How to use differential trails to attack compression functions

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UNIVERSITÉ DE VERSAILLES
ST-QUENTIN-EN-YVELINES

Structure of this Talk

The Serial Construction

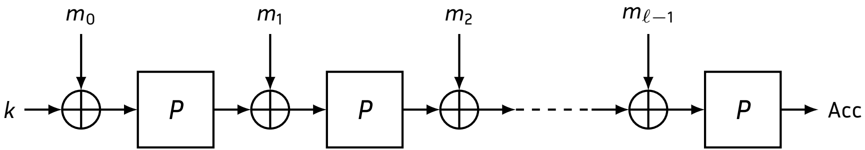


Figure: The Serial Construction

Parallel Construction

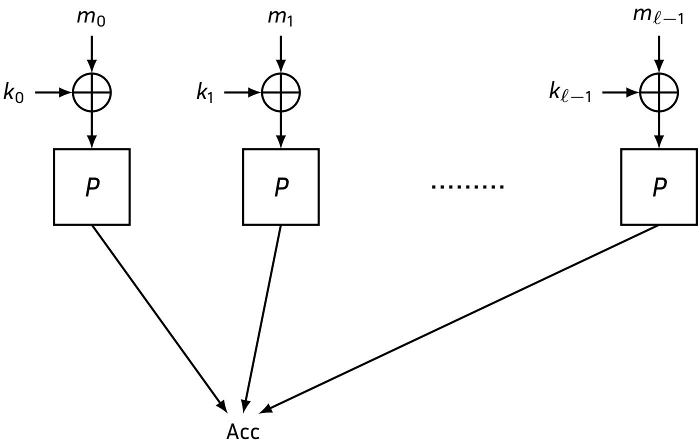
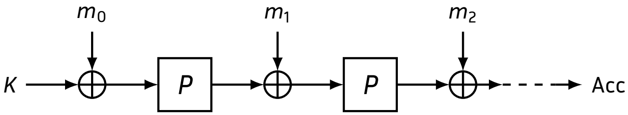
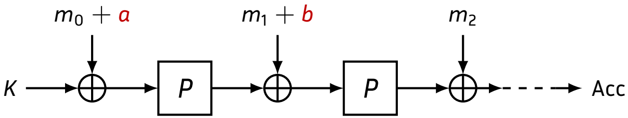
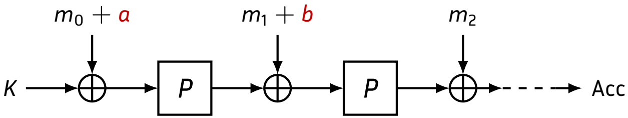


Figure: The Parallel Construction

Plan of this Section

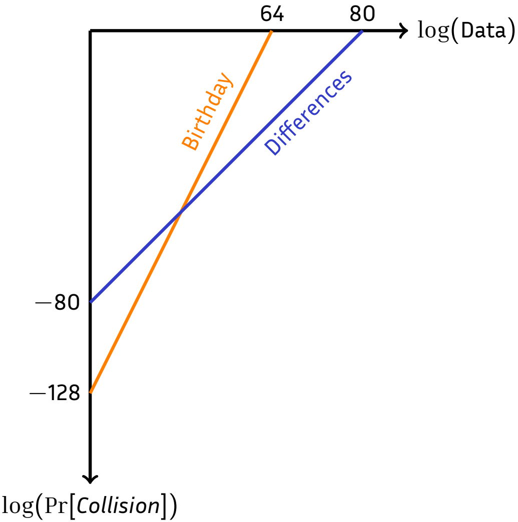

m_0
m_1
m_2
K
P
P
Acc


$m_0 + a$
$m_1 + b$
m_2
K
P
P
Acc

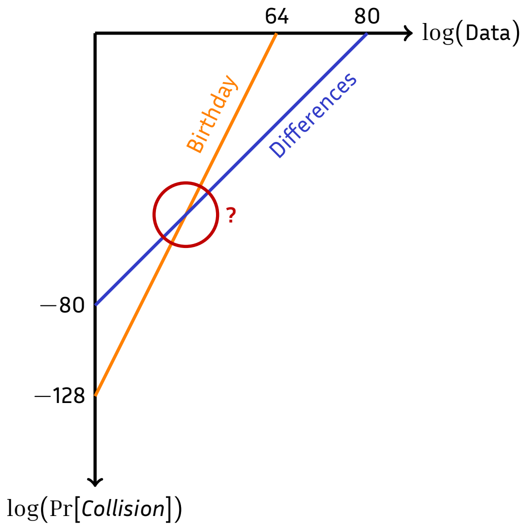


$$\Pr[\mathit{Collision}] = \mathsf{DP}(a, b)$$

Birthday VS Difference



Birthday VS Difference



Using Covering Vector spaces

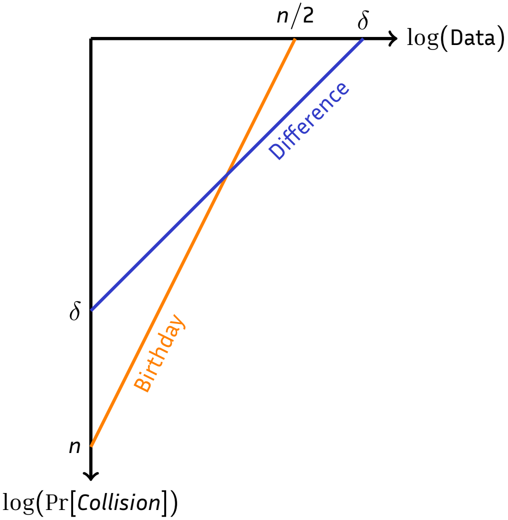
$\langle (a_1, b_1), (a_2, b_2), \ldots, (a_v, b_v) \rangle = V$ such that

$$\sum_{(a,b)\in V} \delta_{a,b} > \delta\,.$$

By making this strategy:

$$\boxed{\begin{array}{c} M_0, M_1 \\ M_0 + a_1, M_1 + b_1 \\ M_0 + a_2, M_1 + b_2 \\ M_0 + a_1 + a_2, M_1 + b_1 + b_2 \\ \vdots \\ M_0 + \sum a_i, M_1 + \sum b_i \end{array}} \quad \boxed{\begin{array}{c} M'_0, M'_1 \\ M'_0 + a_1, M'_1 + b_1 \\ M'_0 + a_2, M'_1 + b_2 \\ M'_0 + a_1 + a_2, M'_1 + b_1 + b_2 \\ \vdots \\ M'_0 + \sum a_i, M'_1 + \sum b_i \end{array}} \quad \ldots\ldots\ldots$$

In terms of Security



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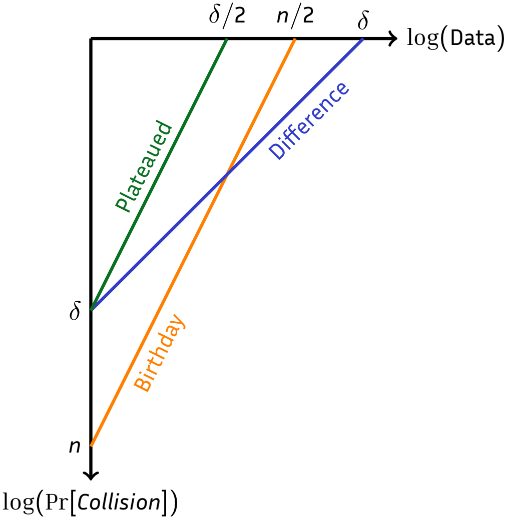

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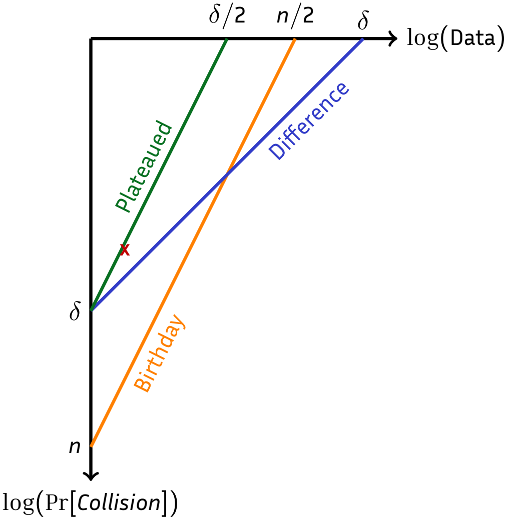

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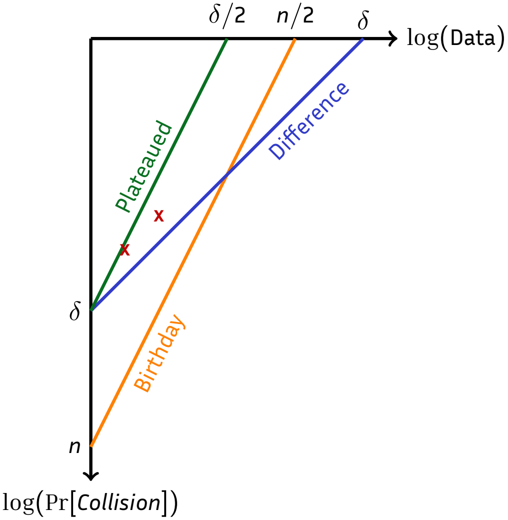

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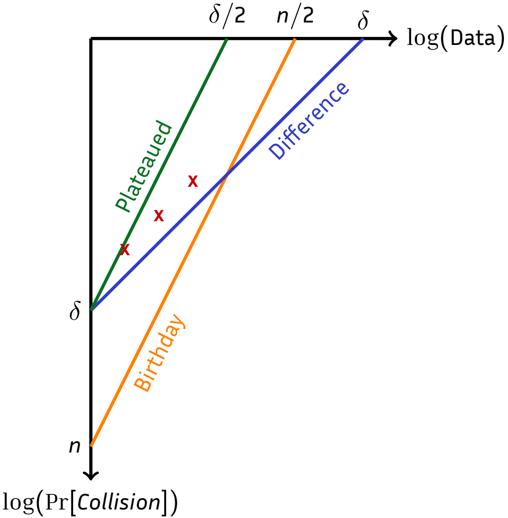

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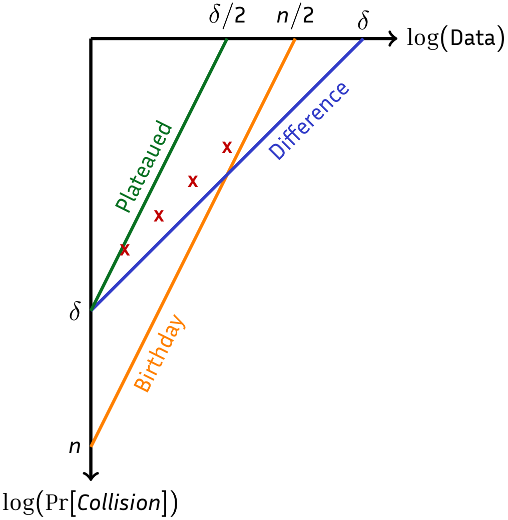

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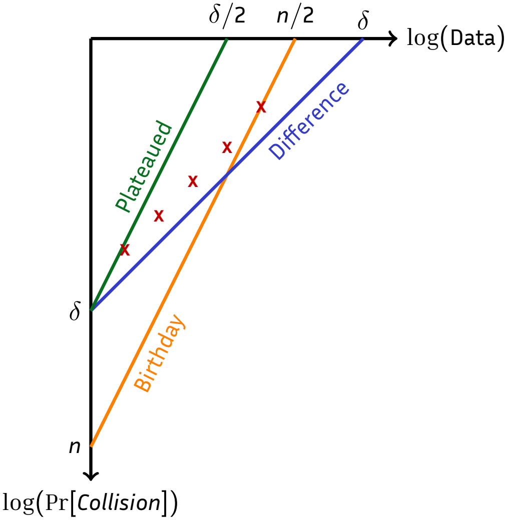

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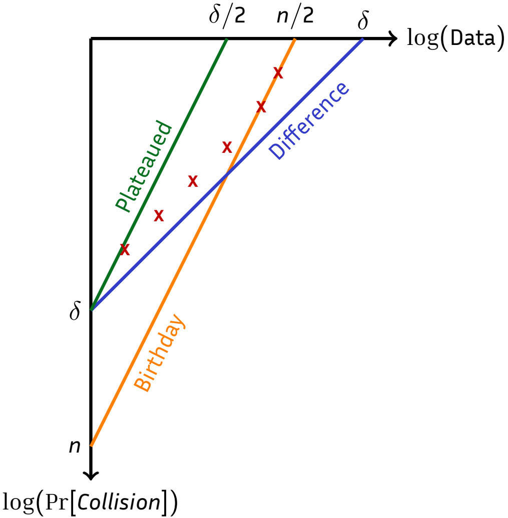
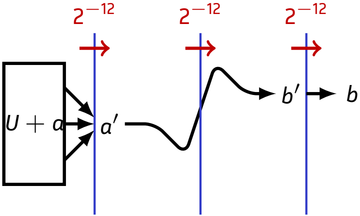


In Practice: XooDoo



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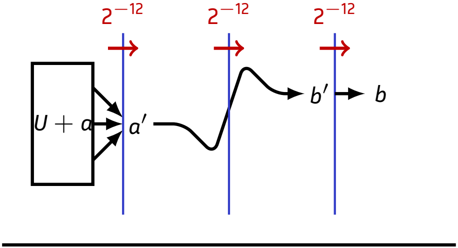

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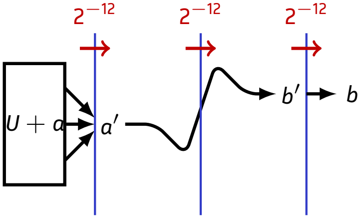

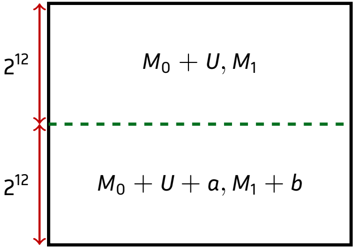

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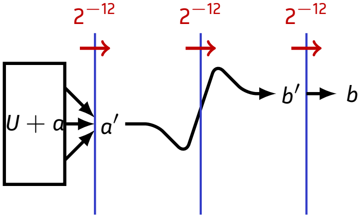
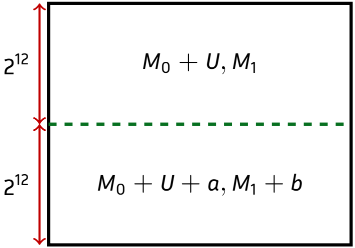
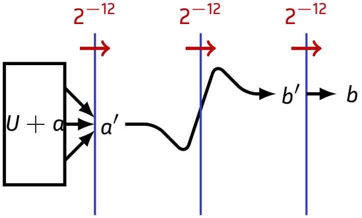


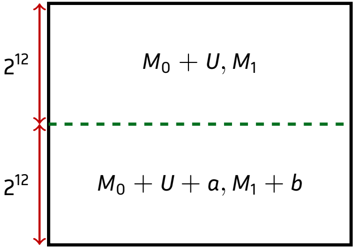


Number of pairs st a': 2^{12}

$$\Pr[Collision] = 2^{12} \times 2^{-24}$$

In Practice: XooDoo





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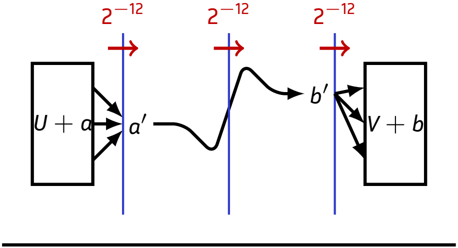

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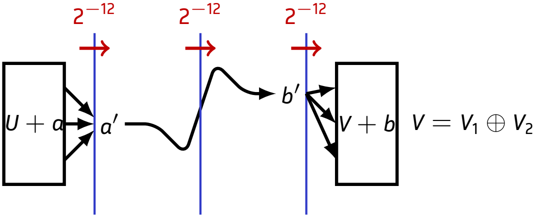

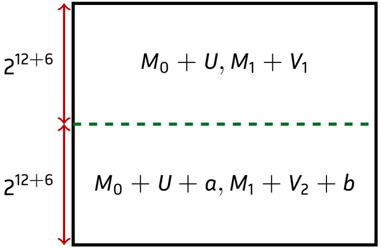

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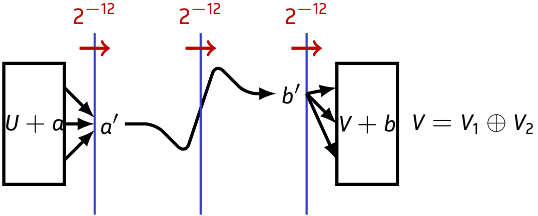

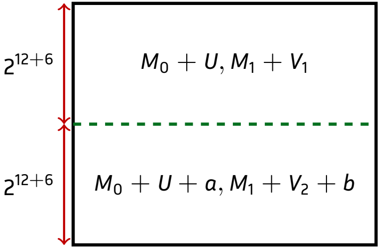

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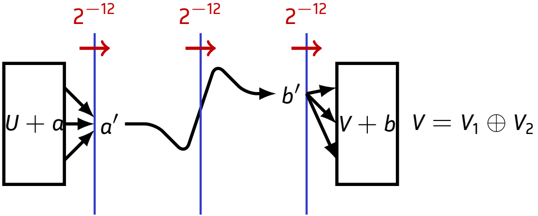
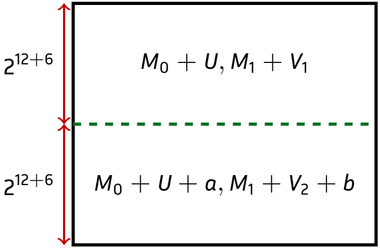
Catching b': $2^{12} \times 2^{-12} = 1$

In Practice: XooDoo





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Catching b': $2^{12} \times 2^{-12} = 1$

Win wp. 1 with 2^{19}.

Security Criteria

If trail $a \mapsto b$ with probability $2^{-w_1 - w_2 - w_3 \cdots - w_r}$, we get collision with probability

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$$2^{w_1-w_2-w_3-\cdots-w_{r-1}}$$

using

$$D = 2^{1+w_1+w_r/2}$$

We gain the first round and the half of the last round

Plan of this Section

New Criteria: Squared pseudo-Walsh Coefficient

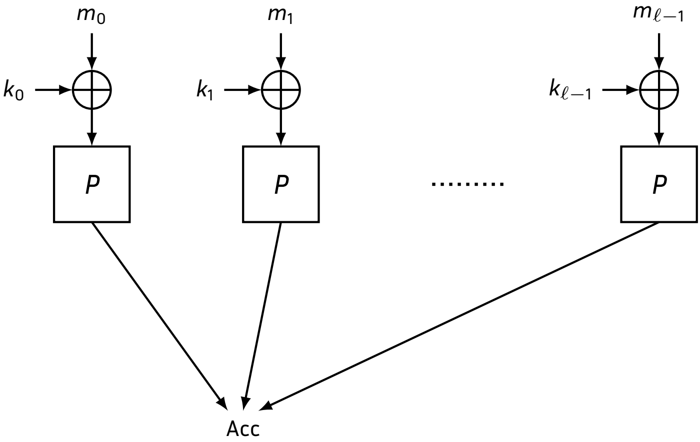

Figure: The Parallel Construction

Results

If Keys are independent and uniformly distributed, then

$$\Pr[F(M) = F(M')|M + M' = \Delta]$$

is maximal when Δ has the same value on two blocks exactly.

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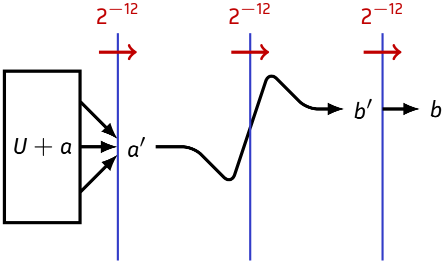
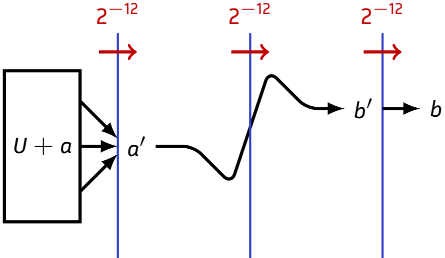
The relevant criteria is

$$\max_a \sum_b (\mathrm{DP}(a, b))^2$$

In iterated construction





Security Criteria

- Complexity: $2^{2w_1+2w_2+\cdots+2w_{r-1}+w_r}$.

Plan of this Section

Conclusion

Both strategies share the same security criteria:

- The first round doesn't count;
- The last round counts for half.

But...

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- The first round doesn't count;
- The last round counts for half.

But... The parallel strategy seems to offer twice the security.