Locks, Deadlocks and Abstractions: Experiences with Multi-Threaded Programming at CloudFlare, Inc.

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Roadmap

• What is CloudFlare

• How we use multi-threading

• Concurrency bugs in two example programs

• Concurrency analysis tools we use
CloudFlare: Next-Gen Content Delivery Network
CloudFlare: exponential traffic, linear hardware
(note log scale)
Supporting:

- 155,000 Sites
- 350,000 Requests / Second (peak)
- 17 Billion Page Views (last 30 days)
- 350 Million Unique Visitors (last 30 days)
Typical Production Server:

- Intel 24 Core CPU (with Hyper-threading)
- 48 MB RAM
- SSD storage
Ways We Write Multi-Threaded Code

• Callback Framework
  (someone else does the hard work)

• Custom Threading
  (up to the implementor)
Callback Frameworks

- Request handling consists of multiple sequential calls
- Multiple requests handled in parallel
- Implement callback functions
- Framework persists data across calls
- Examples:
  - FUSE
  - NGINX
  - DNS
Custom Parallelism

• Boost Library
• Synchronization with locks, db transactions
• Examples:

  • Log Analysis
DNS

ian@carrot:/home/g/import-log$ dig linuxdating.com

; <<< DiG 9.7.1-P2 <<< linuxdating.com
;; global options: +cmd
;; Got answer: 2...1.pdf
;; <<<HEADER<- opcode: QUERY, status: NOERROR, id: 46055
;; flags: qr rd ra; QUERY: 1, ANSWER: 2, AUTHORITY: 0, ADDITIONAL: 0

;; QUESTION SECTION:
;linuxdating.com. IN A

;; ANSWER SECTION:
linuxdating.com. 5 IN A 173.245.60.112 Pinnacle
linuxdating.com. 5 IN A 199.27.134.39 Hilton.pdf

;; Query time: 212 msec
;; SERVER: 192.168.222.2#53(192.168.222.2)
;; WHEN: Thu Oct 20 20:59:22 2011
;; MSG SIZE rcvd: 65
Log Processor: Logs Into Analysis

![Apache Log Viewer](Image)

<table>
<thead>
<tr>
<th>IP Address</th>
<th>Date</th>
<th>Request</th>
<th>Status</th>
<th>Size</th>
<th>Country</th>
<th>Referer</th>
</tr>
</thead>
<tbody>
<tr>
<td>65.55.104.14</td>
<td>03/06/2008 05:46:01</td>
<td>GET /robots.txt HTTP/1.1</td>
<td>200</td>
<td>64</td>
<td>United States</td>
<td></td>
</tr>
<tr>
<td>65.55.104.14</td>
<td>03/06/2008 05:46:01</td>
<td>GET /HTTP/1.1</td>
<td>304</td>
<td>0</td>
<td>United States</td>
<td></td>
</tr>
<tr>
<td>72.32.126.34</td>
<td>03/06/2008 05:52:54</td>
<td>GET /contents.php?prefix=<a href="http://www.patriotic">http://www.patriotic</a>...</td>
<td>404</td>
<td>300</td>
<td>United States</td>
<td></td>
</tr>
<tr>
<td>65.55.25.138</td>
<td>03/06/2008 06:40:30</td>
<td>GET /robots.txt HTTP/1.1</td>
<td>200</td>
<td>64</td>
<td>United States</td>
<td></td>
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<tr>
<td>65.55.25.138</td>
<td>03/06/2008 06:40:31</td>
<td>GET /HTTP/1.1</td>
<td>304</td>
<td>0</td>
<td>United States</td>
<td></td>
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<tr>
<td>65.55.25.138</td>
<td>03/06/2008 07:51:40</td>
<td>GET /shots HTTP/1.1</td>
<td>301</td>
<td>255</td>
<td>United States</td>
<td></td>
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<tr>
<td>65.55.25.138</td>
<td>03/06/2008 07:58:36</td>
<td>GET /home.html HTTP/1.1</td>
<td>200</td>
<td>3390</td>
<td>United States</td>
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<tr>
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<td>03/06/2008 08:12:10</td>
<td>GET /faq.txt HTTP/1.1</td>
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<td>943</td>
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<tr>
<td>65.55.25.138</td>
<td>03/06/2008 08:24:55</td>
<td>GET /shots/openpic.php?pic=seealso_se.png ...</td>
<td>200</td>
<td>316</td>
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<tr>
<td>65.55.25.138</td>
<td>03/06/2008 08:24:57</td>
<td>GET /shots/openpic.php?pic=main_menu_sub...</td>
<td>200</td>
<td>319</td>
<td>United States</td>
<td></td>
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<tr>
<td>65.55.25.138</td>
<td>03/06/2008 08:26:12</td>
<td>GET /versionhist.html HTTP/1.1</td>
<td>304</td>
<td>0</td>
<td>United States</td>
<td></td>
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<td>65.55.25.138</td>
<td>03/06/2008 08:26:19</td>
<td>GET /shots/openpic.php?pic=sure_tour.png H...</td>
<td>200</td>
<td>311</td>
<td>United States</td>
<td></td>
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<td>65.55.25.138</td>
<td>03/06/2008 08:26:21</td>
<td>GET /shots/openpic.php?pic=sidebar.png HT...</td>
<td>200</td>
<td>309</td>
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<tr>
<td>65.55.25.138</td>
<td>03/06/2008 08:27:13</td>
<td>GET /shots/openpic.php?pic=toolbar.png HT...</td>
<td>200</td>
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<td>GET /hyperExpi HTTP/1.1</td>
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<td>65.55.25.138</td>
<td>03/06/2008 08:28:15</td>
<td>GET /shots/openpic.php?pic=main_minim.png ...</td>
<td>200</td>
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<td>65.55.232.15</td>
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<td>GET /flock/HTTP/1.1</td>
<td>301</td>
<td>255</td>
<td>United States</td>
<td></td>
</tr>
<tr>
<td>65.55.25.138</td>
<td>03/06/2008 08:31:28</td>
<td>GET /robots.txt HTTP/1.1</td>
<td>200</td>
<td>64</td>
<td>United States</td>
<td></td>
</tr>
</tbody>
</table>

Welcome to Apache Logs Viewer...Please Donate, Thanks
Log Processor
Map / Reduce
# Errors Across Projects:

<table>
<thead>
<tr>
<th></th>
<th>Logger</th>
<th>DNS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LoC (Excluding Frameworks)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Source Commits</td>
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<tr>
<td>Transactions</td>
<td></td>
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<tr>
<td>Locks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Concurrent Threads</td>
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<tr>
<td>Race Conditions</td>
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<tr>
<td>Deadlocks</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Native</td>
<td>Callback</td>
</tr>
<tr>
<td></td>
<td>2,833</td>
<td>1,276</td>
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<tr>
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<td>85</td>
<td>79</td>
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<tr>
<td></td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0</td>
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<tr>
<td></td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

Sunday, October 23, 2011
// accept a visitor to a record
bool accept(const char* kbuf,
    size_t ksiz,
    Visitor* visitor,
    bool writable = true) {
    _assert_(kbuf && ksiz <= kc::MEMMAXSIZ && visitor);
    kc::ScopedRWLock lock(&mlock_, false);
    size_t rsiz;
    const char* rbuf;
Log Errors: Write Synchronization

```cpp
boost::mutex::scoped_lock lock(g_apache_feed_mutex);
(*apache_file_out) << linebuf << endl;
lock.unlock();
```
Tools Used:

- gdb
- Valgrind
- Helgrind
- aptitude install
What we need from a tool

• Have heard about it
• Easy to install
• Good documentation
GCC: g++ -O2

ICC: icpc -Ofast

ICC ~30% Faster for log code than gcc
atop: gamification of performance profiling
T-Shirts?
T-Shirts!