# CTR-Mode Encryption

**Helger Lipmaa**

Helsinki University of Technology (Finland)
University of Tartu (Estonia)

**Phillip Rogaway**

University of California - Davis (USA)
Chiang Mai University (Thailand)

**David Wagner**

University of California - Berkeley (USA)

## What is CTR Mode?

* The simplest correct way to encrypt using a block cipher

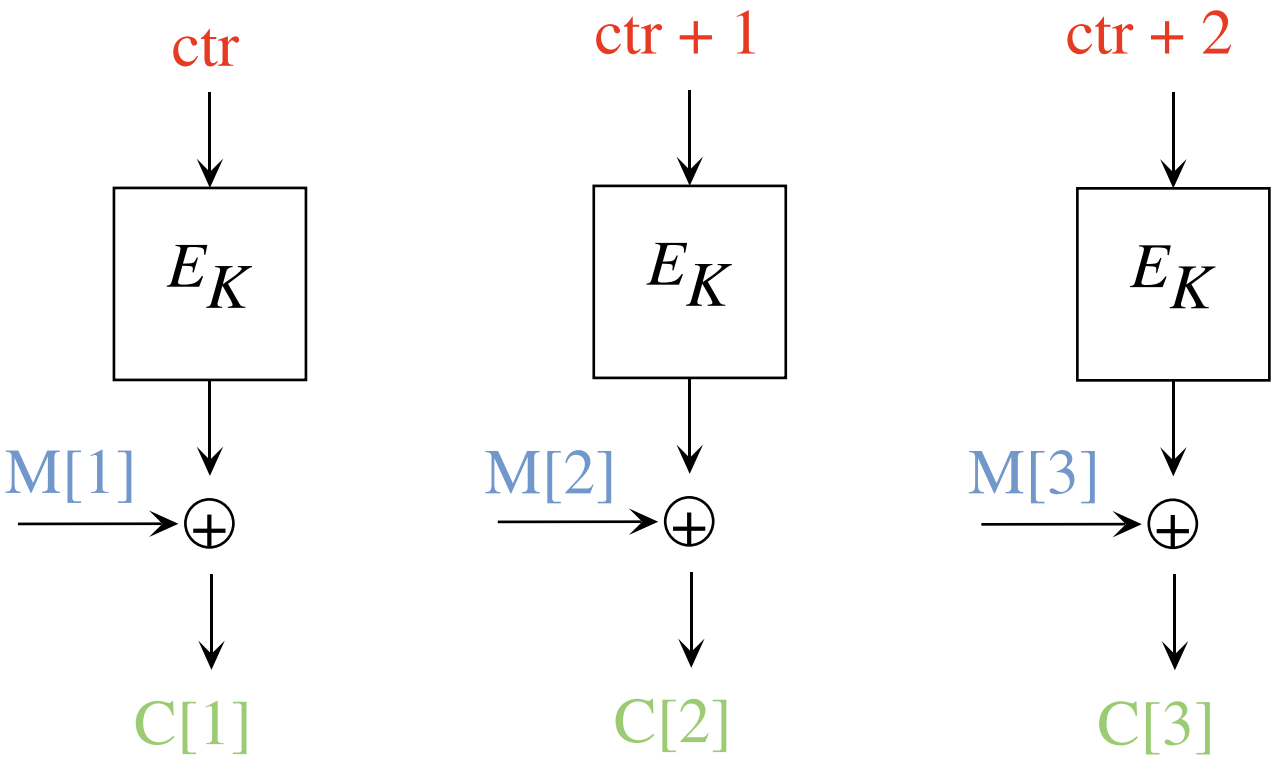
* An old mode, dating to DH79, but omitted from earlier FIPS

* A Vernam cipher (like a one-time pad), but no state is maintained by the sender

## Why the renewed interest?

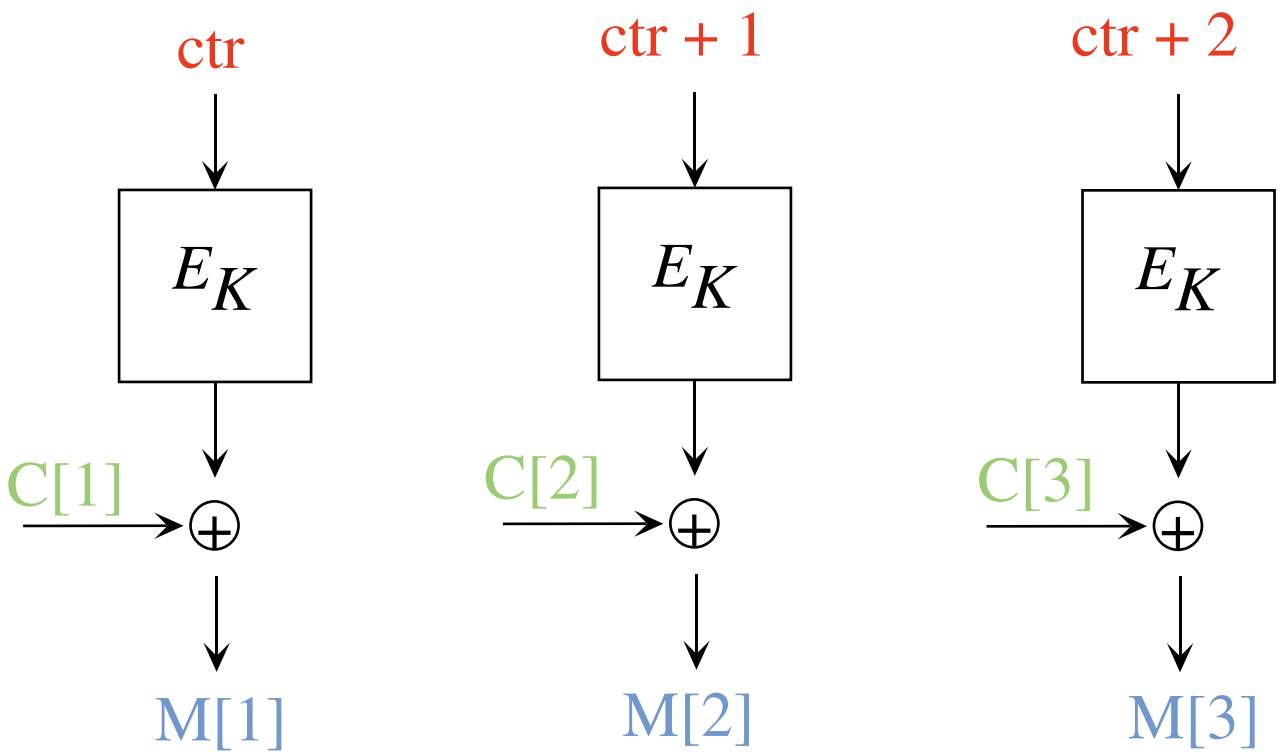
* Because CTR mode is fully parallelizable, making it much more efficient, in many contemporary usage scenarios, than modes like CBC.

# CTR Mode Encryption




The ciphertext is C[1] C[2] C[3] and something adequate to recover ctr

# CTR Mode Decryption




The plaintext is M = M[1] M[2] M[3]

## Where does the ctr come from?

* It is supplied on the encrypting side (like the IV in CBC mode)

* It is **crucial** that no ctr+i value be repeated - repeating such a value is like reusing a one-time pad.

* Recommended way of making ctr :

$$\text{ctr} = \text{nonce} \;\|\; 0000 \cdots 0000$$

*..64 bits ..* *... 64 zero bits ...*

# Advantages

* Faster SW speed on modern processors (Itanium, Alpha, AltiVec, etc.)
* Essentially unlimited HW speed
* Provably secure (Same bounds as CBC MAC, same assumption [BDJR])
* Random access to the "middle" of the ciphertext
* Preprocessing possible
* Arbitrary message lengths
* No need to implement $E^{-1}$
* Completely patent-free

| Complaint | Answer |
| --- | --- |
| No integrity | Right. Just like all the other conventional modes. For integrity, use a MAC — or an authenticated-encryption mode. |
| No error propagation | So what. |
| Sender needs state or $ | Right. True of any secure enc scheme |
| Sensitive to usage errors | Some validity. Be clear : *do not reuse a* ! Counter/nonce distinction helps |
| Quad sec bound | |
| Interaction with weak ciphers | Use with strong block cipher<br>Like other modes; n=128 makes OK |

*ctr value*