5G mMTC: Challenges and Solutions

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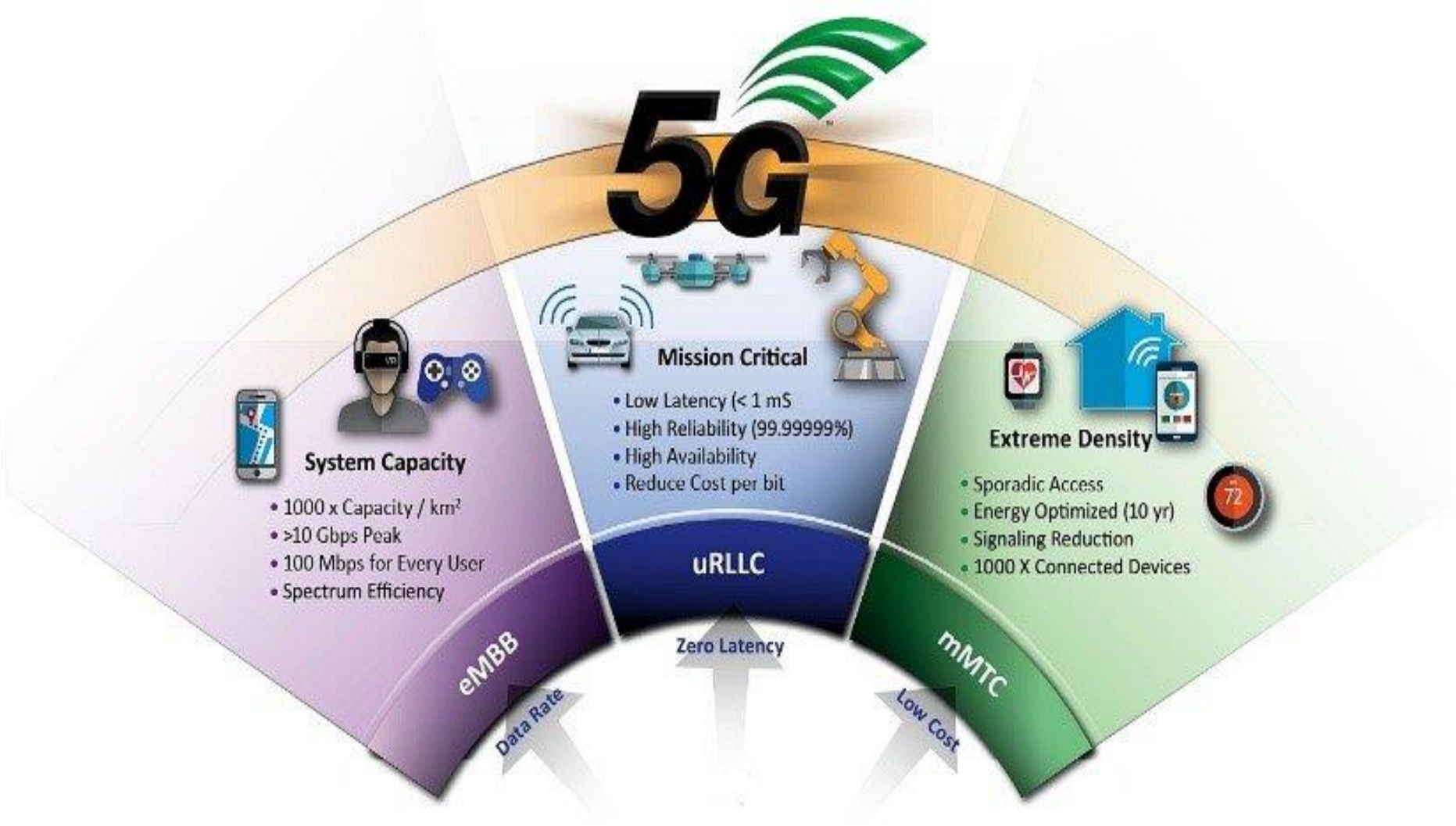
Agenda

- 5G : Features and Services
- Current MTC Technologies & Their Shortcomings
- 5G MTC : Design Considerations & Challenges
- Potential Solutions

5G Features & Services



Source : https://electronics360.globalspec.com

MTC : Machine Type Communication

- Automated data communication among devices without human intervention
- Also referred to as IoT : Internet of Things

Current Non-3GPP MTC Technologies

- Use unlicensed spectrum
- Sparse infrastructure presence
- Use proprietary or open standards
- Early Movers

Current 3GPP MTC Technologies (2G & 4G)

- Use licensed spectrum
- Ubiquitous infrastructure presence of cellular networks
- Standards controlled by 3GPP

NB-IoT

LTE-M

GSM

EC-GSM

Their Shortcomings

Each technology takes care of only some specific use cases

Unable to meet the latency and reliability considerations of next generation use cases

Unable to handle the massive device density being predicted

Not optimized for sporadic & uplink centric transmissions of small packets

5G MTC

- Standardization in 5G Phase 2
- To be included in 3GPP Release 16

5G mMTC

Massive Machine Type Communication

- Scalability to handle billions of devices
- Optimised for small packets, sporadic activity
- Latency agnostic use cases

5G uMTC

Ultra-Reliable Machine Type Communication

- Low latency
- High availability
- Highly Reliable connectivity for mission critical applications

mMTC Characteristics

- Small packets typically of a few bytes
- Up to 300,000 devices in a single cell
- Uplink dominated transmissions
- Low user data rates, around 10 kb/s per user
- Sporadic user activity
- Low device complexity and cost
- Optimal power usage and long battery life

Challenges in front of mMTC

A common framework to handle all possible MTC use cases

Current packet sizes, channel estimation pilots, link adaptation feedback mechanisms unsuitable for MTC

Small packet size related challenges

- Higher radio resource granularity needed
- Current Channel coding schemes inefficient for small packets

Inefficient control signaling: a lot of control signaling happens before data can be sent

Handling of massive number of uncoordinated accesses in uplink

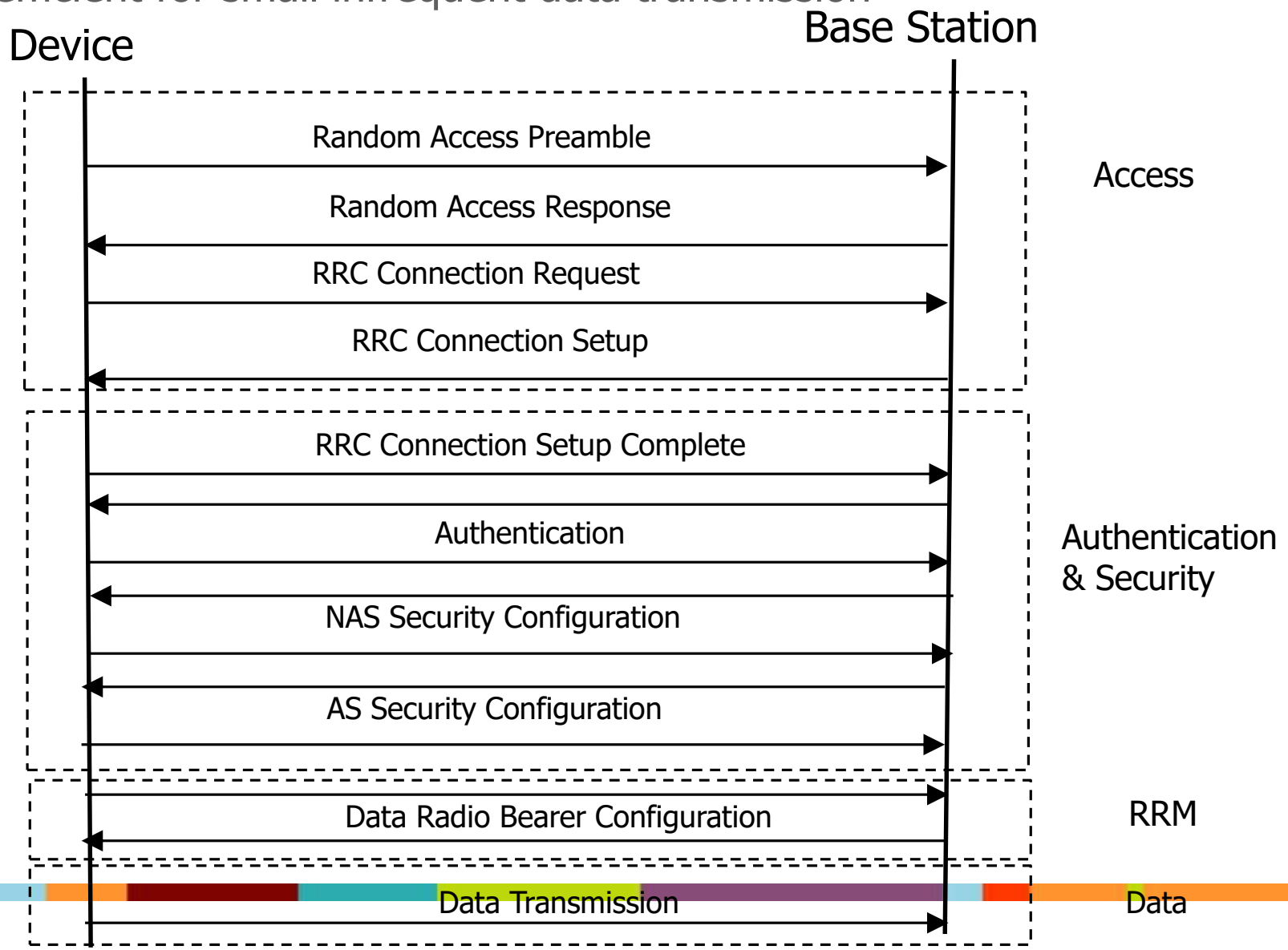
Coverage Enhancement

Control Signaling Optimization

- Integrating Protocol Procedures

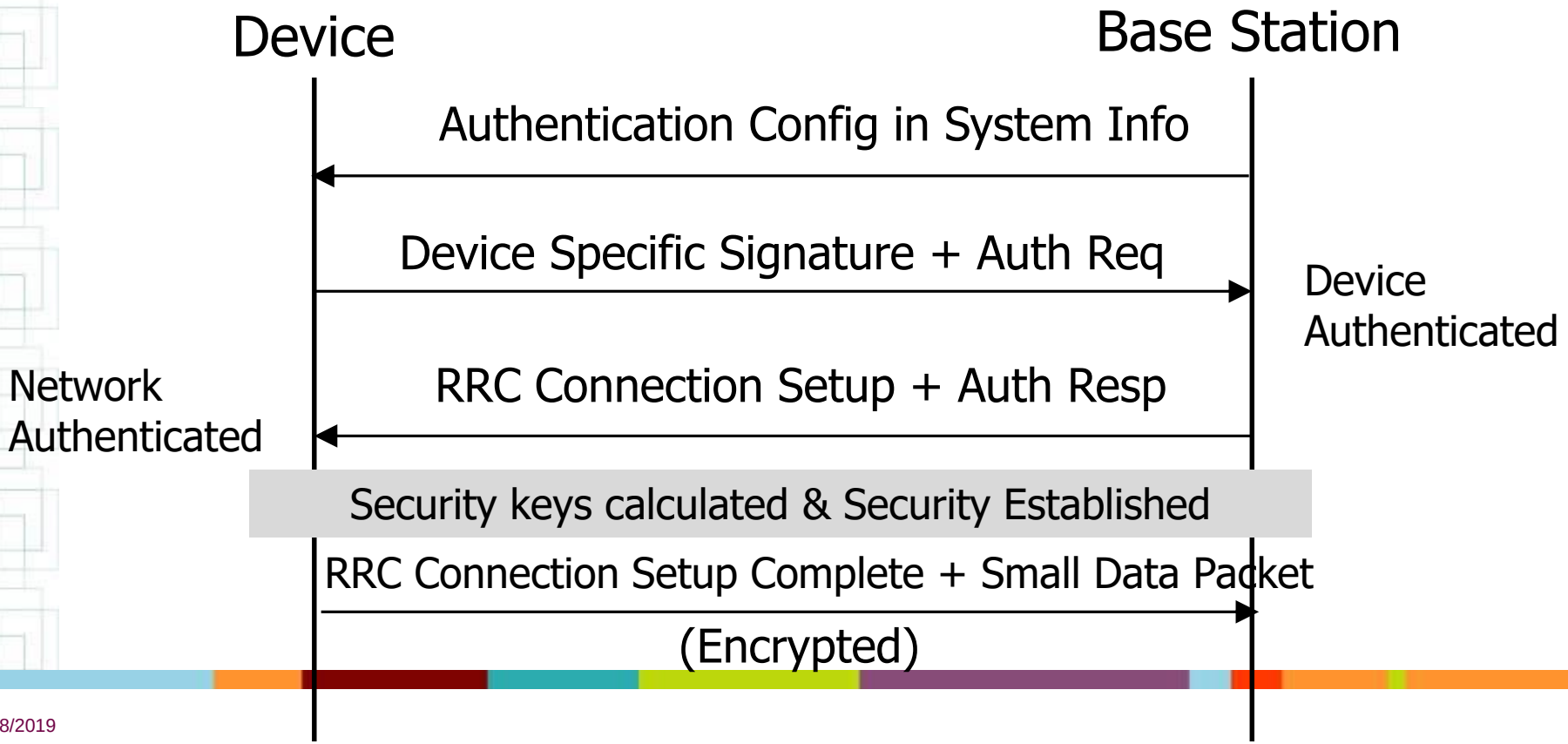
LTE Access and Data Transfer

Inefficient for small infrequent data transmission



Signature Based Initial Access

- Device Authentication integrated with initial access by using unique signatures
- Security and data transfer integrated with Connection Establishment

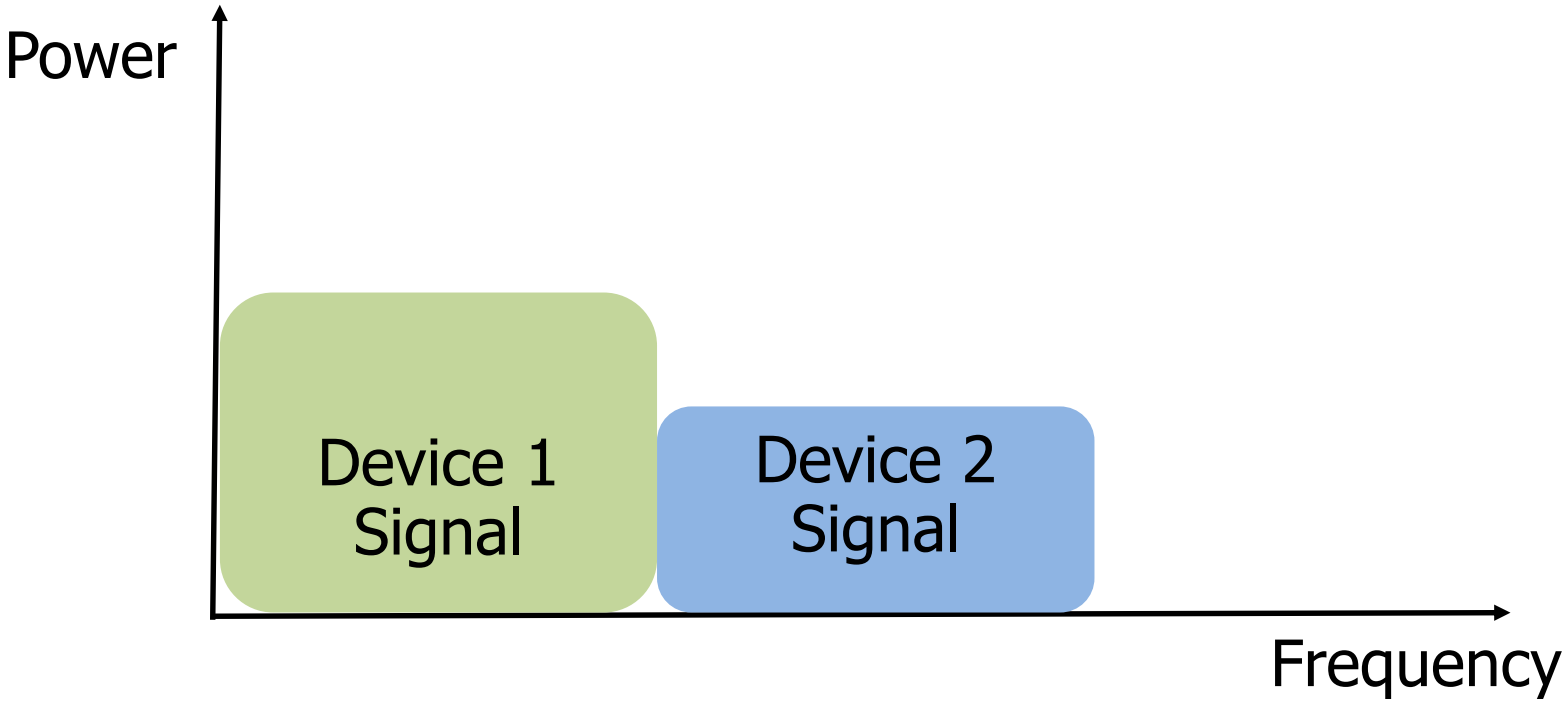


Efficient Initial Access

- Non Orthogonal Multiple Access at Device
- Multi User Detection at Network
- Grant Free One Shot Transmission

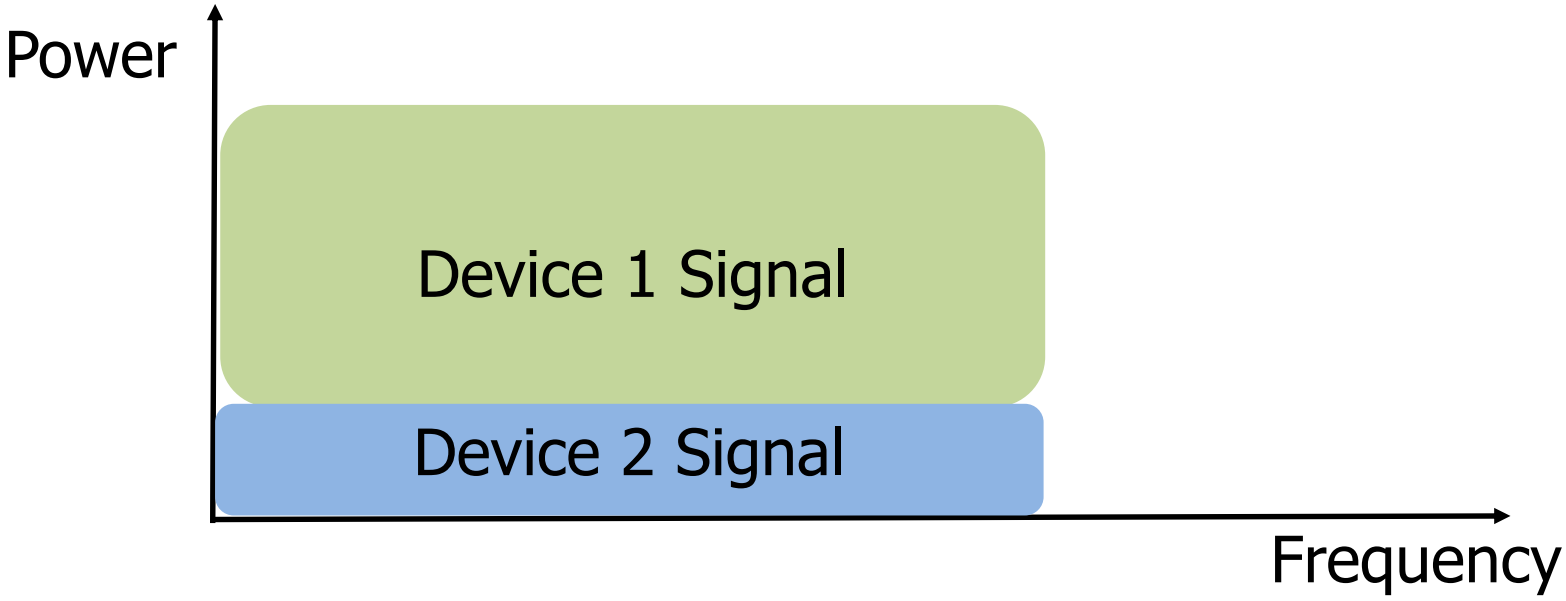
Orthogonal Multiple Access

- Single user on each radio resource
- No inter user collisions / interference
- Low receiver complexity
- Less resource utilization

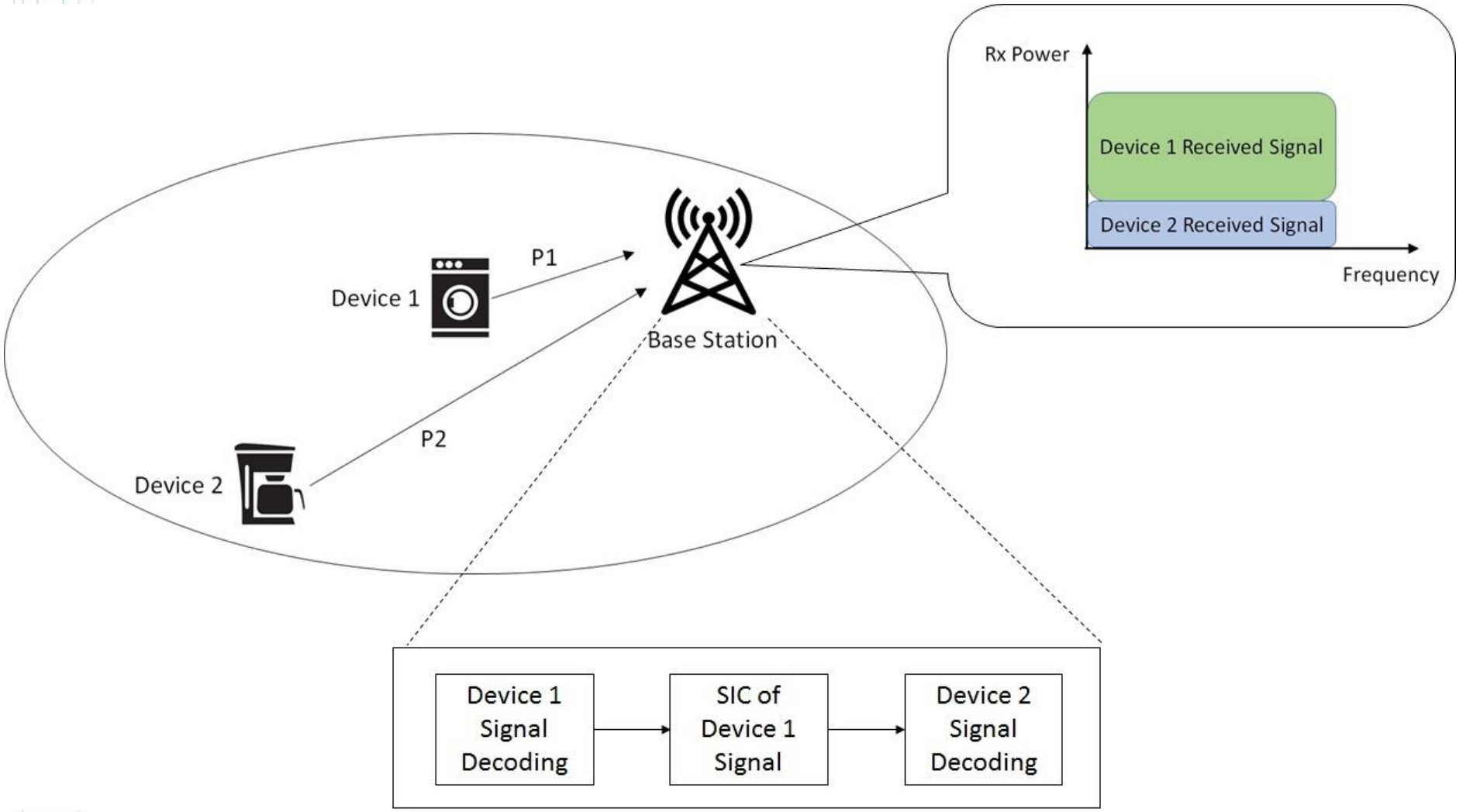


Non-Orthogonal Multiple Access

- Transmitter Side : Multiple users with different channel conditions superimposed on same radio resource by multiplexing in power domain
- Receiver Side : Multi user retrieval from collisions
- More receiver complexity due to successive interference cancellation
- High resource utilization

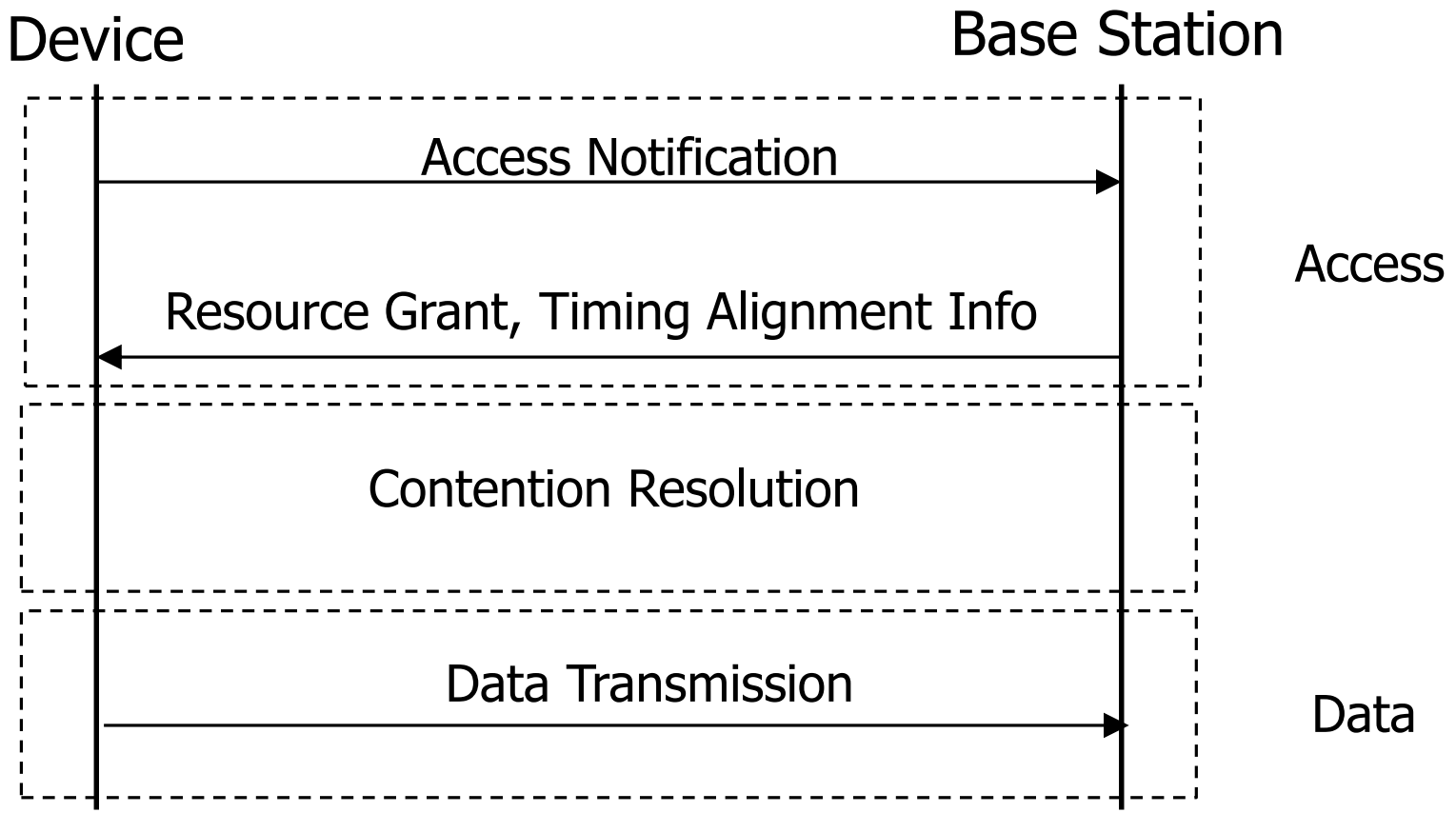


NOMA at Device and SIC at Base Station



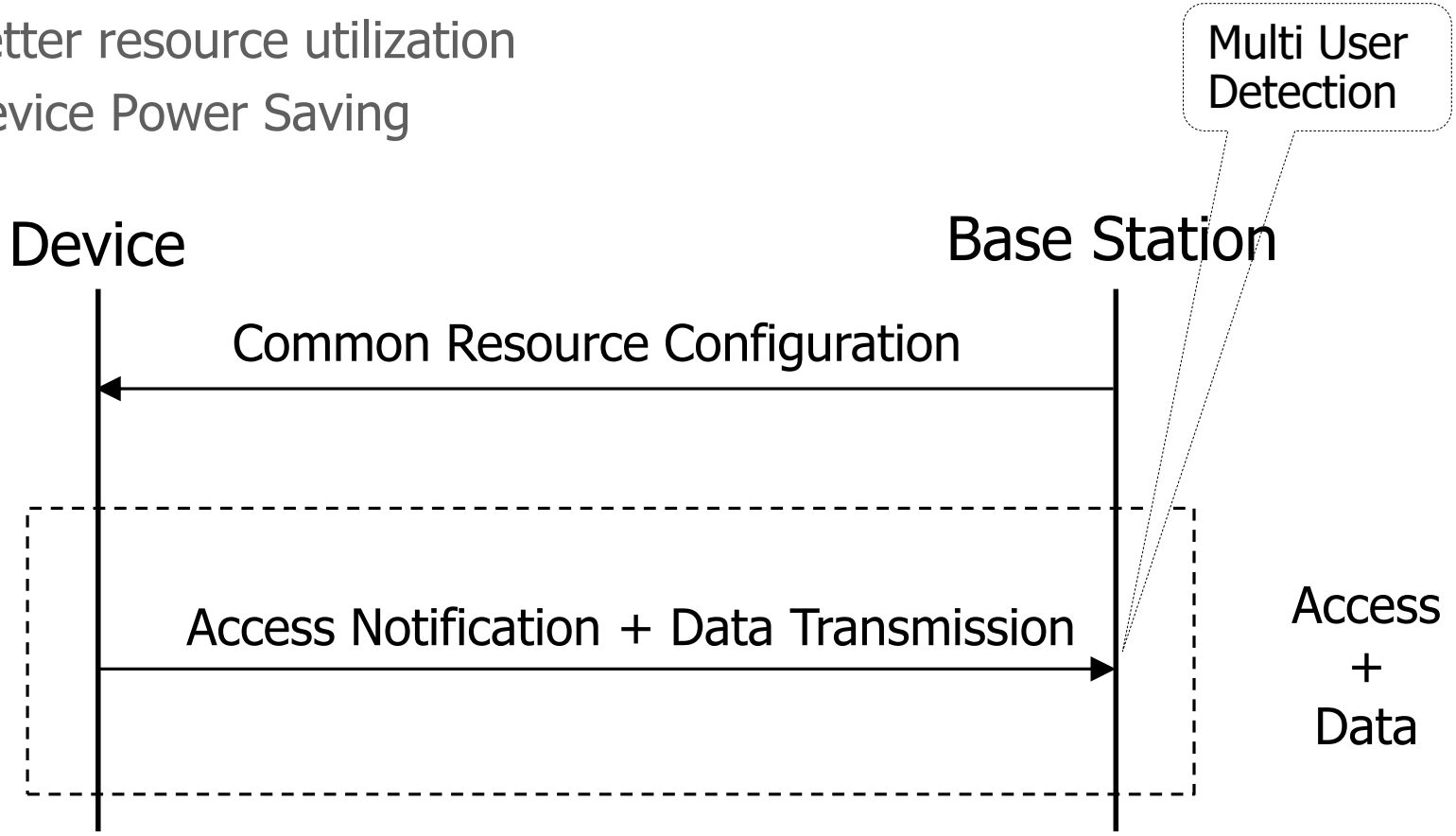
LTE : Multi Stage Access Protocol

Significant overhead for small amount of data leading to latency and device power wastage



One Stage Access Protocol

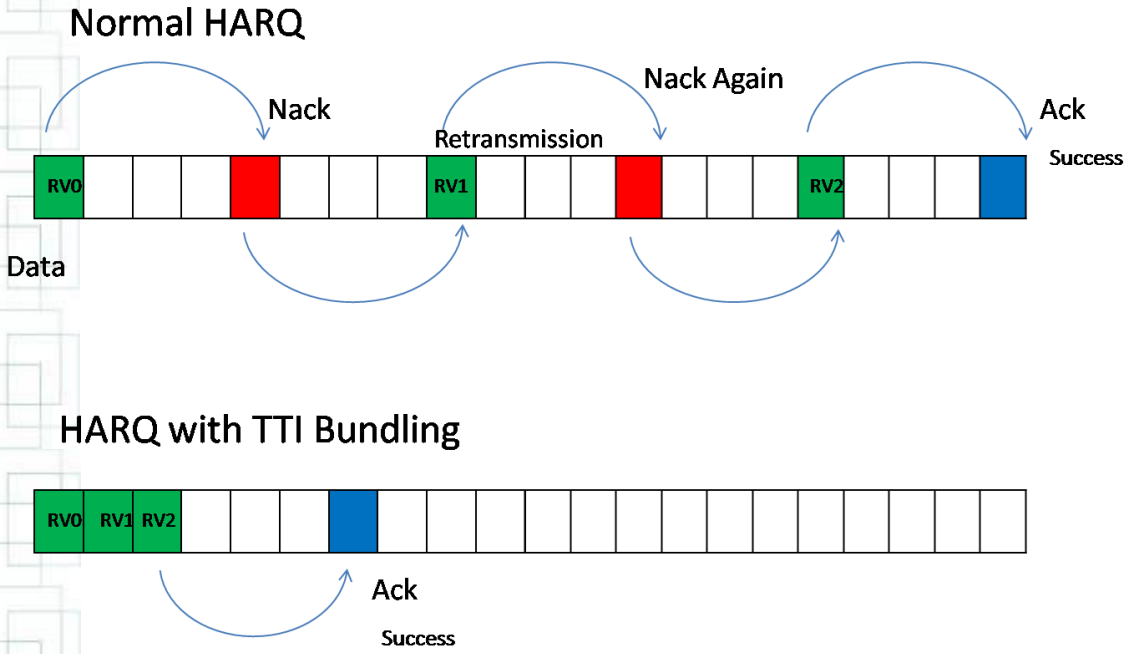
- Grant free scheduling
- Using preconfigured transmission resource, MCS, power
- Low latency
- Better resource utilization
- Device Power Saving



Coverage Enhancement

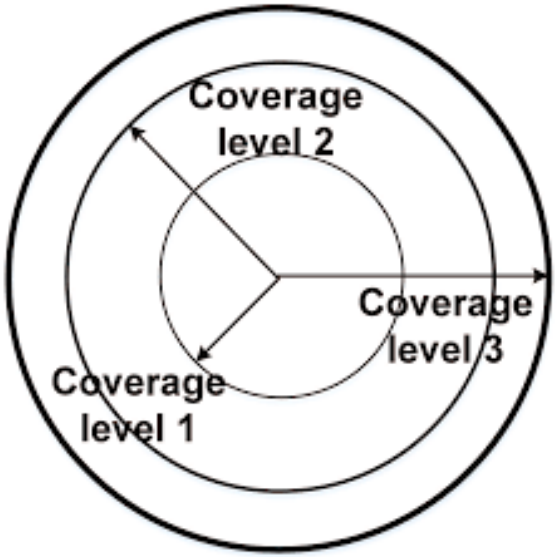
- Smart Repetitive Transmission

Coverage Extension



Repeating each transmission multiple times improves probability of reception

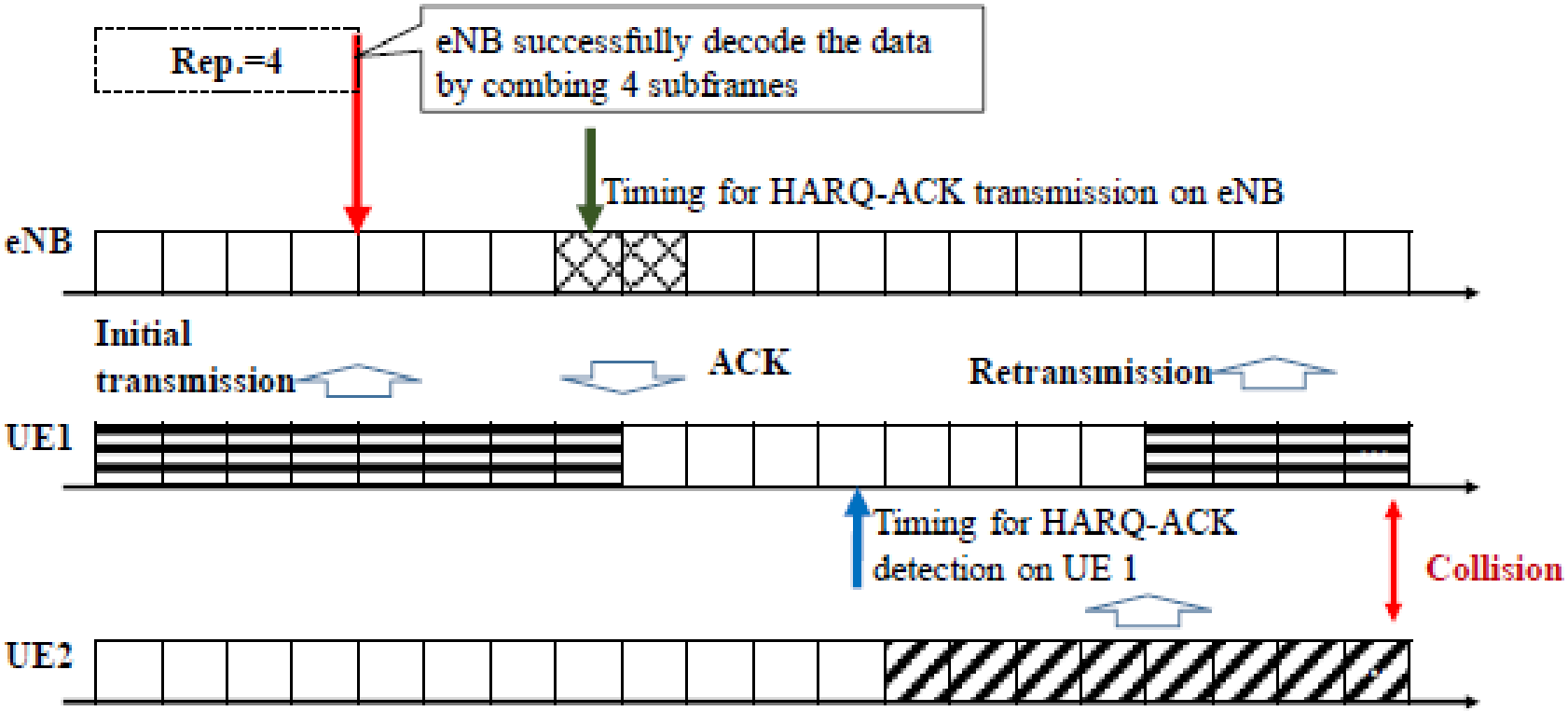
Source: http://www.simpletechpost.com



- CE Levels defined based on the reception quality at the Device location (normal, robust, severe …)
- Number of repetitions of transmissions depend upon CE level

Device Network differ on repetition count

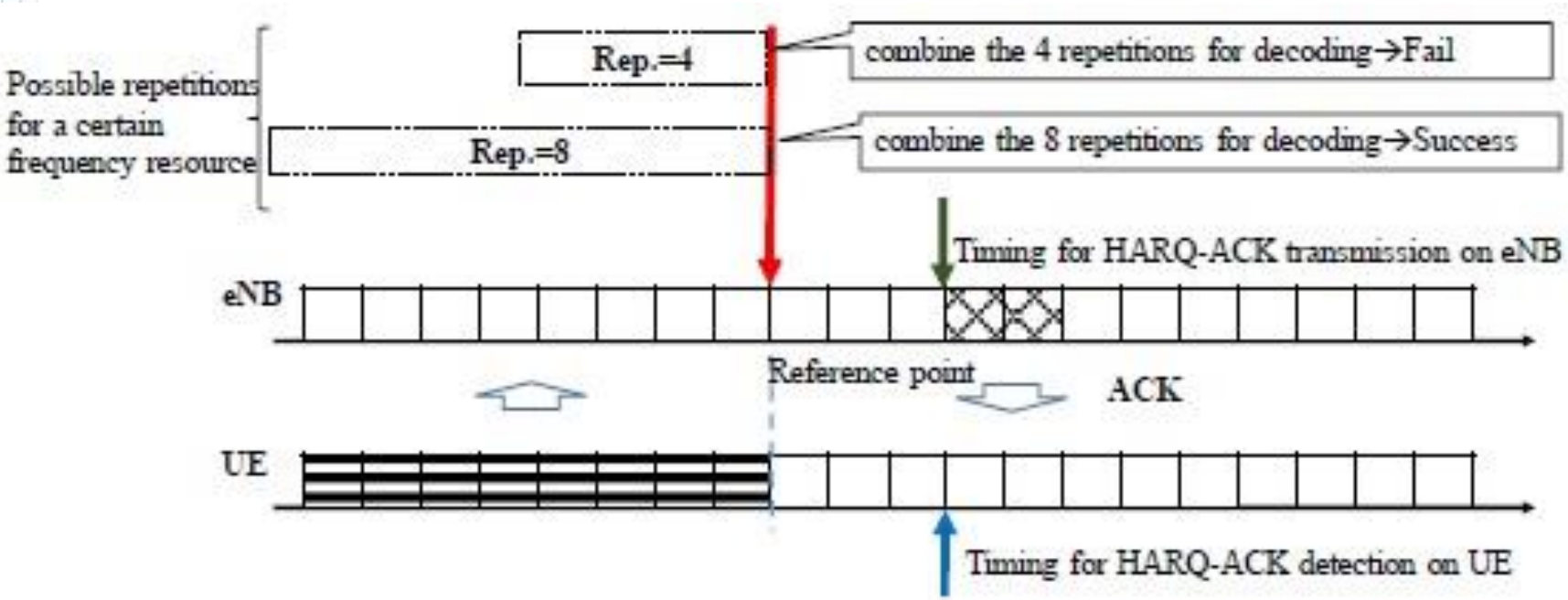
Unnecessary retransmissions causing device battery wastage, radio resource wastage, collision with other users



Source : UL Coverage Enhancement for Massive Machine Type Communication in 5G

Device & Network concur on repetition count

Network made aware of repetition count by scrambling a CE level specific sequence on data



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Thank You !