# Security vulnerabilities in LoRaWAN

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# Low-Power Wide Area Networks

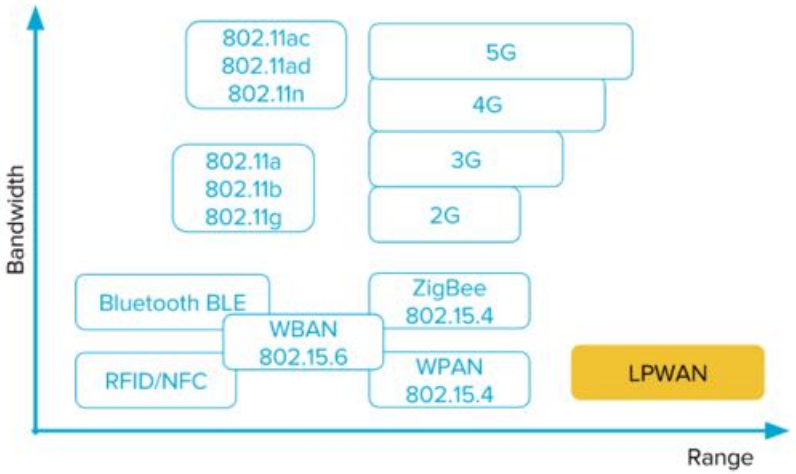
**Unlicensed bands - Non 3GPP**

LoRa™ sigfox

**Licensed bands - 3GPP**

NB-IoT Lte-M

Bandwidth versus range




Use cases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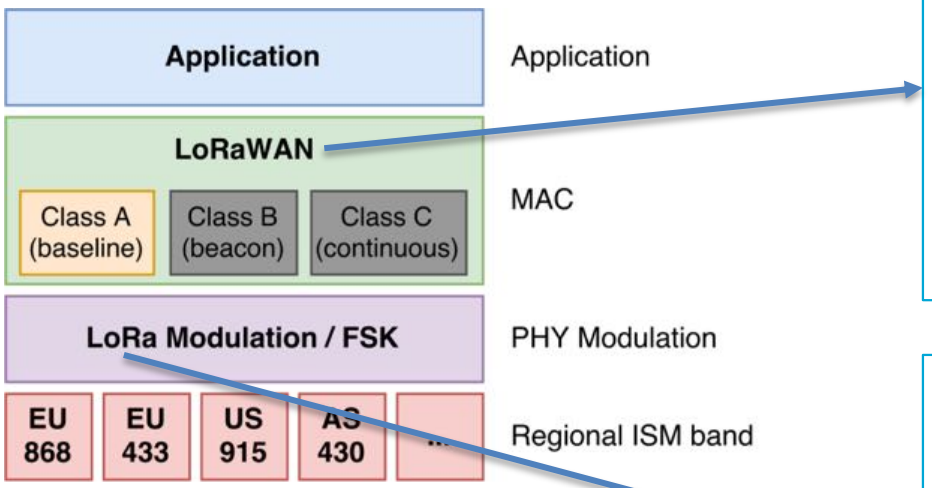
# LoRa vs LoRaWAN




- Communication protocol (MAC) and architecture for LoRa/FSK
- Specified by LoRa Alliance
- LoRaWAN version
  - Common: 1.0.2 (July 2016)
  - Recent: 1.1 (October 11, 2017)

- Semtech's proprietary wireless modulation technology
- Physical layer (PHY) for long range communications
- Based on Chirp Spread Spectrum (CSS)
- Robust against multipath, Doppler shift

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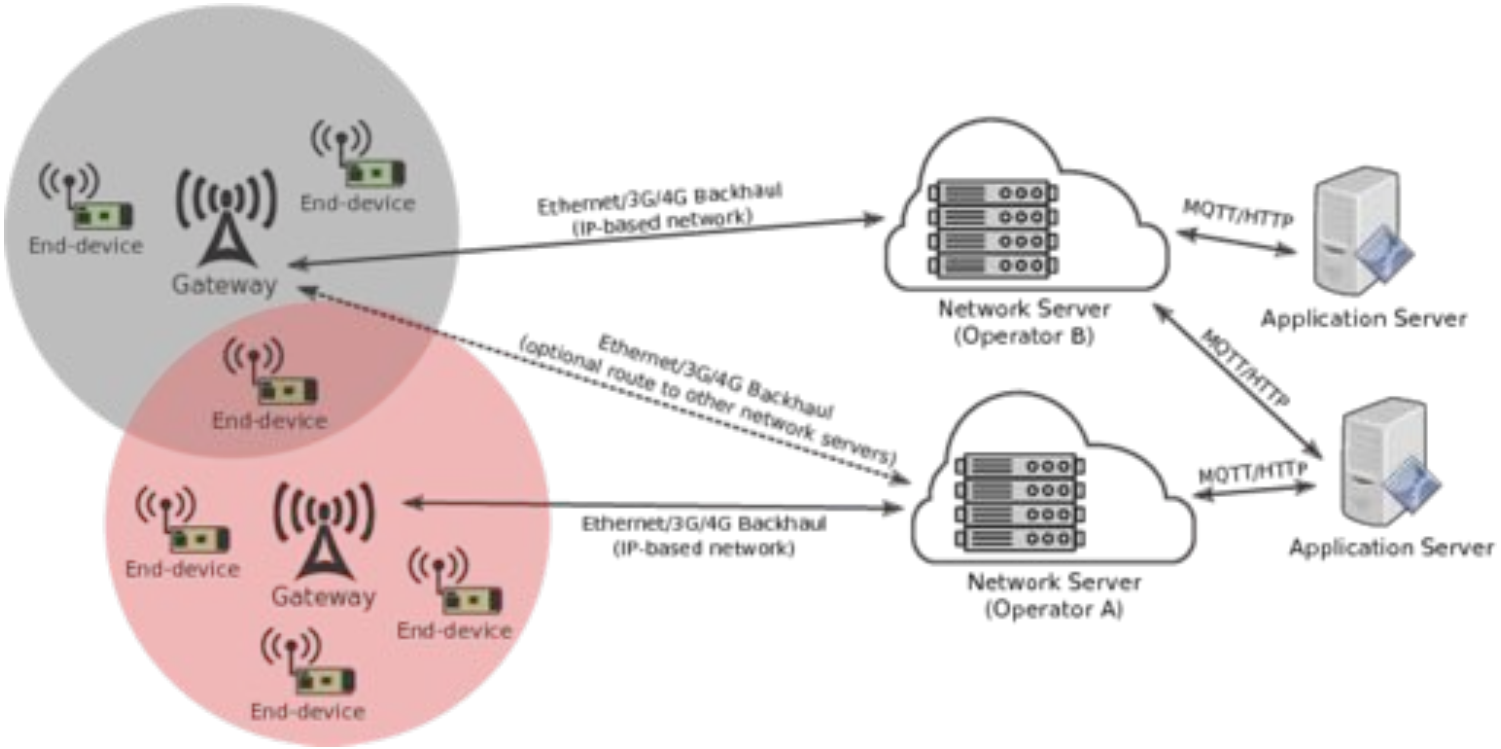
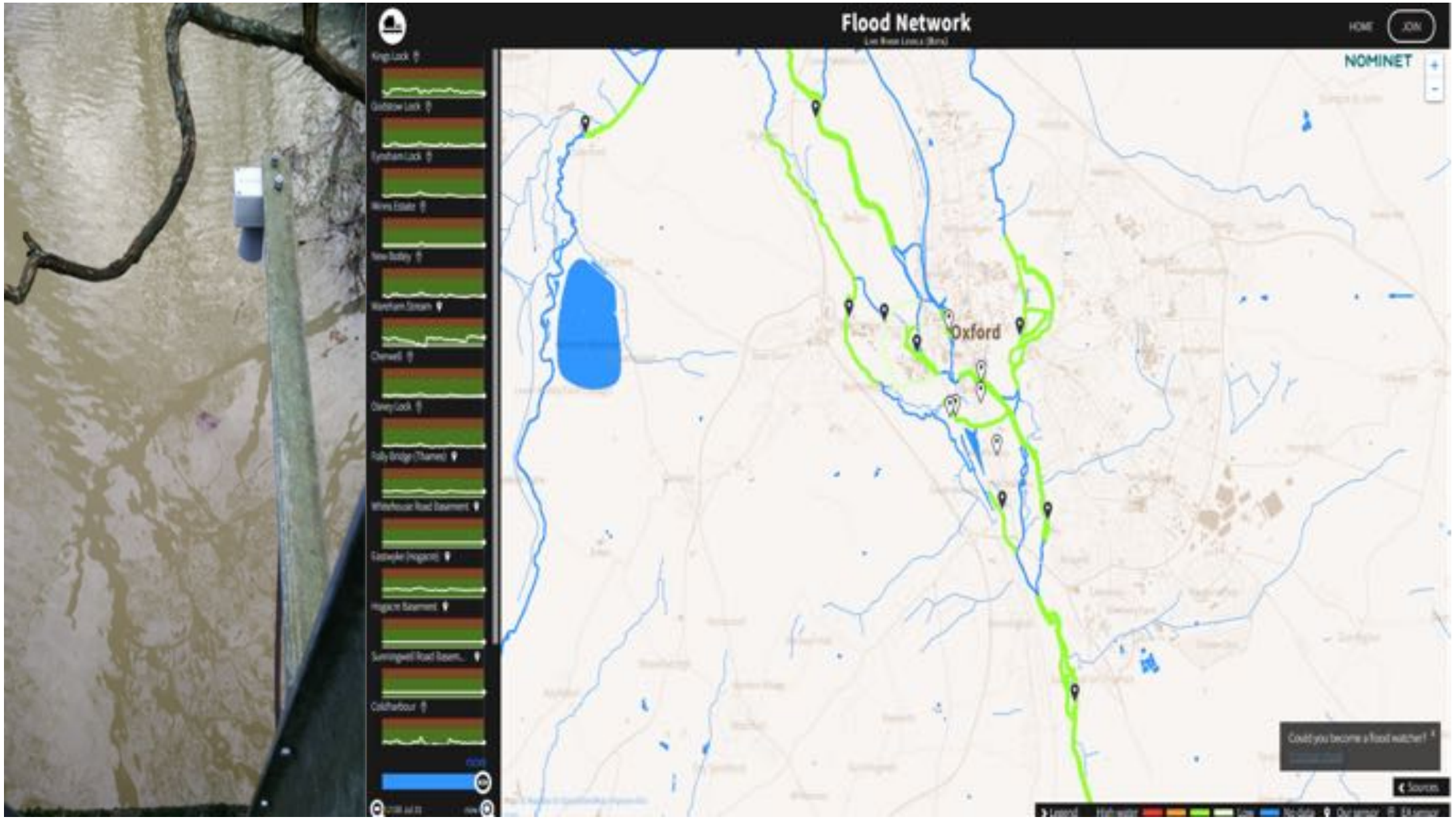
# LoRaWAN architecture




Flood Network
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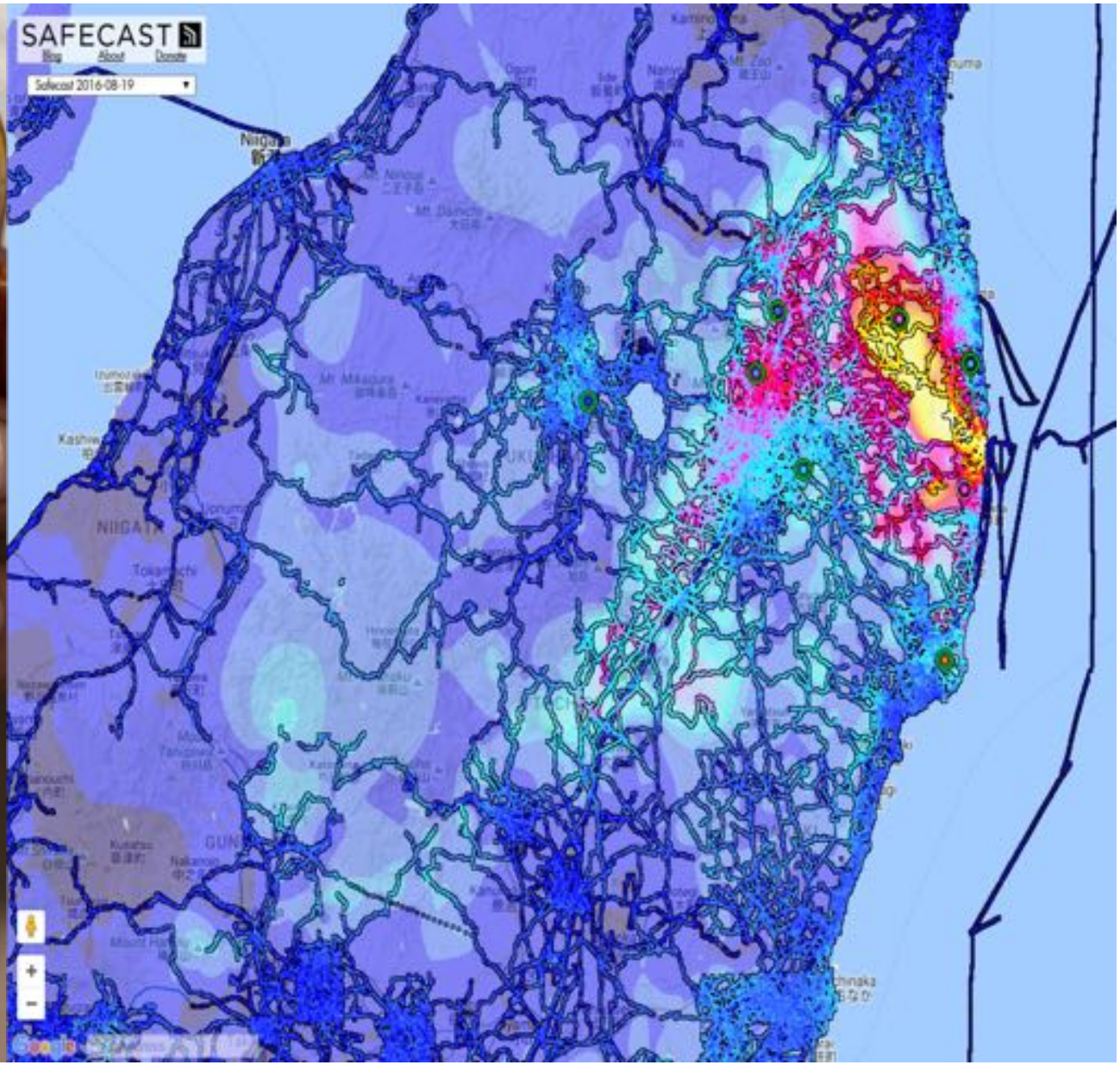
Oxford
Could you become a flood watcher?
Sources


0.144 uSv/h
SAFECAST


SAFECAST
Blog
About
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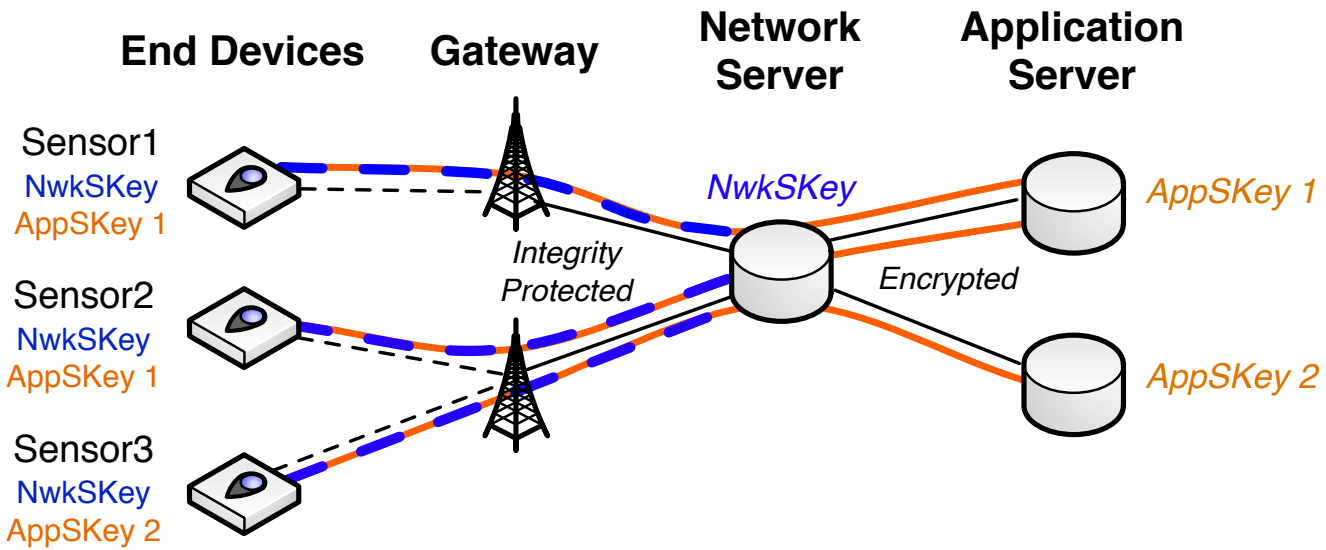
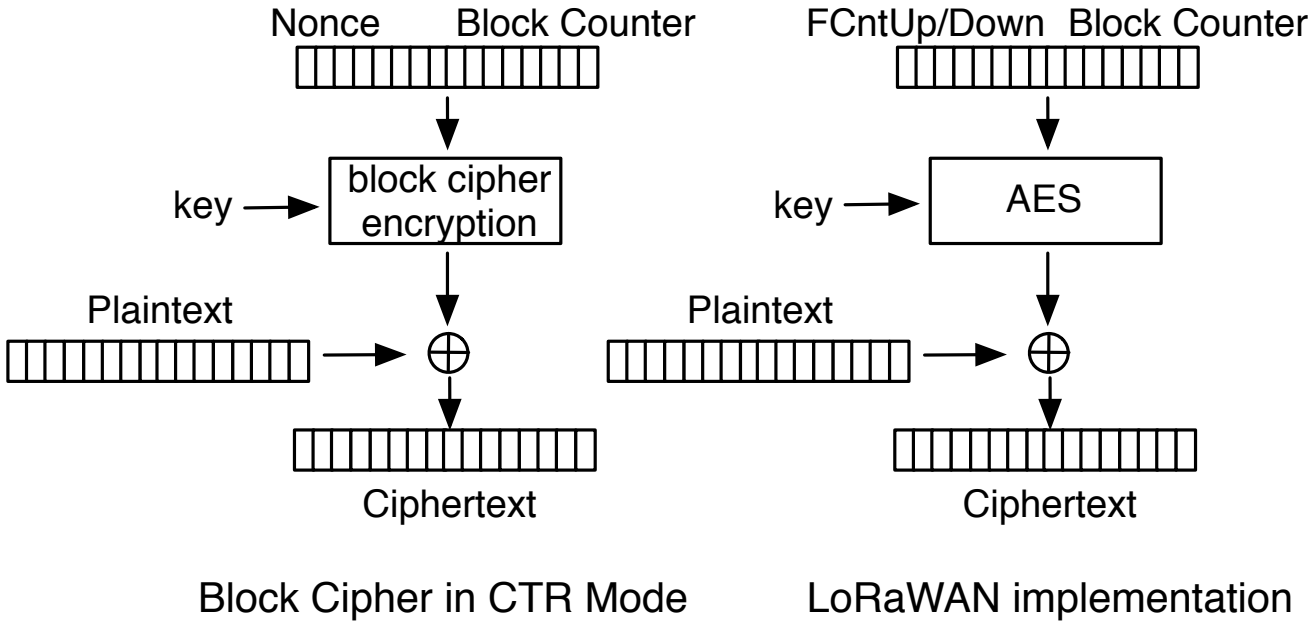
# Security features of LoRaWAN

- Channel confidentiality
  - Network and application keys
  - End-to-end encryption
- Enrollment protocol
  - Activation by Personalization (ABP)
  - Over-the-Air Activation (OTAA)
- Integrity and authenticity validation
  - Message Integrity Code (MIC)

# Channel confidentiality



# Encryption by AppSKey




Block Cipher in CTR Mode

LoRaWAN implementation

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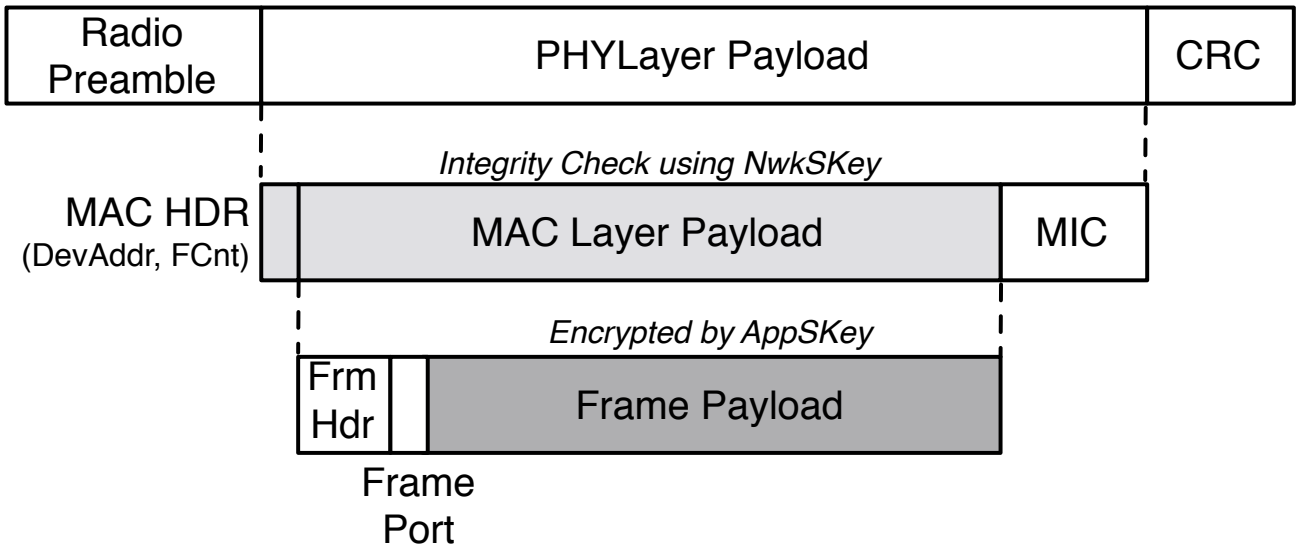
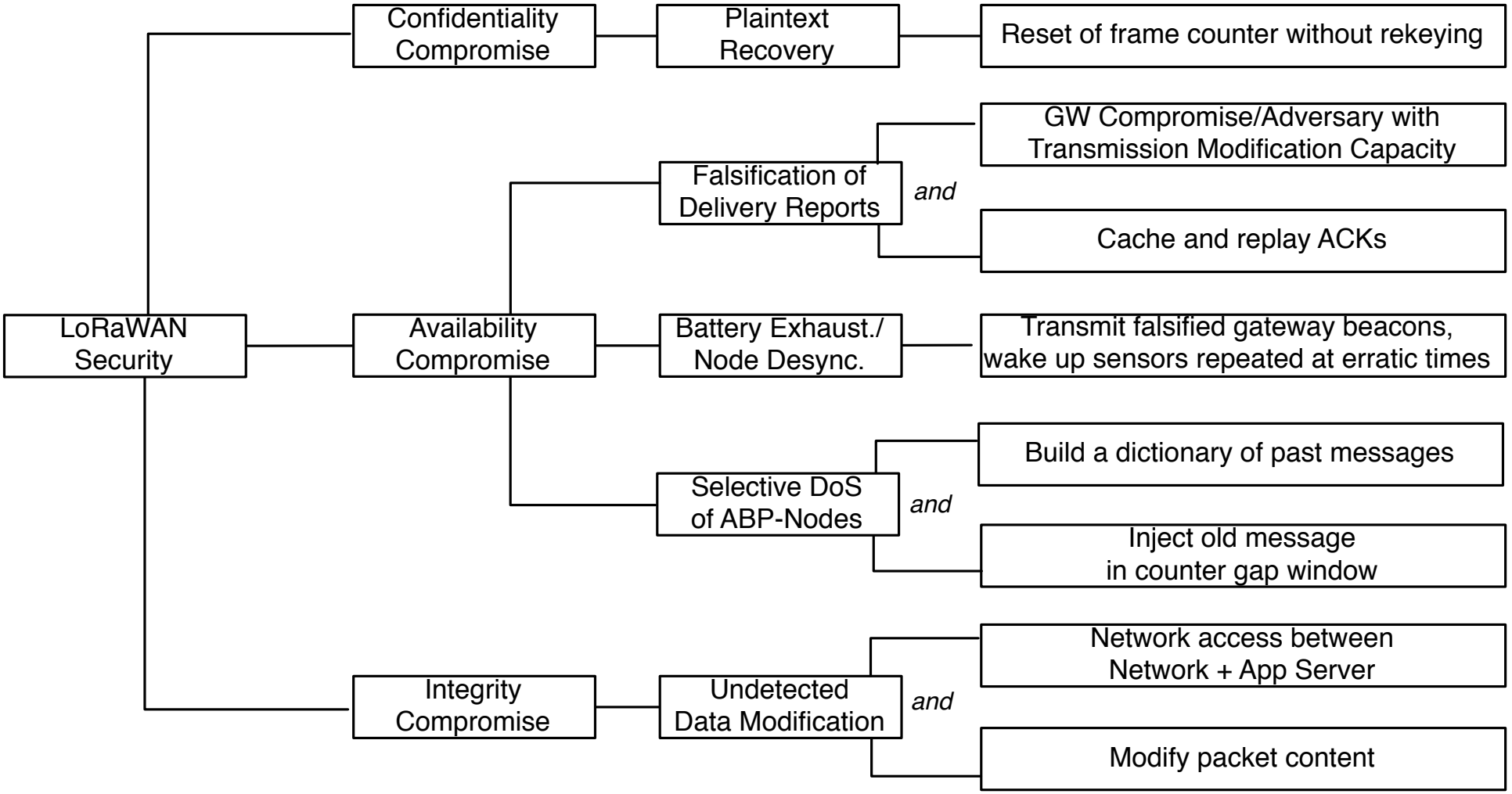
# Enrollment protocol

- OTAA:
  - End-device sends *Join Request*
  - Network server sends *Join Accept* with AppNonce
  - AppNonce to generate NwkSKey and AppSKey

- ABP:
  - No exchange of join messages
  - NwkSKey and AppSKey pre-assigned

# Integrity and Authenticity validation




LoRaWAN Security
Confidentiality Compromise
Plaintext Recovery
Reset of frame counter without rekeying
Availability Compromise
Falsification of Delivery Reports
and
GW Compromise/Adversary with Transmission Modification Capacity
Cache and replay ACKs
Battery Exhaust./ Node Desync.
Transmit falsified gateway beacons, wake up sensors repeated at erratic times
Selective DoS of ABP-Nodes
and
Build a dictionary of past messages
Inject old message in counter gap window
Integrity Compromise
Undetected Data Modification
and
Network access between Network + App Server
Modify packet content

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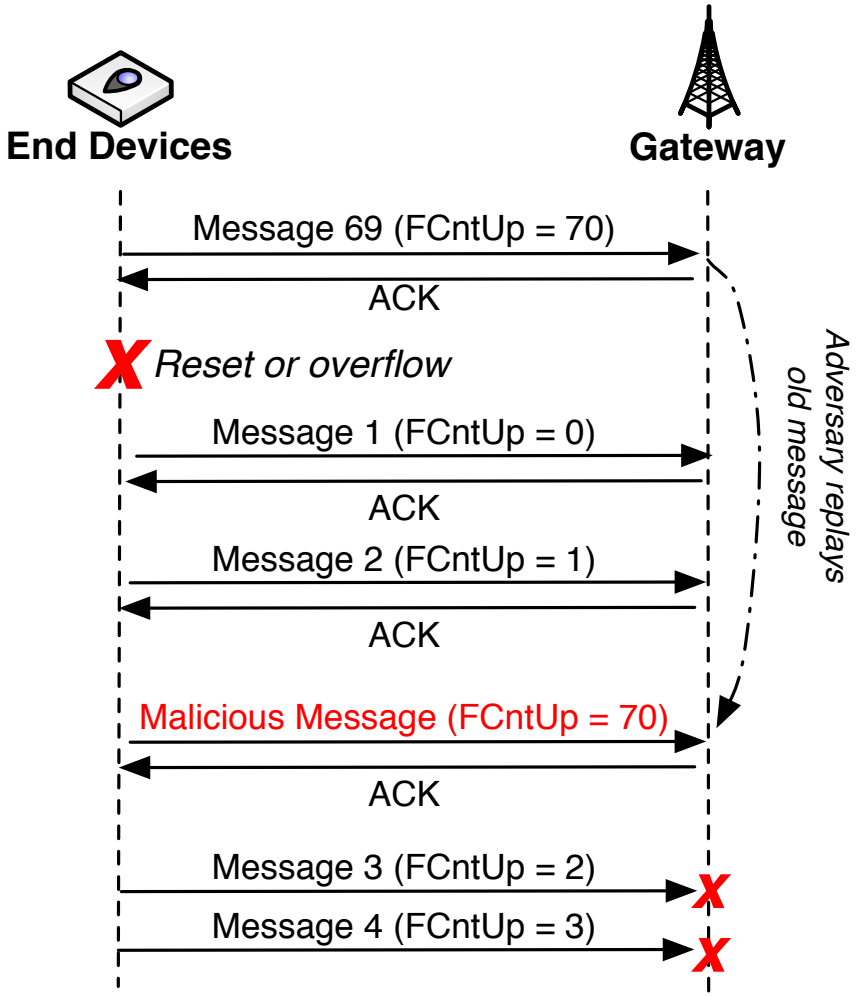
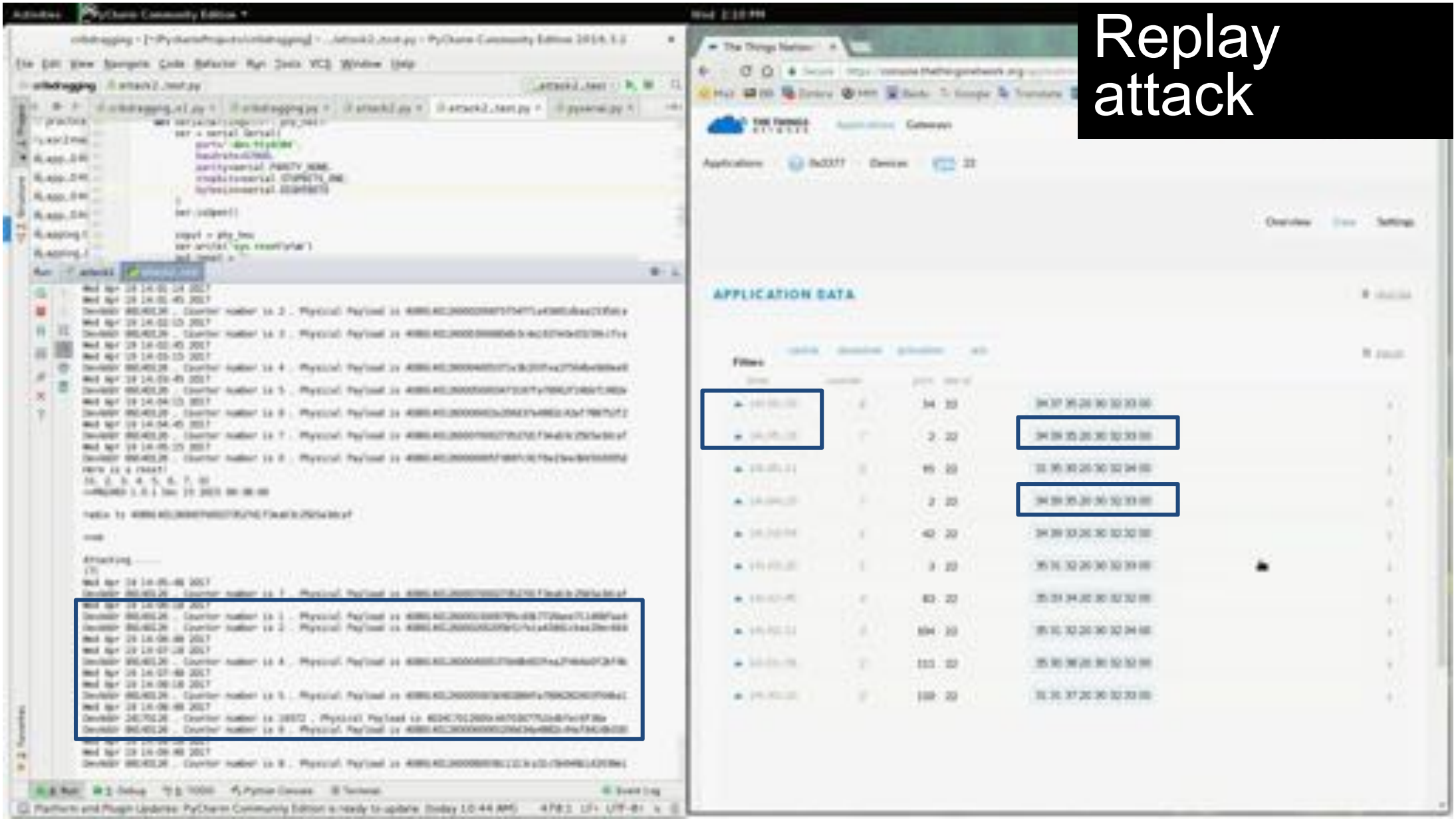
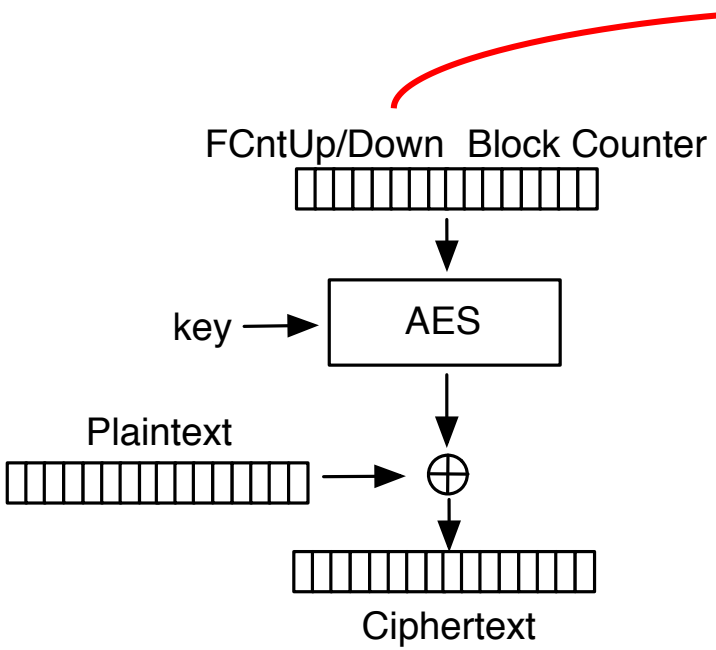
# Replay attack




Replay
attack
APPLICATION DATA

# Eavesdropping




LoRaWAN implementation

If FCnt is re-used

$$C_1 \oplus C_2 = (P_1 \oplus K) \oplus (P_2 \oplus K)$$
$$= P_1 \oplus P_2 \oplus \underbrace{(K \oplus K)}_{\text{cancels out}}$$
$$= P_1 \oplus P_2.$$

Guess one word to derive the other

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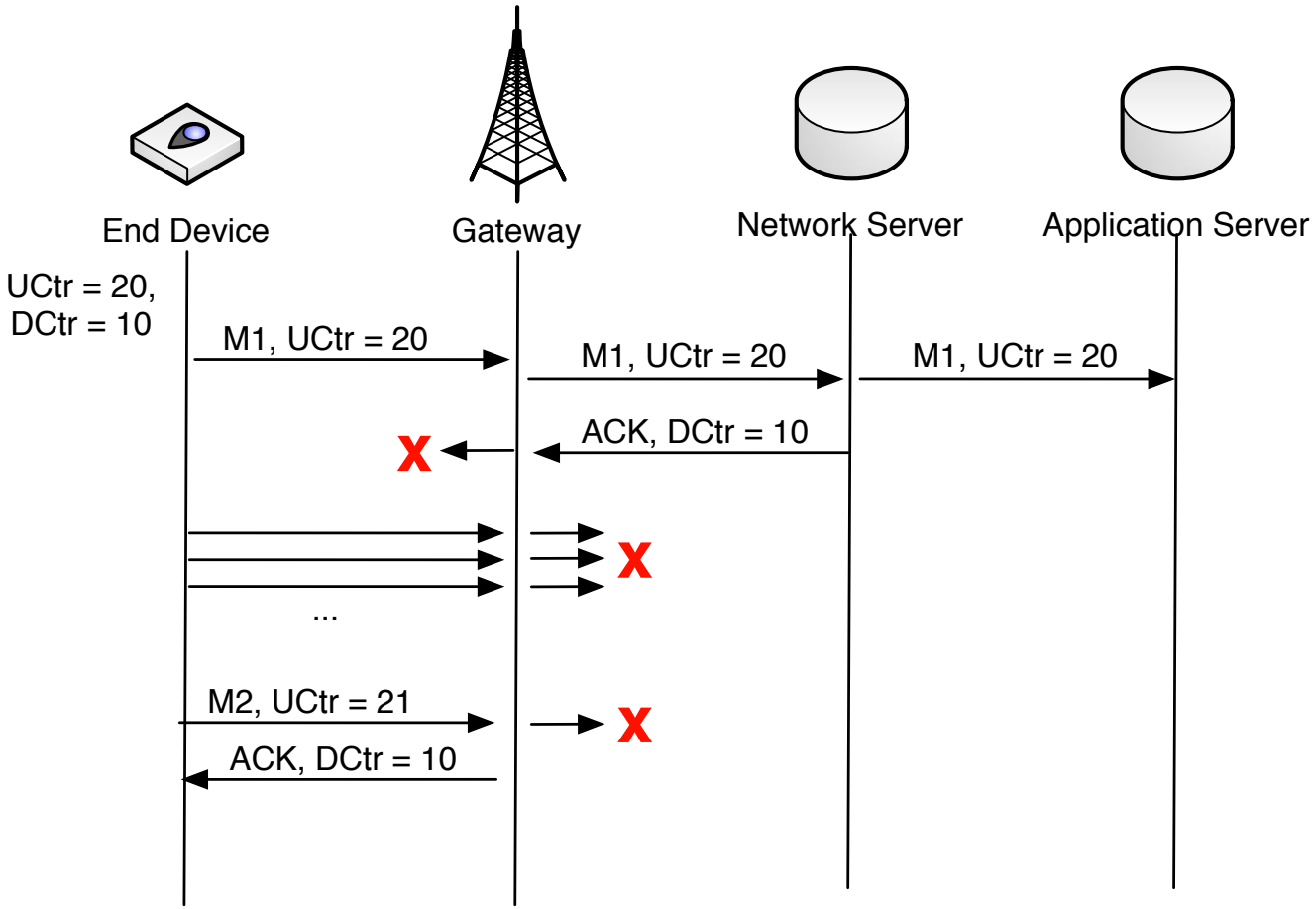
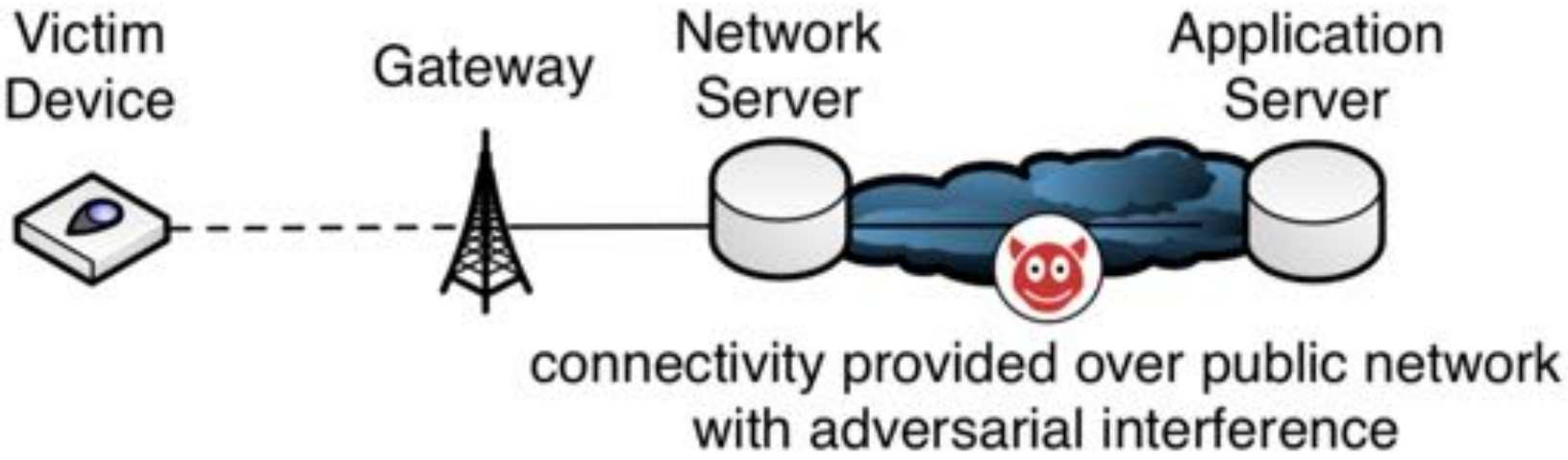
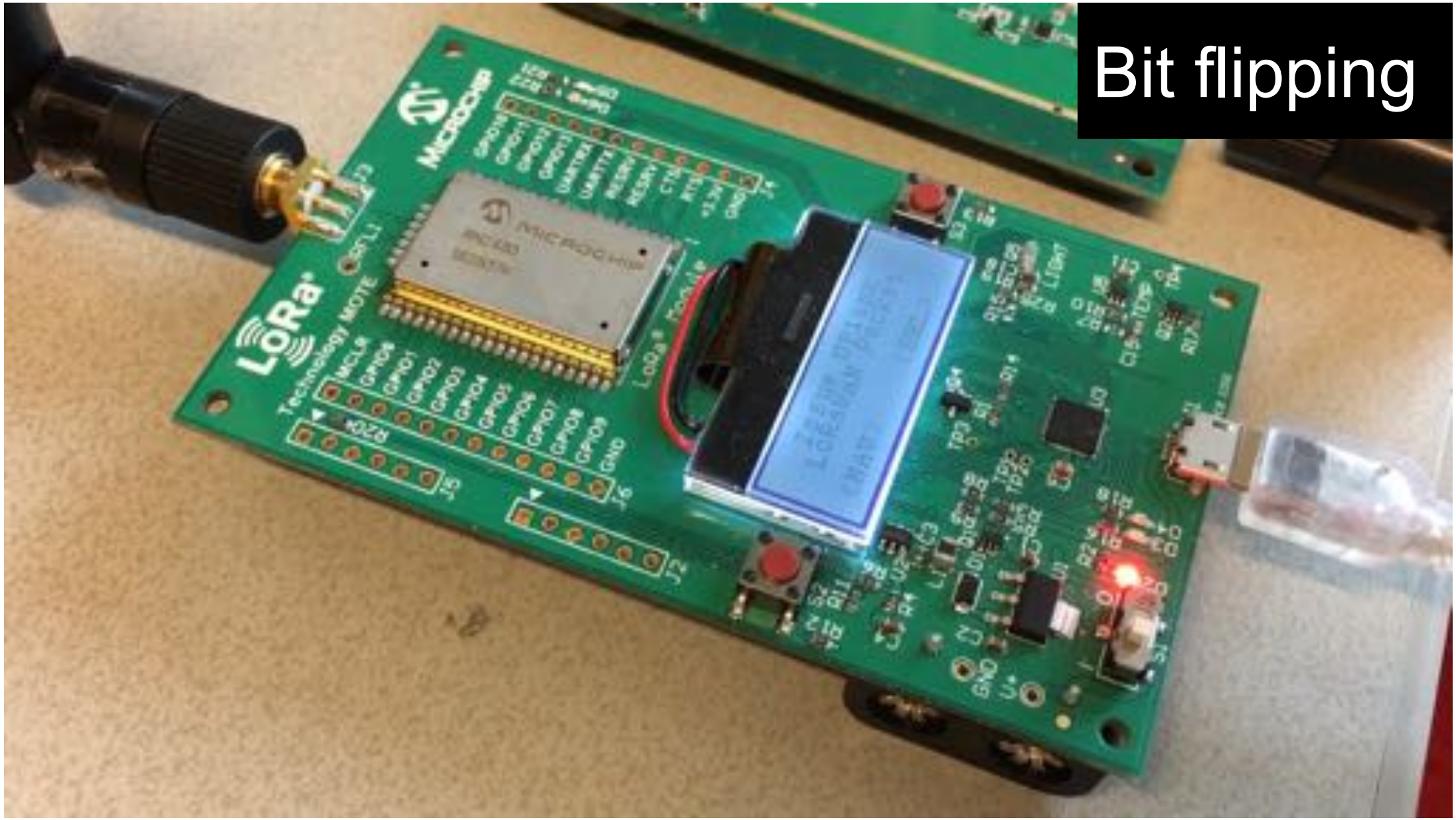
# ACK spoofing

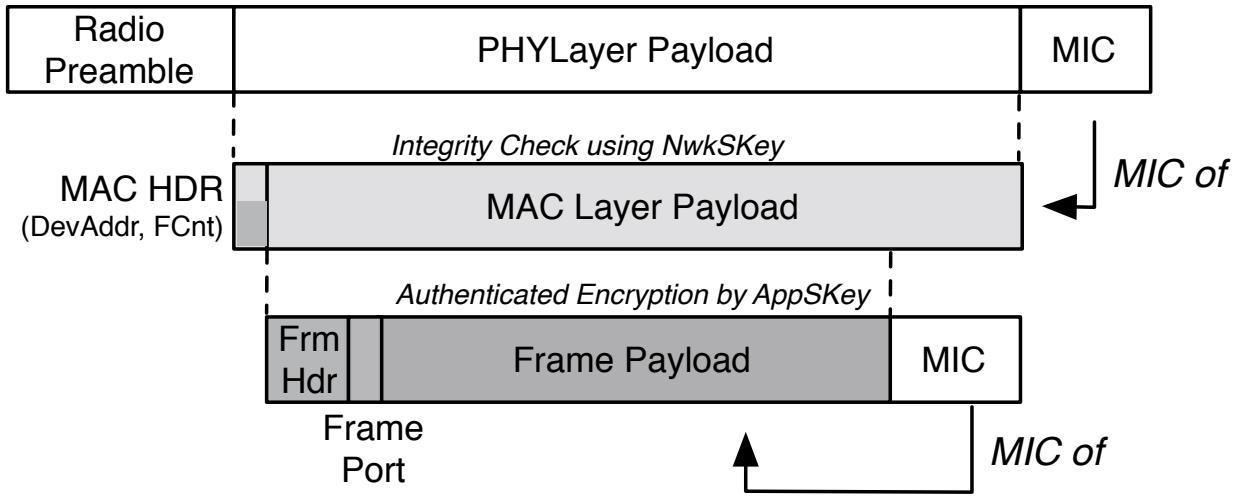


# Bit flipping




Bit flipping
LoRa
MICROCHIP

# Counter-measure



# More attacks and counter-measures in our paper

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X. Wang, E. Karampatzakis, C. Doerr, and F.A. Kuipers, “Security Vulnerabilities in LoRaWAN,” ACM/IEEE IoTDI, 2018.