Managing Parallelism/Concurrency in Servers

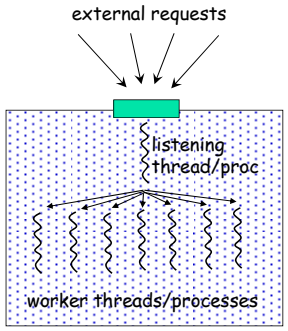
Kai Shen

Server

- Computer application serving (potentially many) interactive clients
  - Parallelism: many requests run concurrently in a server
- But unlike the parallel applications we have seen so far
  - Easily partitioned to fine-grained requests without inter-request dependencies, no need for synchronization ⇨ embarrassingly parallel
  - Highly multiprogrammed, many context switches
  - Performance (quality-of-service) and resource accounting at each request

Multi-processing vs. Multi-threading

- Multi-processing server
  - each request is served by a process (Apache).
- Multi-threading server
  - each request is served by a thread.
- Compare multi-processing server with multi-threading server
  - efficiency
  - robustness/isolation
- Pooling can be used to reduce the overhead on process/thread creation and termination

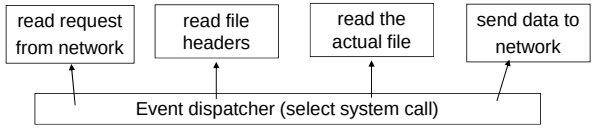


User-level Threads

- Kernel threads
  - thread management/scheduling done by the OS kernel
- User threads
  - thread management/scheduling done at user-level
  - Benefit: efficiency, e.g., less context switching overhead
- Problem of user threads
  - oblivious to kernel events, so all threads in a process are put to wait when only one of them blocks on I/O (e.g., read())
- How to solve this problem?
  - helper (kernel) threads
  - asynchronous I/O

Event-driven Servers

- Event-driven servers
  - divide request processing into stages, each of which is non-blocking
  - each stage is triggered by an event
  - the whole event controller runs in a single user thread



- Flash Web server [Pai et al., USENIX1999]
- Problems: difficult programming, hidden I/O?

Request Scheduling

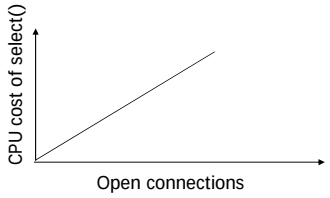
- Scheduling or request execution
  - normal multi-tasking (a task is a process/thread or a request)
- Staged resource-aware request scheduling
  - Each request execution is partitioned into stages (like in event-driven servers)
  - Each stage has particular resource needs.
  - Throttling early stage for admission control.
- SEDA [Welsh et al., SOSP2001]

High Concurrency Threaded Server

- What is your first problem when you try to run 10,000 requests/threads concurrently in a server?
- Capriccio [von Behren et al., SOSP2003]

Overhead with High Concurrency

- More frequent context switches? Cache pollution?
- Scalability of the select() system call [Banga et al., USENIX1998]

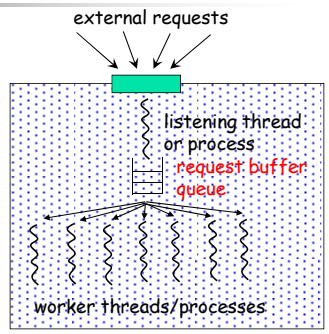


Overhead with High Load Network Server

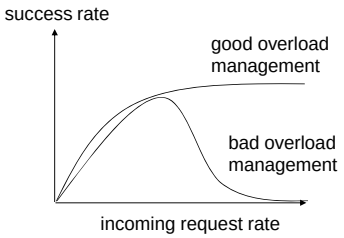
- With gigabit Ethernet:
  - 125,000,000 bytes per second for 1,500bytes/frame ⇒ 12us per frame
  - if an interrupt handler consumes 3us CPU, then 25% CPU processing on interrupt handling
- Soft timers [Aron and Druschel, SOSP1999]
  - NIC buffers frames; only interrupt after multiple frames arrive
  - CPU does a coarse-granularity polling

Control the Concurrency

- How to control the execution concurrency?
  - use a request buffer queue

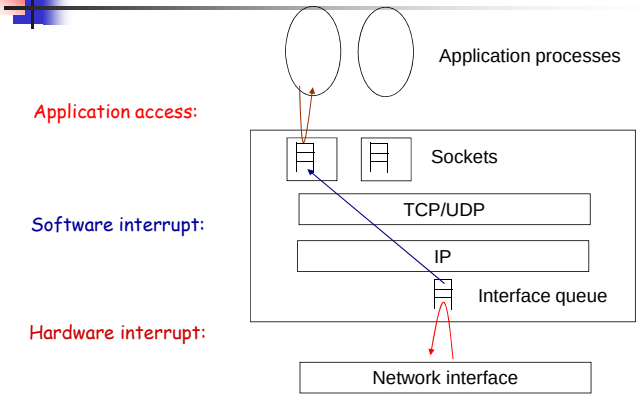


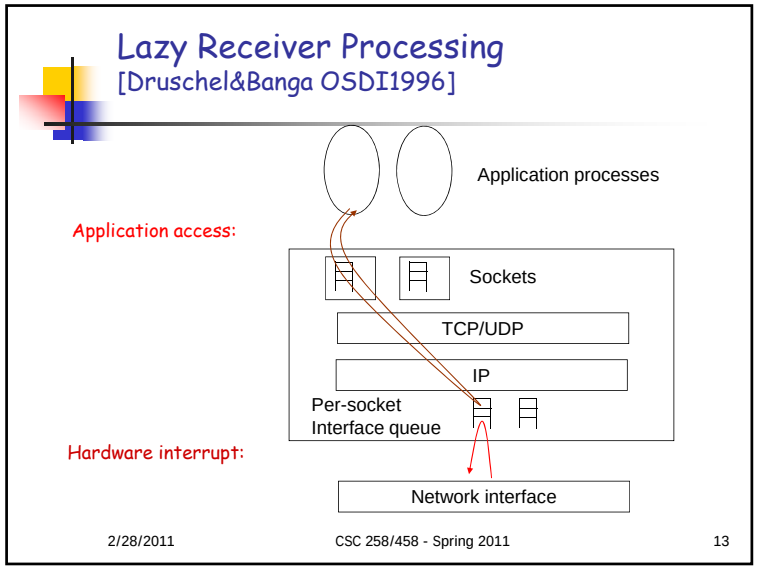
Handle Server Overload



- Overhead of server overload:
  - some requests have to be abandoned
  - when a request has to be abandoned, resources already consumed by this request is wasted
- Principle: when abandoning a request, do so as early as possible
  - drop new requests if the buffer queue is already long

OS Overhead for Each Request




Lazy Receiver Processing
[Druschel&Banga OSDI1996]
Application processes
Application access:
Sockets
TCP/UDP
IP
Per-socket
Interface queue
Hardware interrupt:
Network interface
2/28/2011
CSC 258/458 - Spring 2011
13