AGH University of Science
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Selected Topics in Cryptography
Quantum cryptanalysis

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Quantum crypanalysis

Agenda

1. Bra-ket notation
2. Quantum gates
3. Grover's Database Search
4. Shore's factorization algorithm
   - Fast modular exponentiation
   - Quantum Fourier Transform

Bra-ket notation

Origins

Bra–ket notation: $\langle x|y\rangle$ is a standard notation for describing quantum states. It can also be used to denote abstract vectors, linear functionals and scalar product in mathematics.

The left part: $\langle x|$, called the bra, is a row vector.
The right part: $|y\rangle$, called the ket, is a column vector.

Gates

Origins

In quantum computing and specifically the quantum circuit model of computation, a quantum gate (or quantum logic gate) is a basic quantum circuit operating on a small number of qubits.

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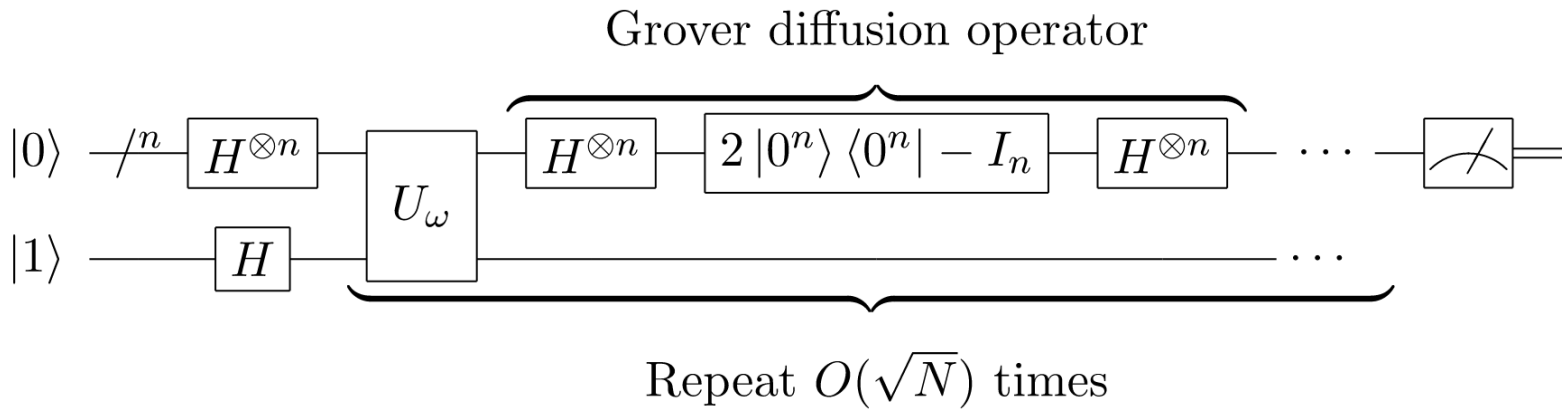
Fast database search

Grover's database search uses possibility to pararell process of qbit. The algorithm allows us to find selected element in unsorted set. Complexity $\sqrt{n}$

Advanced Encryption Standard

Overwiev of AES



Advanced Encryption Standard

3.MixColumns

Each column is represented as four-bytes vector.

Each column of State is replaced by a new column which is formed by multiplying that column by a certain matrix of elements of the field.

Together with ShiftRows, MixColumns provides *diffusion* in the cipher.

MixColumns step is used in every cycle **except** the last one cycle.

Advanced Encryption Standard

3.MixColumns

It is also possible to see this operation as polynomial multiplication where each column is represented with polynomial a(x):

$$a(x) = c(x).a(x) mod x^4 + 1 =$$
$$(03x^3 + 01x^2 + 01x + 02).(a_3x^3 + a_2x^2 + a_1x^1 + a_0) mod x^4 + 1$$

$$c(x) = \begin{bmatrix} 02 & 03 \\ 01 & 02 \end{bmatrix}$$

Advanced Encryption Standard

Key Schedule: Rcon Table

Rcon Constants			
Round	Constant(Rcon)	Round	Constant(Rcon)
1	01 00 00 00	6	20 00 00 00
2	02 00 00 00	7	40 00 00 00
3	04 00 00 00	8	80 00 00 00
4	08 00 00 00	9	1B 00 00 00
5	10 00 00 00	10	36 00 00 00

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Time for questions

Advanced Encryption Standard

Bibliography

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Thank you for attention!