Low power wireless scenarios and techniques for saving bandwidth without sacrificing security

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Low power wireless

Wireless and IoT

802.15.4: ZigBee, 6LoWPAN
LoRaWAN
Bluetooth
WiFi

Data encryption, JOSE, CMS, TLS, IPsec

Power cost

- Cost of transmission and reception often greater than cost of encryption and decryption
- Longer messages more likely to need retransmission

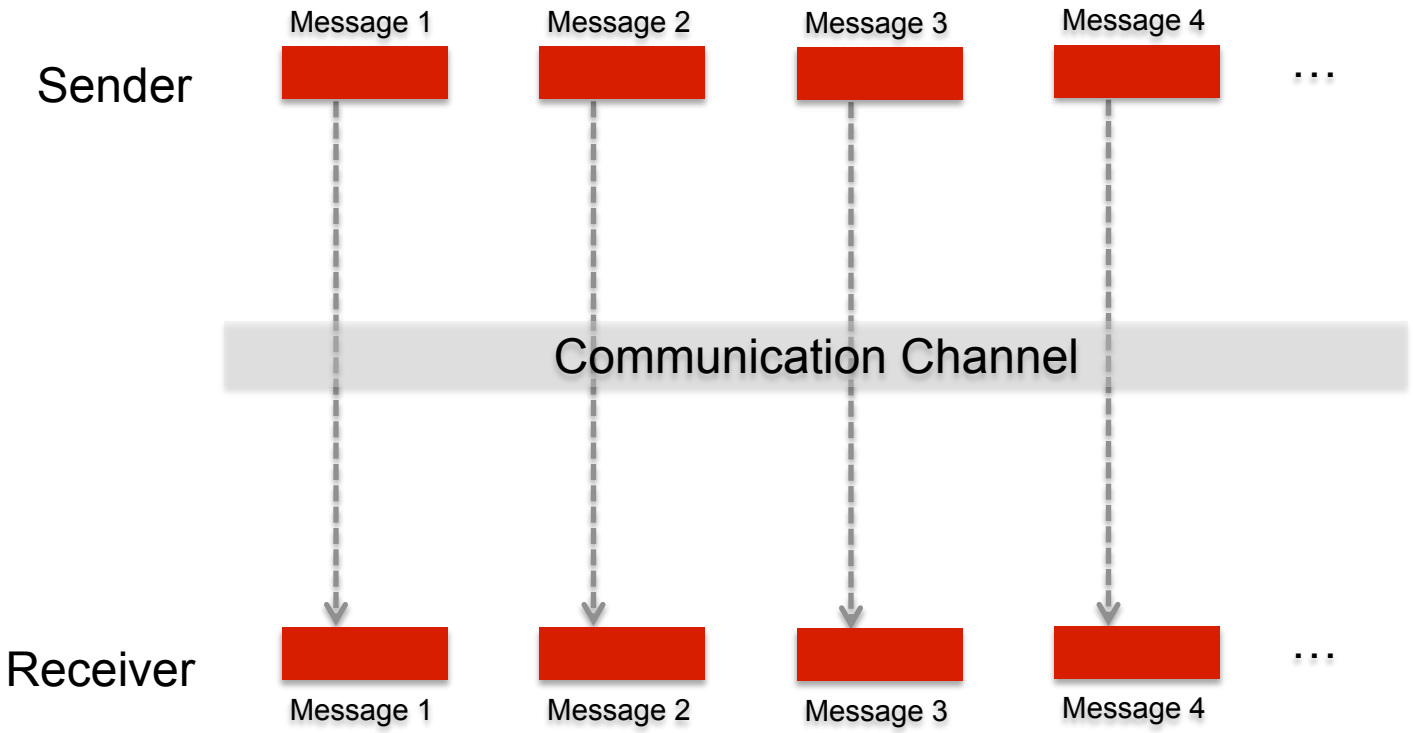
Seys and Preneel, WiMob 2005

Message and payload sizes

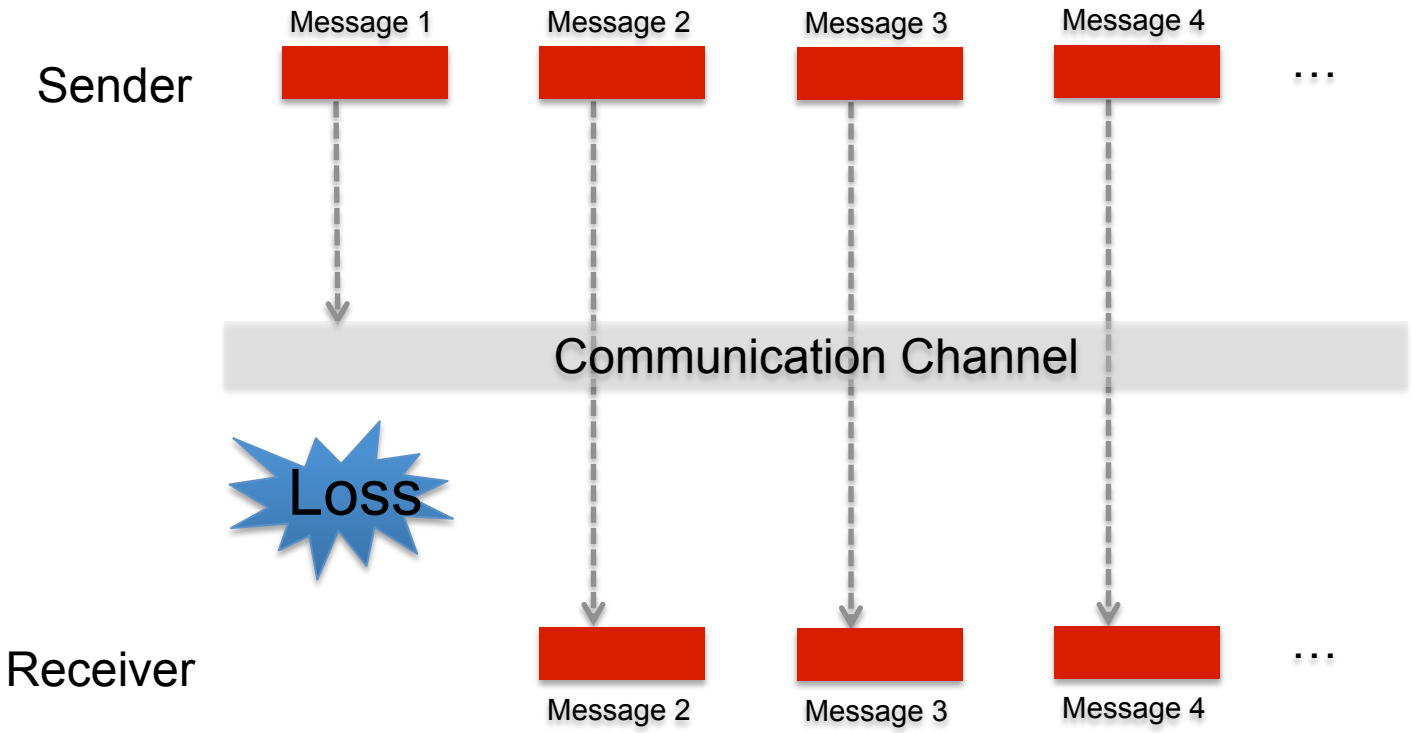
- Most 802.15.4g implementations limit 6LoWPAN to **800 bytes**
- Distributed Network Protocol DNP3 (IEEE Std 1815- 2010) has a maximum payload size of **292 bytes**
- LoRaWAN protocol supports packets up to **255 bytes**
  Includes operating modes for **11, 15, 129, and 242 bytes**
- ANSI C12.22, has plaintexts with an average size ranging from **64 to 600 bytes**

Communication Security

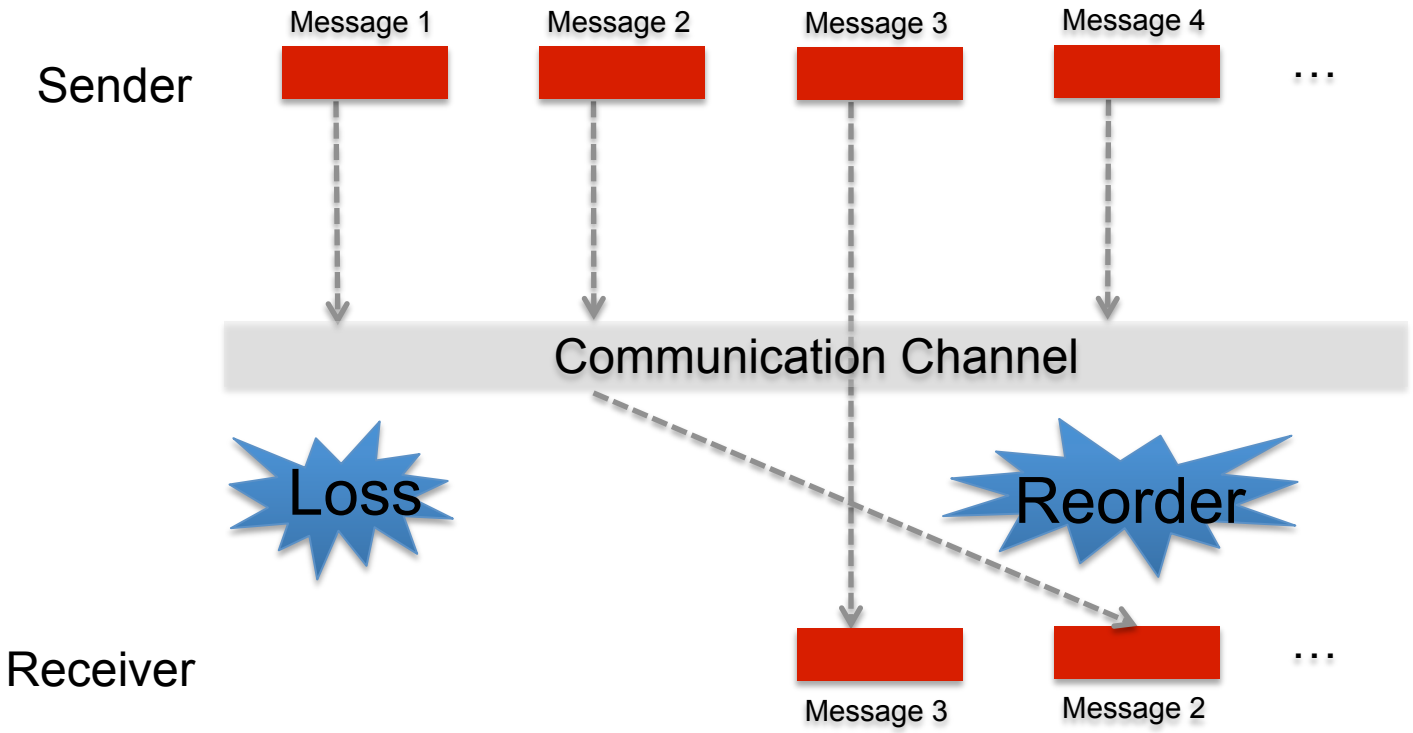
Unreliable Communication



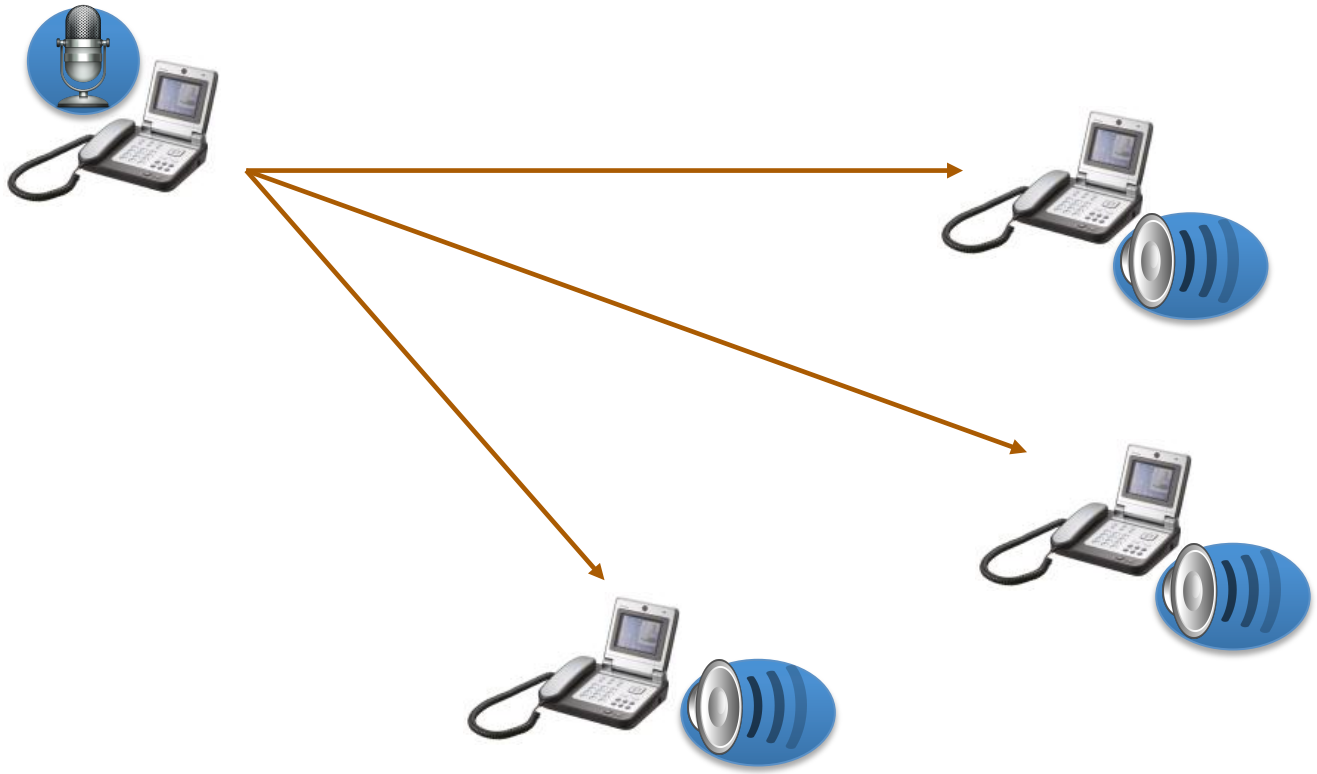
Unreliable Communication



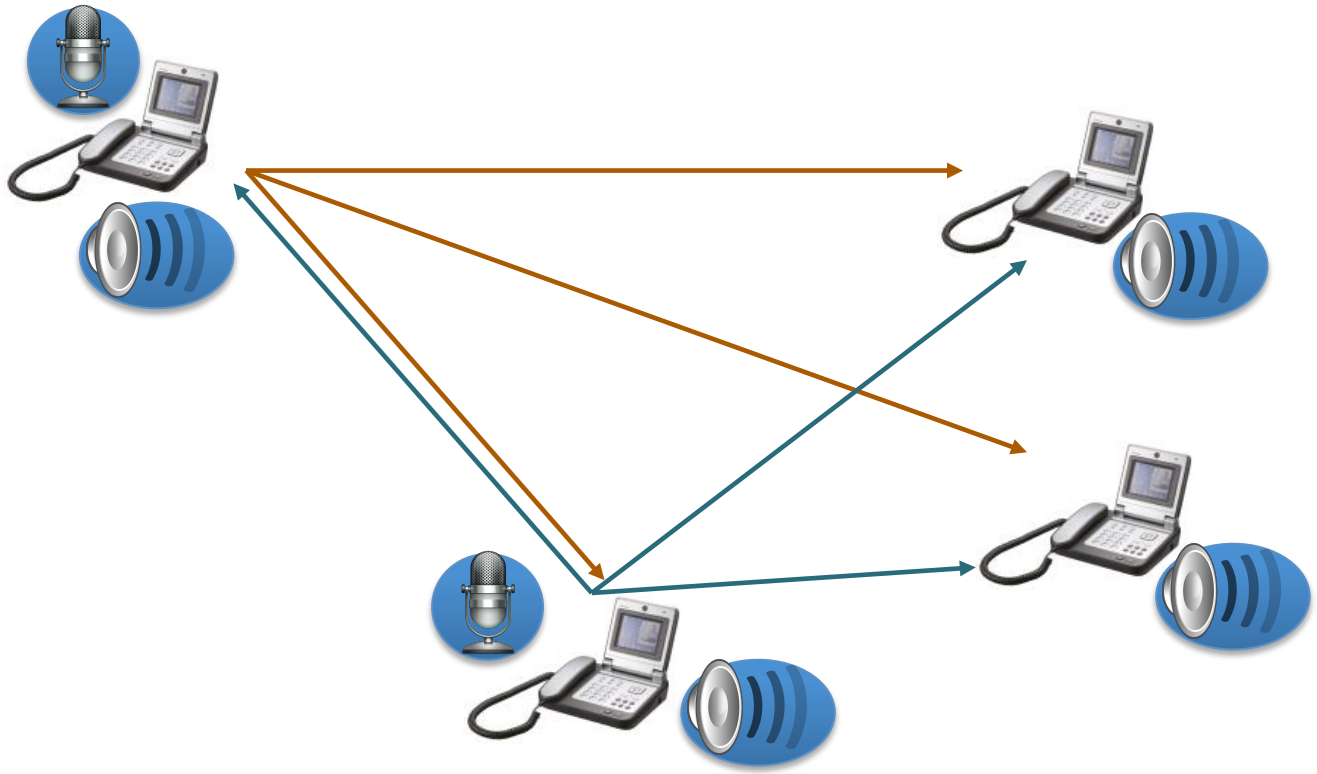
Unreliable Communication



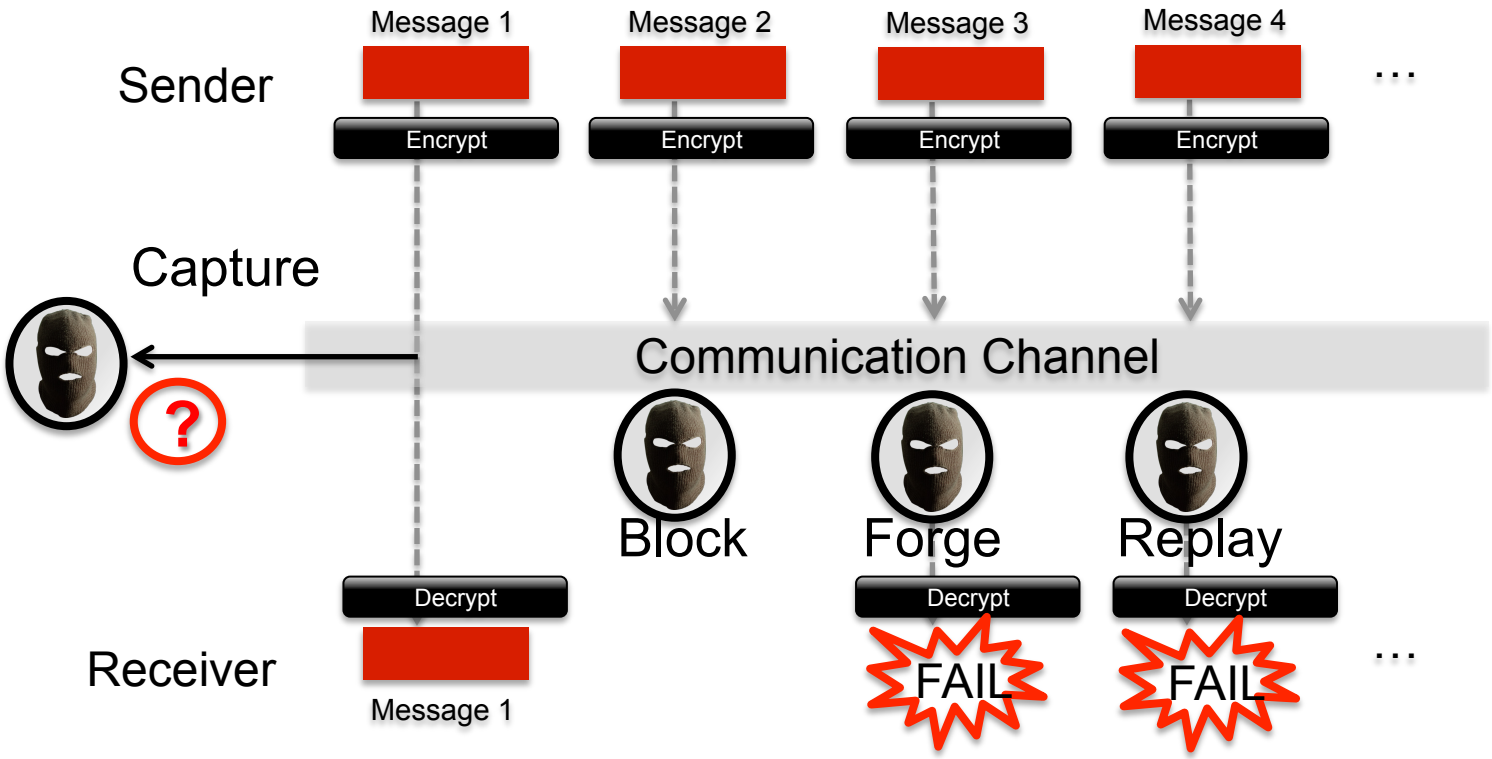
Multiple Receivers



Multiple Senders

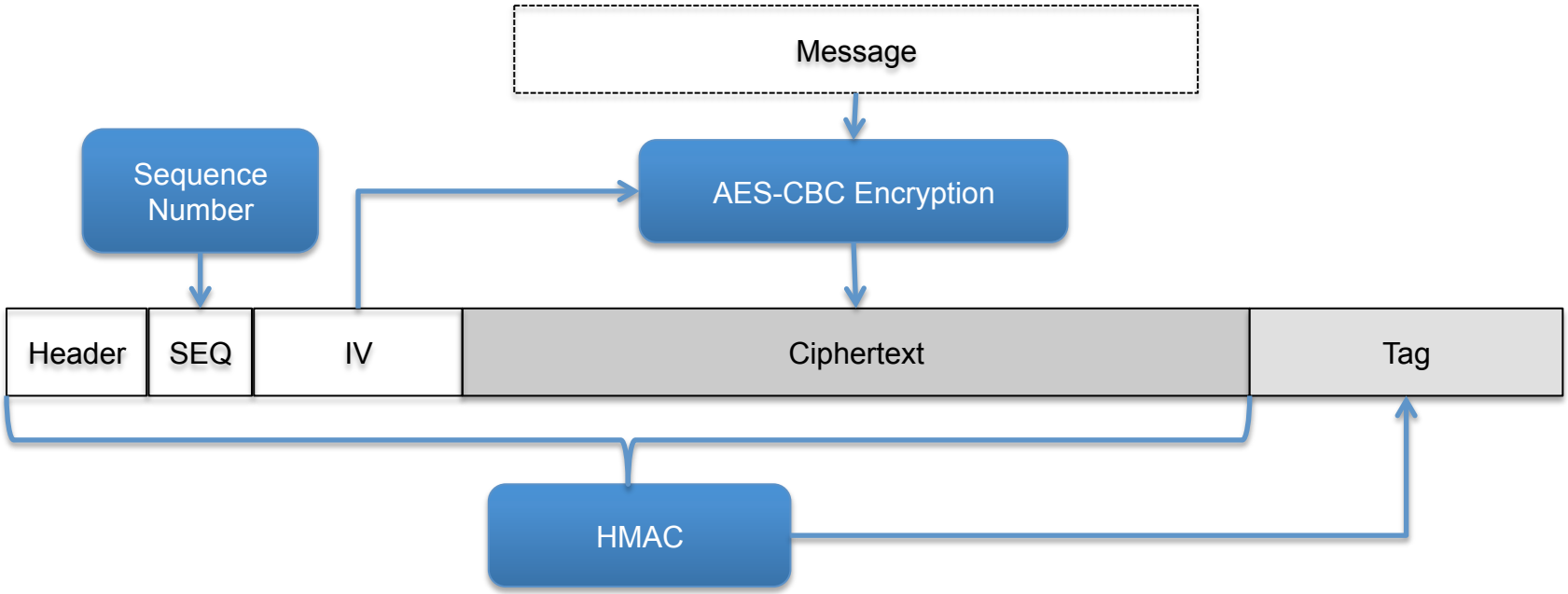


Authenticated encryption

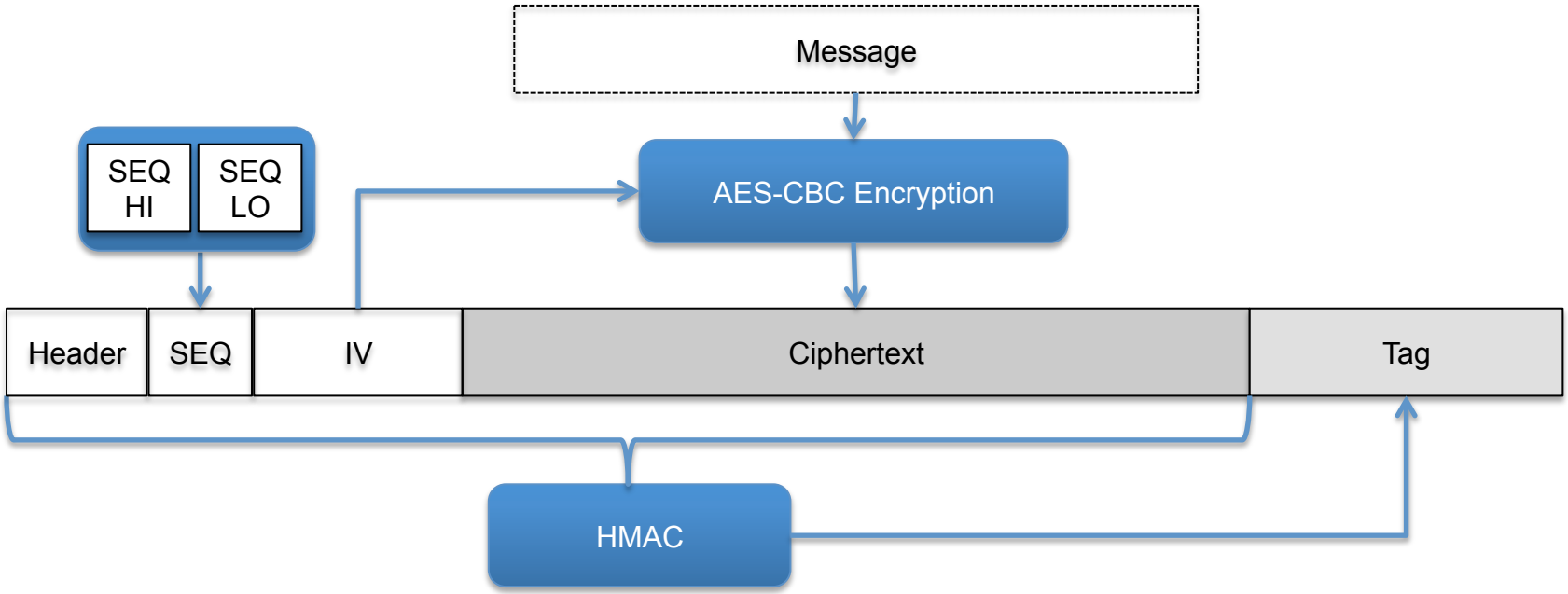


Conventional communication security

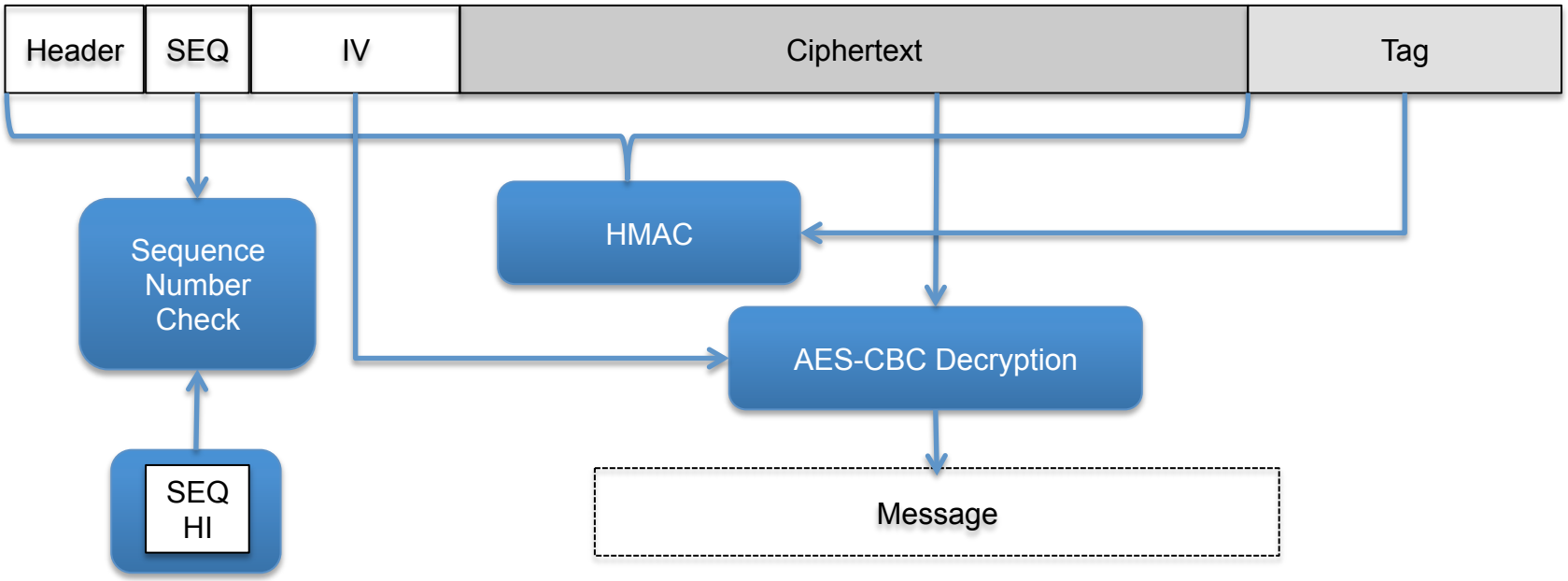
IPSec ESP


Message
Sequence Number
AES-CBC Encryption
Header
SEQ
IV
Ciphertext
Tag
HMAC

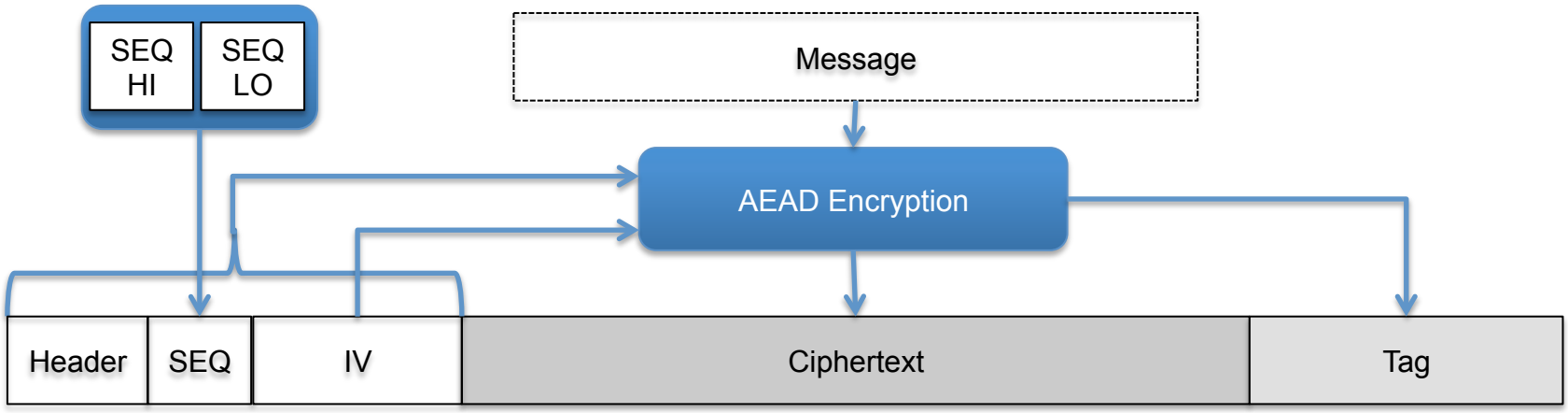
IPSec ESP


Message
SEQ HI
SEQ LO
AES-CBC Encryption
Header
SEQ
IV
Ciphertext
Tag
HMAC

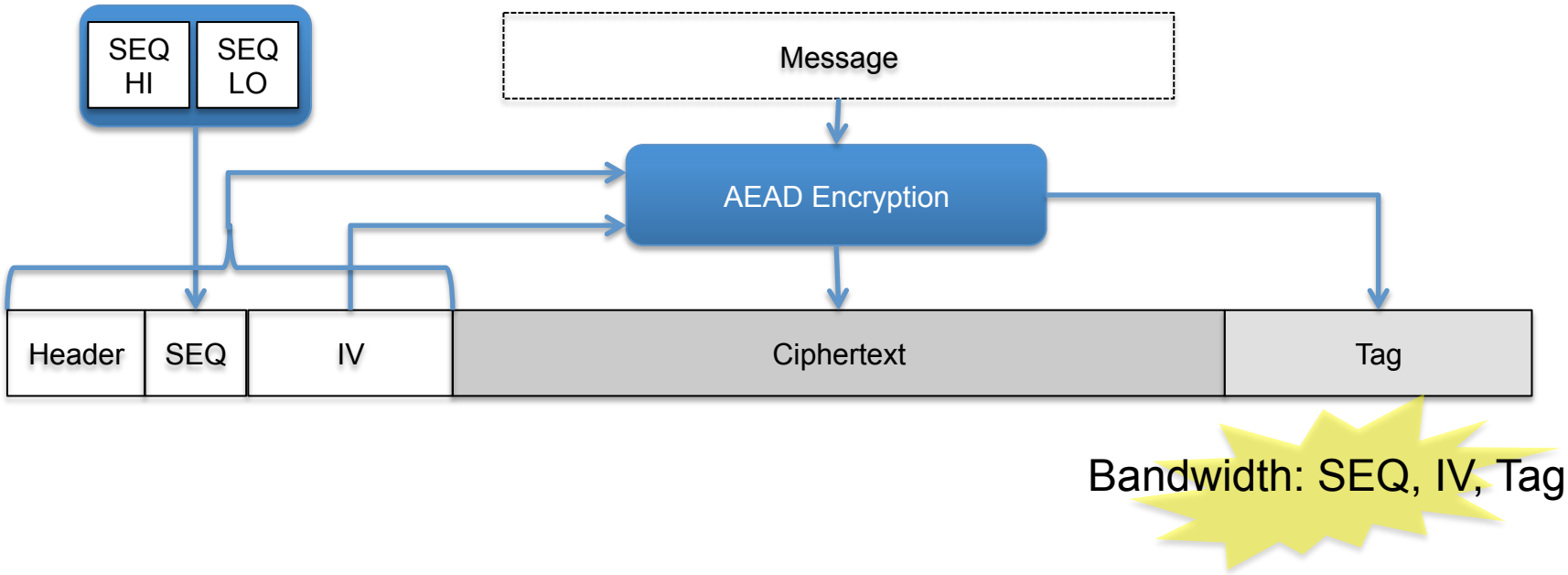
IPSec ESP


Header
SEQ
IV
Ciphertext
Tag
Sequence Number Check
HMAC
AES-CBC Decryption
SEQ HI
Message

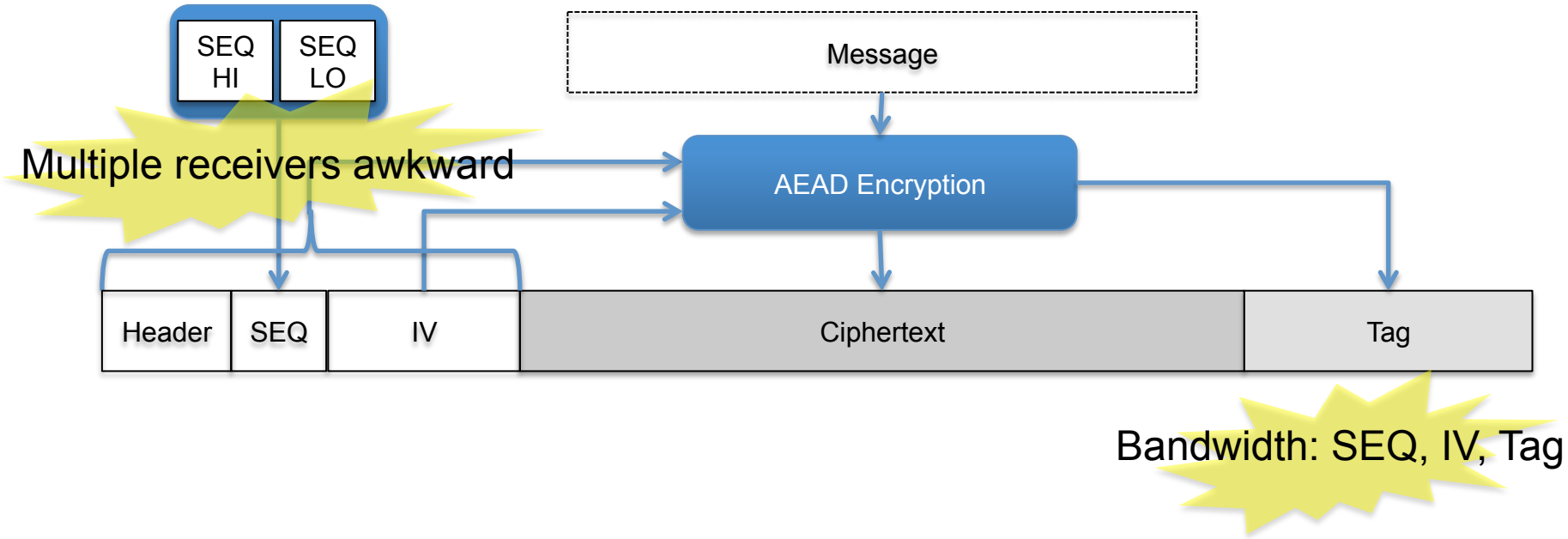
IPSec ESP with Authenticated Encryption



Problems with conventional practice



Problems with conventional practice



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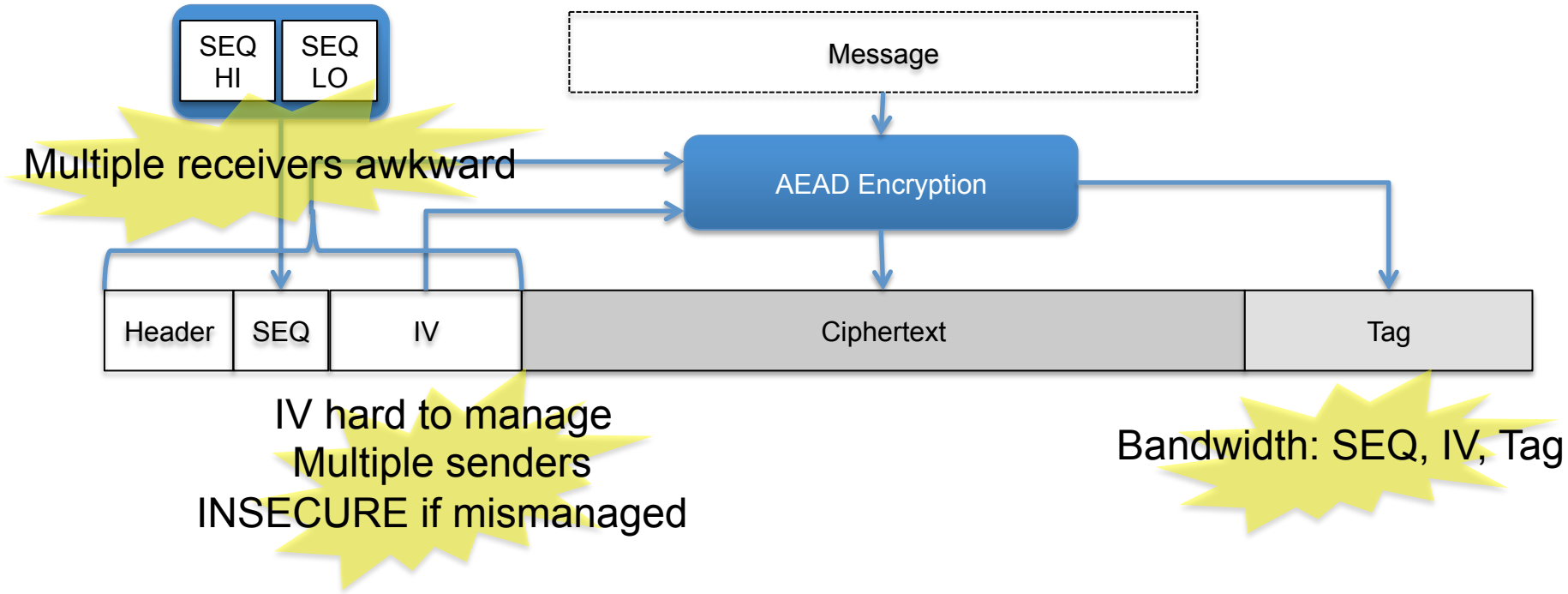
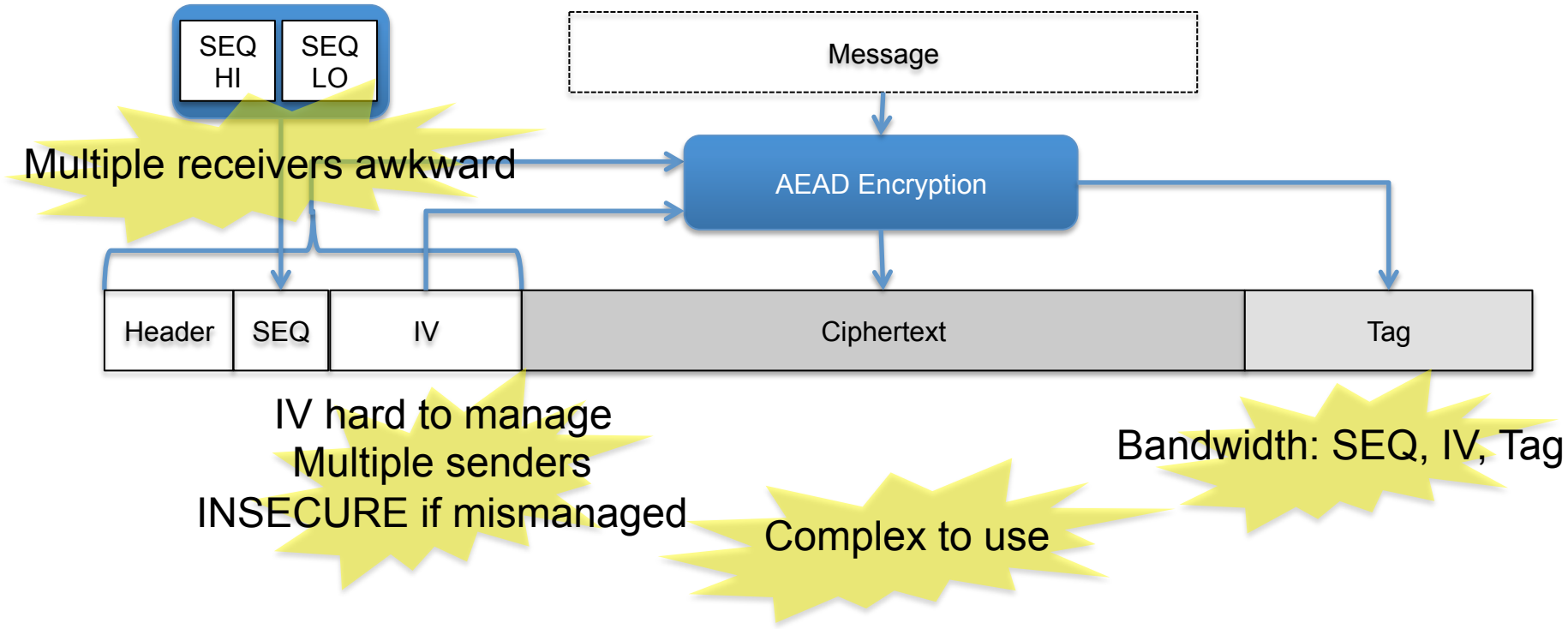
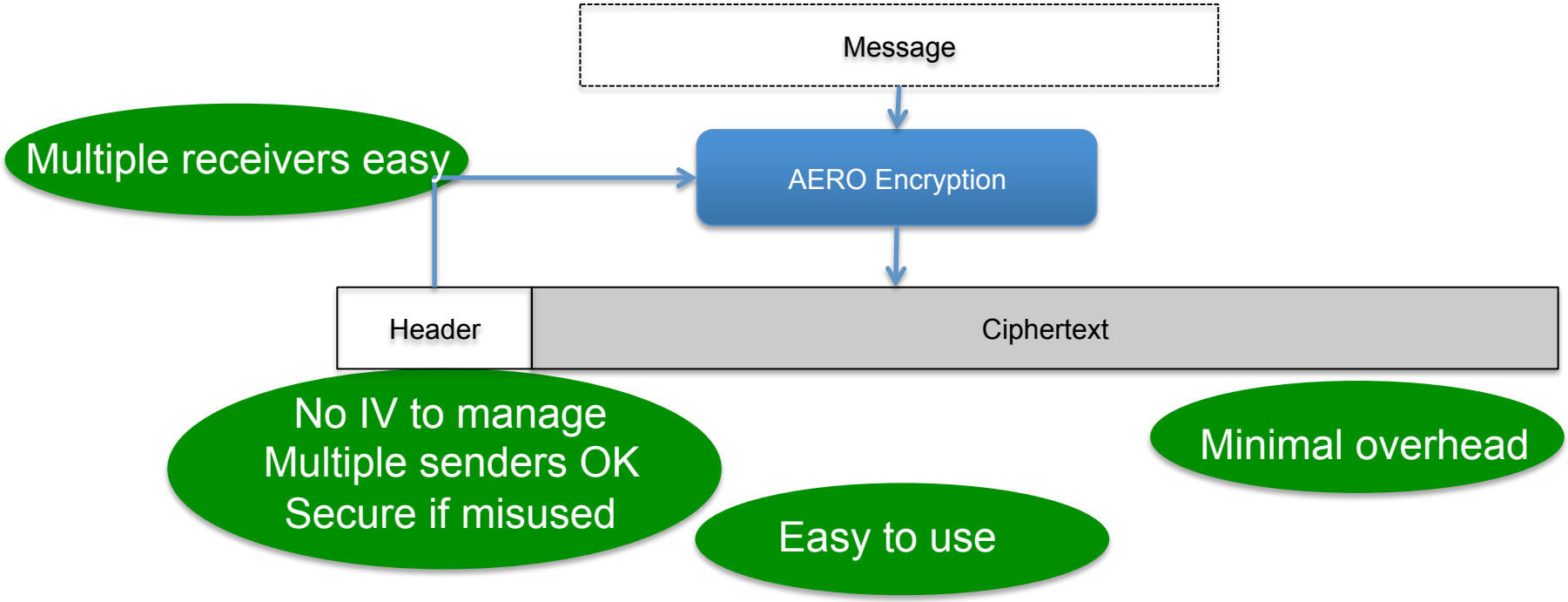


Problems with conventional practice



Authenticated Encryption with Replay prOtection

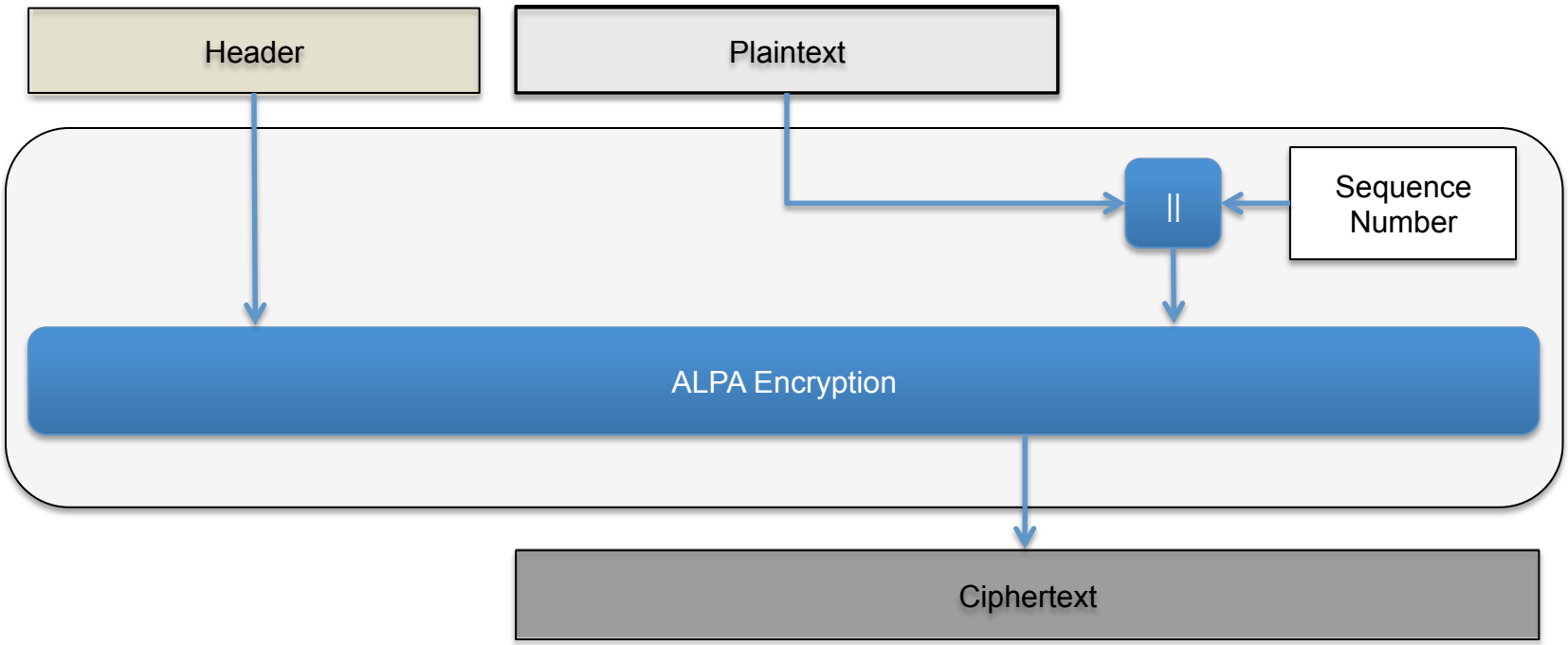


Authenticated Encryption with Replay prOtection (AERO)

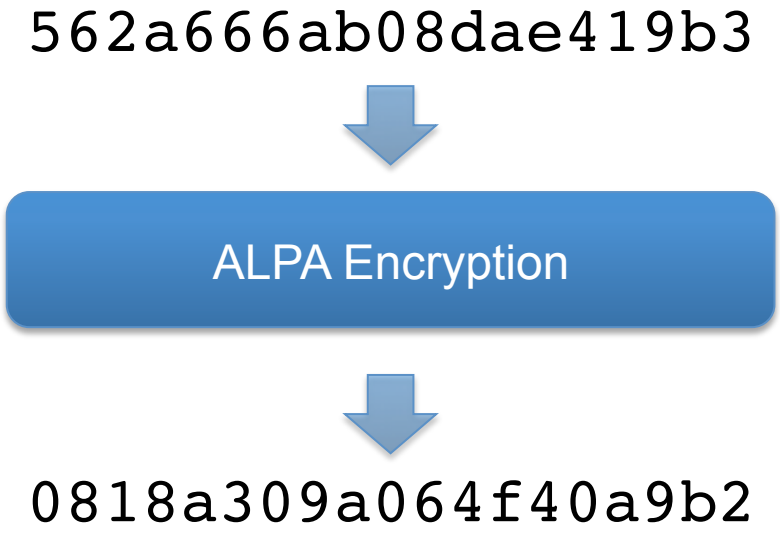
`draft-mcgrew-aero-01.txt`

Collaborators: John Foley, Stefan Lucks

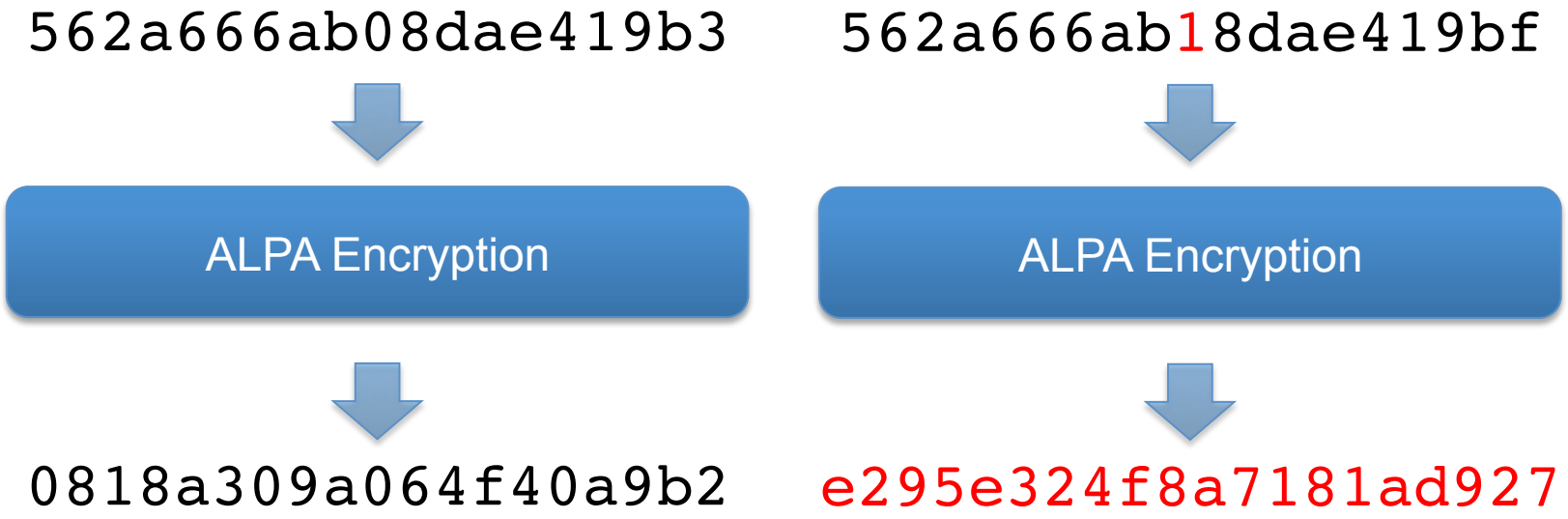
AERO Encryption



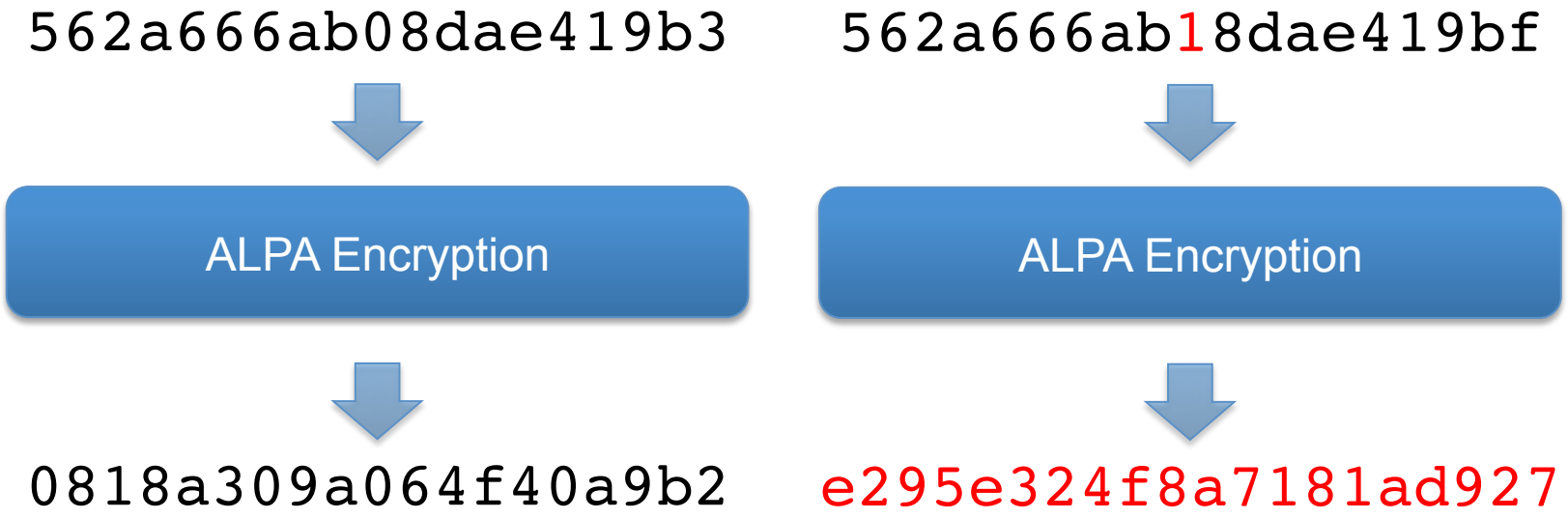
Arbitrary length permutation w/associated data



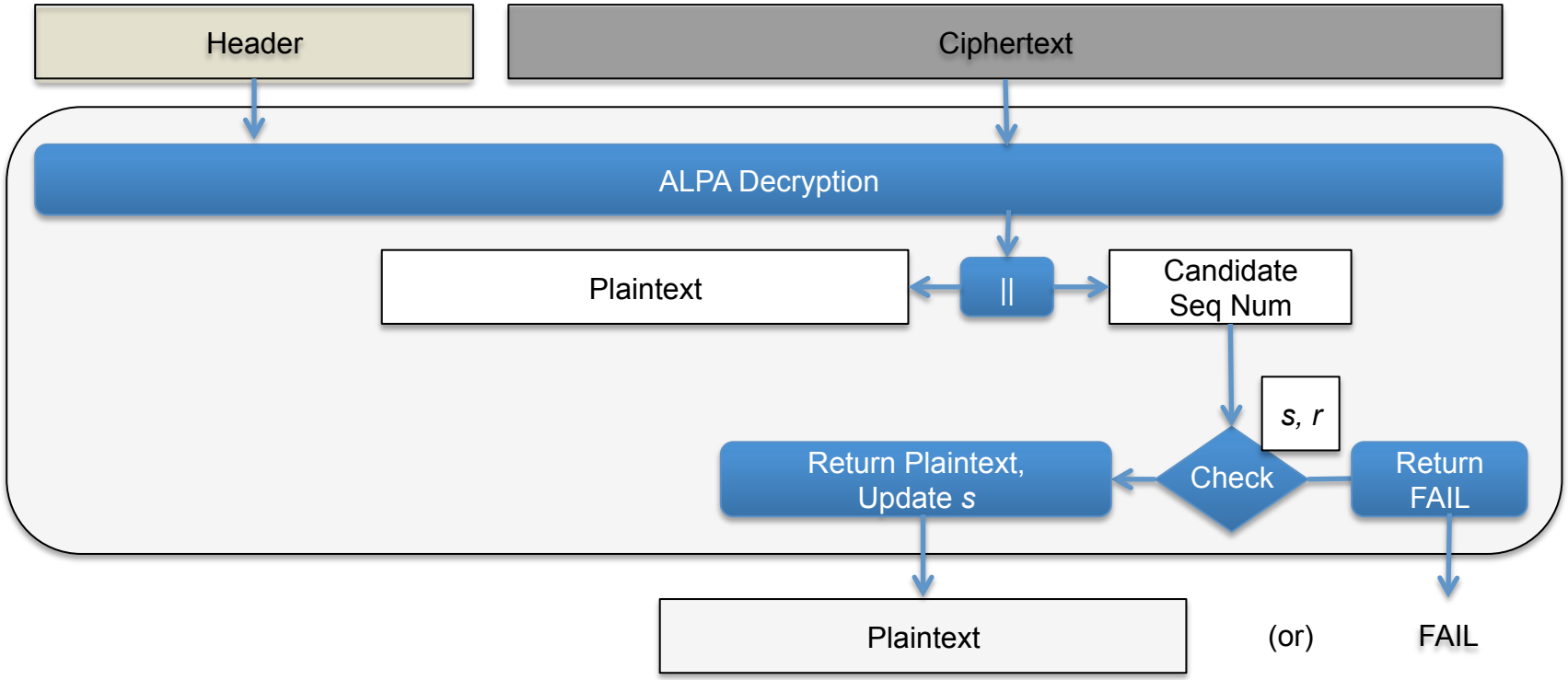
Arbitrary length permutation w/associated data



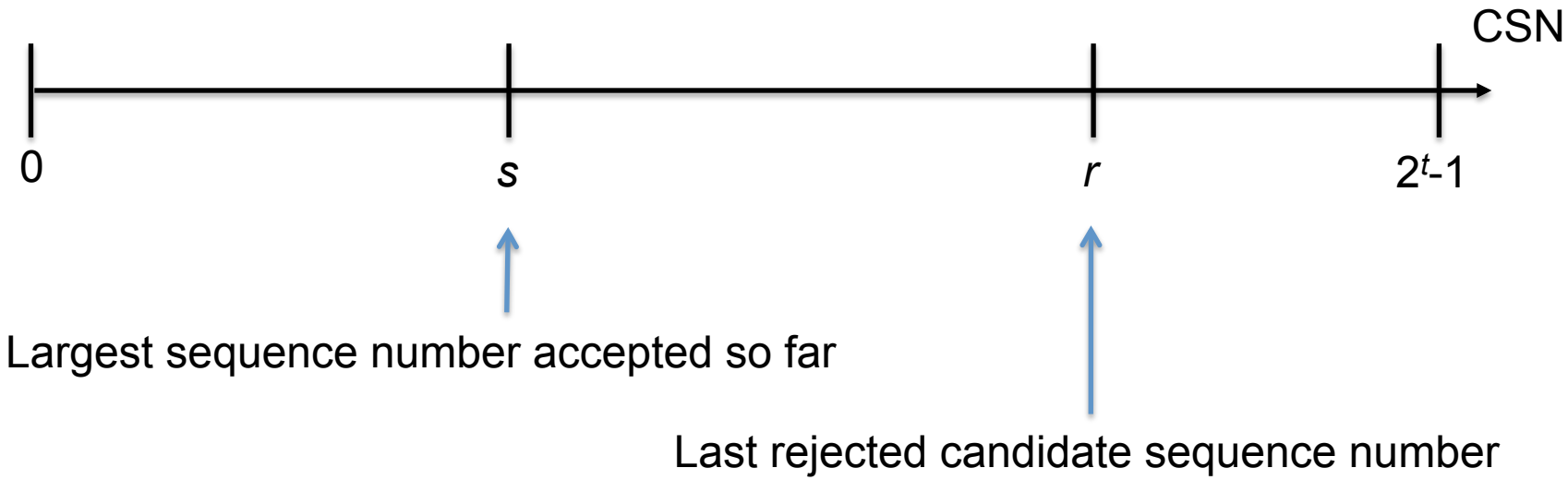
Arbitrary length permutation w/associated data



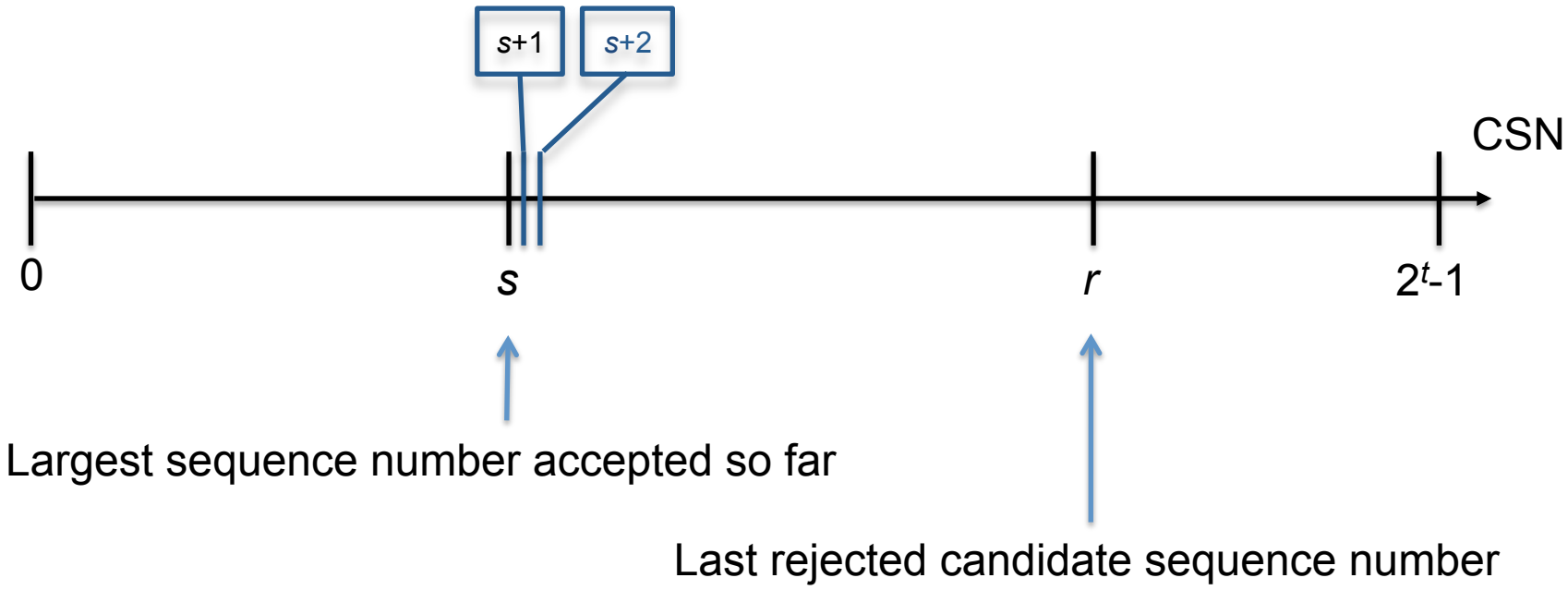
AERO Decryption



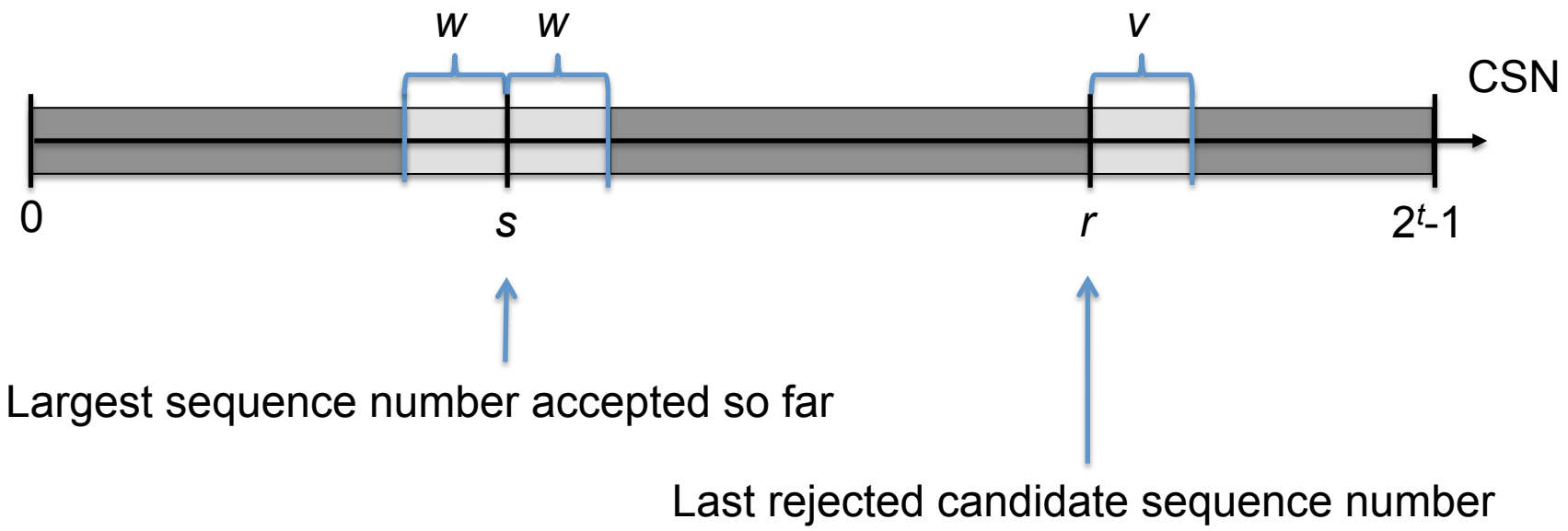
Candidate Sequence Number checking



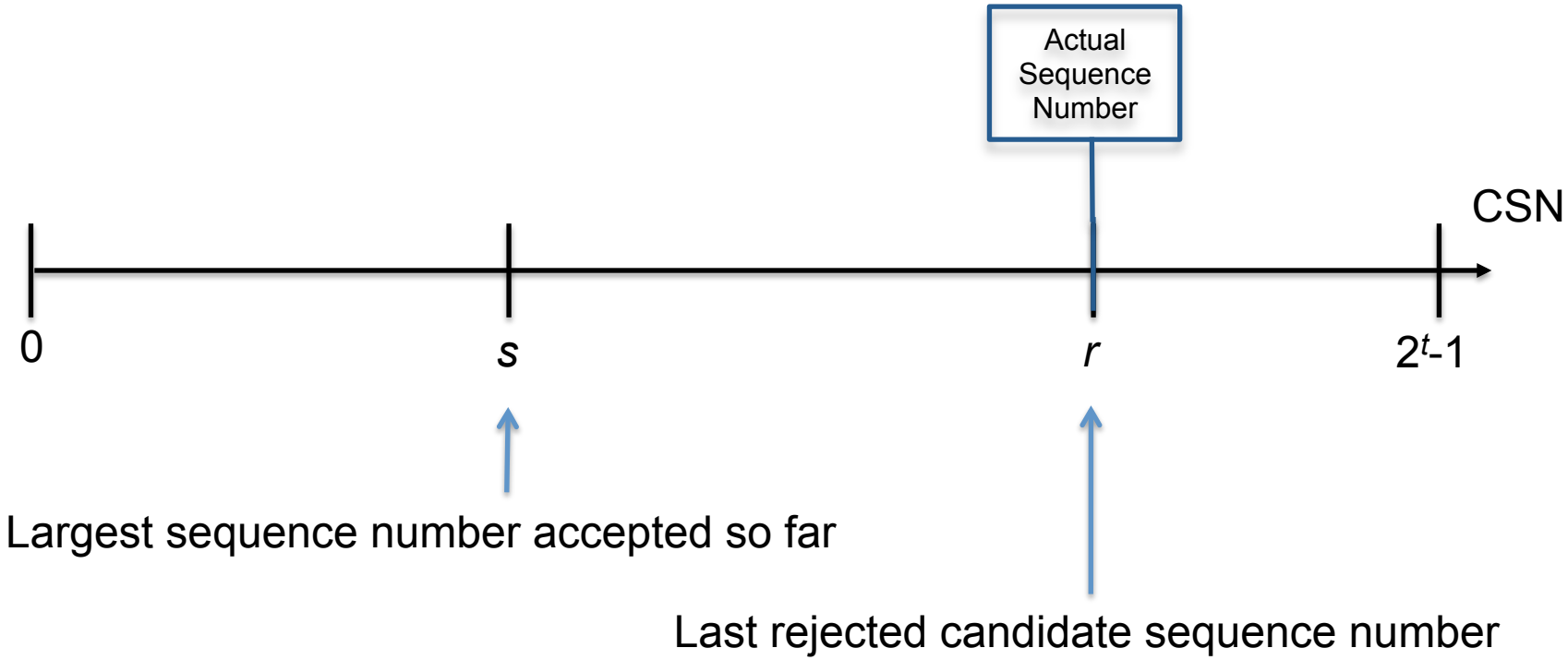
Likely next candidates



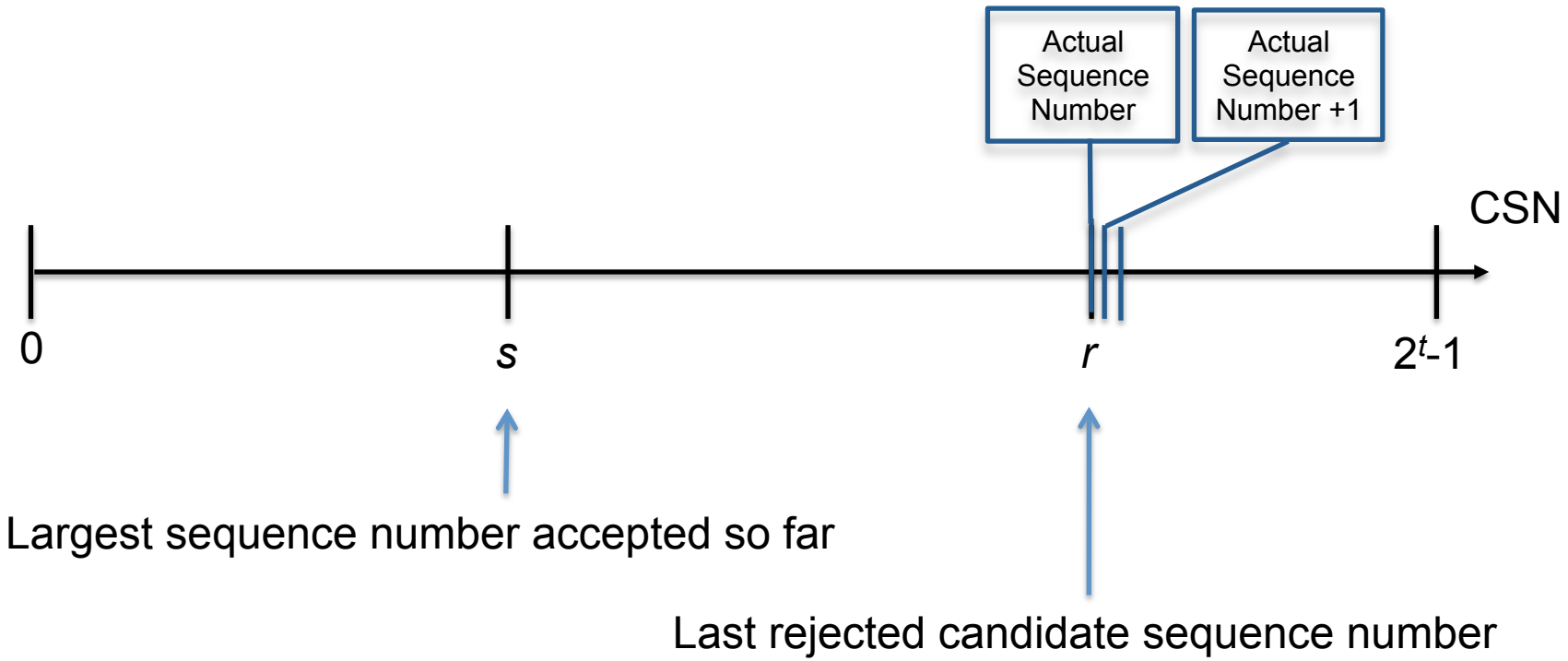
Candidate Sequence Number checking



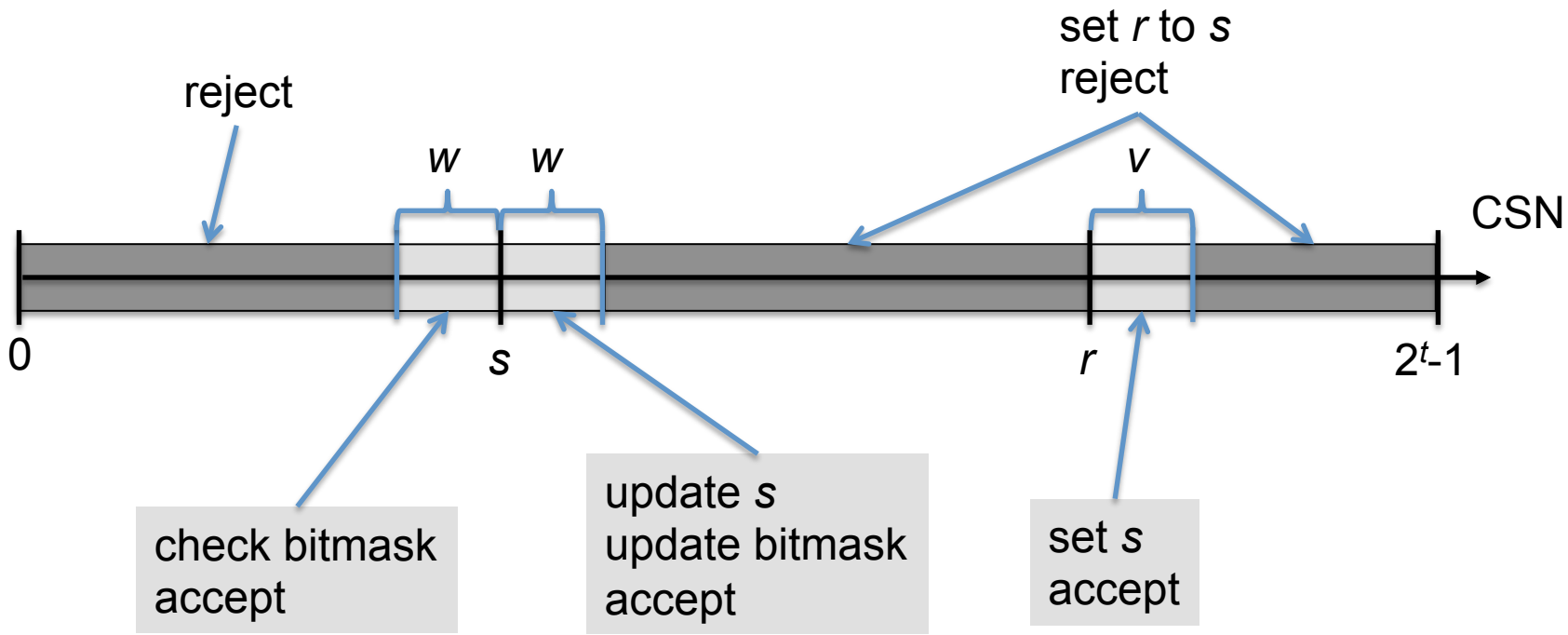
(Re)synchronization



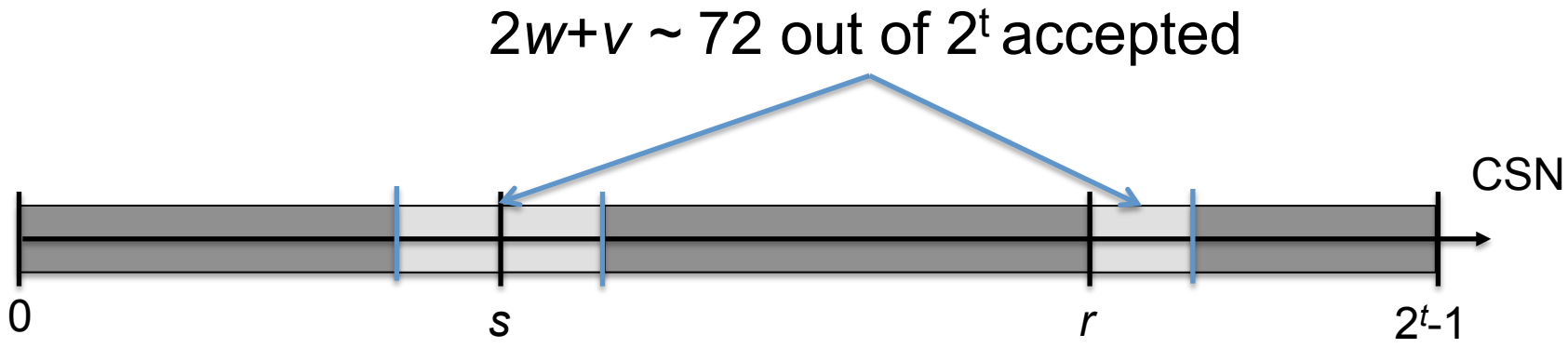
(Re)synchronization



Candidate Sequence Number checking



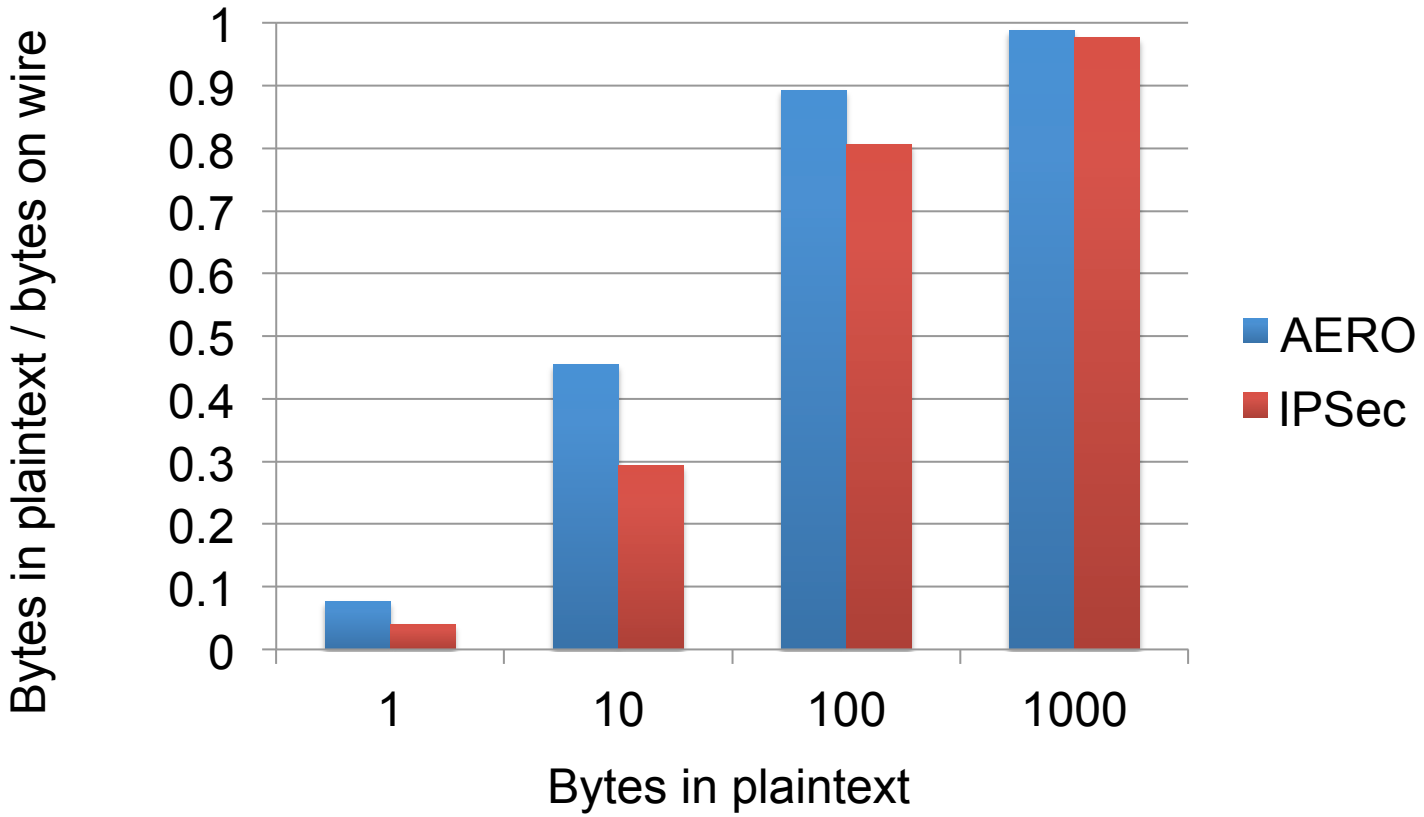
Security of authentication



Probability of successful forgery $= \frac{72}{2^t} \sim 2^{-t+7}$

AERO efficiency

Data efficiency



Primitives needed for AERO

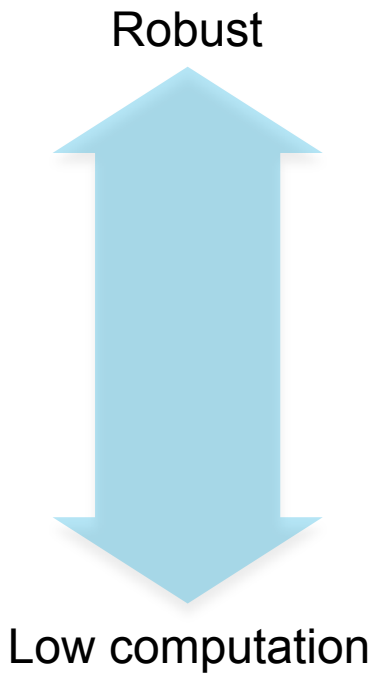
- Arbitrary length PRP

  Requires three (XCB) or four (LR) passes over data

- Online PRP

- AES-SIV adaptation (Stefan Lucks)

  IV = tweakable encryption of the sequence number, using the MAC as the tweak



XCB: IEEE 1619.2 *AES Extended Codebook Mode of Operation*

Conclusions

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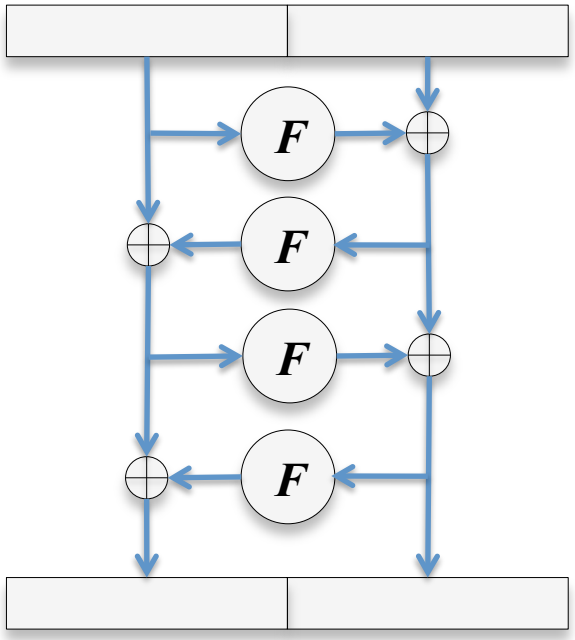
- Cryptography for low power wireless should
  - Minimize data overhead
  - Minimize computational cost
  - Be robust and simple
- Authenticated Encryption with Replay Protection
  - Can minimize data overhead
  - Analysis of primitives, performance, and security goals needed
- Opportunity

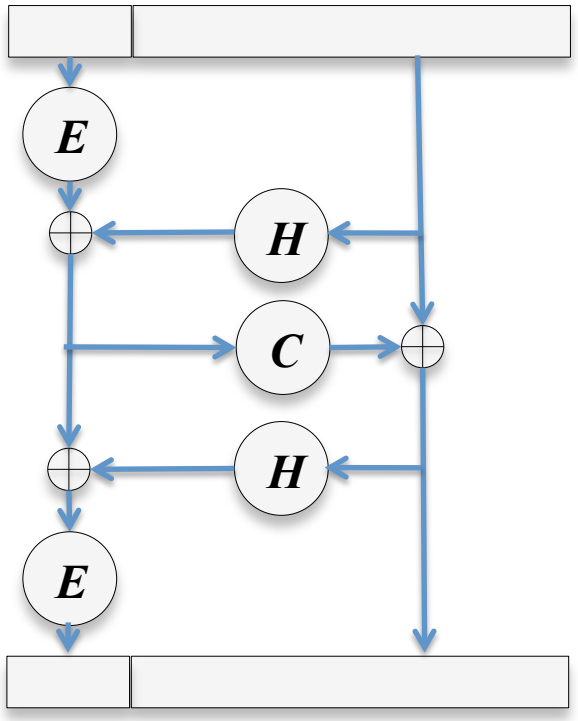
Thank you.

Backup slides

Arbitrary length PRP



Fiestel

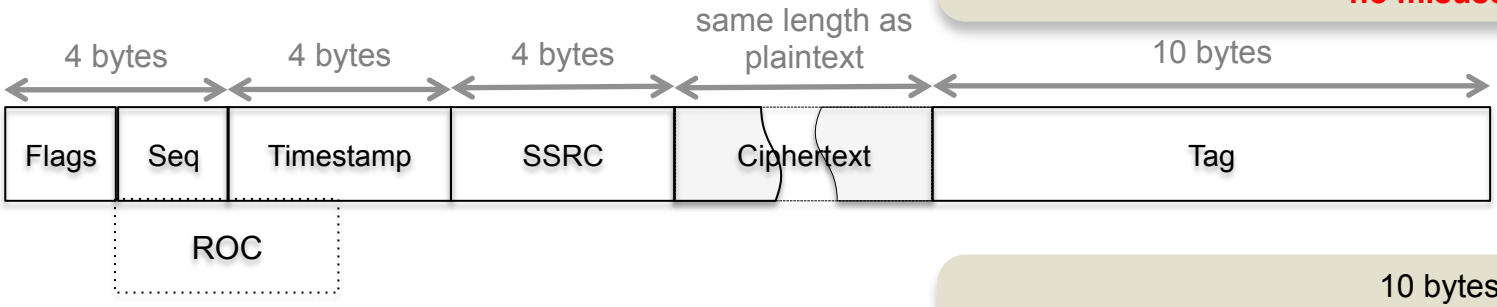


XCB

Secure RTP

SRTP AES-CTR
HMAC-SHA1

10 bytes overhead per packet
4 bytes of state needing sync
no misuse resistance



SRTP AERO

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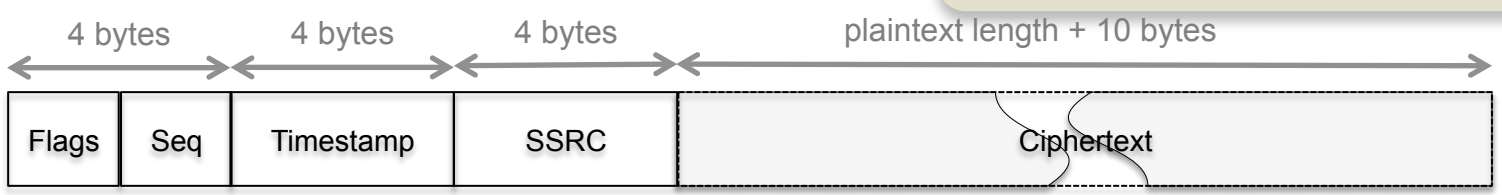
misuse resistance



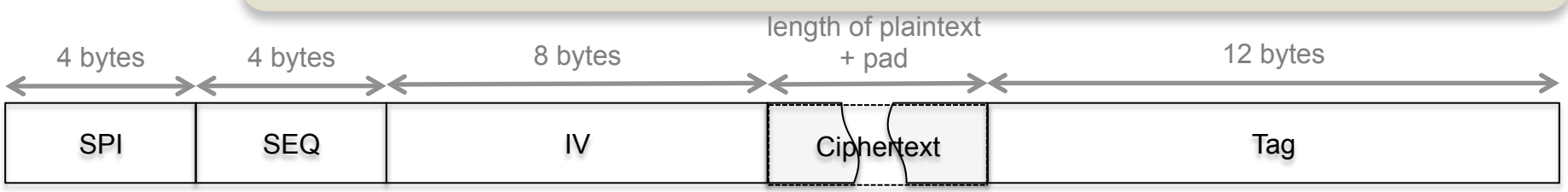
http://tools.ietf.org/search/draft-mcgrew-srtp-aero-01

IPSec

ESP AES-GCM, AES-CCM, or AES-CTR plus HMAC-SHA1

no misuse resistance

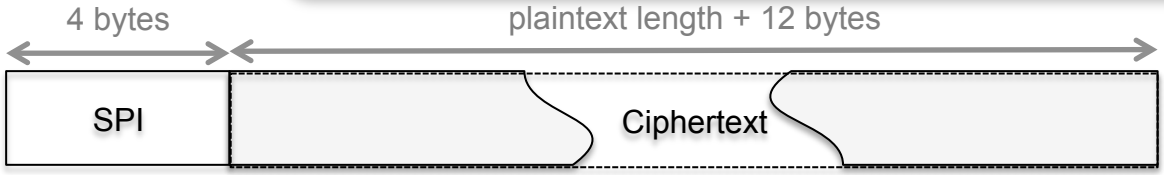
24+ bytes overhead per packet



ESP AERO

misuse resistance

12 bytes overhead per packet



AERO in Secure RTP

AERO in Secure RTP