Using OpenSSL to boost Tomcat

Jean-Frederic Clere
What I will cover

● Who I am.

● Connectors
  – NIO, NIO2, APR
  – OpenSSL Implementation
  – HTTP/2 and ALPN in Tomcat.

● Performance tests
  – With ab and h2load as client load generator.

● Questions?

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Who I am

Jean-Frederic Clere

Red Hat

Years writing JAVA code and server software

Tomcat committer since 2001

Doing OpenSource since 1999

Cyclist/Runner etc

Lived 15 years in Spain (Barcelona)

Now in Neuchâtel (CH)

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What is a Connector?

- Tomcat's interface to the world
- Binds to a port
- Understands a protocol and possible upgrades.
- Dispatches requests (example)
Tomcat Connectors

- Java Non-blocking I/O (NIO)
- Native / Apache Portable Runtime (APR)
- Java NIO.2

Technically, there are combinations of all of the above with HTTP and AJP protocols.

The presentation focuses on HTTP and on NIO/NIO2.
What is new in Tomcat 9 / 8.5

- Property sslImplementationName
  - Allows replacement of the SSL code
  - OpenSSLImplementation (use OpenSSL)
  - JSSEImplementation (use JSSE)

- UpgradeProtocol
  - Allows protocol upgrade from HTTP/1.1
  - HTTP/2 (yes)

- Websocket (cool) / Speedy (no plan to support it).
Why a new SSL Implementation

- **JSSE:**
  - Very slow
  - Missing features: like ALPN (JEP 244: TLS Application-Layer Protocol Negotiation)
  - Hardware acceleration very partial (like AES in java8)

- **Native connector:**
  - Fast but a lot of native code
  - Use OpenSSL for SSL/TLS.

- **New OpenSSL implementation:**
  - Fast.
  - Uses only OpenSSL for native code (no native socket, poller etc).
  - Works with NIO and NIO2.
  - Uses OpenSSL for SSL/TLS. (warp, unwarp, handshake etc).
OpenSSL Implementation

- Code originates from netty-tcnative a forked Tomcat Native
- Prototype (last year):
  - Done with the BeFriNe University
  - Tested and ported to tc_trunk last summer
- SSL Configuration compatible with the JSSE connection (*)
- Uses keystores (*)
- Uses SSL BIO to wrap/unwarp, handshake
- Uses java NIO or NIO2 Sockets for the reads and writes
- Automatically enabled when TC native is installed/enabled (*)
How TLS is done in Tomcat

Webserver

JSSE Con.

JSSE SSL Engine

NIO/NIO2

OpenSSL Impl.

APR Connector

OpenSSL Impl.

APR JNIs

OpenSSL

APR Internals

OS Sockets

Java stdlib

C/ Native

Tomcat Native
How does that work?

SSLContext

JSSESSLContext
- createSSLEngine()

SSLEngine

OpenSSLContext
- createSSLEngine()
- wrap()
- unwrap()
- getSession()
- etc...

OpenSSLEngine
- Overrides

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How does wrap works

wrap(plaintext, encrypted)

writePlainTextData
write_ToSSL
SSL_write

BIO_new_bio_pair

internalBIO

networkBIO

SSL_set_bio

readEncryptedData
readFromBIO
BIO_read

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How does unwrap works

unwrap(encrypted, plaintext)

BIO_new_bio_pair

readPlaintextData
readFromSSL
SSL_read

internalBIO

networkBIO

writeEncryptedData
writeToBIO
BIO_write

SSL_set_bio

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Connector Performance

- Compare connectors throughput against each other
- Only static content was compared, varying file sizes
- Run on “fast” machines, 10 Gbps local network
- Tests:
  - Compare the connectors (trunk) NIO, NIO2 and APR
  - Using JSSE and OpenSSL
  - First without “sendfile”
Connector Throughput (c40)

Concurency 40

File Size

Throughput KBytes/sec

0 100000 200000 300000 400000 500000 600000 700000

4KiB.bin 16KiB.bin 32KiB.bin 64KiB.bin 128KiB.bin 256KiB.bin 512KiB.bin 1MiB.bin 2MiB.bin 4MiB.bin 8MiB.bin 16MiB.bin 32MiB.bin

coyote_aprHttps
coyote_nio2_opensslHttps
coyote_nio_jssseHttps
coyote_nio_opensslHttps

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Connector Throughput (c80)

File Size

- 4KiB.bin
- 8KiB.bin
- 16KiB.bin
- 32KiB.bin
- 64KiB.bin
- 128KiB.bin
- 256KiB.bin
- 512KiB.bin
- 1MiB.bin
- 2MiB.bin
- 4MiB.bin
- 8MiB.bin
- 16MiB.bin
- 32MiB.bin

Throughput: KB/sec

- coyote_apr_https
- coyote_nio2_openssl_https
- coyote_nio_jsse_https
- coyote_nio_openssl_https

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Connector Performance

- With sendfile
  
  In fact with TLS/SSL sendfile is emulated
Connector Throughput (c8)

Concurency 8

Throughput in Kbytes/sec

File Size

- coyote_aprHttps
- coyote_nio2_opensslHttps
- coyote_nio_jsseHttps
- coyote_nio_opensslHttps

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Connector Throughput (c40)

Concurency 40

Throughput in Kbytes/Sec

File Size

4KiB.bin 8KiB.bin 16KiB.bin 32KiB.bin 64KiB.bin 128KiB.bin 256KiB.bin 512KiB.bin 1MiB.bin 2MiB.bin 4MiB.bin 8MiB.bin 16MiB.bin 32MiB.bin

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Connector Throughput (c80)

File Size

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Concurency 80

- coyote_apr_https
- coyote_nio2_openssl_https
- coyote_nio_jsse_https
- coyote_nio_openssl_https

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Connector CPU Use

Concurreny 8

Concurreny 40

Concurreny 80

- coyote_apr_https
- coyote_nio2_openssl_https
- coyote_nio_jsse_https
- coyote_nio_openssl_https

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Conclusion:
- OpenSSL performs better than JSSE
- NIO and NIO(2) give similar results
- Emulated sendfile doesn't help a lot (bigger files better).
- APR isn't needed
- Until Java9 is released OpenSSL is needed for HTTP/2
Questions?
Thank you!

- jfclere@gmail.com
- users@tomcat.apache.org
- Repo with the scripts for the tests:
  - https://github.com/jfclere/AC2014scripts