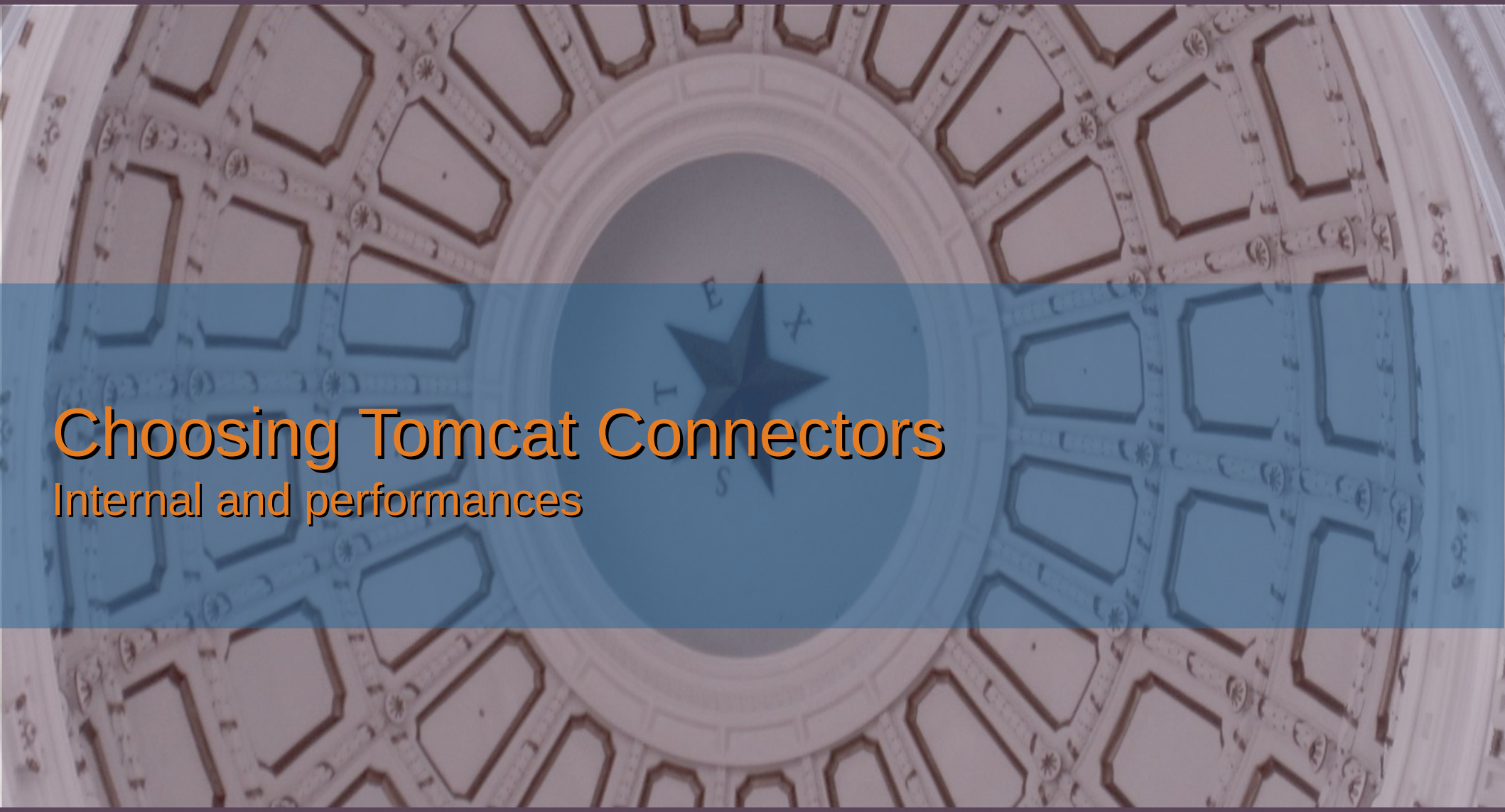
Jean-Frederic Clere

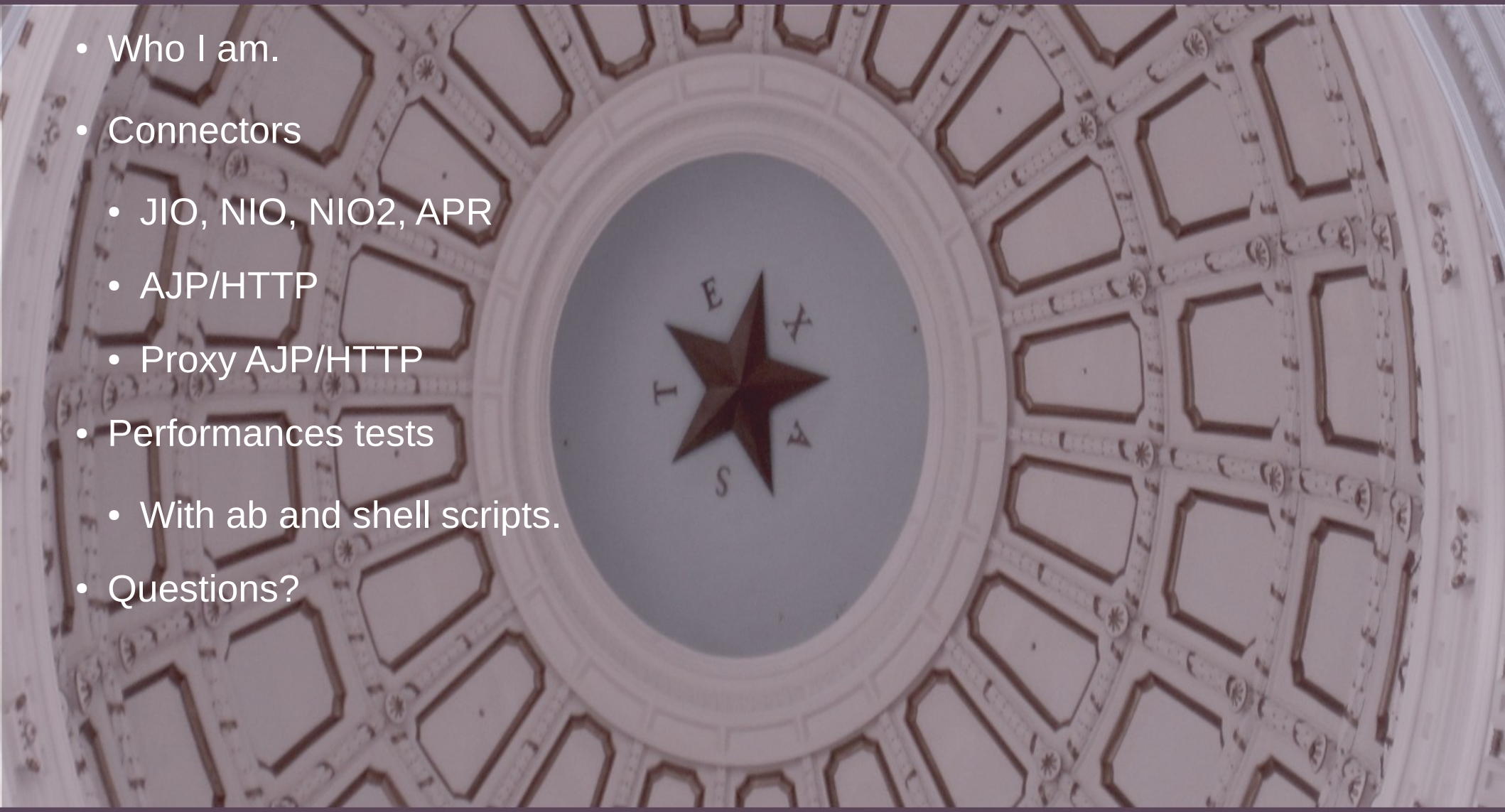
Red Hat



Choosing Tomcat Connectors

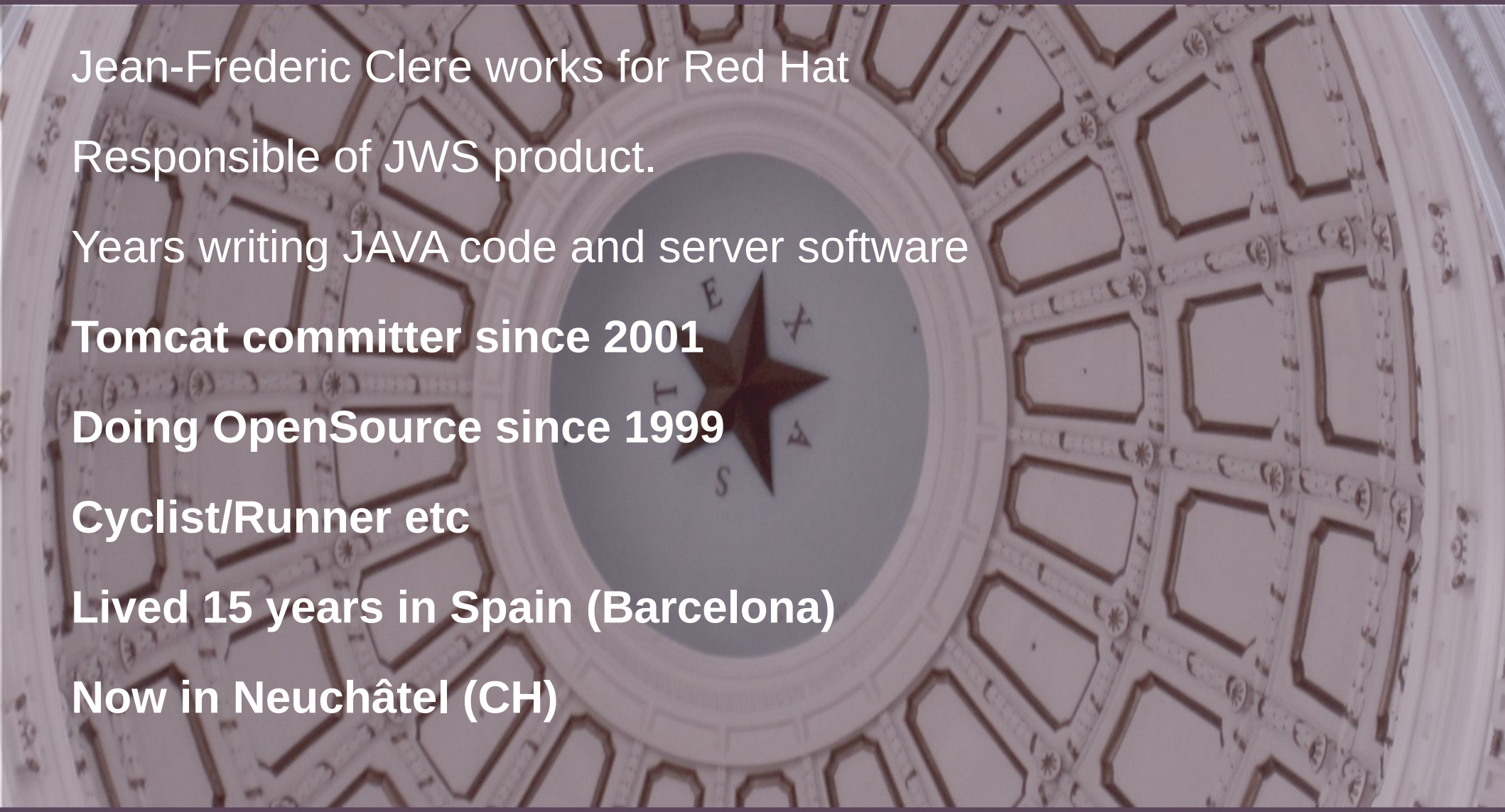
Internal and performances

What I will cover



- Who I am.
- Connectors
  - JIO, NIO, NIO2, APR
  - AJP/HTTP
  - Proxy AJP/HTTP
- Performances tests
  - With ab and shell scripts.
- Questions?

Who I am



Jean-Frederic Clere works for Red Hat

Responsible of JWS product.

Years writing JAVA code and server software

Tomcat committer since 2001

Doing OpenSource since 1999

Cyclist/Runner etc

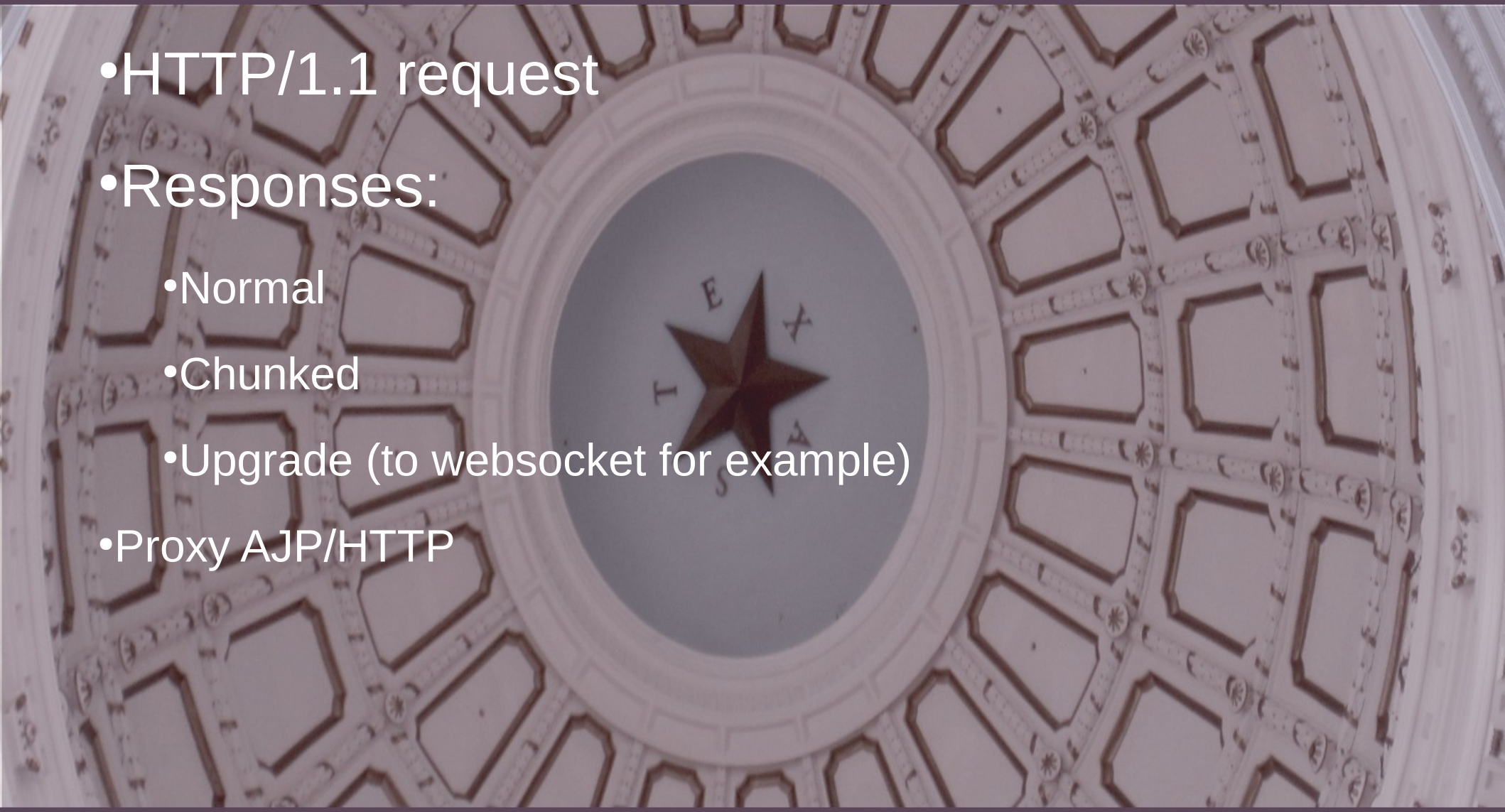
Lived 15 years in Spain (Barcelona)

Now in Neuchâtel (CH)

Remote location

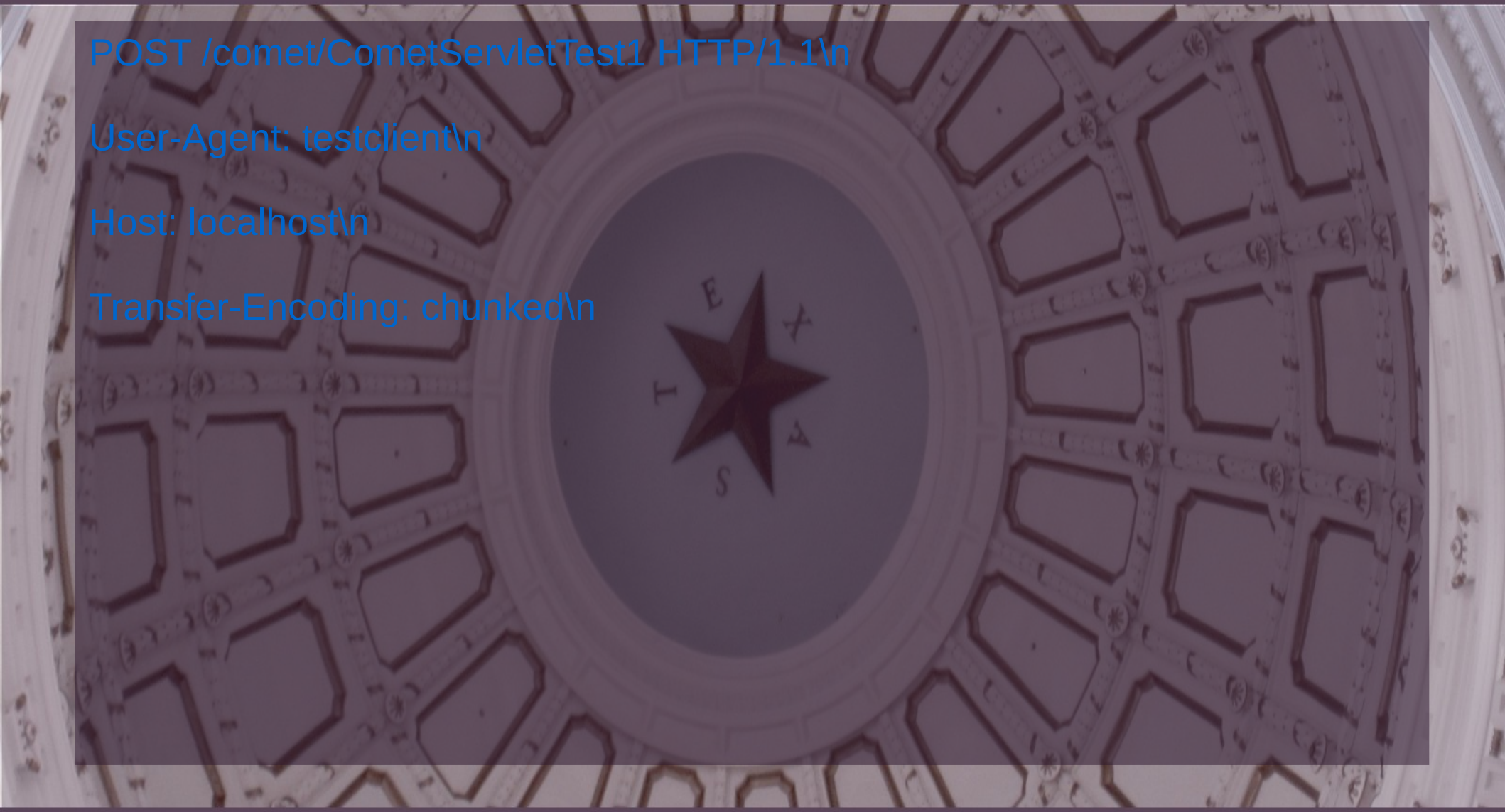
Red Hat Office Neuchâtel

Protocol basic



- HTTP/1.1 request
- Responses:
  - Normal
  - Chunked
  - Upgrade (to websocket for example)
- Proxy AJP/HTTP

Request HTTP/1.1



```
POST /comet/CometServletTest1 HTTP/1.1\n
User-Agent: testclient\n
Host: localhost\n
Transfer-Encoding: chunked\n
```

Response for example

Chunked:

HTTP/1.1 200 OK\n

Server: Apache-Coyote/1.1\n

Set-Cookie: JSESSIONID=obcoR30qJz7DMJfZmsVTt+Uv; Path=/comet\n

Transfer-Encoding: chunked\n

Date: Mon, 07 Nov 2011 22:09:33 GMT\n

Upgrade:

HTTP/1.1 101 Switching Protocols

Upgrade: websocket

Connection: Upgrade

Sec-WebSocket-Accept: HSmrc0sMlYUkAGmm5OPpG2HaGWk=

Sec-WebSocket-Protocol: chat

What is a Connector?

- Tomcat's interface to the world
- Binds to a port
- Understands a protocol
- Dispatches requests
  - protocol="org.apache.coyote.http11.Http11Protocol"
  - protocol="org.apache.coyote.http11.Http11AprProtocol"
  - protocol="org.apache.coyote.http11.Http11NioProtocol"
  - protocol="org.apache.coyote.http11.Http11Nio2Protocol"

Tomcat Connectors

- Java Blocking I/O (BIO or sometimes JIO)
- Native / Apache Portable Runtime (APR)
- Java Non-blocking I/O (NIO)
- Java NIO.2

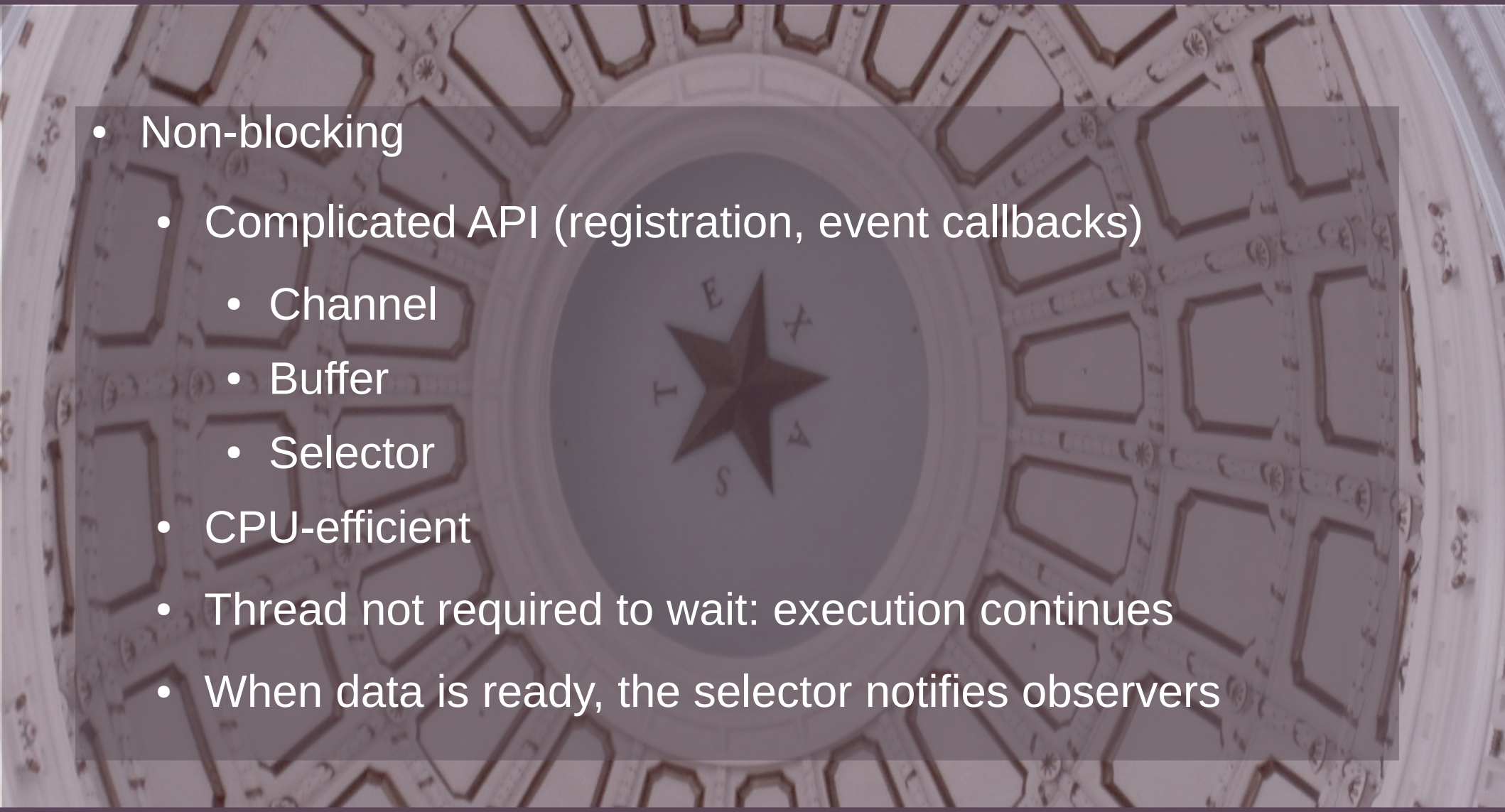
Technically, there are combinations of all of the above with HTTP and AJP protocols.

We'll discuss those a bit later.

Types of I/O

- Polling
  - Straightforward API: peek()
  - CPU-inefficient
  - Thread loops while waiting for data
- Blocking
  - Straightforward API: read()
  - CPU-efficient (blocks)
  - Thread stalls while waiting for data

Types of I/O



- Non-blocking
  - Complicated API (registration, event callbacks)
    - Channel
    - Buffer
    - Selector
  - CPU-efficient
  - Thread not required to wait: execution continues
  - When data is ready, the selector notifies observers

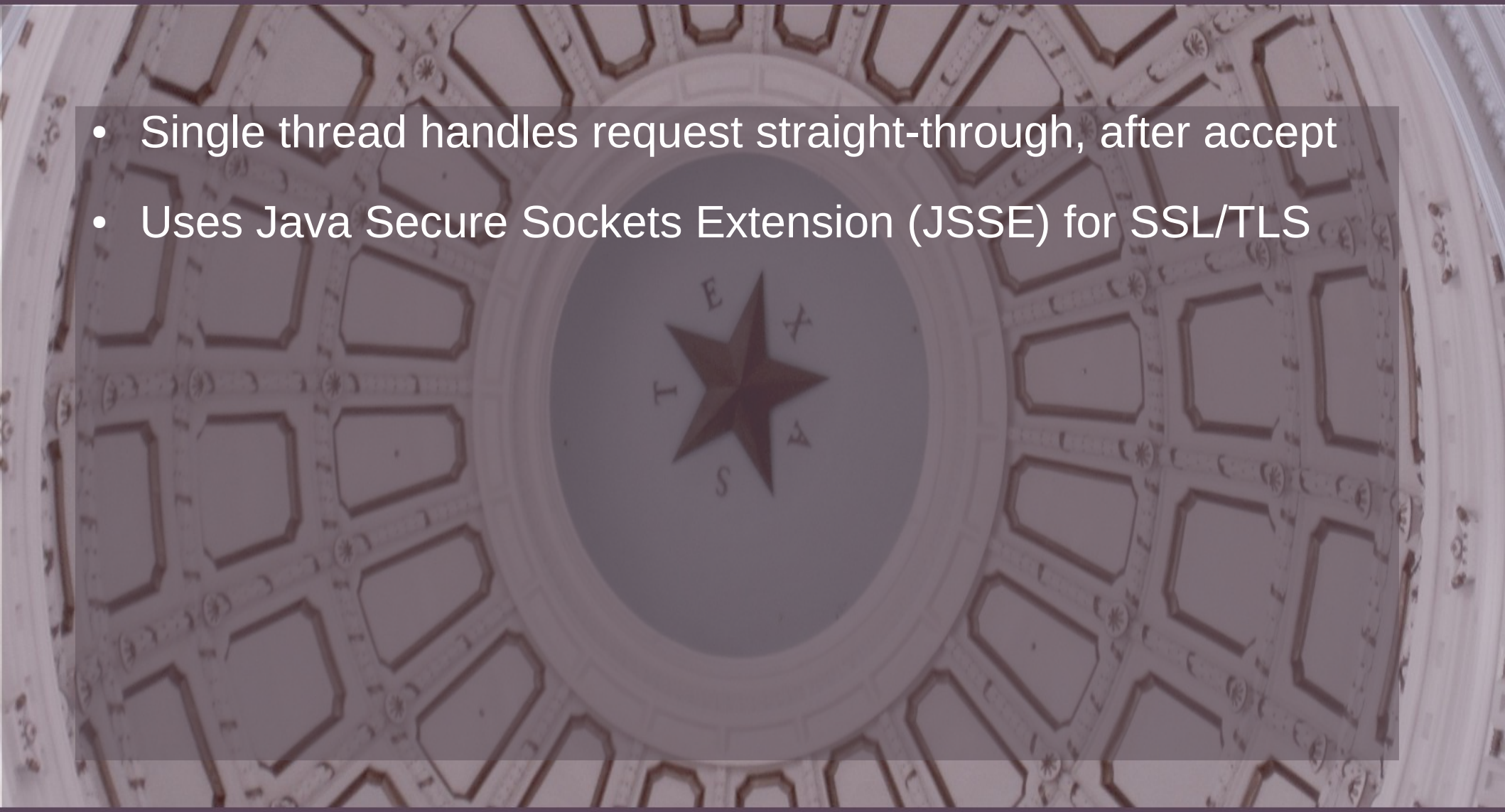
Common Connector Features

- Support for all protocols
  - HTTP, AJP, Websocket
- Support for all dispatch methods
- Standard, Comet, Servlet 3.0 async
  - Support for HTTPS (SSL/TLS)
- Acceptor thread(s) call accept() and hand-off
- Request processor thread pool

Blocking I/O Connector (1)

- All I/O operations are blocking in processor thread
  - SSL handshake
  - Read request line (e.g. GET, POST, etc.)
  - Read request body
  - Write response
  - Read next request (HTTP keep-alive)
- Simple, stable, mature

Blocking I/O Connector (2)

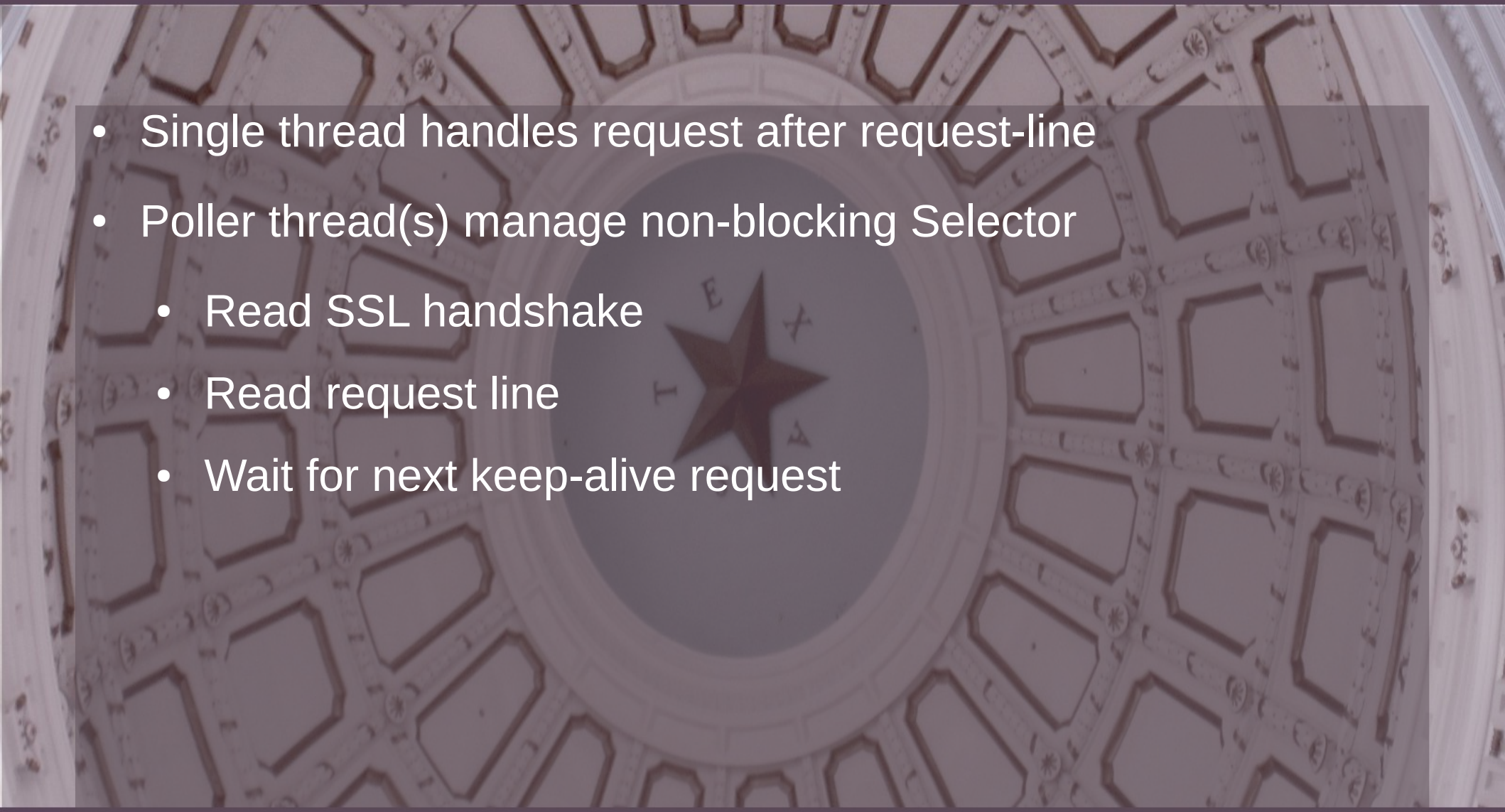


- Single thread handles request straight-through, after accept
- Uses Java Secure Sockets Extension (JSSE) for SSL/TLS

Blocking I/O Connector (3)

- Request throughput limited by thread count
- Clients can waste threads
  - Slow request line (mobile)
  - Aborted keep-alive stalls thread (default=20sec!)
- Unfair: accepted connections get priority for keep-alive requests
- Gone from tomcat9

NON-Blocking I/O Connector (1)



- Single thread handles request after request-line
- Poller thread(s) manage non-blocking Selector
  - Read SSL handshake
  - Read request line
  - Wait for next keep-alive request

NON-Blocking I/O Connector (2)

- Block poller simulates blocking
  - Request header/body reads
  - Response writes
  - Processor thread sleeps during sim-blocking
- Uses JSSE for SSL/TLS
- Supports sendFile

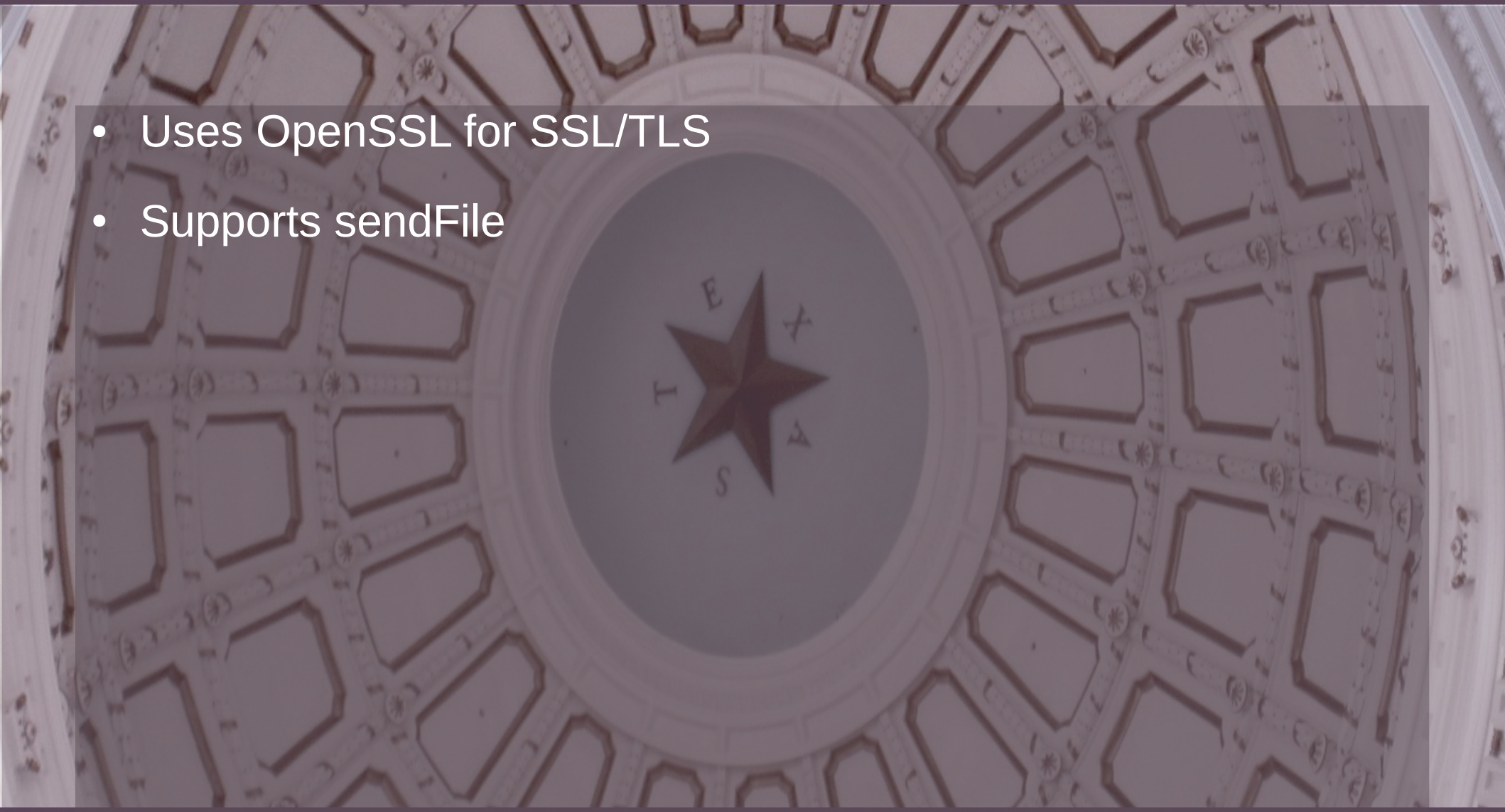
NON-Blocking I/O Connector (3)

- Allows huge number of parallel requests
  - Not limited by request-processor threads
- Slow clients do not stall threads
- Aborted keep-alives die in the poller queue
- Simulated blocking adds overhead

Native Connector (APR) (1)

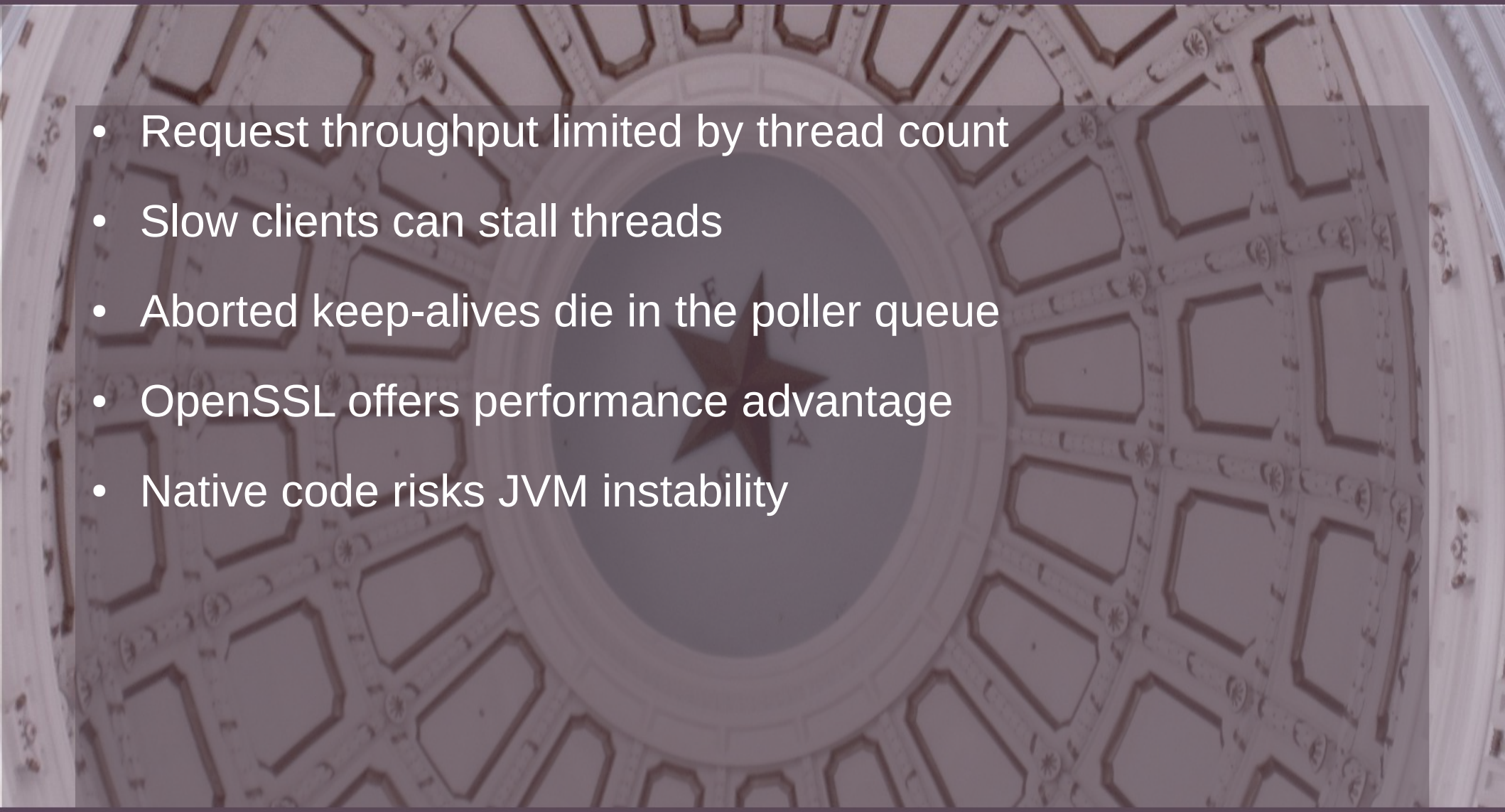
- Single thread handles request after accept()
- Poller thread(s) handle certain I/O reads
  - Wait for next keep-alive request
- Some I/O operations block processor thread
  - SSL handshake
  - Read request line
  - Read request body
  - Write response

Native Connector (APR) (2)



- Uses OpenSSL for SSL/TLS
- Supports sendFile

Native Connector (APR) (3)



- Request throughput limited by thread count
- Slow clients can stall threads
- Aborted keep-alives die in the poller queue
- OpenSSL offers performance advantage
- Native code risks JVM instability

“Non-blocking” I/O Connector NIO.2 (1)

- Single thread handles request after request-line
- The thread are handled via an AsynchronousChannelGroup and completion call backs
  - Read SSL handshake
  - Read request line and headers
  - Wait for next keep-alive request

“Non-blocking” I/O Connector NIO.2 (2)

- NIO2 implementation takes care of blocking using Future objects waiting for IO
  - Request body reads
  - Response writes
  - Processor thread sleeps during blocking
- Uses JSSE for SSL/TLS
- It emulates sendFile (NIO1 transferTo doesn't work with NIO2)

“Non-blocking” I/O Connector NIO.2 (3)

- Allows huge number of parallel requests
  - Not limited by request-processor threads
- Slow clients do not stall threads
- High level of abstraction and blocking over async adds overhead
- NIO 2 provides blocking capabilities over its async IO. The tomcat code is simpler (good) but an overhead still exists.

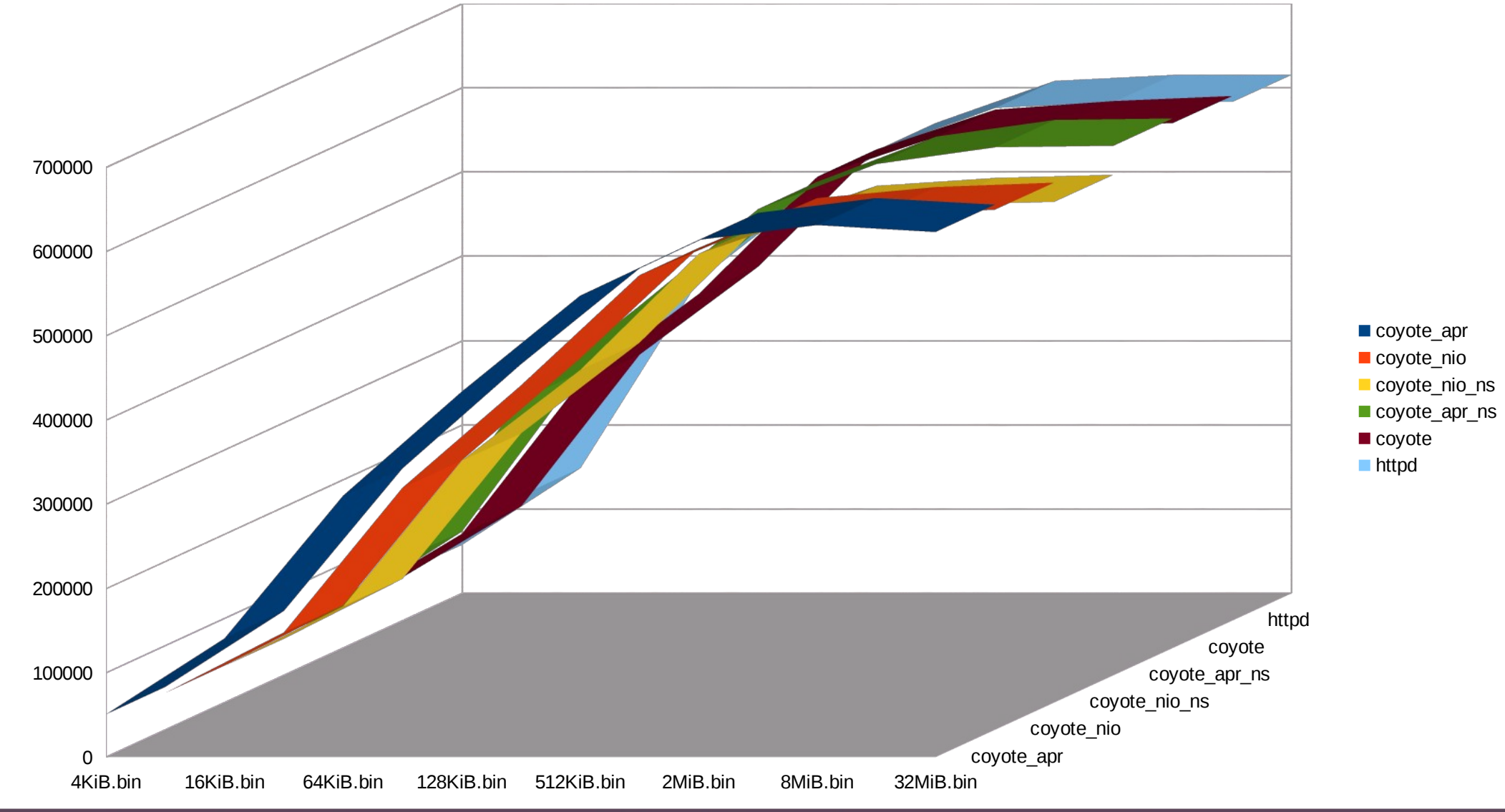
Technical constraints

- Don’t try bother using non-blocking protocols with blocking connectors (BIO+Websocket = bad)
- AJP can be thought of as 100% keep-alive
- AJP doesn’t support HTTP upgrade
- Use of sendFile is highly recommended for any static-content (APR or NIO.1)
- Remember JIO/BIO will be gone in Tomcat9

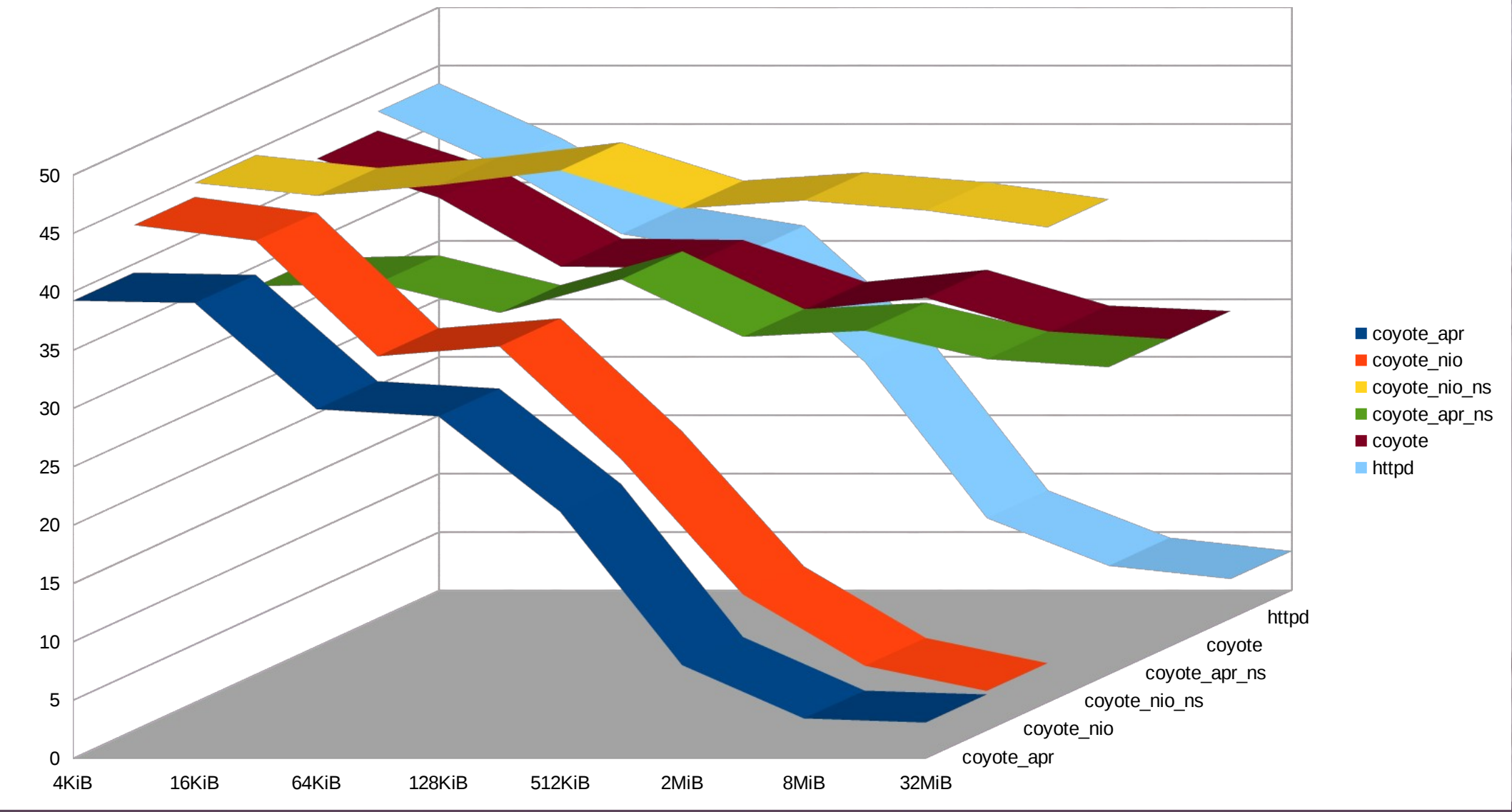
Connector Performance

- Compare connector throughput against each other
- Only static content was compared, varying file sizes
- Run on fast machines, 10 Gbps local network
- Tests:
  - Compare the connectors (tc8.0.14) with httpd (2.2.22) no SSL.
  - Same with SSL also with a recent tc (8.0.21) and httpd (2.4.10) and using java (1.8.0_40).
  - What about using a proxy: compare proxies.

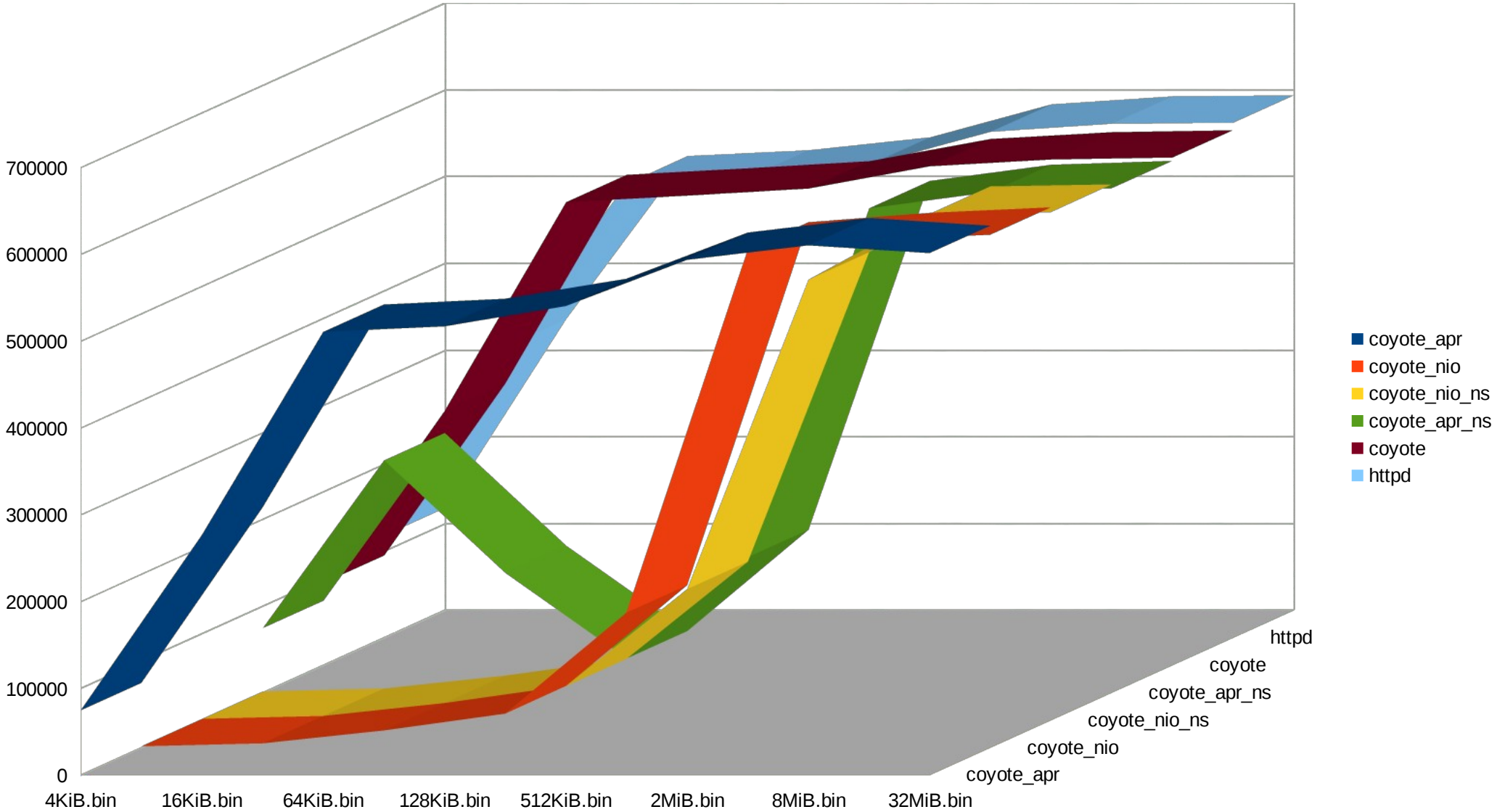
Connector Throughput (c4)



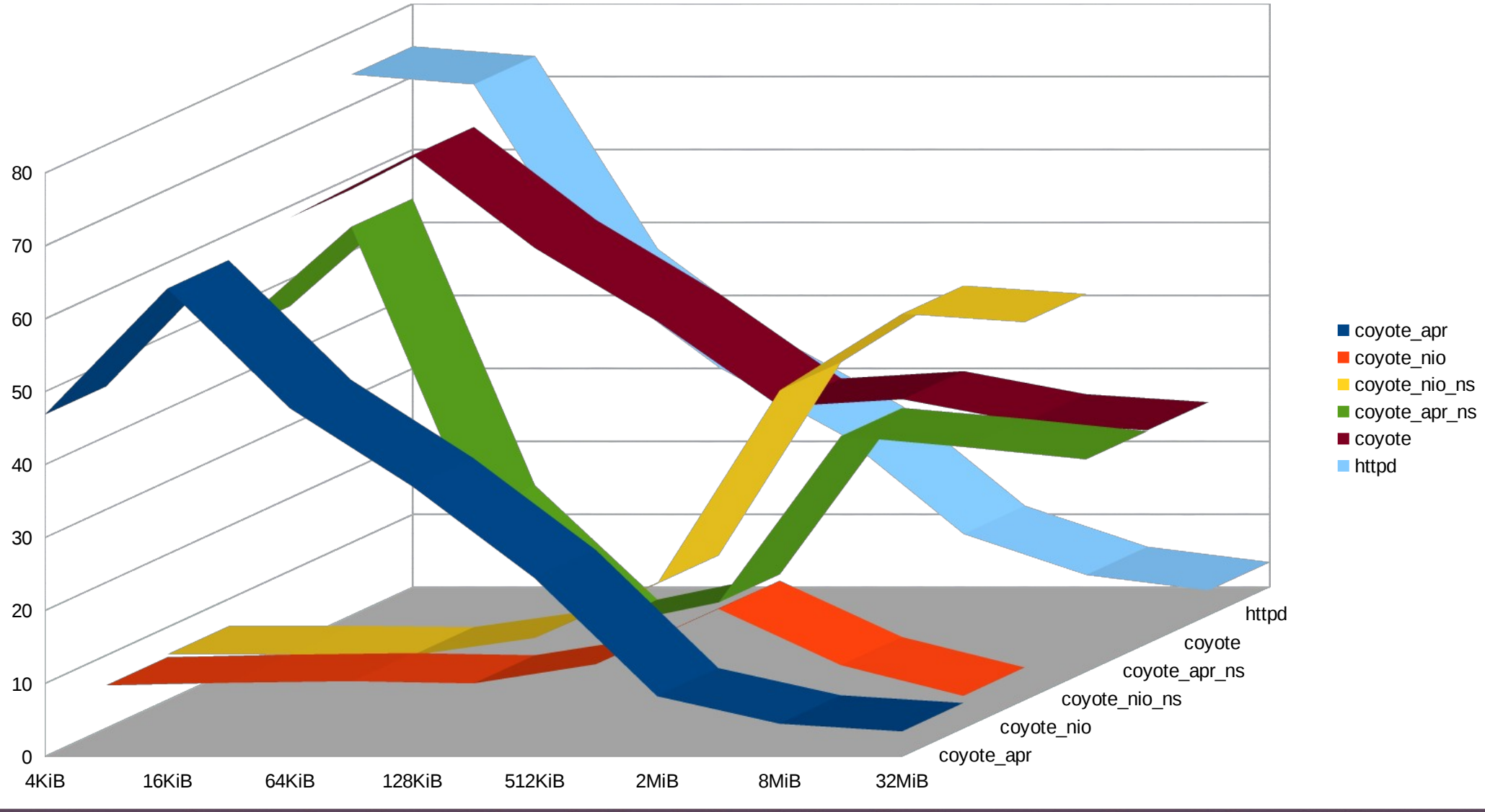
Connector CPU Use (c4)



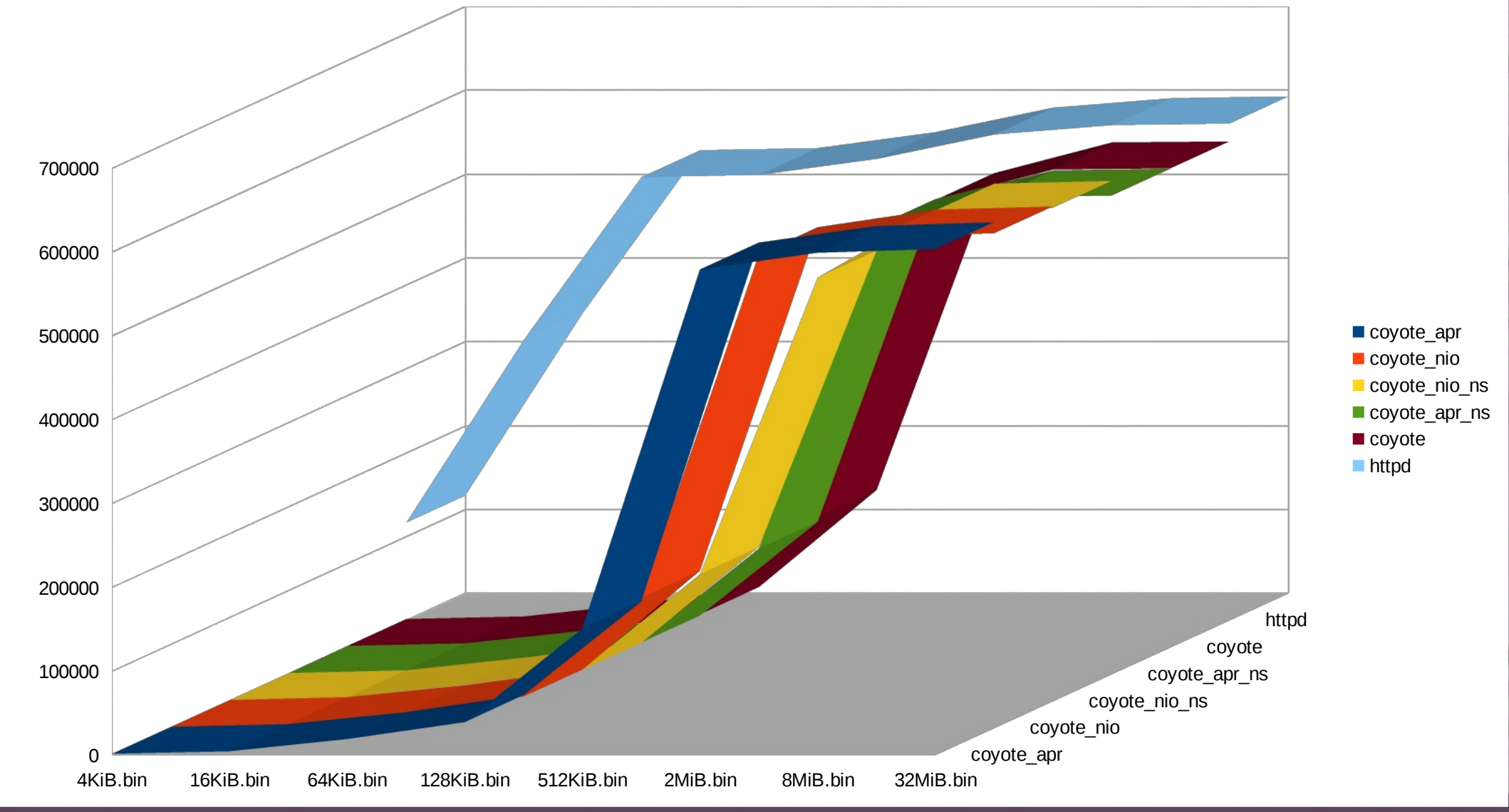
Connector Throughput (c40)



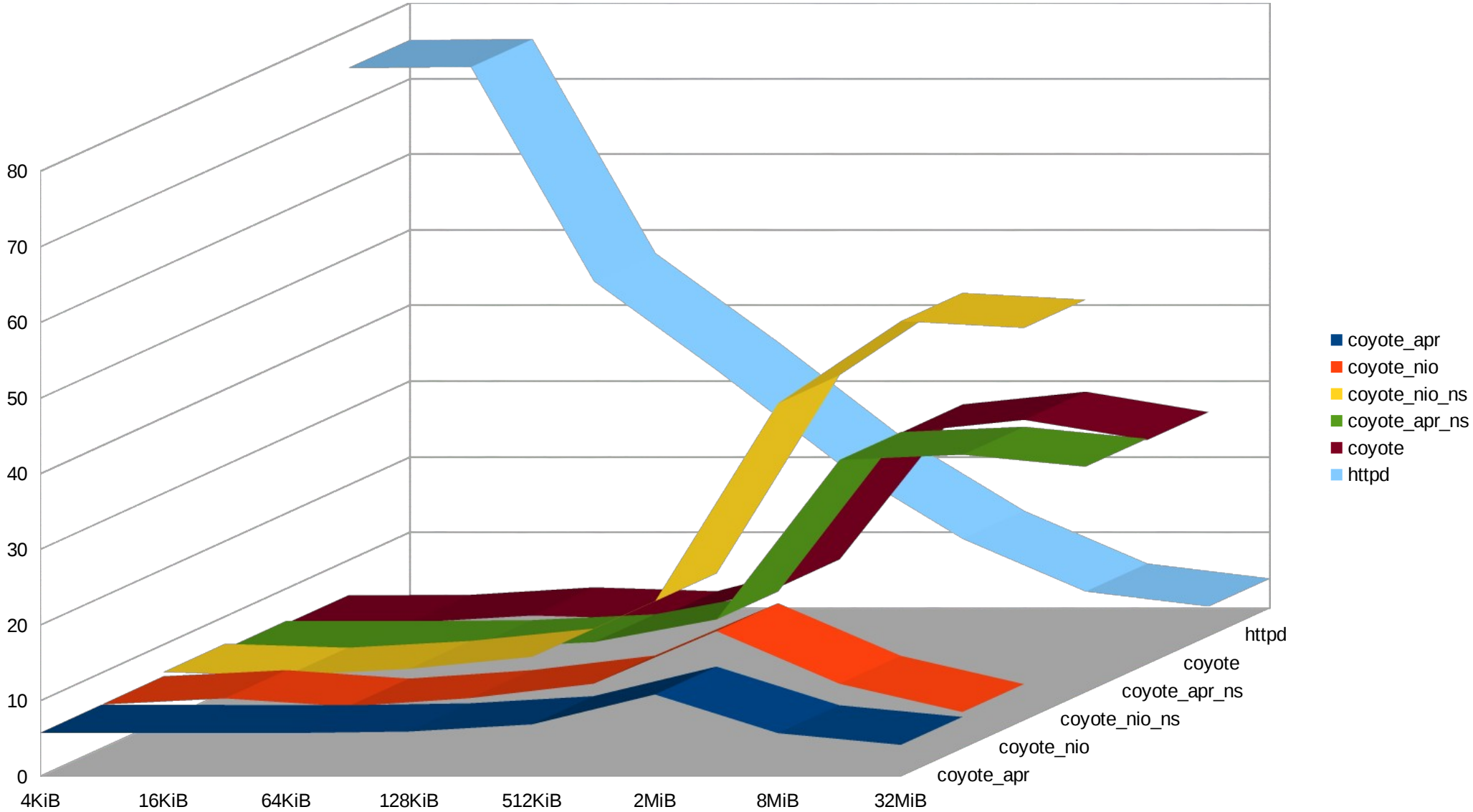
Connector CPU Use (c40)



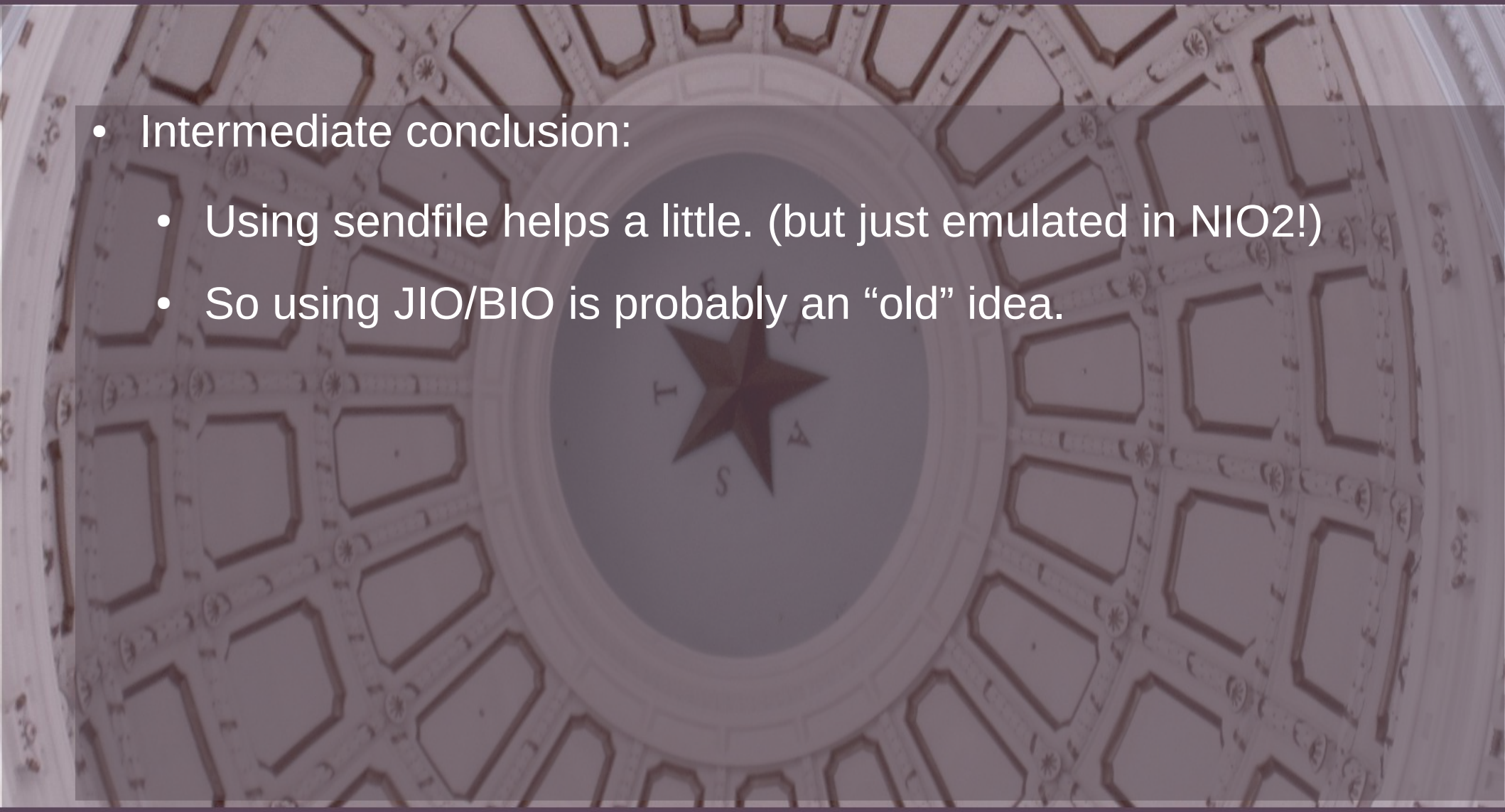
Connector Throughput (c80)



Connector CPU Use (c80)

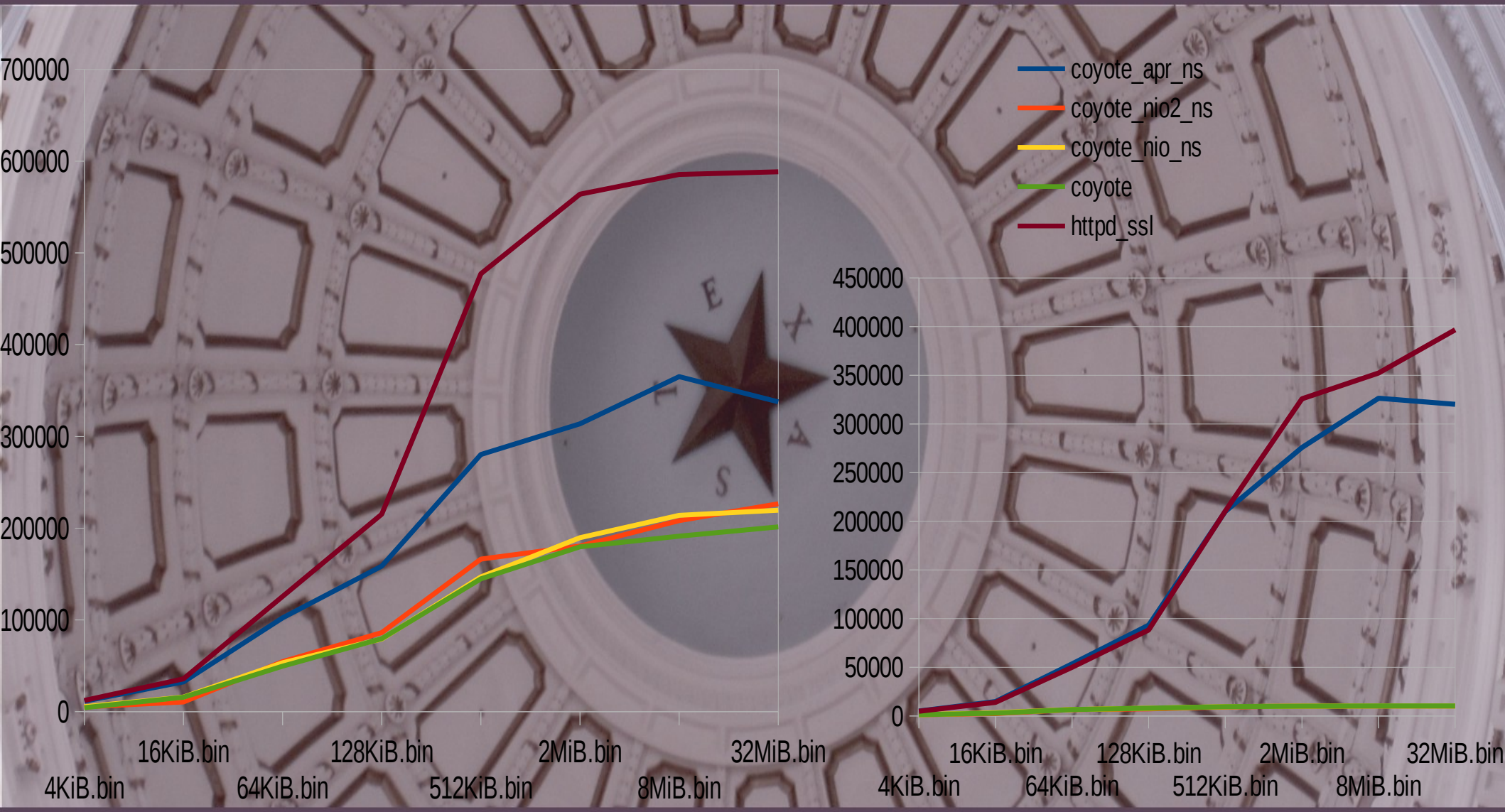


Connector Performance



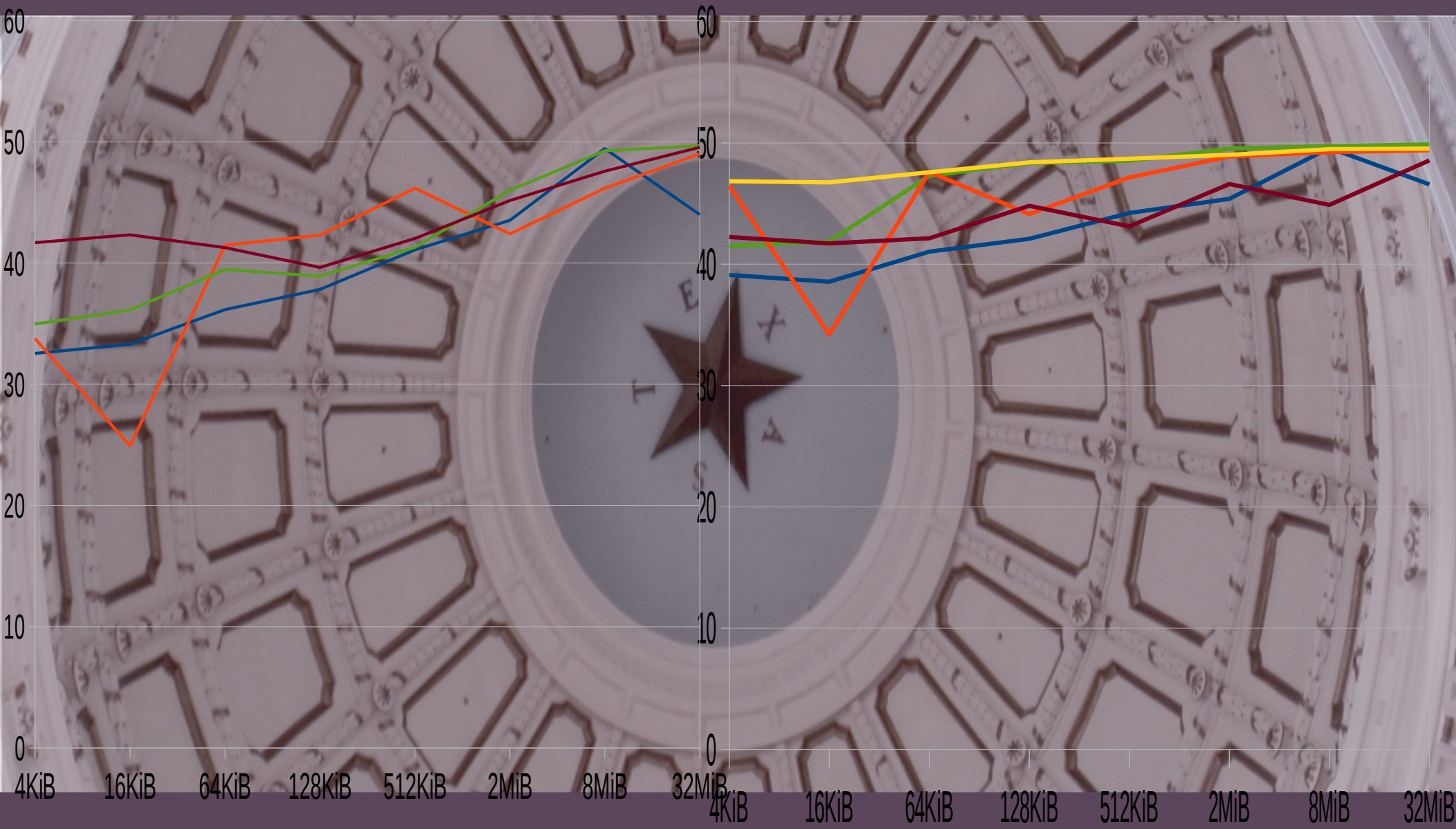
- Intermediate conclusion:
  - Using sendfile helps a little. (but just emulated in NIO2!)
  - So using JIO/BIO is probably an “old” idea.

SSL Connector Throughput (c4)

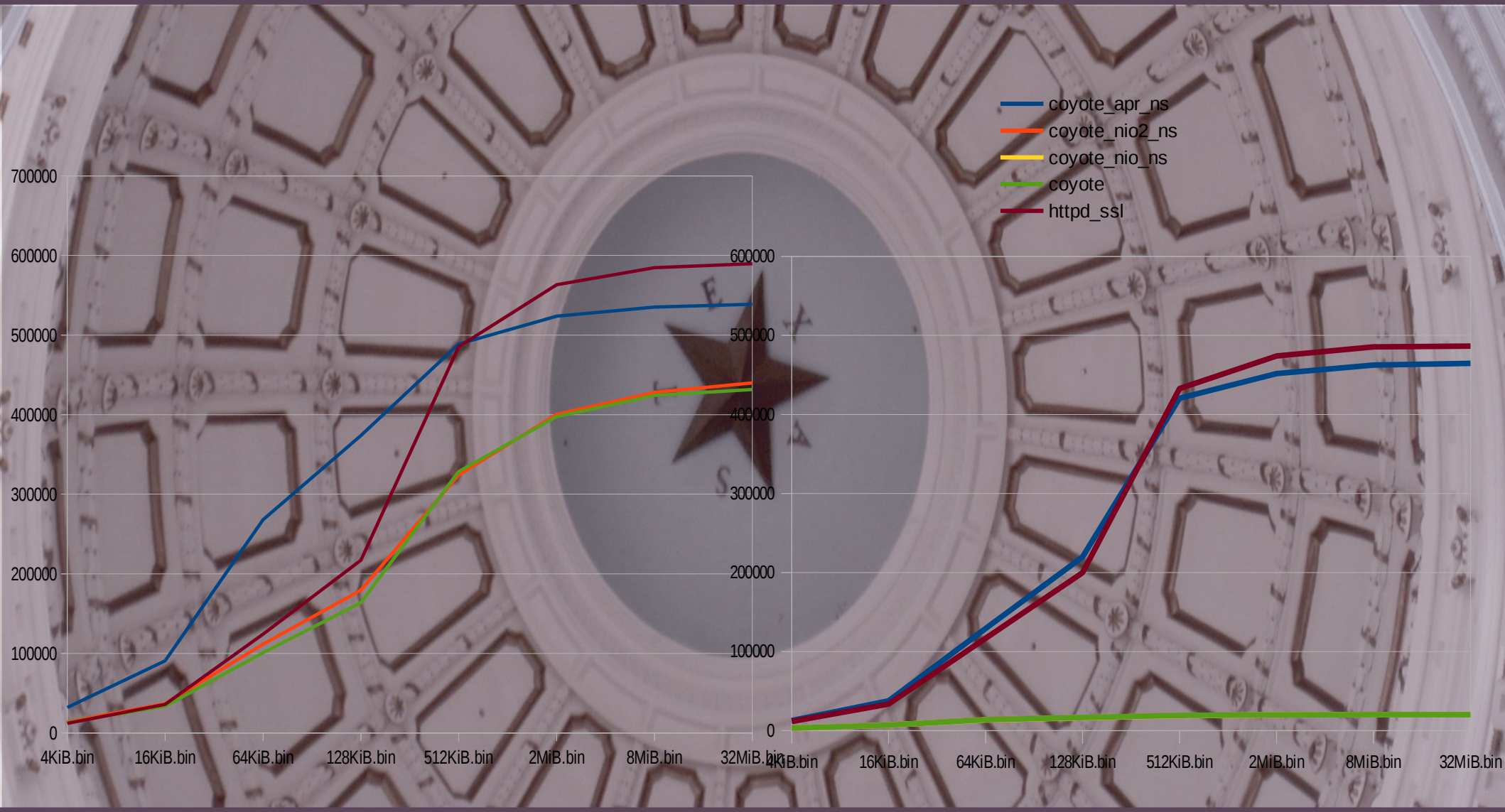


RC4-SHA and AES128-GCM-SHA256

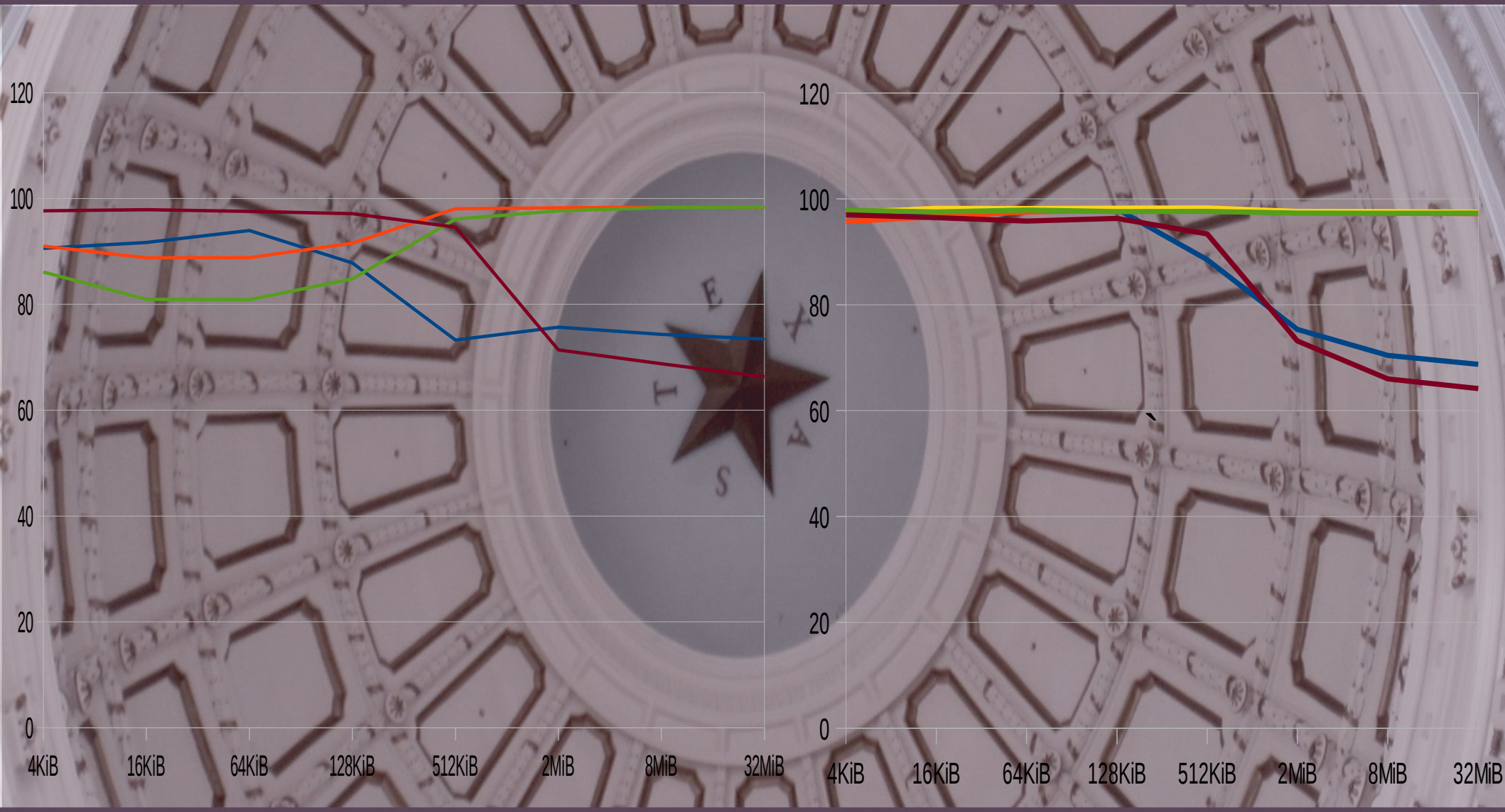
SSL Connector CPU Use (c4)



SSL Connector Throughput (c40)



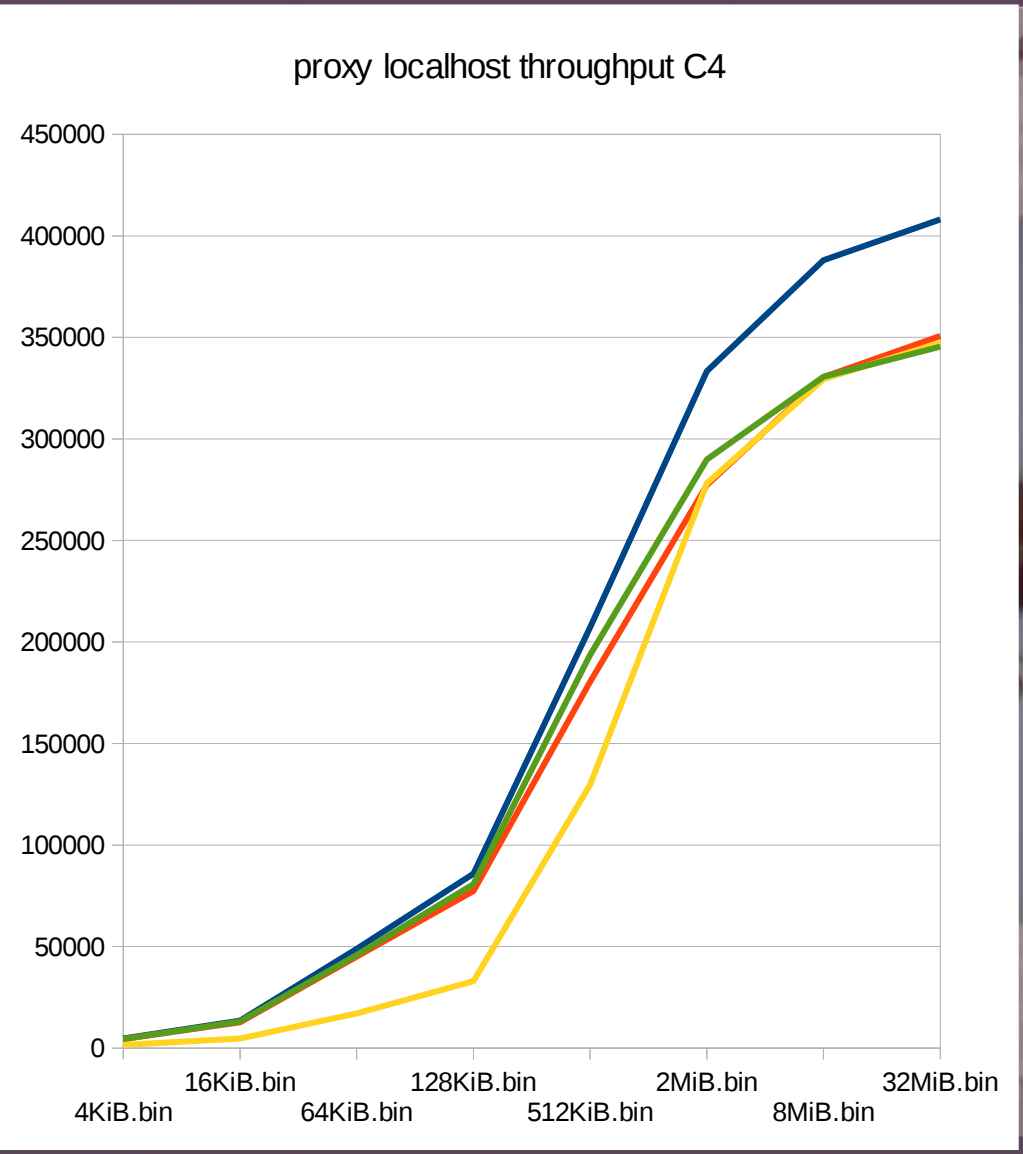
SSL Connector CPU Use (c40)

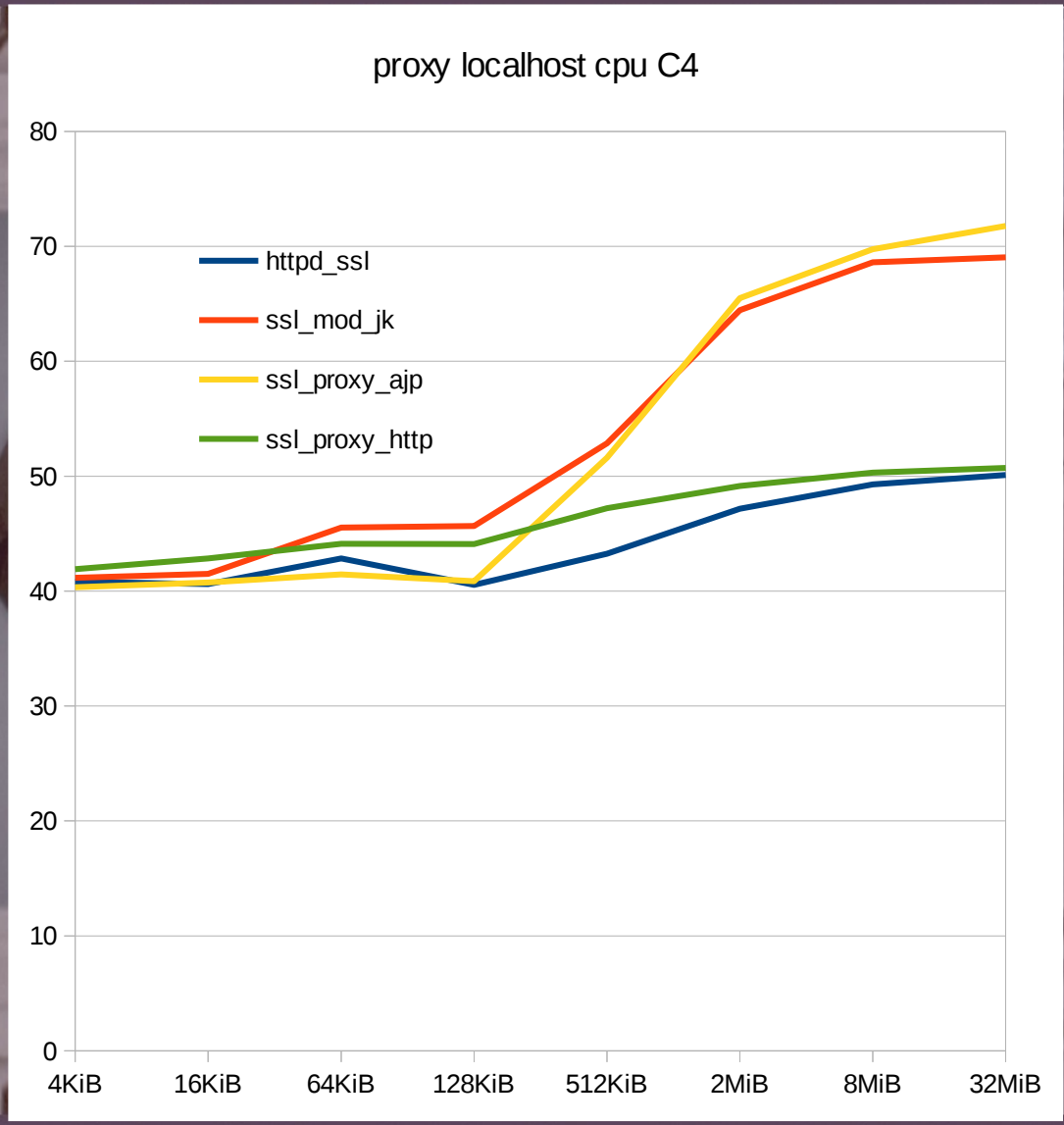


Connector Performance

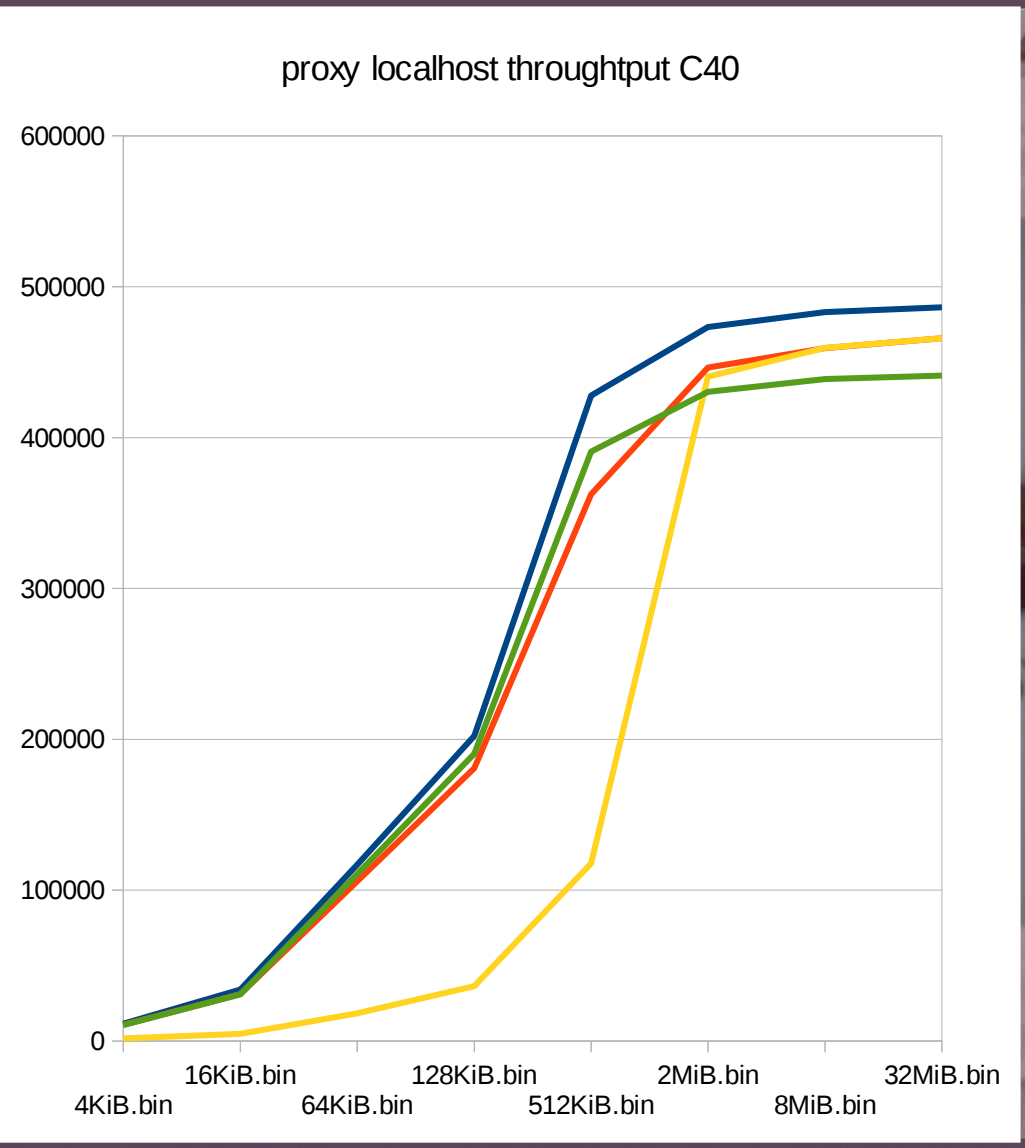
- Intermediate conclusion:
  - OpenSSL performs better that JSSE
  - JIO/BIO and NIO(2) give similar results.
  - Modern and safer cryto suites use more cpu.

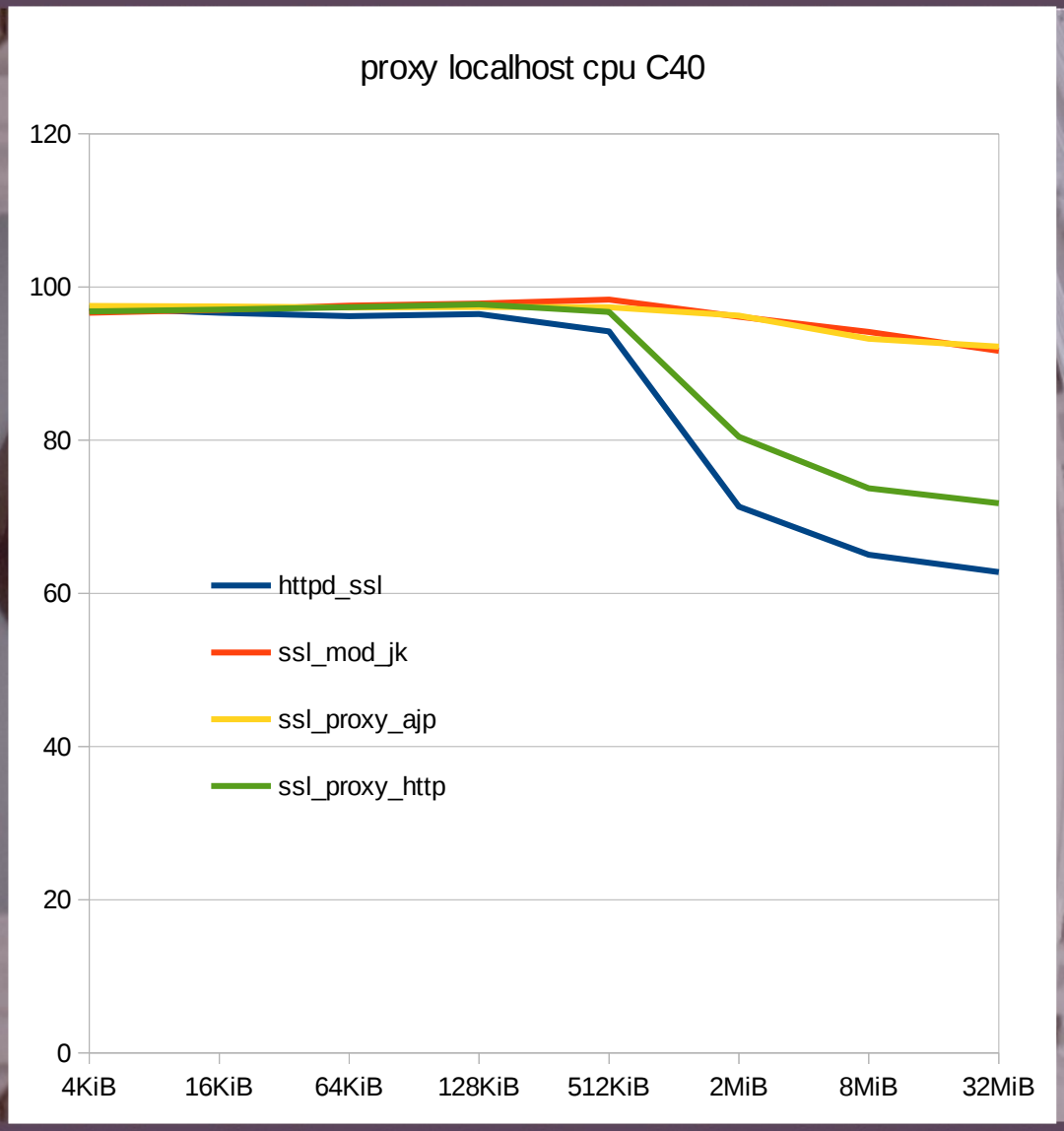
Proxy using localhost



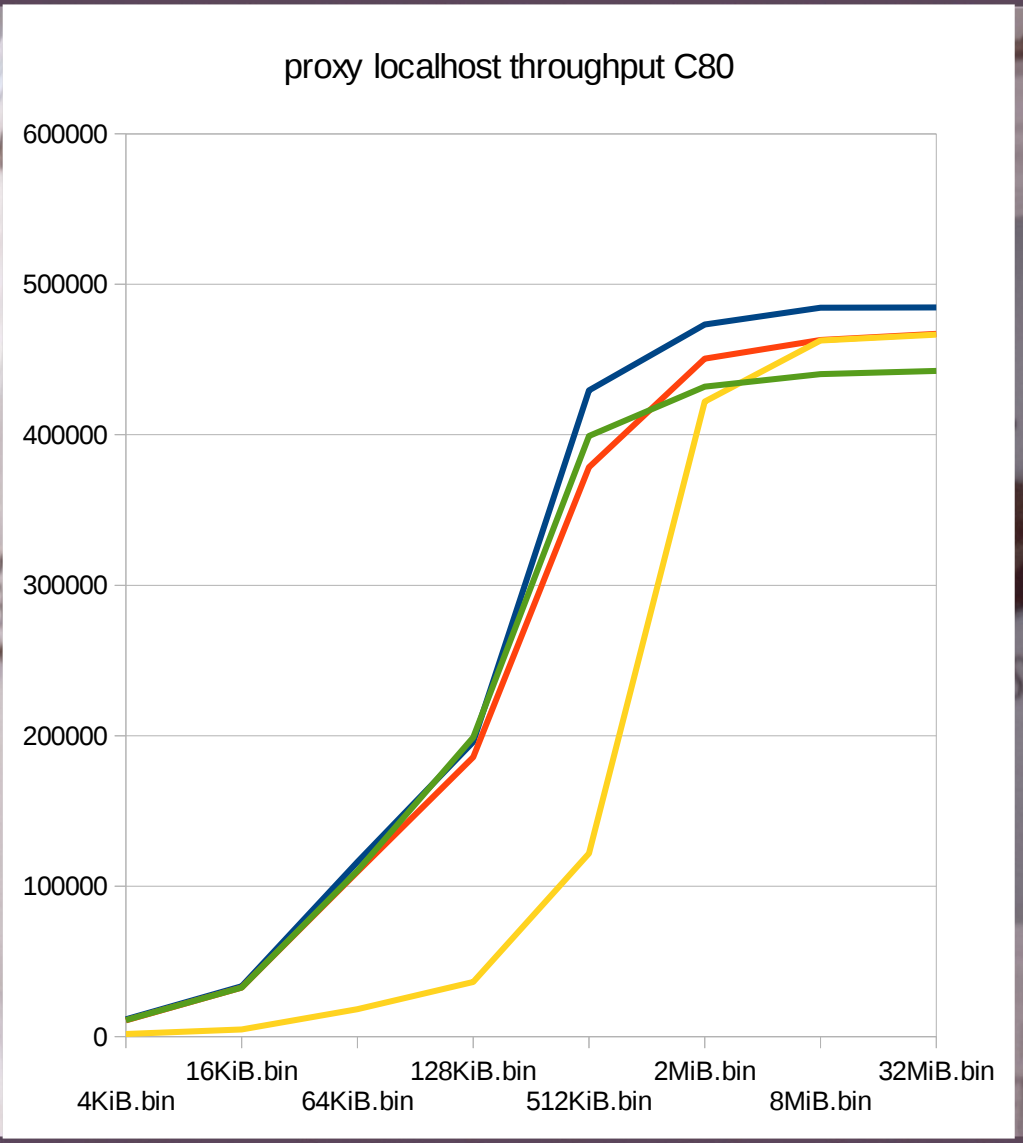


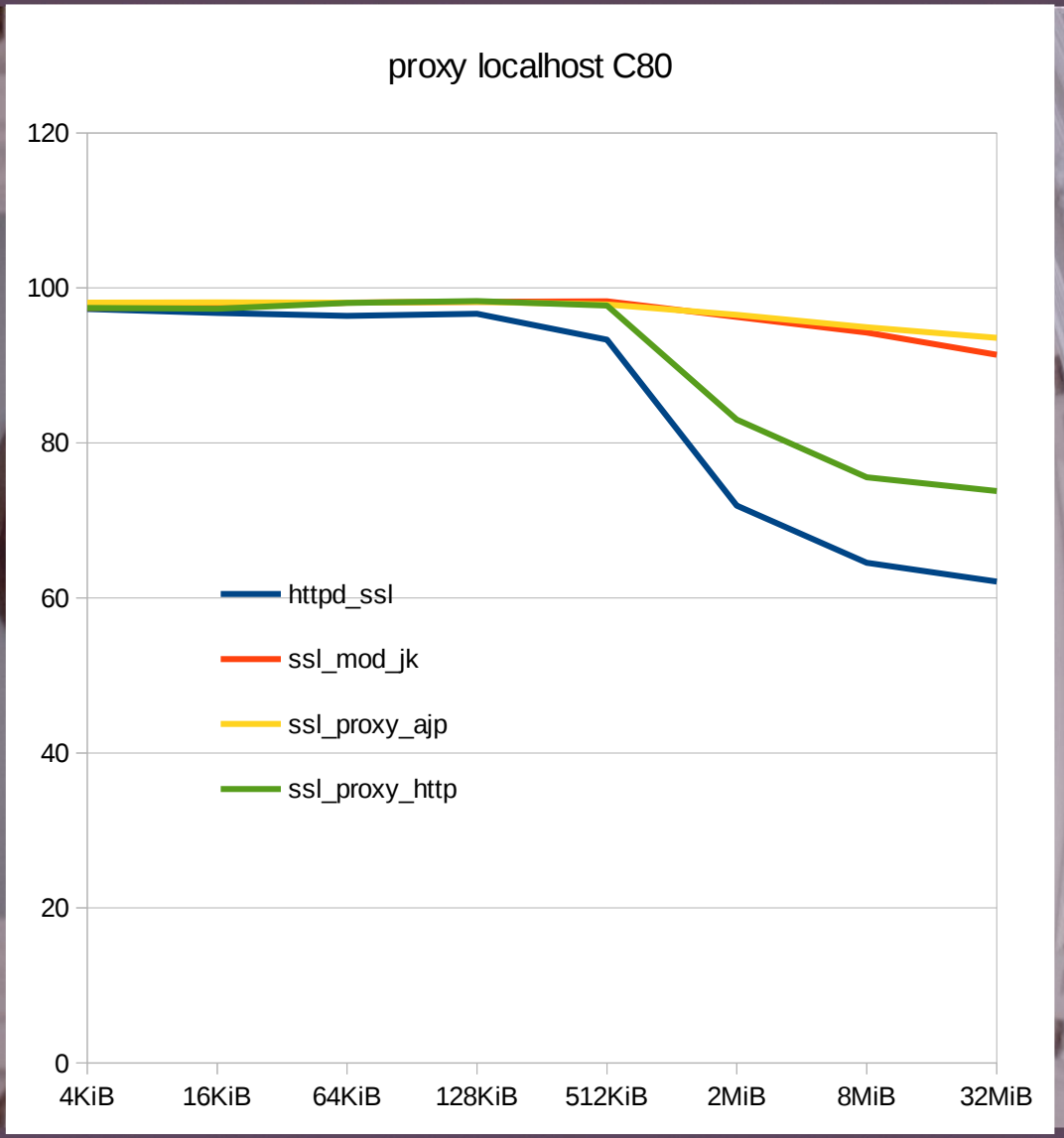
Proxy using localhost





Proxy using localhost

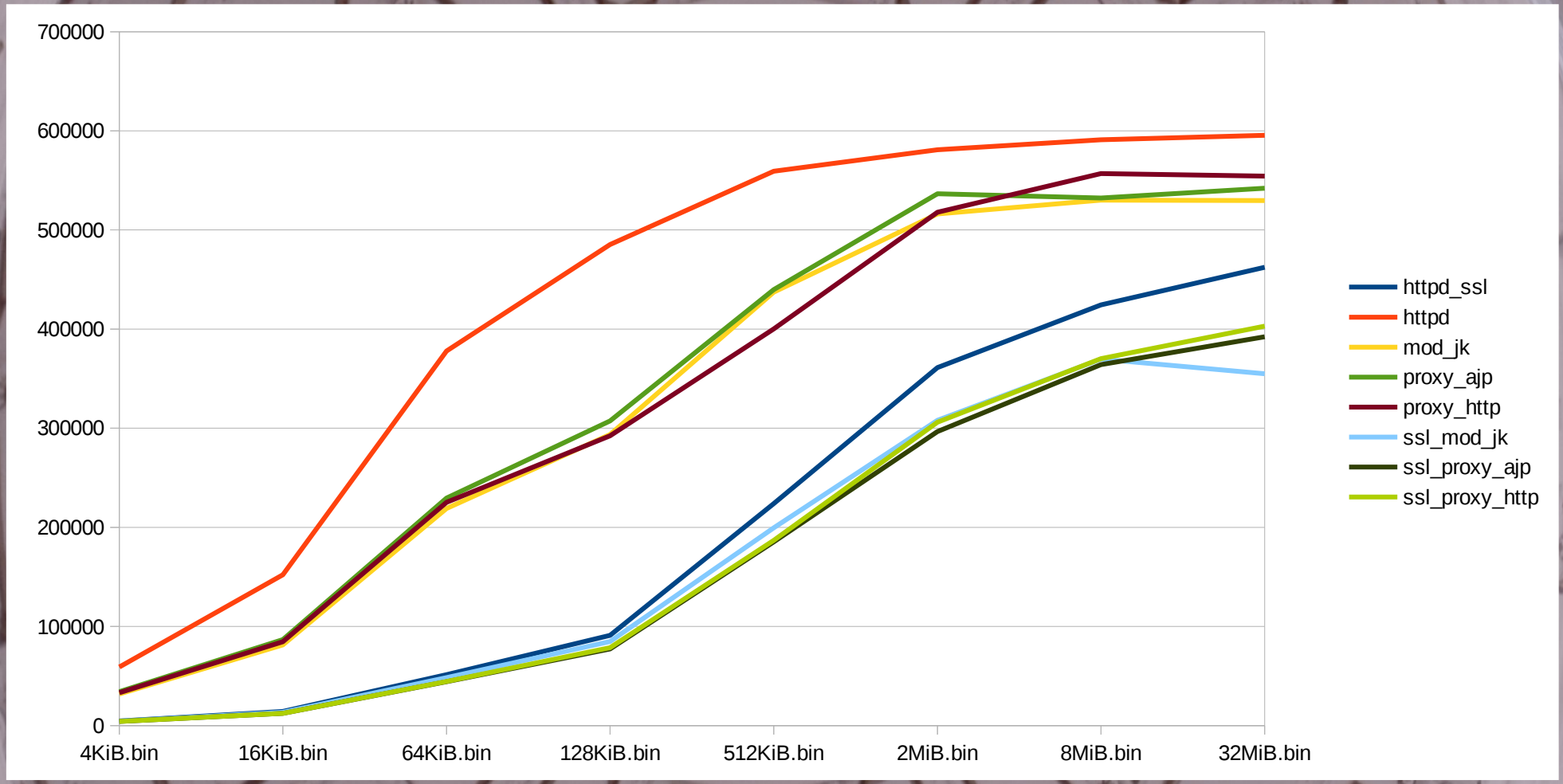




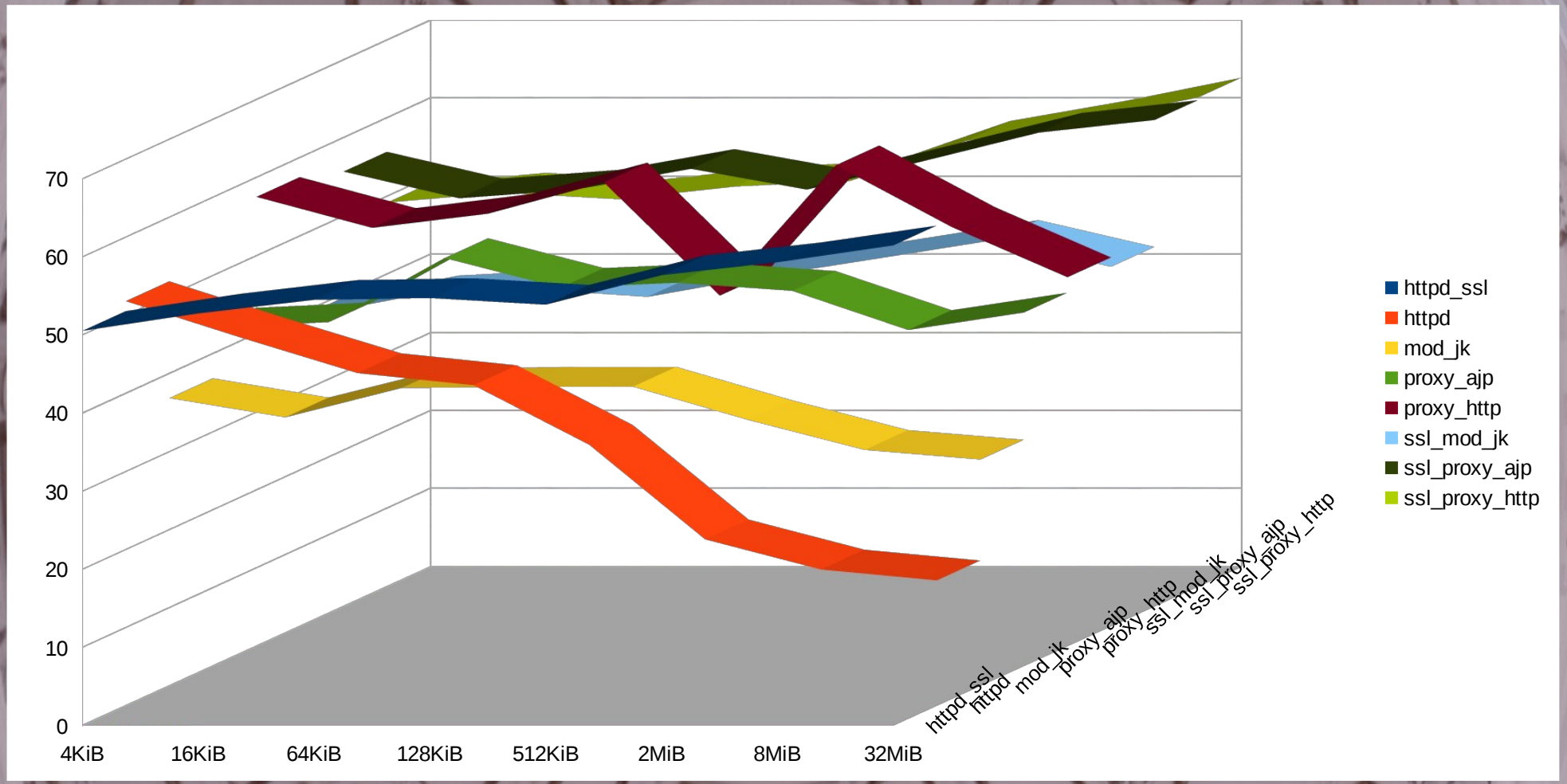
Proxy using localhost

- Conclusions:
  - Using httpd as proxy boost the performances
  - mod_jk looks better that proxy AJP
- Technical constraints
  - application with SSL information better use AJP

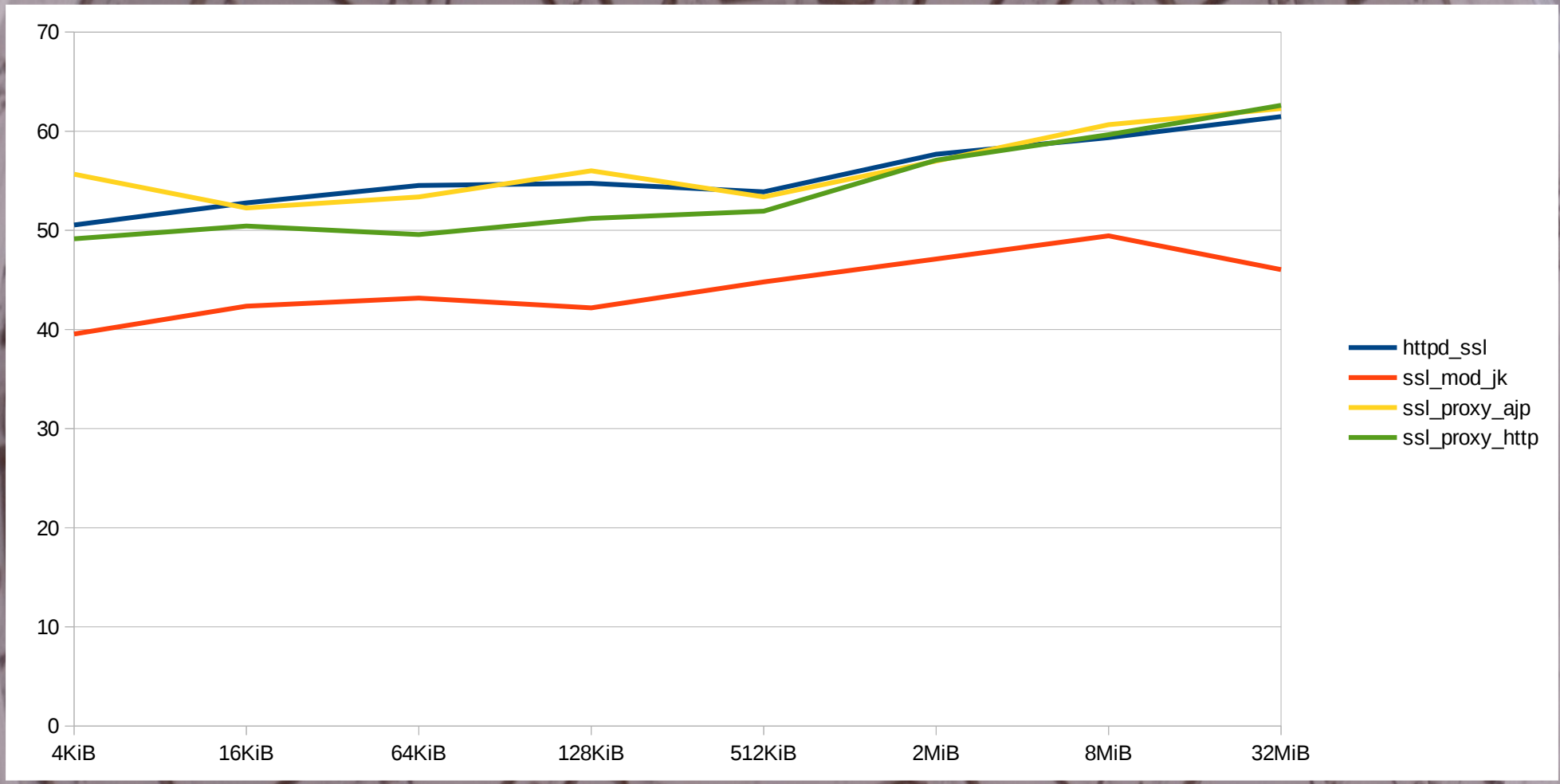
Proxy Throughput (c4)



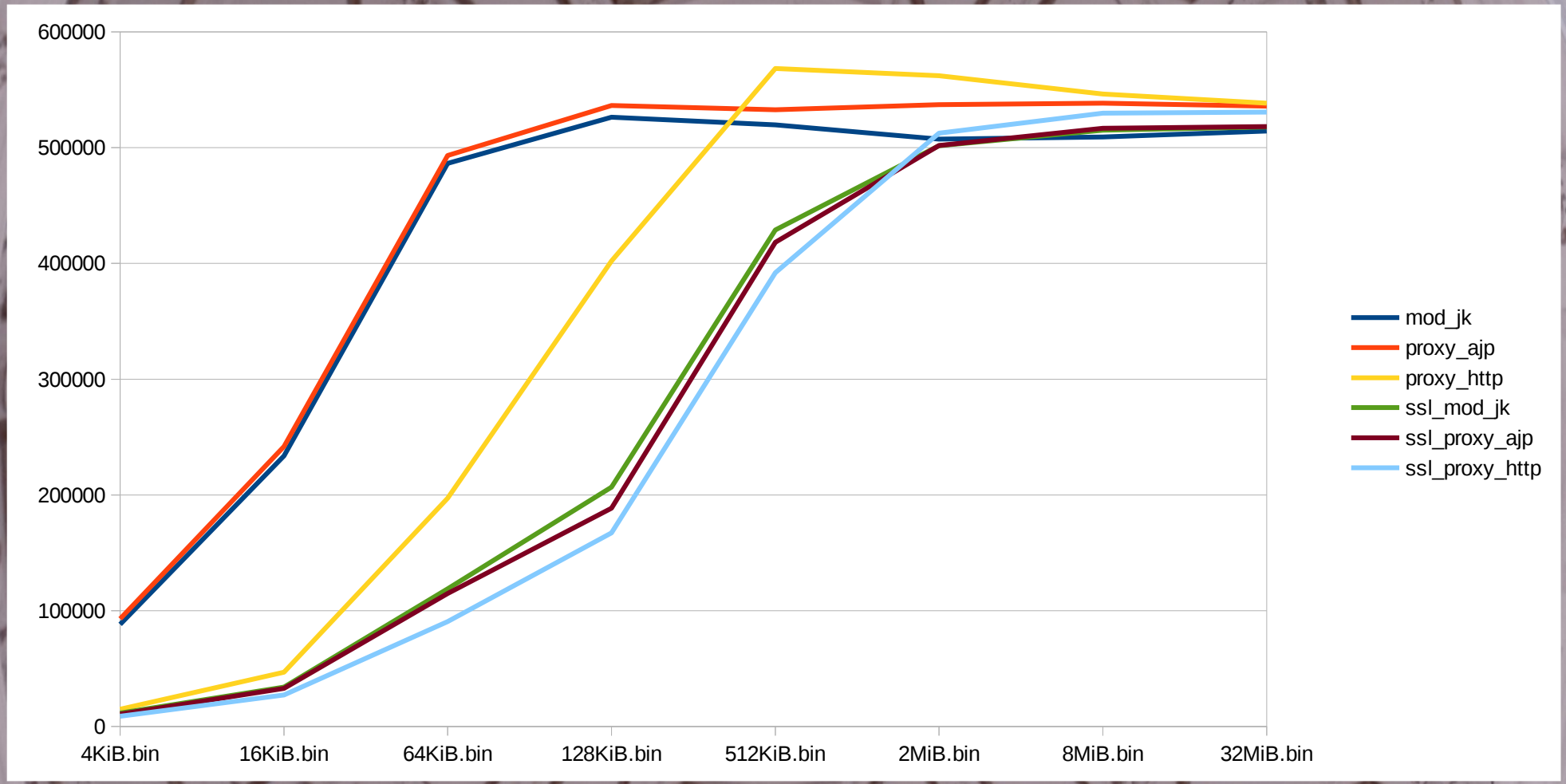
HTTPD CPU Use (c4)



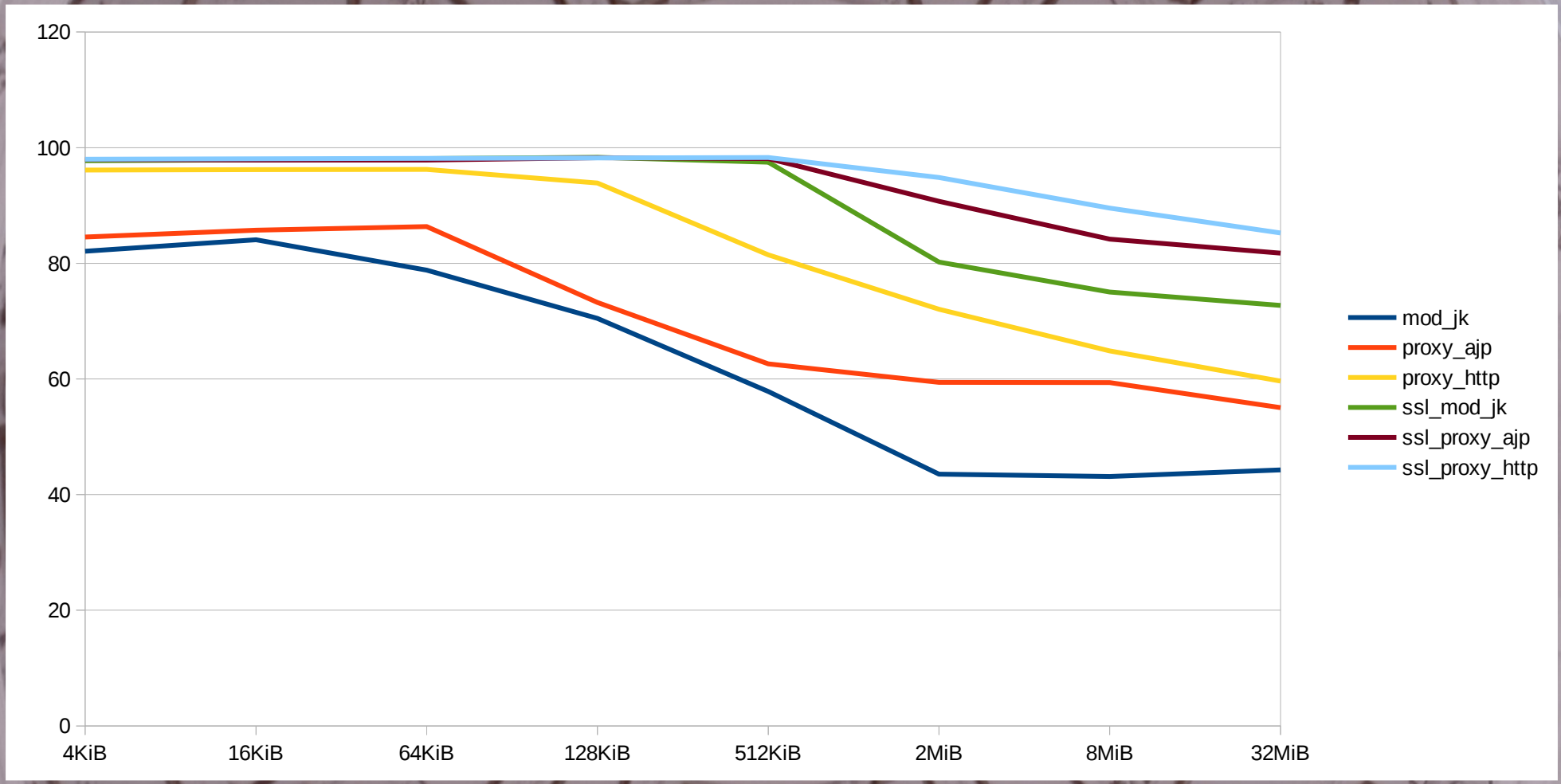
SSL Proxy CPU Use (c4)



Proxy Throughput (c40)



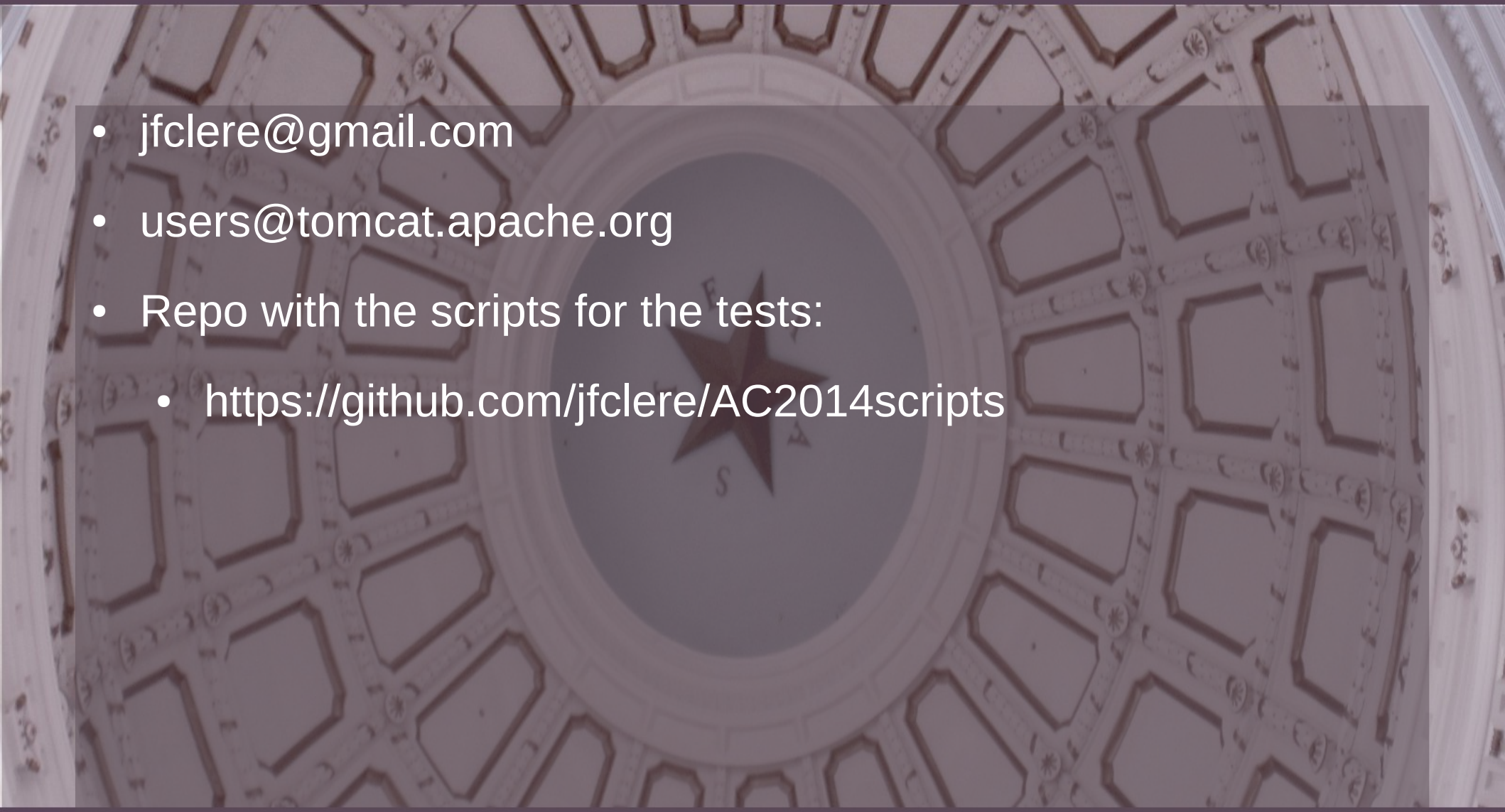
Proxy CPU Use (c40)



Connector/Proxy What use?

- Conclusion:
  - If you need SSL better use a proxy
    - Basically any “httpd proxy” will do the work.
    - Use mod_jk if you need a Swiss knife configuration.
    - Use http otherwise
  - WebSocket
    - Use httpd-2.4.x for mod_proxy_wstunnel.

Questions? Thank you!



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

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