Adding AES-ICM and AES-GCM to OpenCrypto

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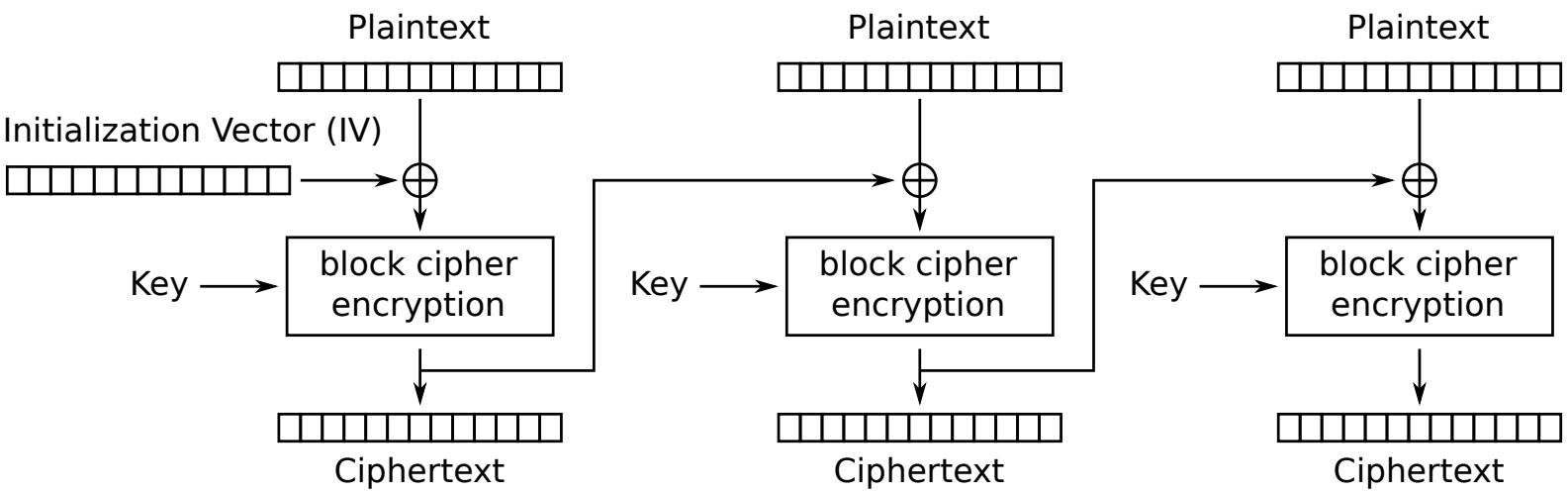
Why is AES-GCM and AES-ICM Necessary?

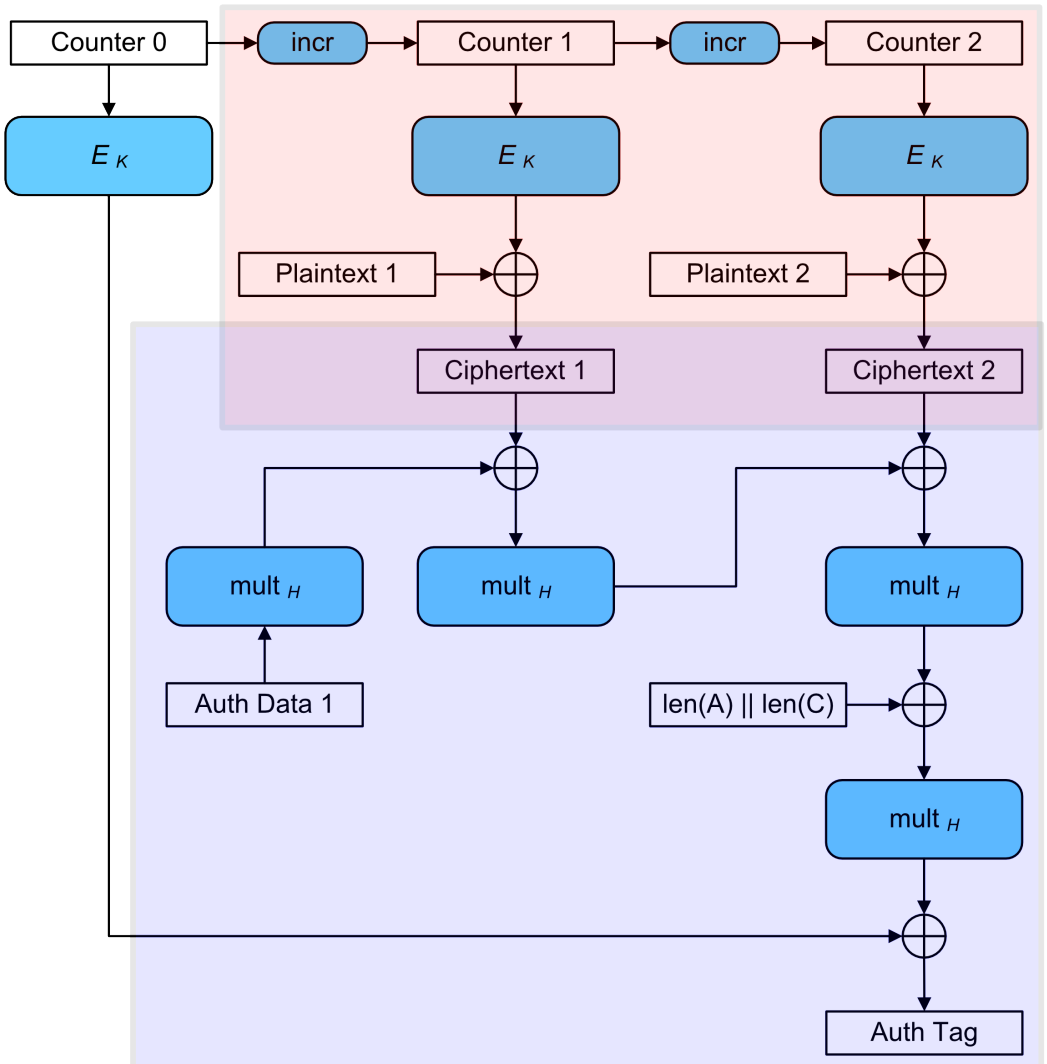
- Performance
- Security (AES-NI)
- More complete IPsec cipher mode support
- AES-GCM is an AEAD mode

Why not AES-CBC?



Cipher Block Chaining (CBC) mode encryption

What is AES-GCM?



Multiplication in GF(2^{128})

- Addition does not carry:

+	0	1
0	0	1
1	1	0

aka XOR or $\oplus$

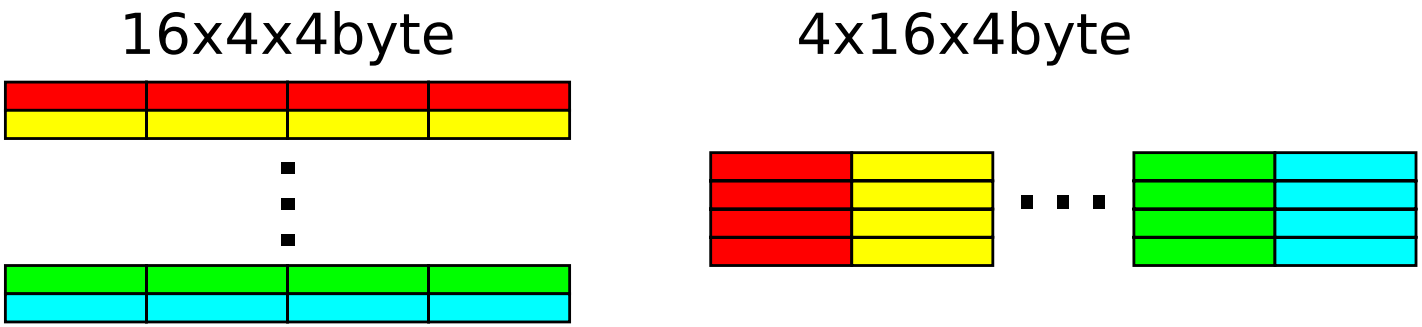
- $11_b \cdot 11_b = 110_b + 11_b = 101_b$
- Multiplication is otherwise the same, add the reducing factor when value is $\geq 2^{128}$
- Distribution works: $(a + b) \cdot c \equiv a \cdot c + b \cdot c$

Dangers of Side Channel Attacks

- In 2010, Bonan Huang wrote his masters thesis [1] on attacking AES-GCM's secret authentication value H
- Not just GHASH, AES is vulnerable too [2]
- Fixing side channels can bring performance improvements, but usually not

Compromise

- Even intra-cache line accesses have timing variations [3]
- 4-bit lookup is a compromise between performance and side-channel resistance



Optimizing Opportunities

- Pipelining: $((((((a \cdot H) + b) \cdot H) + c) \cdot H) + d) \cdot H \equiv a \cdot H^4 + b \cdot H^3 + c \cdot H^2 + d \cdot H$
- Precompute the powers of H
- Performance increase even for software, not just AES-NI

AES-NI Avoids Cache Timing Attacks

- AES Instructions
- PCLMULQDQ (Carry-less multiply) instruction – 64x64->128
- Needs work to make a 128x128->128 needed for GHASH

Reviews Are Necessary

- Require nonce to be specified for AES-ICM and AES-GCM
- Found bug in reference code for comparing GCM tags

Testing and Verification Are Too

- tests/sys/opencrypto/runtests
- requires python and nist-kat ports

Thanks

Mike Hamburg
Watson Ladd

For Further Reading

- B. Huang, “Cache-collision timing attacks against AES-GCM.” University of Delaware, 2010.
  http://udspace.udel.edu/handle/19716/9765.
- D. J. Bernstein, “Cache-timing attacks on AES.” The University of Illinois at Chicago, 2005.
  http://cr.yp.to/papers.html#cachetiming.
- D. J. Bernstein and P. Schwabe, “A word of warning.” CHES 2013 Rump Session, 2013.
  https://cryptojedi.org/peter/data/chesrump-20130822.pdf.