Security Analysis of ORANGE-Zest

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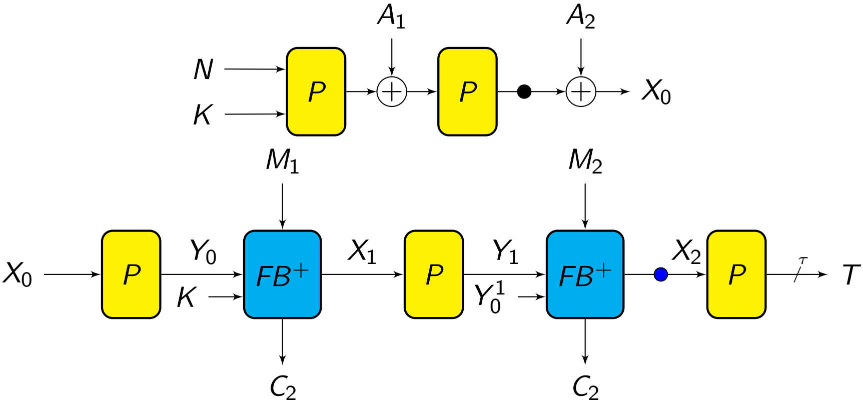
ORANGE-Zest Mode of AEAD



1. Rate is 1 (256-bit message with 256-bit permutation).
2. Additional state size is 128-bit.

ORANGE-Zest Mode of AEAD

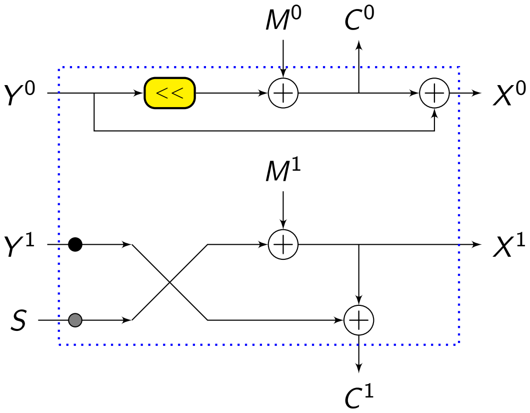


Figure: The Feedback Processing (FB^+). Black dot means α^m multiplication where $m = 0/1/2$ for intermediate block, complete last block, partial last block respectively. Gray dot means α multiplication.

Forgery Attack (Dobraunig, Mendel, Mennink)

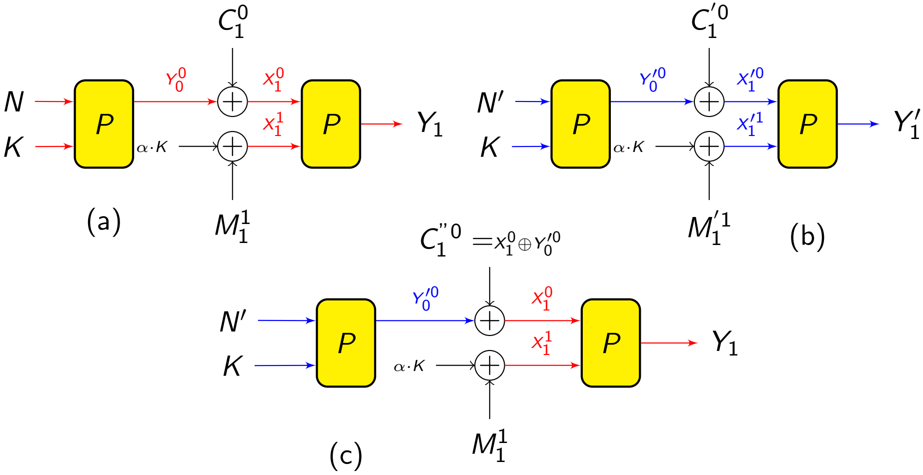


Figure: (a) 1st query, (b) 2nd query, (c) Forgery.

Modified ORANGE-Zest

- the extra state input while processing the first message block to be nonce dependent.
- When $|A| = 0$, To make $S_1 \neq K$ we pad A so that $|\text{pad}(A)| = n$.
- The **modified** ORANGE-Zest is well secured within NIST requirements.

Modified ORANGE-Zest

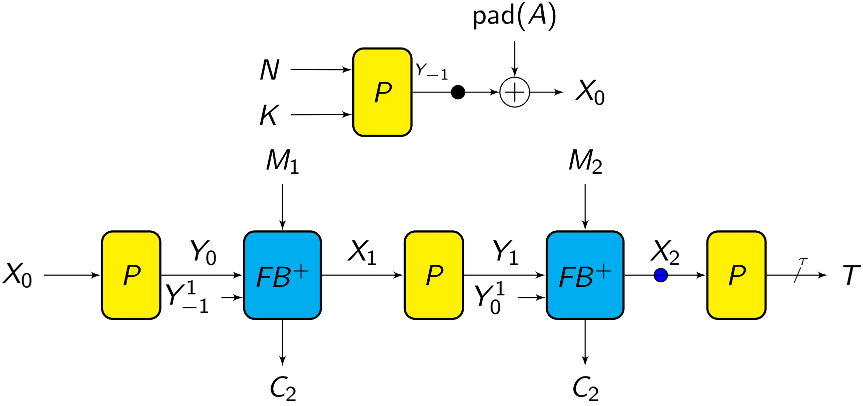


Figure: Modified ORANGE-Zest encryption ($|A| = 0, |M| = 2n$)

ORANGISH Hash Function

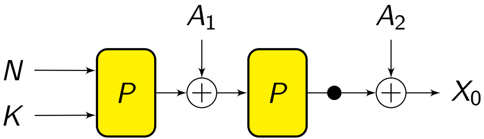


Figure: ORANGE-Zest AD Module

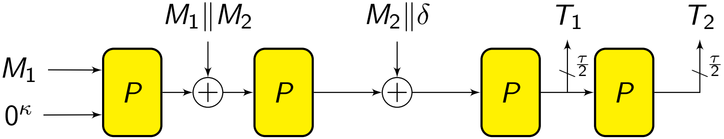


Figure: ORANGISH Hash Function

Security Analysis

1. Similar to Transform-then-Permute (though it does not fall under this paradigm).
2. Need multi-chain analysis (note that tag generation is same as CBC type MAC over ciphertext.)
3. Refer workshop paper for details.

Conclusion

- The **modified** ORANGE-Zest satisfies NIST requirements.
- Among all Sponge type submissions: Only ORANGE-Zest has Rate 1. (absorbs 256-bit massage/associated data per 256-bit permutation call.)
- High rate from using a small extra state.
- The hash function ORANGISH can be implemented by suitably using ORANGE-Zest associated data processing module.
- ORANGISH is a JH-hash type construction which is well analyzed.

Thank You!