# How cryptographic benchmarking goes wrong

Daniel J. Bernstein

Thanks to NIST 60NANB12D261 for funding this work, and for not reviewing these slides in advance.

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PRESERVE, ending 2015.06.30, was a European project "Preparing Secure Vehicle-to-X Communication Systems".

Project cost: 5383431 EUR, including 3850000 EUR from the European Commission.



"About PRESERVE": "The mission of PRESERVE is, to *design, implement, and test a secure and scalable V2X Security Subsystem for realistic deployment scenarios*. . . . [Expected Results:] 1. Harmonized V2X Security Architecture. 2. Implementation of V2X Security Subsystem. 3. Cheap and scalable security ASIC for V2X. 4. Testing results VSS under realistic conditions. 5. Research results for deployment challenges."

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[10] says "ECDSA was implemented using MIRACL and following the Fig.1."
For NIST P-224/P-256 on "Pentium D 3.4GHz workstation":
2.50ms/3.33ms to sign,
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But NIST P-224 and NIST P-256 are defined over prime fields!

[21] says "For elliptic curves over prime fields, OpenSSL has the best performance under all platforms."

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| 256 | 144 | Simon: 106 op |
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Bit operations per bit of plaintext (assuming precomputed subkeys), as listed in recent Skinny paper:

| key | ops/bit | cipher |
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| 128 | 88 | Simon: 60 ops broken |
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| 128 | 117 | Skinny |
| 256 | 144 | Simon: 106 ops broken |
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Bit operations per bit of plaintext (assuming precomputed subkeys), not entirely listed in Skinny paper:

| key | ops/bit | cipher |
|---|---|---|
| 256 | 54 | Salsa20/8 |
| 256 | 78 | Salsa20/12 |
| 128 | 88 | Simon: 60 ops broken |
| 128 | 100 | NOEKEON |
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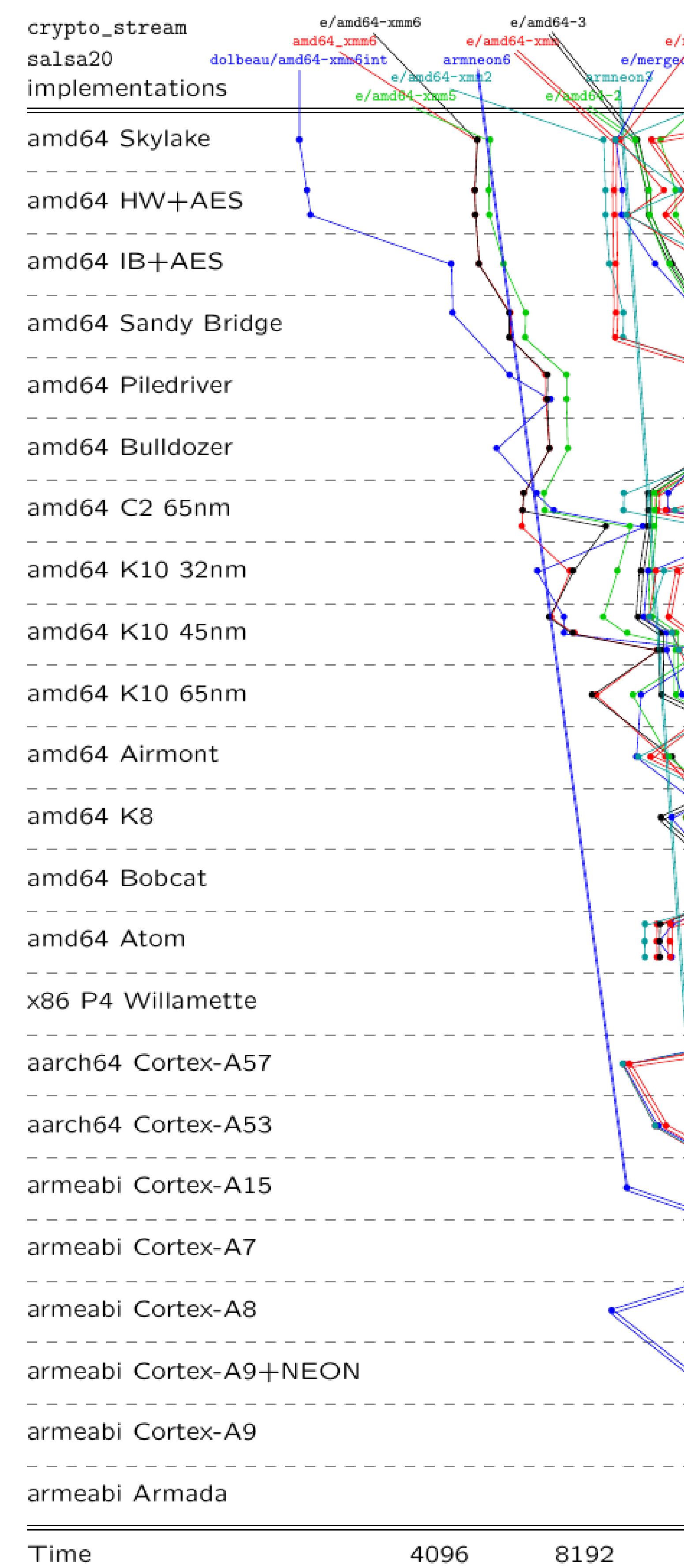

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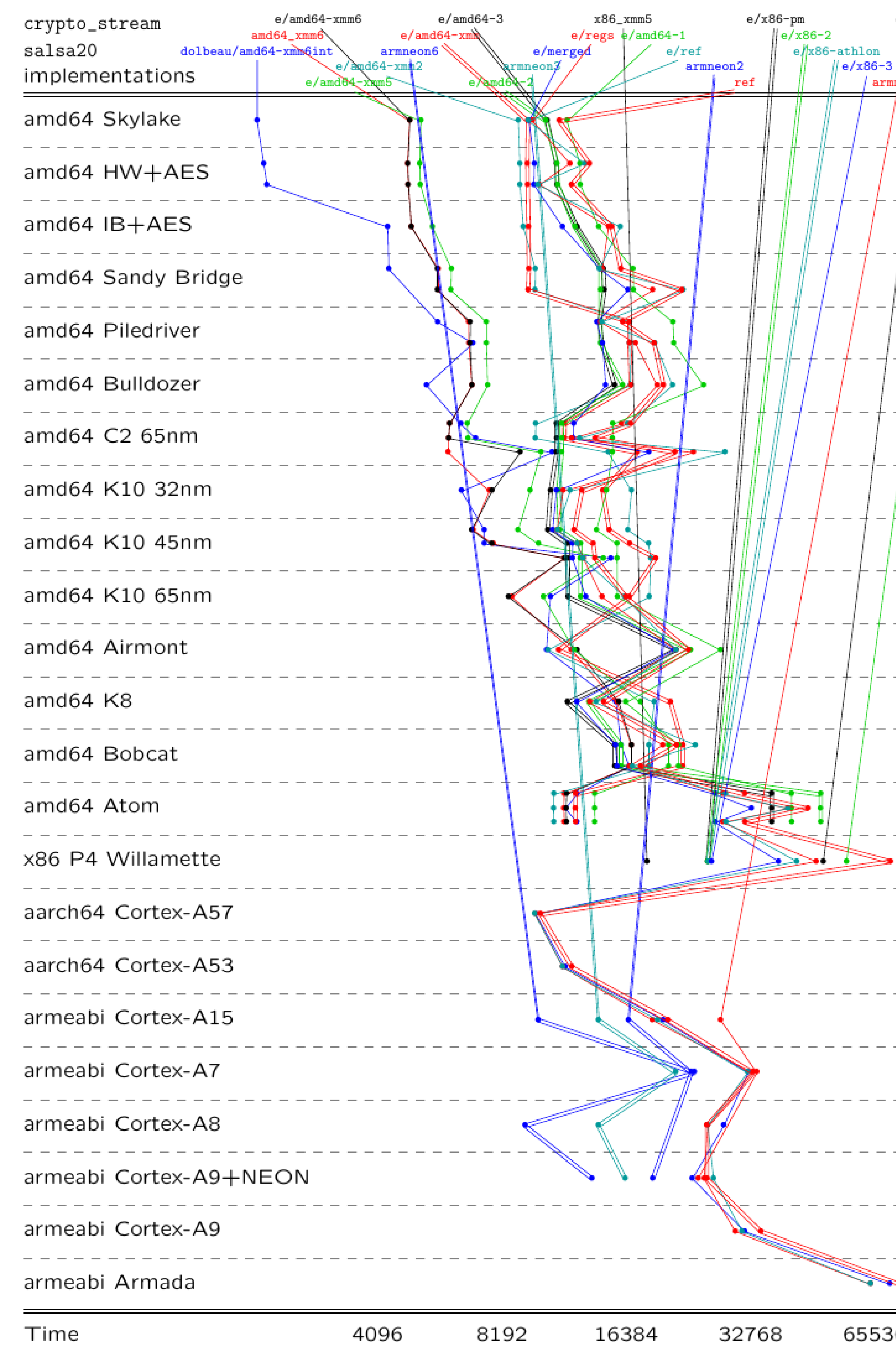

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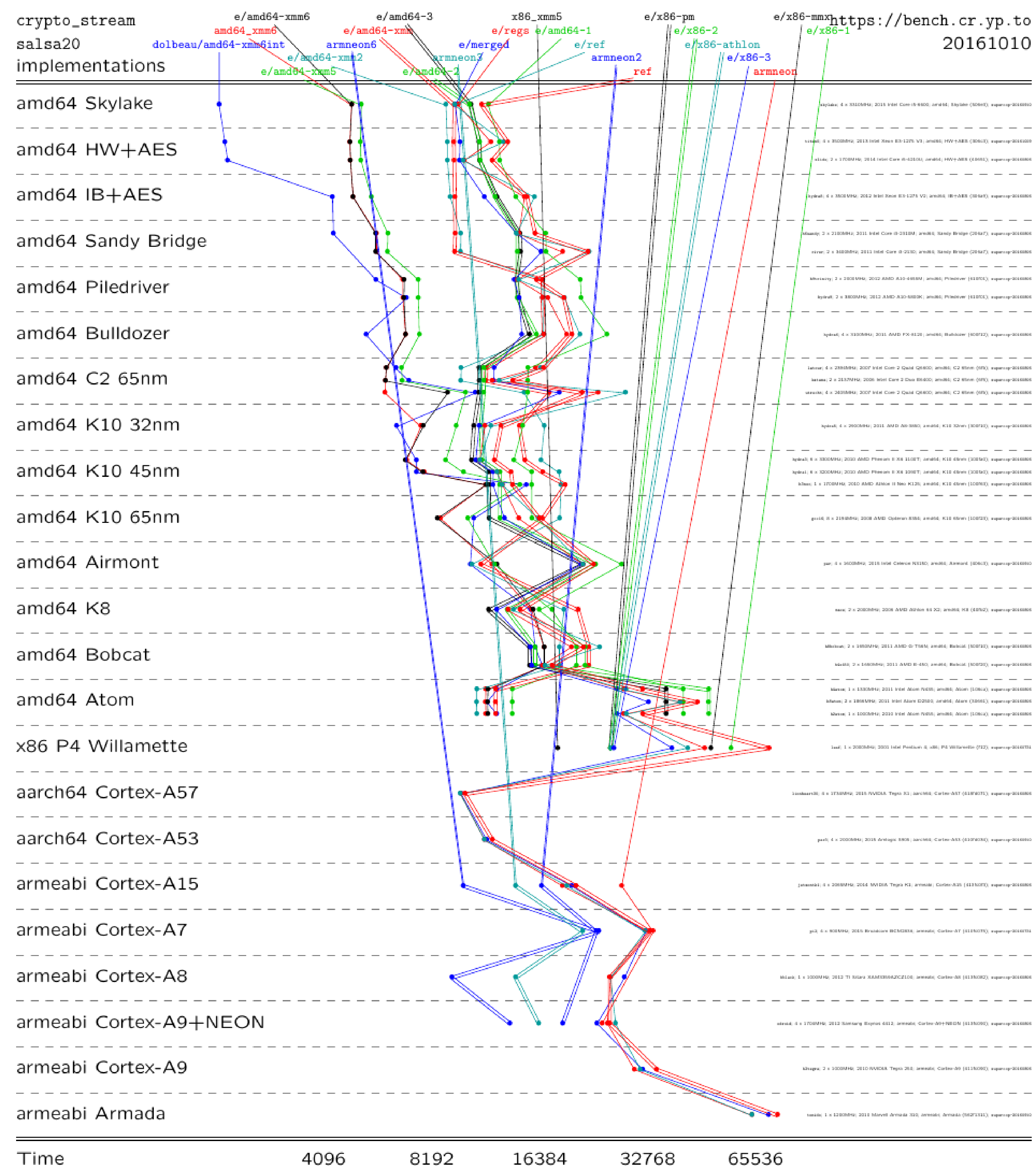

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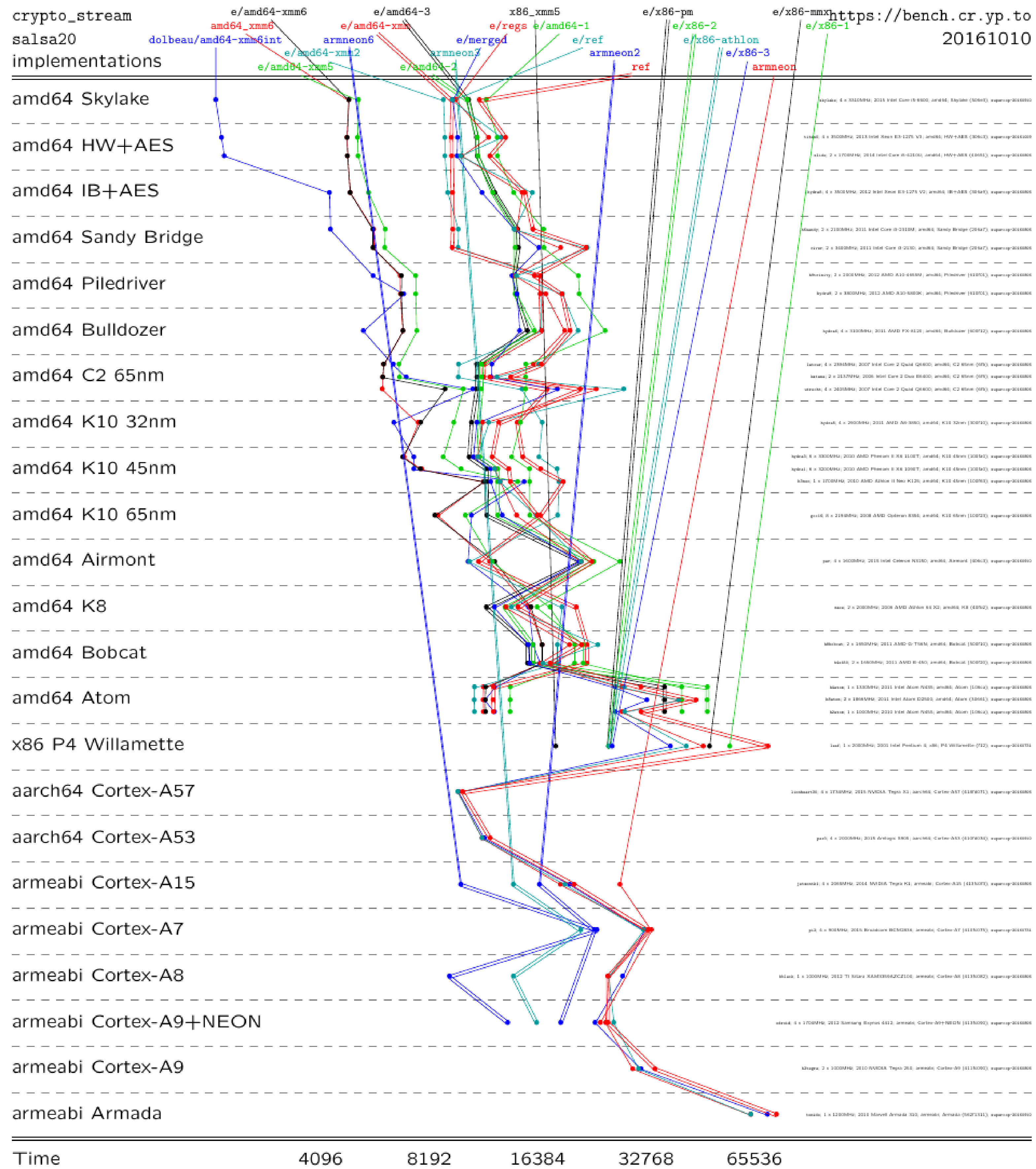


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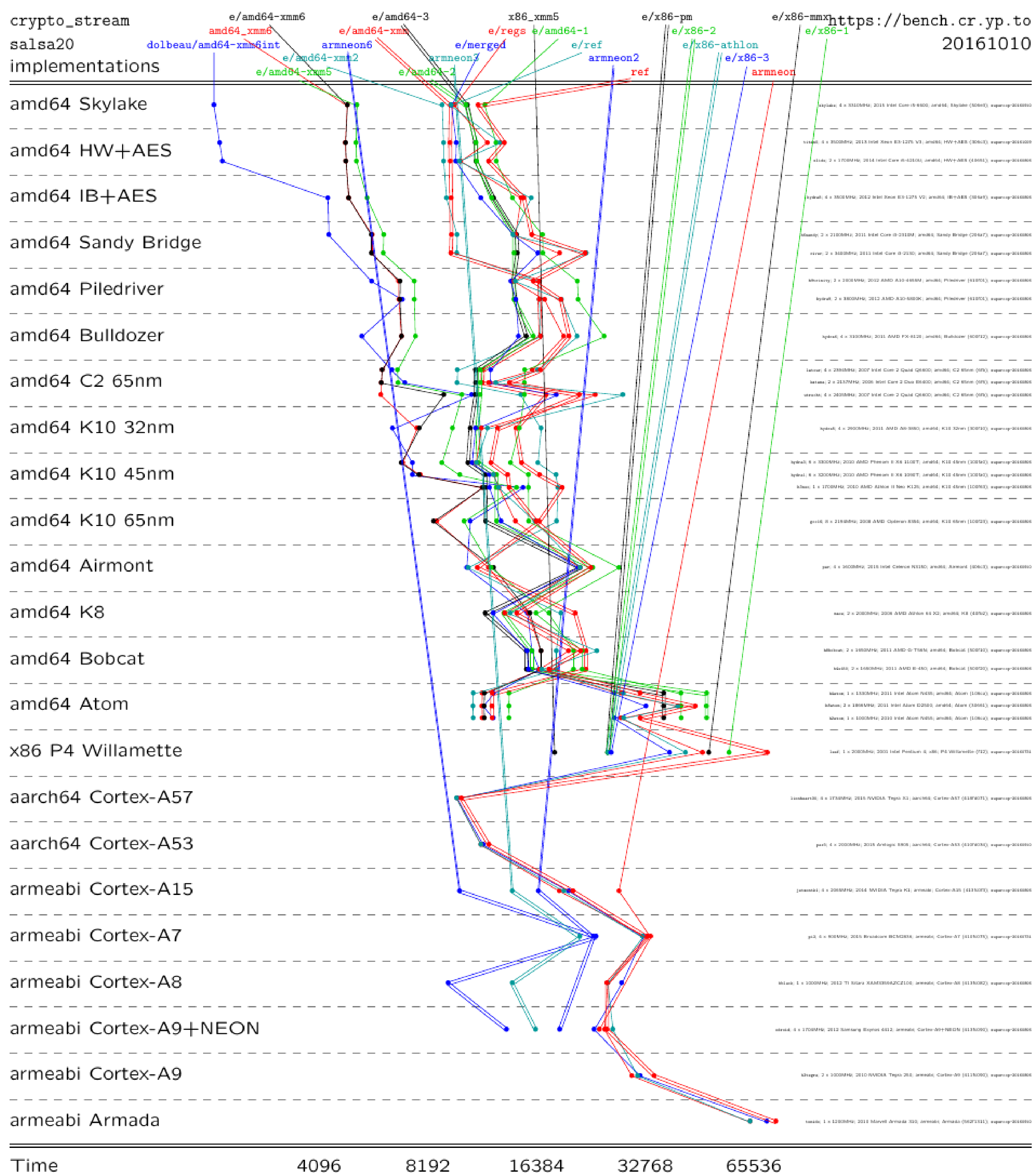


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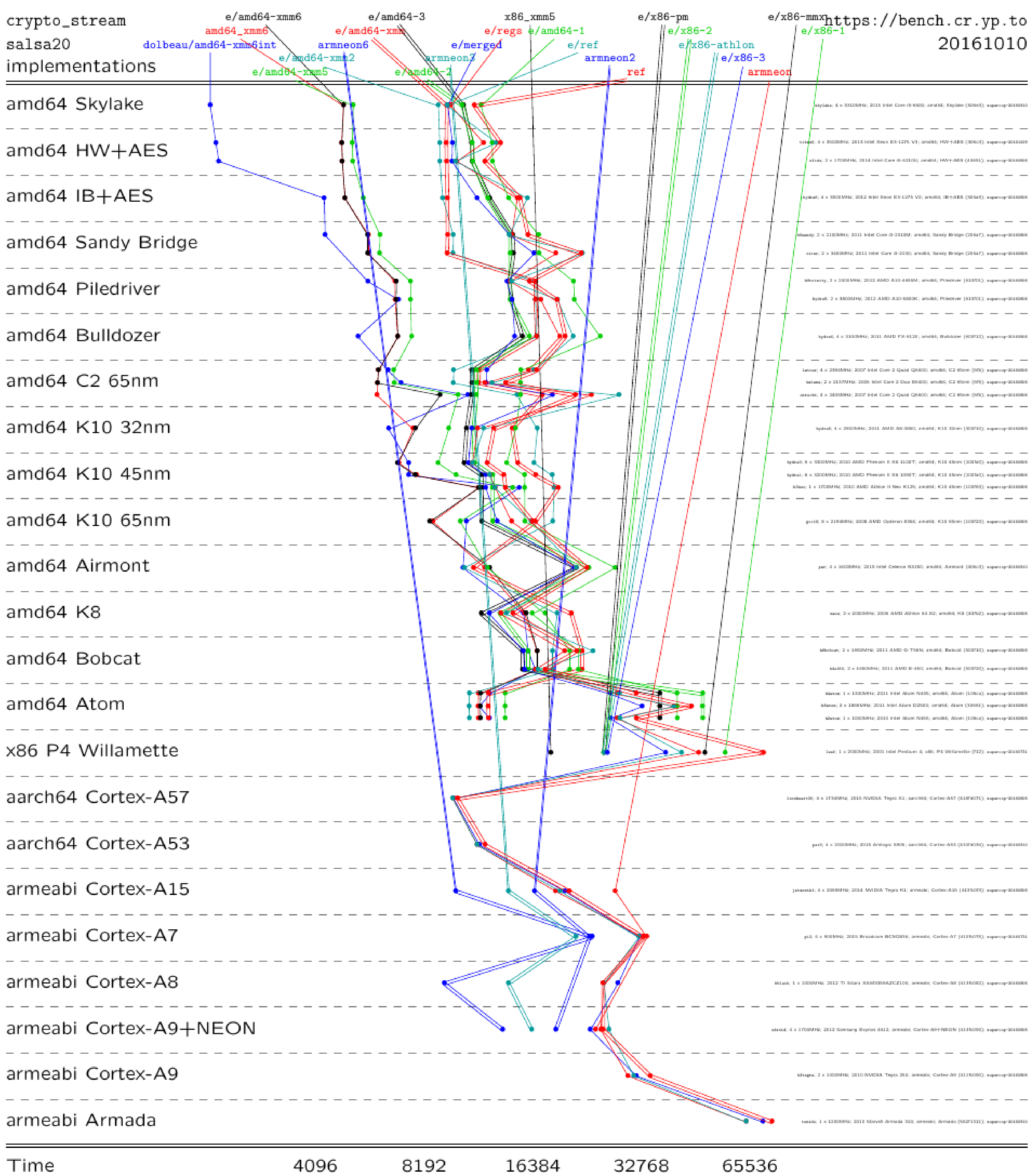


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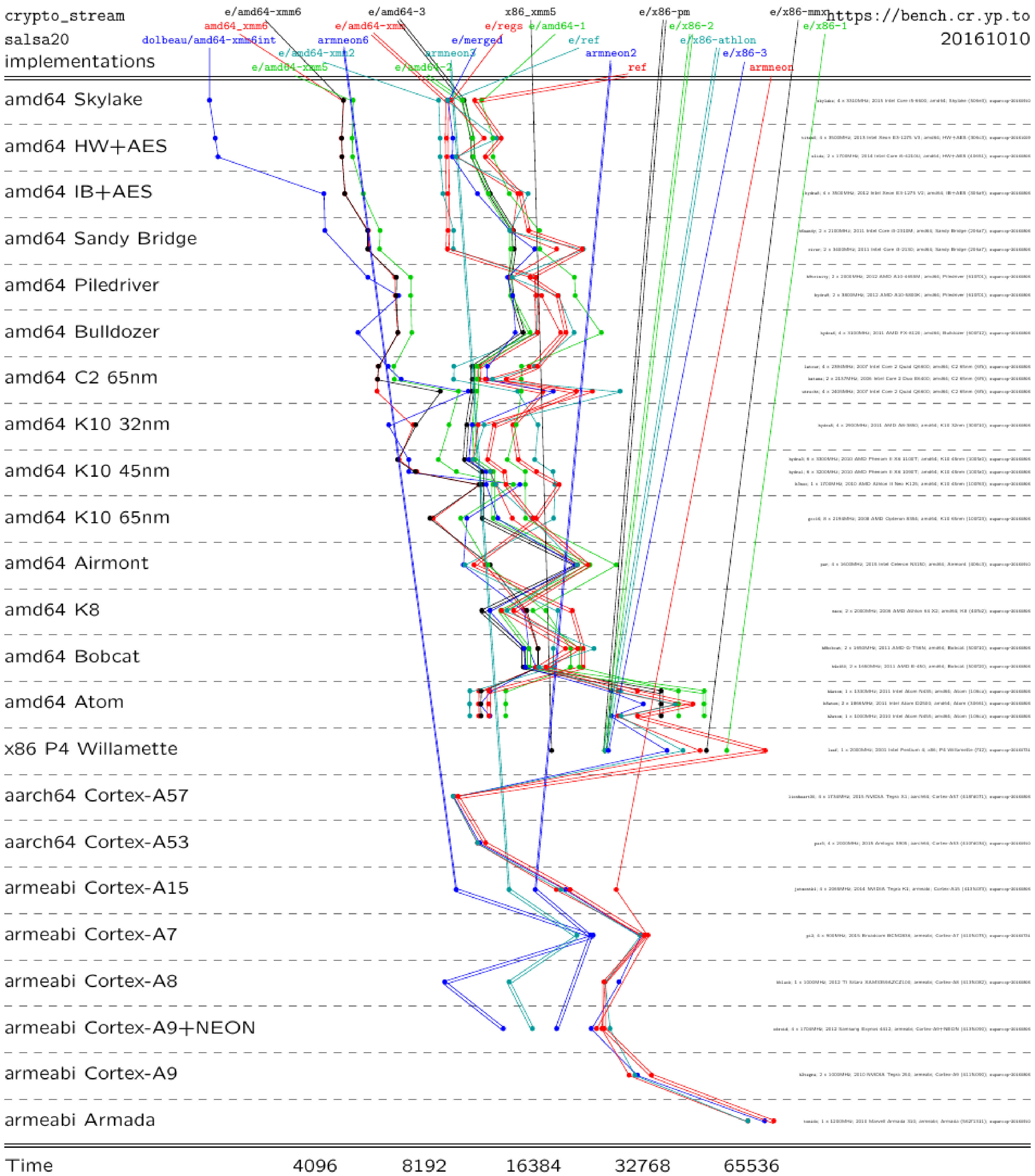




SUPERCOP benchmarking toolkit includes 2155 implementations of 595 cryptographic primitives. >20 implementations of Salsa20.

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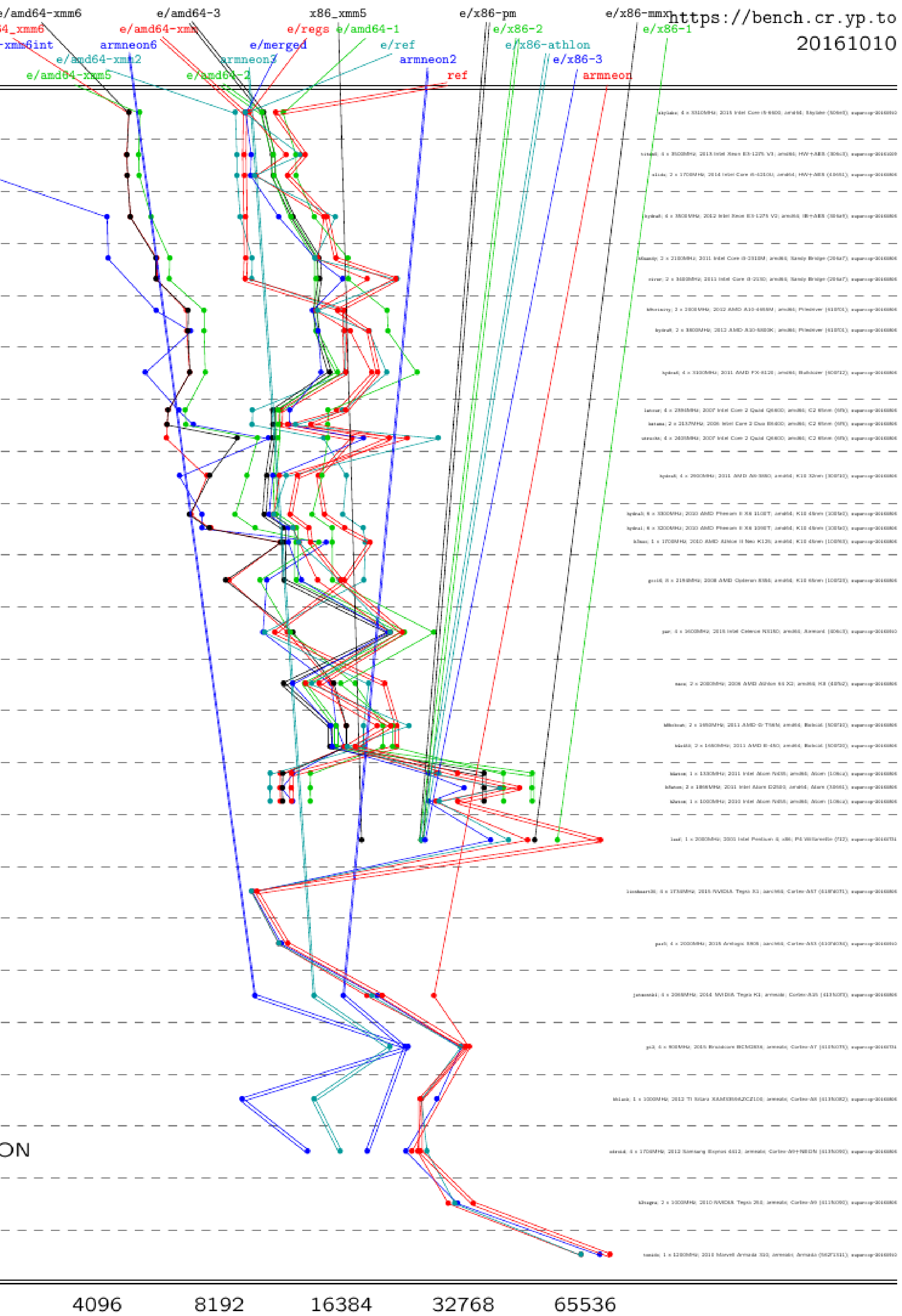




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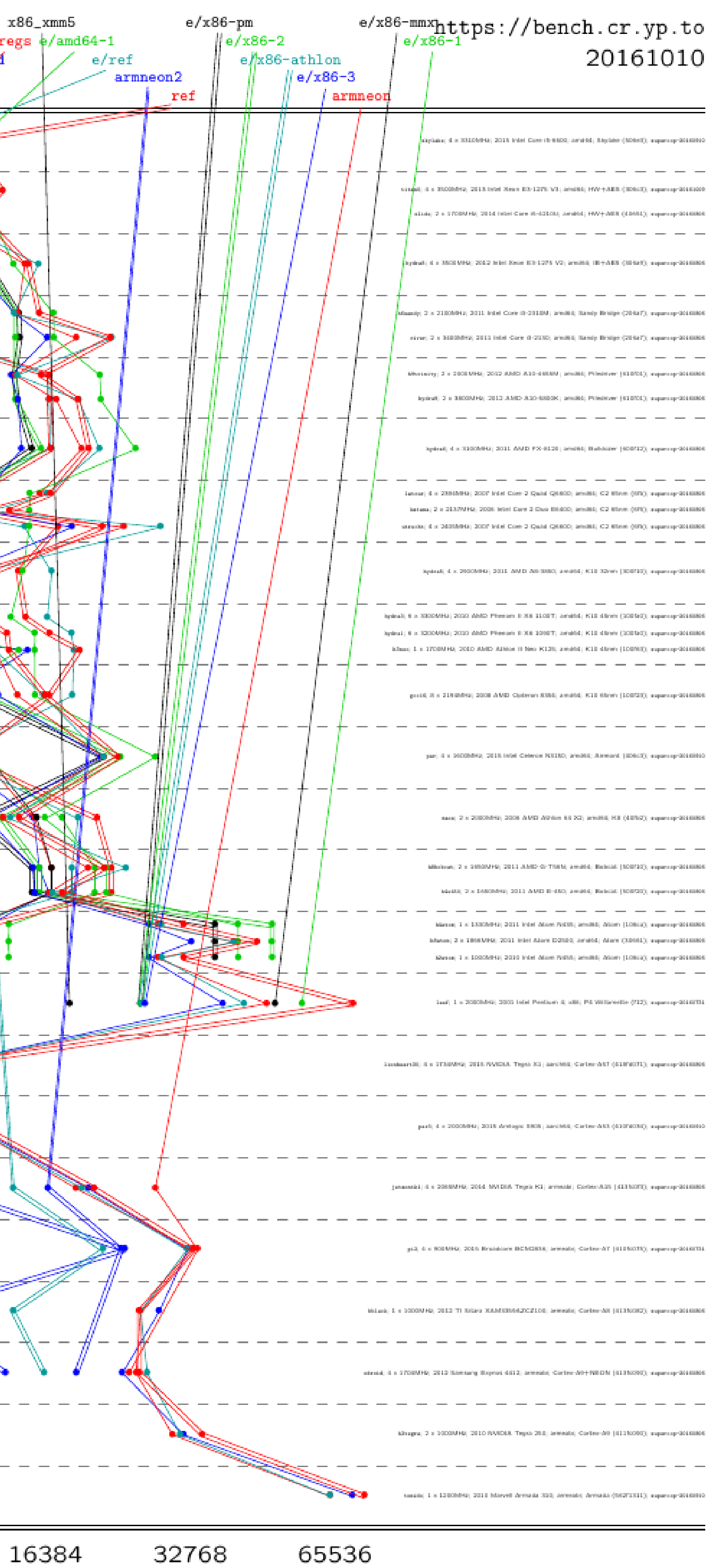




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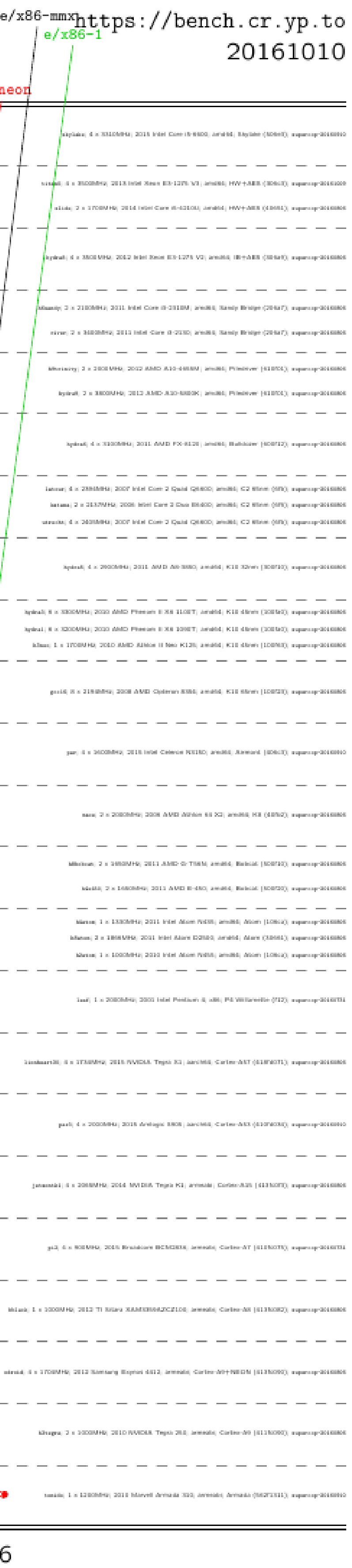




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SUPERCOP benchmarking toolkit includes 2155 implementations of 595 cryptographic primitives. >20 implementations of Salsa20.

Haswell: Reasonably simple `ref` implementation compiled with `gcc -O3 -fomit-frame-pointer` is 6.15× slower than fastest Salsa20 implementation.

`merged` implementation with "machine-independent" optimizations and best of 121 compiler options: 4.52× slower.



Another interesting example: lattice-based signing typically means generating a huge number of random Gaussian samples.

2017.03 Brannigan–Smyth–Oder–Valencia–O'Sullivan–Güneysu–Regazzoni "An investigation of sources of randomness within discrete Gaussian sampling": benchmarks for RNGs, samplers.

Qualitatively large impacts: choice of RNG ⇒ cost of sampling ⇒ cost of signing.

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But wait. eBACS reports 0.92 cycles/byte for AES-256-CTR, 1.18 cycles/byte for ChaCha20.

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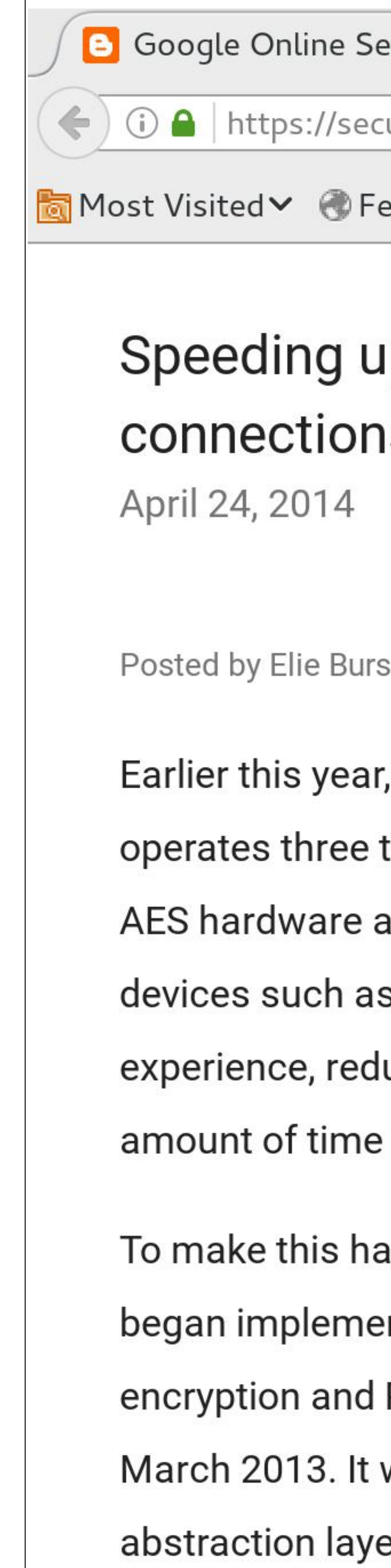
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Speeding u
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April 24, 2014

Posted by Elie Burs

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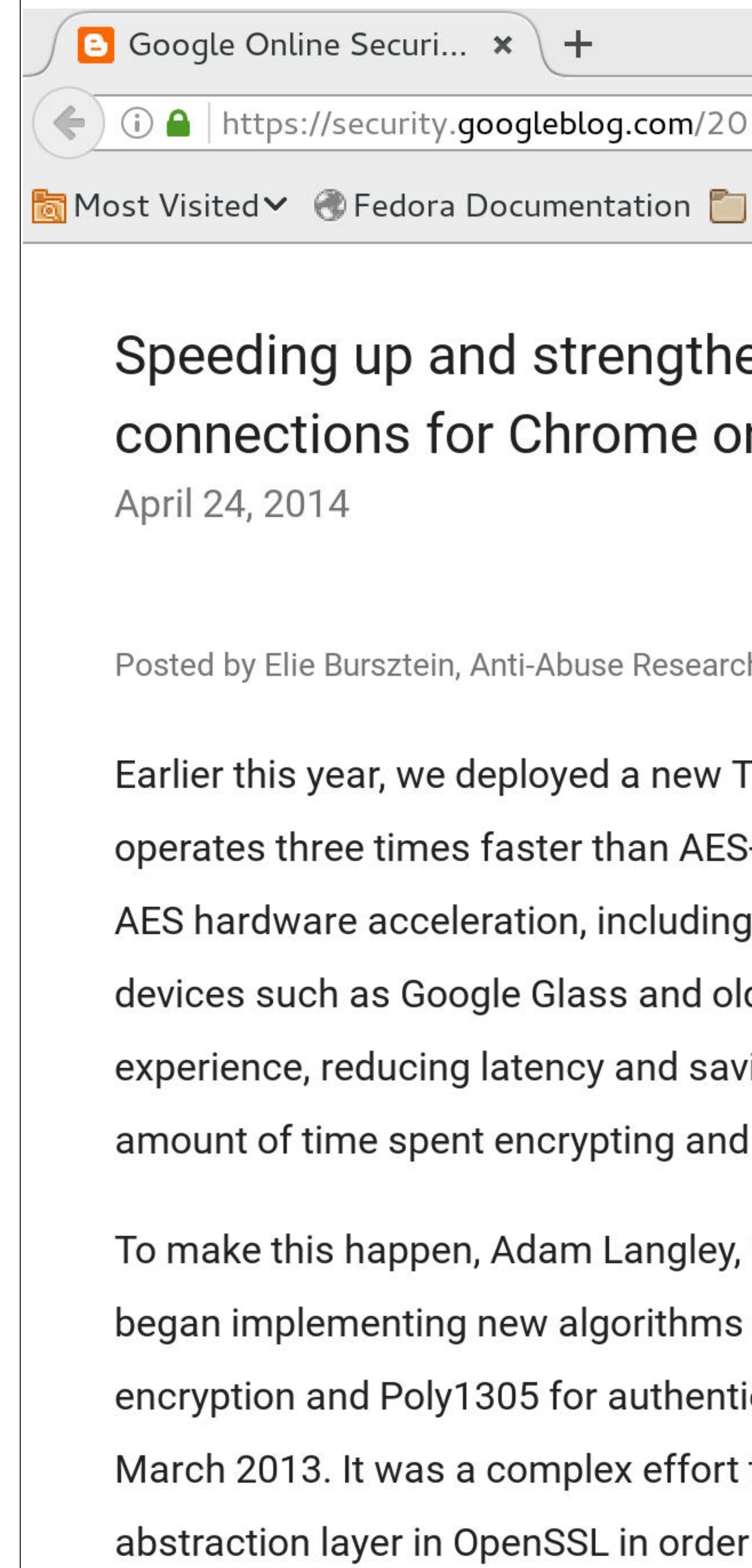


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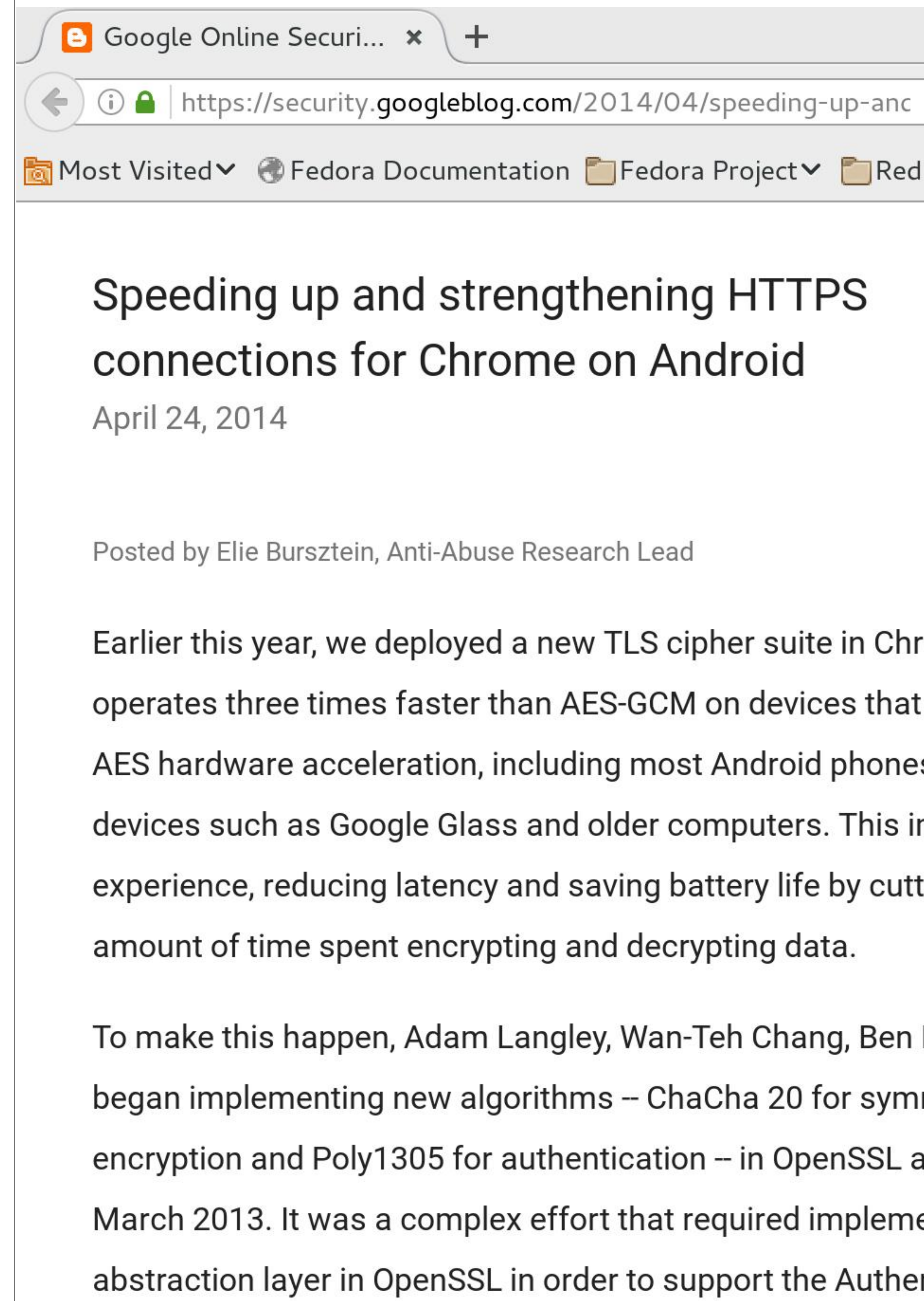

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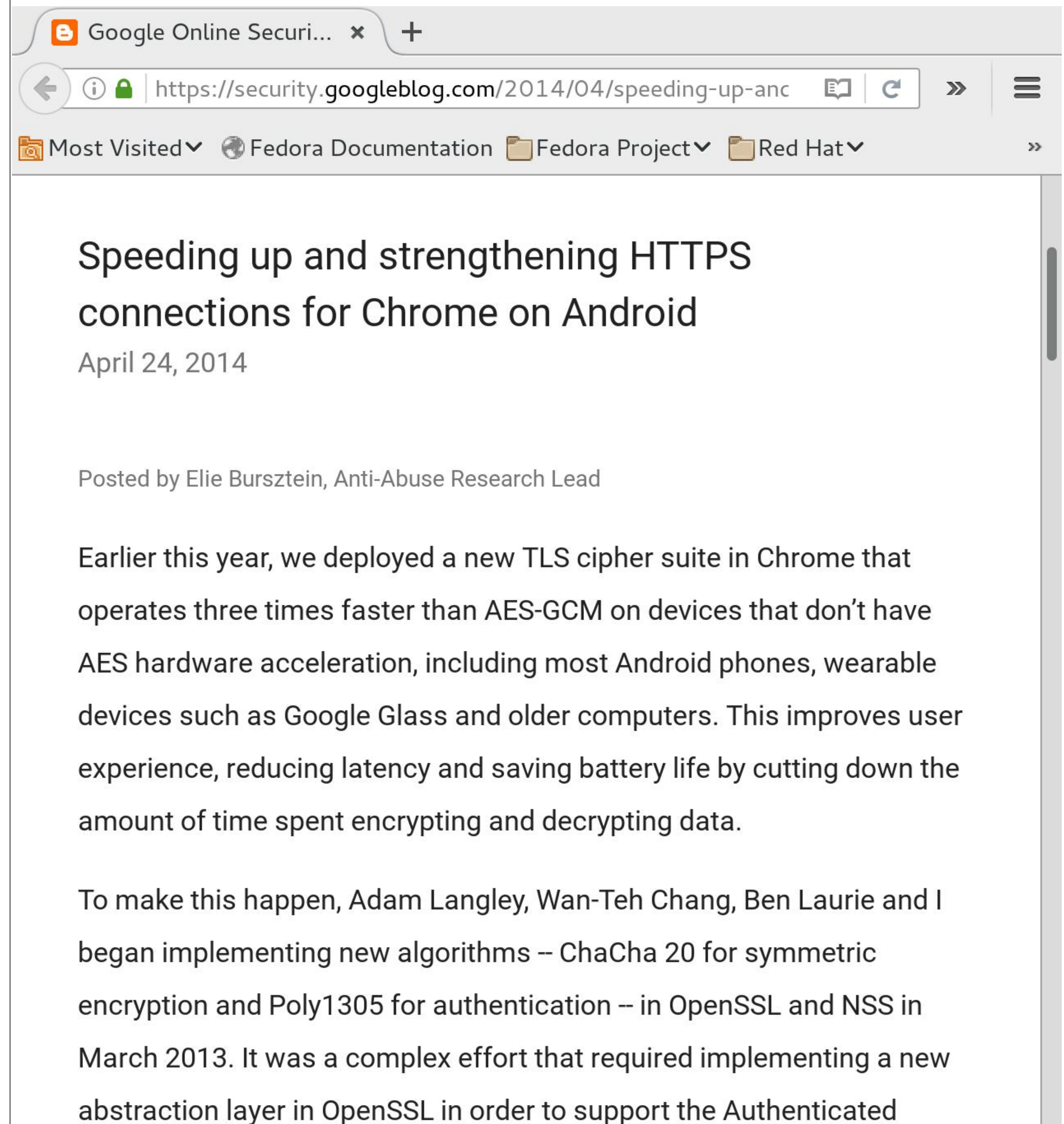


Speeding up and strengthening HTTPS connections for Chrome on Android

April 24, 2014

Posted by Elie Bursztein, Anti-Abuse Research Lead

Earlier this year, we deployed a new TLS cipher suite in Chrome that operates three times faster than AES-GCM on devices that don't have AES hardware acceleration, including most Android phones, wearable devices such as Google Glass and older computers. This improves user experience, reducing latency and saving battery life by cutting down the amount of time spent encrypting and decrypting data.

To make this happen, Adam Langley, Wan-Teh Chang, Ben Laurie and I began implementing new algorithms -- ChaCha 20 for symmetric encryption and Poly1305 for authentication -- in OpenSSL and NSS in March 2013. It was a complex effort that required implementing a new abstraction layer in OpenSSL in order to support the Authenticated

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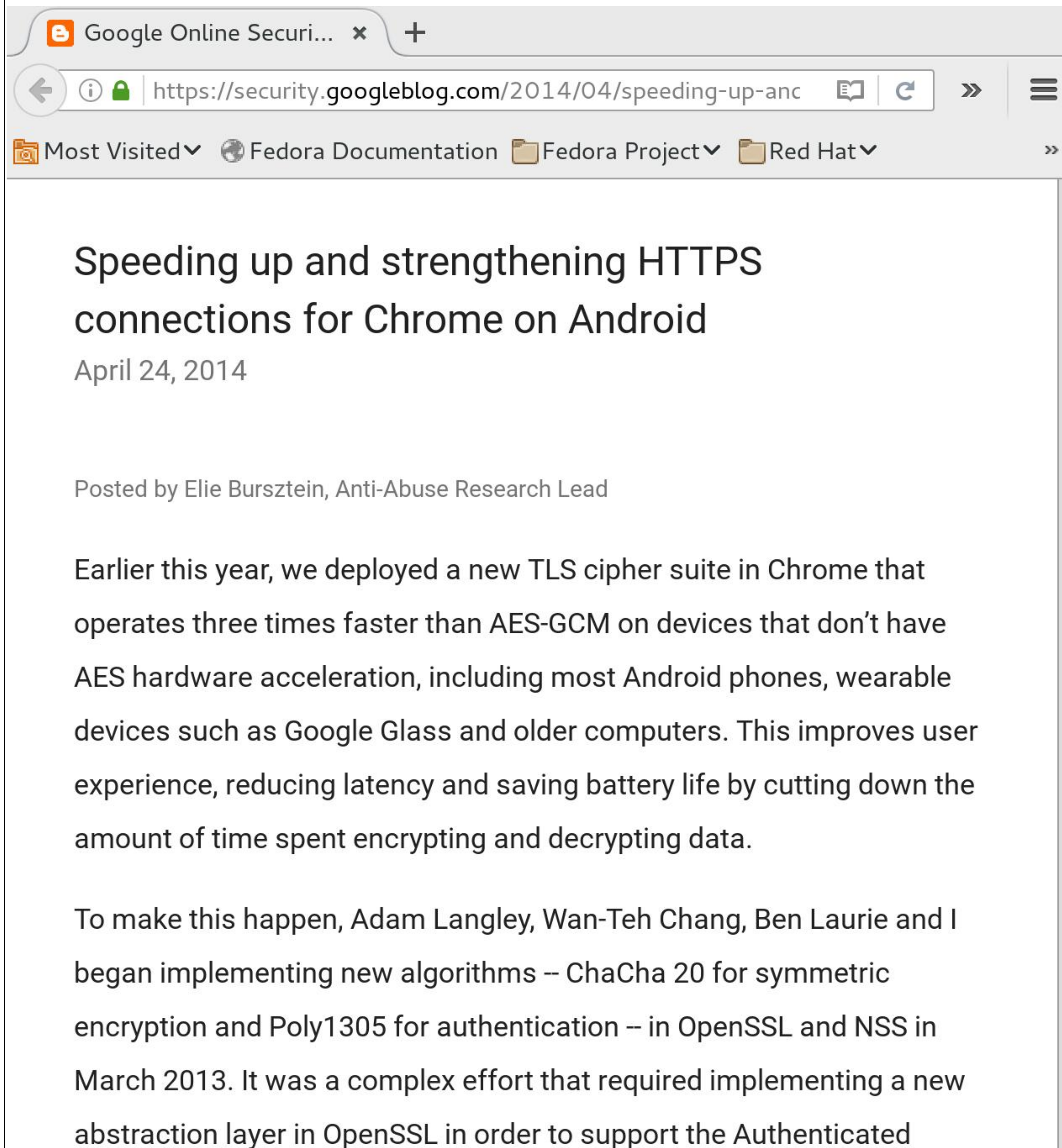
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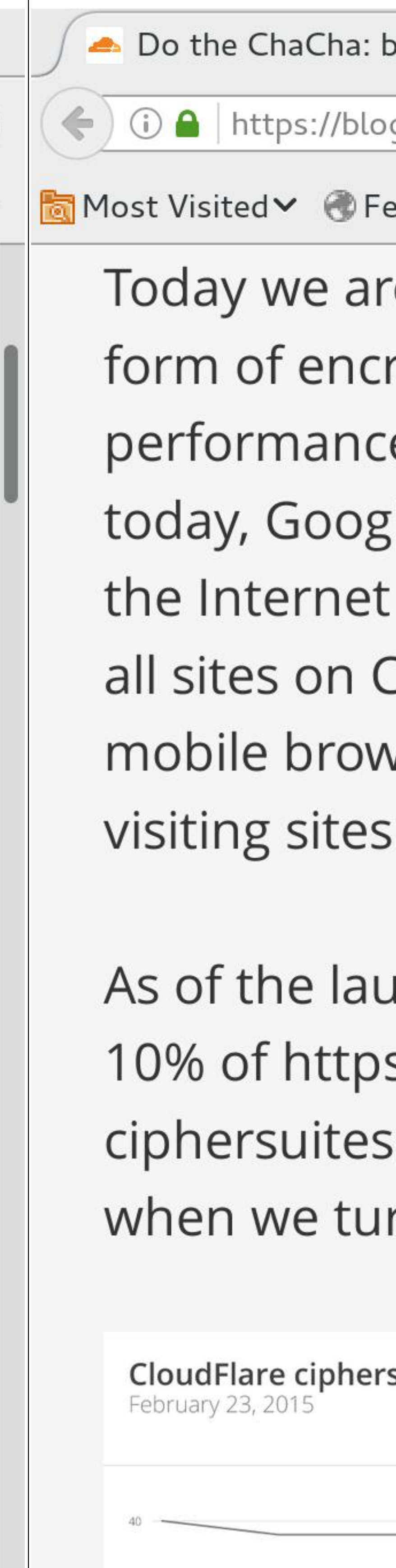
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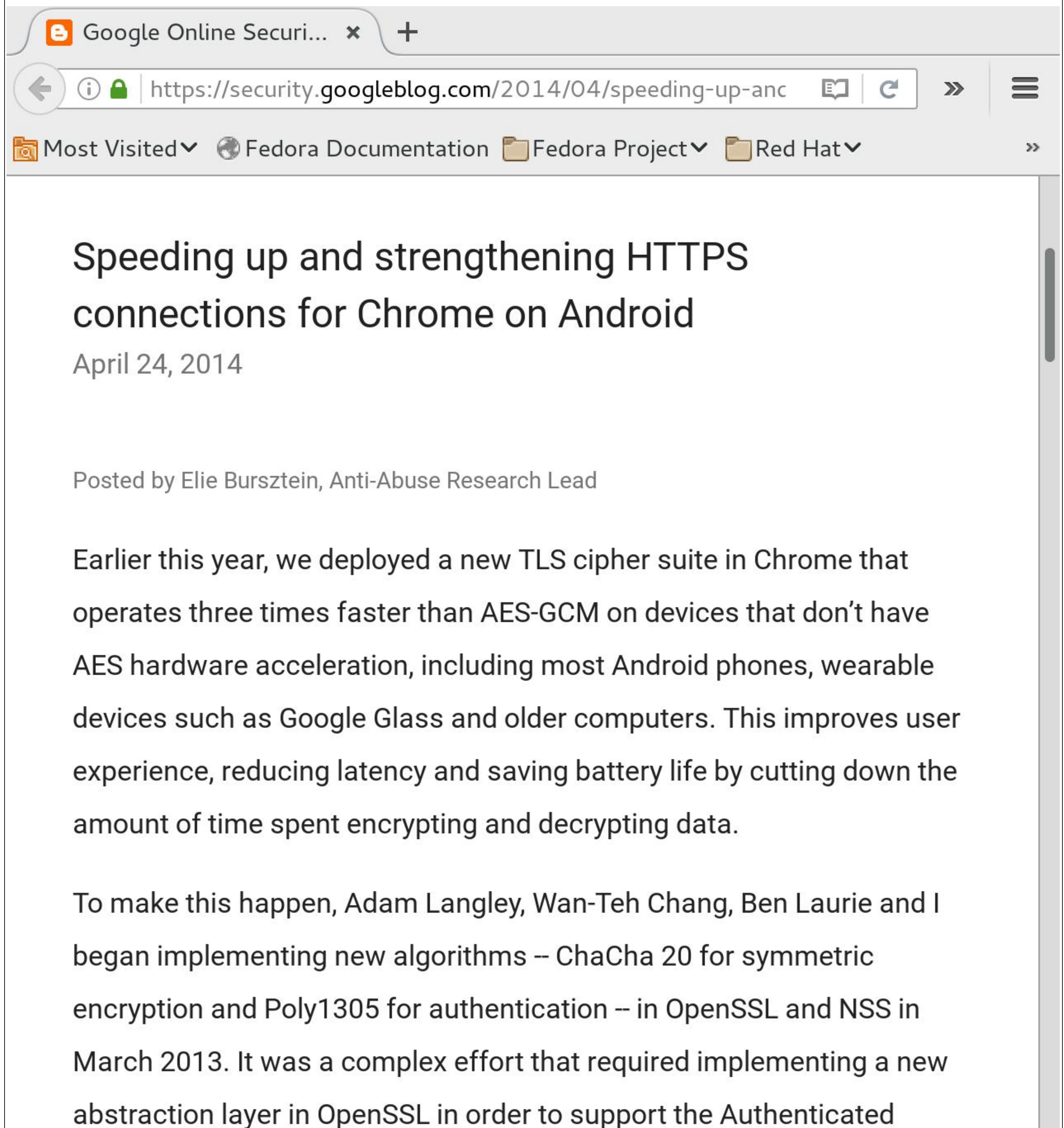


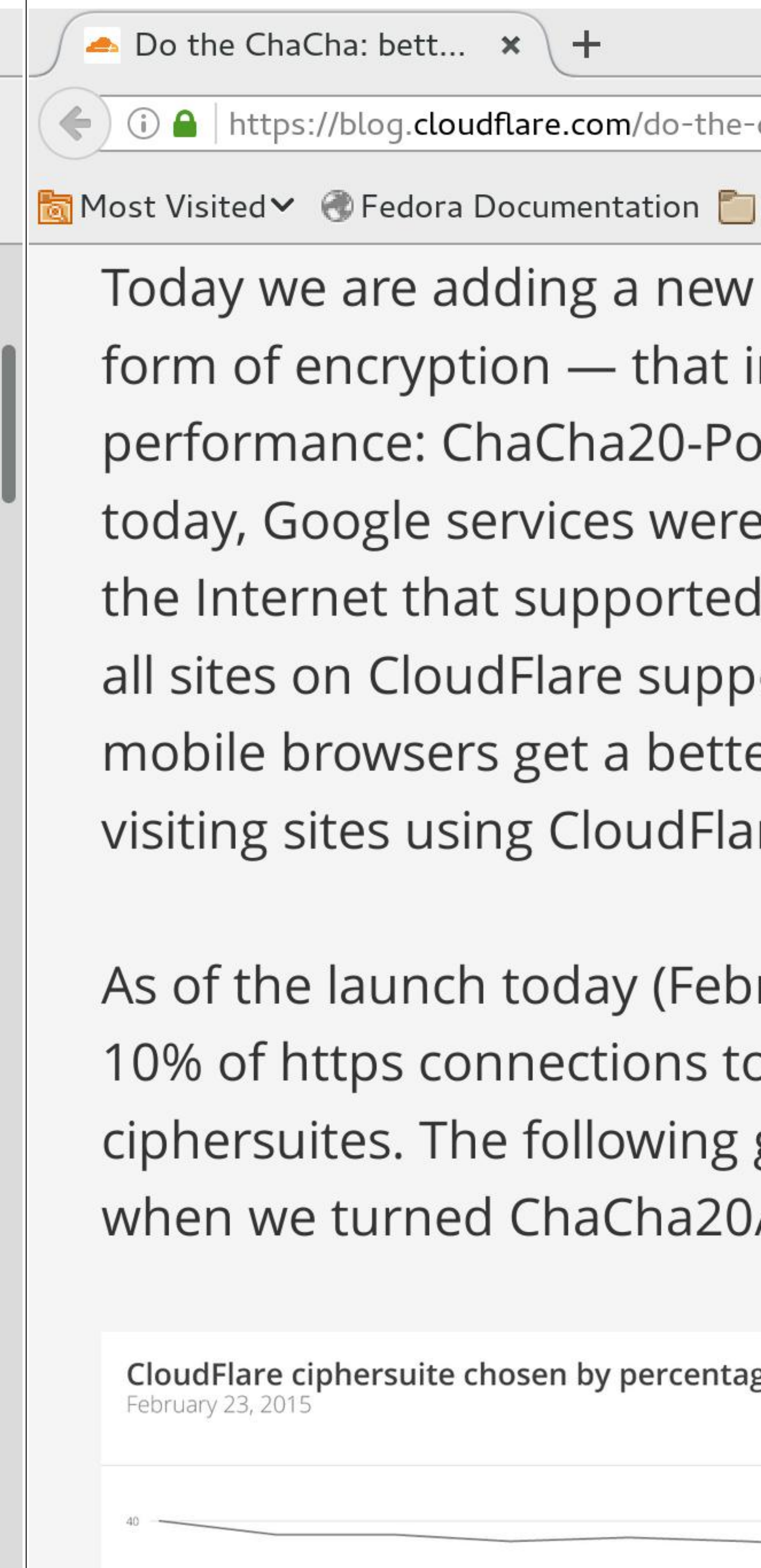

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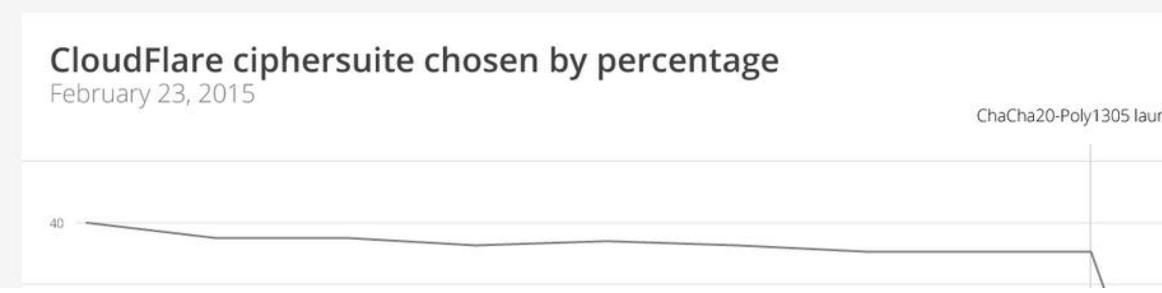

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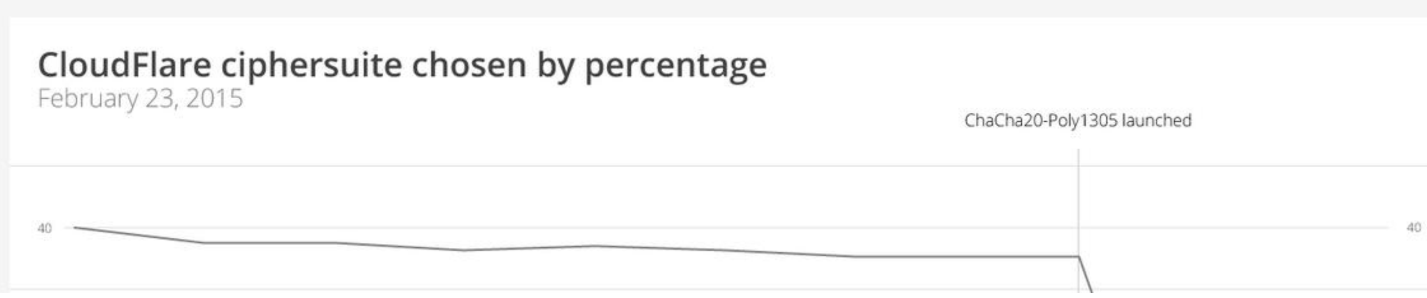


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Maybe Skip SHA-3 (31 May 2017

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## Maybe Skip SHA-3 (31 May 2017)

In 2005 and 2006, a series of significant results were published against SHA-1 [1][2][3]. These repeated break-throughs caused something of a crisis of faith as cryptographers questioned whether we knew how to build hash functions at all. After all, many hash functions from the 1990's had not aged well [1][2].

In the wake of this, NIST announced (PDF) a competition to develop SHA-3 in order to hedge the risk of SHA-2 falling. In 2012, Keccak (pronounced "ket-chak", I believe) won (PDF) and became SHA-3. But the competition itself proved that we *do* know how to build hash functions: the series of results in 2005 didn't extend to SHA-2 and the SHA-3 process produced a number of hash functions, all of which are secure as far as we can tell. Thus, by the time it existed, it was no longer clear that SHA-3 was needed. Yet there is a natural tendency to assume that SHA-3 must be better than SHA-2 because the number is bigger.

As I've mentioned before, diversity of cryptographic primitives is expensive. It contributes to the exponential number of combinations that need to be tested and hardened; it draws on limited developer resources as multiple platforms typically need separate, optimised code; and it contributes to code-size, which is a worry again in the mobile age. SHA-3 is also slow, and is even slower than SHA-2 which is already a comparative laggard amongst crypto primitives.