Performance Evaluation of AES Finalists on the High-End Smart Card

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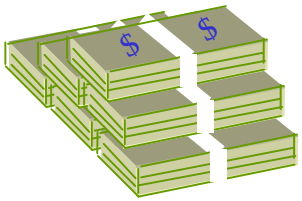
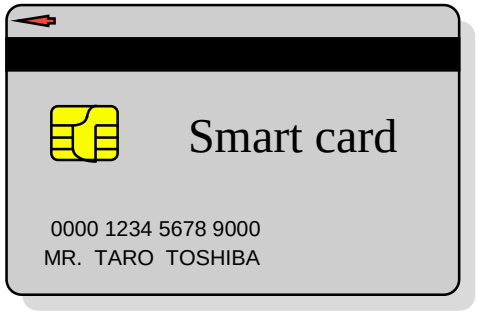
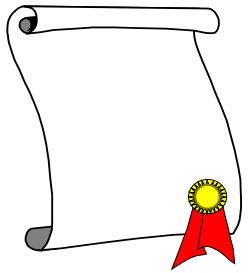
Applications of smart card

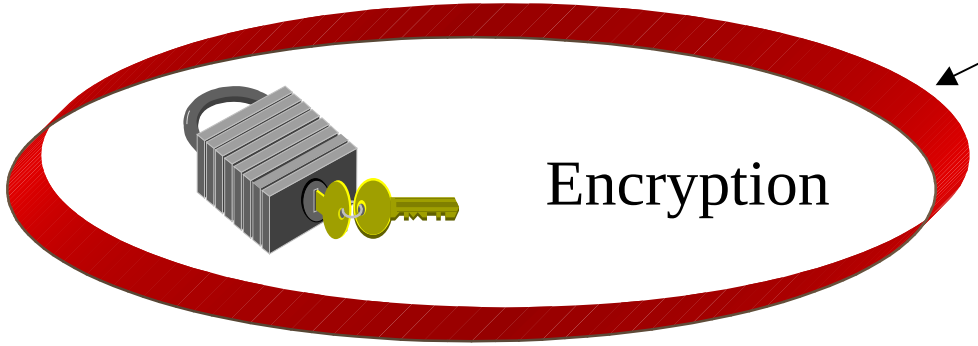


Digital cash





Digital signature



Common key cryptosystem

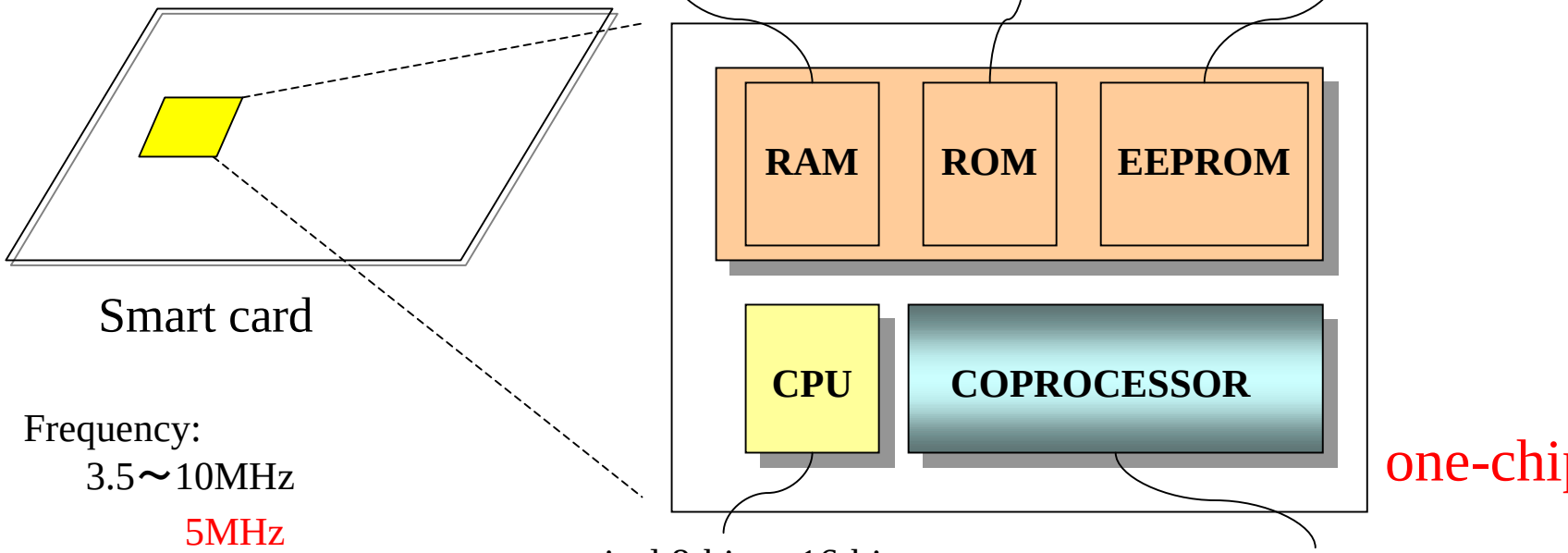
e.g. secure messaging

DES/Triple DES

AES

replace

High-end smart card platform (JT6N55)



Frequency:
3.5～10MHz
5MHz

Power supply:
external

typical 8-bit or 16-bit
(special 32-bit)

Z80 (8-bit architecture)

Aid multiple-precision integer arithmetic

Max. of Modulus 2,048-bit

Previous works -- only CPU

On various 8-bit CPUs

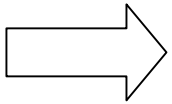
6805, 8051, Z80, etc.

low-power, and small circuit.
They are good for smart card.

Some of AES finalists can be implemented.

Question (on high-end smart card)

High-end smart cards will be popular.
Is the coprocessor efficient for AES?



It will enhance the performance.

Implementation for coprocessor

Role of coprocessor

Speed up multiple-precision integer arithmetic.
Mainly used for public key cryptosystems.
(e.g. modular exponentiation modulo 1,024 bits.)

new role

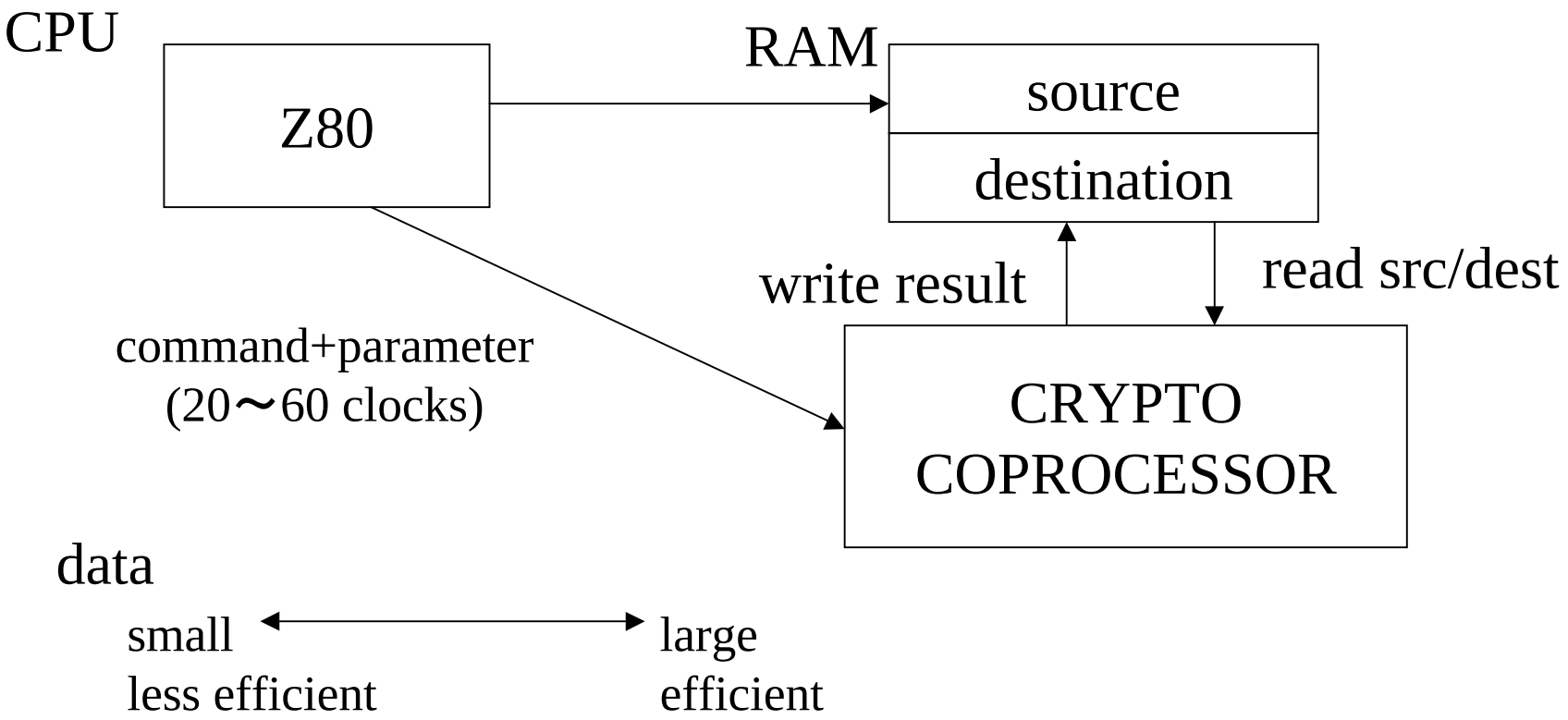
Addition, multiplication, division, and logical operations.

Applying to common key cryptosystems.

The use of coprocessor reduces…

- code size,
- time for encryption and key scheduling.

Sketch


CPU
Z80
RAM
source
destination
write result
read src/dest
command+parameter
(20～60 clocks)
CRYPTO
COPROCESSOR
data
small
less efficient
large
efficient

Implementation

Rules for coding

- On-the-fly key generation, if possible.
- We use all registers on the Z80.
- No data depended branches.
  - Tamper-resistance.
- Use operations performed by the coprocessor, if efficient.
  - Previously mentioned.

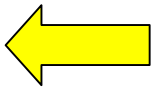
Available resources

- ROM and RAM

  EEPROM area is used for user's data or JAVA applets.

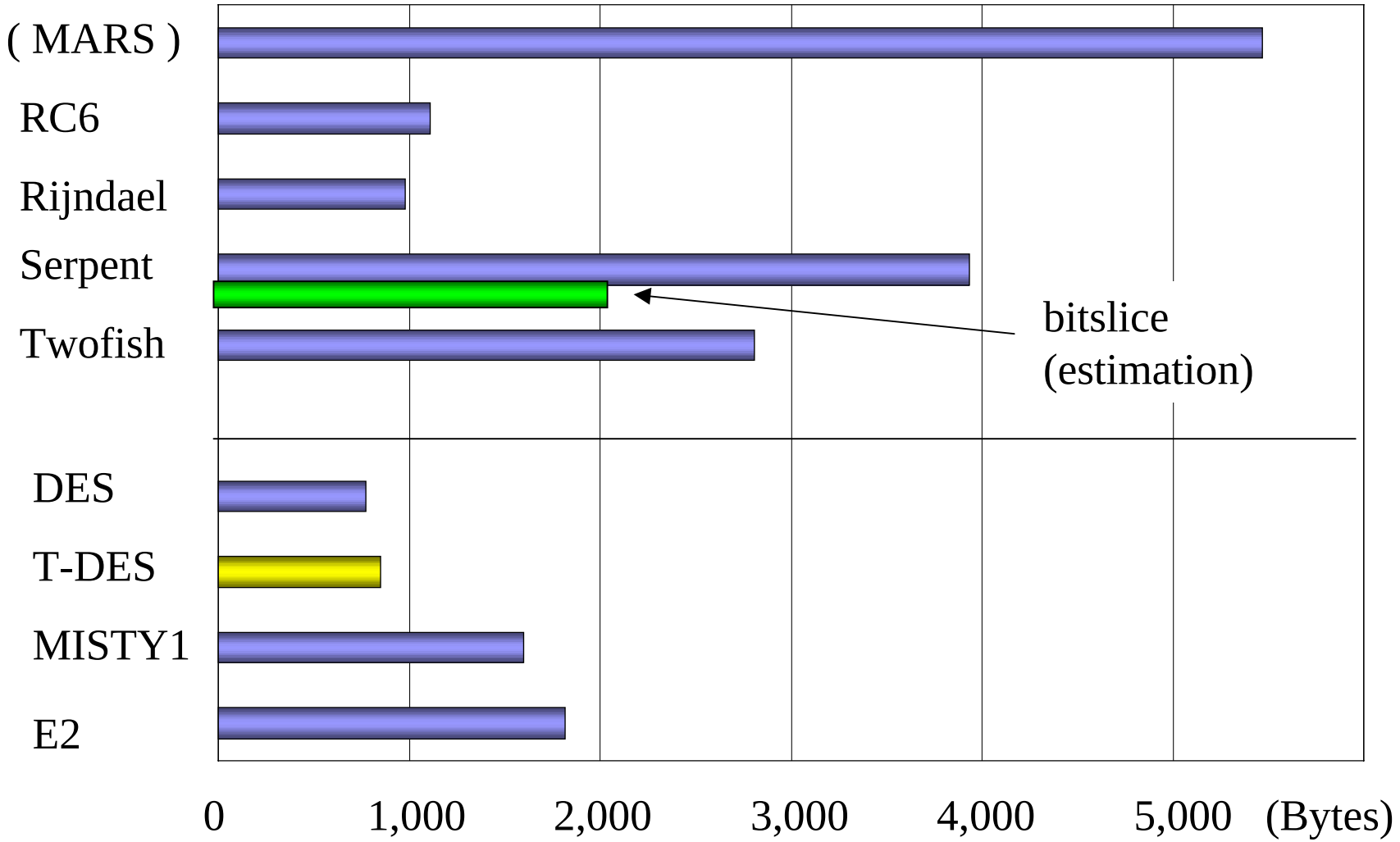
Comparison

Evaluation measures:

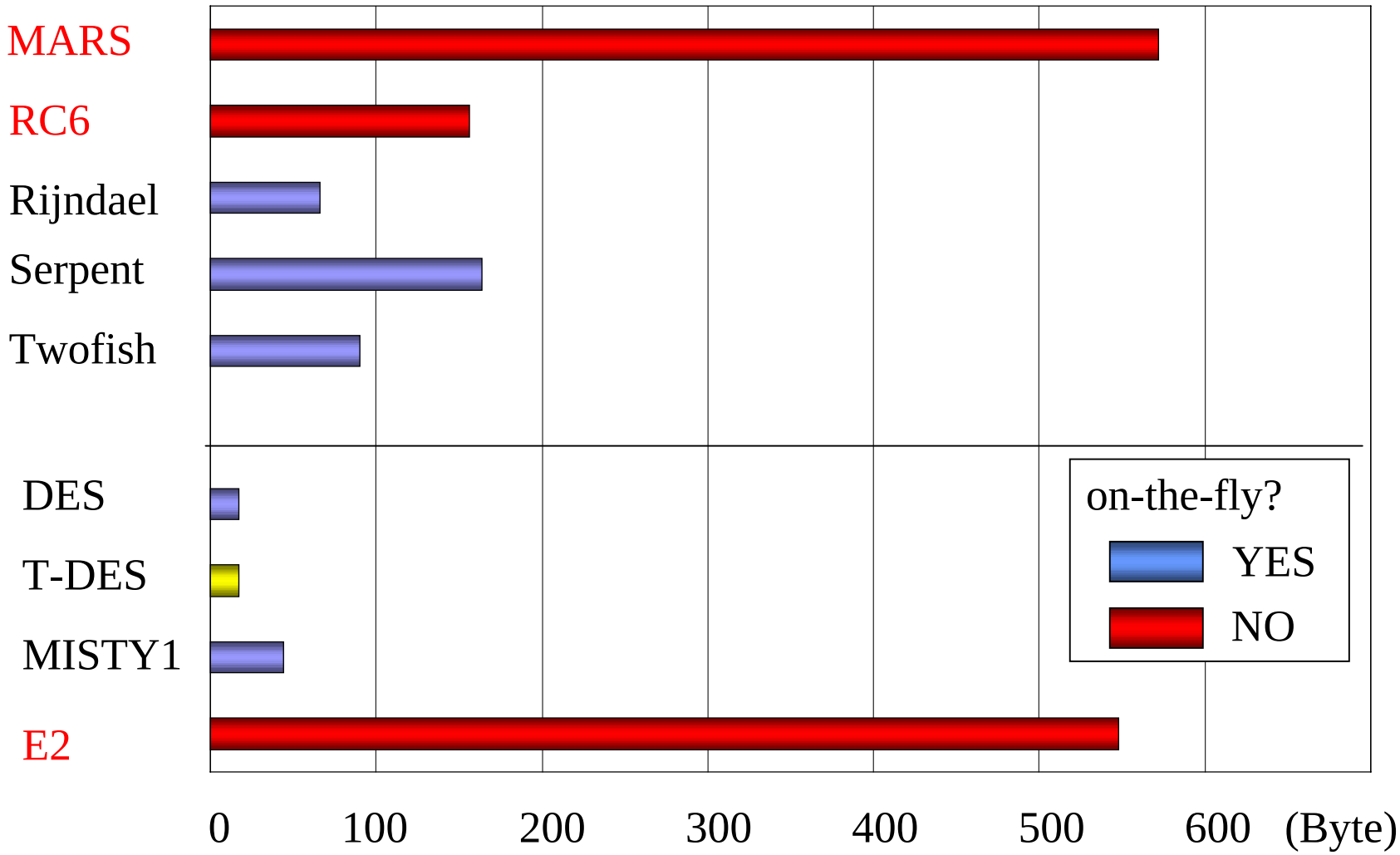
- ROM (important)
  - Most environment doesn't have enough ROM.
  - The less ROM requirements, the more excellent.
- RAM
  - The high-end smart card has an enough memory.
  - It is an optional measure.
- Speed (key scheduling and encryption)
  - faster than DES?
  - faster than Triple DES?  **Target of speed.**
  - better throughput than DES?
  - better throughput than Triple DES?
  - an allowable performance on specification?

MARS, RC6, Rijndael, and Serpent: 256-bit key.
Twofish: 128-bit key (includes padding).

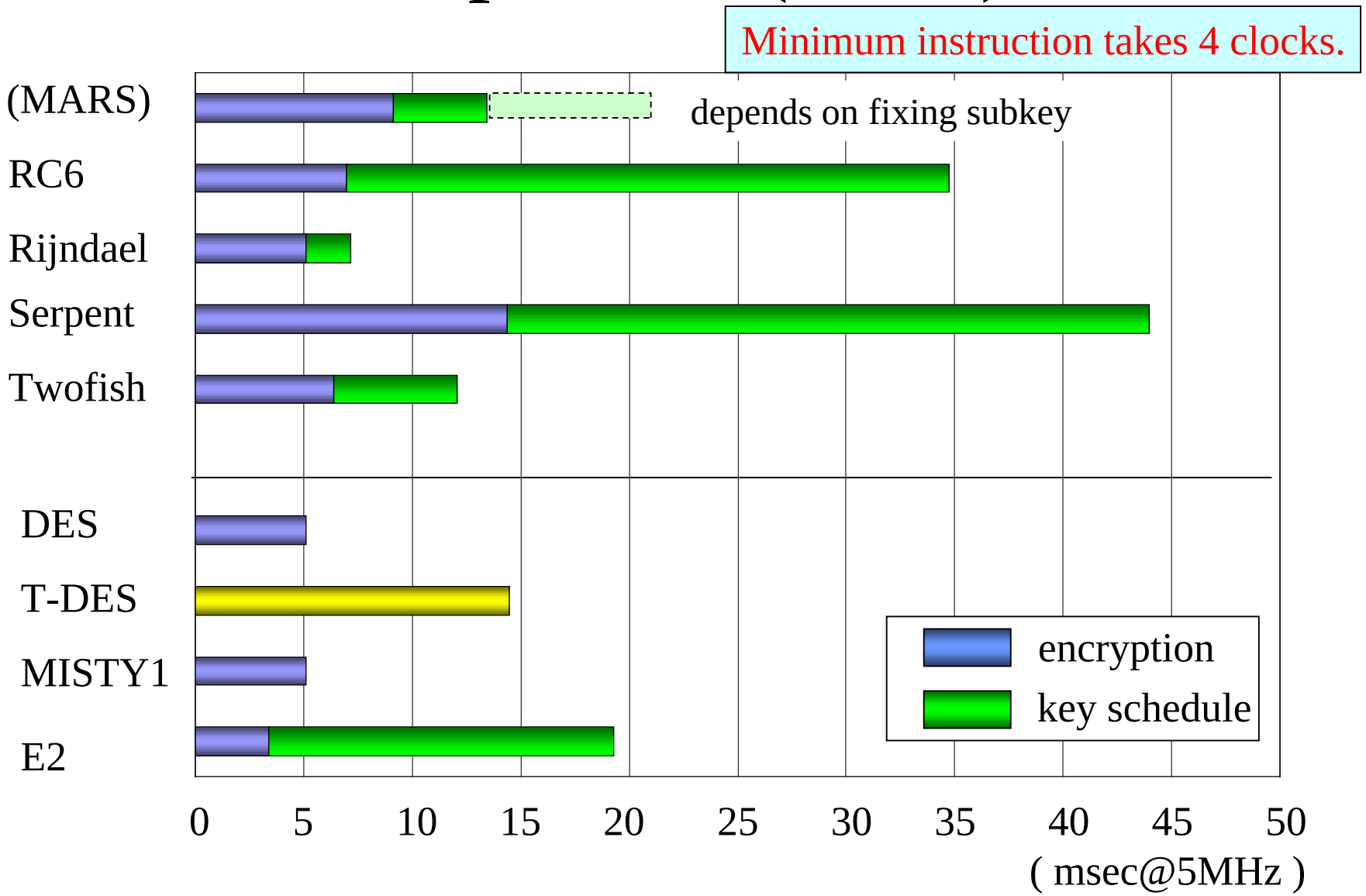
Comparison (ROM)



Comparison (RAM)

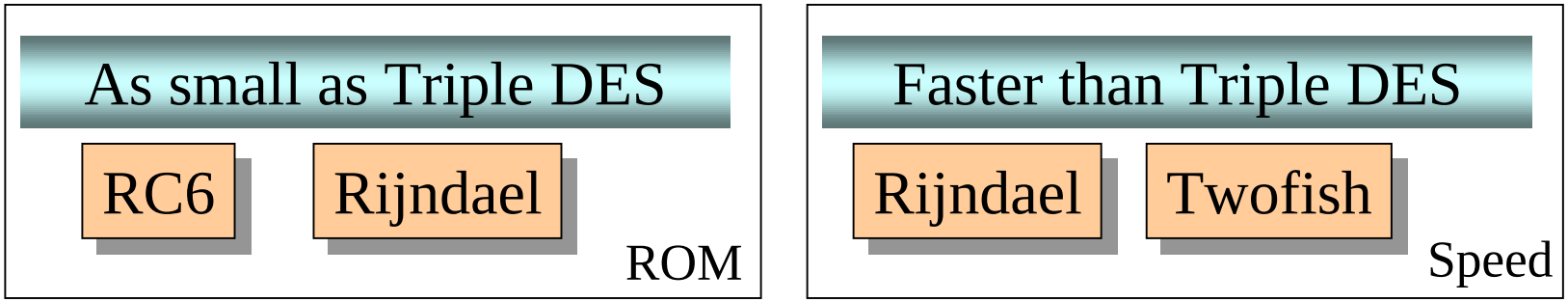


Comparison (Time)



Conclusion

We report the performance of AES finalists on the high-end smart card.
(8-bit CPU and crypto-coprocessor)



Remarks

- Rijndael is the most efficient algorithm on the high-end smart card.
- All finalists can be implemented on the high-end smart card.
- The performance of MARS will depend on subkeys.
- Do you need hardware?

  costly, lead time, ...