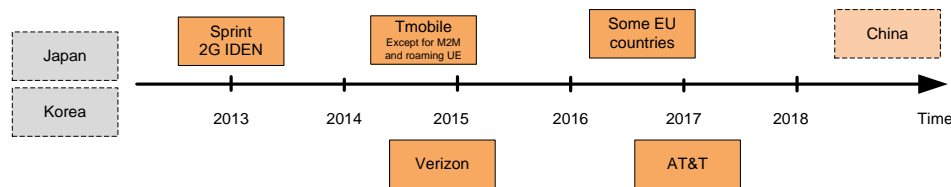


# Motivation for Narrow Band and Power Efficient LTE for MTC

# Motivation

- Why LTE-, not GSM-based MTC?
  - Longer life cycle of LTE network to fit M2M service requirements
  - Global GSM spectrum refarming



- LTE-based MTC can be optimized to meet the cost and coverage demand on GSM-based MTC

## Rel-12 MTC

- A single band modem can achieve BOM cost comparable to that of GSM
  - Single Rx
  - Lower peak rate (1 Mbps)
  - Use of half-duplex FDD to support all LTE fragmented spectrum

## Rel-13 Targets/requirements

- Further cost reduction to reach GSM comparable BOM with only narrow band UE (1.4MHz for both RF and BB)
- 15-20dB coverage enhancement (deferred scope from Rel-12)
- Power consumption improvement

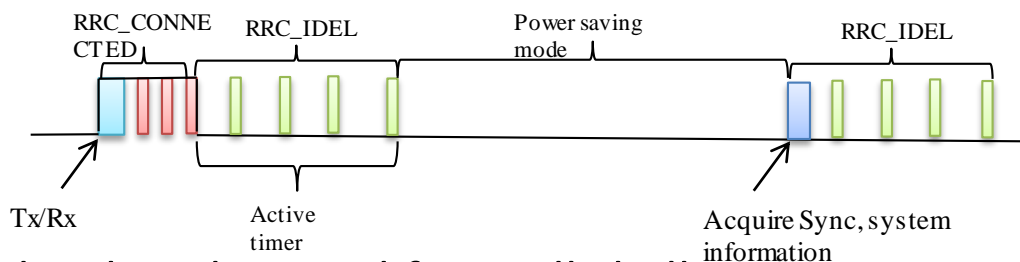
# Competing Technologies

- It is critical for LTE to offer competitive solution to stimulate cellular IoT/M2M market for telecom operators

	Technology #1	Technology #2	Technology #3	GSM/GPRS
<b>Data rate</b>	10b/s and 1kb/s typical range	UL 62.5 bits/s DL 500 bits/s,	(High)500 kbps - 16 Mbps (Low)2.5 kbps - 500 kbps	35kbps
<b>Coverage</b>	30-50Km rural 3-10Km urban areas	2 to 6 km in urban areas and up to 20 km in rural areas	5Km or more	3km (city) 30km (country)
<b>Spectrum</b>	Unlicensed band Up to 2.6GHz Current: 169MHz and 868 MHz	UHF ISM Band:868-MHz (Europe) and 902- to 928-MHz (U.S.) unlicensed bands	TV white space(400-800MHz) or licensed band (900MHz)	900, 1800 MHz
<b>Battery life time</b>	20 years (with 2.5Ah battery)		10 years	~0.2 year
<b>Device cost</b>	<\$1 modem cost		\$1-2 chip, less than \$5 for module	\$2-5
<b>Target applications</b>	Alarm, telemetry, control, sensing, tracking	Street Lighting Control	Alarm, telemetry, control, sensing, tracking	Telemetry, metering, control, tracking,
<b>Others</b>	•bi-directional & mono- directional •* Up to 140 messages per object per day * Payload size for each message is 12 bytes	UNB base station need to using 3G/4G to talk with server	Long sleep periods: 15min (listen briefly 100ms)	

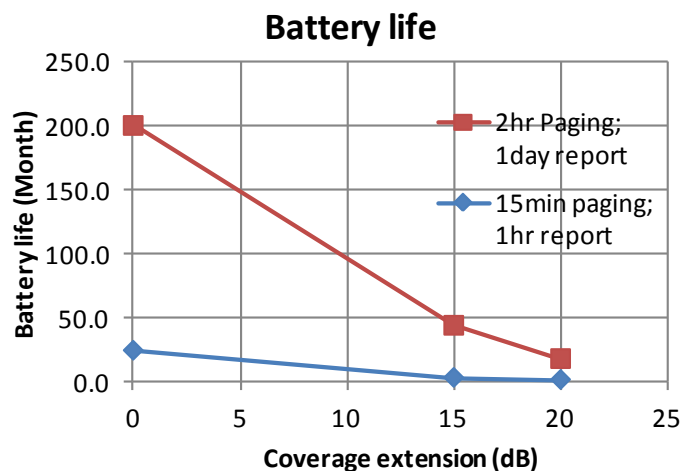
# Target on >10Years Battery Life

- LTE MTC should target on extremely long (e.g. >10 years) battery life time
  - Rel-12 UE power saving mode (PSM) is helpful but not sufficient



- Support of ultra long battery life is still challenging
  - Especially when supporting coverage extension

5w-h battery; 100-bit UL package

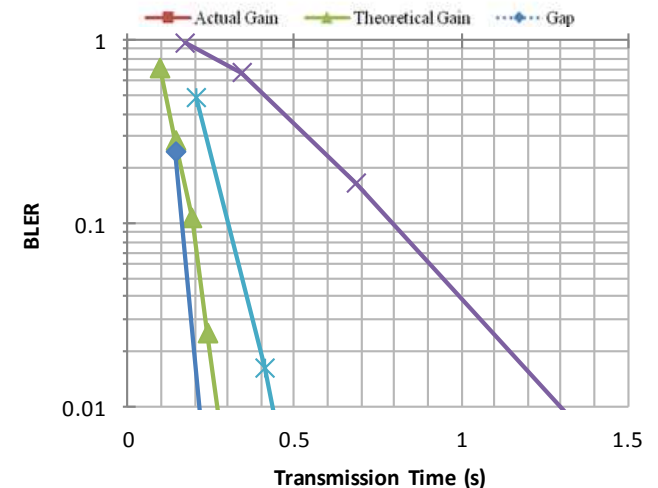
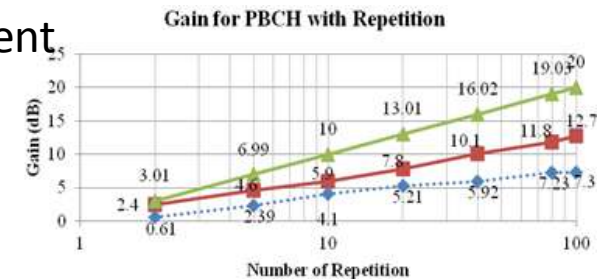


Coverage	UL data transmission cycle	Paging cycle			
		15min	1hr	2hr	1day
Normal coverage/ 15dB coverage extension/ 20dB coverage extension (Year)	1hr	2.09/ 0.33/ 0.19	6.48/ 0.45/ 0.26	-	-
	1day	2.32/ 0.66/ 0.33	7.66/ 1.83/ 0.62	16.72/ 3.72/ 1.55	156.25/ 10.73/ 6.24
	1week	2.32/ 0.77/ 0.33	7.7/ 2.06/ 0.65	16.96/ 4.83/ 1.78	180.41/ 33.02/ 12.98
	none	2.33/ 0.78/ 0.33	7.7/ 2.08/ 0.66	17/ 5.11/ 1.83	185.18/ 50.49/ 16.56

# More Efficient Coverage Extension

- Rel-12 UL repetition solution is very inefficient
  - e.g.  $\sim 70/\sim 1000$  times repetition are required to achieve 10/20dB gain for 160 bits payload
    - Combining gain may become diminishing when working SINR become very low (e.g. due to time variant channel, worse channel estimation, noise dominant...)
- PSD boosting by UL bandwidth reduction is more efficient
  - Concentrate UL power to avoid inefficient repetition

	UE1	UE2	UE3	UE4
Target MCL	160 dB			
Total bit number	136 bit +24 bit CRC			
Resource per block	15kHz x 12 subc x 12 symbol	15kHz x 1 subc x 144 symbol	3.75kHz x 1 subc x 144 symbol	1.25kHz x 1 subc x 144 symbol
UL Rx SINR	-20.55dB	-9.76dB	-3.47dB	0.99dB
#of repetition	934	30	4	2
Transmission time (s)	0.8	0.3	0.2	0.16
Effective data rate (bps)	200	533.3	800	1000
Effective Spectral Efficiency (Bit/s/Hz)	0.001	0.035	0.213	0.8
Supportable UE number per 180kHz x 1 second	1	36	240	864



180kHz SNR=-20.55dB      15kHz SNR=-9.76dB  
 3.75kHz SNR=-3.47dB      1.25kHz SNR=0.992dB

# Further Cost Saving by Rel-13 LTE MTC

- Target on comparable cost as GSM/EDGE MTC module
  - 1 Rx
  - Reduced UE RF bandwidth of 1.4 MHz in downlink and uplink
  - Reduced maximum transmit power of [20 dBm] with the state-of-the-art on-chip PA technologies
  - Half duplex FDD and TDD support
  - Further reduced transport block size for unicast and/or broadcast signalling

	Rel-8 Cat -1 UE	Rel-12 MTC	Rel-13 MTC
UE RF Bandwidth	20MHz	20MHz	1.4MHz
UE receive RF chain	2	1	1
Peak rate (DL/UL)	10Mbps/5Mbps	1Mbps/1Mbps	[100kbps]
Duplex mode	Full duplex	Half duplex(opt)	Half duplex
Maximum UE transmit power	23dBm	23dBm	[20dBm] (on-chip PA)
Cost saving	100%	50%	~20%