SEDA – Staged Event-Driven Architecture

SEDA: An Architecture for well-conditioned scalable internet services. Matt Welsh, David Culler & Eric Brewer

Presented by Rahul Agarwal

Overview

- Motivation
- Key Points
- Thread vs. Event concurrency
- SEDA
- Experimental Evaluation
- *My* Evaluation
- Questions to Consider

Authors

- Main Author
  - Matt Welsh's PhD thesis at UC Berkeley
  - Now Assistant Professor in CS Dept at Harvard
  - Currently working on wireless sensor networks
  - Research interests in OS, Networks and Large Scale Distributed Systems
- Culler & Brewer - Advisors

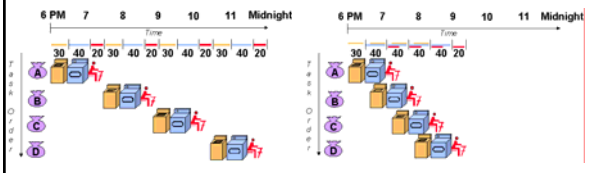
Motivation

- High demand for web content – for example concurrent millions of users for Yahoo
- Load Spikes – "Slashdot Effect"
  - Over provisioning support not feasible financially and events unannounced
- Web services getting more complex, requiring maximum server performance

Motivation – Well-conditioned Service

- A well-conditioned service behave like a simple pipeline
- As offered load increase throughput increases proportionally
- When saturated it **does not** degrade throughput – *graceful degradation*

Pipelining



- How can we improve throughput in a pipeline? Potential problems?

Key Points

- Application as a network of event-driven **stages** connected by **queues**
  - Dynamic Resource Controllers
  - Automatic load tuning
    - Thread pool sizing
    - Event Batching
    - Adaptive load shedding
- Support massive concurrency and prevent resources from being overcommitted

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Thread-Based vs. Event-Based Concurrency

- Thread
  - Thread-per-request
  - OS switches and overlaps computation and I/O
  - Synchronization required
  - Performance Degradation
    - Eg: RPC, RMI, DCOM
  - Overcome by more control to OS
    - Eg: SPIN, Exokernel, Nemesis
  - Overcome by reuse of threads
    - Eg: Apache, IIS, Netscape... everyone!
- Event
  - One thread per CPU (controller)
  - Process events generated by apps and kernel
  - Each task implemented as a FSM with transitions triggered by events
  - Pipelining!
    - Eg: Flash, Zeus, JAWS
  - Harder to modularize and engineer

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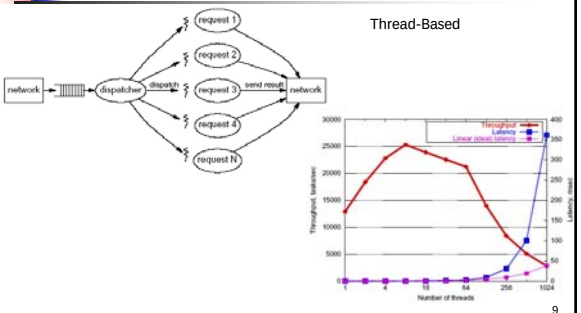
Thread-Based vs. Event-Based Concurrency (Contd.)



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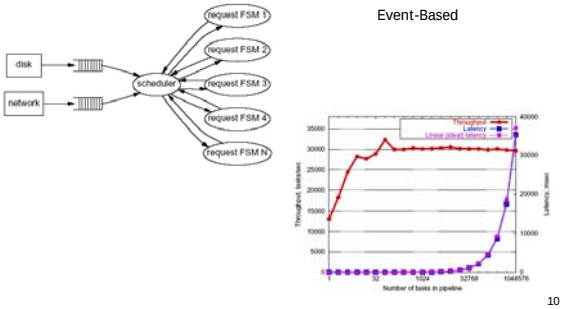
Thread-Based vs. Event-Based Concurrency (Contd.)



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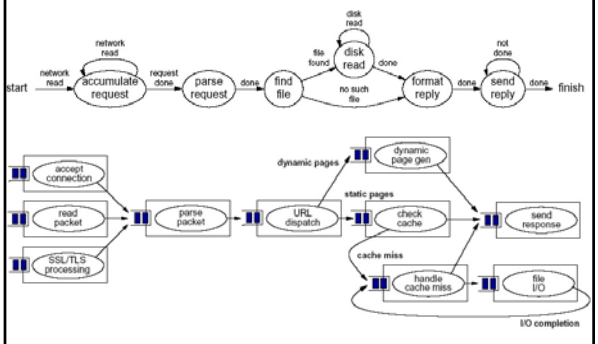
SEDA



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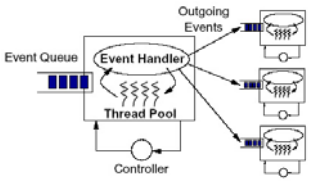
SEDA - Stage



- Each stage has its own thread pool
- Controller adjusts resources
  - Controller may set "admission control policy"
    - Threshold, rate-control, load shedding
  - Adjust thread pool size
  - Adjust number of events processed

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Overload Management

- Resource Containment
  - Static method
  - Usually set by admin
- Admission Control
  - Parameter based
  - Static or dynamically adjusted
- Control-theoretic approach
- Service Degradation
  - Deliver lower fidelity Service

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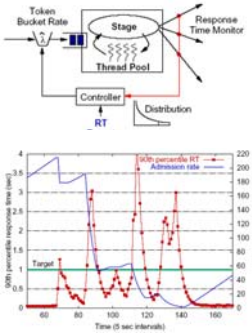
SEDA Admission Control Policy

- Using 90th percentile of set response time as performance metric
- Adaptive admission control
  - Uses user classes (IPs, HTTP header info)
  - Uses token bucket traffic shaper
  - Possible to use drop-tail, FIFO, RED or other algorithms



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Event-driven programming

- Benefits ☺
  - Applications can map cleanly into modules
  - Each stage self-contained
  - Typically little/no data sharing
- Challenges
  - Determining stages
  - Stages can block
  - Managing continuations between stages
  - Tracking events

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Software Contribution

- Sandstorm: SEDA Framework
- NBIO: Non-blocking I/O implementation
- Haboob: Implementation of a web-server
- aTLS: library for SSL and TLS support
  - All Java implementations, NBIO uses JNI
  - Last updated July 2002

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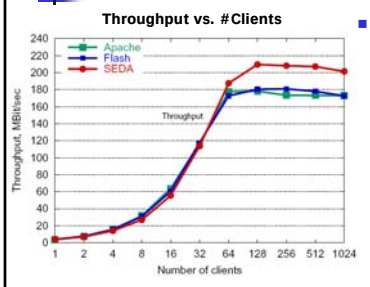
Experimental Evaluation



- Haboob web-server
  - Static and dynamic file load – SpecWEB99 benchmark
  - 1 to 1024 clients
  - Total files size 3.31Gb
  - Memory Cache of 200Mb

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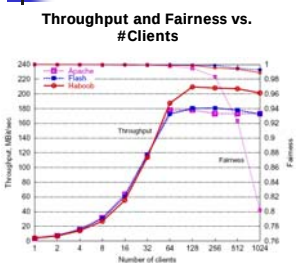
Evaluation (Contd.)



- Jain's Fairness Index
  - Equality of services to all clients
  - Suppose server can support 100 requests
  - Totally fair if it processes 10 requests of each
  - Unfair if say it processes 20 requests each for 5 users

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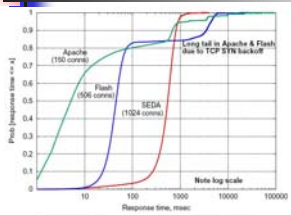
Evaluation (Contd.)

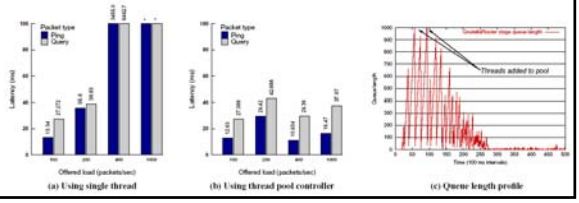


Cumulative response time distribution for 1024 clients

	SEDA	Flash	Apache
Mean RT	547 ms	665 ms	475 ms
Max RT	3.8 sec	37 sec	1.7 minutes

Evaluation (Contd.)

- Gnutella packet router
  - Non-traditional internet service, routing P2P packets
  - Ping: Discover other nodes
  - Query: Search for files being served



Summary

- Notion of stages
- Explicit event queues
- Dynamic resource controllers
- + Improved performance
- + Well-conditioned services
- + Scalability

My Evaluation

- Increased performance at higher loads which was the motivation
- Marginal increase in throughput but significantly more fair for higher loads
- Throughput does not degrade when resources exhausted
- Response times of other servers better at lower loads

My Evaluation

- In context of duality of OS structures (Lauer & Needham)
  - SEDA is message-oriented
  - Message and Procedure oriented can be directly mapped, however independent of the application under consideration can performance indeed be similar?
  - We will see how Capriccio does this – but no simple mapping!

Questions to consider

- SEDA is so good but the whole world (Apache, IIS, BEA, IBM, Netscape…) still uses thread-based servers?
- In real world scenarios how often are there load spikes, should goal be to increase average case performance instead?
- Is throughput or fairness a better metric?
- Being faster “despite” being in Java a bias or poor choice of language?

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