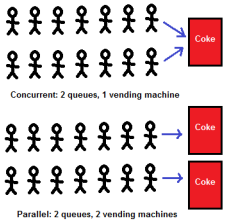
Concurrency vs. Parallelism



Concurrency

Tasks start, run and complete in an interleaved fashion

Parallelism

Tasks run simultaneously

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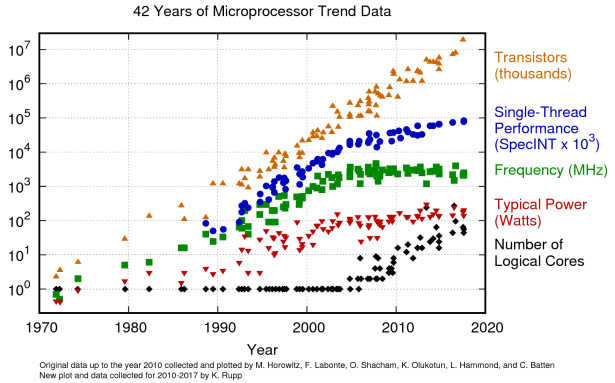
Microprocessor Trends



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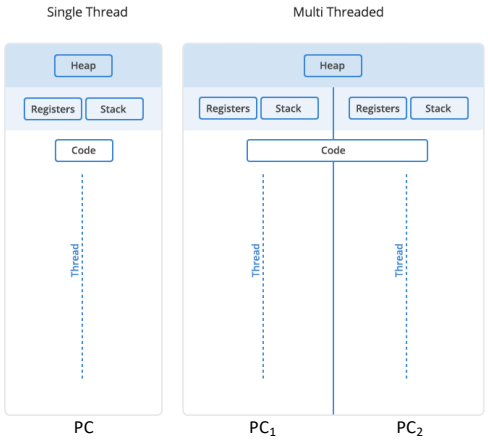
Processes vs. Threads



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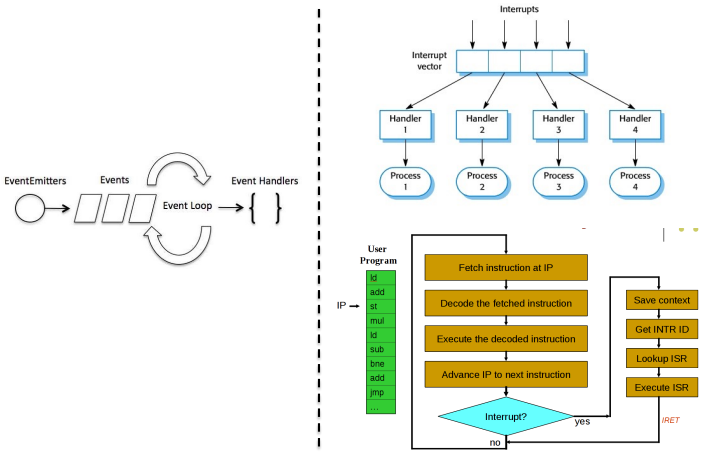
Events



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Types of Threads

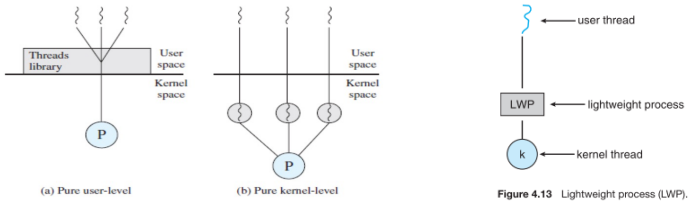

Figure 4.13 Lightweight process (LWP).

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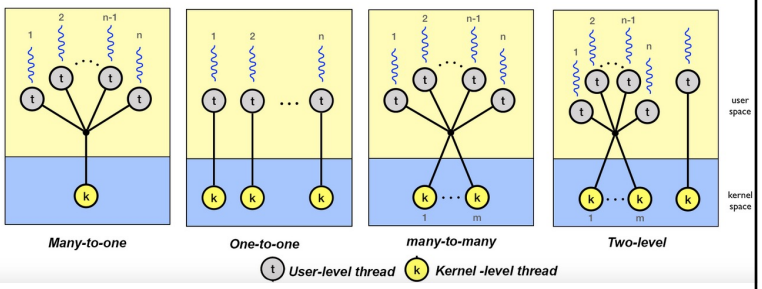
Thread Models



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Paper Discussion

- Why are threads cheaper than processes?
- How is IPC performed using threads?
- Why is synchronization between threads needed?
- Two creation approaches: create ALL threads or create only CALLING thread; difference?
- What is “thread-local storage”?
- What are bound threads and why are they useful?
- Why is signaling challenging?

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Pthreads (POSIX 1003.1c)

```
#include <stdio.h>
#include <pthread.h>
void printMsg(char* msg) {
    int status = 0;
    printf("%s\n", msg);
    pthread_exit(&status);
}
int main(int argc, char** argv) {
    pthread_t thrdID;
    int* status = (int*)malloc(sizeof(int));
    printf("creating a new thread\n");
    pthread_create(&thrdID, NULL, (void*)printMsg, argv[1]);
    printf("created thread %d\n". thrdID);
    pthread_join(thrdID, &status);
    printf("Thread %d exited with status %d\n", thrdID, *status);
    return 0;
}
```

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Common Programming Models

Multi-threaded programs tend to be structured as:

- **Producer/consumer**
  Multiple producer threads create data (or work) that is handled by one of the multiple consumer threads
- **Pipeline**
  Task is divided into series of subtasks, each of which is handled in series by a different thread
- **Defer work with background thread**
  One thread performs non-critical work in the background (when CPU idle)

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Threads vs. Events

- *What is biggest problem with threads (in reading assignment)?*
- Threads:
  - Independent execution streams
  - Preemptive scheduling
  - Synchronization
  - Deadlocks
  - Debugging
  - "Threads break abstraction"
  - Getting good performance
  - OS support of threads

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Threads vs. Events

- Events:
  - No CPU concurrency
  - Callbacks; event handlers
  - No preemption
  - Long-running handlers
  - State across handler invocations
  - Debugging
  - Overheads
  - Portability

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