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IQRF® Communication Standard: Reliability for Lossy, Low-Rate Wireless Mesh Networks

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Abstract
Wireless mesh networks are still a topic even over twenty years from the first indication of market success at Gartner Hype Cycles.

Too many trade-offs and limitations exist in latency, hop count limits, determinism, and reliability through all the globally supported wireless mesh networking technologies until today. The reason is simple: technical concepts focused primarily on routing optimization rather than reliability.

Contrary to that approach, the IQRF® has focused on reliable message delivery as the primary value. With 250+ routing hops and reliable message delivery, the IQRF® excels nowadays, especially in street lighting applications, where the long-range should be achieved, and high reliability must be guaranteed.

After two decades on the market, the IQRF® gets standardized, allowing everyone to use and implement all technical achievements and reliable protocols protected by dozens of patents under one royalty-free license.

Key words: iqrf, wireless, mesh, iot, reliability

IQRF® main features and benefits

IQRF® is a complete technology, standard and ecosystem including hardware (transceivers, gateways, repeaters, complete electronic devices, accessories, development tools), software, protocols, support, commissioning tools and services.

Since 2004, MICRORISC and IQRF Tech have developed IQRF®, a reliable, low-power, bidirectional, wireless mesh communication technology. With its IQMESH® protocol, IQRF® enables extremely robust and sophisticated mesh topology. Thousands of wireless systems worldwide are the proof of that.

More than 20 years of continuous research and development for and with customers crystalized in state-of-art communication technology featuring:

- **industrial reliability**

Thanks to the IQMESH® protocol, more network nodes mean higher reliability.

It is deterministic and reliable even in difficult environments.

It delivers robustness and industrial reliability to the wireless IoT.

In the IQRF® network using the IQMESH® routing protocol, the FRC® (Fast Response Commands) protocol can be used, which enables fast data aggregation and confirmation of broadcasts or multicasts.

With 200+ repeating nodes in one network cooperating in a mesh topology you can cover huge facilities, industrial halls, and streets and reliably deliver the message despite bad RF conditions in area.

- **simple integration**

Modular architecture, lightweight yet efficient DPA protocol, hardware and software development tools, plenty of guides, examples, and tutorials along with excellent technical support make development easy.

- **ultimate security**

The complex approach from device association to a network to automatically encrypted communication is based on security standards.

The security services layer is responsible for ensuring the following security objectives: frame integrity, networking frame authenticity, footer and payload confidentiality, replay protection.

- **interoperability and huge ecosystem**

The interoperability of devices from different manufacturers is based on IQRF interoperability standards.

Products certified on IQRF interoperability are listed in the IQRF Alliance marketplace at a website and can be easily used in complex IoT projects.

- **IQRF True Low Power® consumption**

IQRF® is designed to operate efficiently with minimal power consumption, making it suitable for battery-powered devices and applications where energy efficiency is crucial.

Low wireless consumption pushes battery limits to the new boundaries defined only by the battery's self-life.

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A smart combination of different power consumption modes, from transmit mode to deep-sleep mode, makes it possible to achieve really low total power consumption.

For example, a sensor transmitting data every minute can run for more than 20 years on a single AA battery, twice the actual battery life.

IQRF® network with IQMESH® protocol

IQRF® networks are managed and organized[1]. The controlling element for other network devices called Nodes is the Coordinator. Nodes with routing capabilities are called routers. Network communication is always encrypted and authenticated according to the latest security standards.

Association process

Nodes are associated with the network by the Coordinator. During the association, the Coordinator transmits the association data to the Nodes in a secure way through an encrypted message. The IQRF MAC is the unique identifier of the IQRF® device used for authentication. The coordinator securely shares information such as communication keys and network settings and assigns each Node a unique logical address used for addressing.

Topology discovery process

During this process, the Coordinator discovers the topology of routing Nodes (routers) and assigns them a virtual routing number (VRN), a unique number reflecting the distance from the Coordinator in hops and defining the time period for routing a given Node.

Each router knows its position in the network and has its dedicated time slot. TDMA-based directional flooding guarantees deterministic and collision-free routing. The IQMESH® routing protocol ensures that routing works well even in large networks. No vectors or routing tables are stored on routers or passed in communication messages.

Communication using the IQMESH® routing protocol is primarily synchronous. It is initiated by the Coordinator and the Nodes only respond to the request. Timing is strictly deterministic. Each Node of the router type forwards the message in a precisely given time slot corresponding to its VRN. The answer goes back the same way in exactly the opposite order. For a better idea of how sending a message on an IQRF® network using the IQMESH® routing protocol is done, see www.iqrf.org/technology/iqmesh/unicast (Figure 1).

Routing extends the range and enables to deliver data to difficult areas. IQRF® mesh routing protocol is called IQMESH®. It is based on an optimized directional flooding. Its main advantages are higher throughput and much higher robustness which primarily becomes apparent in industrial and other applications where a high reliability is a must.

IQMESH® is implemented above the IQRF OS by the DPA framework layer:

- Up to 240 devices in the network - 1 Coordinator + 239 Nodes
- Up to 240 hops
- Low latency (STD) as well as low power (STD+LP) network types supported
- Routing in real time:
    - Max. 60 ms per hop for STD network, based on the payload
    - Max. 100 ms per hop for LP network, based on the payload
- Payload up to 64 B
- All communication is automatically encrypted by AES-128
- Autonetwork functionality for automated network build-ups

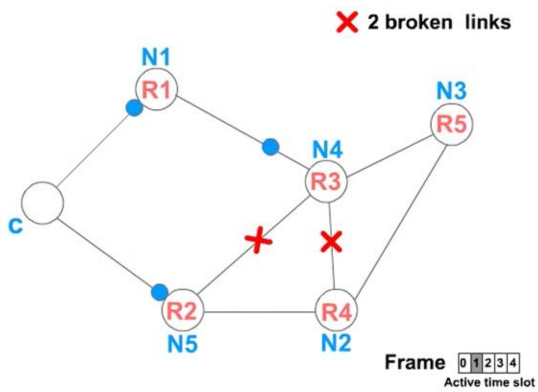

Figure 1 Routing in the IQRF network

FRC® (Fast Response Commands) protocol

The FRC® protocol allows to quickly send a command to multiple Nodes in the network and collect small data from them. It is a significantly faster method than polling individual Nodes one after the other using unicasts.

FRC® in its current implementation allows sending up to 30 B of user data to all or selected Nodes and collecting:

- 2 b from up to z 239 Nodes
- 1 B from up to 63 Nodes

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- 2 B from up to 31 Nodes
- 4 B from up to 15 Nodes

The FRC® protocol has three phases:

1. A request is sent to the network. Once received, all devices are synchronized and ready to execute the desired command.

2. The addressed devices send the requested data to their neighbours.

3. The required data is aggregated step by step and sent back.

The command execution time is strictly deterministic and independent of the topology. Watch the animation of the whole process on https://www.iqrf.org/technology/iqmesh/frc (Figure 2).

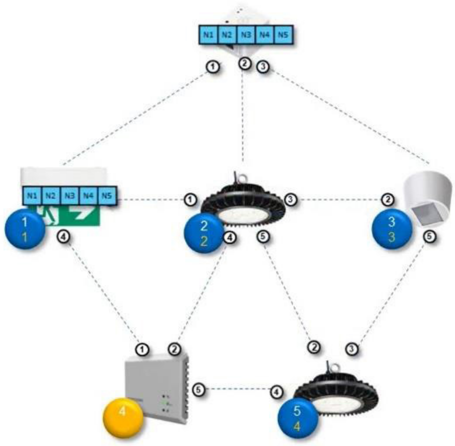

Figure 2 FRC® protocol

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IQRF® interoperability certification

Companies that manufacture products for the IQRF ecosystem join together in the IQRF Alliance[3]. IQRF Alliance tests products for interoperability at the application level.

You can find detailed description of IQRF Standard for sensors and other devices in the section IQRF Interoperability on IQRF Alliance website[3]. When a product manufacturer follows the description of IQRF standard on the communication level, then from the point of view of integrators it does not matter if they communicate with sensors from one manufacturer or another, because they communicate uniformly and get predictable, uniformly structured responses.

The IQRF interoperability certification procedure includes getting HWPID for the certified product, inspecting required documents and the product, checking its compliance with the IQRF interoperability standard, fixing possible issues, and finally, product listing in the IQRF repository and marketplace.

When manufacturers use certified IQRF® transceivers, they don’t need to care about this lower basic part of the IQRF® interoperability.

Otherwise, they need to follow also guidelines for IQRF Communication Standard Specification, which defines IQRF Standards Association[2].

IQRF Standards Association is a non-profit organization responsible for the IQRF Communication Standard Specification, royalty-free licensing of the open IQRF Communication Standard, and the IQRF MAC's management.

The IQRF Communication Standard specifies communication in the IQRF wireless mesh network and enables electronic devices to communicate reliably and securely. Manufacturers can implement the IQRF Communication Standard in their devices under a single royalty-free license. IQRF Standards Association certifies interoperability at the basic communication level. It means manufacturers can implement IQRF® technology directly into the electronics of their products or can manufacture their own IQRF® transceivers. It is a lower-level, basic part of the IQRF interoperability certification.

Conclusion

Today's market is deeply fragmented, there is no globally accepted standard due to many limitations. So, there is a plenty of different wireless technologies available on the market.

They are usually assorted according the range to personal, local, neighbourhood or wide area networks.

Thanks to the routing, IQRF® can reliably communicate from short distances up to few kilometres.

Thus, perfectly addresses many low power applications from monitoring, automation or control.

It perfectly fits to applications from security, through building automation, up to Smart City.

The benefit of IQRF® technology lies in its combination of low-power operation, the ability to operate in a mesh topology with high reliability and range, the interoperability of IQRF® ecosystem products, security features, and ease of integration, making it a versatile solution for a wide range of IoT applications using wireless transmission.

References

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