

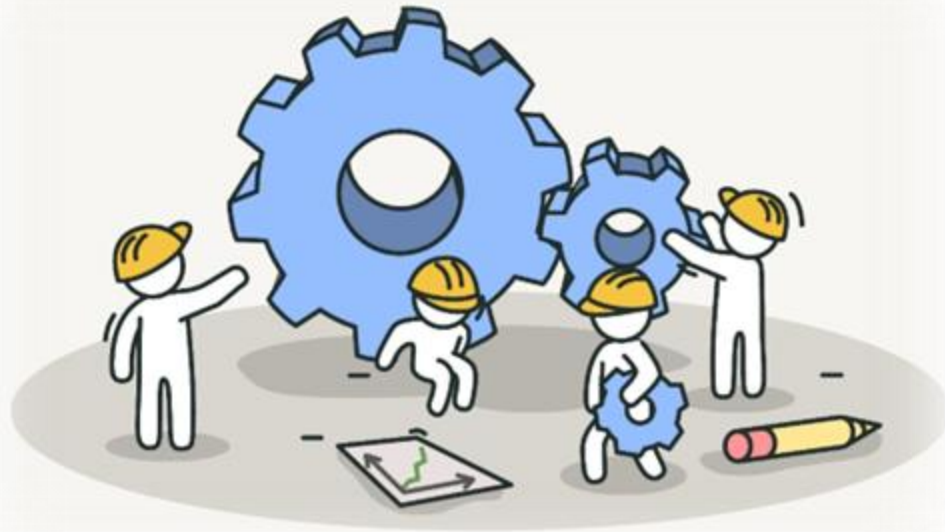
Tech Talk
June 22, 2023

**Explore the latest
connectivity innovations
for IoT sensor applications**

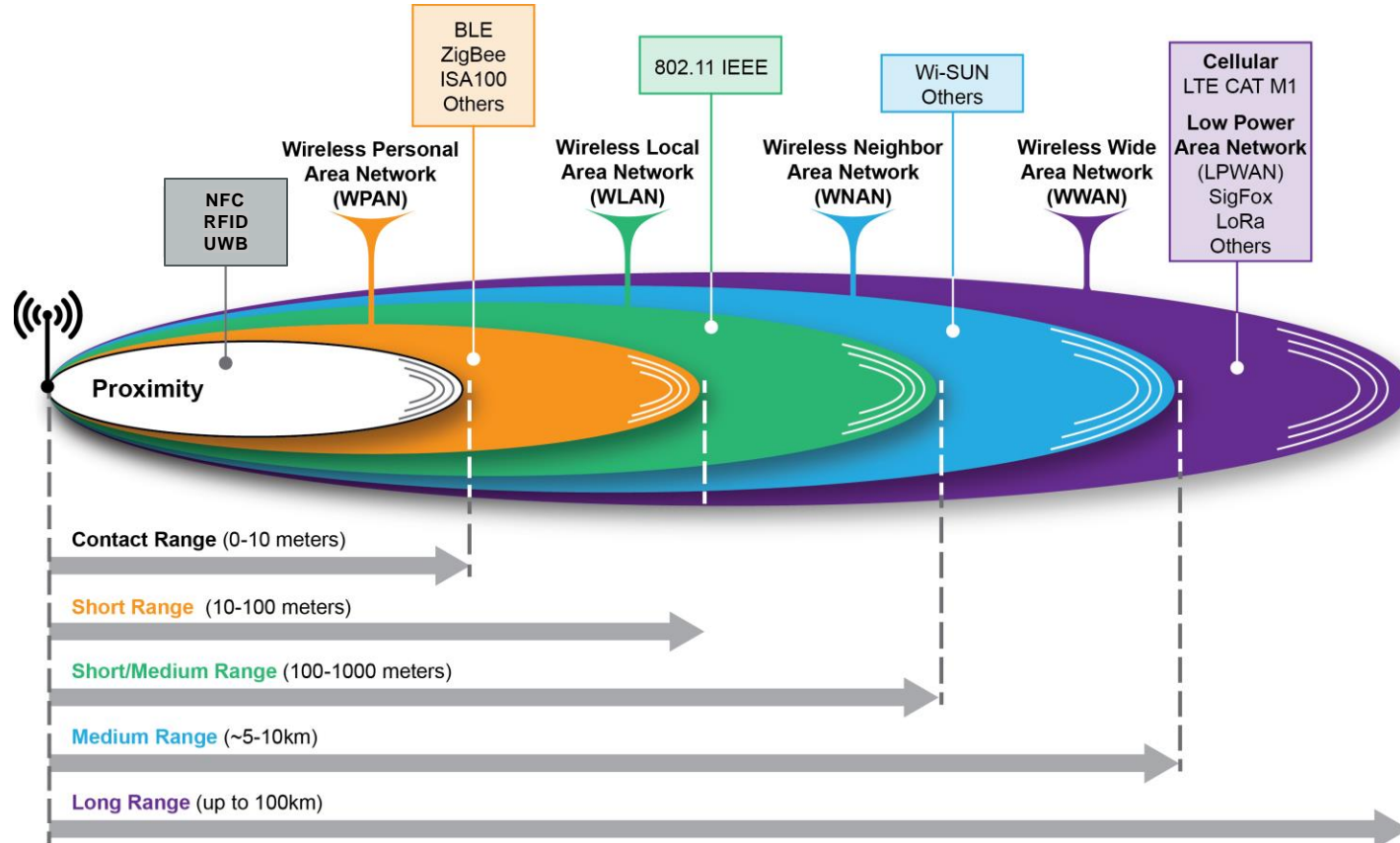
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What are your major challenges when deciding on a Wireless Technology to add to your design?

- Technology
- Regulatory
- Availability
- Cost



Communication Protocol





When it comes to wireless technologies and sensor applications many things should be considered.

- Range & throughput are major considerations. Another important consideration would be regulatory certifications required.
- Which technology will best serve your design needs?
- LTE (Long Term Evolution)
- LoRa (Long Range)
- Wireless LAN (2.4GHz, 5 GHz, 6GHz)
- Bluetooth®
- 802.15.4
- UWB (Ultra Wide Band)
- GNSS (Global Navigation Satellite System)
- Others (NFC/RFID)



- LTE and LoRa have the longest ranges however there through-put is lower but very usable in long distance sensor monitoring that does not require high through-put.
- One example would be to monitor a simple state such as on or off. LTE relies on carrier availability or a private network. LTE may require carrier certifications.
- LoRa can be used with a Network operator, or you can build your own gateway system.

Applications:

Agricultural monitors such as moisture sensing
or animal monitoring

Meter applications (Water, gas, electric)

Wireless LAN (Wi-Fi®)



Wireless LAN has some of the highest through-put.

- **Wi-Fi 7 – 802.11be** (under development)
- **Wi-Fi 6 – 802.11ax** (6E support 6GHz band) hundreds of Mbps to Gbps
- **Wi-Fi 5 – 802.11ac** (2.4GHz and 5GHz) Mbps to low hundreds of Mbps
- **Wi-Fi 4 – 802.11n** (2.4GHz) Mbps to low hundreds of Mbps

Data rates can vary depending on if the device is SISO (single in single out / 1 antenna) and MIMO (multiple in multiple out, 2x2, 3x3....).

Other determining factors to the through-put would be the processor and operating system.

For example, a 2x2 MIMO device connected to an ARM 9 processor over PCIe running Linux would run faster than a SISO device connected the same way.

Matter – using a tri-band radio (Wi-Fi, BT, 802.15.4)



- Bluetooth Classic or Bluetooth Low Energy operate in the 2.4GHz ISM band. With the advances in Bluetooth Low Energy, it can be used for more and more applications and has lower power consumption than Bluetooth Classic.
- Bluetooth Classic has 79, one MHz channels while Bluetooth Low Energy has 40, two MHz channels.
- Bluetooth can be used for multiple applications such as provisioning, mesh networks, positioning [AoA (angle of arrival), AoD (angle of departure), RTLS]. The newer Bluetooth Low Energy can be used for hearing aid applications.

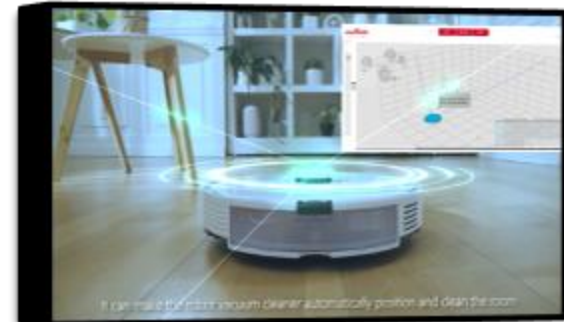
802.15.4



- The 802.15.4 is being included in more combination chipsets. There are many stand alone 802.15.4 enabled devices that are often tied together with gateways and then the data was sent over another network such as Wi-Fi or others.
- The Wi-Fi IC manufacturers are now including 802.15.4 in tri-band radios which include Wi-Fi, Bluetooth® and 802.15.4.



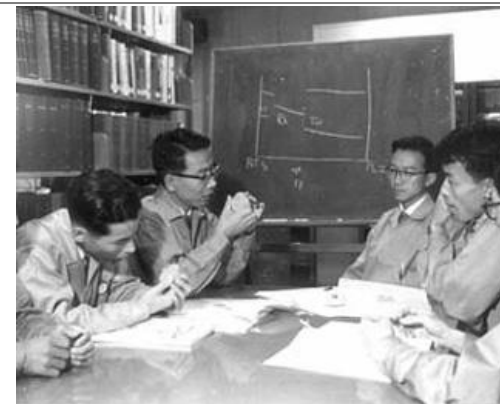
- Ultra-wide (UWB) band has been around for many years and this technology is being used for many applications. With this technology now being included with some smart phones use cases are increasing.
- This technology is being used for tracking and proximity applications.
- For tracking applications, you will need to use UWB anchors for best results.





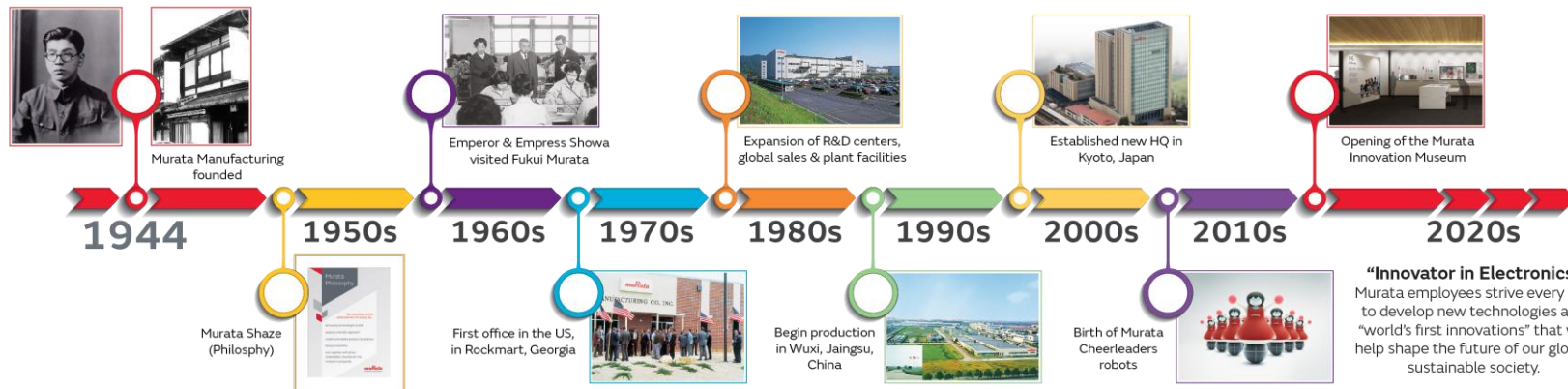
- Global Navigation Satellite System can be combined with other wireless technologies to report location activity.
- Imagine very expensive equipment on a construction jobsite, if you want to make sure the equipment is on the jobsite you may want to track it.

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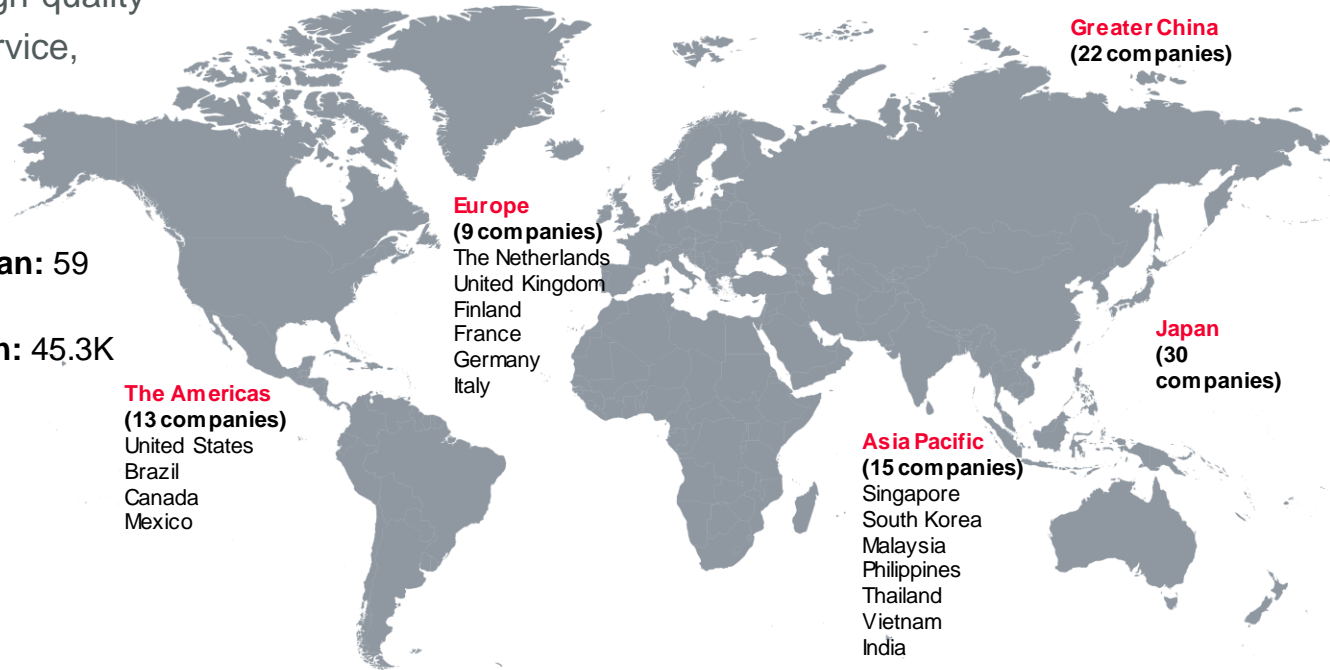
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Murata's strength lies in our expansive footprint that allows us to deliver high-quality solutions, unsurpassed service, and a vast global network.

Subsidiaries outside of Japan: 59
Subsidiaries in Japan: 30
Employees outside of Japan: 45.3K
Employees in Japan: 32.3K

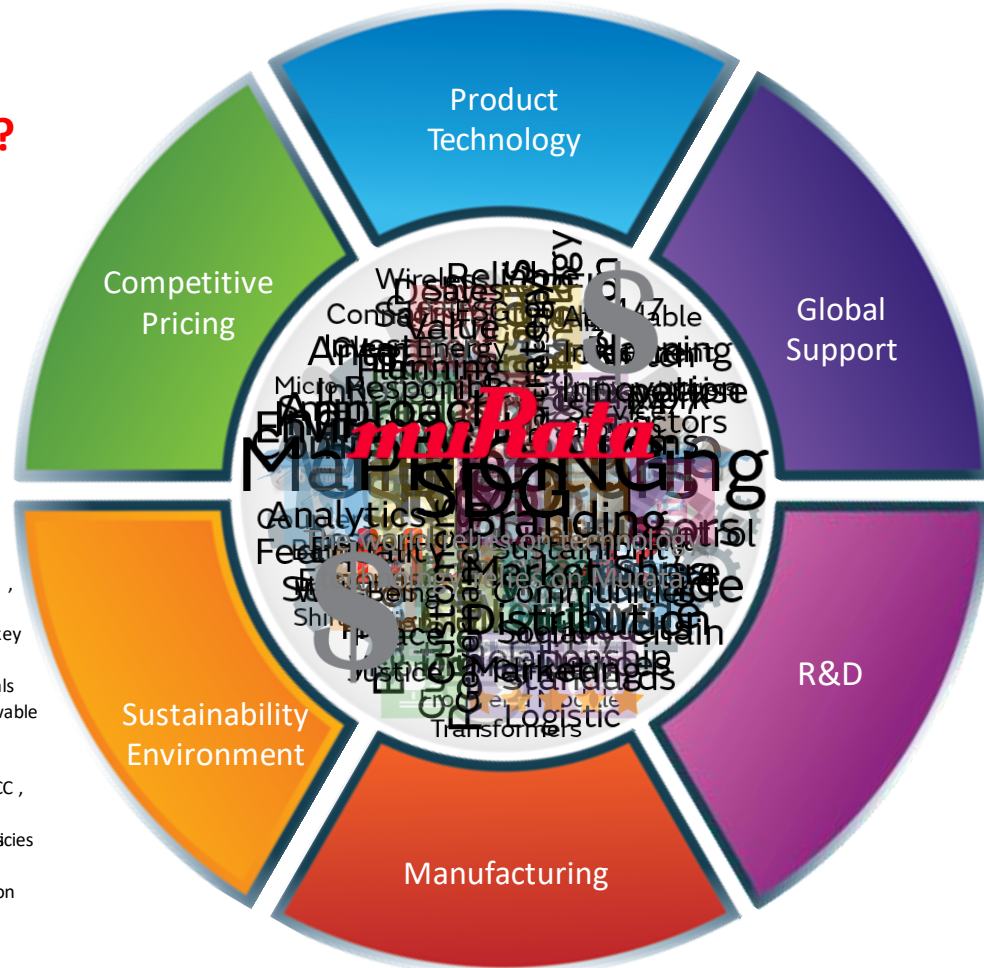


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- Attractive pricing models to support channel sales (distribution) and EMS markets
- High volume pricing models to support Tier 1 customers

- Member of participating fair trade organizations, ISO 14001 and other matrix
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- Global based factories and miniaturization
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- Advanced materials processing capabilities (FSSC , PIRATE, etc.)
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Q & A ?



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