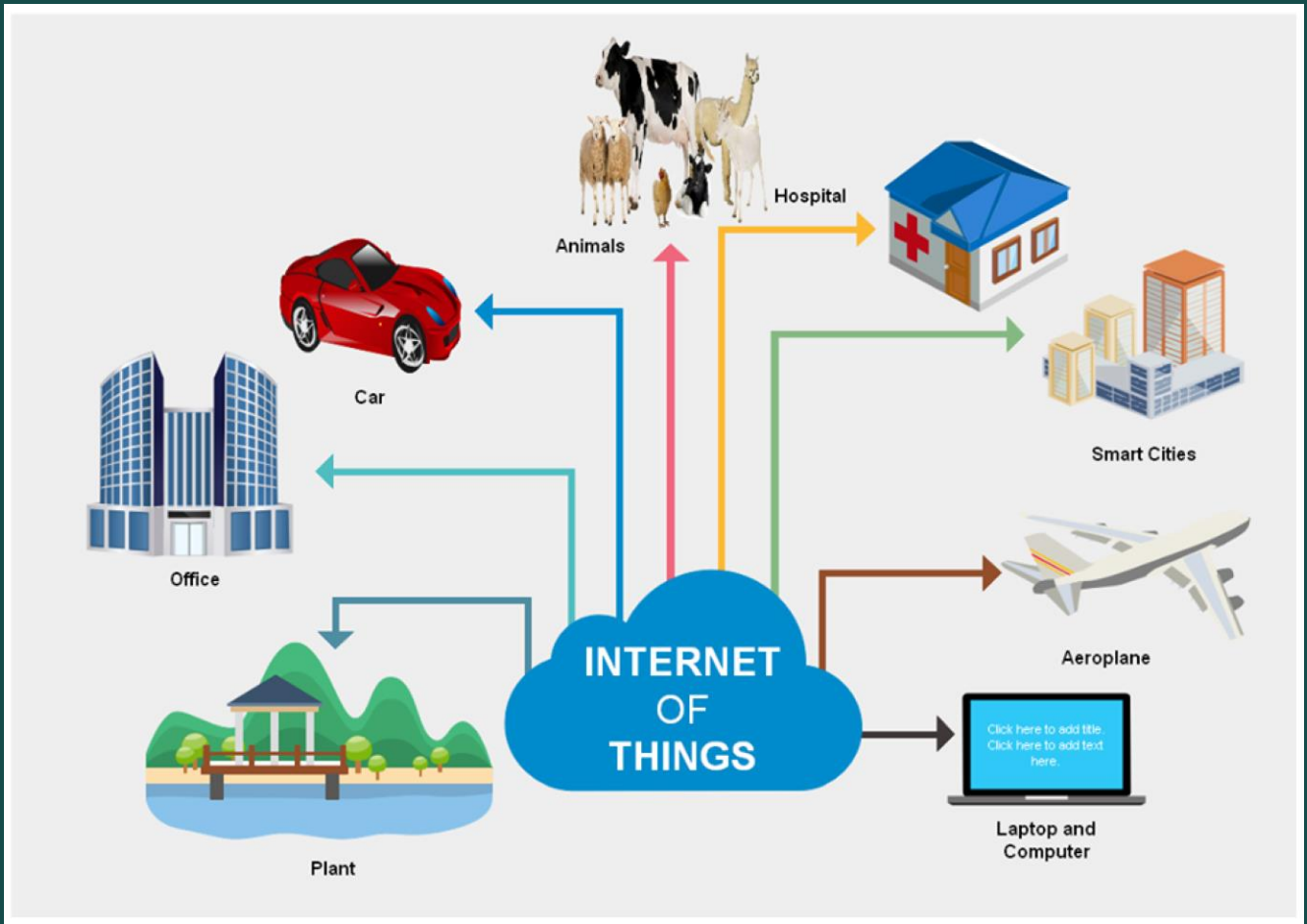
A STUDY OF LORA

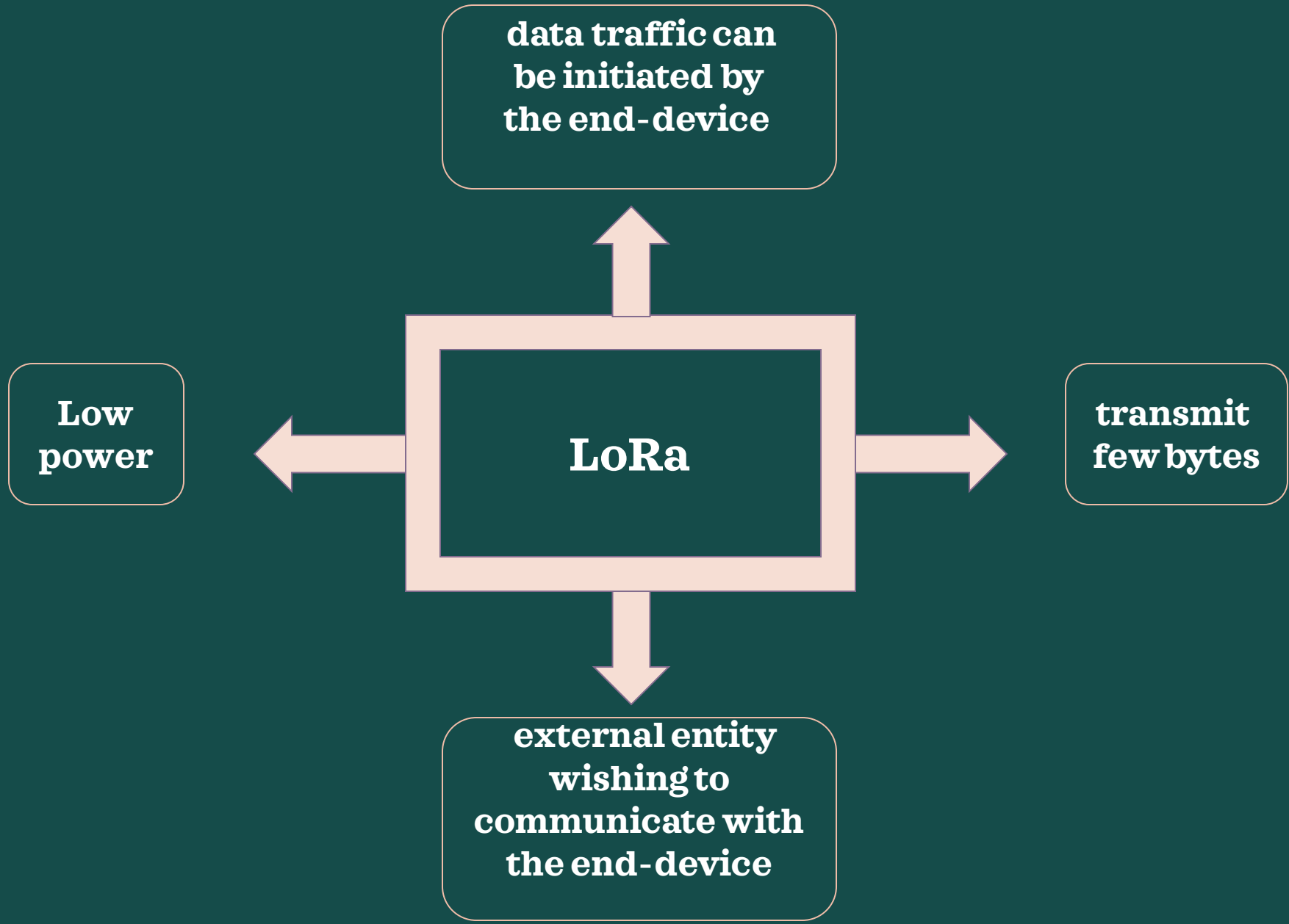

Animals
Hospital
Car
Smart Cities
Office
Aeroplane
INTERNET
OF
THINGS
Plant
Laptop and
Computer

IOT

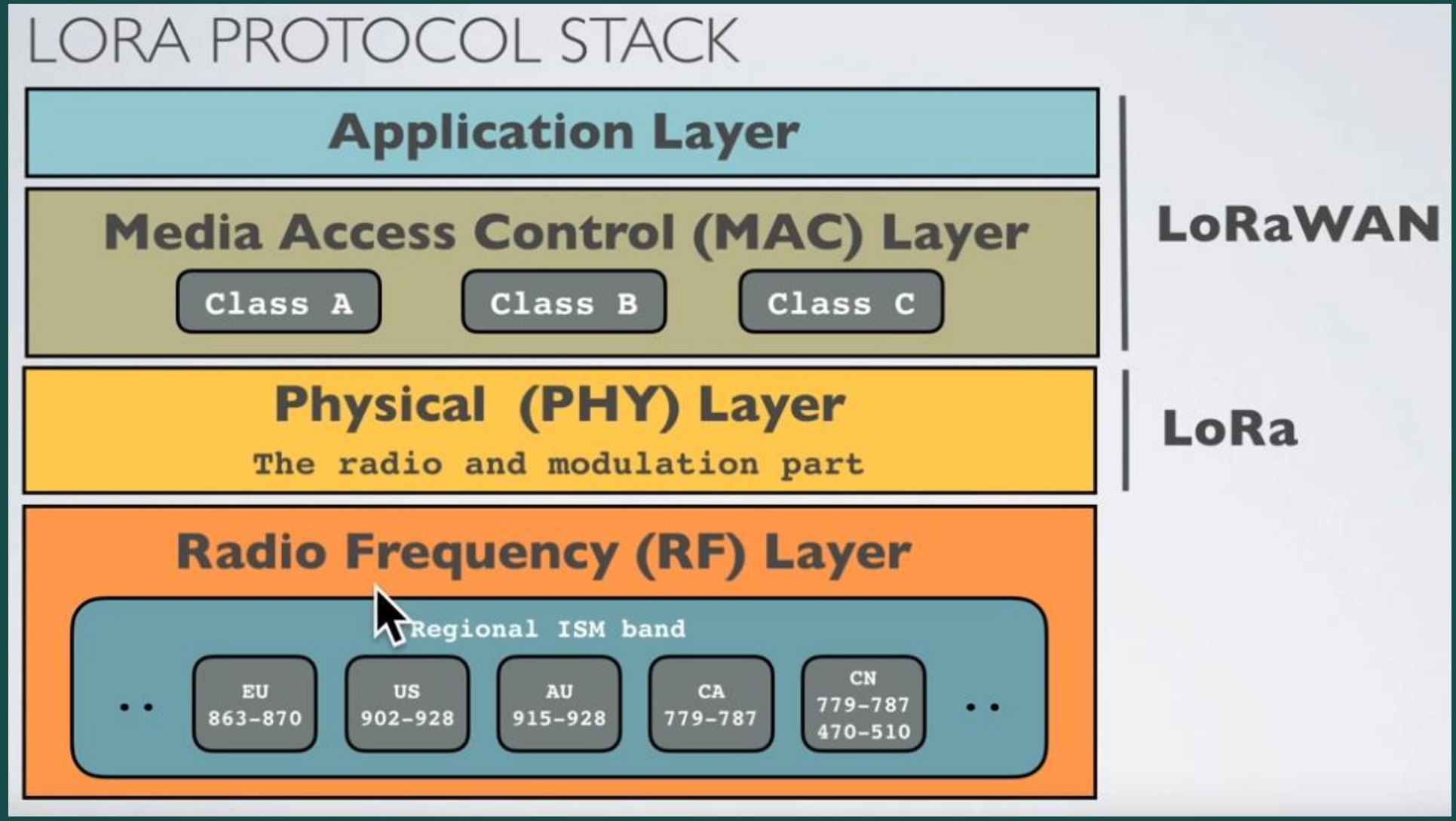
Short-range wireless communication

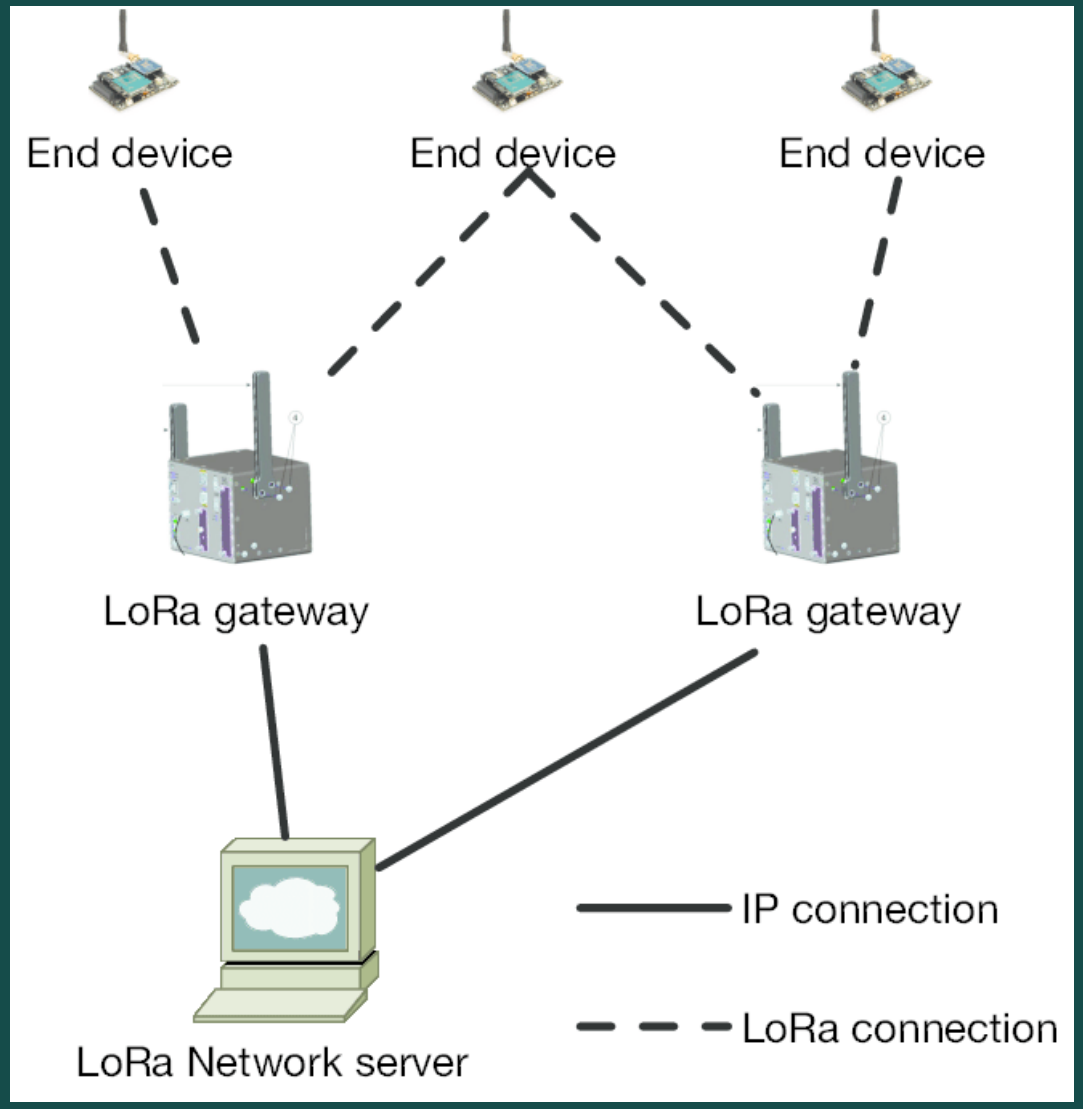
Cellular communication

LPWAN communication

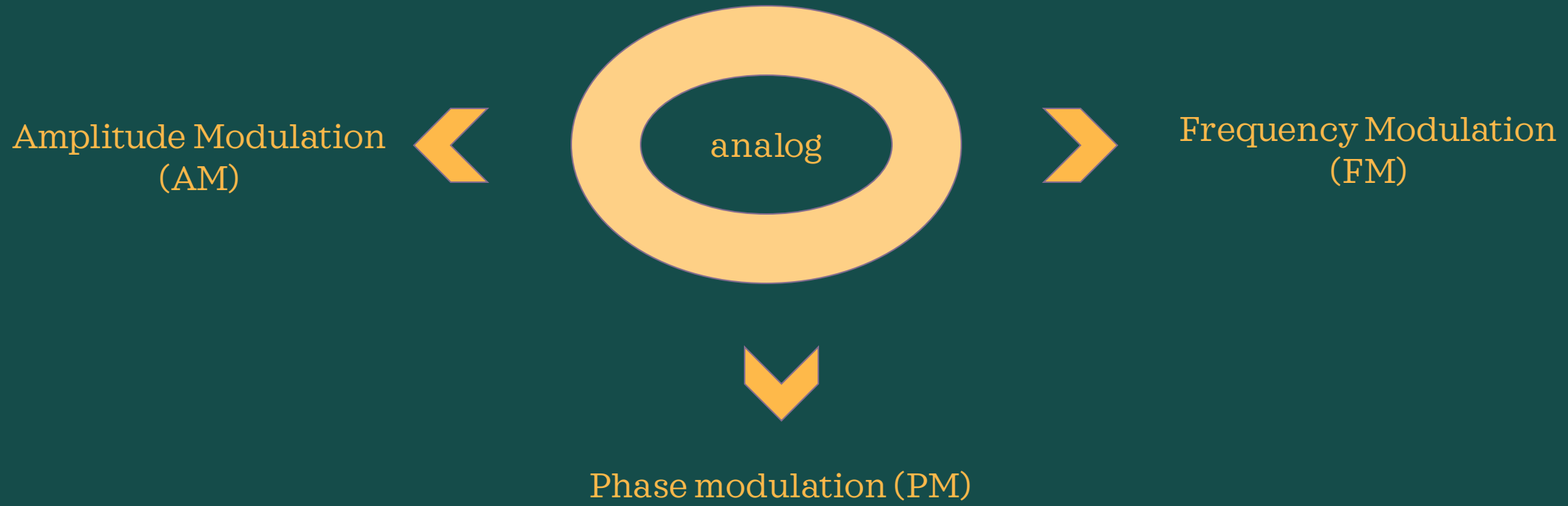

data traffic can be initiated by the end-device
Low power
LoRa
transmit few bytes
external entity wishing to communicate with the end-device

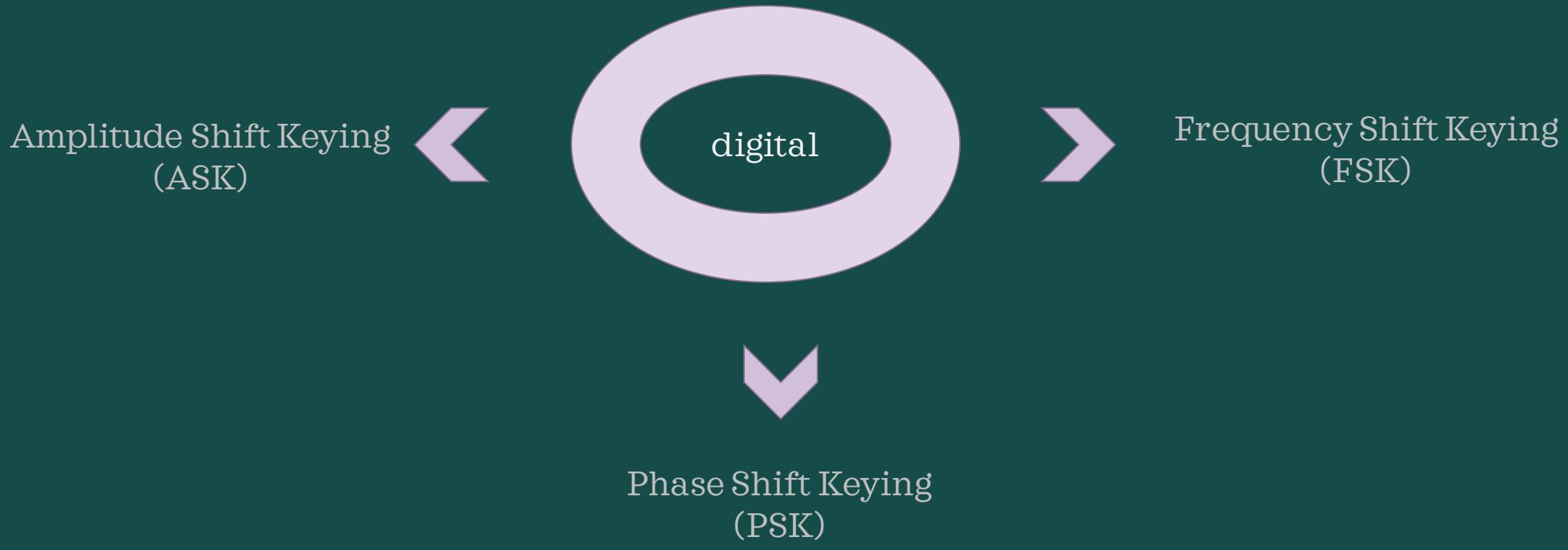
LORA PROTOCOL STACK





"a star-of-stars topology"


Amplitude Modulation
(AM)
analog
Frequency Modulation
(FM)
Phase modulation (PM)


Amplitude Shift Keying
(ASK)
digital
Frequency Shift Keying
(FSK)
Phase Shift Keying
(PSK)

chirp spread spectrum

Spreading Factor

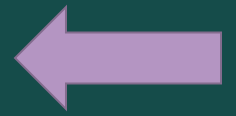
Symbol

chip

Symbol = 10
SF = 2
sweep signal is divided in 4 chips

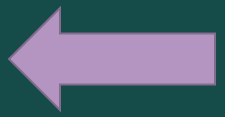
Chip rate = bandwidth

CHIP RATE



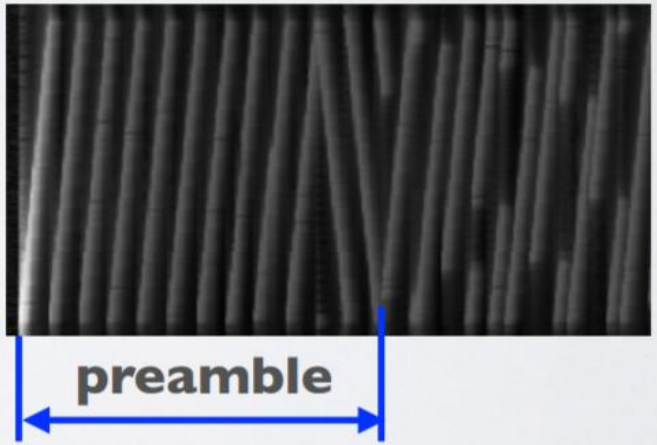
Symbol rate = bandwidth/2^SF

SYMBOL RATE



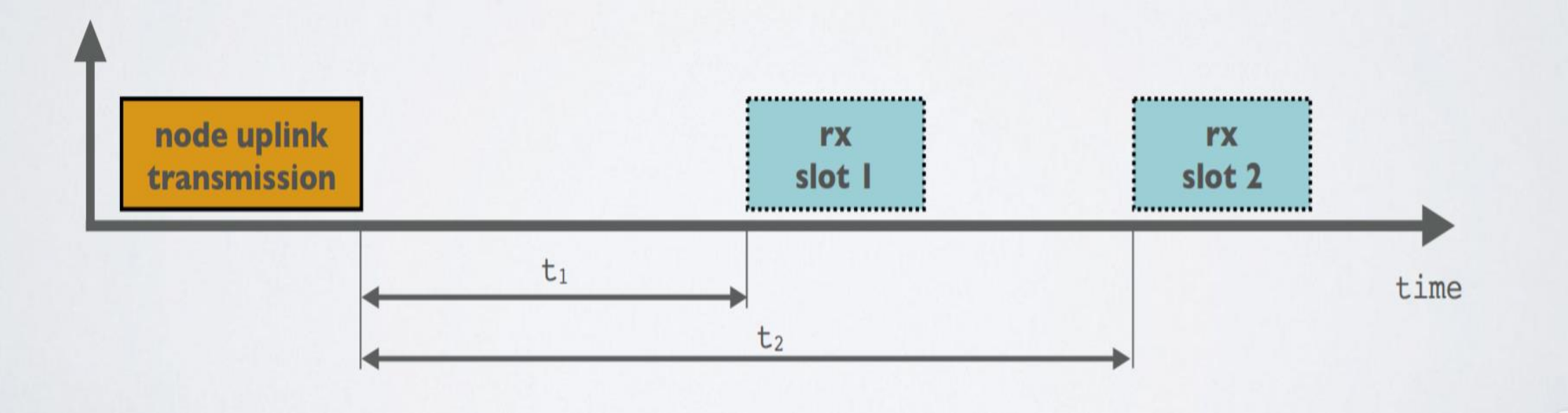
Explicit header mode

Implicit header mode

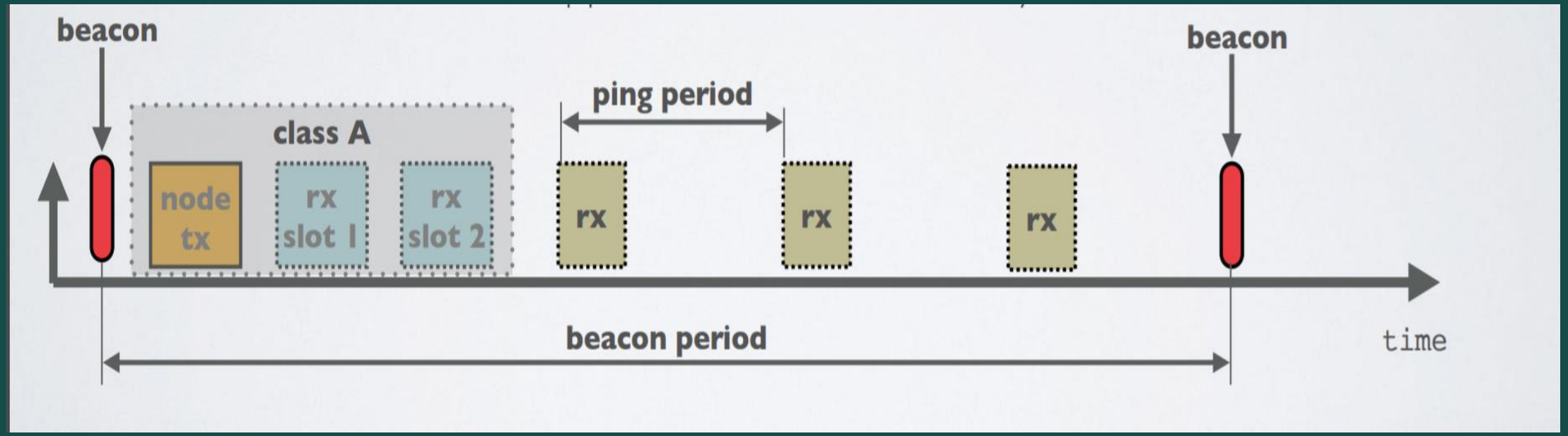


$$n_s = 8 + max\left(\left\lceil \frac{8PL - 4SF + 8 + CRC + H}{4 \times (SF - DE)} \right\rceil \times \frac{4}{CR}, 0\right)$$

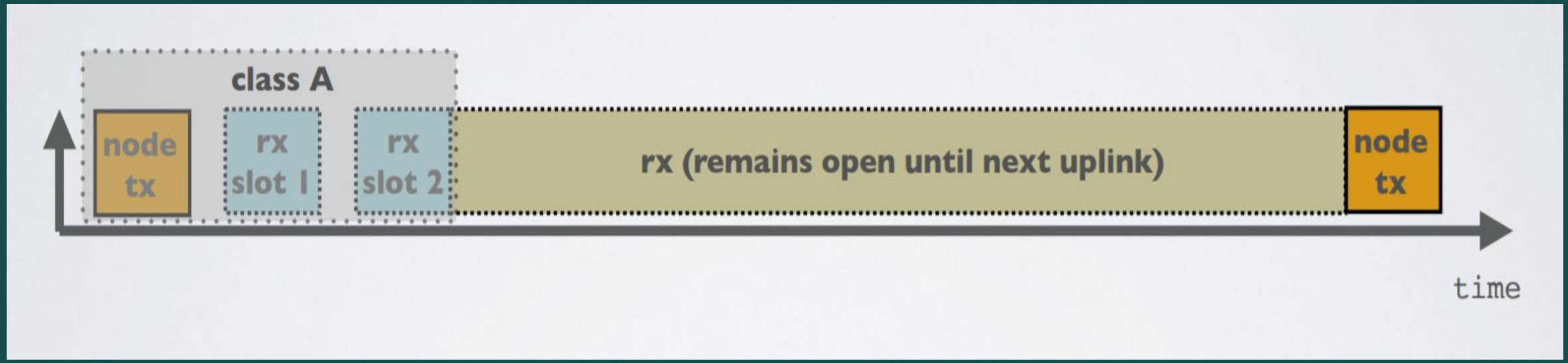
CLASS A

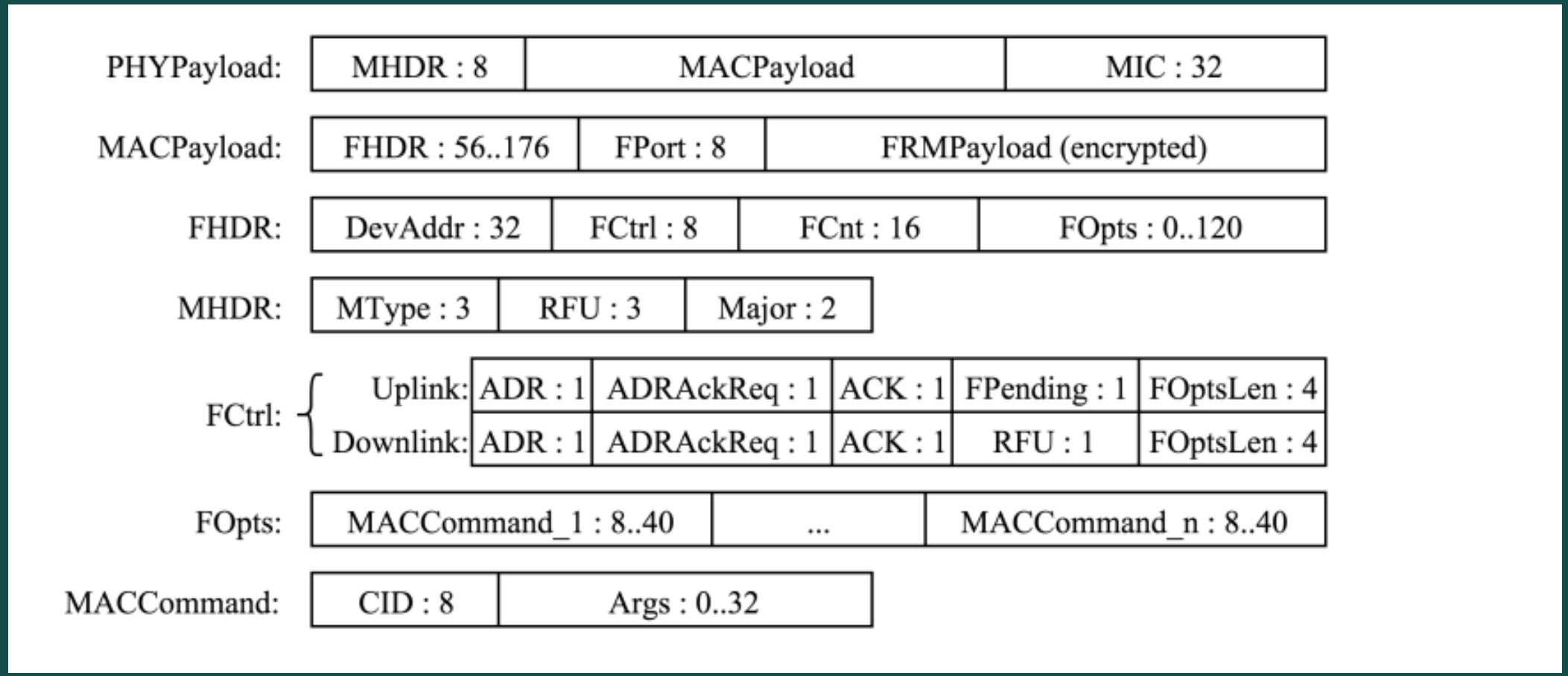


CLASS B


beacon
beacon
ping period
class A
node
tx
rx
slot 1
rx
slot 2
rx
rx
rx
beacon period
time

CLASS B


class A
node tx
rx slot 1
rx slot 2
rx (remains open until next uplink)
node tx
time

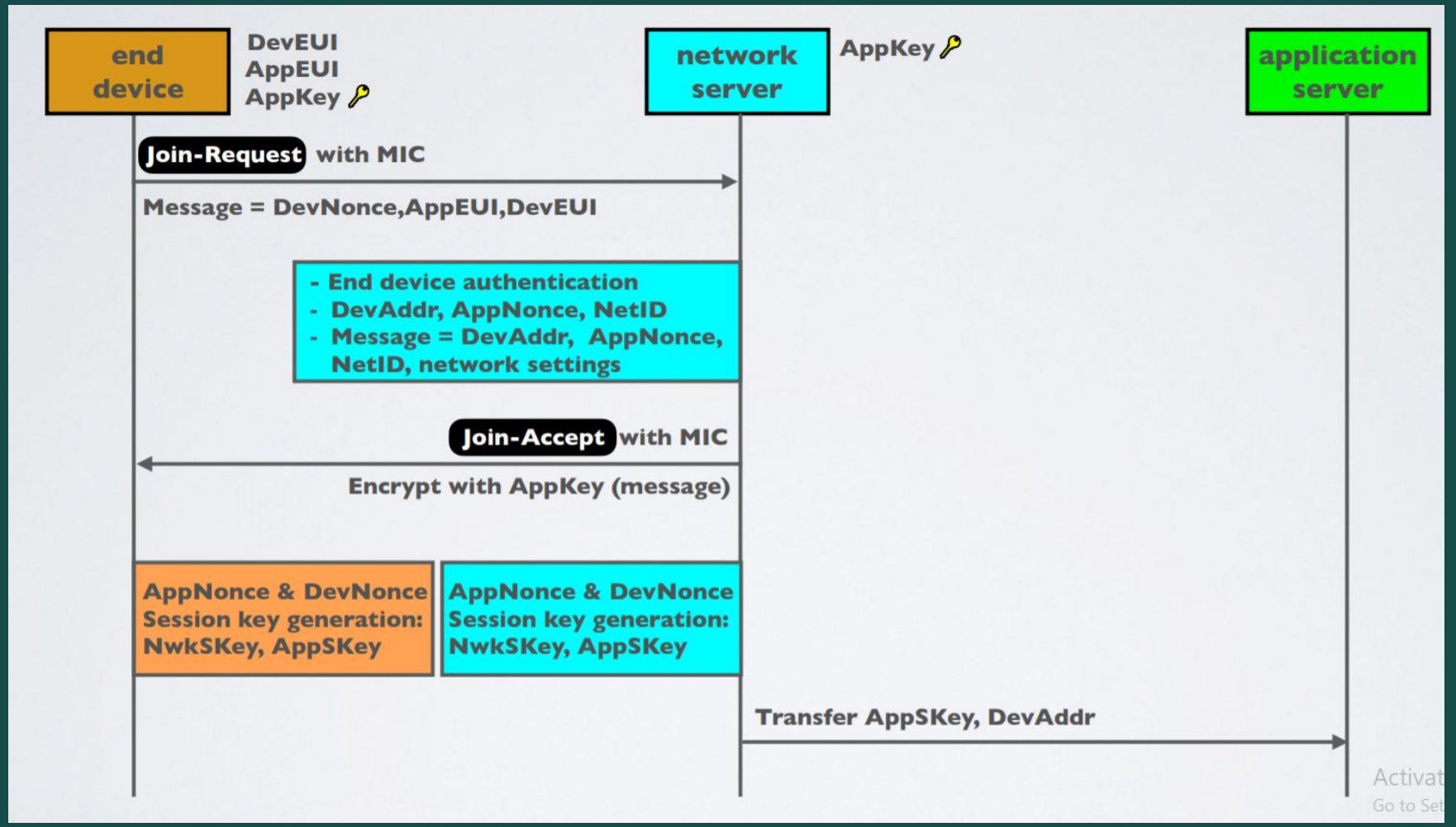

PHYPayload:
MHDR : 8
MACPayload
MIC : 32
MACPayload:
FHDR : 56..176
FPort : 8
FRMPayload (encrypted)
FHDR:
DevAddr : 32
FCtrl : 8
FCnt : 16
FOpts : 0..120
MHDR:
MType : 3
RFU : 3
Major : 2
FCtrl:
Uplink:
ADR : 1
ADRAckReq : 1
ACK : 1
FPending : 1
FOptsLen : 4
Downlink:
ADR : 1
ADRAckReq : 1
ACK : 1
RFU : 1
FOptsLen : 4
FOpts:
MACCommand_1 : 8..40
...
MACCommand_n : 8..40
MACCommand:
CID : 8
Args : 0..32

ACTIVATION METHODS

Over-The-Air-Activation (OTAA)

Activation-By-Personalisation (ABP)

Over-The-Air-Activation (OTAA)



Activation-By-Personalisation (ABP)