

Your IoT pilot project up and running within couple of days

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Internet of Things is a young but very promising market segment which is catching attention of many companies all around the world. All technicians as well as businessmen want to realize a simple, fast and cost effective Proof of Concept project to evaluate both technical and business aspects of a specific use case. This is not a simple task since IoT is a very complex area with hundreds of elements that must fit one to each other. The goal of the members of the IQRF Alliance is to provide these elements from end devices, through gateway hardware and software up to clouds and mobile apps so building up an IoT project is matter of couple of days. How far we get, what is ready and what are the challenges ahead are the key questions answered in this paper.

Internet of Things, IQRF Technology, IQRF Alliance, IQRF Ecosystem, Wireless Mesh Network, fog/edge computing

I. INTRODUCTION

IoT seems to be, and at the end of the day must be, very simple. For user it should be just a matter of using his smart phone or tablet to monitor, manage and control his home, business, city or any other “thing”. On the other hand if you take a closer look at the IoT ecosystem you realize it's a large puzzle of dozens or rather hundreds of pieces that must fit one to each other.

To build up a well working solution, and do it easily, fast and cost effective, is a big challenge even for a very experienced team. There is no company world-wide which can realize an IoT project from A to Z: manufacturing all components, write all SWs, run own clouds, provide own mobile apps, market the solutions, deploy it, maintain it and support it.



Fig. 1. Internet of Things puzzle

Due to this you need 1) an open community providing 2) an ecosystem of ready elements for building an IoT solution quickly and effectively.

With this challenge in mind and proven wireless mesh technology called IQRF [1] in hands, couple years ago we started to build up the IQRF Alliance [2] so you can find all necessary IoT elements on one place and make your IoT pilot project up and running within couple of days.

II. ALLIANCE – BUILDING IOT COMMUNITY

Although we are talking about the Internet of Things here, first of all you need to get together people who will analyze customer needs, develop and manufacture appropriate devices, put together reasonable solutions and provide valuable services to end customers. We believe that the best way how to do this is to build up a community of cooperating commercial and non-profit entities having the same goal and values.

IQRF Alliance is an open international community of IoT professionals (developers, manufacturers, cloud providers, telco operators, system integrators, research and innovation centers, technical high schools and universities) providing wireless solutions for IoT and M2M communication based on the IQRF platform.

The IQRF Alliance focuses on these 3 areas: community, interoperability and promotion.

COMMUNITY

In the community area we focus on the real and effective cooperation of the members so system integrators share their needs according to their opportunities with manufacturers and SW and cloud providers so they develop what is really needed by the end customer. IQRF Alliance also supports joint pilot projects since we see it as the most effective way how to build and sell different IoT solutions with significant added value to the end-customer. Two examples of joint IoT projects could be found in the chapter 5 of this document and more at [3].

IQRF Alliance has currently (October 2017) around 80 members from 17 countries [4] and the number is steadily growing. The portfolio of members is really wide from global corporations, through successful SMEs up to small start-ups.



Fig. 2. Members of the IQRF Alliance, October 2017

INTEROPERABILITY

The IQRF platform, specifically the IQRF DPA framework [5], provides built-in wireless compatibility so devices from different manufacturers can communicate in one wireless mesh network. The trouble was that every device was usually controlled with different commands and provided data in a little bit different structure (based on the manufacturer preference). This made integration of devices from different manufacturers more complex and disabled using the key IQRF functions such as Fast Respond Commands [6].

Due to this the IQRF Alliance members agreed on standardization of the most used commands and sensor/meter quantities. In October 2017 the IQRF Alliance released the first version of the IQRF Interoperability Standard and published it on its website [7].

The standardization enables control of devices without integration special commands and reading sensor/meter data without special data parsing algorithms.

Every certified device gets a unique HWPID (Hardware Profile ID) so gateway or cloud can recognize what type of device is connected. Currently (October 2017) the IQRF Alliance is testing the IQRF Repository which contains all relevant information about certified products so gateway or cloud can automatically download them. In the second stage the Repository will include drivers of IQRF-certified devices, so gateway can start controlling these devices automatically.

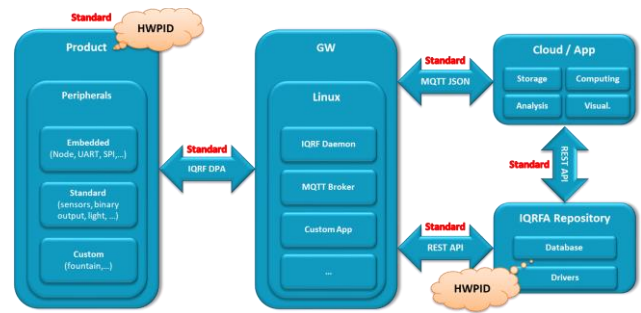


Fig. 3. IQRF Ecosystem

PROMOTION

The third key area covered by the IQRF Alliance is promotion of the products and solutions based on the IQRF Technology. IQRF Alliance uses different channels to communicate the benefits of the IQRF Ecosystem to the IoT professionals such as website, social media, participation on conferences and exhibitions, organization of IQRF Summit and local meet-ups and much more.

III. ECOSYSTEM – BUILDING IOT PORTFOLIO

In order to build up your IoT solution effectively you need ready components so you don't have to waste your time on development of everything from A to Z. This would not be only very time and money consuming process but also skills and know-how requiring operation.

With this having in mind IQRF Alliance is supporting its members to prepare ready devices, software, clouds, services, mobile apps, etc. so putting together an IoT solution is really a job for just couple of days.

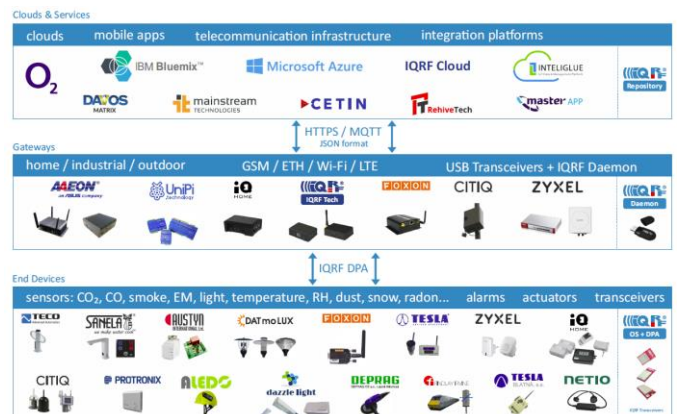


Fig. 4. IQRF Ecosystem [8]

In the following text we will describe the key attributes of all levels of an IoT solution. Having said that, as we are the Alliance focused on wireless connectivity we will not go too much into a detail on the cloud level in this document.

A. Wireless connectivity

One of the first challenges of any IoT solution is the last-mile-communication. The well-known and massively used wireless technologies such as GSM/LTE, WiFi or Bluetooth don't fit well most of the IoT use cases' needs: low-power, high number and high density of connected devices, low data rate, reliability, security,...

Thus, there is a big boom of young technologies for IoT especially in the area of Wireless Wide Area Networks

(WWAN) such as LoRa or Sigfox. These technologies are designed mainly for collecting data from remote sensors. On the other side there is a high number of IoT use cases where features and parameters of WWAN technologies don't fit well, either. Those are typically real time (local) control applications (lights, heating, air-condition, motors) and deep indoor applications (large buildings, underground, tunnels, industrial operations, etc.).

For these types of applications wireless mesh networking technologies are much better fit.

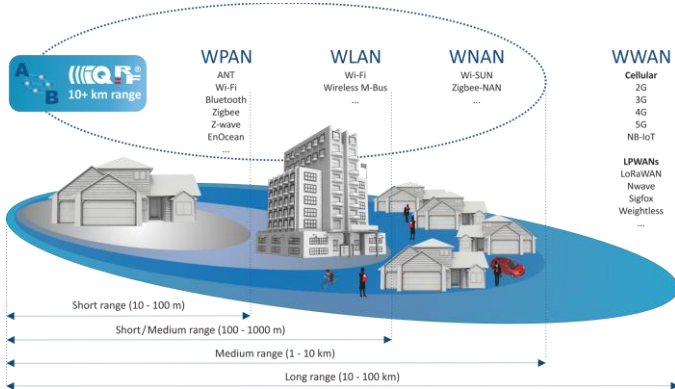


Fig. 5. Positioning of IQRF Technology

IQRF

IQRF [1] is a mature technology connecting devices to IoT via wireless mesh networks. IQRF provides simple integration, standards-based-security, interoperability of end-devices, robust and reliable mesh networking, low-power operation and full bidirectional communication.

TABLE I. BASIC IQRF PARAMETERS

Parameter	IQRF
SW:	OS + DPA + Appl. + SDK
Band:	433 / 868 / 916 MHz
Network topology:	mesh
Range (device-to-device):	500+ meters
Range (device-to- gateway):	tens of kilometers
Native multi-hop:	240 hops per packet
Routing algorithm:	oriented flooding
Security:	multilayer, AES-128, dynamic keys
Directionality:	bidirectional
End devices OTA management:	for all operations needed
Main benefit:	easy adoption/reliability
Low power:	several years on a battery

BEST-FIT TYPE OF PROJECTS

There is no technology fitting every use case. Here is a list of typical parameters of projects where IQRF fit the best:

TABLE II. IQRF BEST-FIT TYPE OF PROJECTS

Project needs	IQRF
Data acquisition	sensor / operation data – tens of bytes
Control	actuators (ON/OFF, dimming, rotation,..)
Gateway	local control and data processing (fog/edge computing)
Number of nodes per GW	tens / hundreds
Ready infrastructure and signal coverage	not needed
Cost of wireless operation	free of charge
Density of nodes	< 200m from each other to ensure robust (redundant) mesh networking
Environment	outdoor / indoor / deep indoor / RF harsh
Power	ultra-low-power – 5+ years on battery ^a
OTA upgrades	yes, all levels (OS, plug-ins, custom app.)
Robustness and reliability	very high due to mesh networking
Cloud	any cloud, standard protocols (MQTT, https)

^a Depends on use case, type of battery, etc

As the consequence of typical project parameters here are the typical use cases of the IQRF technology:

TABLE III. IQRF USE CASES

Area	IQRF Typical Use Cases
Smart City	street lighting, street parking, traffic monitoring and control, environment sensors, waste management,...
Smart Building	indoor/ emergency / design lighting, HVAC control, environment monitoring, metering, operation monitoring, ...
Industry 4.0	machine and tool monitoring, employee and forklifts tracking, infrastructure monitoring,...

B. End devices

In order to be flexible when putting together your IoT project you need a wide range of interoperable sensors and actuators.

Interoperable means that the devices not only communicate in one network but that the actuators are controlled with the same commands and sensors provide data in the same structure. Interoperability thus significantly simplifies integration of different devices from more manufacturers in one network.

Overview of available IQRF end-devices could be found at [8].

C. Gateways

In IQRF Ecosystem gateways are the key component of the whole design. Gateways don't provide only a link from IQRF network to the internet but they are the control unit of the complete IQRF network. It means that they collect data from sensors, analyze them and based on the results control actuators in the network. Apparently they also report data up to a connected cloud or receive commands from the cloud or users.

This “fog/edge computing” approach enables much bigger flexibility and reliability than standard cloud-controlled-installations and is the future of the real-time IoT.

When talking about IQRF gateways we don’t mean only hardware but also included software and remote management.

HARDWARE

Regarding gateway hardware the goal is to be as much as possible independent on a specific hardware and to let the integrator choose the hardware according to his priorities. Nowadays actually any Linux computer can operate as an IQRF Gateway. In general two things are needed:

- IQRF Transceiver connected to the gateway through SPI or USB connector/protocol
- IQRF Daemon – universal software which can control IQRF network and communicate to a cloud or a mobile app

IQRF DAEMON

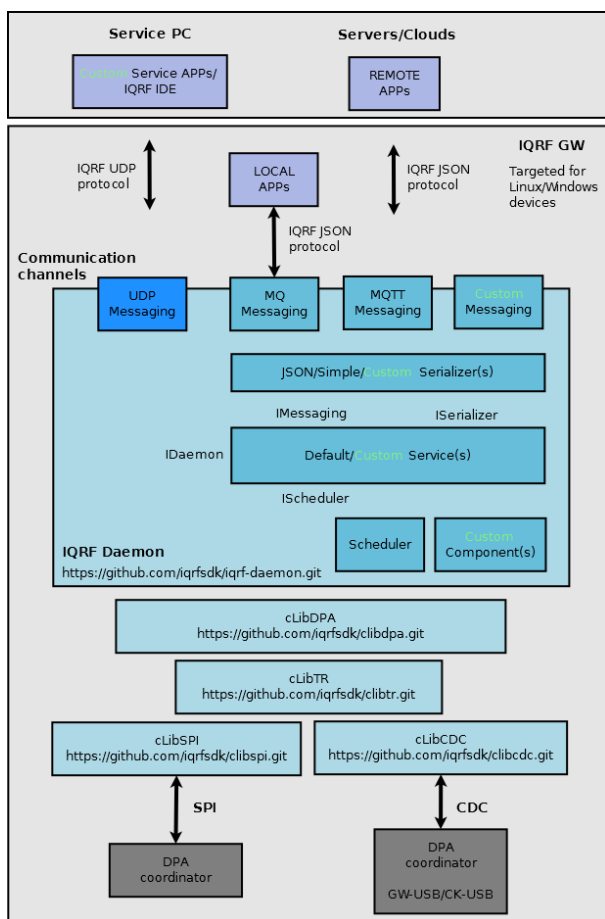


Fig. 6. IQRF Daemon [9]

IQRF Daemon is the second key building block of an IQRF gateway. It provides all necessary services for control of an IQRF network, gateway configuration, remote access through UDP protocol, link to local user application through MQ messaging and communication to remote cloud or app through MQTT messaging.

REMOTE GATEWAY MANAGEMENT

Very important service, or rather must-to-have service, is a remote management of the gateways. If you need to do any upgrade or change a configuration you must be able to do it not only remotely but with dozens or rather hundreds of gateways

simultaneously, as well. You can check IQRF-ready remote gateway management systems from RehiveTech at [10].

D. Remote visualization and control

Another important layer of any IoT solution is the data storage, analysis, visualization and user control interface. Currently these tasks are usually covered by cloud solutions, mobile applications and integration platforms.

The IQRF Ecosystem is fully open to any cloud solution which communicates on standard protocols such as MQTT or https. Thanks to this you as a system integrator or a customer have a full flexibility to use any cloud or platform.

IQRF Alliance cooperates with providers and integrators of the key cloud services such as Microsoft Azure or IBM Bluemix as well as with small cloud service providers such as Intelimints, CIS or CTI software.

Part of the IQRF Ecosystem is also a universal mobile app by Master Internet that enables you to build and control an IQRF network directly from your cell phone.

IV. HOW TO BUILD YOUR IoT PILOT PROJECT

In the previous paragraphs we described what you need as a base line to start your IoT pilot project and realize it effectively. In this chapter we will focus on the step by step guide how you can build up your simple IoT solution and how you can extend it into a real IoT installation.

A. Start with the IoT Starter Kit

Members of the IQRF Alliance joined their efforts and put together a starter kit [11] where you should find all you need to start your IoT project.

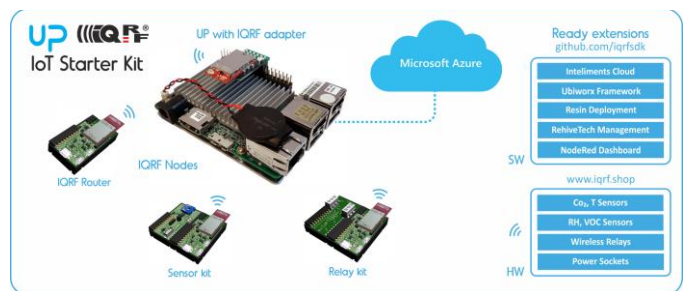


Fig. 7. IoT Starter Kit by IQRF Alliance members

There are two IQRF wireless kits – a sensor kit providing temperature, illumination and potentiometer inputs and a relay kit. These kits are enough for you to learn how to collect data from sensors and how to control actuators. You can make these kits up and running and connected in a wireless mesh network using IQRF IDE according to on-line video tutorials [12].

UP board is a computer for makers and professional makers bridging the gap between hobby and industrial computers [13]. It usually serves as a gateway controlling the IQRF wireless mesh network and connecting it to the Internet through Ethernet, WiFi, GSM or LTE.

STEP-BY-STEP GUIDE

To make the UP board working as an IQRF gateway you need to do the following steps:

1. Install and configure Linux

2. Install and configure IQRF Daemon that will handle the control of your IQRF network
3. Install Node-RED for basic control of your network.
4. Install MQTT broker so you can get connected to one of the supported cloud services such as Microsoft Azure, IBM Bluemix, etc.

Everything you need to realize these five steps is available on the IoT Starter Kit Github [14].

B. Add more end-devices

There is a growing portfolio of IQRF interoperable devices – both sensors and actuators. You can see the complete portfolio of IQRF related products, solutions and services on the IQRF Marketplace [8] and purchase end-device samples at IQRF Alliance e-shop [15]. You can select devices that you need, purchase them on one single e-shop and bond them to your wireless network.

C. Test different Software from Github

As you can extend your solution with different end-devices you can also test different software for your gateway. Go to IQRF Github extensions [16] where you can download software and/or demo access to different services free of charge.

D. Test different clouds and mobile apps

There is number of cloud and mobile apps providers and integrators in the IQRF Alliance providing access to Microsoft Azure, IBM Bluemix, Inteligluie, Master App etc. Based on the documentation available on the IQRF Github you can test different products and find you the one most fitting goals of your IoT project [16].

E. Work with a system integrator

Potential cooperation with a system integrator depends on the scale of your project, experience of your team and timeframe you have for realization of your project. You can do everything yourself or you can cooperate with system integrators or consultants who can help you to make your project up and running much faster and more effective.

V. CASE STUDIES

This paper would be just a poor theory without mentioning real case studies where the approach described above was taken. More case studies can be found at [3].

A. Air quality monitoring in a Prague school

IDEA

Because of the assumption that there is a bad air in schools, and therefore students have concentration problems, Protronix and his partners (O2 IT Services, IQRF Alliance, MICRORISC, Camea,...) decided to make a 4-month-long measurement. The CO₂, temperature and relative humidity values were monitored. Data were continuously analyzed followed by recommendations for ventilation and other corrective actions.

SOLUTION

This solution consists of

- 10 combined sensors of CO₂, temperature and relative humidity
- IQRF wireless mesh network for data transfer

- UP board based gateway enabling data transfer from the IQRF network to TCP/IP network
- O2 data storage and a web application with visualization of measured data.

RESULTS

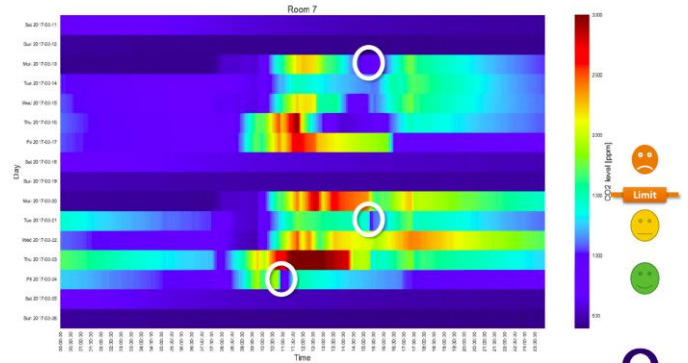


Fig. 8. CO₂ concentration graph of a monitored classroom

As a result, it was found that minimum recommended values of relative air humidity had not been reached for most of the school time and maximum allowed CO₂ values had been exceeded for almost half of the time. These variables and their values are directly linked to the concentration and health of students.

CONCLUSION

Thanks to using ready end-devices, gateway and remote management system it was very easy and cost-effective to realize this project.

B. Water metering

IDEA

CETIN as the key Czech telecommunication infrastructure provider wanted to evaluate IQRF technology and compare it to W-MBUS when reading data from water meters. The goal was to do it cost and time effectively.

SOLUTION

CETIN involved five members of the IQRF Alliance into this project:

- Mainstream technologies providing integration services, data analysis in MS Azure and visualization in PowerBI;
- AAEMON providing UP board as a gateway;
- IQRF Tech with IQRF Daemon and customization services;
- RehiveTech with their remote management system of gateways
- Bitspecta providing W-MBUS / IQRF protocol bridge

RESULTS

As a result, using services and products of other IQRF Alliance members CETIN was able to evaluate benefits of mesh networking in the area of water metering in a very limited budget and time frame.

There are many other running projects where cooperation of members and using of ready IQRF ecosystem elements is the key to successful and effective pilot projects.

VI. FURTHER DEVELOPMENT

As expected, we definitely don't stop where we are. There is plenty of work ahead to make your life, as a user of the IQRF Ecosystem, even easier.

A. Community

As mentioned, community is the base of the whole ecosystem. We will involve more partners with more skills in to the IQRF community, so the overall flexibility of the Alliance steadily grows.

B. Ecosystem

From the IQRF Ecosystem perspective we see the weakest point in the limited portfolio of ready end-devices and gateways. This is the challenge and opportunity for manufacturers to develop and manufacture sensors and actuators that is needed on the market.

C. Standard

The IQRF Alliance will not only extend the current standard but will develop an on-line repository of IQRF Certified devices so building up a wireless network will be literary in the "plug-and-play" mode.

VII. CONCLUSION

The Internet of Things is a really very complex ecosystem and enabling pilot projects to be done quickly and effectively is not the simple task. The IQRF Alliance did number of steps to prepare ready and open ecosystem including not only end-devices and gateways but gateways software, clouds, mobile apps, services and development tools as well.

These days (October 2017) using the IoT Starter Kit you can build up your device-to-screen IoT solution in matter of hours and within couple of days extend it, using different end-devices and software, in to pilot-project-solutions in a matter of days. There is a limited number of end-devices you can use for your project at the moment, but the portfolio is growing pretty fast following to the market needs.

You can join us in our effort to make the IoT really useful and cost effective for the end user. You are always welcome to step on the board of the IQRF Alliance.

VIII. REFERENCES

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