Smarter Wireless. Simply.

11th International Conference on Wireless and Mobile Communications
ICWMC *2015* | Oct 11-16, 2015 | St. Julians, Malta

Wireless Mesh Networks. IQRF.

Vladimír Šulc
MICRORISC s.r.o.

Wireless Mesh Networks. IQRF.

Smarter Wireless. Simply.

MICRORISC s.r.o.

Why we need WMN?

WMN as a challenge

IQMESH®protocol

IQRF® ecosystem

IQRF® Data Controlled Transceivers

FRC® - Fast Response Commands

Summary

MICRORISC s.r.o.

Smarter Wireless. Simply.

CZECH

MODERN

TECHNOLOGICAL

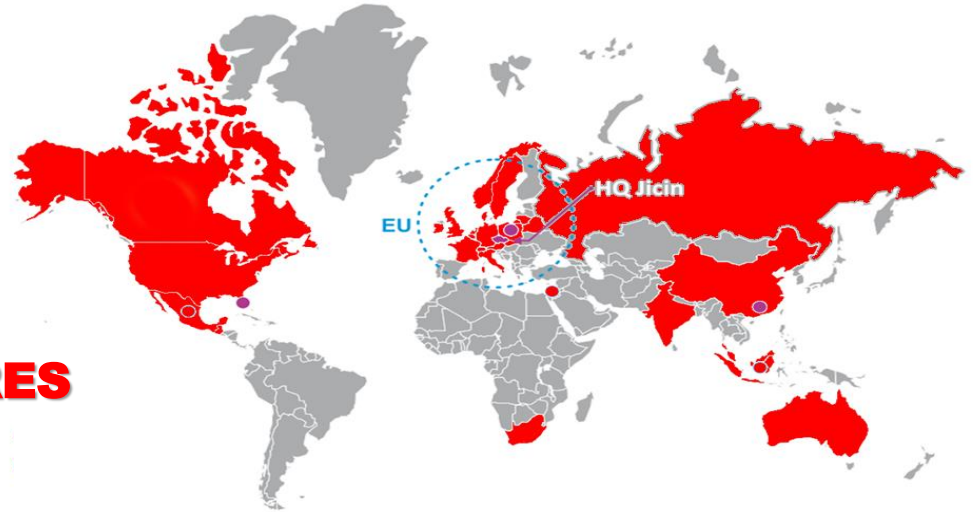
WITH CLEAR VISIONS

ORIENTED TO MANUFACTURES

PRIVATELY OWNED

INNOVATIVE

GLOBAL

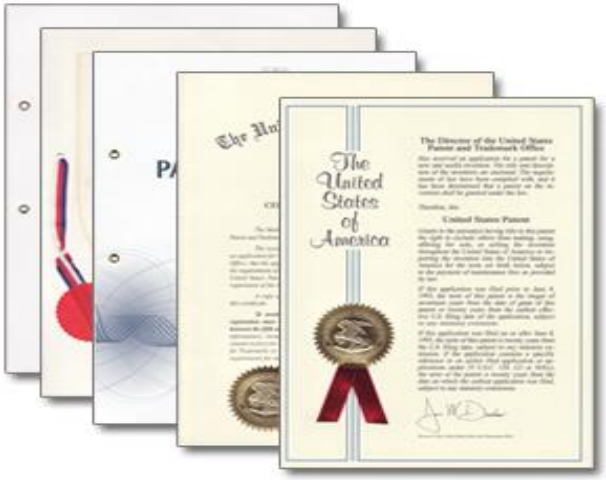


MICRORISC

... ENABLING FUTURE INNOVATION®

MICRORISC s.r.o.

Smarter Wireless. Simply.



2014 - Few Innovation Awards
2013 - Golden Amper
2012 - Company of the Year
2011 - Exporter of the Region

MICRORISC

... ENABLING FUTURE INNOVATION®

MICRORISC s.r.o.

Smarter Wireless. Simply.

MICRORISC

... ENABLING FUTURE INNOVATION®

MICRORISC s.r.o.

Why we need WMN?

WMN as a challenge

IQMESH®protocol

IQRF® ecosystem

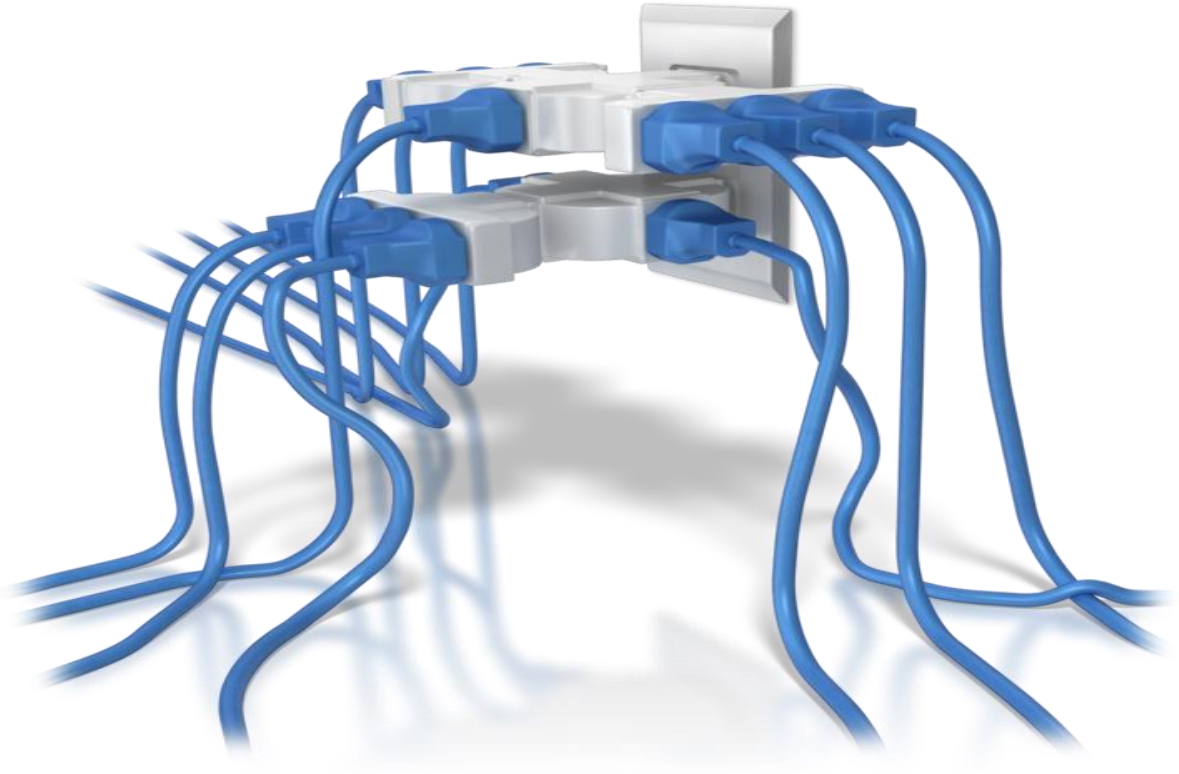
IQRF® Data Controlled Transceivers

FRC® - Fast Response Commands

Summary

We Need Wireless …

Smarter Wireless. Simply.



We Need Wireless …

Smarter Wireless. Simply.

We Need Wireless …

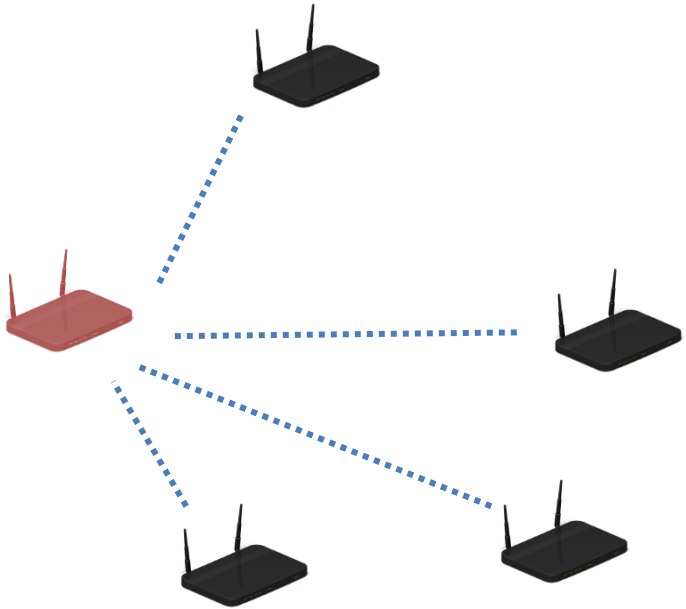
Smarter Wireless. Simply.

The most popular topologies

Smarter Wireless. Simply.

- Point / Point

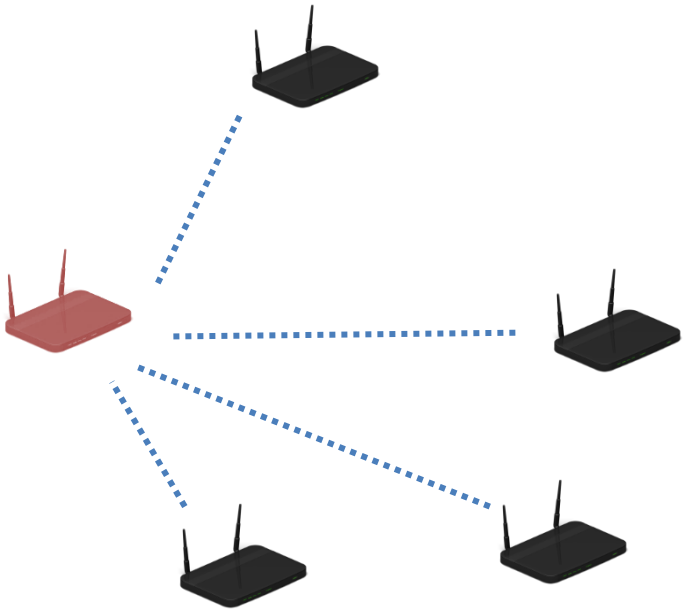
- Star topology



Why we need WMN?

Smarter Wireless. Simply.

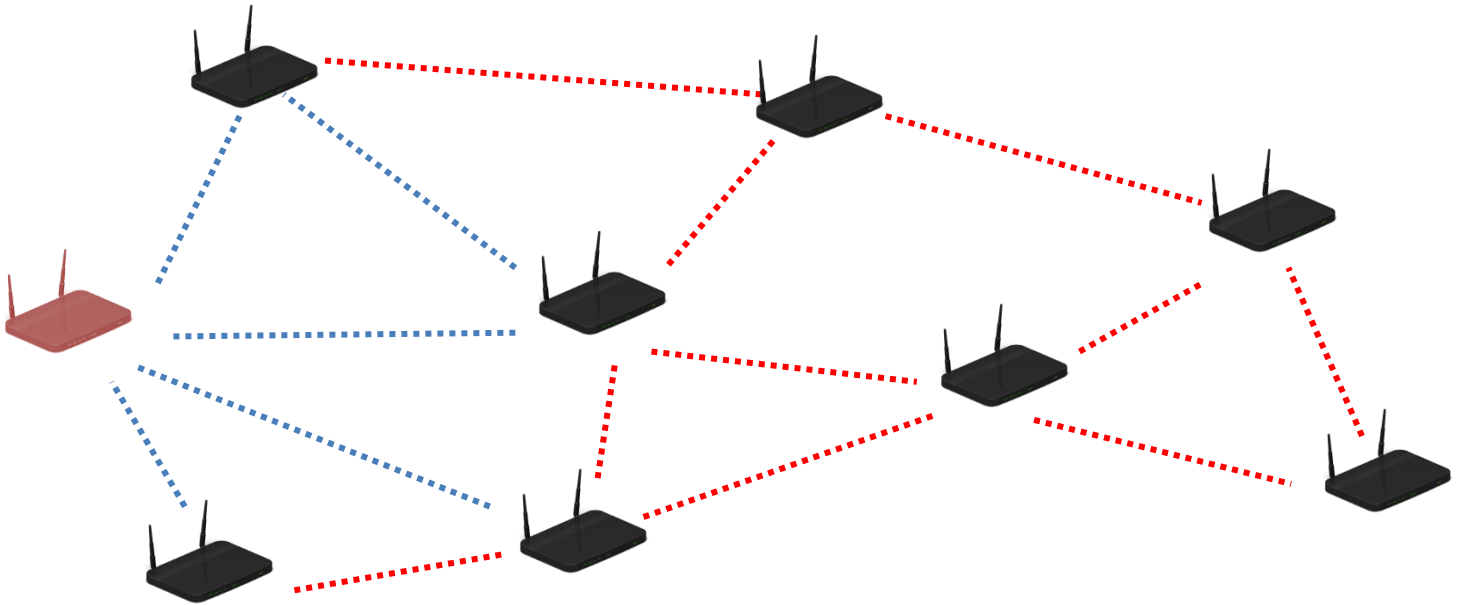
- WMN fixes potential problems of Star topology



Why we need WMN?

Smarter Wireless. Simply.

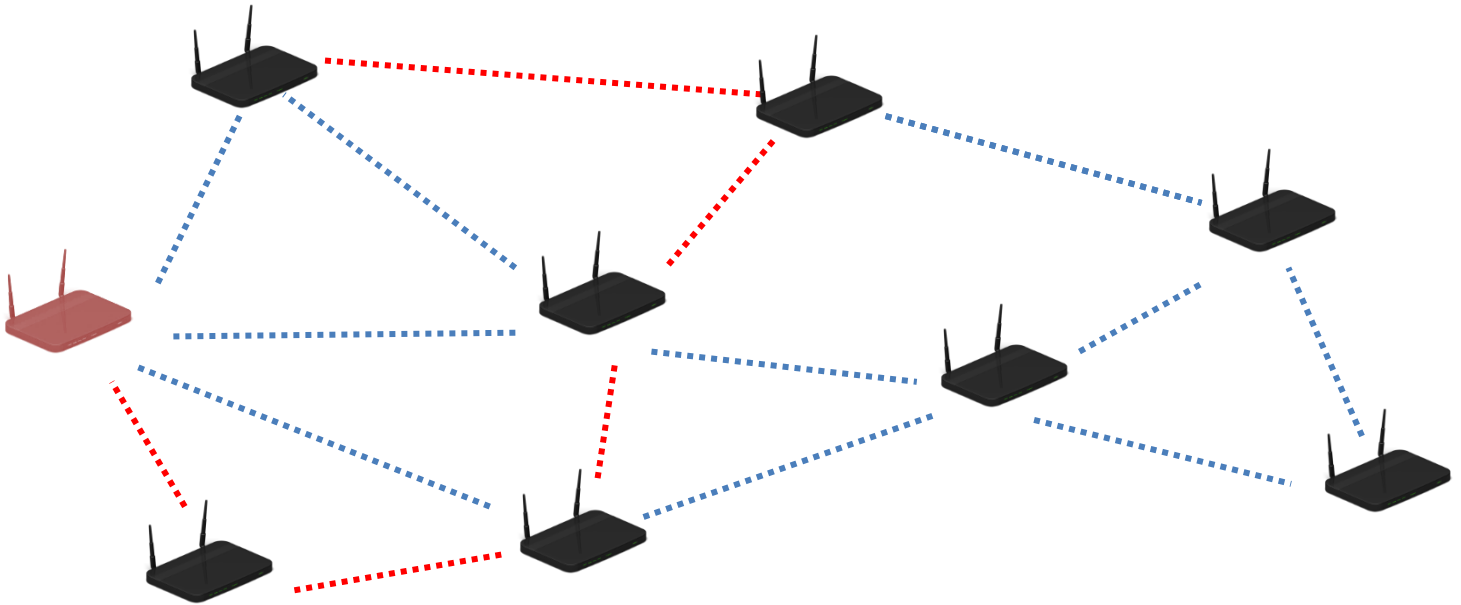
- WMN extends the range



Why we need WMN?

Smarter Wireless. Simply.

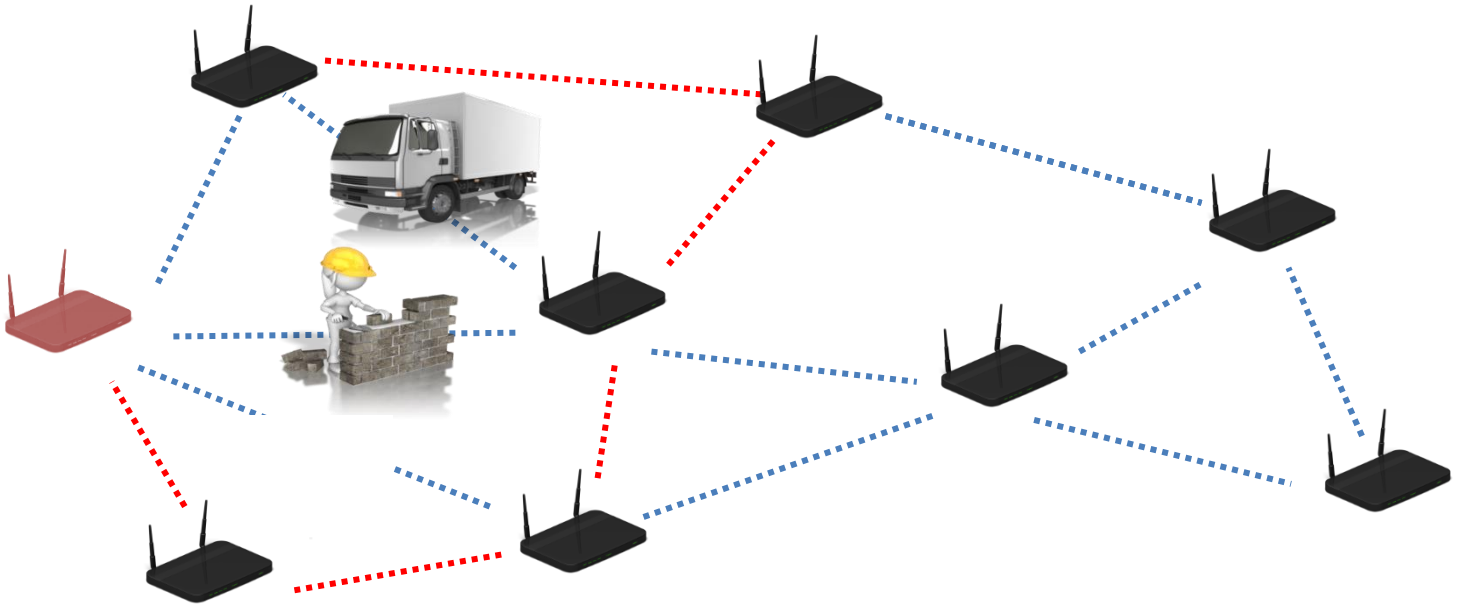
- WMN increases robustness and reliability



Why we need WMN?

Smarter Wireless. Simply.

- WMN respects physics and environment



Why we need WMN?

Smarter Wireless. Simply.

- WMN extends communication range
- WMN increases robustness and reliability
- WMN respects physics and environment

- WMNs enable new applications and opportunities

Why we need WMN?

Smarter Wireless. Simply.

- ❑ WMN extends communication range
- ❑ WMN increases robustness and reliability
- ❑ WMN respects physics and environment

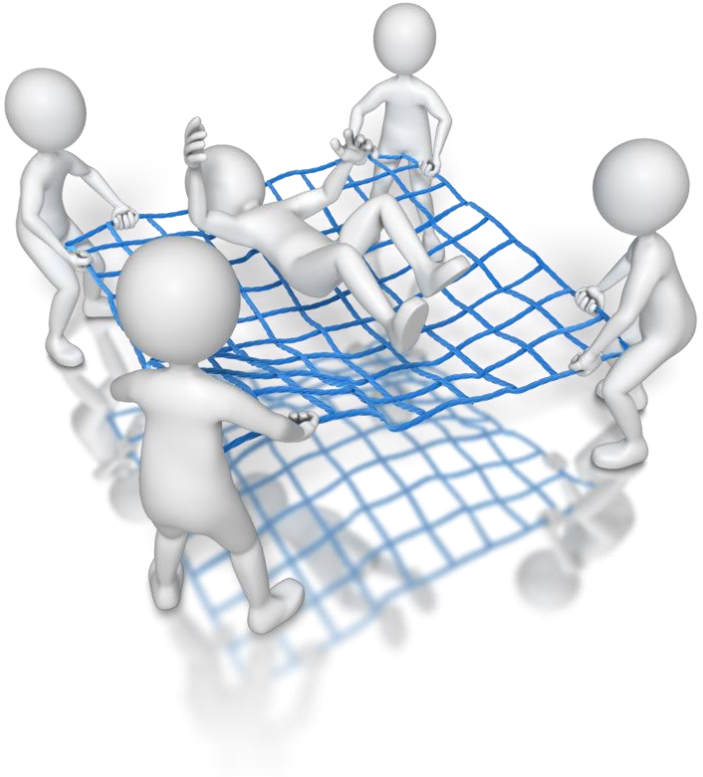
- ❑ WMNs enables new applications and opportunities

Why everybody does not use it, if it is so great?

WMN word genesis

a word

(before 2004)



strange word

(2004 – 2005)

nice word

(2006 – 2007)

magic word

(2007 – 2010)

… and after few years

black magic

(2015 – unwanted)

Why we need WMN?

Smarter Wireless. Simply.

… because WMN brings big algorithmic challenges

MICRORISC s.r.o.

Why we need WMN?

WMN as a challenge

IQMESH®protocol

IQRF® ecosystem

IQRF® Data Controlled Transceivers

FRC® - Fast Response Commands

Summary

WMN as a challenge

Smarter Wireless. Simply.

Each path can be 1 – N hops long

We are working with slow bit rates

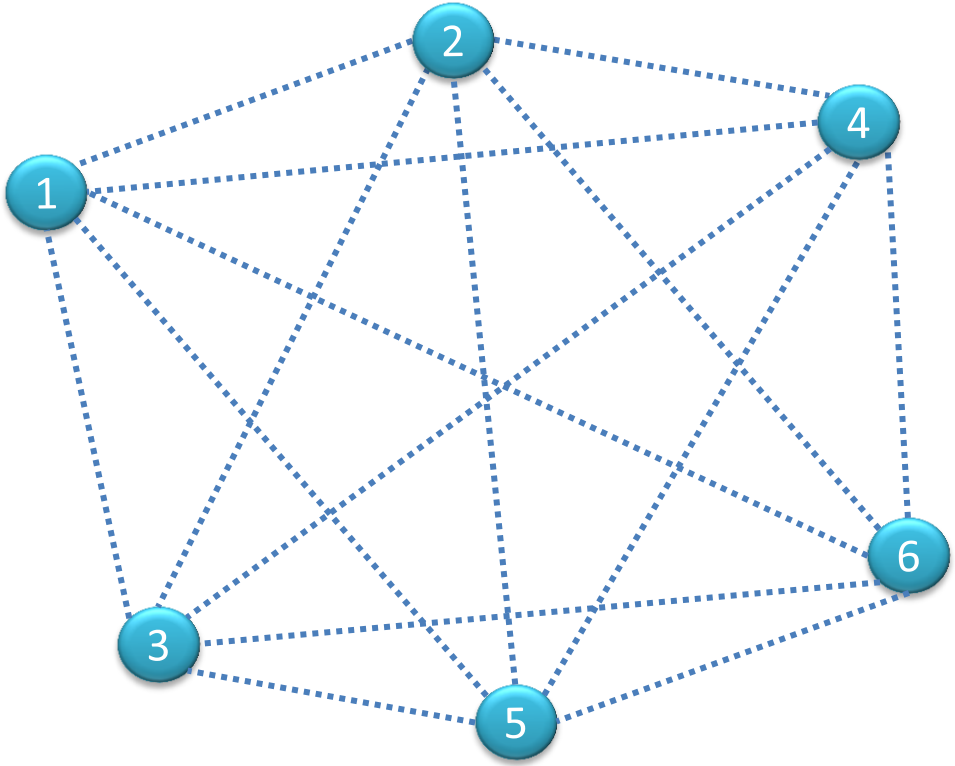
Conditions can change in time

Links may not be symmetrical

There are limited HW resources

Routing should be realized in real time

WMN as a challenge

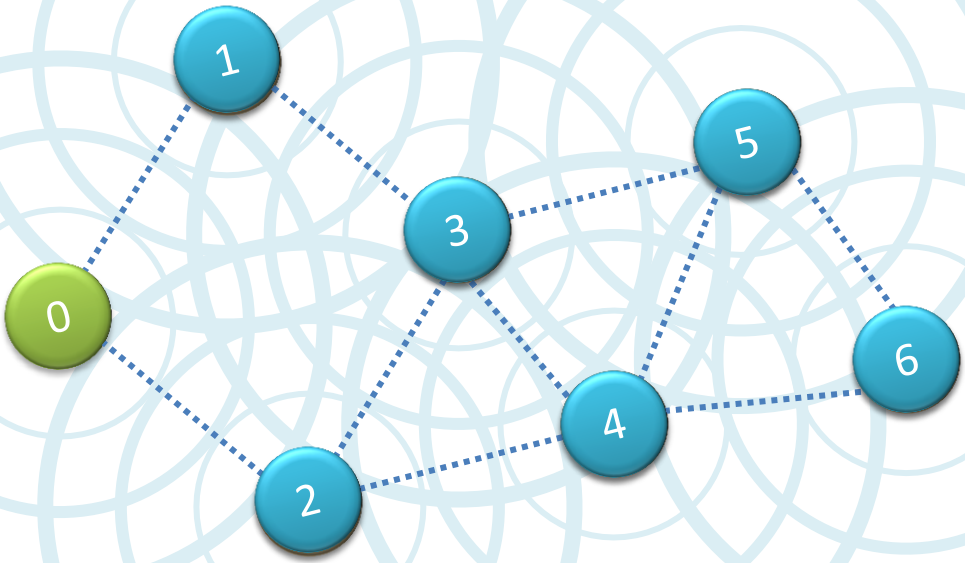


n:	N_{MAX}
2:	1
3:	3
4:	6
5:	10
6:	15
100:	4950
240:	28680

$$N_{MAX} = \frac{n\,(n-1)}{2}$$

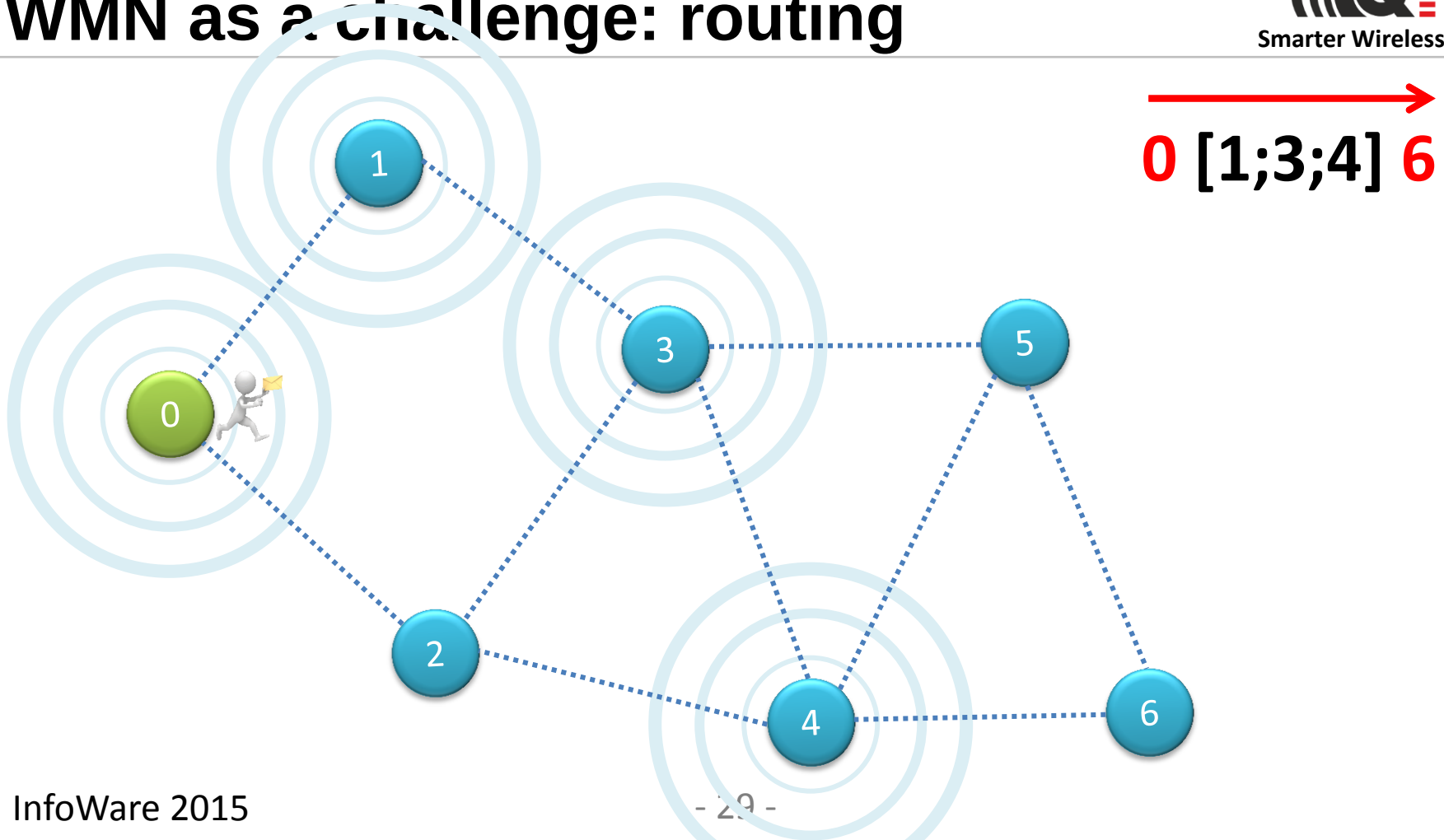
WMN as a challenge: forming

Smarter Wireless. Simply.



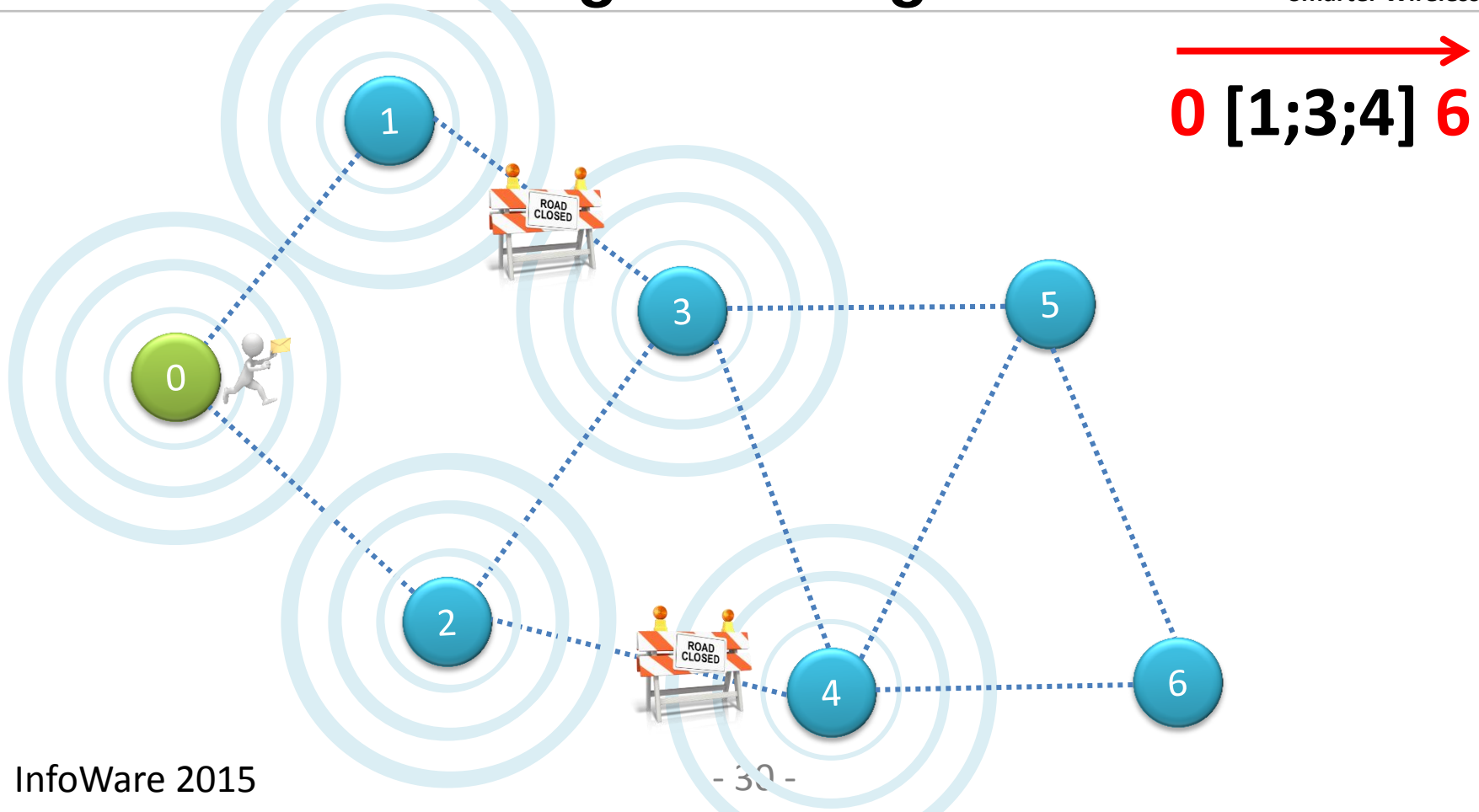
WMN as a challenge: routing

Smarter Wireless. Simply.



WMN as a challenge: routing

Smarter Wireless. Simply.



WMN as a challenge: routing

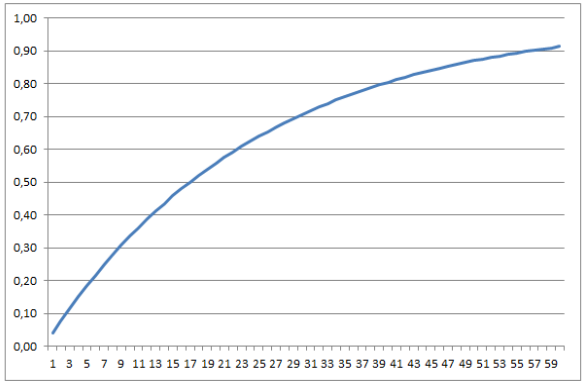
Smarter Wireless. Simply.

Optimizing may lead to unefficiency

(8 transmissions instead of 4)

WMN as a challenge: routing

Optimizing may lead to unefficiency



P_{errRT} = f(i); 80 B packets, TR-7xD, Spirit 1

$$P_{errRT} = 1 - (1 - P_p)^i$$

WMN as a challenge: routing

Smarter Wireless. Simply.

Unefficiency means higher power consumption

WMN as a challenge: routing

Smarter Wireless. Simply.

Optimizing needs system resources

WMN as a challenge: routing

Smarter Wireless. Simply.

Task: “Optimize efficiently to route reliably”

Wireless Mesh Networks. IQRF.

Smarter Wireless. Simply.

MICRORISC s.r.o.

Why we need WMN?

WMN as a challenge

IQMESH®protocol

IQRF® ecosystem

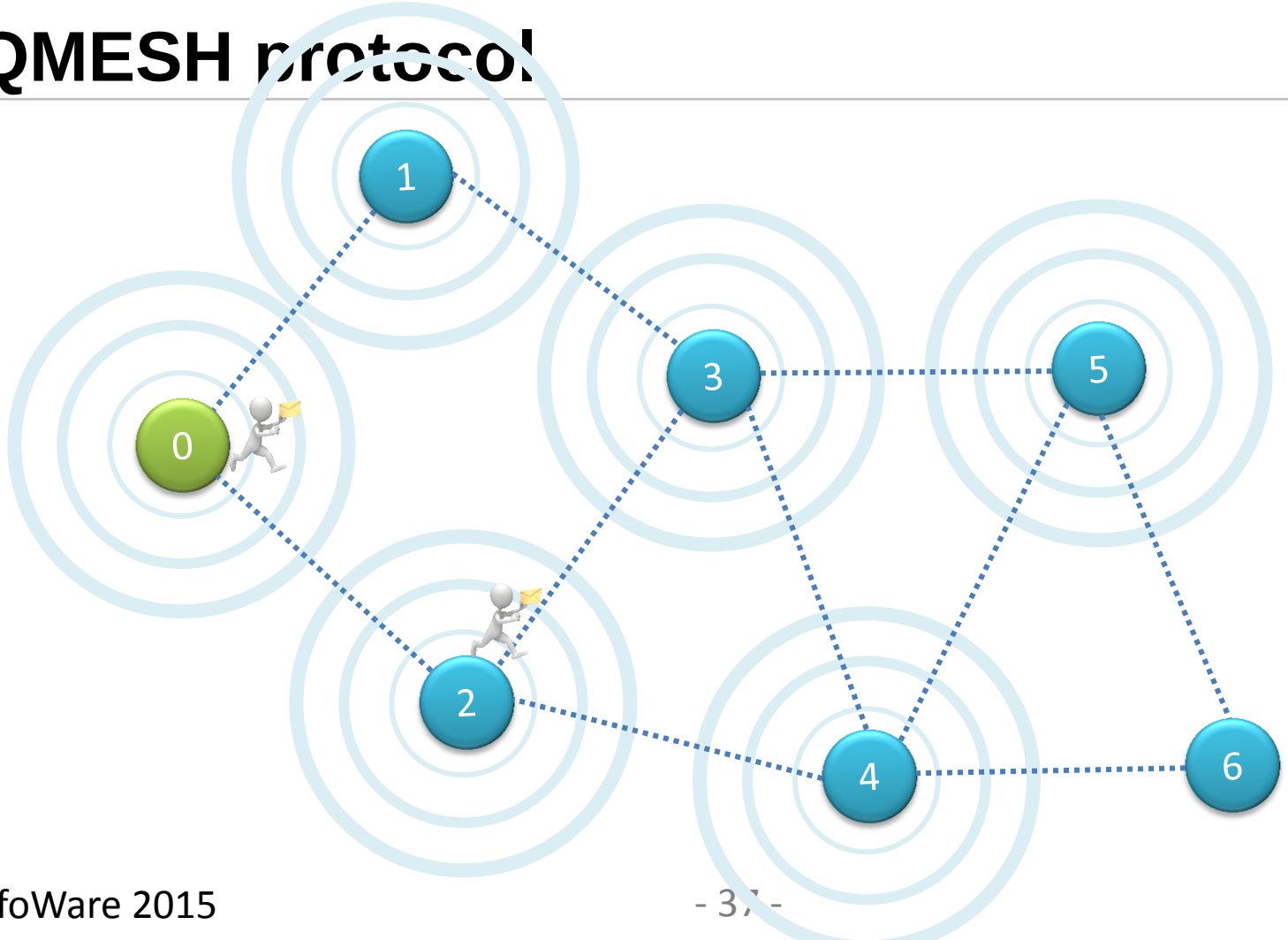
IQRF® Data Controlled Transceivers

FRC® - Fast Response Commands

Summary

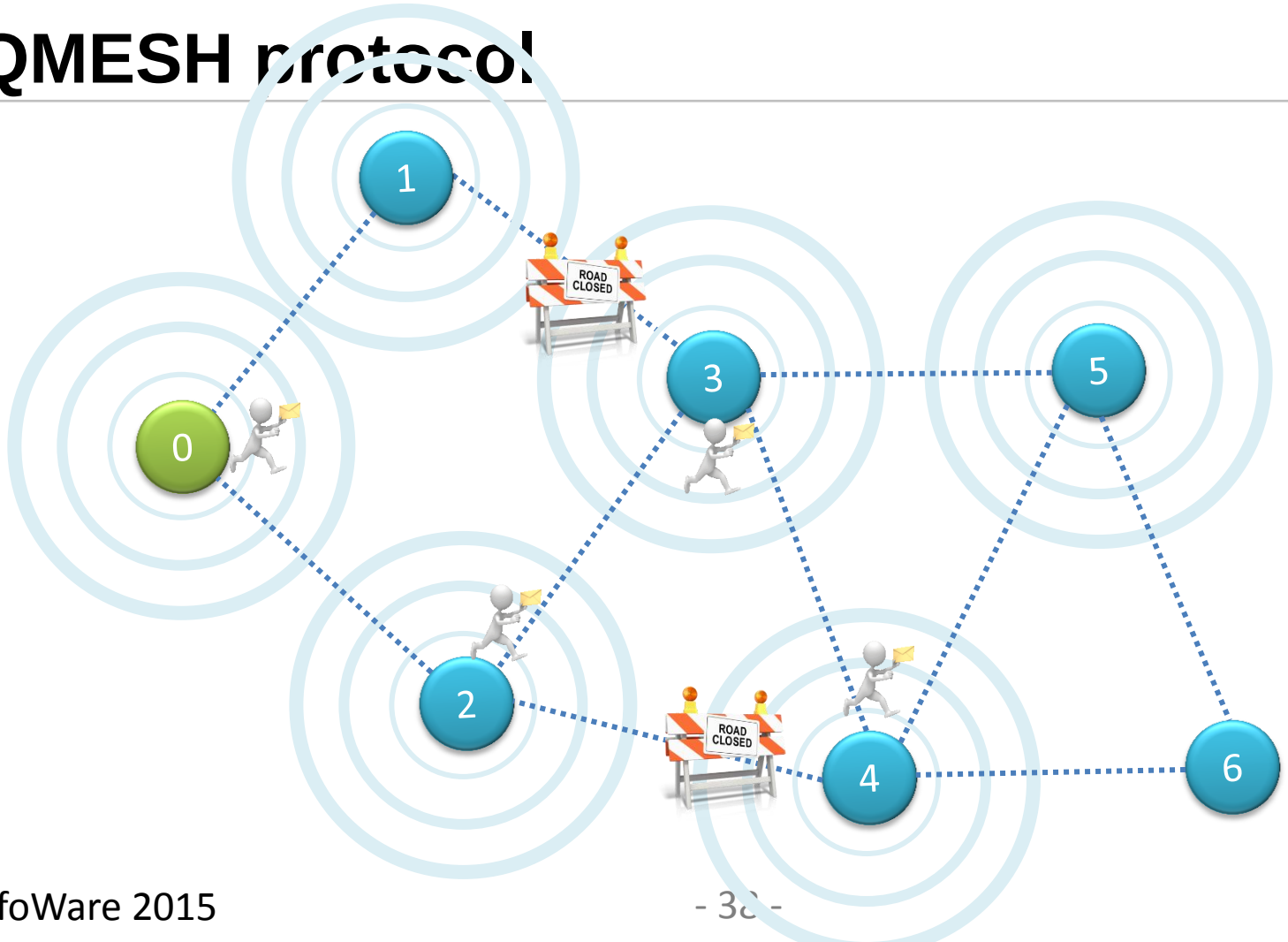
IQMESH protocol

Smarter Wireless. Simply.



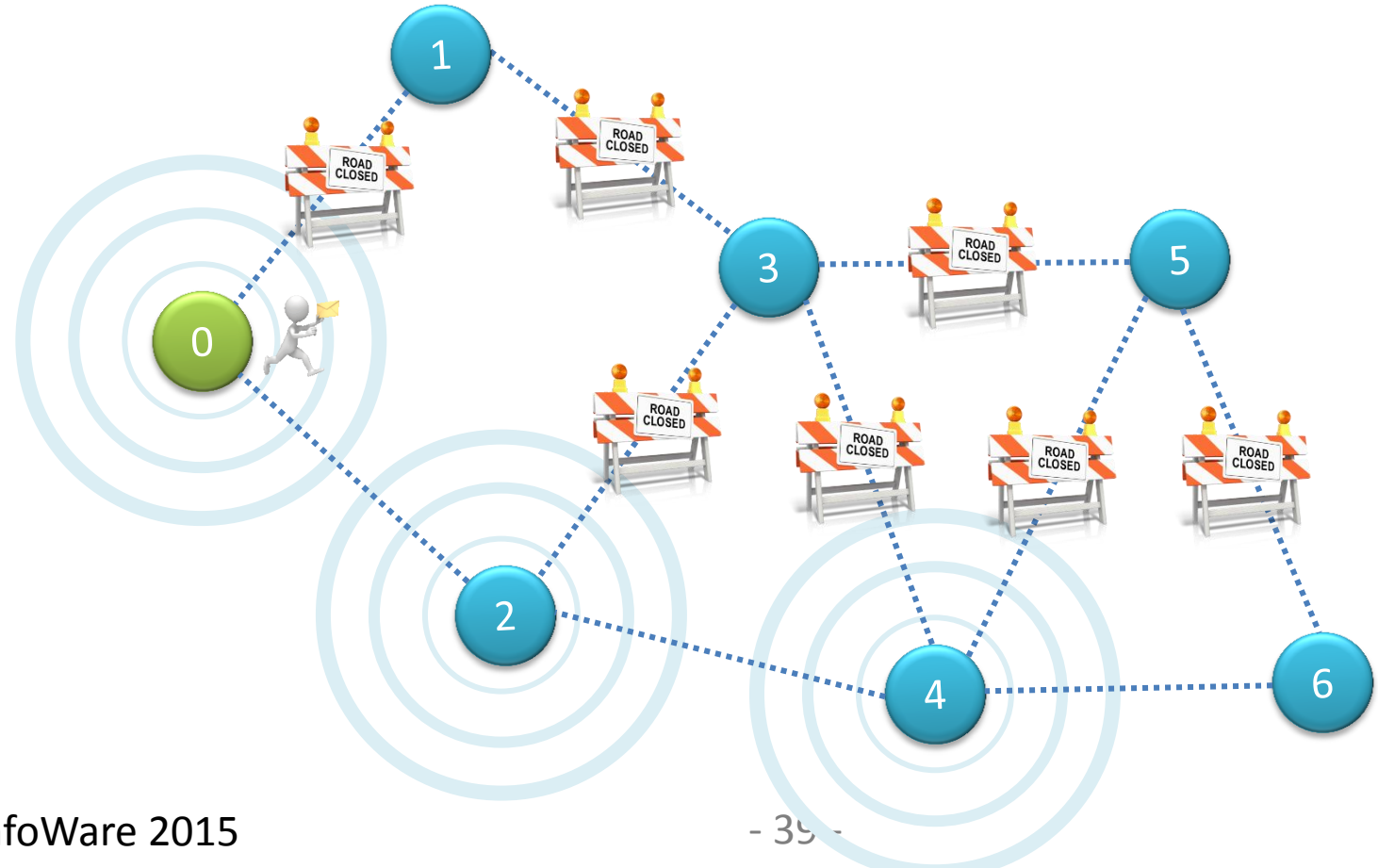
IQMESH protocol

Smarter Wireless. Simply.



IQMESH protocol

Smarter Wireless. Simply.

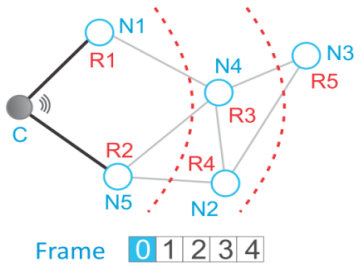


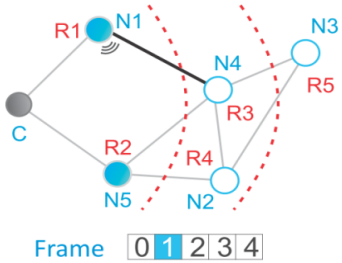
Deterministic and reliable

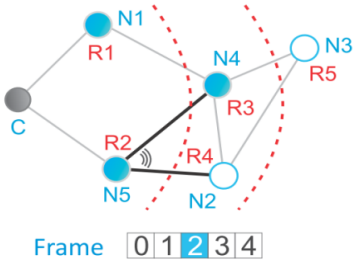
(Even under very bad conditions)

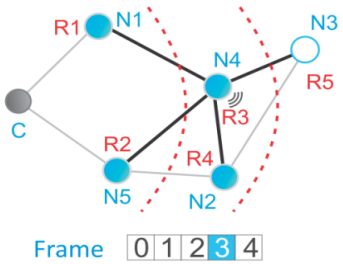
IQMESH protocol: addressing vs. routing

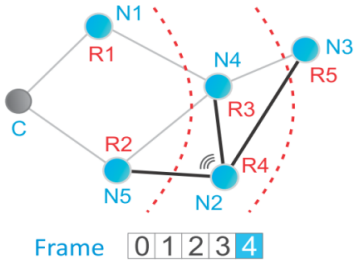
Smarter Wireless. Simply.

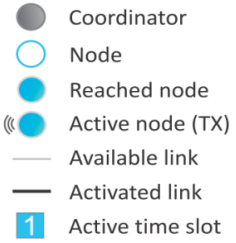






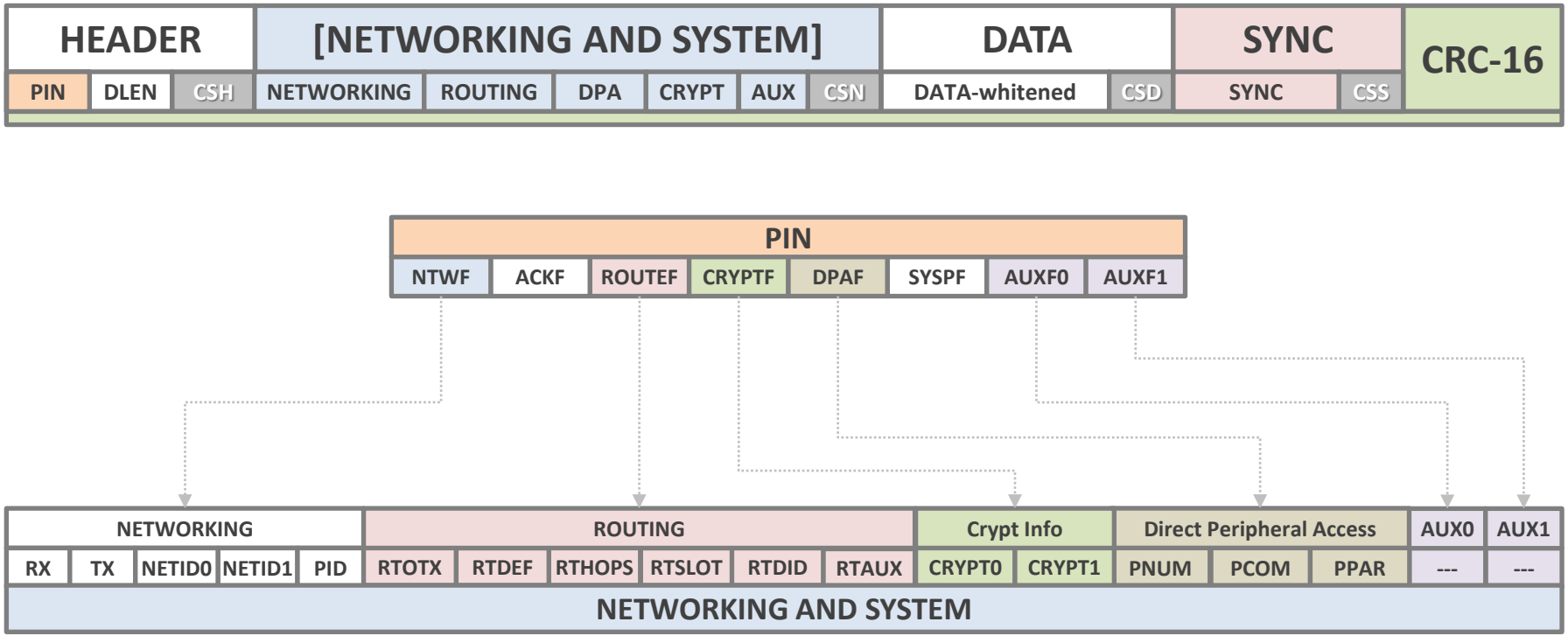






IQMESH protocol

Smarter Wireless. Simply.



IQMESH protocol

Smarter Wireless. Simply.

Non-redundancy routing

$$P_{errRT} = 1 - (1 - P_p)^i$$

Failure probability increase by each hop

***Expected* low time latency**

Higher implementation costs

IQMESH oriented flooding

$$P_{okZONE} = 1 - (1 - P_p{}^k)^i$$

Successful RX probability dramatically increases

Deterministic time latency

Very low implementation costs

IQMESH protocol

IQMESH® protocol is deployed in IQRF® ecosystem

MICRORISC s.r.o.

Why we need WMN?

WMN as a challenge

IQMESH®protocol

IQRF® ecosystem

IQRF® Data Controlled Transceivers

FRC® - Fast Response Commands

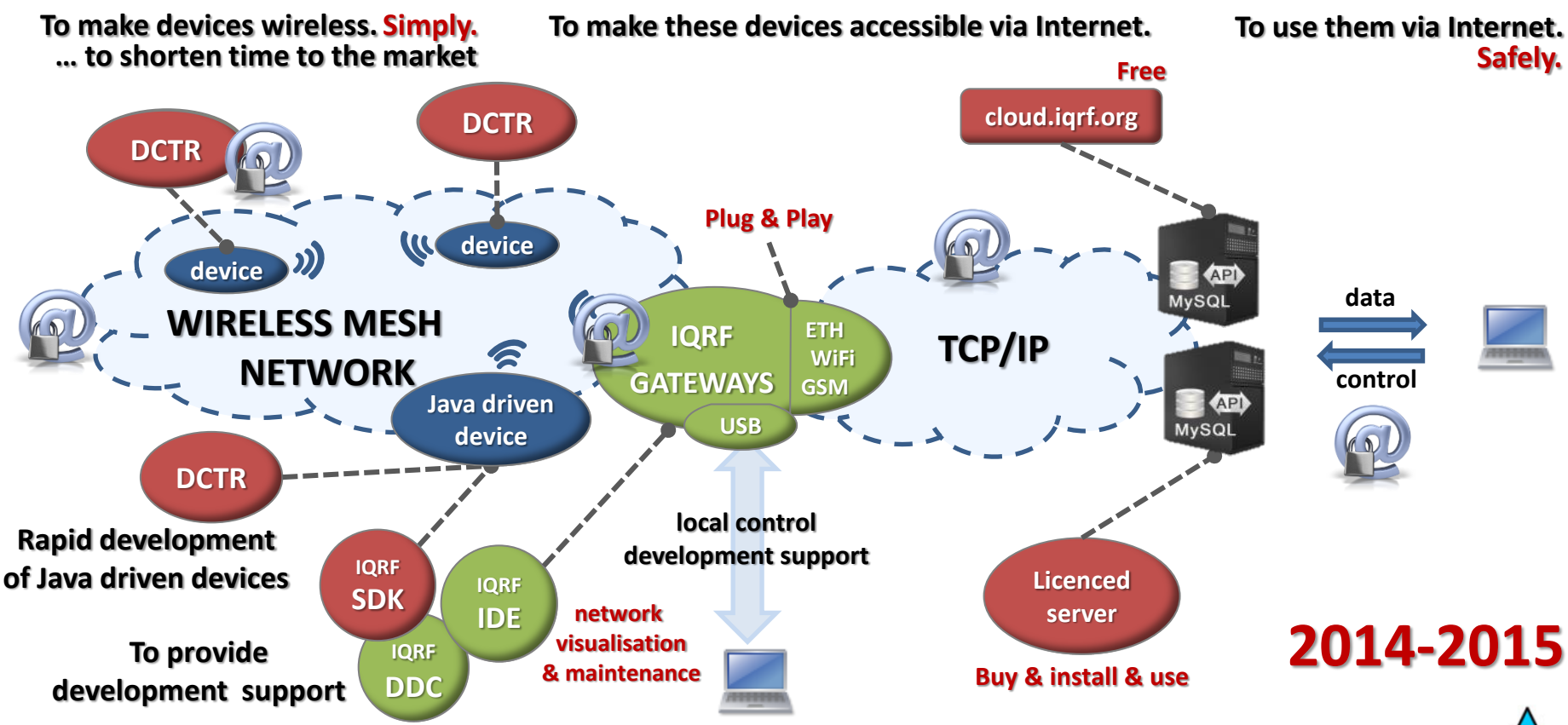
Summary

IQRF ecosystem

Smarter Wireless. Simply.

IQRF ecosystem

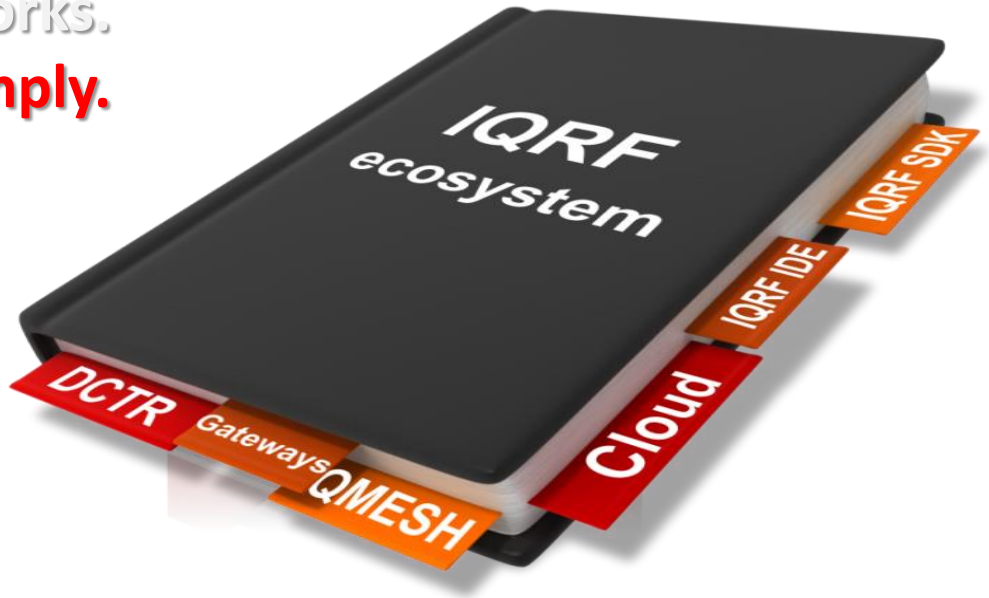
Smarter Wireless. Simply.



IQRF ecosystem

Smarter Wireless. Simply.

IQRF® is a communication platform
connecting any device to Internet
through wireless mesh networks.
Simply.



IQRF ecosystem: system components

Smarter Wireless. Simply.

TR-72Dx

TR-76Dx

GW-GSM-02A

GW-WIFI-01

DS-START-04

IQRF-BB-01

GW-USB-06

GW-ETH-02A

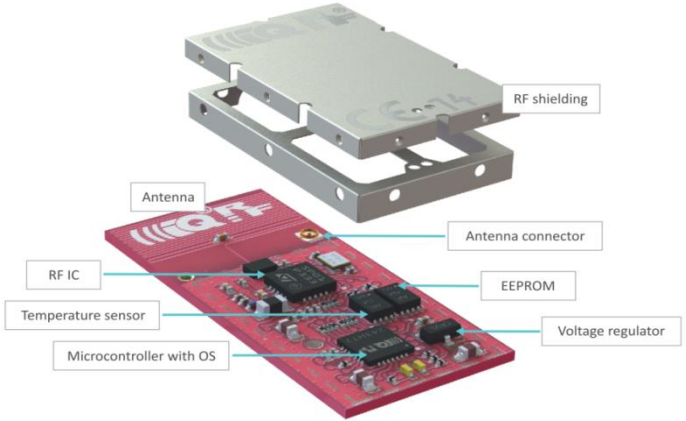
RT-230-06

DS-DPA-02

Complete product info is available at http://iqrf.org

IQRF ecosystem: excellent transceivers

Smarter Wireless. Simply.



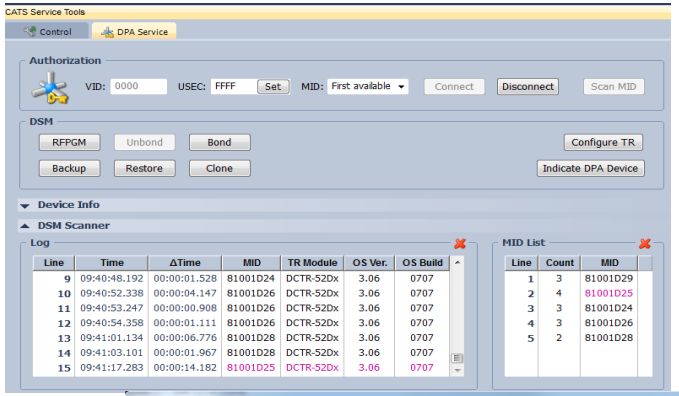
700 m

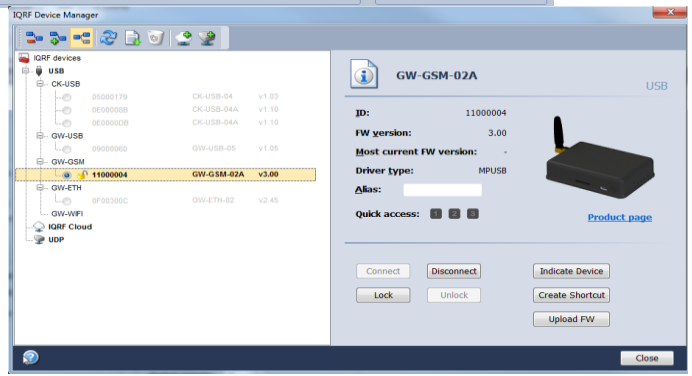
@19.836 bps

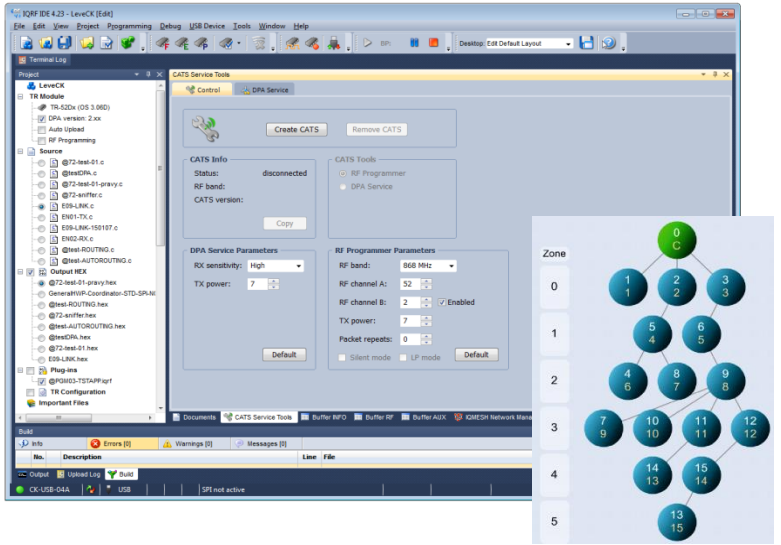
		TR-72Dx	TR-76Dx	
				
RX				
	STD:		12.3 mA	
	LP:		230 µA	
	XLP:		16 µA	
TX				
	setTXpower(0):		7.9 mA	-30 dBm
	setTXpower(1):		8.2 mA	-24 dBm
	setTXpower(2):		9.0 mA	-12 dBm
	setTXpower(3):		10.1 mA	-6 dBm
	setTXpower(4):		10.7 mA	0 dBm
	setTXpower(5):		12.9 mA	5 dBm
	setTXpower(6):		14.7 mA	9 dBm
	setTXpower(7):		17.6 mA	11 dBm
SLEEP	iqrfSleep():		<1 µA	

IQRF ecosystem: IQRF IDE

Smarter Wireless. Simply.

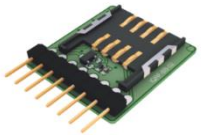


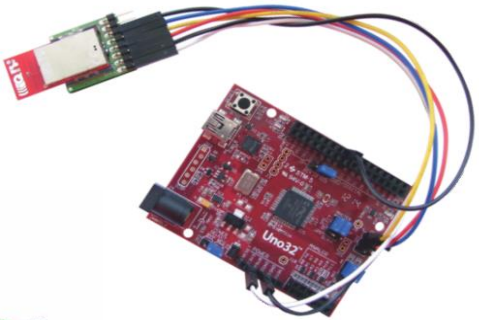


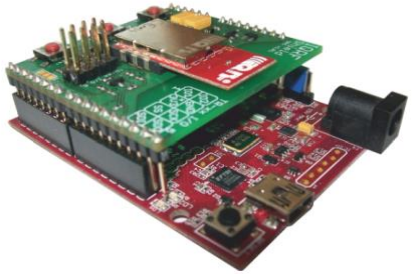


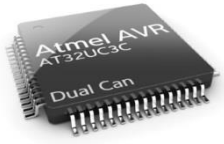
IQRF ecosystem: shields & support libraries

Smarter Wireless. Simply.









MOST processors: PIC, MSP, AVR, ARM
FREE compiler: GCC
DCTR interface: SPI, UART

IQRFSDK library with examples: cLibDPA

https://github.com/MICRORISC/iqrfsdk/tree/develop/libs/mcu/spi-uart

IQRF ecosystem: member's products

Smarter Wireless. Simply.

Complete product info is available at http://iqrfalliance.org

Interoperability + Community = Solution

Do It Wireless. Simply.

The integration of the IQRF Technology into the CO2 sensor, connection to the IQRF Cloud through a plug-and-play GSM or ETH gateway from MICRORISC and customization of the IQRF Cloud took thanks to the close cooperation of the IQRF Alliance members only 7 weeks.

Complete product info is available at http://iqrfalliance.org

MICRORISC s.r.o.

Why we need WMN?

WMN as a challenge

IQMESH®protocol

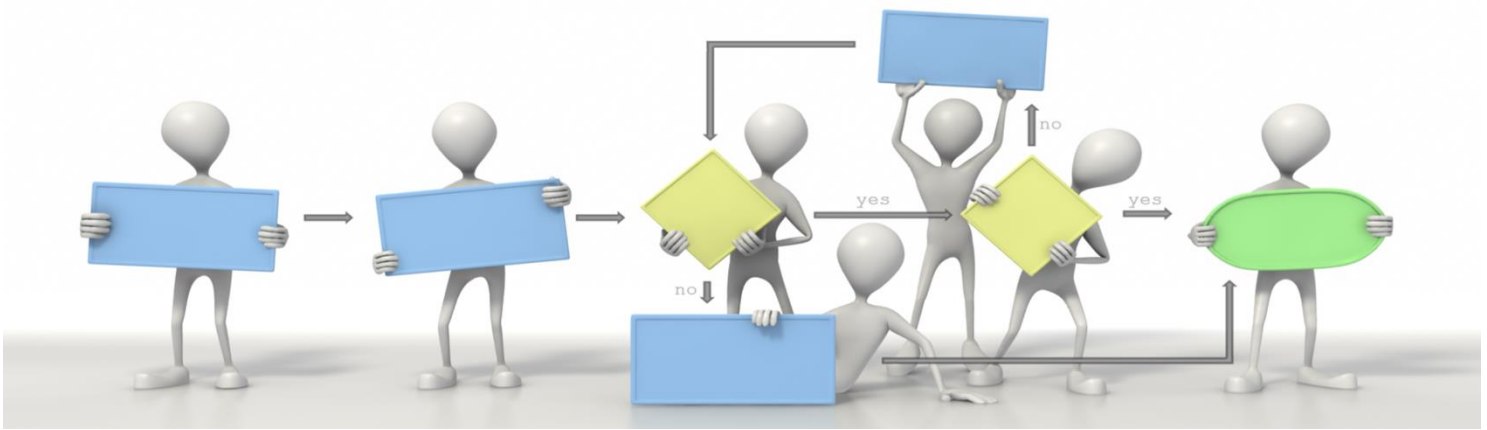
IQRF® ecosystem

IQRF® Data Controlled Transceivers

FRC® - Fast Response Commands

Summary

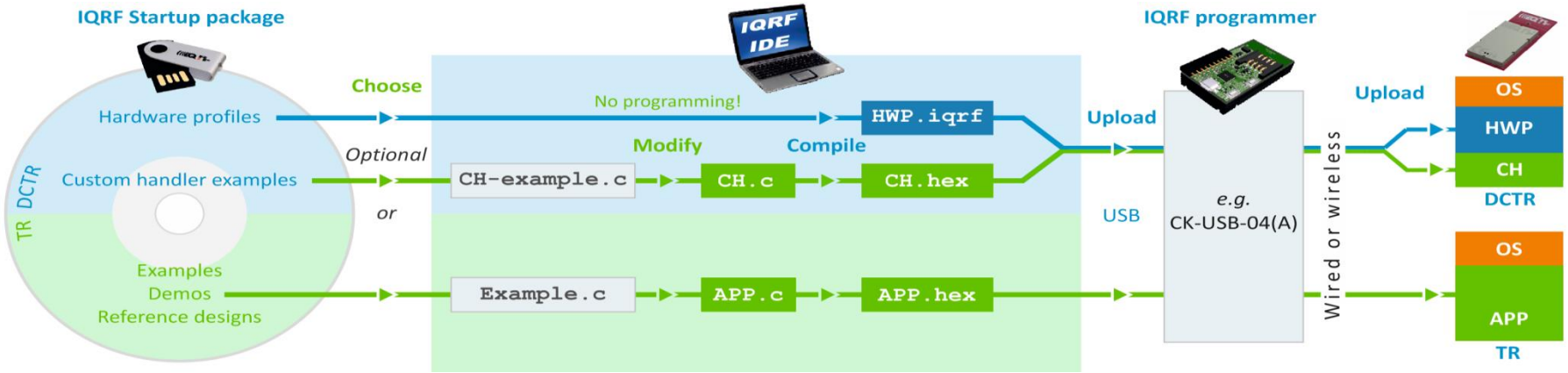
What is the biggest challenge?



IQRF Data Controlled Transceivers

Smarter Wireless. Simply.

Programming and uploading process



IQRF Data Controlled Transceivers

Smarter Wireless. Simply.

1981: AT Commands

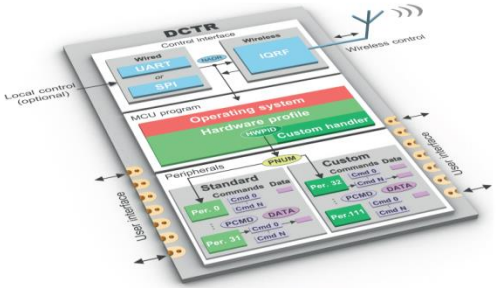
D.Hayes introduced command set enabling LOCAL control

2007: DPA technology

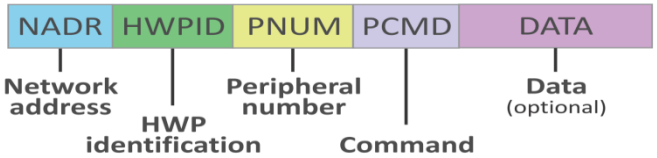
MICRORISC introduced concept of DPA for general NETWORK environment

2014: IQRF® DCTR

IQRF Data Controlled Transceivers® enable everybody who is able to send data via SPI or UART to communicate directly with WMN peripherals



Network devices are completely controlled by DPA commands, specifying where and what should be performed:



Wireless Mesh Networks. IQRF.

Smarter Wireless. Simply.

MICRORISC s.r.o.

Why we need WMN?

WMN as a challenge

IQMESH®protocol

IQRF® ecosystem

IQRF® Data Controlled Transceivers

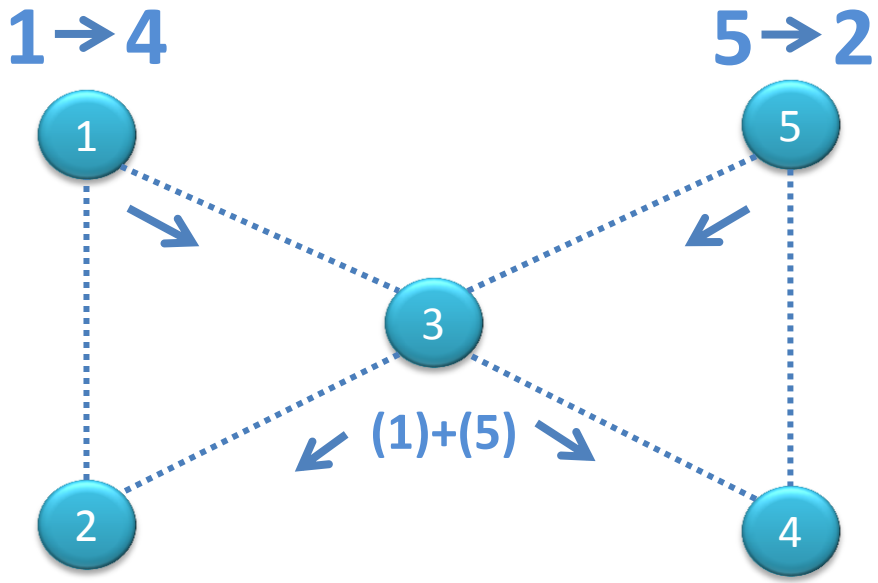
FRC® - Fast Response Commands

Summary

FRC – Fast Response Commands

Smarter Wireless. Simply.

- Linear Network Coding



FRC – Fast Response Commands

Smarter Wireless. Simply.

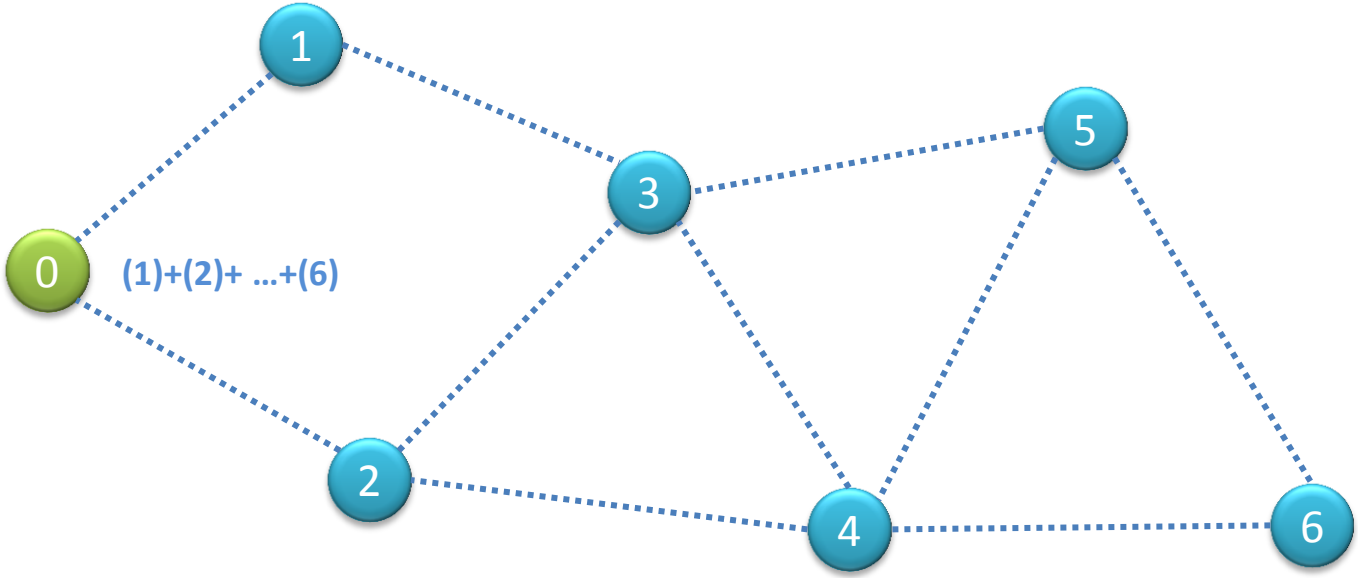
Bring efficiency and reliability to control systems.

Increase efficiency of data collection in WSN.

FRC – Fast Response Commands

Smarter Wireless. Simply.

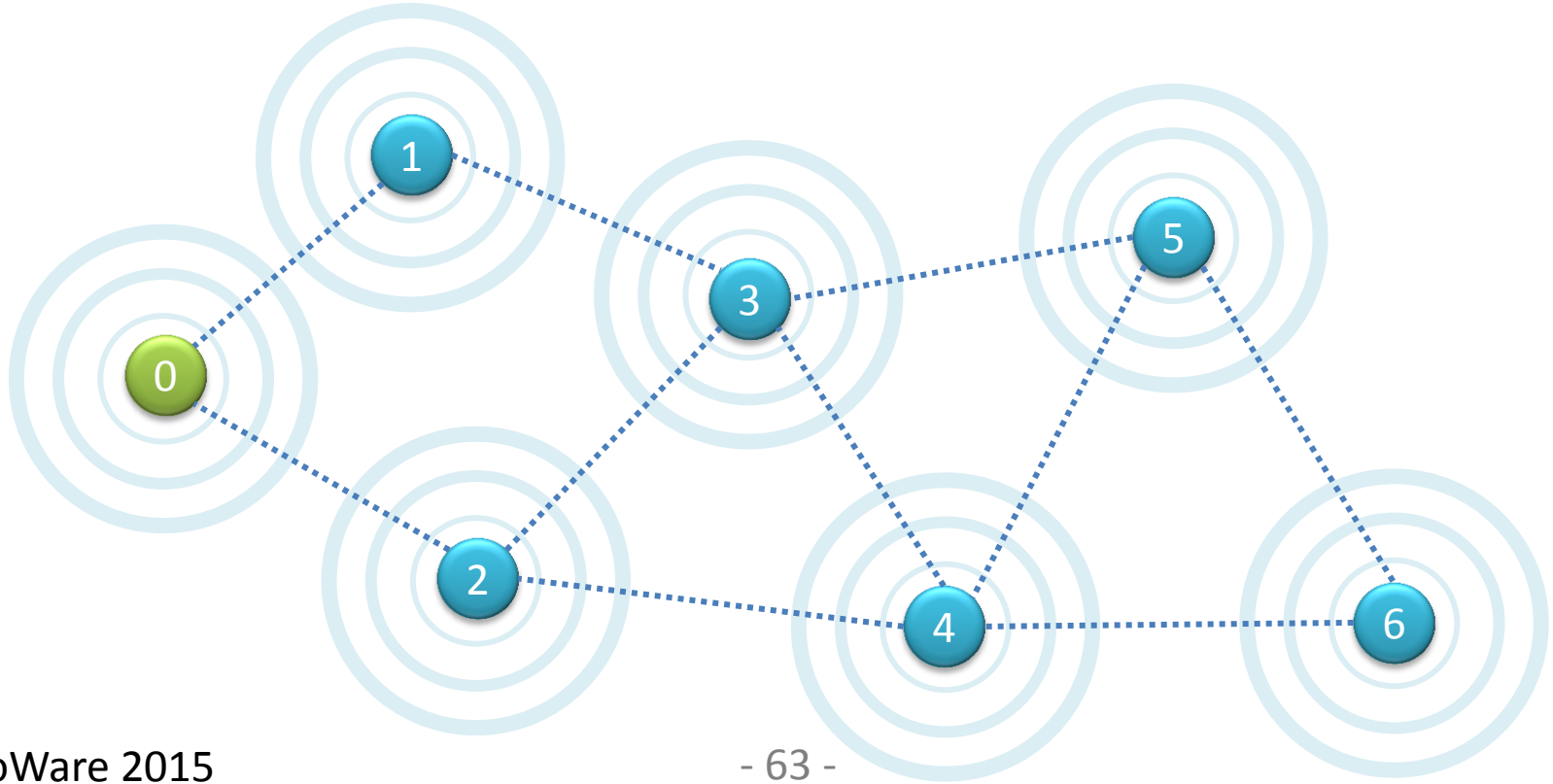
- Data aggregation
- Commands acknowledgements



FRC – Fast Response Commands

Smarter Wireless. Simply.

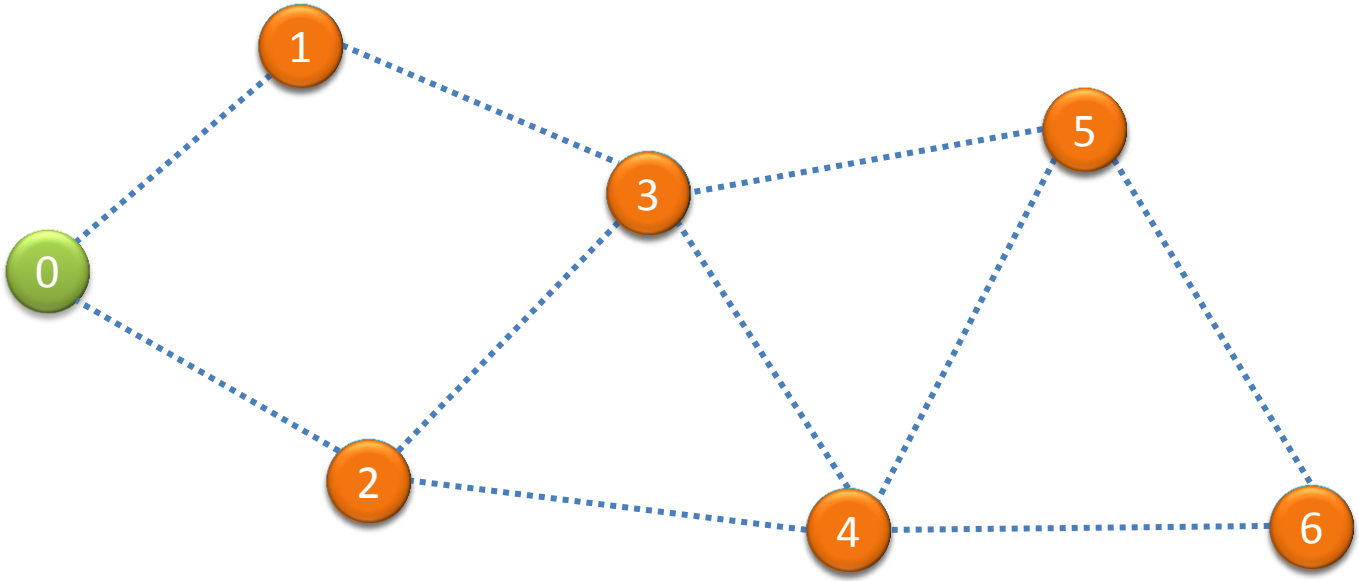
- Command distribution



FRC – Fast Response Commands

Smarter Wireless. Simply.

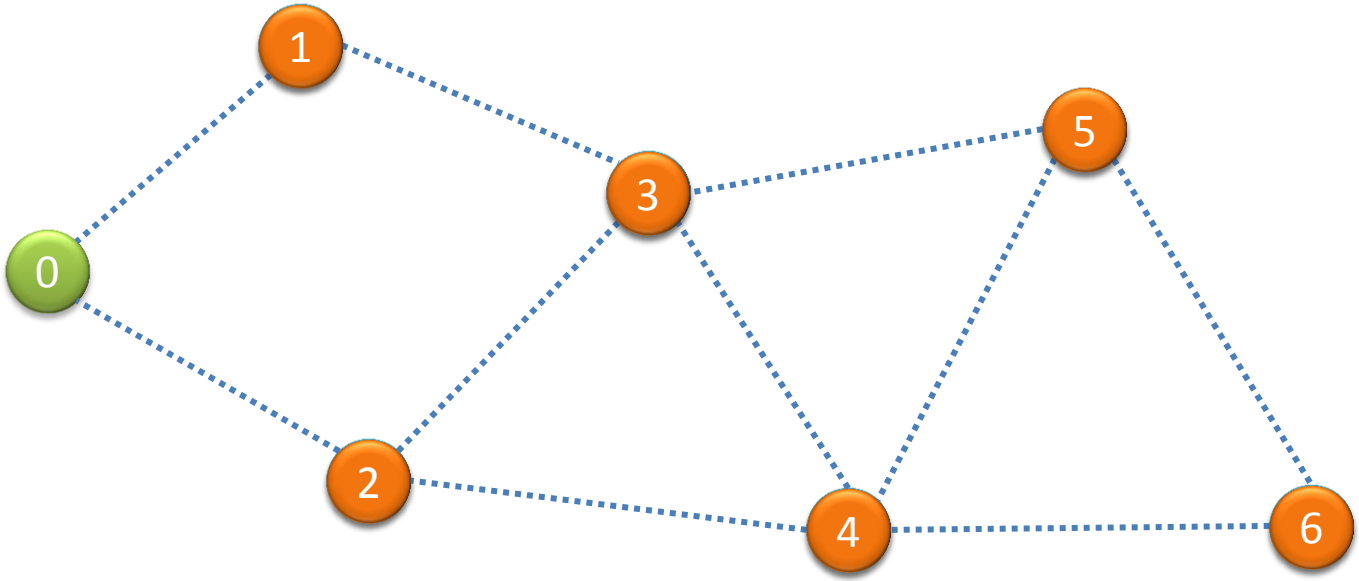
- Command execution



FRC – Fast Response Commands

Smarter Wireless. Simply.

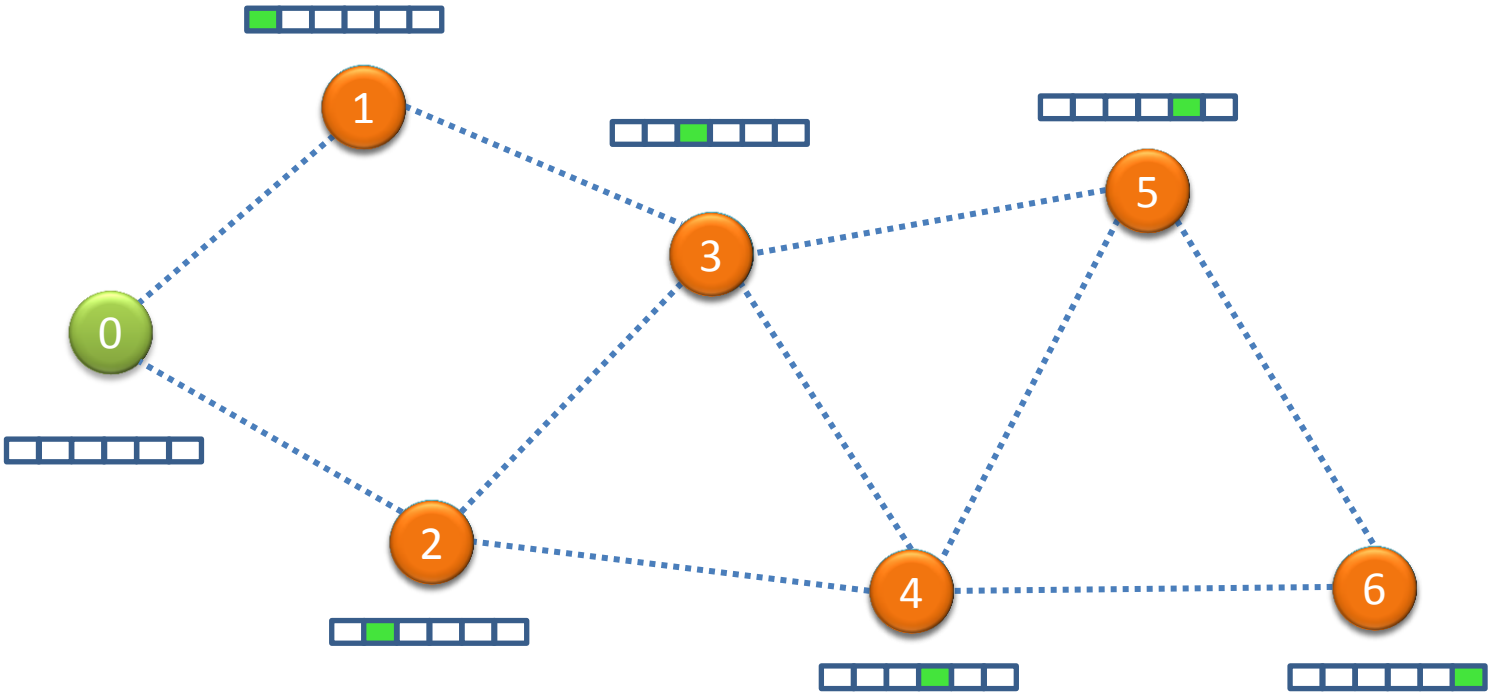
- Optional synchronization delay



FRC – Fast Response Commands

Smarter Wireless. Simply.

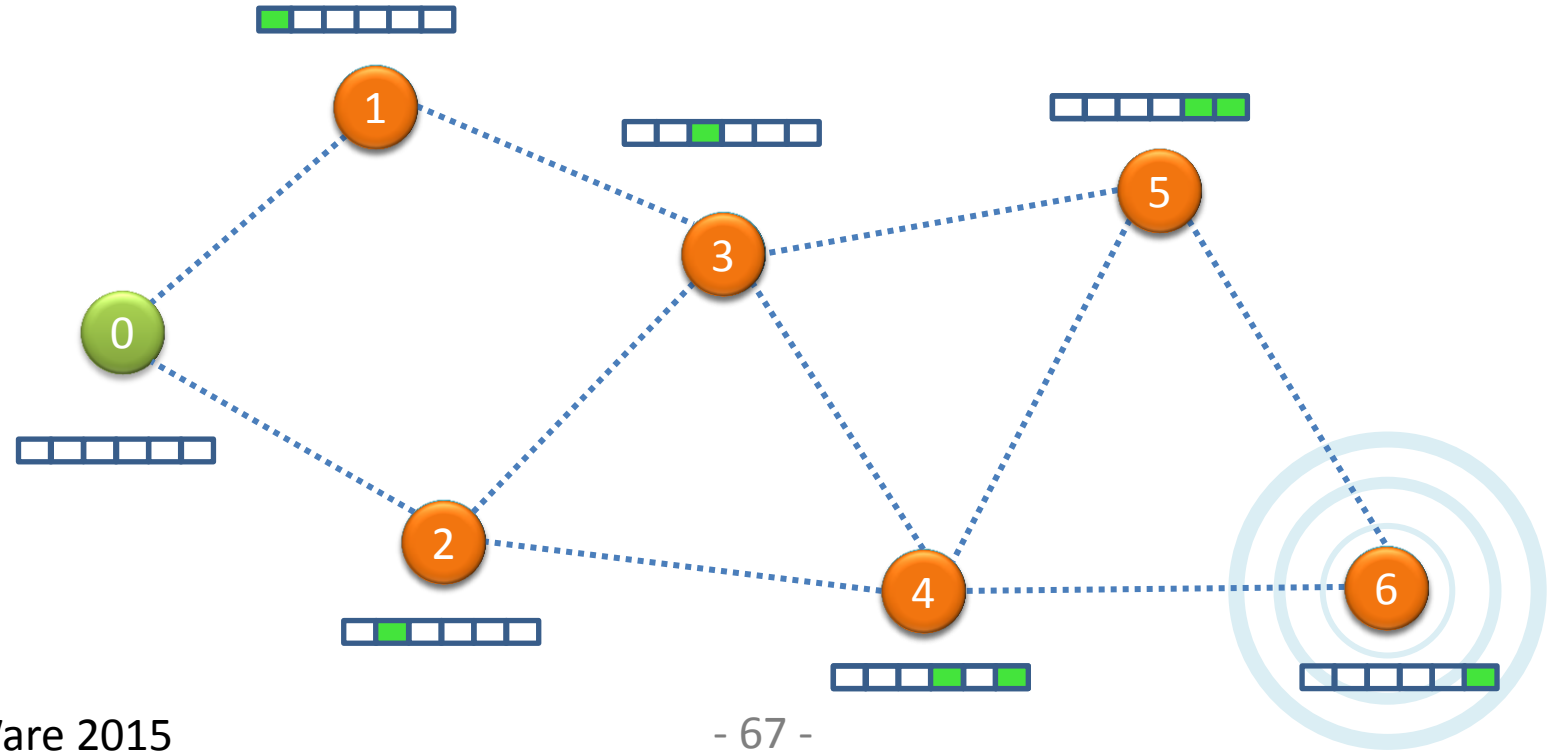
- Command acknowledgements



FRC – Fast Response Commands

Smarter Wireless. Simply.

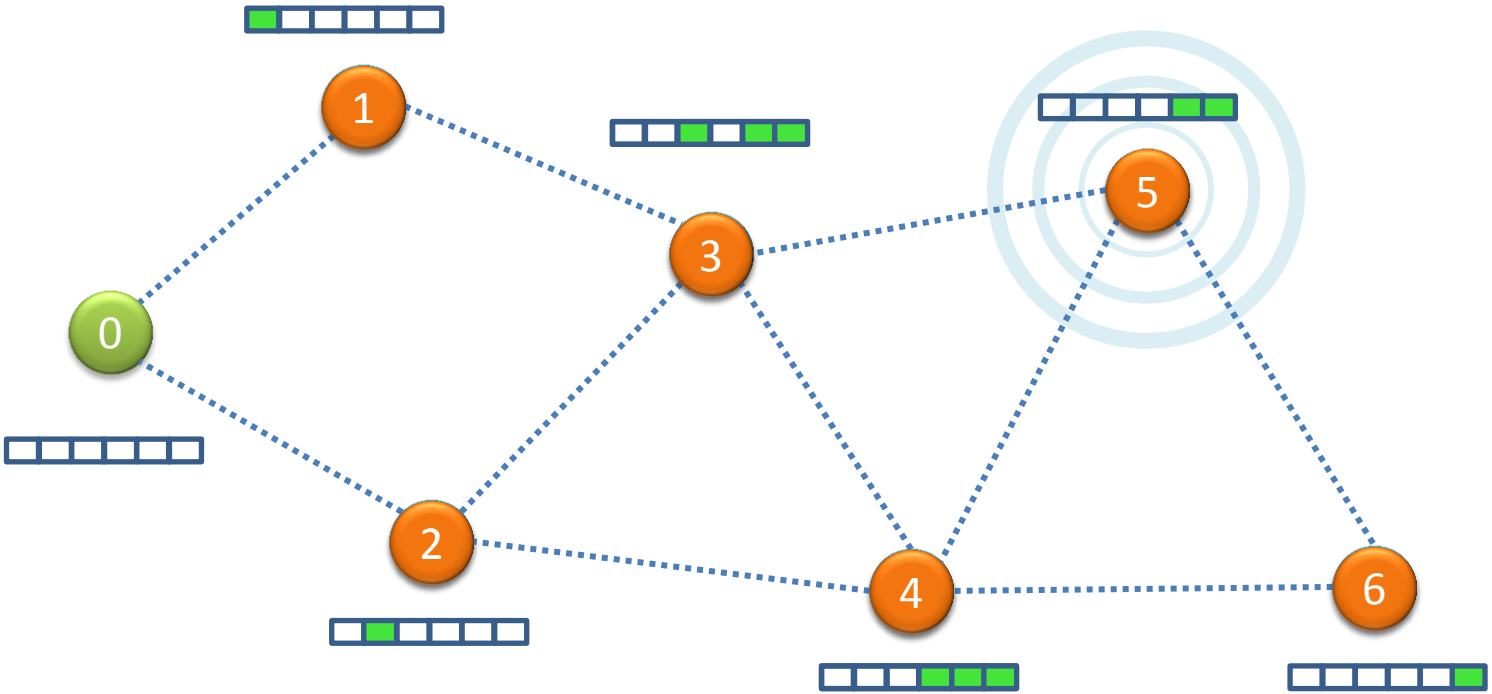
- Command acknowledgements



FRC – Fast Response Commands

Smarter Wireless. Simply.

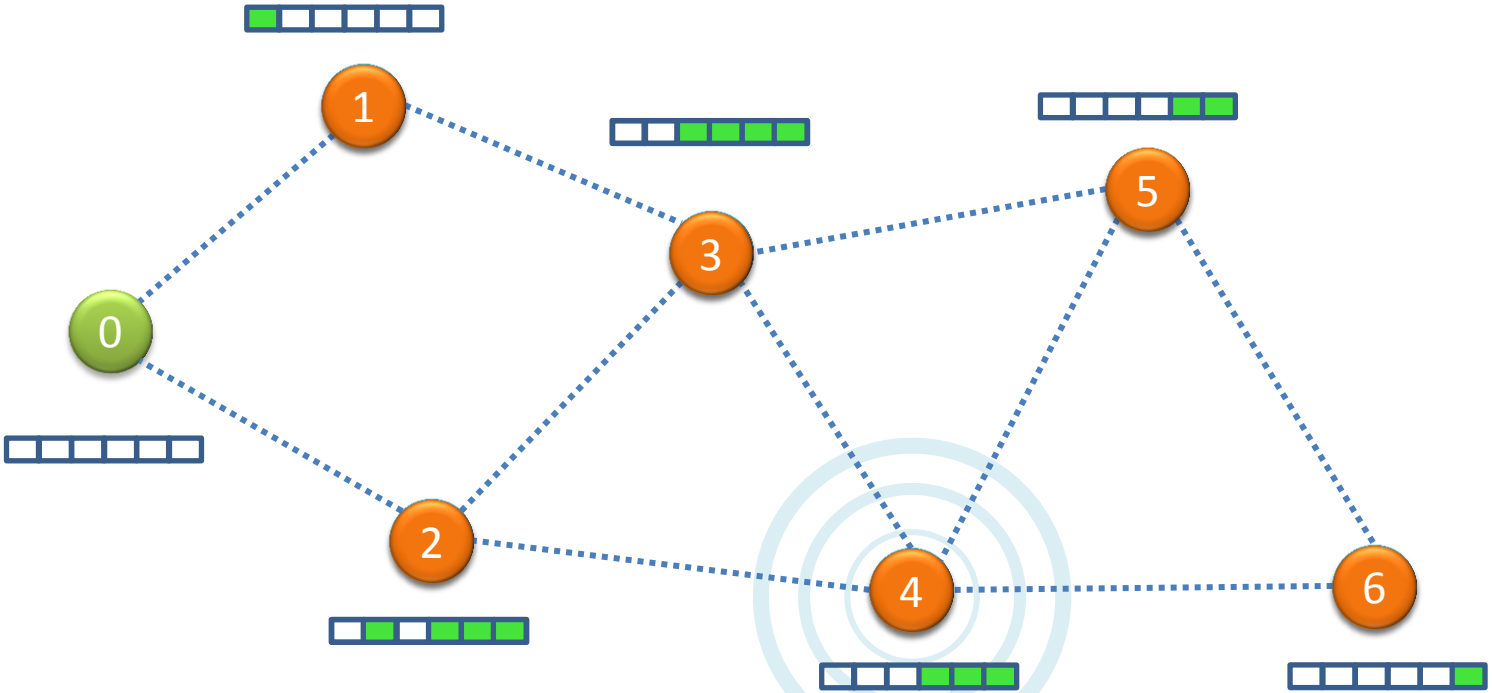
- Command acknowledgements



FRC – Fast Response Commands

Smarter Wireless. Simply.

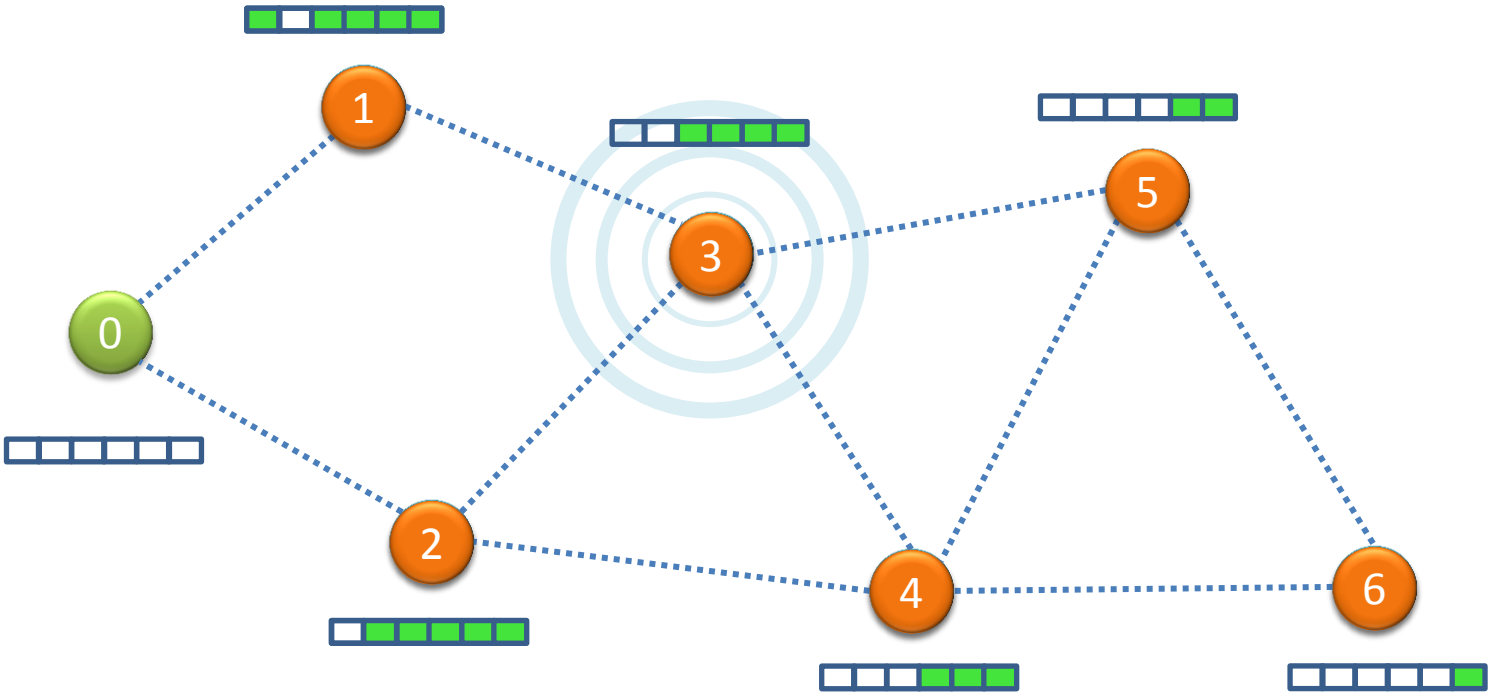
- Command acknowledgements



FRC – Fast Response Commands

Smarter Wireless. Simply.

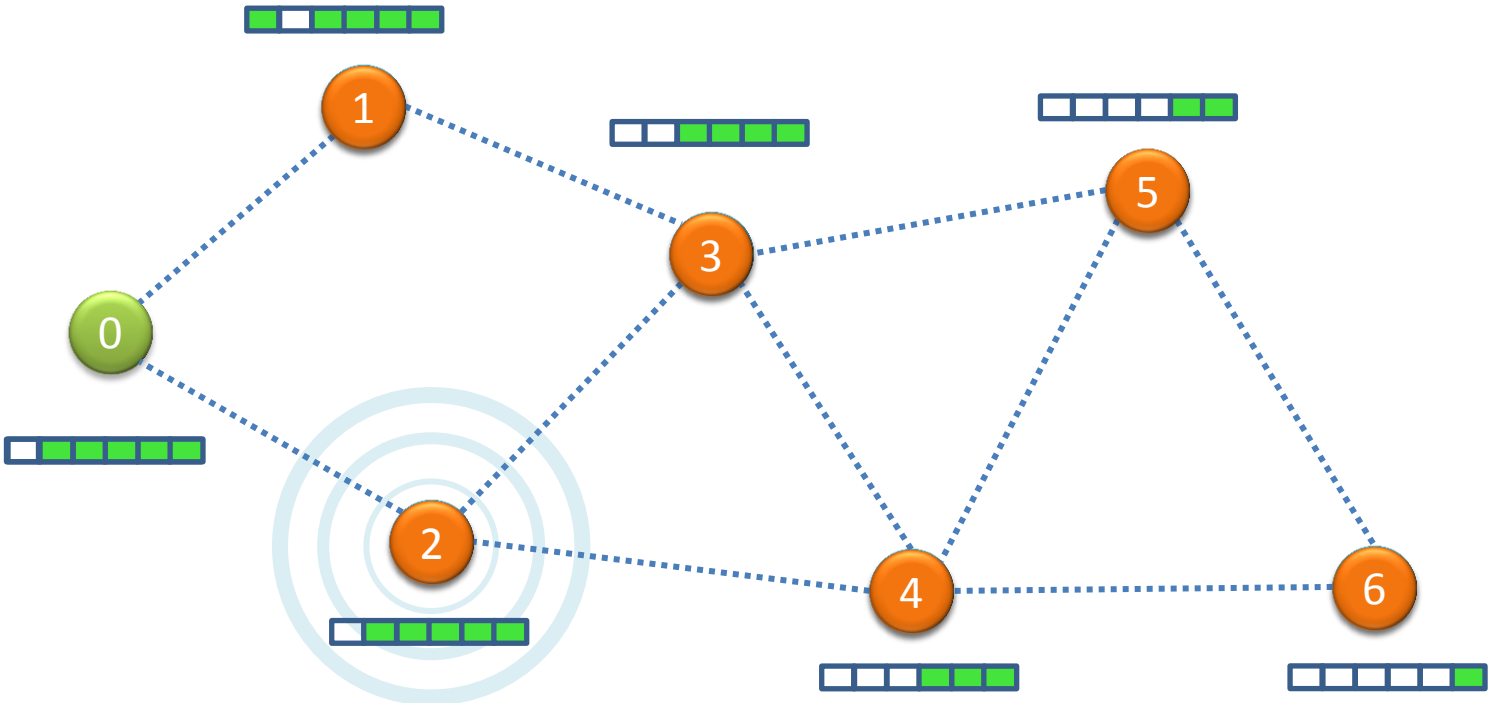
- Command acknowledgements



FRC – Fast Response Commands

Smarter Wireless. Simply.

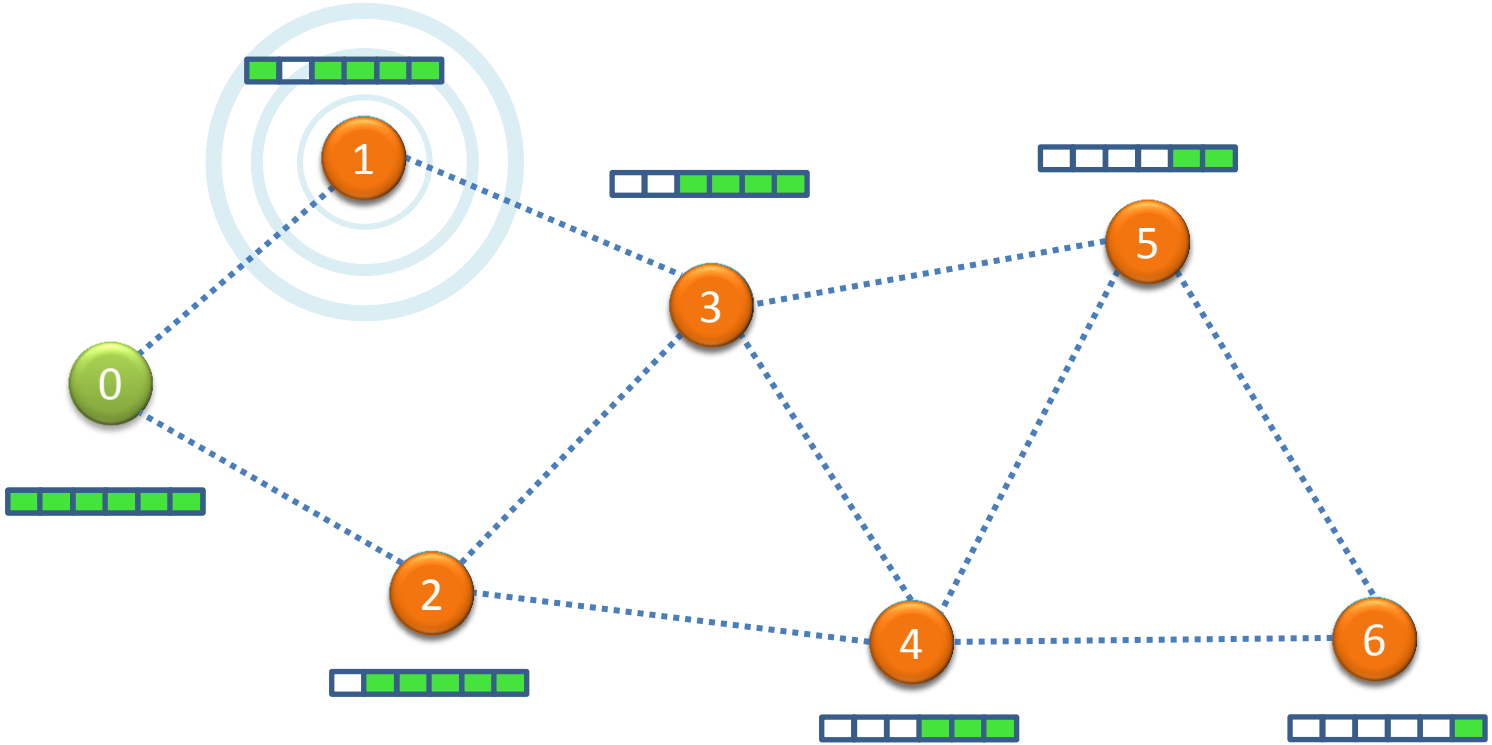
- Command acknowledgements



FRC – Fast Response Commands

Smarter Wireless. Simply.

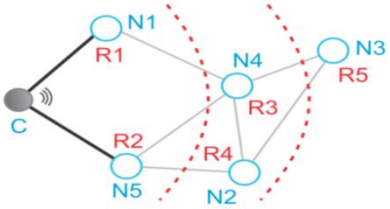
- Command acknowledgements



FRC – Fast Response Commands

Smarter Wireless. Simply.

HEADER			[NETWORKING AND SYSTEM]						DATA		SYNC		CRC-16
PIN	DLEN	CSH	NETWORKING	ROUTING	DPA	CRYPT	AUX	CSN	DATA-whitened	CSD	SYNC	CSS	

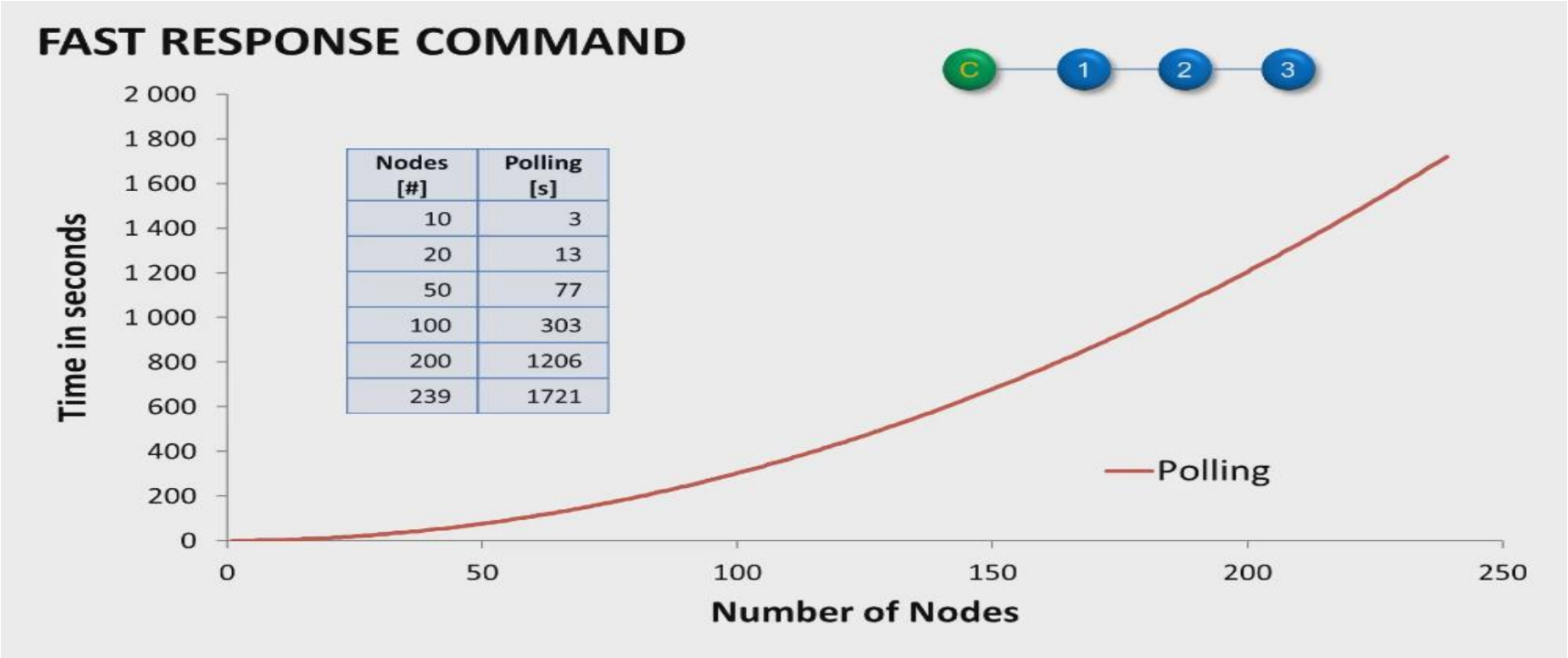


PIN							
NTWF	ACKF	ROUTEF	CRYPTF	DPAF	SYSPF	AUXF0	AUXF1

NETWORKING					ROUTING						Crypt Info		Direct Peripheral Access			AUX0	AUX1
RX=FF	TX	NETID0	NETID1	PID	RTOTX	RTDEF	RTHOPS	RTSLOT	RTDID	RTAUX	CRYPT0	CRYPT1	PNUM	PCOM	PPAR	---	---
NETWORKING AND SYSTEM																	

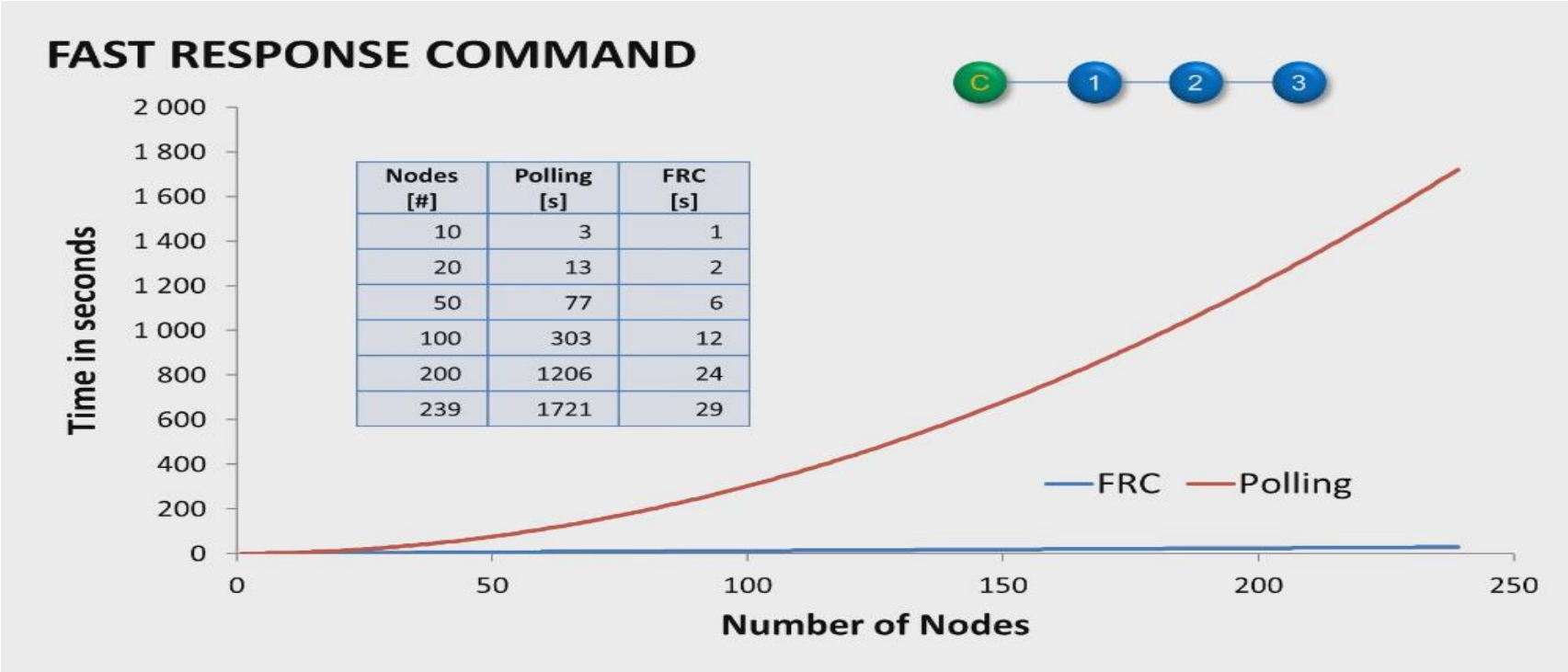
FRC – Fast Response Commands

Smarter Wireless. Simply.



FRC – Fast Response Commands

Smarter Wireless. Simply.



Nodes [#]	Polling [s]	FRC [s]
10	3	1
20	13	2
50	77	6
100	303	12
200	1206	24
239	1721	29

FRC – Fast Response Commands

Smarter Wireless. Simply.

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 846 584 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
09.09.2015 **Bulletin 2015/37**

(51) Int Cl.:
H04W 40/20 *(2009.01)* ***H04L 12/733*** *(2013.01)*

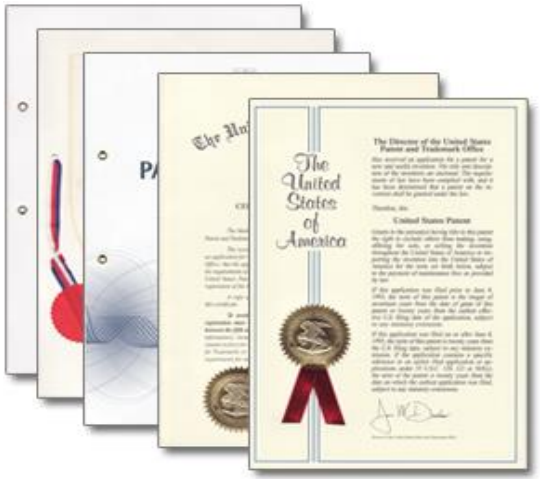
(21) Application number: **14002790.5**

(22) Date of filing: **11.08.2014**

(54) **Method of message acknowledgement and /or data collection**

Verfahren zur Nachrichtenbestätigung und/oder Datensammlung

Procédé de confirmation de réception de messages et/ou de collecte de données



FRC – Fast Response Commands

Smarter Wireless. Simply.

- Deploys network virtual configuration
- Each node combines messages and transmits just once
- FRC is time and energy extremely efficient
- Makes data aggregation linearly dependent on number of nodes in the network
- It is fully supported in IQRF OS and in IQRF DPA

POTENTIAL APPLICATIONS

- WSN - data collection
- Broadcast acknowledgements
- Scenes realization
- WMNs maintenance

MICRORISC s.r.o.

Why we need WMN?

WMN as a challenge

IQMESH®protocol

IQRF® ecosystem

IQRF® Data Controlled Transceivers

FRC® - Fast Response Commands

Summary

Summary

Smarter Wireless. Simply.

- WMN can be an excellent tool
- WMN is an algorithmic challenge
- Optimal does not mean the shortest
- Redundancy helps to increase reliability
- IQMESH networks are virtually reconfigured
- IQMESH networks use synchronized directional flooding
- IQMESH networks are energy efficient, each node is transmitting and listening just once during the frame
- DPA accelerates technology deployment
- FRC is extremely efficient tool for data aggregation or for messages acknowledgements

Summary

Smarter Wireless. Simply.

- WMN can solve the main task of any application

Reliable and efficient control + monitoring

- **IQRF ecosystem shows practically that WMNs can be efficiently deployed and bring new opportunities to all industrial sectors.**


ZONE


Thank you

IQRF Wireless Challenge II

Smarter Wireless. Simply.

Smarter Wireless. Simply.

Technology info is available at http://iqrf.org