Pragmatism vs. Elegance

comparing two approaches to Simple Power Analysis on AES

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AES: Advanced Encryption Standard

- Symmetric-key block cipher
- Key size: **128**, 192, and 256 bits
- Block size: **128** bits

- Announced by the NIST as U.S. FIPS PUB 197 on 26.11.2001

Classic Simple Power Analysis (SPA) Attacks

- Classic SPA attacks can be compared to brute-force
- Side-channel information makes this approach feasible against modern-day ciphers
- Most common leakage models: **8-bit Hamming weight** and Hamming distance

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- In practice, side-channel information cannot be measured perfectly (i.e., **noise**)
  - average over a few measurements
  - drop information with high error probability
  - encapsulate side-channel information as a set of (consecutive) possible values, **always containing the correct value**

Classic SPA Attacks on AES

Mangard's Attack

- Targets Key Schedule
- 5 consecutive round keys
- Side-channel information: **correct HW value** or **no information at all**

ASCA Attack

- Targets Encryption Rounds
- All encryption rounds
- Side-channel information: **sets of up to 3 possible HW values**

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- Targets Key Schedule
- 5 consecutive round keys
- Side-channel information: **correct HW value** or **no information at all**
- Result: Reduced keyspace

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Pragmatism vs. Elegance

Our goals:

- require less side-channel information
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Our approach:

- Combine information of Encryption Rounds *and* Key Schedule of a single round
- Side-channel information: sets of up to **5** possible values

The AES Encryption algorithm

Encryption Rounds

- Initial Round
  - AddRoundKey
- Intermediate Rounds
  - SubBytes
  - ShiftRows
  - MixColumns
  - AddRoundKey
- Final Round
  - SubBytes
  - ShiftRows
  - AddRoundKey.

The AES Encryption algorithm

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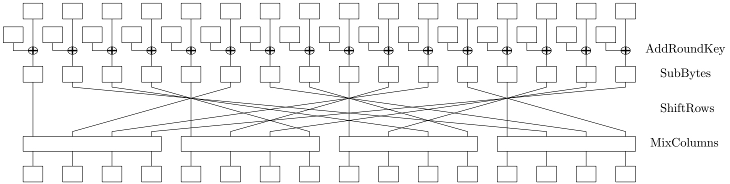
The AES Encryption algorithm

Attacking the Encryption Round Function



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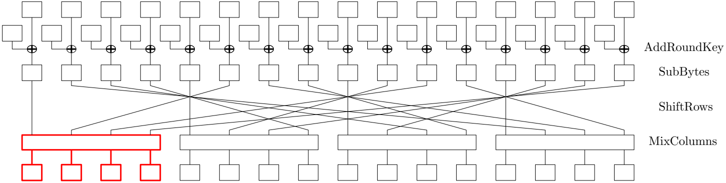

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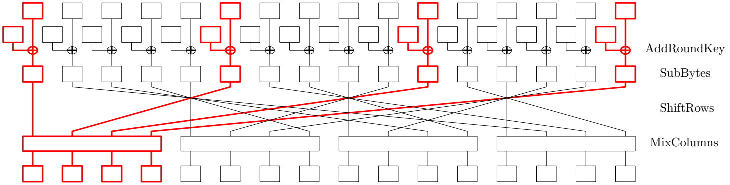

The AES Encryption algorithm

Key Schedule

- Represent the secret key as a set of 4-byte words
- Derive one new word at a time from two previous words
- Operations:
  - Circular shift of word bytes
  - S-box lookup
  - XOR-ing with a round constant
  - XOR-ing two words

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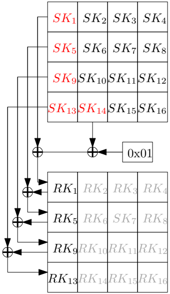
Attacking the Key Expansion Function



The AES Encryption algorithm

Attacking the Key Expansion Function

SK_1	SK_2	SK_3	SK_4
SK_5	SK_6	SK_7	SK_8
SK_9	SK_{10}	SK_{11}	SK_{12}
SK_{13}	SK_{14}	SK_{15}	SK_{16}

The AES Encryption algorithm

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Results

Previous results

Mangard's Attack (attacking 5 consecutive Round Keys, 1000 experiments)

HW used	**100%**	**95%**	**50%**
key space	11	16.5	$1.7 \cdot 10^{12}$
time	5m30s	5m	5h

ASCA Attack success rate (known PT and CT, 100 experiments)

# rounds	**2**	**4**	**6**
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(Using leaks from one encryption round and one round key. The PT is known. Averaged over 500 experiments)

	Encryption only		Key Schedule only		Combined	
Set size	**Key space**	**Execution time**	**Key space**	**Execution time**	**Key space**	**Execution time**
1	1	0.02 s	2^{58}	0.4 s	1	0.03 s
2	2^{20}	2.9 s	2^{74}	5 s	2^{12}	27 s
3	2^{48}	73.9 s	2^{95}	10 s	2^{13}	4 m
4	2^{64}	27 m	2^{106}	30 s	2^{52}	35 m
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Moreover, our attack gives a clear indication of the key space that needs to be brute-forced

Thank you for your attention