Deploying Dense LoRa networks for Smart-Cities

Opportunities and Challenges

Special Session: SCEI – Danang Smart Cities: Experiences and Innovations
Keynotes and Panel Discussion

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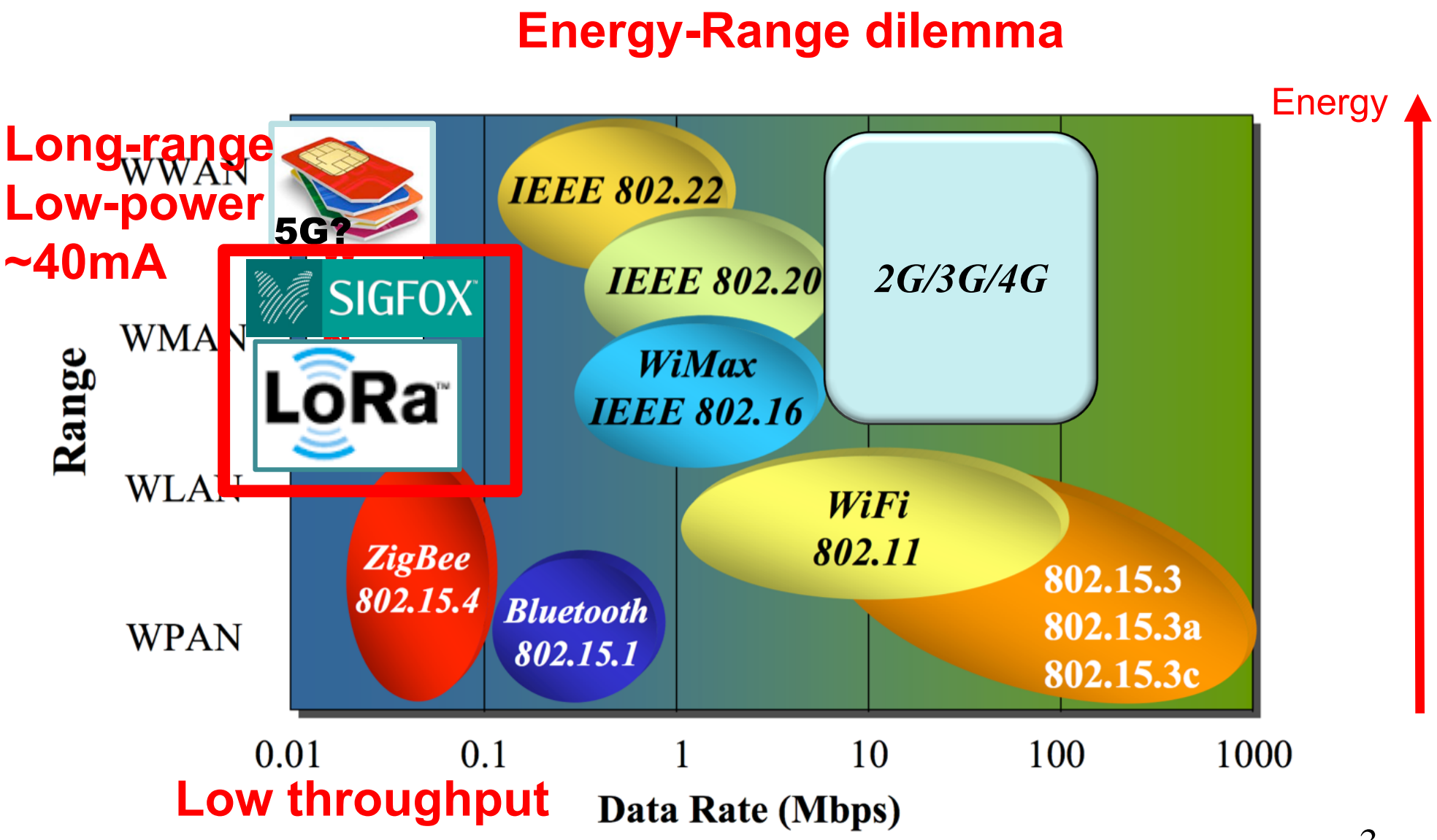
IoT – from idea to reality

Low-power & long-range radio technologies

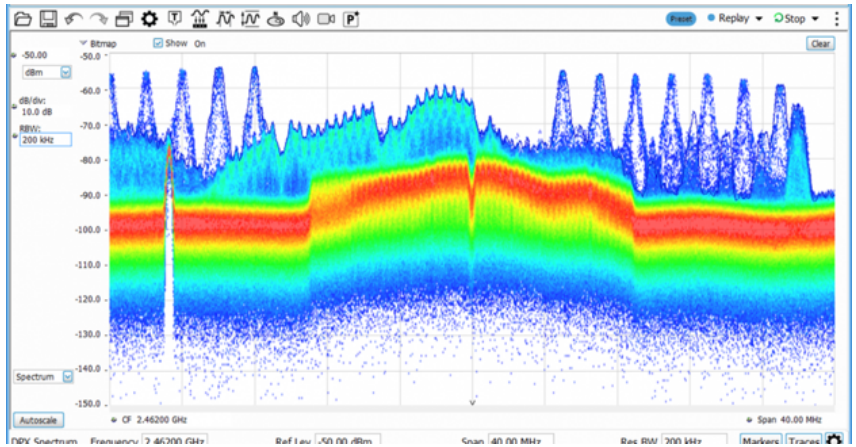


Typical range for LoRa

- Open space, near LoS conditions
  - More than 20kms can be easily achieved
- Sea, lake, …
  - More than 20kms can be easily achieved
- Rural, with sparse vegetation
  - 2kms to 6kms (with gateway antenna on roof of farms)
- Indoor
  - For indoor, a whole building can easily be covered
- Dense urban
  - High impact of gateway height !
  - If gateway on high building: 6 to 8kms

Deploying in dense environment

- Many devices: more traffic, more interferences & collisions



- Many gateways: increased packet reception rate but LPWAN roaming is needed for E2E!

The impact of frequency plan

LoRa Alliance

Modulation	Bandwidth [kHz]	Channel Frequency [MHz]	FSK Bitrate or LoRa DR / Bitrate	Nb Channels	Duty cycle
LoRa	125	868.10 868.30 868.50	DR0 to DR5 / 0.3-5 kbps	3	<1%

Table 2: EU863-870 default channels

Modulation	Bandwidth [kHz]	Channel Frequency [MHz]	FSK Bitrate or LoRa DR / Bitrate	Nb Channels	Duty cycle
LoRa	125	923.20 923.40	DR0 to DR5 / 0.3-5 kbps	2	< 1%

Table 39: AS923 default channels

EU863-870

THE THINGS NETWORK

Uplink:

1. **868.1** - SF7BW125 to SF12BW125
2. **868.3** - SF7BW125 to SF12BW125
3. **868.5** - SF7BW125 to SF12BW125
4. **867.1** - SF7BW125 to SF12BW125
5. **867.3** - SF7BW125 to SF12BW125
6. **867.5** - SF7BW125 to SF12BW125
7. **867.7** - SF7BW125 to SF12BW125
8. **867.9** - SF7BW125 to SF12BW125
9. **868.8** - FSK

Frequency plan means common adoption for uplink frequencies which will increase interference level

AS923-925

Used in Brunei, Cambodia, Hong Kong, Indonesia, Laos, Taiwan, Thailand, Vietnam

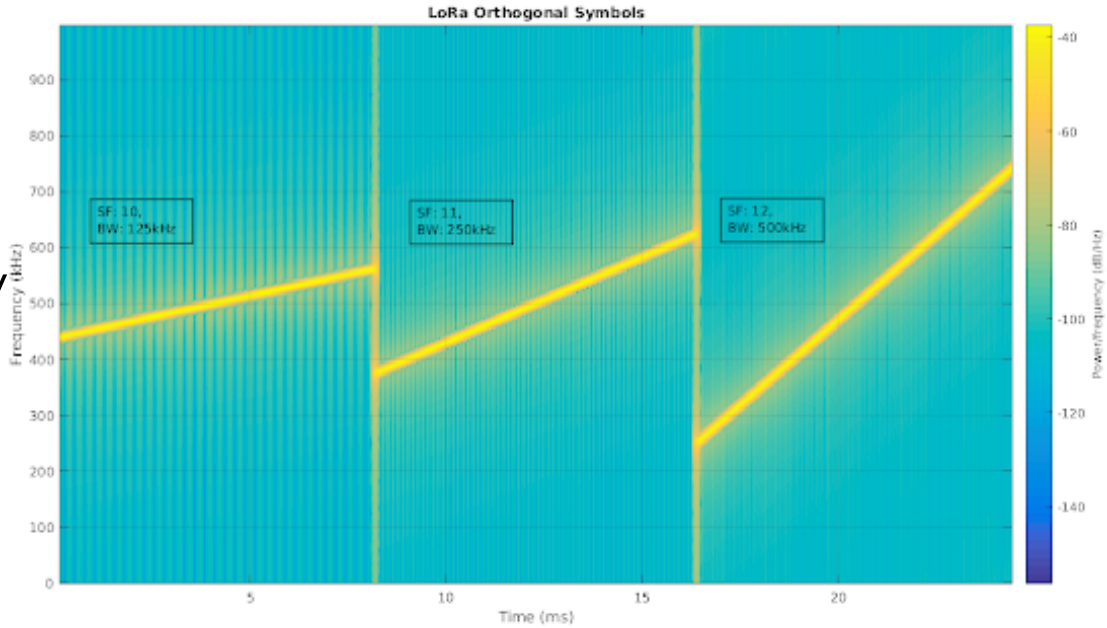
Uplink:

THE THINGS NETWORK

1. **923.2** - SF7BW125 to SF12BW125
2. **923.4** - SF7BW125 to SF12BW125
3. **923.6** - SF7BW125 to SF12BW125
4. **923.8** - SF7BW125 to SF12BW125
5. **924.0** - SF7BW125 to SF12BW125
6. **924.2** - SF7BW125 to SF12BW125
7. **924.4** - SF7BW125 to SF12BW125
8. **924.6** - SF7BW125 to SF12BW125
9. **924.5** - SF7BW250
10. **924.8** - FSK

Low-level LoRa interference mitigation techniques

- Orthogonal "chirpyness"
- Different chirp rate can be achieved by different spreading factors and/or by different bandwidths
- LoRa symbols can by simultaneously transmitted and received on a same channel without interference
- LoRa has 6 spreading factors (SF7 - SF12) and 3 different bandwidths (125kHz, 250kHz & 500kHz)



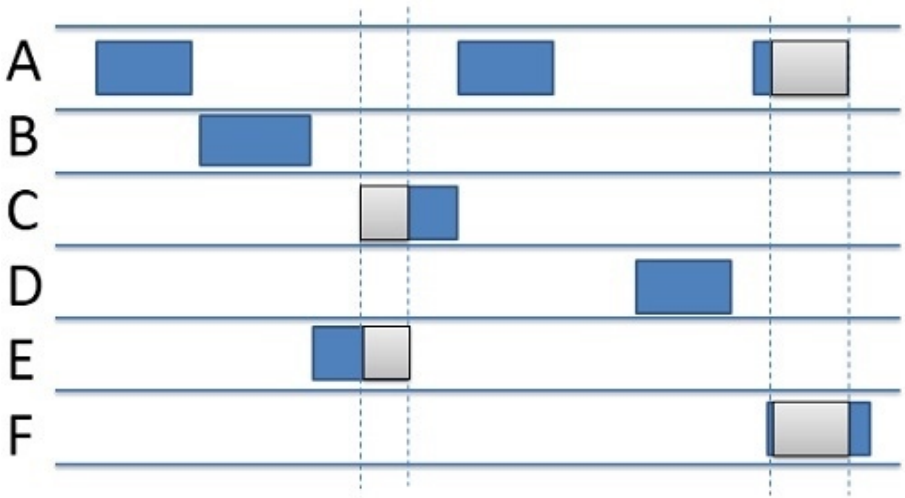
SF=10 BW=125kHz | SF=11 BW=250kHz | SF=12 BW=500kHz

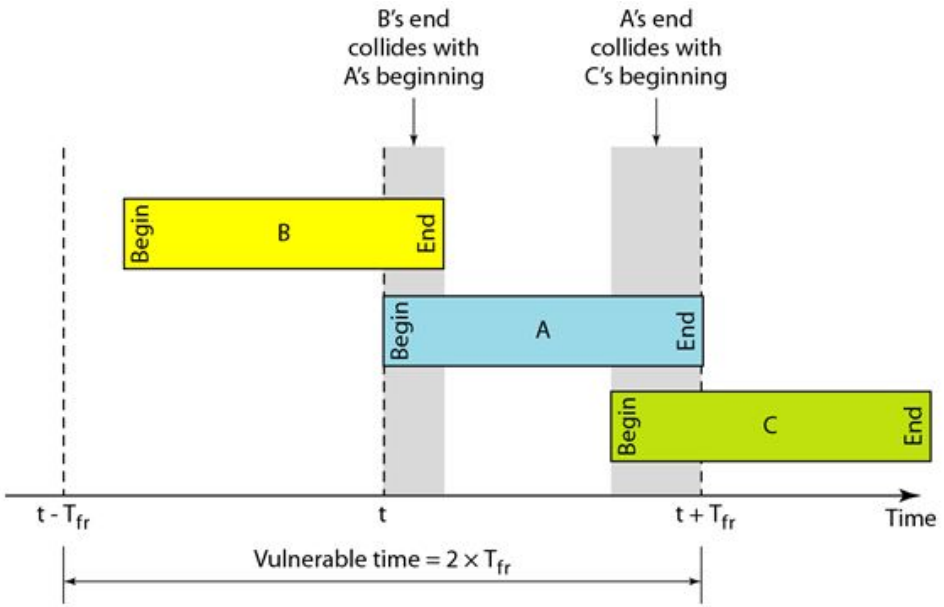
But SF=12 is the setting that allow the highest sensitivity, thus the longest range

From "All About LoRa and LoRaWAN", https://www.sghoslya.com

Concurrent channel access issue

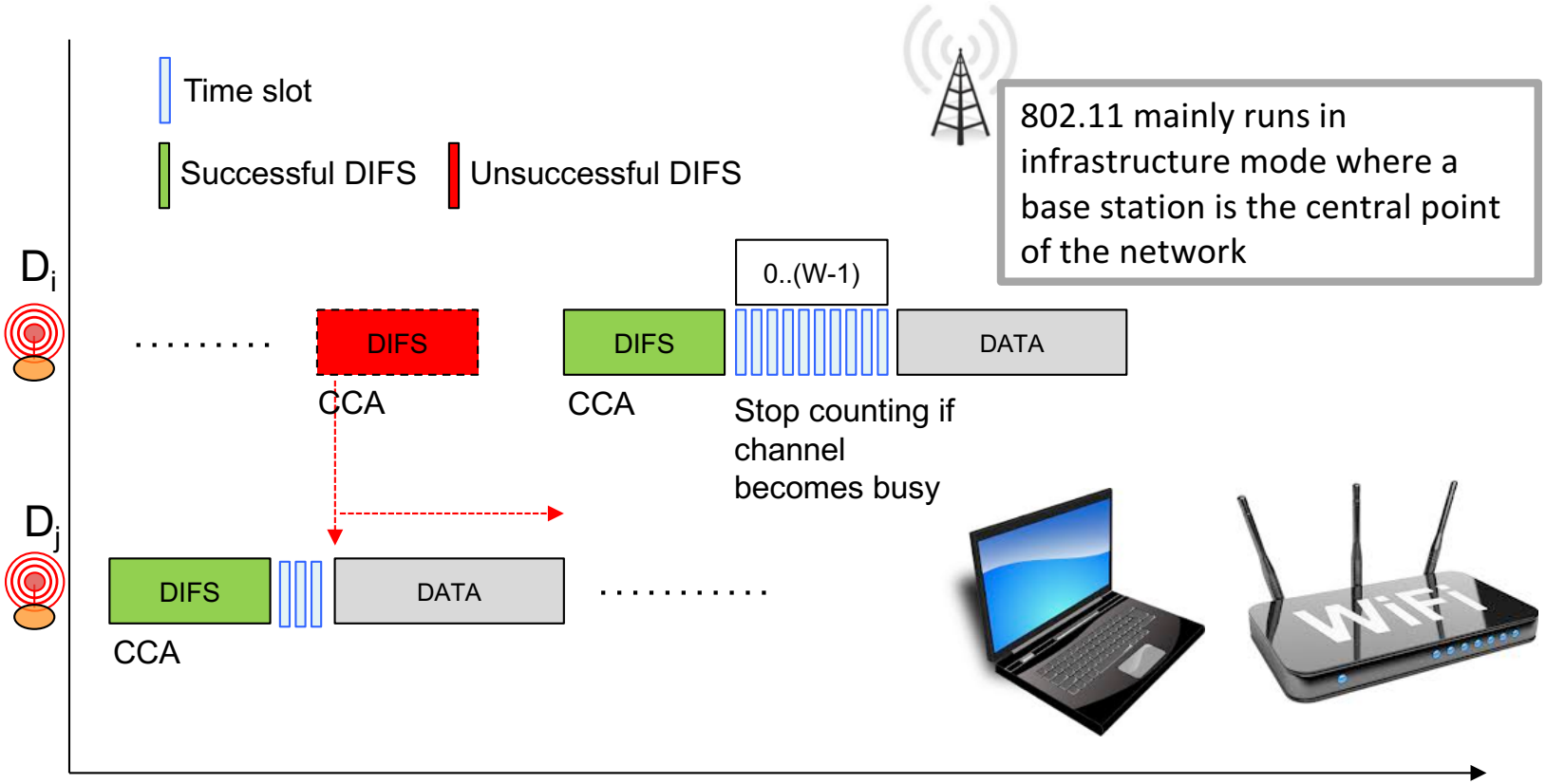
- Considering a given frequency, multiple transmitters on that frequency interfere each other
- Pure ALOHA system
  - Anybody can talk at any time
  - Efficiency is about 18%
- For LoRa, capture effect can help a little





Adding Listen Before Talk

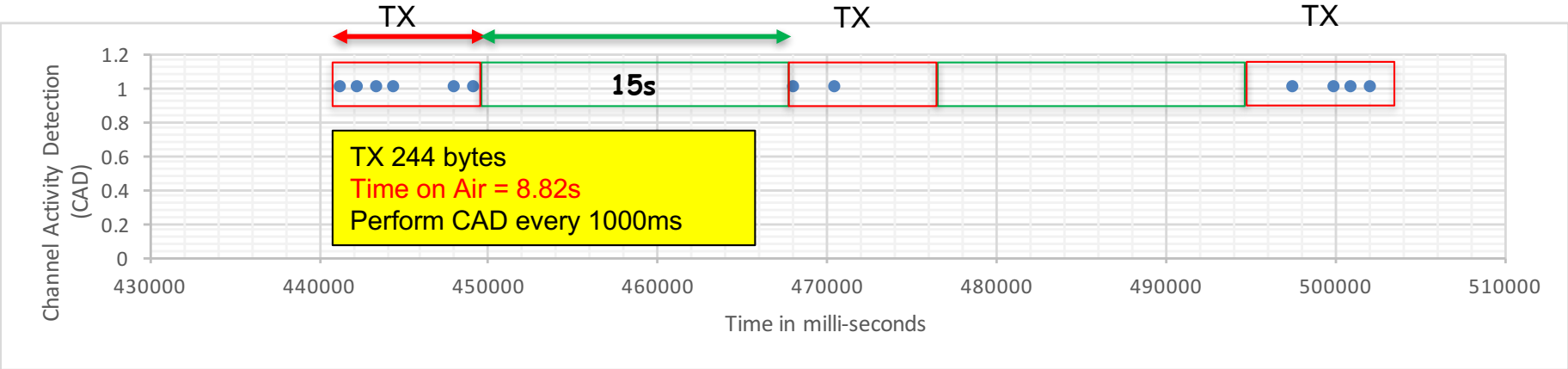
- Ex: Carrier Sense in WiFi
  - DIFS, SIFS
  - Clear Channel Assessment (CCA)
  - Random backoff [0..W[



LoRa's Channel Activity Detection

- CAD reliability decreases as distance increases
  - A CAD returning false does not mean that there is no activity!
- However, during a long transmission (i.e. several seconds) there is usually at least one CAD returning true

But ad-hoc mechanism is needed



Conclusions

- Low-Power Wide Area Networks (LPWAN) have created great opportunities for connecting IoT device
- In dense, urban environment
  - Gateway must be on high location!
  - range is about 6 to 8kms
- Increasing gateway density is the solution
  - determine the appropriate deployment approach: private/public/hybrid
  - how multi-actor roaming can be realized

ADDED SLIDES AFTER PRESENTATION

Coverage test performed by Fabien Ferrero on March 21st and March 22nd

- LoRaWAN gateway on top of DSP building by Fabien, U. Danang and DSP team. Congrats Fabien!