Wireless Connectivity Technologies Selection Guide

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Introduction

Different applications and different use-cases will need different wireless connectivity technologies. Therefore, selecting the right wireless technology is a critical design decision. Based on radio performance requirements and other criteria, this selection guide will point out the differences between the technologies to help selecting the right one.

We will start with a technology overview, and then review each of them looking at advantages, features and some potential limitations which should be considered for a certain application. At the end you will find a table showing radio modules supporting different technologies and applications.

Technologies overview

Radiocrafts offer a range of wireless technologies as summarized in the table below. Some of these are open standards, and some are proprietary protocols. The table below presents some of the main features of each technology.

Technology	Application	Frequency	Topology	Network size	PHY throughput	Battery operation
Wireless M-Bus 433/868 MHz	Smart metering, Industrial sensors, Energy management	Sub-1 GHz	Star	10+	Up to 100 kbps	Very good
Wireless M-Bus 169 MHz / Wize	Long range LPWAN, Smart metering, Smart City, Industrial sensors	VHF 169 MHz	Star	1000+	2.4 to 19.2 kbps	Good
RC232 - proprietary P2P	Industrial sensors, cable replacement	Sub-1 GHz, 2.45 GHz	Peer-to-peer, Broadcast	100+	Up to 250 kbps	Very good
TinyMesh - proprietary mesh	Industrial sensors, Smart metering, Street lighting	Sub-1 GHz, 2.45 GHz	Mesh	100+	Up to 250 kbps	No
RIIoT - IEEE 802.15.4 P2P	Industrial sensors	Sub-1 GHz	Star	100+	Up to 50 kbps	Very good, Ultra low power
RIIM - 6LoWPAN IP mesh	Industrial sensors, Streetlighting, Irrigation control	Sub-1 GHz	Mesh	1000+	Up to 50 kbps	Very good, Ultra low power
KNX	Building Automation	Sub-1 GHz	Star	100+	Up to 32 kbps	Good
ZigBee	Home automation	2.45 GHz	Mesh	100+	Up to 250 kbps	Fair
Sigfox	Long range LPWAN	Sub-1 GHz	Star	1000+	100 to 600 bps	Good
Mioty	Large LPWAN, Smart metering, Smart City	Sub-1 GHz	Star	10 000+	Up to 4.8 kbps	Very good, Ultra low power

Notes to the table:
P2P (peer-to-peer) means any node can talk to any other node in the network.
The network size indicated is not necessarily a maximum, but what is typically used and a practical limit.

Wireless M-Bus (UHF)

Network type
Wireless M-Bus (Metering bus) is a standard (European Norm) that was developed for utility meter data communication especially suitable for battery operated meters. It supports two-way communications in star networks. Optionally, a single hop repeater can be used to extend the range.

Physical layer properties
It is offered in sub-GHz bands 433, 865, 868 and 915 MHz. Data rates are 4.8, 32 and 100 kbps. It is very well suited for battery operation, also providing two-way communication. Achievable range is typically 50 – 100 meters in buildings, and 500 – 1000 meters outdoors.

Application examples
The main applications are utility meter reading (electricity, gas, water, heat) and valve control. But more and more sensors for energy management use this standard due to its simplicity, robustness, and low power. The M-Bus standard also includes an application layer and a range of security elements that are used “on top” of Wireless M-Bus.

Main advantages
Being a standard (EN 13757), devices are interoperable. The protocol is widely used and proven with tens of millions of devices in the field. All leading meter manufacturers support the standard. OMS has made detailed specification for how to use the standard also with frequency bands outside Europe (South America, Middle East, India, Australia, New Zealand), and prescribe device compliance testing for full interoperability.

Limitations
Wireless M-Bus has been developed to transfer fairly small amounts of data (maximum 255-byte packets), and the data rate is limited to less than 100 kbps. Two-way communication is supported but results in high latency as it happens only while listening after transmissions (because of sleeping devices). Therefore, Wireless M-Bus is not suitable for applications requiring real-time high-speed links with high throughput.

Wireless M-Bus / Wize (VHF)

Network type
Wireless M-Bus (Metering bus) at 169 MHz is a fairly new standard (European Norm) that was developed for long range communication with gas and water meters, due to its excellent radio penetration properties. It supports star networks, and two-way communication. The Wize Alliance has made a companion standard with a detailed specification for how to use the protocol and adding new security elements (encryption and authentication).

Physical layer properties
It uses the 169 MHz VHF band with narrowband modulation. Data rates are 2.4, 4.8, 6.4 and 19.2 kbps. It is very well suited for battery operation, despite of 500 mW transmission power, also supporting two-way communication by short reception windows after the transmission. Typical range is 1 - 5 km outdoors, even in urban areas and devices placed in hard-to-reach locations (underground, basements or pits) can be reached. Despite the low data rate, FW download OTA (over-the-air) is possible using broadcast.

Application examples
The main applications are utility meter reading (gas, water), valve control and distribution network monitoring. But more and more Smart City sensors use this standard due to its range and wide coverage, still being low power for battery operation with 15 – 20 years lifetime.

Main advantages
Being a standard (EN 13757), or following the Wize specification, compliant devices are interoperable. VHF frequency, narrowband radio and high transmission power gives very long range and very good penetration enabling communication to hard-to-reach places. Large gas and water meter reading networks are already deployed, in particular in southern Europe (France, Italy, Spain). The protocol is widely used and proven with millions of devices in the field. Wize Alliance has made a detailed specification for how to use the standard, also for non-metering applications.

Limitations
The relatively low frequency requires a fairly large antenna (5 – 20 cm helical antennas is typically used) to be efficient. During the transmission, current consumption is high and must be supported by large batteries (typically AA-cells) and super-capacitors, even if the average power consumption is low and can give 15 – 20 year battery lifetime. The 169 MHz band is only available in Europe as a license free band. It supports quite small amounts of data (255-byte packets), and the data rate is limited to less than 20 kbps. Two-way communication only with very high latency (only after transmission).

RC232

Network type
The RC232 protocol is a Radiocrafts proprietary protocol for peer-to-peer communication and star networks. It is designed as a "cable replacement" with UART interface, for two-way communication. A multi-hop feature can be used to extend the range.

Physical layer properties
The RC232 is a large product family with frequency variants covering "all" license-free bands including 169, 433, 865, 868, 915 and 2450 MHz. Data rates are configurable from 1.2 to 250 kbps, supporting two-way communication. Narrow band modules (12.5 and 25 kHz bandwidth) and high power (500 mW) modules are available. RC232 is very well suited for battery operation, using the sleep mode. Typical range is 50 – 100 meters in buildings, and up to 10 km outdoors (depending on frequency, modulation and output power).

Application examples
The main applications are industrial bus communication, sensor networks, data collection and control (SCADA). Due to their simple integration and use, they are used in a wide range of products in many different applications and are the "working horse" among the Radiocrafts modules.

Main advantages
RC232 is very easy to use, acting as a transparent modem or two-way serial cable replacement with UART interface (RS232, RS485). The modules are configurable for a wide range of data rates and output power levels. Different module variants support most license-free frequency bands throughout the world, both sub-GHz and 2.45 GHz. All modules are pin compatible and can be changed to target different markets.

Limitations
The radio protocol is proprietary preventing interoperation with other equipment on the air. But as the data channel is transparent, any application protocol can be transferred. The protocol does not provide retries or acknowledge, leaving this to the host application protocol. As a cable replacement, note that the radio channel is half-duplex, not supporting full duplex communication.

Tinymesh

Network type
Tinymesh is a proprietary mesh protocol. It is designed for two-way communication with uplink to a gateway by multi-hop routing within the mesh, and downlink using flooding.

Physical layer properties
The Tinymesh modules is a large product family with frequency variants covering “all” license-free bands including 169, 433, 865, 868, 915 and 2450 MHz. Data rates are configurable from 1.2 to 250 kbps, supporting two-way communication. Narrow band modules (12.5 and 25 kHz bandwidth) and high power (500 mW) modules are available. Typical range is 50 – 100 meters in buildings, and up to 10 km outdoors (depending on frequency, modulation and output power).

Application examples
The main applications are meter reading, streetlighting, industrial sensor networks, data collection and control (SCADA). It is also used as a “backbone” in building automation systems. Due to its flexibility it covers a wide range of applications.

Main advantages
It is easy to use and can work with multiple gateways for redundancy. The mesh networking provides alternative communication routes and hence a more robust connection. The modules are configurable for a wide range of data rates and output power levels. Different modules support most license-free frequency bands throughout the world, both sub-GHz and 2.45 GHz. All modules are pin compatible and can be changed to target different markets. The modules have configurable I/O and can be set to automatically read sensors and send data.

Limitations
The radio protocol is proprietary preventing interoperation with other equipment on the air. The mesh protocol will increase the duty-cycle (airtime) and therefore the amount of data to transfer should be limited.

RIIoT

Network type
RIIoT (Radiocrafts Industrial IoT) is a proprietary protocol, utilizing a star network for data collection and control. It is designed for industrial applications with a Linux based gateway and network controller.

Physical layer properties
RIIoT operates at sub-GHz bands (868, 915 MHz) depending on geographical location and is based on industry standard IEEE 802.15.4. The data rate is 50 kbps, or 5 kbps for longer range. Range is typically 50 meters in a building, up to 1 km outdoors. The long range 5 kbps mode gives up to 8 km range.

Application examples
The main applications are industrial sensors and control, building automation, solar plants and similar.

Main advantages
The RIIoT network is a robust industrial solution for data collection and control. The RIIoT radio module provides an API, so that user application software (such as sensor drivers) can run directly on the module, sharing MCU resources and reducing overall hardware cost. It is a very low power module and can run on a coin-cell battery.

Limitations
RIIoT is a proprietary protocol, in general preventing interoperation on air with other systems. The gateway must run a network controller on a Linux platform.

RIIM

Network type
RIIM (Radiocrafts Industrial IP Mesh) is a proprietary protocol but built on industrial standards like IEEE 802.15.4, 6LoWPAN (RFC 4944 and more), RPL (RFC 6550), CoAP (RFC 7252), UDP (RFC 768) and DTLS. It is a mesh protocol, thereby increasing the reliability of the network. The protocol is based on IPv6 and provides seamless interoperation with the internet through a border router. Up to 29 hops are supported, and networks with up to 1000 nodes.

Physical layer properties
RIIM operates at sub-GHz bands (868, 915 MHz) depending on geographical location and is based on industry standard IEEE 802.15.4. The data rate is 50 kbps. Range is typically 50 meters in a building, up to 1 km outdoors using the low RF power variant. A high power (HP) variant is available reaching more than 8 km in LoS link and up to 1 km in an urban city environment. Battery operated mesh routers ("sleepy routers") are possible by the use of a Receiver-based TSCH – Time Synchronized Channel Hopping, supported by RIIM.

Application examples
The main applications are street lighting, agriculture (irrigation control and soil sensors), industrial sensors and control, building automation, solar plants and similar.

Main advantages
RIIM is a mesh-based network taking advantage of the longer range of sub-GHz frequencies, to build robust neighborhood area networks with large coverage. Using 6LoWPAN, the radio network provides an extension to the internet, connecting devices to the cloud. It supports up to 1000 nodes in a single network. The RIIM radio module provides an API, so that user application software (such as sensor drivers) can run directly on the module sharing MCU resources and reducing overall hardware cost. It is a very low power module and can run on a coin-cell battery.

Limitations
RIIM is a proprietary implementation, although based on standard building blocks, in general preventing interoperation on air with other systems. The mesh protocol will increase the duty-cycle (airtime) of the router nodes so the total amount of data that can be transferred is limited for some frequency bands. Due to the long headers of internet protocols, data packet overhead will limit the amount of user data that can be contained in one packet.

KNX

Network type
KNX RF specified by the KNX Association is a standard that was developed as a wireless extension to wired data communication for building automation. It supports star networks, and peer-to-peer with two-way communication. Optionally 6-hop repeaters can be used to extend the range.

Physical layer properties
It is offered on sub-GHz bands 433 and 868 MHz. Data rates are 16 and 32 kbps. It is suitable for battery operation. Typical range is 30 – 50 meters in buildings.

Application examples
The main application is building automation, using the KNX RF as a wireless extension to a wired KNX network, being twisted pair (TP) or powerline communication (PLC). It is typically used for lighting control, roller shutters, HVAC, and sensors and actuators for energy management of buildings.

Main advantages
Being a standard with device certification, devices are interoperable. By using media couplers, a hybrid network of wired and wireless devices can be used together. The KNX Association provides certification and software tools for easy installation.

Limitations
It is made for fairly small amounts of data (255-byte packets), and the data rate is limited to less than 100 kbps. Two-way communication is possible but yields higher battery consumption due to polling receivers. The KNX protocol is mostly limited to building automation applications.

Zigbee

Network type
The Zigbee protocol is now a well-established open standard for mesh networking. It is designed for short-range communication mainly for home and building automation.

Physical layer properties
Zigbee operates at 2.45 GHz being a global solution. The data rate is 250 kbps, using DSSS. Range is typically 10-30 meters in a building.

Application examples
The main applications are home automation such as HVAC and light control, building automation and energy management.

Main advantages
Being a mesh network, Zigbee can provide reliable communication in buildings with walls and obstacles. Using a global license-free band means the same design can be used everywhere, although there are some differences in permitted output power.

Limitations
Zigbee shares the 2.45 GHz band with Wi-Fi and Bluetooth and therefore susceptible to interference. 2.45 GHz have limited range and is attenuated by humidity (for example in concrete walls). Many different profiles and new revisions of the specification means not all Zigbee based devices will interoperate.

Sigfox

Network type
The Sigfox protocol is an open standard (but intellectual property rights (IPR) are owned by the Sigfox company) for LPWAN with base stations forming a star network. It is designed for collection of very small amounts of data, and it do also support two-way communication.

Physical layer properties
Sigfox operates in 868 and 915 MHz bands depending on geographical region. The data rate is limited to 100 and 600 bps, using ultra-narrowband radio. The coverage is typically 5-10 km around a base station. Each uplink data packet is limited to 12 byes, with maximum 144 transmissions per day. The downlink is limited to 8 bytes.

Application examples
The main applications are collection of Smart City sensor data (parking space, air quality, sensor data), agricultural soil and humidity sensors, industrial plants or distribution network and structure monitoring.

Main advantages
Easy to use, and simple deployment by connection to telecom operated base stations. The data are retrieved from a cloud service. No investment in base stations are needed, but there is a subscription fee.

Limitations
The use of Sigfox is limited to areas which are covered by Sigfox base stations, which is still missing in many countries or outside the main cities. The amount of data that can be carried is very limited, restricting it to simple sensor data collection, and also limited to maximum 144 messages per day. The downlink channel can only be used after a transmission and will therefore yield very long latency. There is a subscription fee for every device connected to the Sigfox network.

Mioty

Network type
The Mioty protocol is an open standard (ETSI specification, but IPR owned by Fraunhofer and Diehl) for LPWANs with gateways forming a star network. It is designed for collecting data in networks with a huge number of nodes in massive IoT deployments (1M+ devices), with gateways capable of receiving up to 1.5 million messages per day, in crowded and shared license-free spectrum.

Physical layer properties
Mioty operates on 868 and 915 MHz bands depending on geographical region. The data rate is limited to 2.4 and 10 kbps, using ultra-narrowband radio with telegram splitting (UNB-TS). The coverage is typically 10-20 km around a gateway. Ultra-narrowband radio gives very long range. This is combined with telegram splitting and forward error correction, which means the data is spread in small packets (bursts) over time and frequency. Even if 50% of the small packets are lost, the message can be retrieved by the gateway due to redundancy and heavy signal processing. Using short transmission bursts the technology is battery friendly, and lifetime of more than 20 years is achievable.

Application examples
The main applications are massive IoT for smart meter reading, streetlighting, Smart City sensor data (parking space, air quality, sensor data), asset tracking, infrastructure monitoring and control, agricultural soil and humidity sensors, industrial plants or distribution network infrastructure and structure (buildings, bridges) monitoring.

Main advantages
Using UNB-TS technology (time and frequency diversity) combined with Forward Error Correction, the packet error rate is very low even for dense networks (massive IoT) and interference from other system in a shared radio spectrum like the license-free bands. The robustness and decent communication speed open up for many applications.

Limitations
The technology, even being an ETSI specification, is based on privately held IPR involving license fees. The technology is still new (as of 2020), and there are no public networks available yet, but private gateways can be deployed. The availability of off-the-shelf gateways is still limited to a couple of suppliers.

Modules by technology

Technology	Radio modules
Wireless M-Bus 433/868 MHz	RC11x0/HP-MBUS3 / MSM / MPC1
Wireless M-Bus 169 MHz / Wize	RC1701/HP/VHP-MBUS4 / WIZE / MSM / MPC1
RC232 - proprietary P2P	RC11xx/HP-RC232, RC12xx, RC17xx/HP-RC232, RC2500/HP-RC232
TinyMesh - proprietary mesh	RC11xx/HP-TM, RC12xx, RC17xx/HP-TM, RC2500/HP-TM
RIIoT - IEEE 802.15.4 P2P	RC18x0/HP-SPR / GPR
RIIM - 6LoWPAN IP mesh	RC18x2/HP-IPM
KNX	RC11xx-KNX2
ZigBee	RC24xx/HP/AT/CT-ZNM
Sigfox	RC16xx/HP-SIG / SSM
Mioty	RC1880-MIOTY1 / MIOTY2

Modules by frequency band

Frequency in MHz				
169	**433**	**865/868**	**902-928**	**2450**
MBUS4	MBUS3			
RC232				
TM				
		RIIoT		
		RIIM		
	KNX			
				ZNM
		SIG		
		MIOTY		

Modules by application

Application or use	Module family
Metering	MBUS3, MBUS4, WIZE
LPWAN	MBUS4, SIG, MIOTY
NAN, Mesh	TM, RIIM
Industrial	RC232, RIIoT
HA/BA	KNX, ZNM

Next step, technology evaluation

Radiocrafts offer module solutions, and custom designs for all these technologies. All modules are supported by Development Kits for easy testing, evaluation, prototyping and application development. More information, Data Sheets and User Manuals are available on www.radiocrafts.com

Document Revision History

Document Revision	Changes
1.0	First release

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