Concurrent Online Servers

CS 256/456

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Concurrent Online Servers

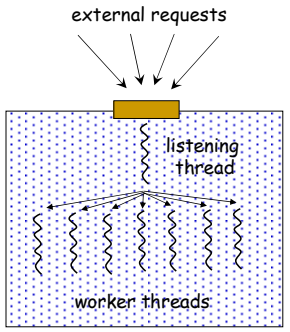
- Servers that
  - accept concurrent requests (potentially high concurrency)
  - serve online users (interactive responses)
- Examples
  - Web server: online server that implements HTTP
  - More complex ones: search engines (Google), online auction sites (eBay), discussion forums (slashdot), … …
- We examine supporting concurrent online servers
  - application level issues (with a good understanding of the OS)
  - OS issues

Issues of Concerns

- Performance
  - potentially high concurrency
  - fluctuating load
- Reliability
- Isolation
  - performance isolation
  - fault isolation
- Security
  - concerning network-oriented services
- Manageability

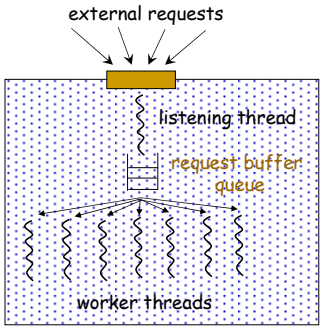
Multi-processing vs. Multi-threading

- 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



Controlling the Concurrency

- Overhead of high concurrency
  - more frequent context switches?
  - or what?
    - e.g., scalability of the select() system call
- How to control the execution concurrency?
  - dropping requests
  - employ a request buffer queue



User-level Threads

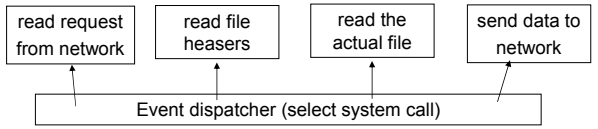
- Kernel threads
  - thread management/scheduling done by the OS kernel
- User threads
  - thread management/scheduling done at user-level
  - Benefits: (lightweight) less context switching overhead
- Problem of user threads
  - oblivious to kernel events, transparent to the kernel
  - e.g., all threads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

How to solve the blocking problem for user threads?

- For each potential blocking operation (e.g., read())
  - the server forwards it to a *helper* process (either spawned or pooled); the server then does something else … …
  - when the blocking operation in the helper process completes, the server is informed through IPC … …
- OS support for asynchronous I/O
  - server doesn't call blocking operations (e.g., read()) directly
  - instead, it calls asynchronous I/O operations (e.g., aio_read()), which doesn't block
  - the server is notified by a signal (e.g., SIGIO) when the asynchronous I/O completes
  - an I/O handler is invoked at the receipt of the signal

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



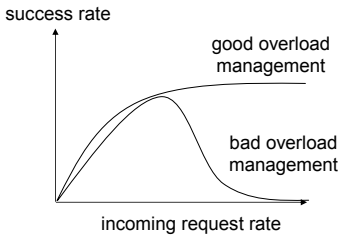
- Flash Web server [Pai et al, USENIX1999]

Resource Management

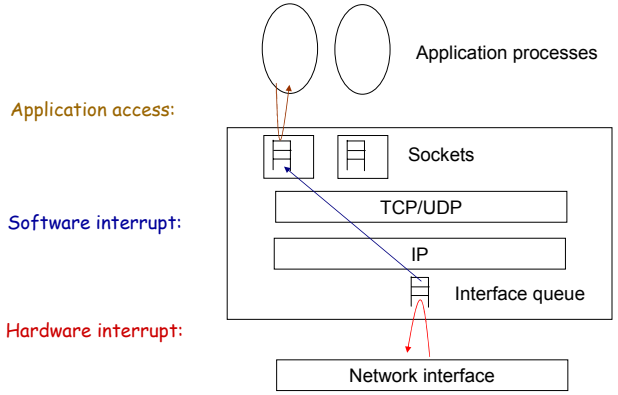
- Scheduling or request execution
  - according to default CPU scheduling policy
- Staged request scheduling
  - Each request execution is partitioned into stages (like in event-driven servers)
  - Request scheduling according to
    - which stage each request execution is at; and
    - whether the primary required resource is scarce or not.
- SEDA [Welsh et al., SOSP 2001]
- Capriccio [von Behren et al., SOSP 2003]

Handle Server Overload

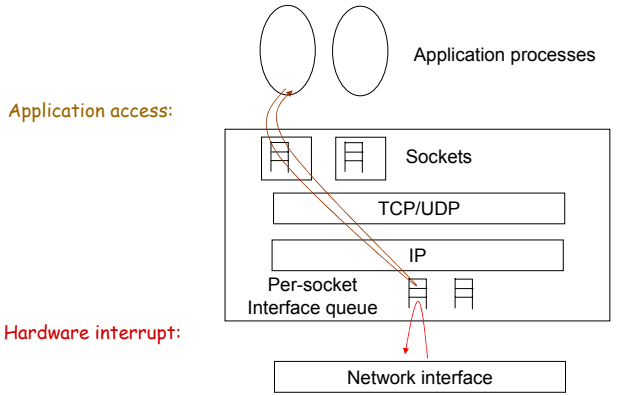
- Overhead of server overload:
  - some requests have to be abandoned
  - when a request has to be abandoned, resources already consumed by this request is wasted
  - principle: when abandoning a request, do so as early as possible
- Managing overload?
  - drop requests if the buffer queue is already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



OS Overhead for Each Request



Lazy Receiver Processing
[Druschel&Banga OSDI 1996]



Isolation in Server Systems

- Isolation of request execution in
  - resource provisioning/accounting
  - fault
  - system/server configuration
- Difficulty
  - process/thread does not complete encapsulate a request execution
- Request execution encapsulation in OS:
  - Resource containers [Banga et al., OSDI 1999]
  - Magpie [Barham et al., OSDI 2004]
- Request execution encapsulation in virtual machines:
  - Denali [Witaker et al., OSDI 2002]