IQRF Basics

ICSNC 2021, October 03, 2021 to October 07, 2021 - Barcelona, Spain
The Sixteenth International Conference on Systems and Networks Communications
IQRF Technical Support Leader
14 years in MICRORISC s.r.o.

Key projects

FI-IM4/034  Smart platform for wireless communication (2007-2010, MPO/Fl)
FR-TI1/058  Intelligent house-open platform (2009-2012, MPO/FR)
FV-40303  Communication infrastructure for battery powered devices (2018-2021, MPO/FV)
• What is IQRF
• Typical applications
• How to use IQRF
• Development tools
• IQMESH® network
• DPA protocol
• Transceiver modules
• How to start with IQRF
IQRF is complete wireless technology for ISM bands 868 MHz, 916 MHz and 433 MHz.

- Transceiver modules with built-in operating system.
- **MESH** networking (max. 240 hops).
- Functionality depends on user application written in C language or ready-to-use DPA plug-in.
- RF range: tens of meters in buildings, hundreds of meters in open space.
- Extra low power (250 uA LP receiving, < 100 nA TR-76D deep sleep).
- Low data rate (19.836 kb/s).
- Packet oriented communication (max. **64 user bytes** / RF packet).
- No license fees.
IQRF Ecosystem

- Transceiver modules
- Accessories
- HW / SW development tools
- Gateways, repeaters, end devices
- IQRF GW Daemon
- IQRF SDK
- Demo examples
- Support
- IQRF Alliance
- IQRF Repository
Typical Applications

• Control systems
• Sensor networks
• Lighting applications
• Building automation
• Industrial automation
• Telemetry
• IoT

... our solution can be found in real applications
Typical Network Application

IQMESH

- TR module Node
- TR module Node
- DPA plug-in
- IQRF GW Daemon

Gateway

- TR module Coordinator

TCP / IP

- User application
- API
- IQRF IDE
- IQRF Repository

IQRF

Repository

DPA plug-in

Daemon

IQRF GW

Repository
Two layers:
- Operating system
- User application

Two approaches

C programming

DPA plug-ins
Development Kits

CK-USB-04A

DK-EVAL-04A

DDC-IO-01

DDC-RE-01

DDC-SE-01
Development Sets

DS-START-04

DS-DPA-02
IQRF IDE

- Uploader
- Terminal
- Debugger
- IQMESH Network Manager
- CATS Service Tool
- Many other tools
- Free
IQRF IDE – TR Configuration

**TR Configuration**

File: my_config_v4

**OS**

- RF band: 868 MHz
- RF channel A: 30
- RF channel B: 2

**DPA**

- Embedded peripherals:
  - EEPROM
  - EEPROM
  - RAM
  - LEDR
  - UART
  - THERMOMETER
  - LP RX timeout
  - Network type: STD+LP
  - TX power: 7
  - RX filter: 5
  - Alternative DSM channel: 40

- Other:
  - Custom DPA Handler
  - DPA Peer-to-Peer
  - User peer-to-peer
  - Local FRC
  - Setup
  - Autoexec
  - Routing off
  - Stay awake when not bonded
  - UART baud rate: 57600 Bd

**Security**

- LP mode
- Incorrect upload

**Description**

- Dual channel
- Termination by MCU pin
- Termination after ~1 minute

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1. Value from 62 to 67 (868 MHz band) allowed only for TR-7x0.
2. Value from 189 to 255 (916 MHz band) allowed only for TR-7xD with IQRF OS 3.0.0D or above.
3. Value 16 (433 MHz band) allowed only for TR-7xD with IQRF OS 3.0.0D or above.
4. Used at RFPGM only.
5. Read only.
6. Valid only for DPA 3.0.3 or higher.
7. Valid only for DPA 4.10 or higher.
8. Valid only for DPA 4.15 or higher.
9. Valid only for DPA 4.14 or lower.
10. See OS tab notes 1, 2, 3.
11. Used at Coordinator only.
12. Used at Node only.
13. For UART interface. For UART peripheral at DPA 4.11 or higher.
IQRF IDE – TR Configuration

TR Configuration

File: my_config_v4

<table>
<thead>
<tr>
<th>OS</th>
<th>DPA</th>
<th>Security</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Access Password**
- Format: ASCII
- Value: ************
- Password strength: Strong
- 15/16

**User Key**
- Format: ASCII
- Value: 
- 0/15

1 Blank entry leaves the value default. For upload only.

Show passwords

Default  Download  Upload  Close
### Terminal Mode: DPA Test

**Data to send**

<table>
<thead>
<tr>
<th>NADR</th>
<th>PIUM</th>
<th>PCMD</th>
<th>HWPID</th>
<th>PDATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>0001</td>
<td>H</td>
<td>06</td>
<td>H</td>
<td>FFFF</td>
</tr>
</tbody>
</table>

- **Auto Repeat**: 10 x 100ms

**Macros**

- Set LEDR on
- Set LEDG on
- Pulse LEDR
- Set LEDR off
- Set LEDG off
- Pulse LEDG
- LEDR flashing
- LEDG flashing

**Terminal Log**

<table>
<thead>
<tr>
<th>Line</th>
<th>ΔTime</th>
<th>Rx/Tx</th>
<th>Length</th>
<th>Data HEX</th>
<th>DPA Message</th>
<th>Error</th>
<th>NAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>N/A</td>
<td></td>
<td>6</td>
<td>01.00.06.01.FF.FF.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>00:00:00.004</td>
<td>Rx</td>
<td>11</td>
<td>01.00.06.01.FF.FF.27.07.08.07.</td>
<td>DPA Request</td>
<td>0x01</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>00:00:00.735</td>
<td>Rx</td>
<td>8</td>
<td>01.00.06.81.00.00.27.</td>
<td>DPA Response</td>
<td>0x01</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>00:00:03.420</td>
<td>Tx</td>
<td>6</td>
<td>01.00.06.06.FF.FF.</td>
<td>DPA Request</td>
<td>0x01</td>
<td>No</td>
</tr>
</tbody>
</table>
IQRF IDE – Packet Inspector

Mode: DPA, Line: 15, Tx
- NADR: 0x0005 00005 Node
- PNUM: 0x06 006 LEDR
- PCMD: 0x01 001 Set on
- HWPID: 0xFFFF 65535 Any
- PDATA[0]

Data: [6]
- [0] 0x05 005 00000101 NADR Lo
- [1] 0x00 000 00000000 NADR Hi
- [2] 0x06 006 00000110 PNUM
- [3] 0x01 001 00000001 PCMD
- [4] 0xFF 255 11111111 HWPID Lo
- [5] 0xFF 255 11111111 HWPID Hi

Mode: DPA, Line: 17, Rx
- NADR: 0x0005 00005 Node
- PNUM: 0x06 006 LEDR
- PCMD: 0x81 129 Set on
- HWPID: 0x0000 00000 General
- ErrN: 0x00 000 No error
- DPA value: 0x44 068
- PDATA[0]

Data: [8]
- [0] 0x05 005 00000101 NADR Lo
- [1] 0x00 000 00000000 NADR Hi
- [2] 0x06 006 00000110 PNUM
- [3] 0x81 129 10000001 PCMD
- [4] 0x00 000 00000000 HWPID Lo
- [5] 0x00 000 00000000 HWPID Hi
- [6] 0x00 000 00000000 ErrN
- [7] 0x44 D 068 01000100 DPA value
IQRF IDE – IQMESH Network Manager
IQMESH® Features

- **1 Coordinator** and up to **239 Nodes**

- Node type: **STD** or **LP** (specified by the uploaded DPA plug-in)

- Network type: **STD** or **STD + LP** (specified in the TR configuration of the Coordinator)

- Routing: up to **240 hops** (directional flooding and TDMA)

- **Synchronous communication**: request from Coordinator, response from Node

- **Beaming**: special asynchronous mode for sleeping (battery operated) Nodes

- Security: **AES-128**
IQMESH® Protocol - Security

Block checksums

Network encryption shield AES-128

Packet

User’s encryption shield AES-128

CRC-16 IBM
IQMESH® Network Creating

• Uploading the proper files into TRs (DPA plug-in, TR config., Custom DPA Handler)

• Including Nodes to the network (Coordinator) to assign the addresses – Bonding
  (local bonding, Smart Connect, IQUIP, Autonetwork)

• Installation of Nodes (placement)
  o Redundancy is required (every Node should be in range to more neighbours)

• Learning the network routing structure – Discovery
  o Only discovered Nodes can route packets
  o Routing Nodes should not be moved
  o Coordinator assigns VRNs to discovered Nodes

• Network testing and finalization (enumeration, backup)
**FEATURES**
- Directed flooding mesh
- Redundant packet delivery
- No lost packets
- No need of self-healing
- Minimal latency after reset
- Predictable packet delivery time

**PURPOSE**
- Central control from coordinator
  - Sending commands
  - Collecting data

**SECURITY**
- Network key
- AES-128
FRC® - Fast Response Command

Coordinator → All or selected Nodes

30 B for DPA request
+ 239 bit field for optional Node selection

2 bits from all 239 Nodes
or
1 byte from max. 63 Nodes
or
2 bytes from max. 31 Nodes
or
4 bytes from max. 15 Nodes
FRC® - Fast Response Command

**PURPOSE**
Data collection / acknowledged control of multiple nodes

**PHASES**
1. Broadcast FRC Request
2. Send FRC values locally
3. Collect FRC values on the way back

**FEATURES**
- Send up to 30 bytes
- Collect 2b, 1B, 2B or 4B FRC values
- Selective FRC
- Acknowledged broadcast

**SECURITY**
- Network key
- AES-128
Autonetwork

**Autonetwork set up**
- Access Password
- Channel Planning
- STD+LP (default) / STD

**AUTONETWORK**

<table>
<thead>
<tr>
<th>Wave 1</th>
<th>Wave 2</th>
<th>Wave ...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prebonding</td>
<td>Prebonding</td>
<td>Empty wave ➔ Autonetwork finished</td>
</tr>
<tr>
<td>Reading MID</td>
<td>Reading MID</td>
<td></td>
</tr>
<tr>
<td>Authorisation - Assigning Logical Address</td>
<td>Authorisation - Assigning Logical Address</td>
<td></td>
</tr>
<tr>
<td>Nodes verification + Discovery</td>
<td>Nodes verification + Discovery</td>
<td></td>
</tr>
</tbody>
</table>

**ENUMERATION**

HWPID, product, manufacturer, OS, DPA, module, peripherals,...
**FEATURES**

- Minimal power consumption of battery powered sensors
- Beaming of all sensor values
- FRC used for efficient data collection from aggregating repeaters

**PURPOSE**

Efficient data collection from battery operated sensors

**PHASES**

1. Beaming with a given period
2. Send FRC request
3. Collect FRC values on the way back

**SECURITY**

- Network key
- AES-128
DSM – DPA Service Mode

**PURPOSE**
Local (last resort) maintenance of any IQRF module with DPA plug-in from IQRF IDE
- Low level service tool
- Configuration
- (Un)bonding, factory setting, local OTA

**PHASES**
1. Scanning
2. IQRF module reset
3. Connectivity set up – full control

**FEATURES**
- DSM (CATS service tool) available in IQRF IDE
- Special firmware on IQRF module
- Dedicated fixed service channel plus optional configurable one

**SECURITY**
- Access Password
- Only after device reset
DPA Plug-in

DPA (Direct Peripheral Access) plug-in is ready to use application with embedded peripherals and services.

No programming needed

Need to modify?

Custom DPA Handler
DPA plug-in can be controlled by a simple byte-oriented protocol that allows:

- Control peripherals and services of the Coordinator and all Nodes in IQMESH network
- Create and manage IQMESH network
- IQMESH network maintenance
- Over The Air (OTA) upgrade of OS and DPA

**Interfaces:**

- SPI
- UART
## DPA Protocol

<table>
<thead>
<tr>
<th>NADR</th>
<th>PNUM</th>
<th>PCMD</th>
<th>HWPID</th>
<th>PDATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ntw. Device Address</td>
<td>Peripheral Number</td>
<td>Peripheral Command</td>
<td>HW Profile Identification</td>
<td>Optional Data</td>
</tr>
</tbody>
</table>

- **NADR (2B)** – specifies an address of a device in a network
- **PNUM (1B)** – code of specific peripheral
- **PCMD (1B)** – code of specific command of given peripheral
- **HWPID (2B)** – uniquely specifies the type (functionality) of the device
- **PDATA** (up to 56 B) – optional message data
## DPA Protocol

<table>
<thead>
<tr>
<th>NADR</th>
<th>PNUM</th>
<th>PCMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x00</td>
<td>0x00</td>
<td>Coordinator 0x01 Get discovered Nodes 0x02 Get bonded Nodes ...</td>
</tr>
<tr>
<td>0x01</td>
<td>0x03</td>
<td>EEPROM 0x00 Read 0x01 Write ...</td>
</tr>
<tr>
<td>0xFF</td>
<td>0x06</td>
<td>Red LED 0x00 Set off 0x01 Set on ...</td>
</tr>
</tbody>
</table>

---

Node 5: switch red LED on

<table>
<thead>
<tr>
<th>NADR</th>
<th>PNUM</th>
<th>PCMD</th>
<th>HWPID</th>
<th>PDATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x05</td>
<td>0x06</td>
<td>0x01</td>
<td>0xFFFF</td>
<td></td>
</tr>
</tbody>
</table>
DPA - Application Example

Raspberry Pi
+ IQRF GW Daemon
+ KON-RASP-01 shield
+ TR module (Coordinator)
Integration of MESH networking has never been easier!
Transceiver Module

- RF shielding
- Microcontroller with OS
- Temperature sensor
- RF IC
- Antenna pad-hole
- EEPROM
- Antenna connector
- Voltage regulator
TR Module – Antenna Options

- Soldering pad-hole: TR-7xD
- U.F.L connector: TR-7xDC
- Built-in PCB: TR-7xDA
TR Module – Mounting Options

- SIM connector: TR-72Dx
- SMT: TR-76Dx
- Vertical soldering: TR-75Dx
TR Module – Several Types

TR-72Dx

TR-76Dx
TR-76Dx Schematics
How to start?

Hardware
One of IQRF development sets (DS-START-04 or DS-DPA-02)

Software
Free IQRF Startup Package (IQRF IDE, DPA plug-ins, examples, documentation)

Starting Point
www.iqrf.org/how-to-start (video tutorials, recommended reading)
Sources and Support

- www.iqrf.org
- www.iqrfalliance.org
- support@iqrf.org
- sales@iqrf.org
Thank you!