

Mobile and Wide-Area IoT: LPWA and LTE connectivity

Technical and Economic Analysis: Matching each application with the best standards

Abstract

Low-power wide-area (LPWA) technologies promise to open new market opportunities by providing power-optimized IoT connectivity instead of data-optimized connectivity that's the hallmark of existing mobile wireless protocols or short-range technologies. Consequently, LPWA received much attention in recent months from the investor community, and with it important questions have been raised on which wireless technology and ecosystem is best positioned to win in this market.

This report takes a comprehensive approach of investigating the spectrum regulatory framework, the wireless protocols, the ecosystems and business models and the IoT applications to develop a complete strategic assessment of the market. We developed techno-economic models for LPWA and LTE-based technologies to couple performance metrics such as coverage and capacity with the Total Cost of Ownership for SigFox, LoRa, Weightless, RPMA, and other LPWA technologies in addition to emerging LTE-based technologies such as Cat-m1 and NB-IoT. Additionally, we show how these technologies and incumbent short-range wireless solutions such as ZigBee, ISA100.11a and WirelessHART match up with more than 80 different IoT applications.

January 2016

Frank Rayal

Published in collaboration with
Mobile Experts LLC



MOBILE EXPERTS

X O N Δ
P A R T N E R S

Table of Contents

List of Figures.....	4
List of Tables	5
Executive Summary	6
The Spectrum Landscape	12
Licensed-Exempt Spectrum for IoT connectivity	12
Regulatory Framework for License-Exempt Spectrum.....	12
FCC Regulations.....	13
European Union Regulations (CEPT/ETSI)	13
TV Whitespaces (TVWS).....	14
Licensed Spectrum.....	14
Key Takeaways Based on Spectrum Regulatory Framework	15
Wide-Area IoT Connectivity Technologies	17
Low-Power Wide Area Technologies	18
SigFox	19
Technology Characteristics and Applications	21
LoRa	21
Technology Characteristics and Applications	23
Weightless SIG	24
Weightless-P	24
Weightless-N	25
Weightless-W	26
Telensa UNB	26
Random Phase Multiple Access (RPMA)	27
Qowisio	28
DART	28
LPWA Technologies Summary	30
3GPP IoT Technologies	31
Narrowband IoT.....	33
3GPP IoT Roadmap and Likely Outcomes	35
Short-Range Wide Area Technologies	37
IEEE 802.15.4.....	37
WirelessHART	37
ISA100.11a.....	38
ZigBee	38
IEEE 802.11ah and 802.11af	38
Technology Comparative Analysis	40
Operating Features	40
Range performance	40
Capacity Performance.....	43
Power Consumption	46
Qualitative Assessment	48
Standards and Interoperability	48
Time to Market	49
Speed of Deployment	49

Global Roaming.....	49
Summary Observations.....	50
Techno-Economic Analysis of LPWA vs. LTE.....	52
Device Costs	52
Network Costs.....	55
The Radio Access Network.....	56
The Core Network.....	58
Total Cost of Ownership	59
MNO Strategy for LPWA	59
Impact of Regulatory Framework on TCO	60
Revenue Model and Profitability	60
Additional Observations from the TCO Model.....	61
The Business Model	63
The Network Operator Model.....	63
The Ecosystem Model.....	64
The Vertical Approach.....	65
The Threat of Incumbents	65
Home Automation Applications	65
Smart City Lighting Applications	66
Industrial Automation	68
LPWA Applications and Markets	70
LPWA Early Adopters.....	70
LPWA and 3GPP Mass Market Applications.....	72
Market Penetration and Market Size	79
Acronyms	82
Appendix 1 – Abridged Weightless-P Features List.....	85
Appendix 2 – Link Budget Calculations	86
Appendix 3 – Descriptions of IoT Applications.....	88
Key Forecast Chart: Global LPWA Device Shipments.....	11

List of Figures

Figure 1 Range vs. data rate for IoT connectivity technologies.....	8
Figure 2 IoT connectivity market structure.....	10
Figure 3 Market prognosis and evolution roadmap for LPWA and 3GPP IoT connectivity technologies.....	11
Figure 4 Network topologies for area connectivity.	17
Figure 5 LPWA General network architecture.	19
Figure 6 Macro diversity in SigFox UNB.....	20
Figure 7 SigFox base station.	21
Figure 8 LoRa network architecture.	23
Figure 9 Network infrastructure sharing among several service providers.....	25
Figure 10 Telensa UNB in smart lighting application.	27
Figure 11 LTE roadmap to support machine-type communications.....	32
Figure 12 Roadmap and projected availability of 3GPP IoT technologies.....	36
Figure 13 Normalized effective range (km) for IoT connectivity technologies.....	42
Figure 14 Number of sites required for contiguous indoor coverage in Paris and San Francisco.....	43
Figure 15 Information rate and power consumption performance of wide area connectivity protocols.....	48
Figure 16 Characteristics of wide area IoT connectivity technologies.....	50
Figure 17 Cost structure for IoT connectivity device.	52
Figure 18 Microchip LoRa and AXSEM SigFox modules.	54
Figure 19 IoT Module average selling price in high volume.	54
Figure 20 Reference model for LPWA IoT networks.....	55
Figure 21 Network operator range of service offering.....	55
Figure 22 Overview of LoRaNet end-to-end network.	59
Figure 23 Capex requirements for LPWA radio access networks buildout. (\$ Millions).....	60
Figure 24 Application of 802.15.4 in street lighting deployment.	67
Figure 25 Leveraging the street lighting grid for smart city applications.	68
Figure 26 Global Mobile Devices and Connections by 2G, 3G, and 4G.....	79
Figure 27 Global Forecast of LPWA device shipments	81

List of Tables

Table 1 Relative ranking of LPWA technologies.	8
Table 2 ISM and SRD bands available for LPWAN.	12
Table 3 FCC 915 MHz regulatory requirements covering LPWA.	13
Table 4 ECC regulatory requirements covering LPWA.	13
Table 5 Duty cycle characteristics for SRD requirements.	14
Table 6 Comparative analysis of licensed and licensed-exempt spectrum.	15
Table 7. SigFox duration of transmissions.	20
Table 8 LoRa regional operating parameters.	22
Table 9 Overview of Weightless series of IoT connectivity standards.	24
Table 10 DART device classes and performance capabilities.	29
Table 11 Technical parameters for LPWA technologies.	30
Table 12 Feature list comparison for different UE categories.	33
Table 13 Key parameters of 3GPP narrowband IoT technologies.	34
Table 14 Frequency bands for 3GPP NB-IoT.	35
Table 15 Comparison between LTE Cat-m1 and NB-IoT.	36
Table 16 Comparative analysis of key LPWA and 3GPP technology parameters.	40
Table 17 Network parameters for LPWA and 3GPP IoT technologies.	41
Table 18 Coverage performance of LPWAN and 3GPP IoT systems.	42
Table 19 Theoretical capacity of SigFox UNB channel.	44
Table 20 Capacity of LPWAN networks.	45
Table 21 Comparative analysis between 3GPP and LPWAN.	51
Table 22 LTE modem complexity and projected module costs.	52
Table 23 IoT module cost structure to achieving sub \$5 cost target.	53
Table 24 Capital expenditures for wide-area IoT connectivity networks.	57
Table 25 Data storage requirements in UNB networks.	57
Table 26 Annual operational expenditures for wide-area IoT connectivity networks.	57
Table 27 Annualized capex and opex expenditure amortized per cell site.	59
Table 28 Total cost of ownership for wide-area connectivity networks per cell site.	59
Table 29 SigFox service packages.	61
Table 30 RAN breakeven parameters for urban LPWAN deployments.	61
Table 31 Approach to market and its context.	63
Table 32 Qualifications of prominent LPWA applications.	70
Table 33 LPWA application characteristics and critical parameters.	72
Table 34 LPWA, 3GPP and SRWA technology applicability per market and application.	73
Table 35 Prime IoT Segments for LPWA deployments.	77
Table 36 IoT Segments where LPWA would have least penetration.	77
Table 37 IoT market segments where LPWA will have mixed impact.	78
Table 38 Link budget for LTE-MTC Cat-m1 (3GPP Release 13).	86
Table 39 Link Budget for NB-IoT (3GPP Release 13).	86
Table 40 Link budget for LPWA technologies per FCC regulations.	87
Table 41 Link budget for LPWA technologies per CEPT/ETSI rules.	87