Dear all,

I looked at Wu et. al's report [1] on LUX and I believe that their observation can obviously be extended to a collision attack and a second preimage attack which would be labeled orange in the SHA-3 zoo according to their computational complexities. The following is the brief sketch of the attacks.

== Wu et. al's observation

Let $H=(h_0, h_1, ..., h_7)$ be the hash value and $h_i=(a_i, b_i, c_i, d_i)$ be its byte expression. Then the following relation holds for $0<i<8$.

$$0xf7^*a_i + 0x4c^*b_i + 0xf4^*c_i + d_i = 0x4e^*S(a(i-1))$$

See [1] Section 3.1 for more detail.

== What does it mean?

Eq.(1) means that 4 bytes of $h_i$ of the output determine 1 byte of $h(i-1)$. In other words, LUX-256 has undesirable property that the 56(=8*7) bits of the output are determined by the remaining 256-56=200 bits without extra computational cost. It obviously reduces the complexity of the birthday attack and the second preimage attack.

== Collision attack and second preimage attack

Find a partial collision such that $b_i=b_i', c_i=c_i', d_i=d_i'$ for $0<=$i$<8$ and $a_7=a_7'$. With help of Eq.(1) and the fact that $S$ is a permutation, we have $a_i=a_i'$ for $0<=$i$<7$.

=== Complexity of collision attack
* Hash function call: $2^{(3*8+1)*8/2} = 2^{100}$.
* Memory: $2^{100}$.

=== Complexity of second preimage attack
* Hash function call: $2^{200}$.
* Memory: none.

== LUX-512
LUX-512 has the same weakness as LUX-256 so that the 56(=8*7) bits of the output are determined by the remaining 512-56=456 bits. In the similar manner to the attacks on LUX-256, the collision attack and the second preimage attack require $2^{456/2}=2^{228}$ and $2^{456}$ complexity respectively.

[1] Shuang Wu, Dengguo Feng, Wenling Wu
Cryptanalysis of the Hash Function LUX-256

Regards,
Dai Watanabe
I have not validated this attack, but if I understand the results correctly, LUX-256 can be seen as a 200-bit hash function with a post-processing function that stretches the 200 bits into a 256-bit result. That means it can't be used in SP 800-90 Hash-DRBG, it generates weak keys if used in a normal hash-based KDF, has reduced security for HMAC-LUX, etc.

A minor point: We can drop the memory requirements for collision finding from $2^{100}$ ($2^{228}$ for LUX-512) to a constant size by using Floyd's or Brent's cycle finding algorithm.

Regards,

Niels

From: hash-forum@nist.gov [hash-forum@nist.gov] On Behalf Of Watanabe Dai [dai.watanabe.td@hitachi.com]
Sent: Wednesday, April 08, 2009 8:02 PM
To: Multiple recipients of list
Subject: OFFICIAL COMMENT: LUX

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The following is the brief sketch of the attacks.

== Wu et. al's observation

Let $H=(h0, h1, ..., h7)$ be the hash value and $hi=(ai, bi, ci, di)$ be its byte expression. Then the following relation holds for $0<i<8$.

$0xf7*ai + 0x4c*bi + 0xf4*ci + di = 0x4e * S(a(i-1))......(1)$

See [1] Section 3.1 for more detail.

== What does it mean?

Eq.(1) means that 4 bytes of $hi$ of the output determine 1 byte of $h(i-1)$. In other words, LUX-256 has undesirable property that the 56=(8*7) bits of the output are determined by the remaining 256-56=200 bits without extra computational cost. It obviously reduces the complexity of the birthday attack and the second preimage attack.

== Collision attack and second preimage attack

Find a partial collision such that $bi=bi',ci=ci',di=di'$ for $0<=i<8$ and $a7=a7'$. With help of Eq.(1) and the fact that $S$ is a permutation, we have $ai=ai'$ for $0<=i<7$.

=== Complexity of collision attack

* Hash function call: $2^{((3*8+1)*8/2)} = 2^{100}$.
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== LUX-512

LUX-512 has the same weakness as LUX-256 so that the 56 (= 8*7) bits of the output are determined by the remaining 512-56 = 456 bits. In the similar manner to the attacks on LUX-256, the collision attack and the second preimage attack require $2^{456/2} = 2^{228}$ and $2^{456}$ complexity respectively.

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Regards,
Dai Watanabe
Re: OFFICIAL COMMENT: LUX

Subject: Re: OFFICIAL COMMENT: LUX
From: Nicky Mouha <Nicky.Mouha@esat.kuleuven.be>
Date: Thu, 9 Apr 2009 17:46:51 -0400
To: Multiple recipients of list <hash-forum@nist.gov>

Hi,

The attack strategy is completely valid, but some hexadecimal values in the formula are incorrect. To demonstrate this, I've uploaded a distinguisher for all digest sizes of LUX at [http://www.nickymouha.be/software-en.html](http://www.nickymouha.be/software-en.html)

All credit for this distinguisher should go to Shuang Wu, Dengguo Feng and Wenling Wu. The only thing I did is correct some calculation errors and trivially extend the results to LUX-384/512.

Kind regards,
Nicky

Niels Ferguson wrote:

I have not validated this attack, but if I understand the results correctly, LUX-256 can be seen as a 200-bit hash function with a post-processing function that stretches the 200 bits into a 256-bit result. That means it can't be used in SP 800-90 Hash-DRBG, it generates weak keys if used in a normal hash-based KDF, has reduced security for HMAC-LUX, etc.

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See [1] Section 3.1 for more detail.

== What does it mean?

Eq.(1) means that 4 bytes of $h_i$ of the output determine 1 byte of $h_{i-1}$.

In other words, LUX-256 has undesirable property that the 56($=8*7$) bits of the output are determined by the remaining 256-56=200 bits without extra computational cost.

It obviously reduces the complexity of the birthday attack
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== Collision attack and second preimage attack

Find a partial collision such that 
\( b_i = b'_i, c_i = c'_i, d_i = d'_i \) for \( 0 \leq i < 8 \) and \( a_7 = a'_7 \).

With help of Eq.(1) and the fact that \( S \) is a permutation, 
we have \( a_i = a'_i \) for \( 0 \leq i < 7 \).

=== Complexity of collision attack
* Hash function call: \( 2^{((3 \times 8 + 1) \times 8 / 2)} = 2^{100} \).
* Memory: \( 2^{100} \).

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* Hash function call: \( 2^{200} \),
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LUX-512 has the same weakness as LUX-256 so that the 56(=8*7) bits of the output are determined by the remaining 512-56=456 bits. 
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Cryptanalysis of the Hash Function LUX-256

Regards,
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Dear all,

We knew about these observations since they are a straightforward consequence of the weaknesses in the output filter only. We already decided to drop the filter due to the observations of Wu et al. We find the recent work on the number of blank rounds of LUX done by Schmidt-Nielsen of more importance.

Best regards,

Ivica, Alex, Dmitry

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2009/4/9 Watanabe Dai <dai.watanabe.td@hitachi.com>

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