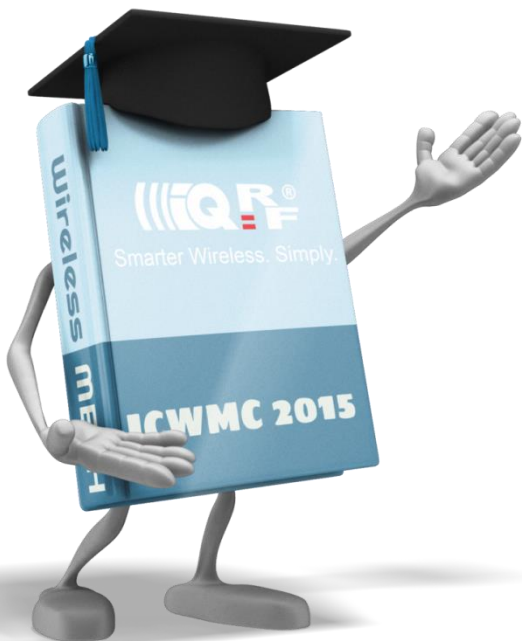


11th International Conference on Wireless and Mobile Communications
ICWMC 2015 | Oct 11-16, 2015 | St. Julians, Malta

Wireless Mesh Networks. IQRF.

Vladimír Šulc
MICRORISC s.r.o.



MICRORISC s.r.o.

Why we need WMN?

WMN as a challenge

IQMESH[®] protocol

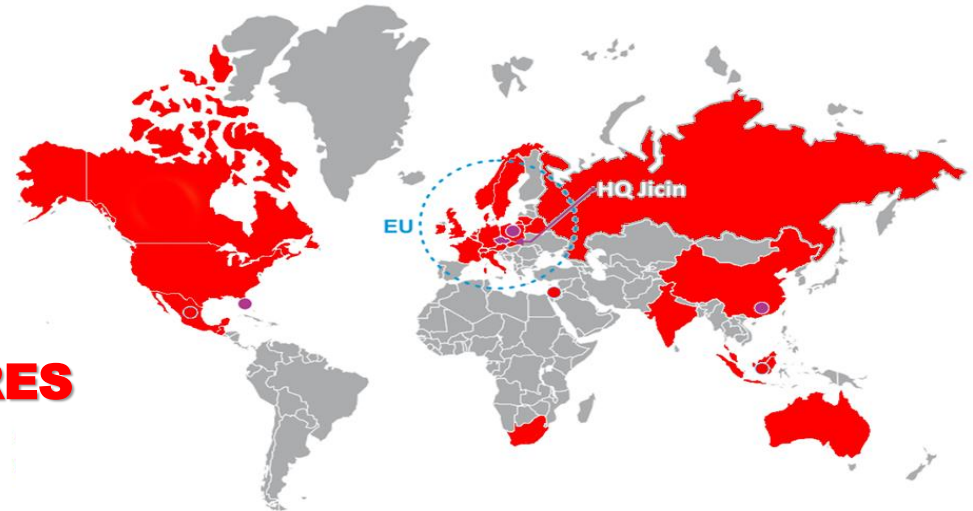
IQRF[®] ecosystem

IQRF[®] Data Controlled Transceivers

FRC[®] - Fast Response Commands

Summary

CZECH
MODERN
TECHNOLOGICAL
WITH CLEAR VISIONS
ORIENTED TO MANUFACTURES
PRIVATELY OWNED
INNOVATIVE
GLOBAL



MICRORISC

... ENABLING FUTURE INNOVATION®

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



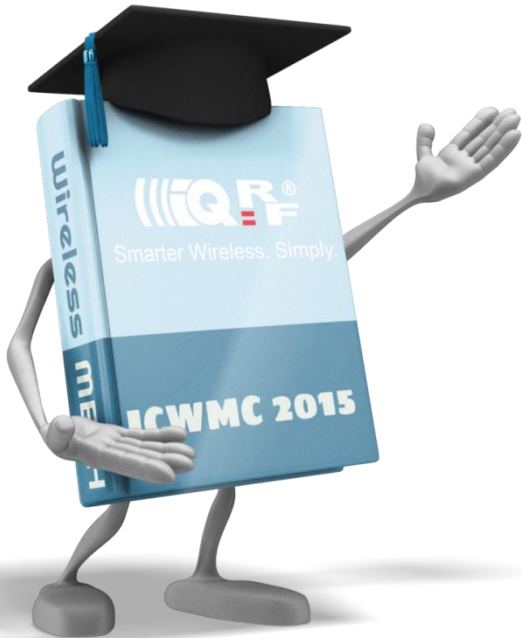
MICRORISC

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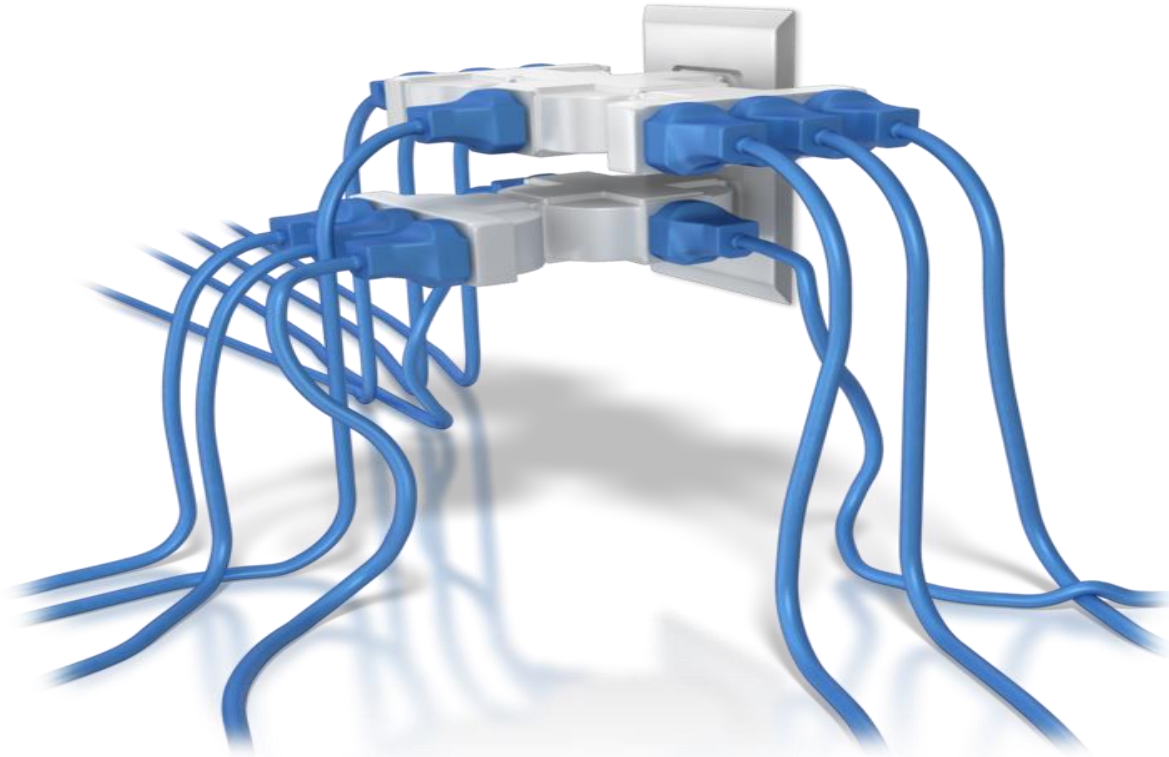
IQRF® ecosystem

IQRF® Data Controlled Transceivers

FRC® - Fast Response Commands

Summary

We Need Wireless ...



We Need Wireless ...



We Need Wireless ...

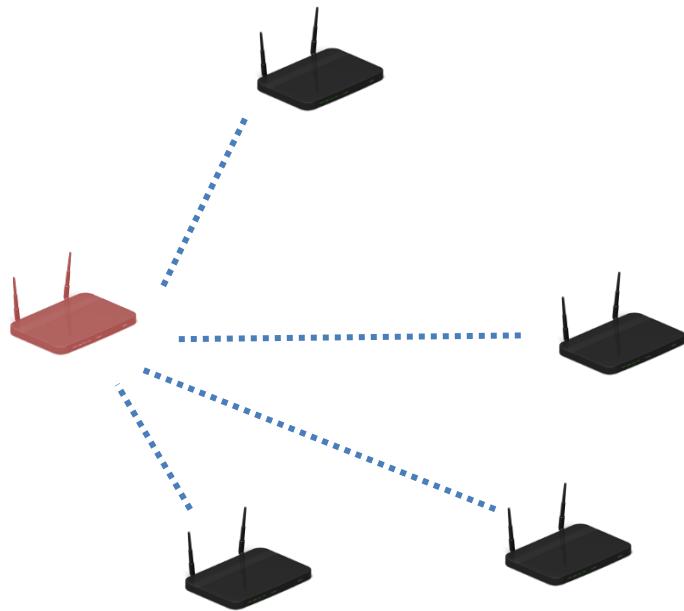


The most popular topologies

☐ Point / Point

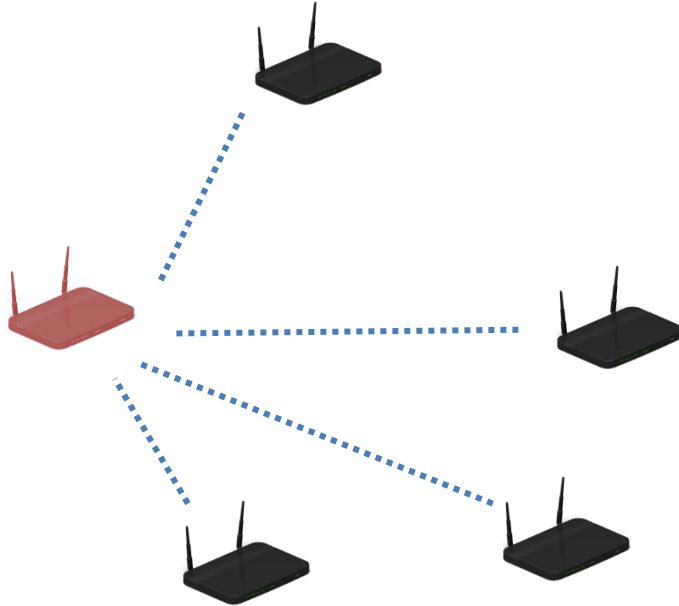


☐ Star topology



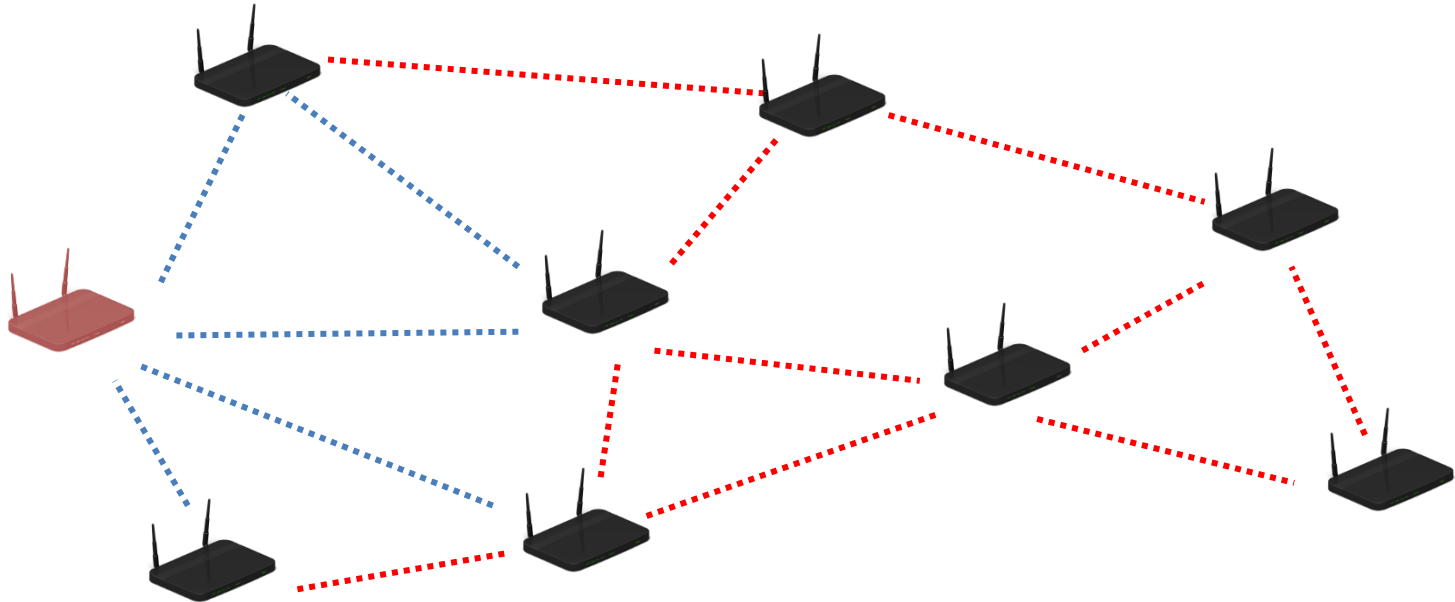
Why we need WMN?

- ❑ WMN fixes potential problems of Star topology



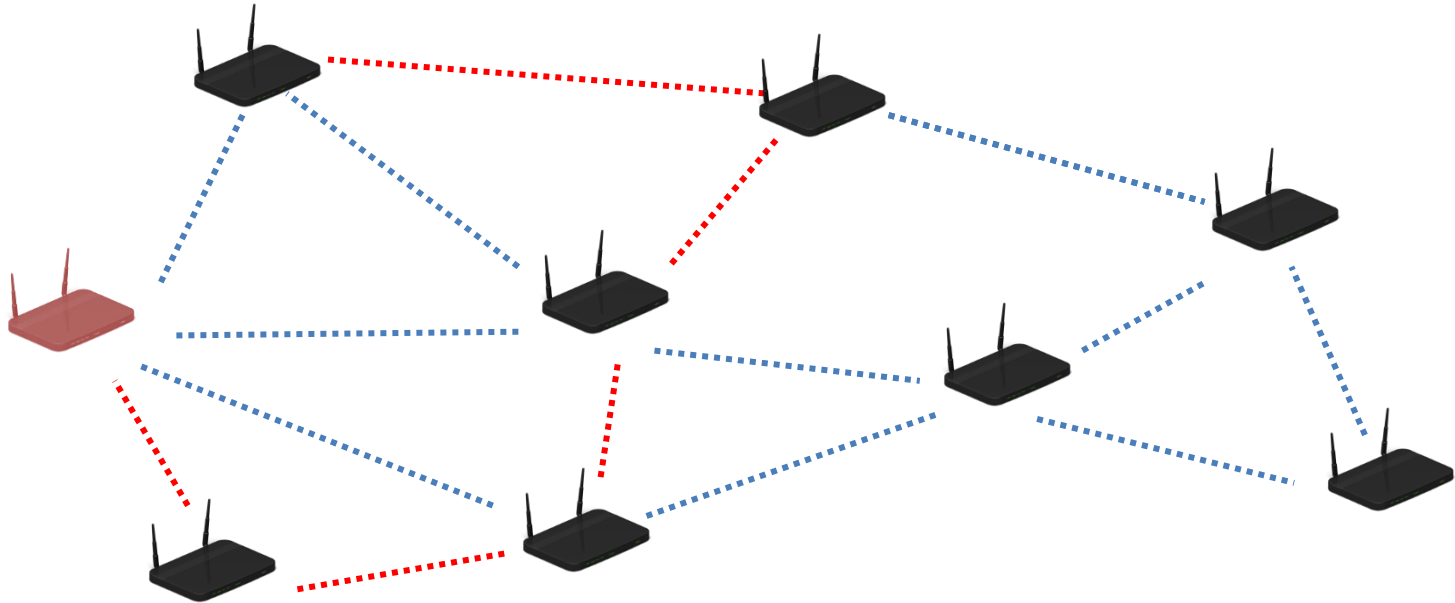
Why we need WMN?

- ❑ WMN extends the range



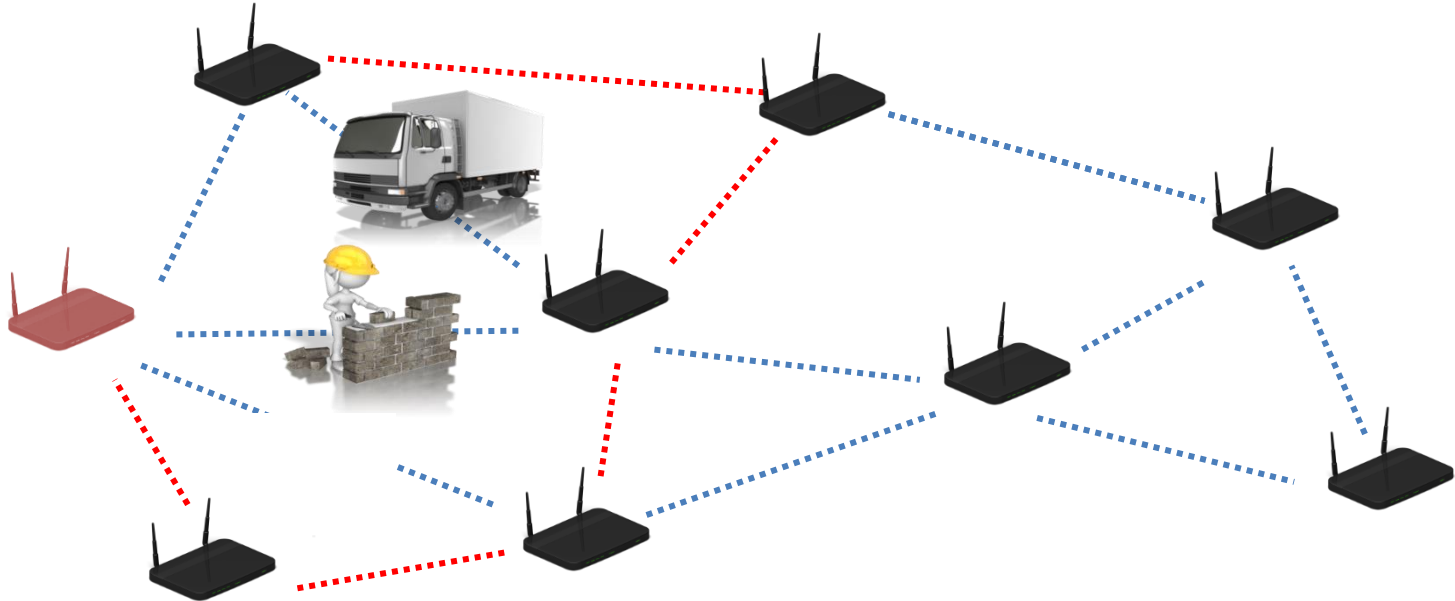
Why we need WMN?

- ❑ WMN increases robustness and reliability



Why we need WMN?

- ❑ WMN respects physics and environment



Why we need WMN?

- ❑ WMN extends communication range
 - ❑ WMN increases robustness and reliability
 - ❑ WMN respects physics and environment
-
- ❑ WMNs enable new applications and opportunities



Why we need WMN?

- ❑ WMN extends communication range
 - ❑ WMN increases robustness and reliability
 - ❑ WMN respects physics and environment
-
- ❑ WMNs enables new applications and opportunities

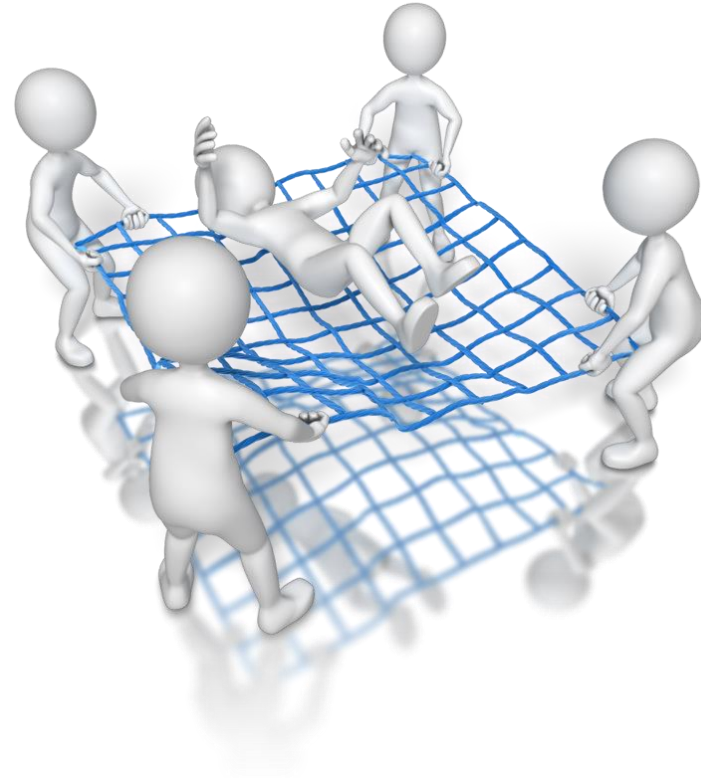
Why everybody does not use it, if it is so great?



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

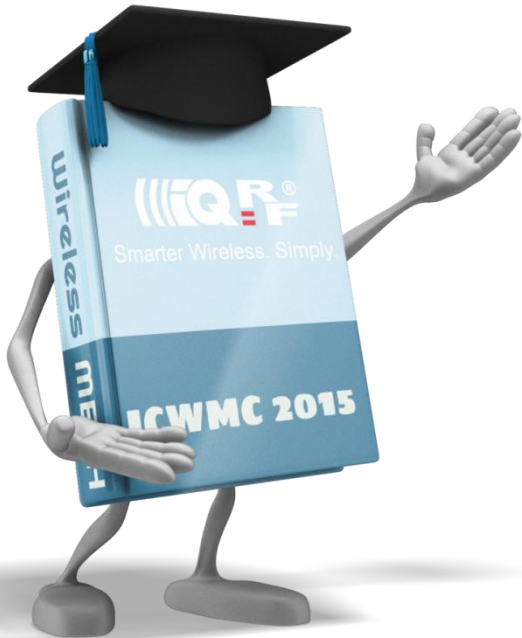
(2015 – unwanted)



Why we need WMN?

... because WMN brings big algorithmic challenges





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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

Each path can be 1 – N hops long

We are working with slow bit rates

Conditions can change in time

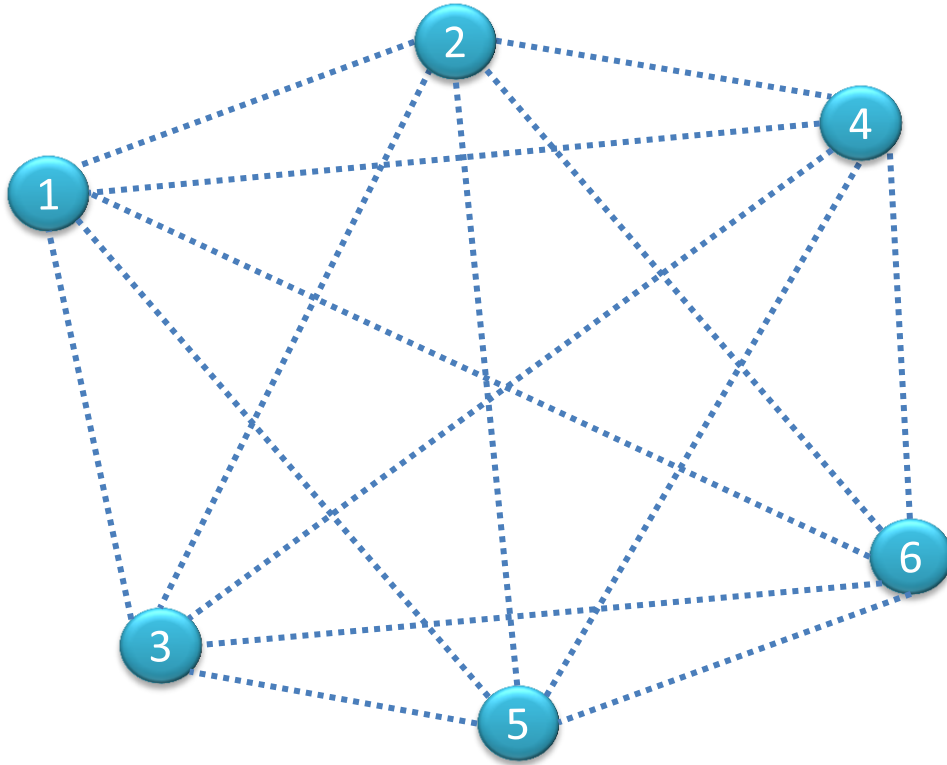
Links may not be symmetrical

There are limited HW resources

Routing should be realized in real time



WMN as a challenge



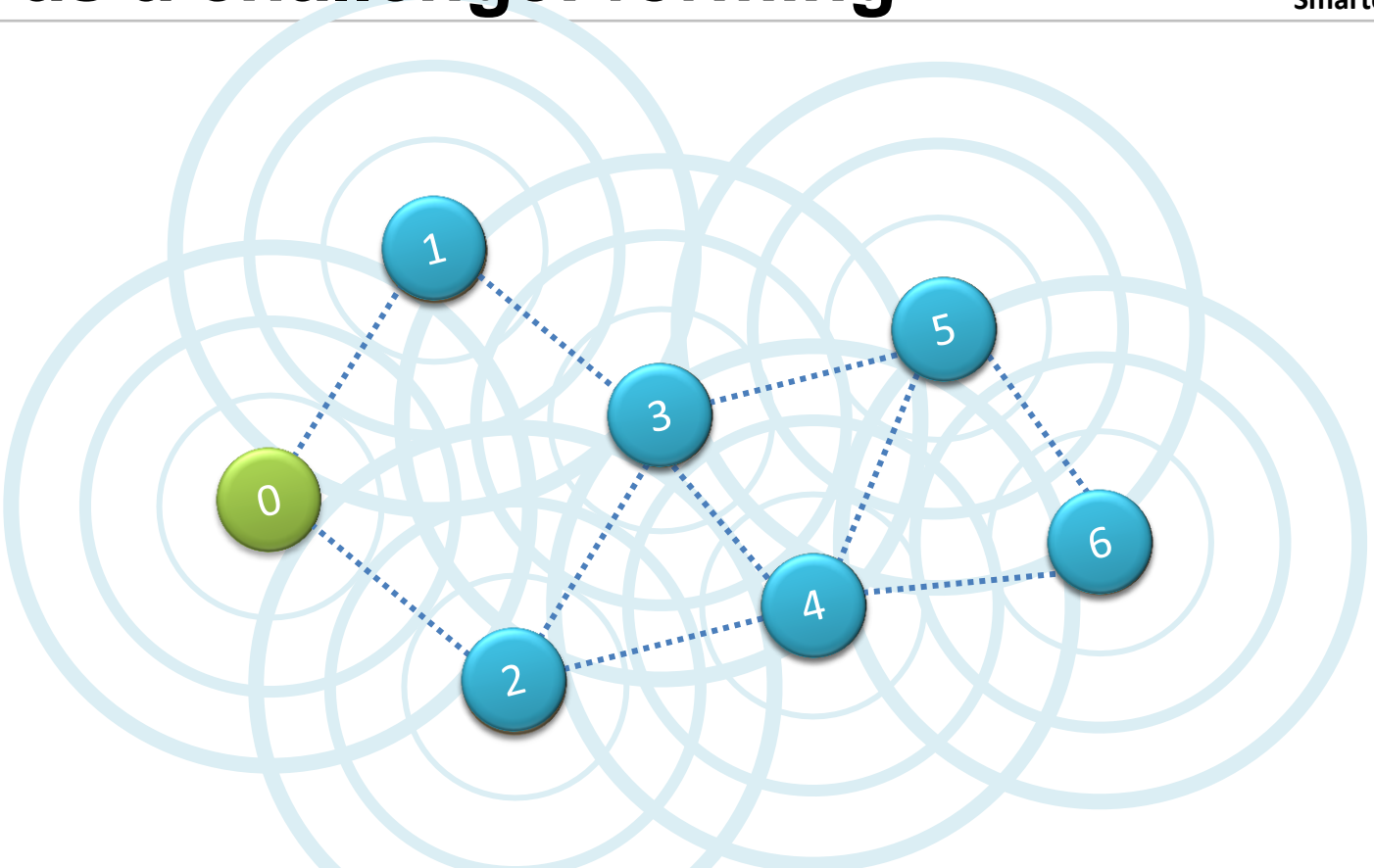
n:	N_{MAX}
2:	1
3:	3
4:	6
5:	10
6:	15

100:	4950

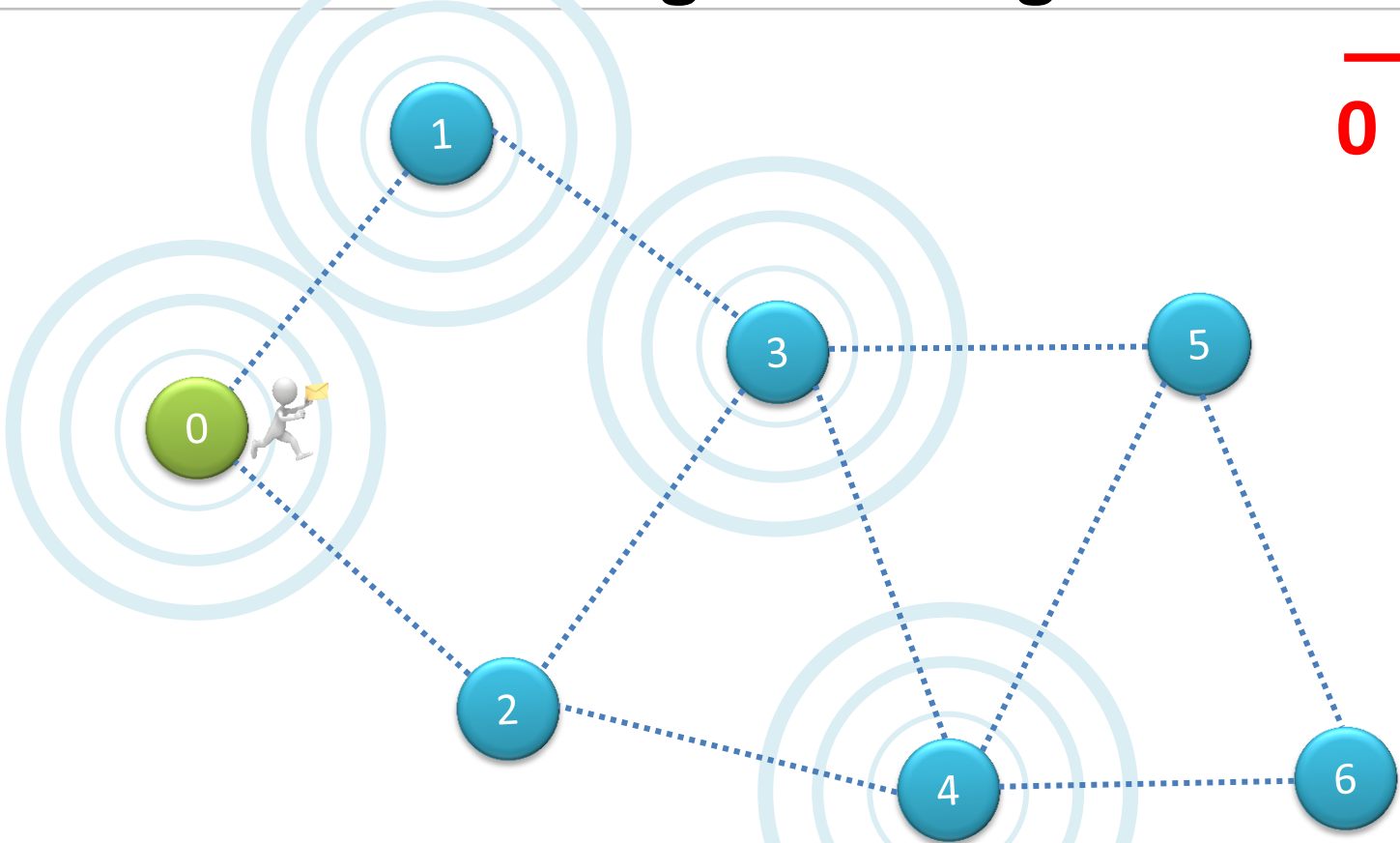
240:	28680

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

WMN as a challenge: forming

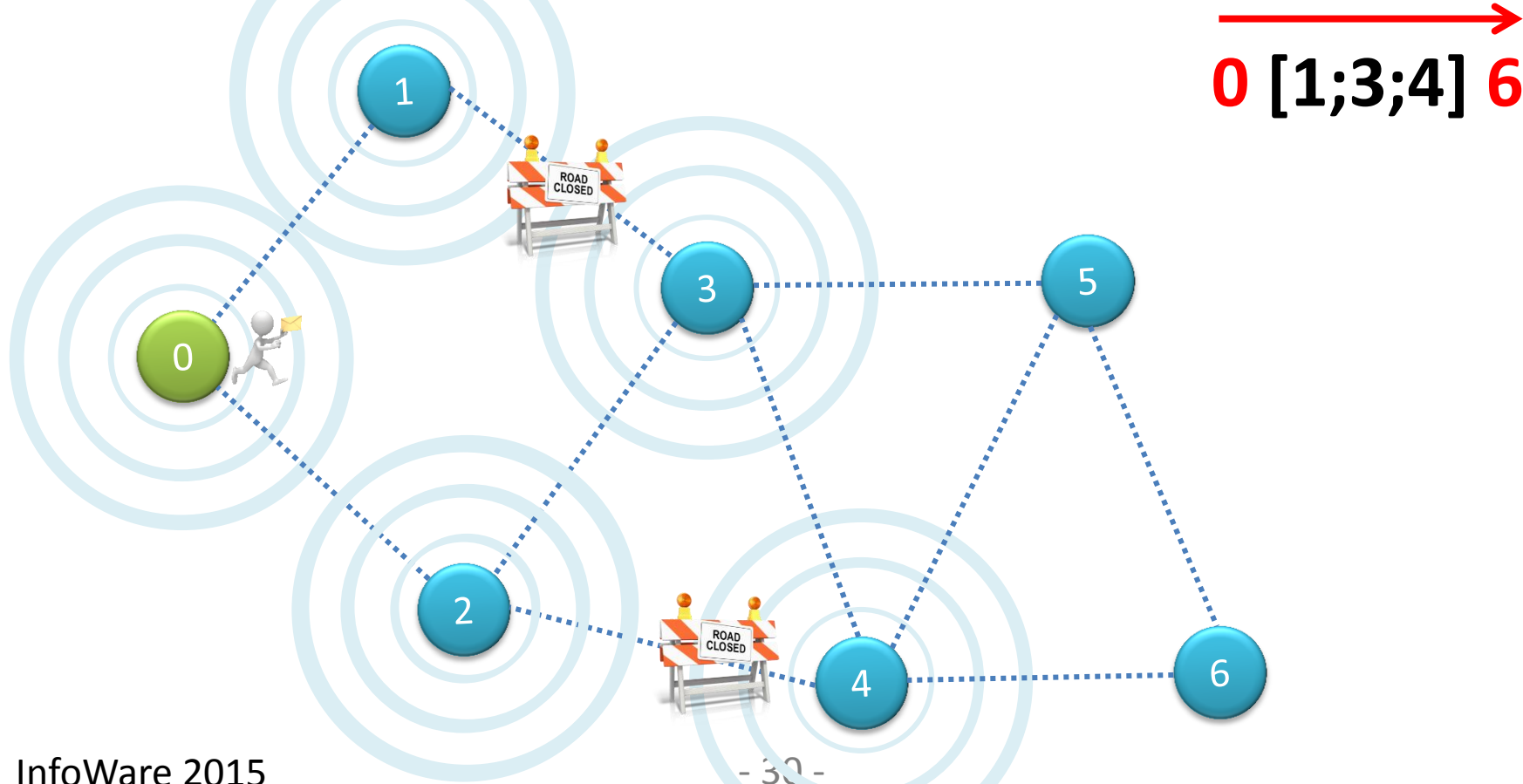


WMN as a challenge: routing



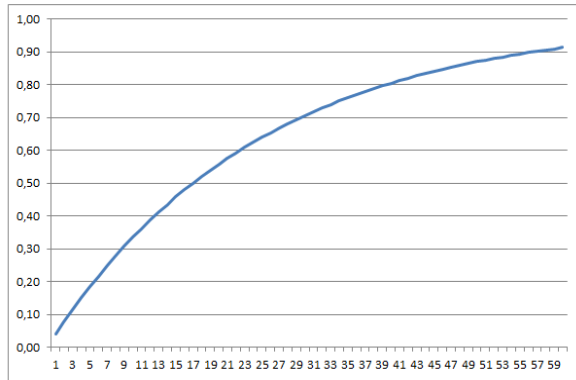
→
0 [1;3;4] 6

WMN as a challenge: routing



**Optimizing may lead to inefficiency
(8 transmissions instead of 4)**

Optimizing may lead to unefficiency



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

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

Unefficiency means higher power consumption

Optimizing needs system resources

Task: “Optimize efficiently to route reliably”



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Why we need WMN?

WMN as a challenge

IQMESH[®] protocol

IQRF[®] ecosystem

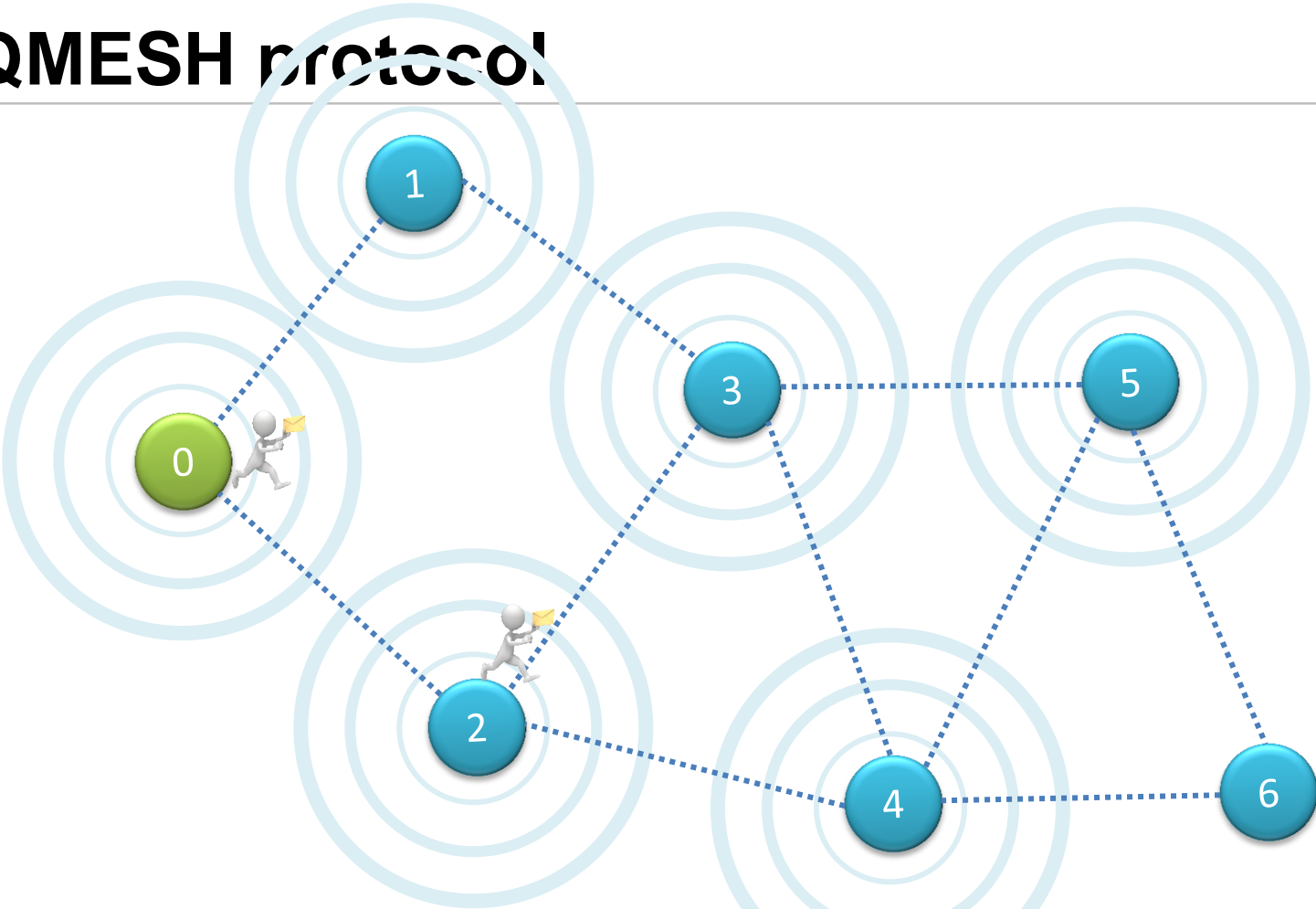
IQRF[®] Data Controlled Transceivers

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Summary

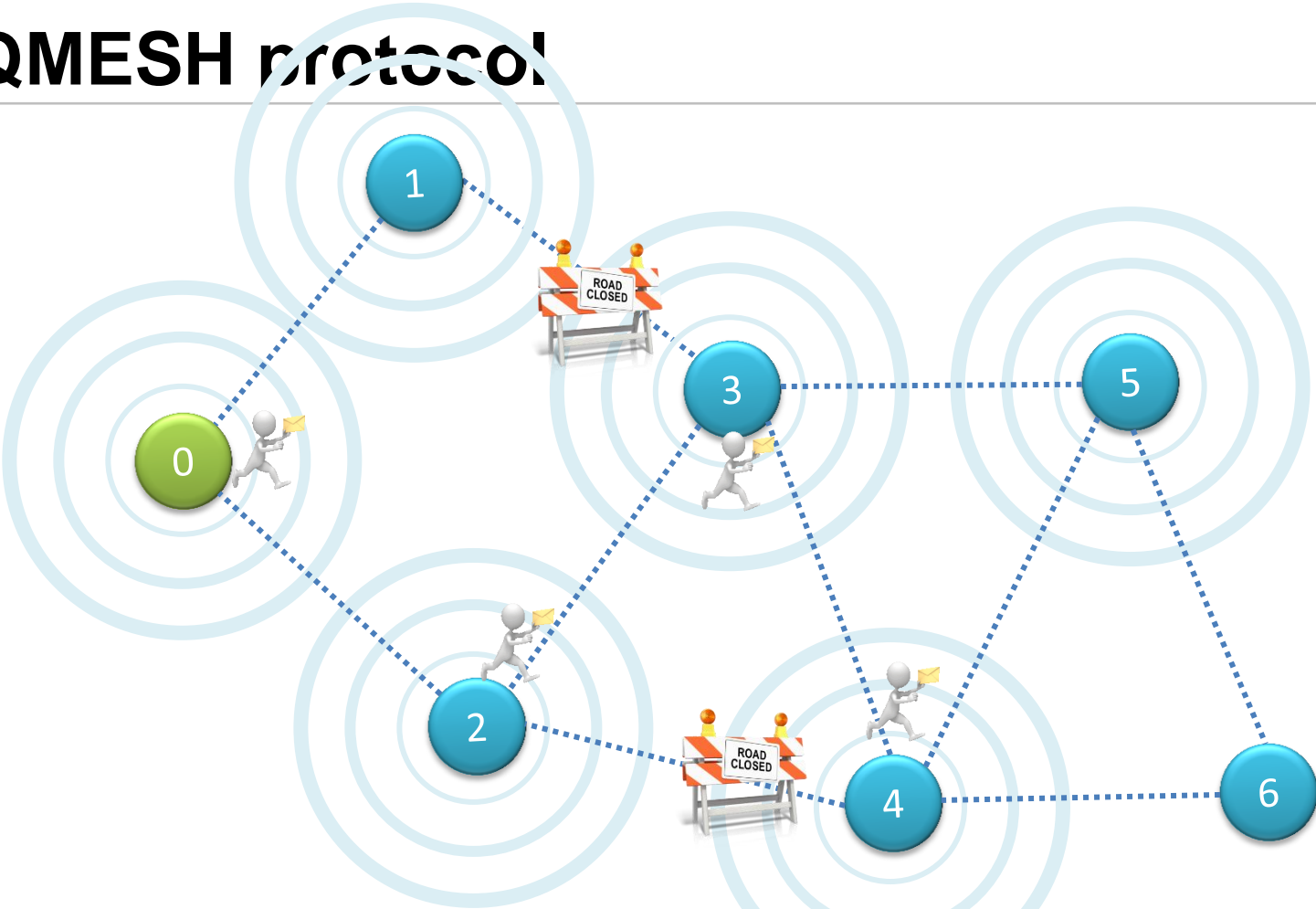
IQMESH protocol

0 → 6



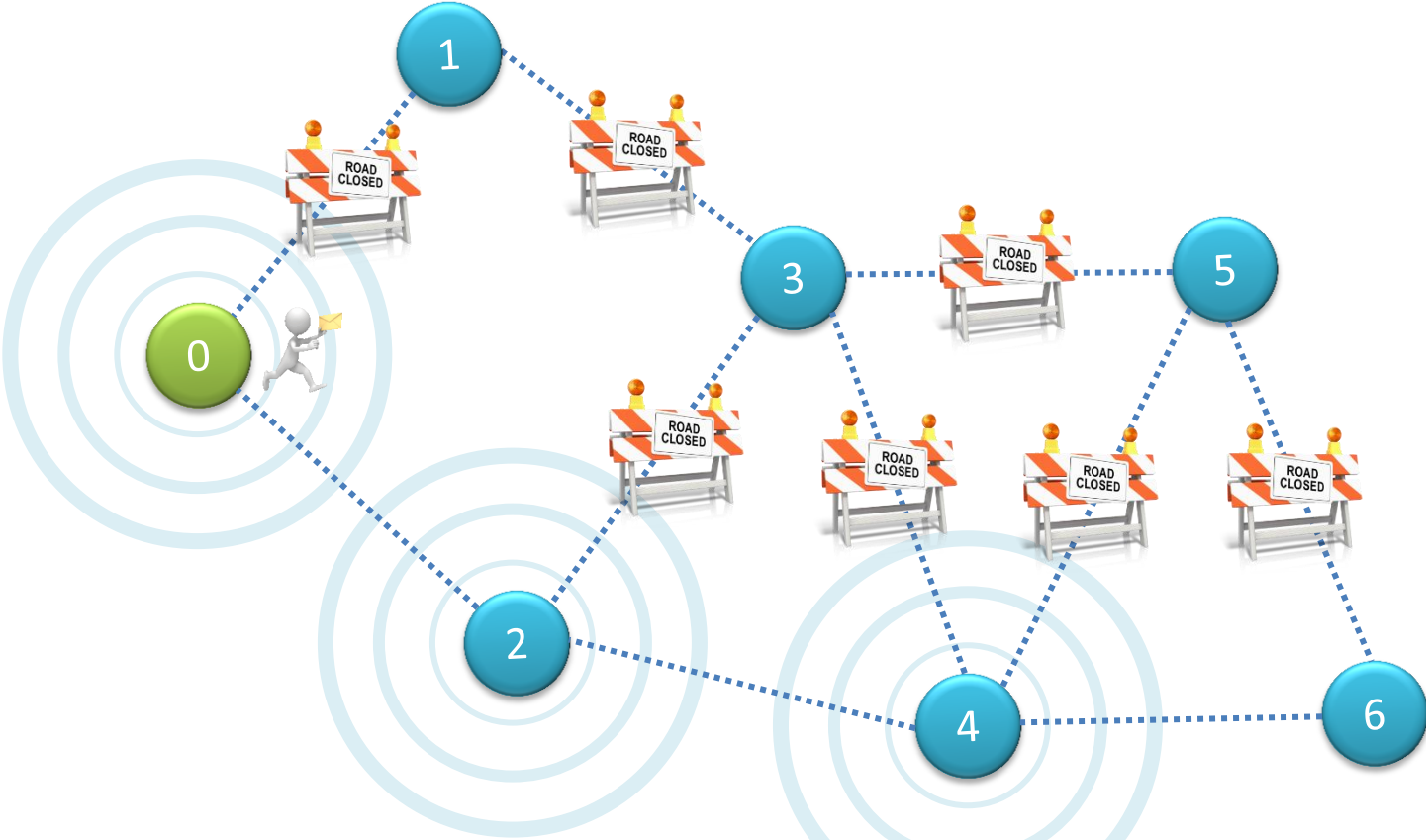
IQMESH protocol

0 → 6



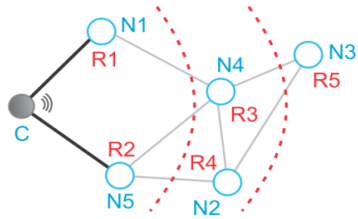
IQMESH protocol

0 → 6

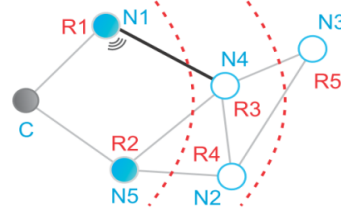


Deterministic and reliable
(Even under very bad conditions)

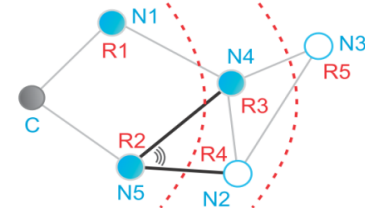
IQMESH protocol: addressing vs. routing



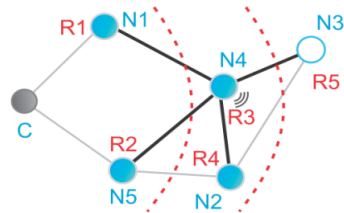
Frame 0 1 2 3 4



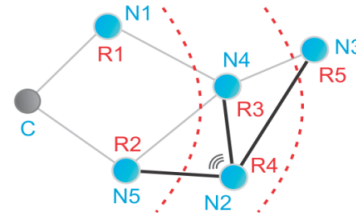
Frame 0 1 2 3 4










Frame 0 1 2 3 4



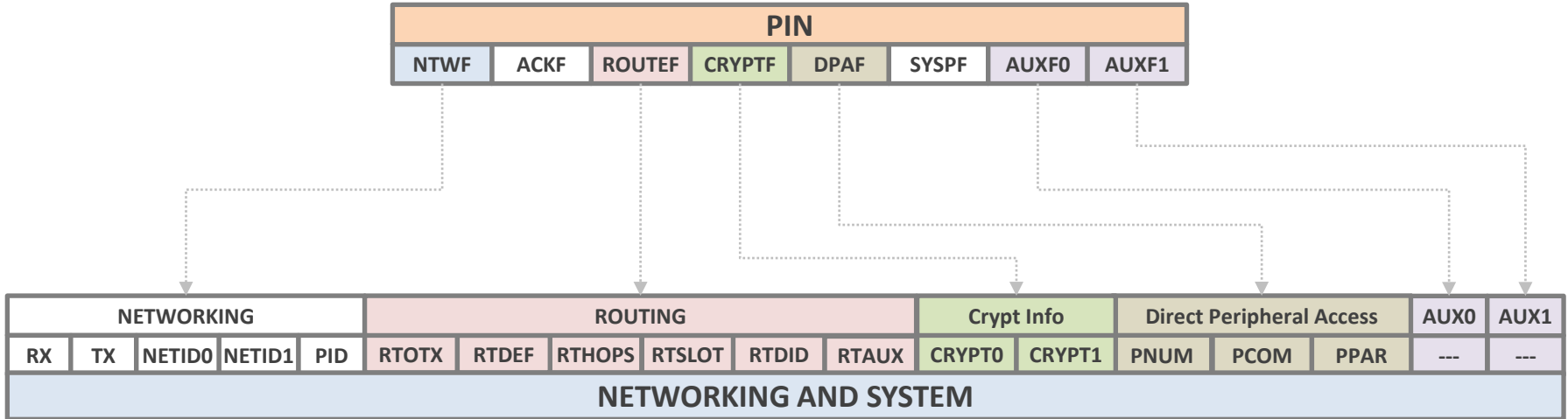
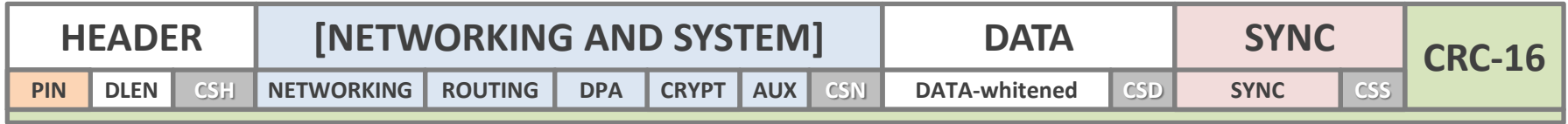
Frame 0 1 2 3 4



Frame 0 1 2 3 4

-  Coordinator
-  Node
-  Reached node
-  Active node (TX)
-  Available link
-  Activated link
-  Active time slot

IQMESH protocol



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

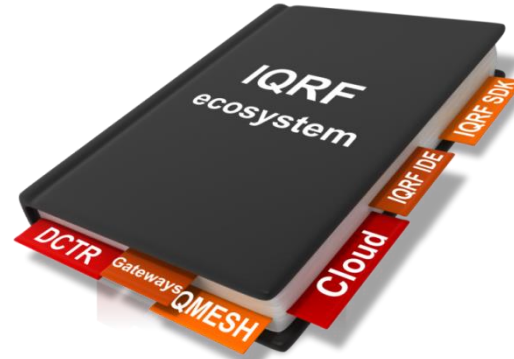
$$P_{okZONE} = 1 - (1 - P_p^k)^i$$

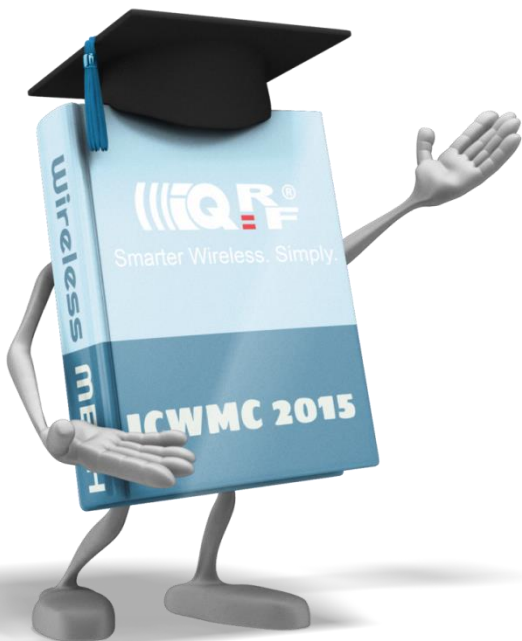
Successful RX probability dramatically increases

Deterministic time latency

Very low implementation costs

IQMESH[®] protocol is deployed in IQRF[®] ecosystem





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IQRF® ecosystem

IQRF® Data Controlled Transceivers

FRC® - Fast Response Commands

Summary

IQRF ecosystem



IQRF ecosystem

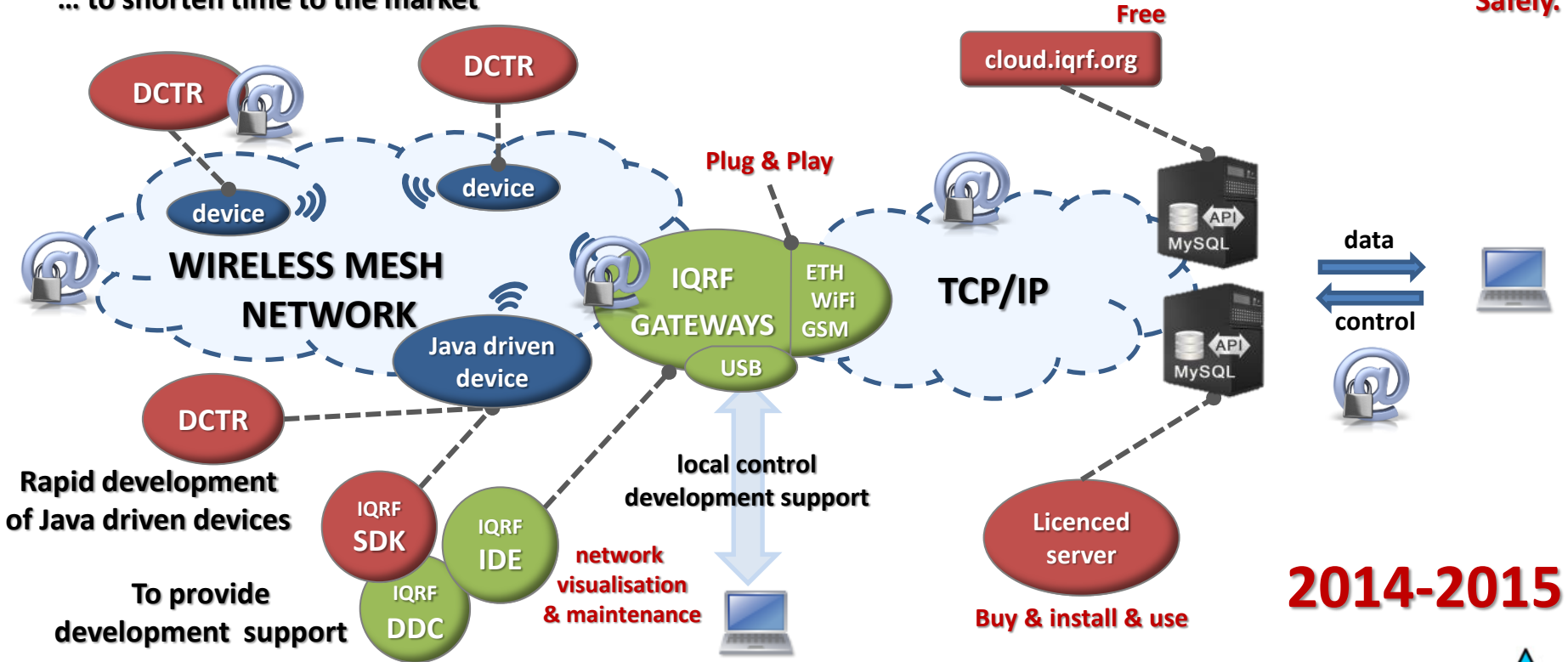


Smarter Wireless. Simply.

To make devices wireless. **Simply.**
... to shorten time to the market

To make these devices accessible via Internet.

To use them via Internet. **Safely.**

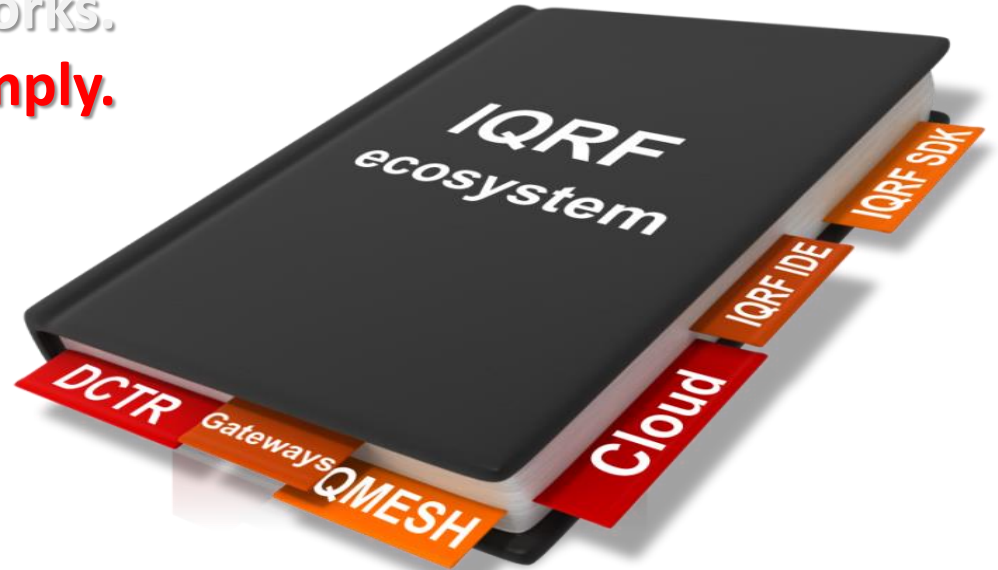


2014-2015



IQRF ecosystem

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



IQRF ecosystem: system components

TR-72Dx



TR-76Dx



GW-GSM-02A



GW-WIFI-01



DS-START-04



DS-DPA-02



IQRF-BB-01

GW-ETH-02A



GW-USB-06

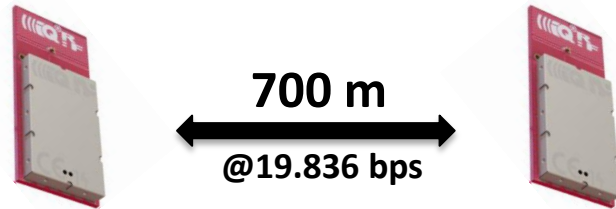
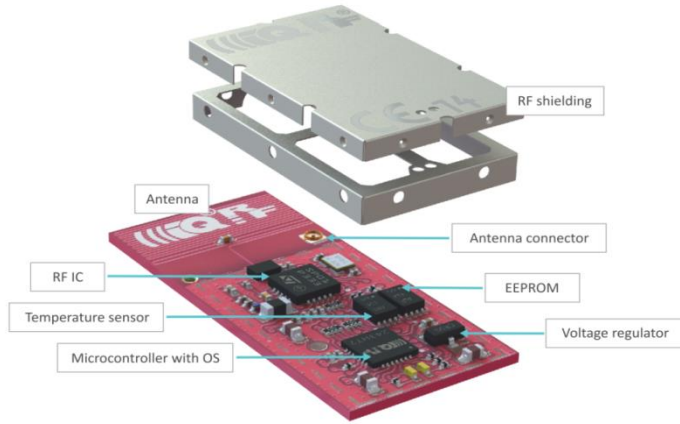


RT-230-06



Complete product info is available at <http://iqr.org>

IQRF ecosystem: excellent transceivers



TR-72Dx

TR-76Dx



RX

STD:

LP:

XLP:

12.3 mA

230 μ A

16 μ A

TX

setTXpower(0):

setTXpower(1):

setTXpower(2):

setTXpower(3):

setTXpower(4):

setTXpower(5):

setTXpower(6):

setTXpower(7):

7.9 mA

8.2 mA

9.0 mA

10.1 mA

10.7 mA

12.9 mA

14.7 mA

17.6 mA

-30 dBm

-24 dBm

-12 dBm

-6 dBm

0 dBm

5 dBm

9 dBm

11 dBm

SLEEP

iqrfSleep():

<1 μ A

IQRF ecosystem: IQRF IDE

CATS Service Tools

Control | DPA Service

Authorization

VID: 0000 USEC: FFFF Set MID: First available Connect Disconnect Scan MID

DSM

RFPGM Unbond Bond Configure TR
Backup Restore Clone Indicate DPA Device

Device Info

DSM Scanner

Log

Line	Time	ΔTime	MID	TR Module	OS Ver.	OS Build
9	09:40:48.192	00:00:01.528	81001D24	DCTR-52Dx	3.06	0707
10	09:40:52.338	00:00:04.147	81001D26	DCTR-52Dx	3.06	0707
11	09:40:53.247	00:00:00.908	81001D26	DCTR-52Dx	3.06	0707
12	09:40:54.358	00:00:01.111	81001D26	DCTR-52Dx	3.06	0707
13	09:41:01.134	00:00:06.776	81001D28	DCTR-52Dx	3.06	0707
14	09:41:03.101	00:00:01.967	81001D28	DCTR-52Dx	3.06	0707
15	09:41:17.283	00:00:14.182	81001D25	DCTR-52Dx	3.06	0707

MID List

Line	Count	MID
1	3	81001D29
2	4	81001D25
3	3	81001D24
4	3	81001D26
5	2	81001D28

IQRF Device Manager

USB services

Device	ID	FW version	Driver type
CK-USB	06500179	CK-USB-04 v1.03	
CK-USB	0650000B	CK-USB-04A v1.10	
CK-USB	0650000B	CK-USB-04A v1.10	
GW-USB	08003000	GW-USB-05 v1.05	
GW-GSM	11000004	GW-GSM-02A v3.00	MPUSB
GW-ETH	0F60300C	GW-ETH-02 v2.45	
GW-WIFI			
IQRF Cloud			
UDP			

GW-GSM-02A USB

ID: 11000004
FW version: 3.00
Most current FW version: -
Driver type: MPUSB
Alias:
Quick access:

Connect Disconnect Indicate Device
Lock Unlock Create Shortcut Upload FW

IQRF IDE 4.23 - LeveCK [541]

File Edit View Project Programming Debug USB Device Tools Window Help

Terminal Log

Project: LeveCK

TR-52Dx (OS 3.060)

DPA version 2.xx

Auth Support

RF Programming

Source

- @72-mal-01.c
- @72-mal-01-privy.c
- @72-amftr.c
- ESB-Lnk.c
- ESB1-TX.c
- ESB-LNK-15197.c
- TR52-Dx.c
- @well-ROUTING.c
- @well-AUTOROUTING.c
- @72-mal-01-privy-hex
- GeneralNWP-Coordinator-STD-SPM
- @well-ROUTING-hex
- @72-amftr-hex
- @well-AUTOROUTING-hex
- @well-DPA-hex
- @72-mal-01-hex
- ESB-LNK-hex
- Plug-ins
- GPS-15197-std
- TR Configuration

CATS Service Tools

Control | DPA Service

Create CATS Remove CATS

CATS Info

Status: disconnected
RF band: 868 MHz
CATS version: Copy

CATS Tools

- RF Programmer
- DPA Service

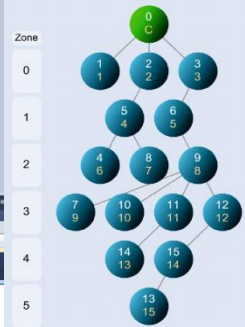
DPA Service Parameters

RX sensitivity: High
TX power: 7

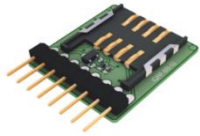
RF Programmer Parameters

RF band: 868 MHz
RF channel A: 52
RF channel B: 2 Enabled
TX power: 7
Packet repeats: 0
Silent mode LP mode Default

Zone



IQRF ecosystem: shields & support libraries



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



Protronix CO₂ sensor
Time-to-market: 7 weeks only!
Read more about the Protronix CO₂ sensor on the [Electronics world](#) or [Electronic_Specifier](#). You can also visit our [IQRF website](#).

PROTRONIX
SENSE & EASY



Save more than 30% with the DATmoLUX industrial lighting

JULI Motorenwerk, Ltd., one of the world's largest manufacturers of handling equipment, was looking for an efficient lighting solution for their production halls. The wireless lighting control system DATMO Radiocontrol was chosen. [Read more](#)

DATmoLUX



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

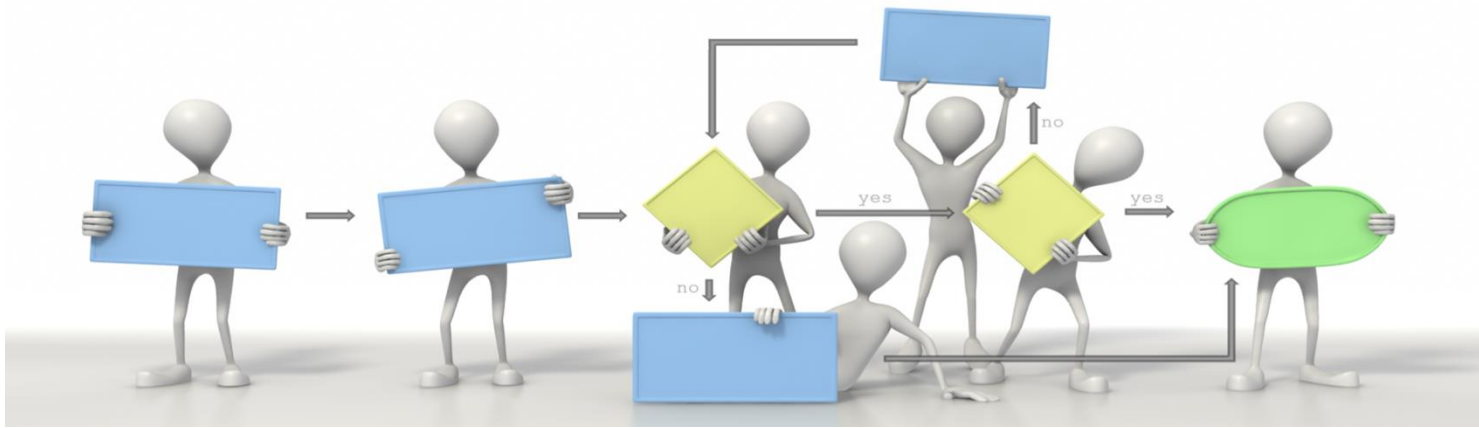
IQRF[®] ecosystem

IQRF[®] Data Controlled Transceivers

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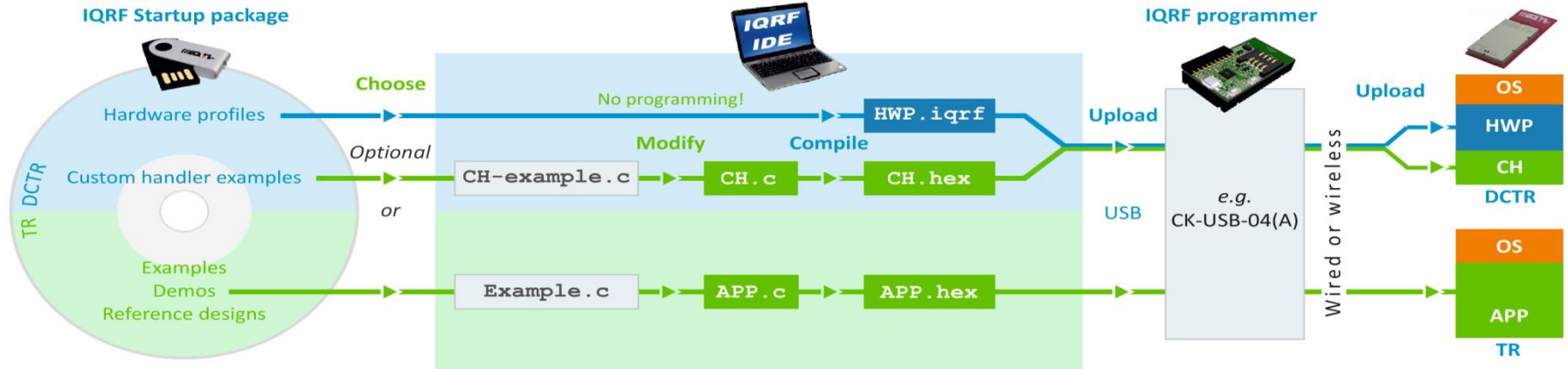
Summary

What is the biggest challenge?



IQRF Data Controlled Transceivers

Programming and uploading process



IQRF Data Controlled Transceivers

1981: AT Commands

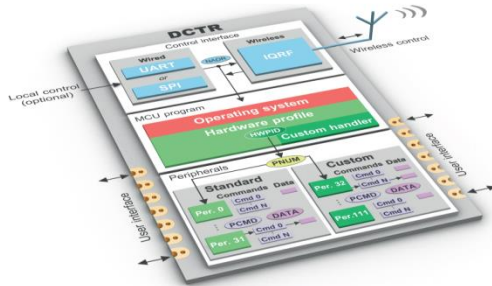
2007: DPA technology

2014: IQRF® DCTR

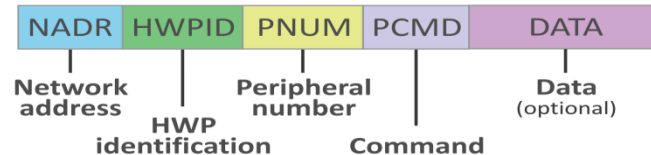
D.Hayes introduced command set enabling LOCAL control

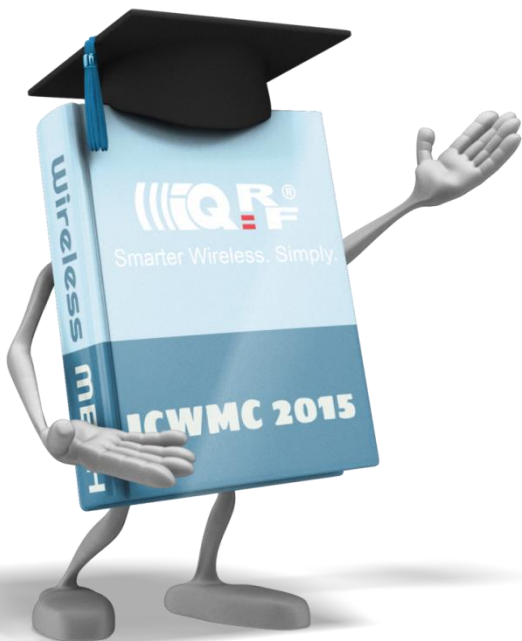
MICRORISC introduced concept of DPA for general NETWORK environment

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:





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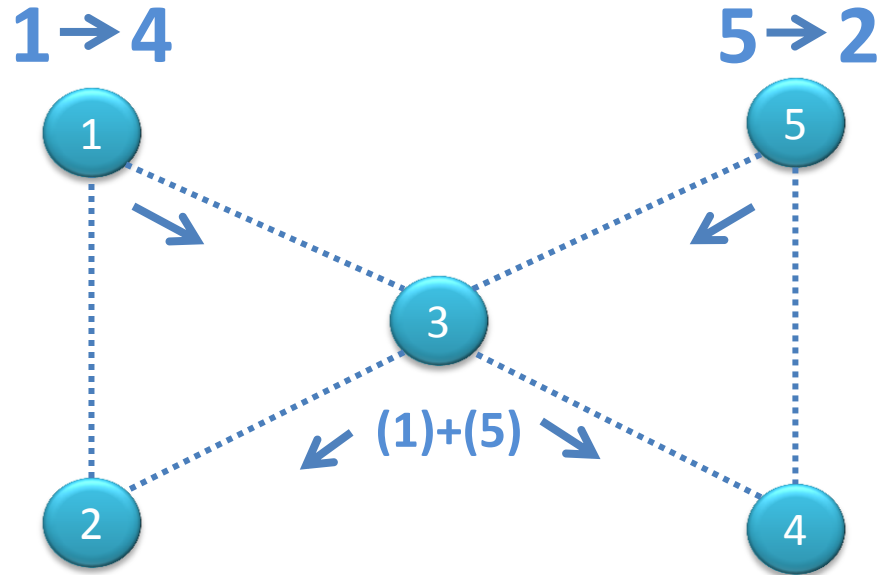
IQRF[®] Data Controlled Transceivers

FRC[®] - Fast Response Commands

Summary

FRC – Fast Response Commands

□ Linear Network Coding

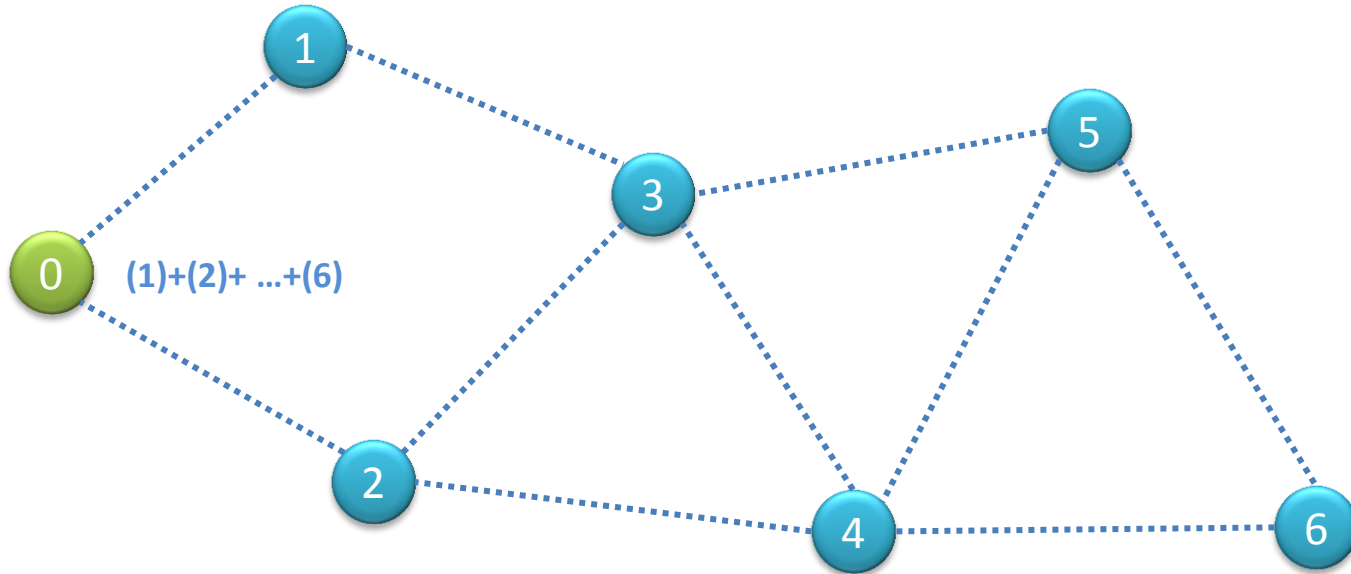


Bring efficiency and reliability to control systems.

Increase efficiency of data collection in WSN.

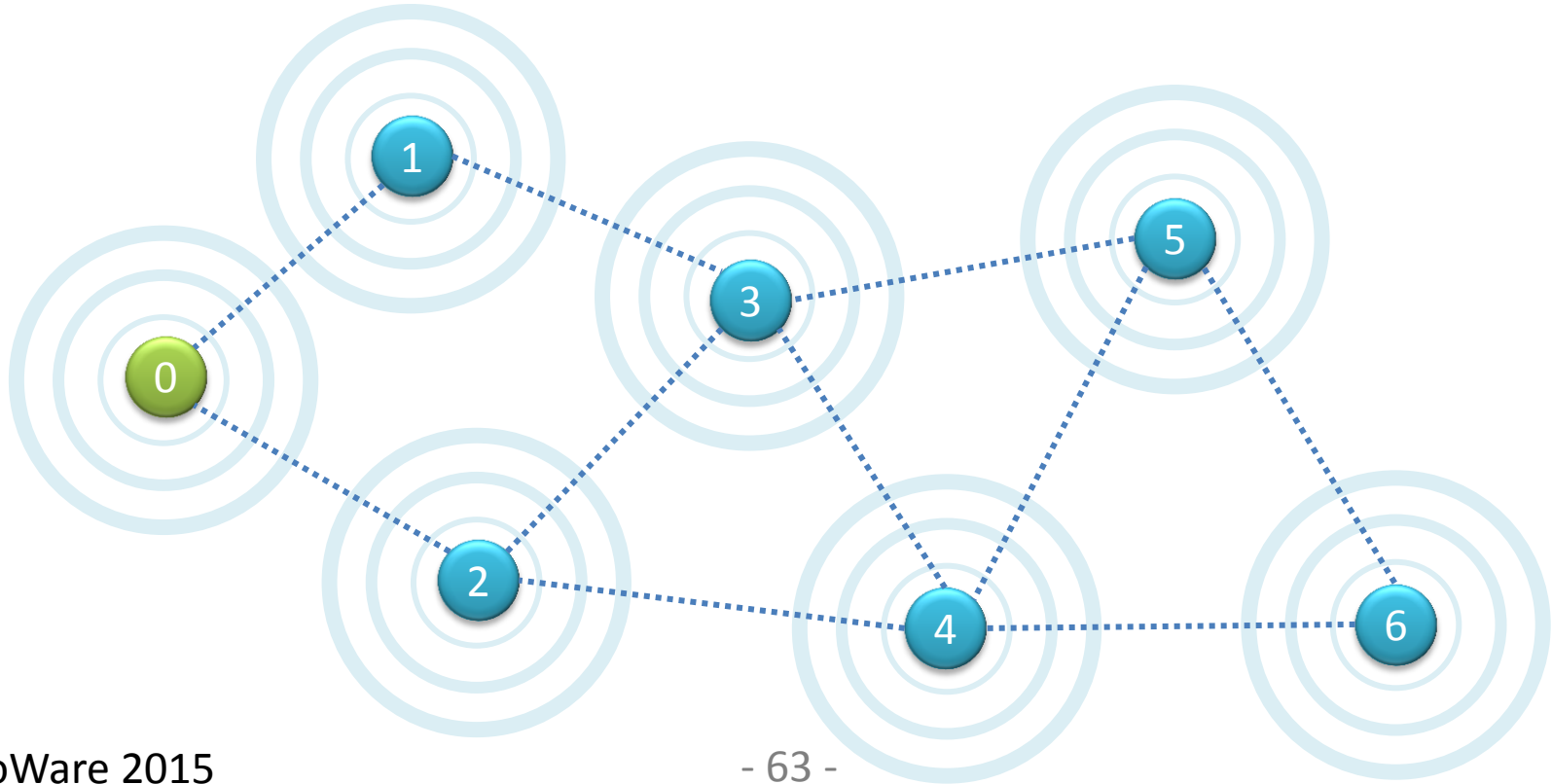
FRC – Fast Response Commands

- Data aggregation
- Commands acknowledgements



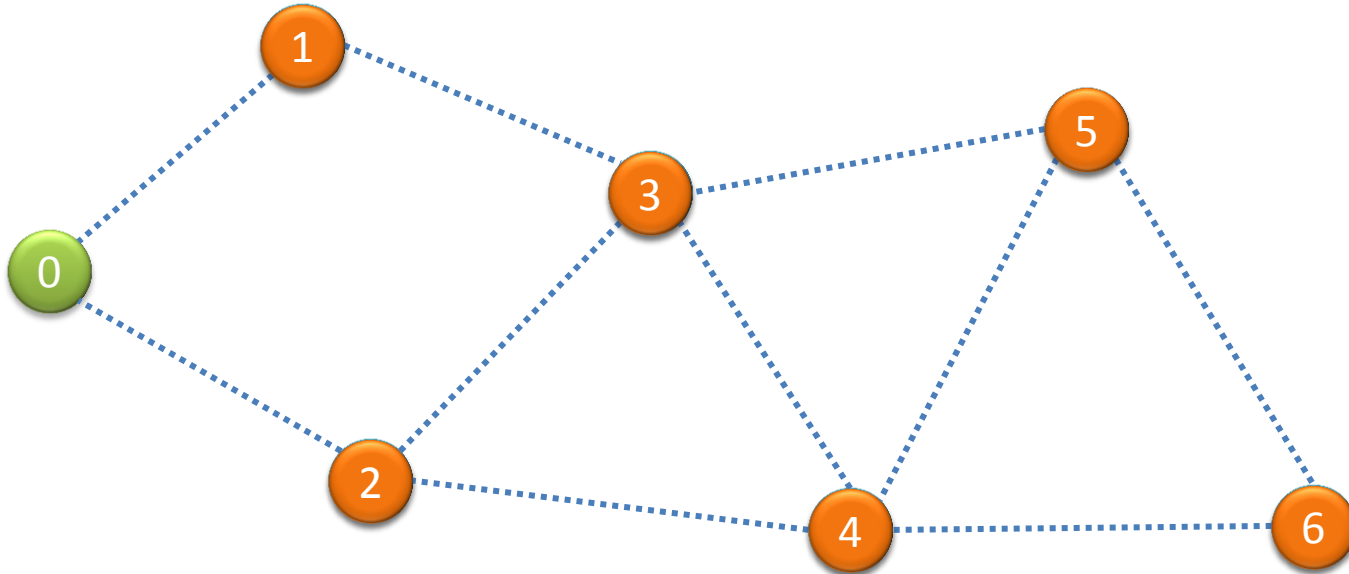
FRC – Fast Response Commands

❑ Command distribution



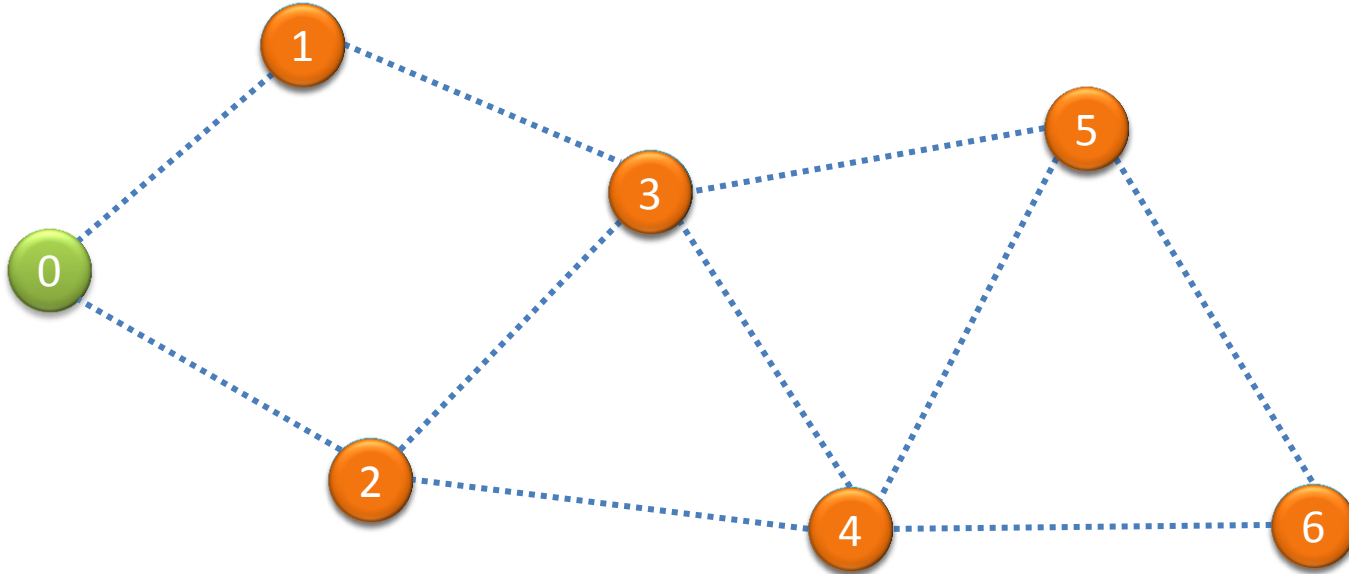
FRC – Fast Response Commands

❑ Command execution



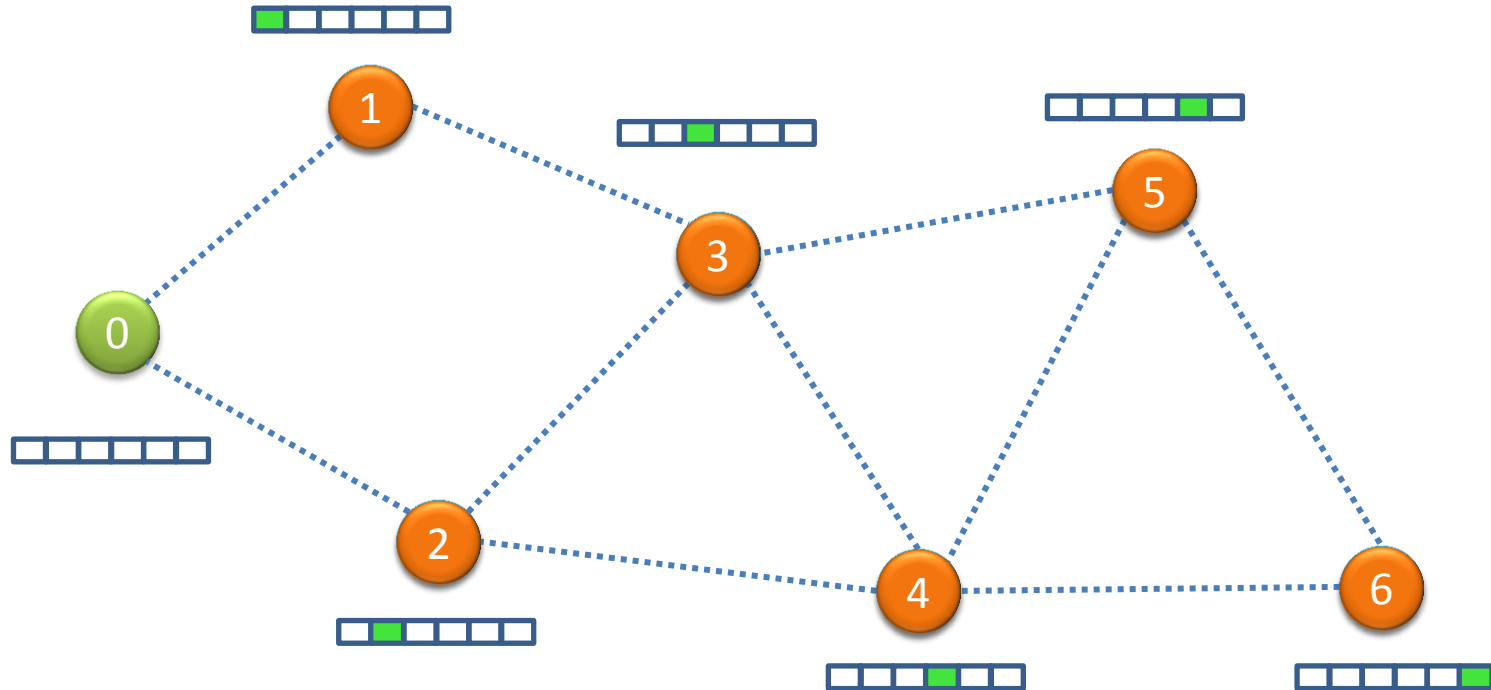
FRC – Fast Response Commands

Optional synchronization delay



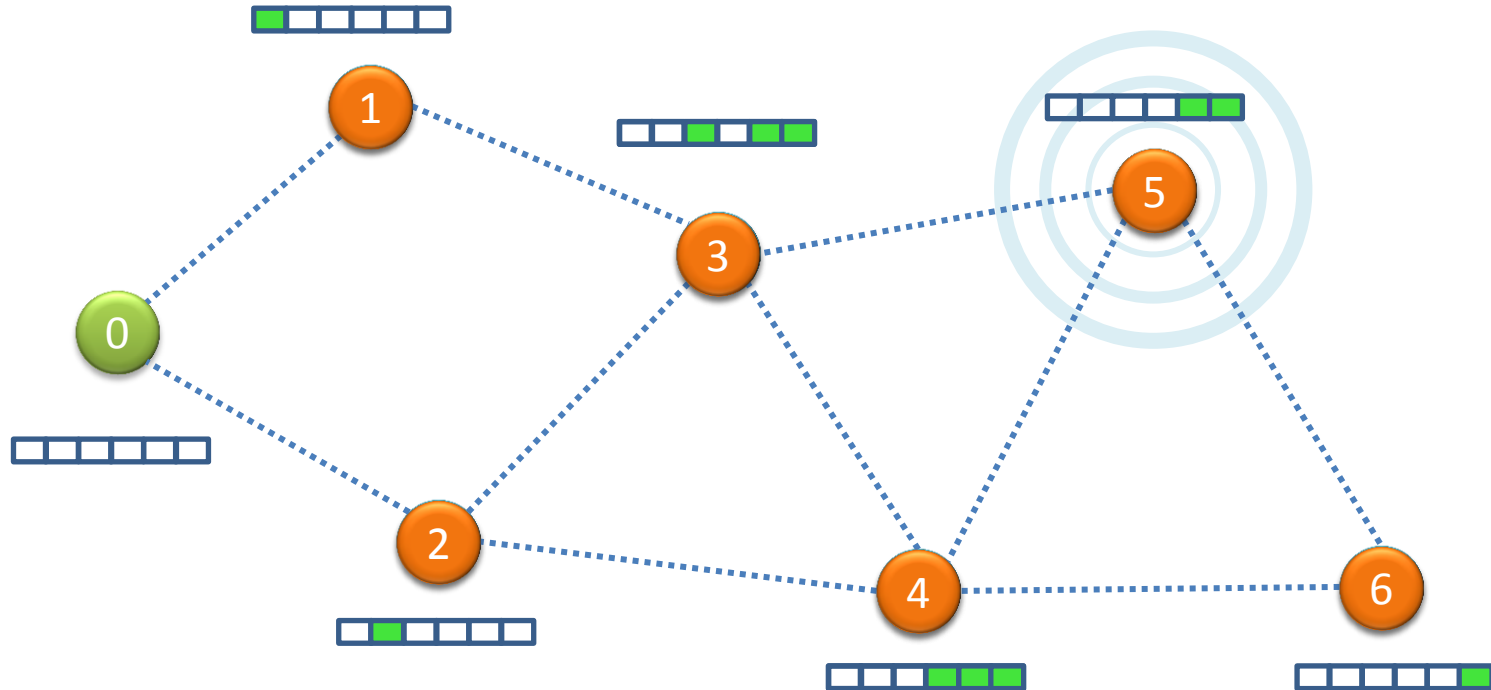
FRC – Fast Response Commands

❑ Command acknowledgements



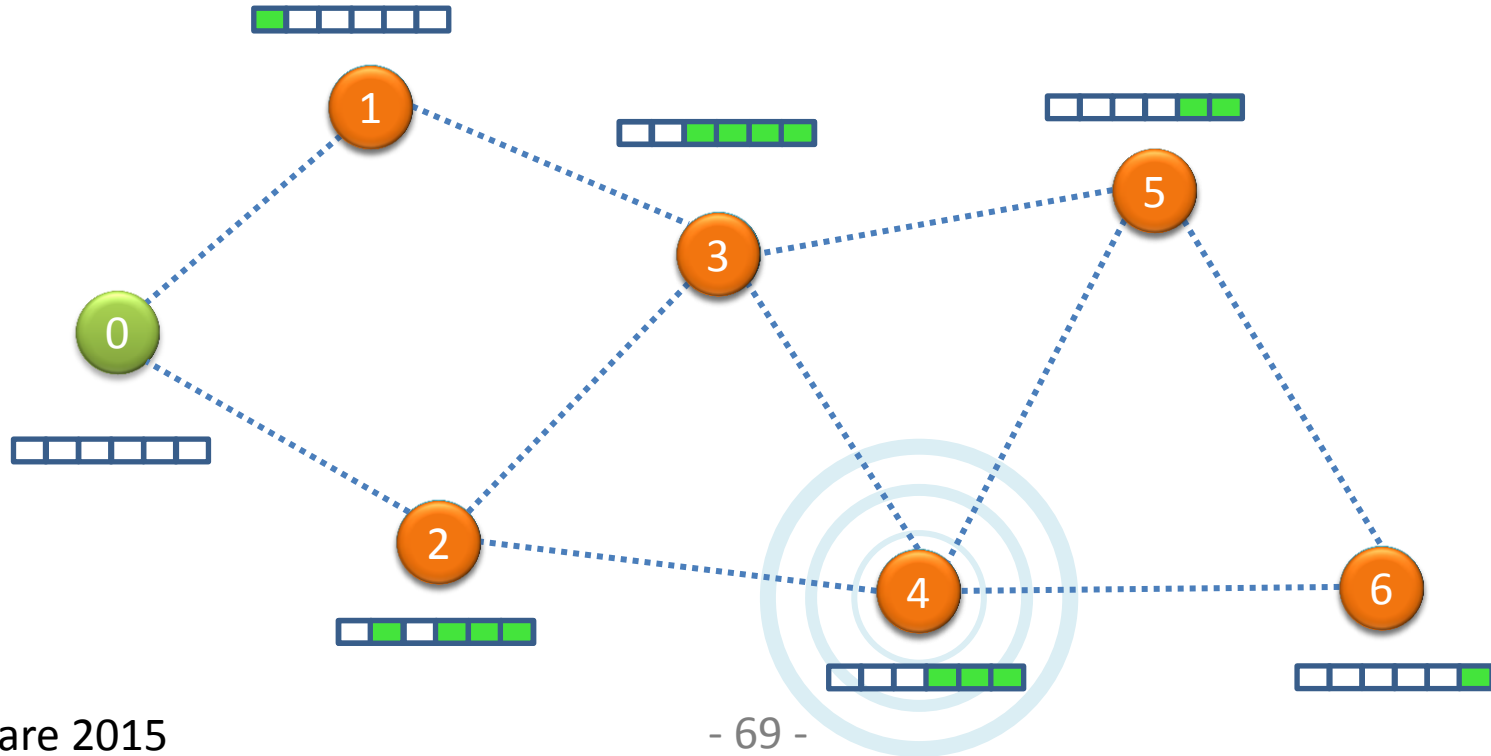
FRC – Fast Response Commands

❑ Command acknowledgements



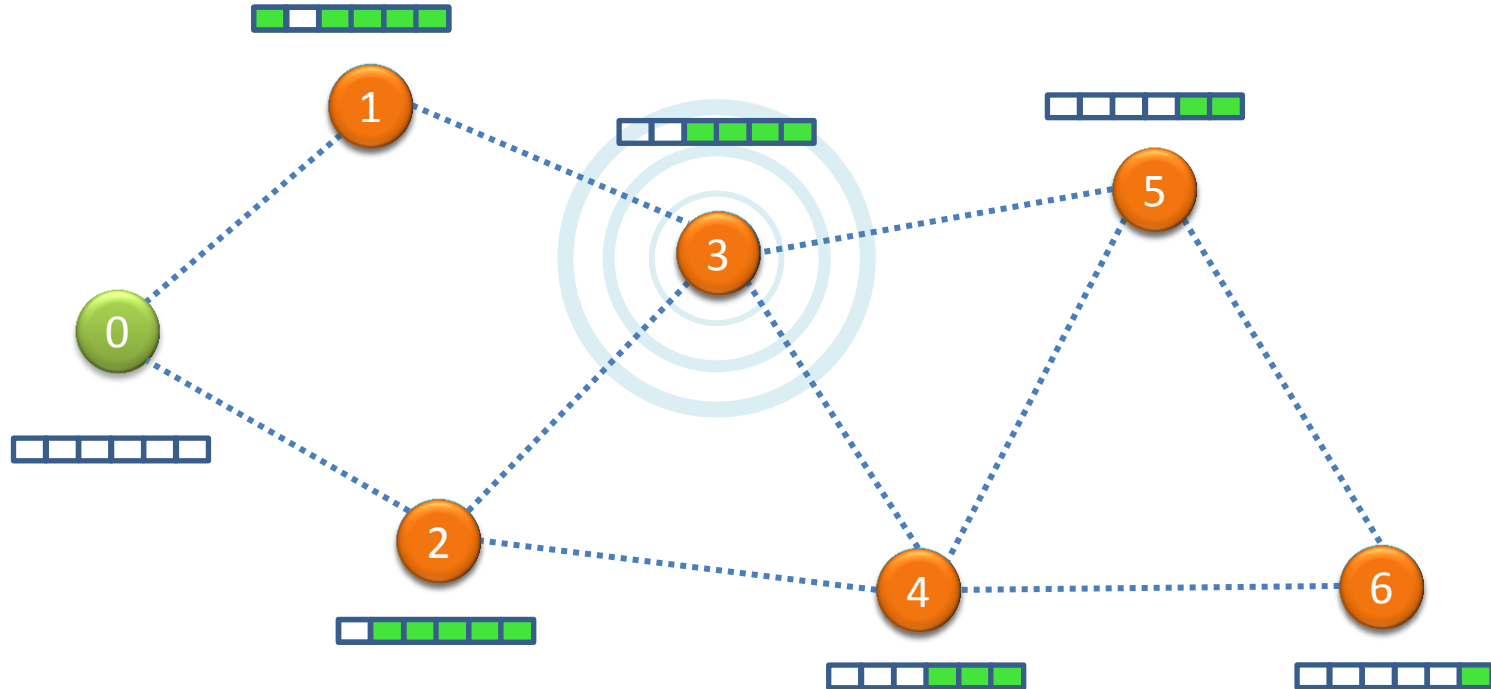
FRC – Fast Response Commands

❑ Command acknowledgements



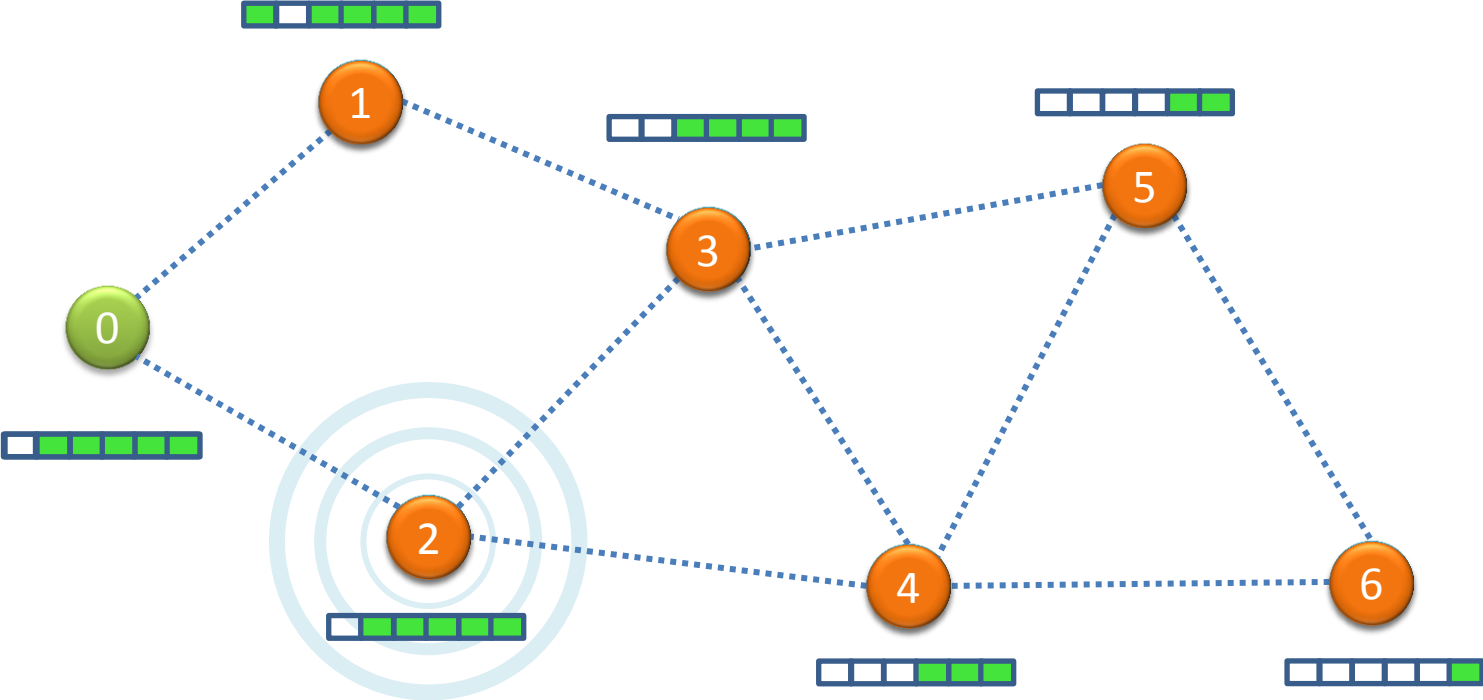
FRC – Fast Response Commands

❑ Command acknowledgements



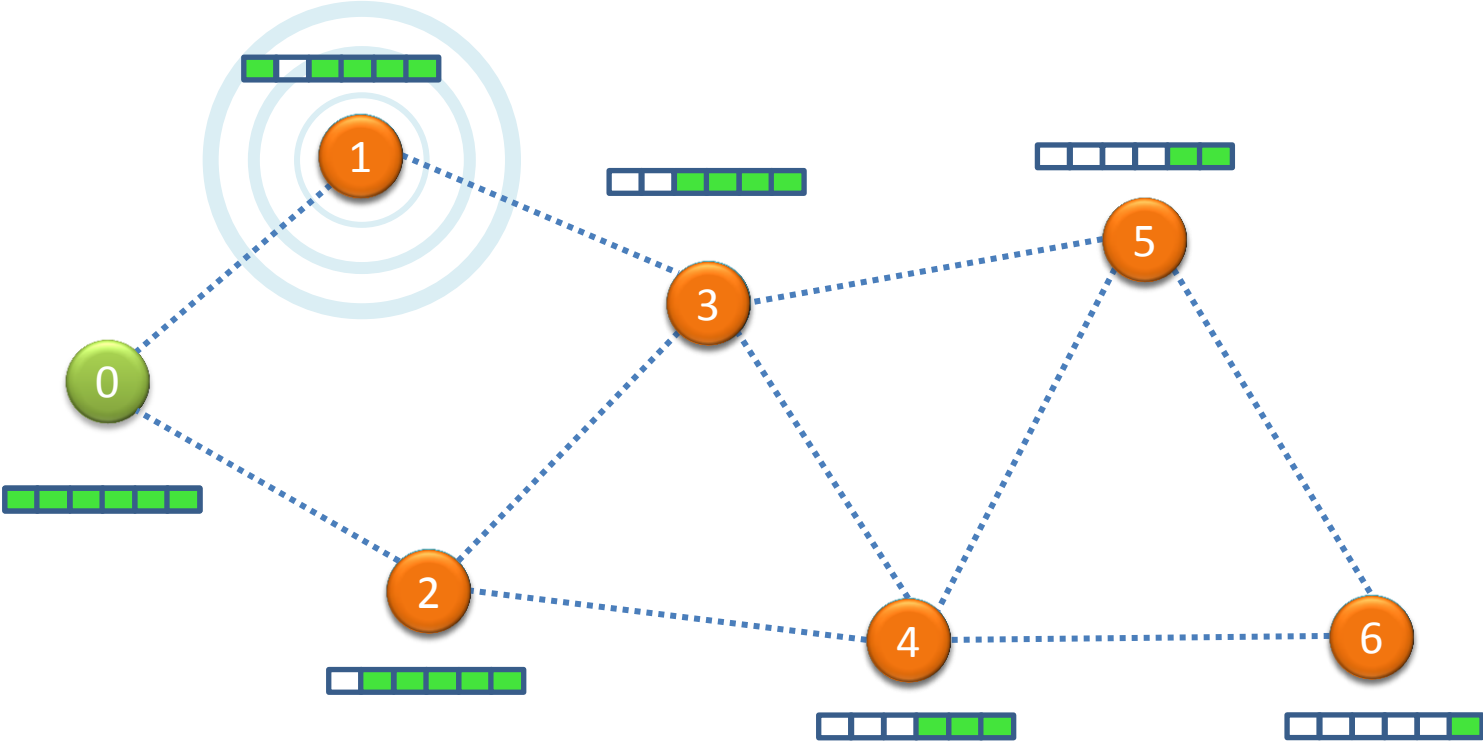
FRC – Fast Response Commands

❑ Command acknowledgements



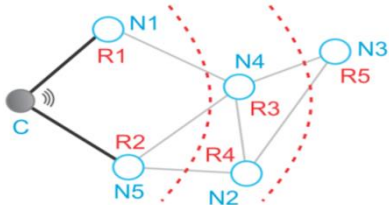
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FRC – Fast Response Commands

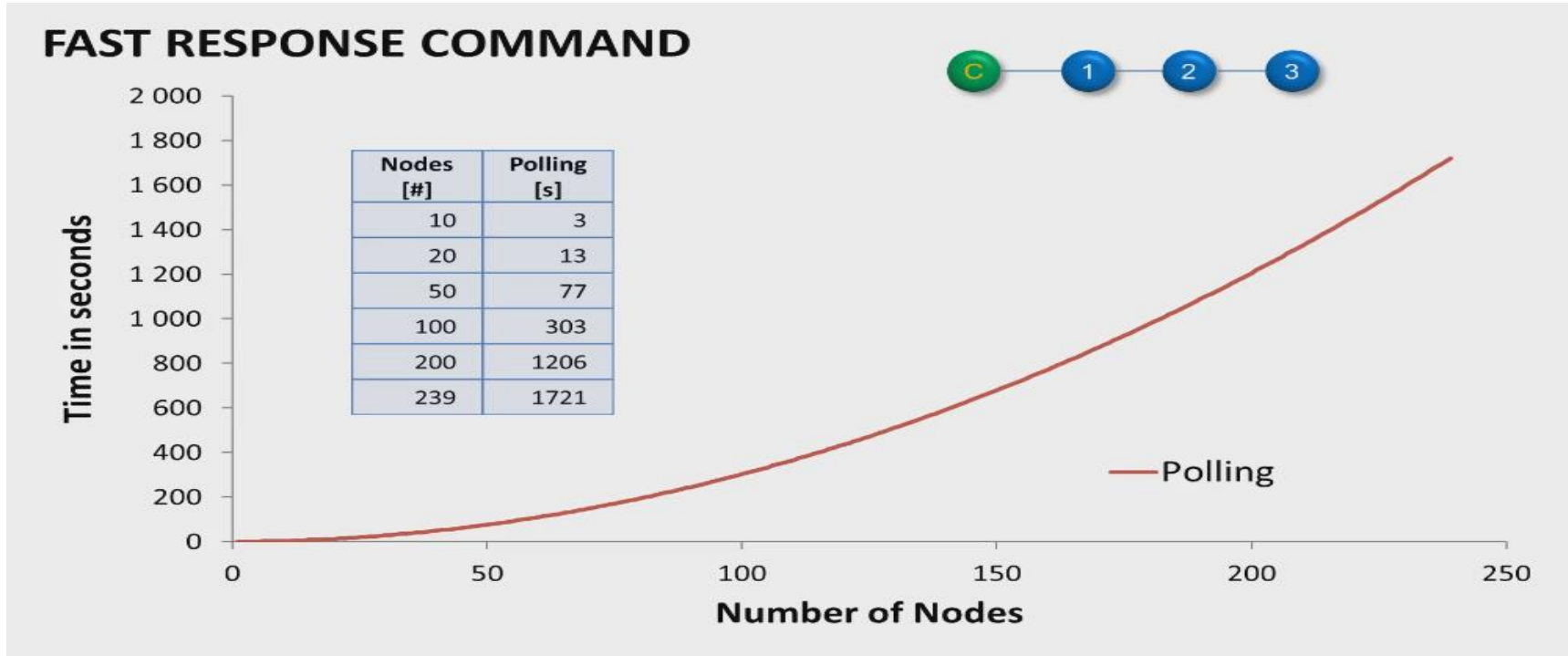
HEADER			[NETWORKING AND SYSTEM]							DATA		SYNC		CRC-16
PIN	DLEN	CSH	NETWORKING	ROUTING	DPA	CRYPT	AUX	CSN	DATA-whitened	CSD	SYNC	CSS		



PIN							
NTWF	ACKF	ROUTEF	CRYPTF	DPAF	SYSPF	AUXF0	AUXF1

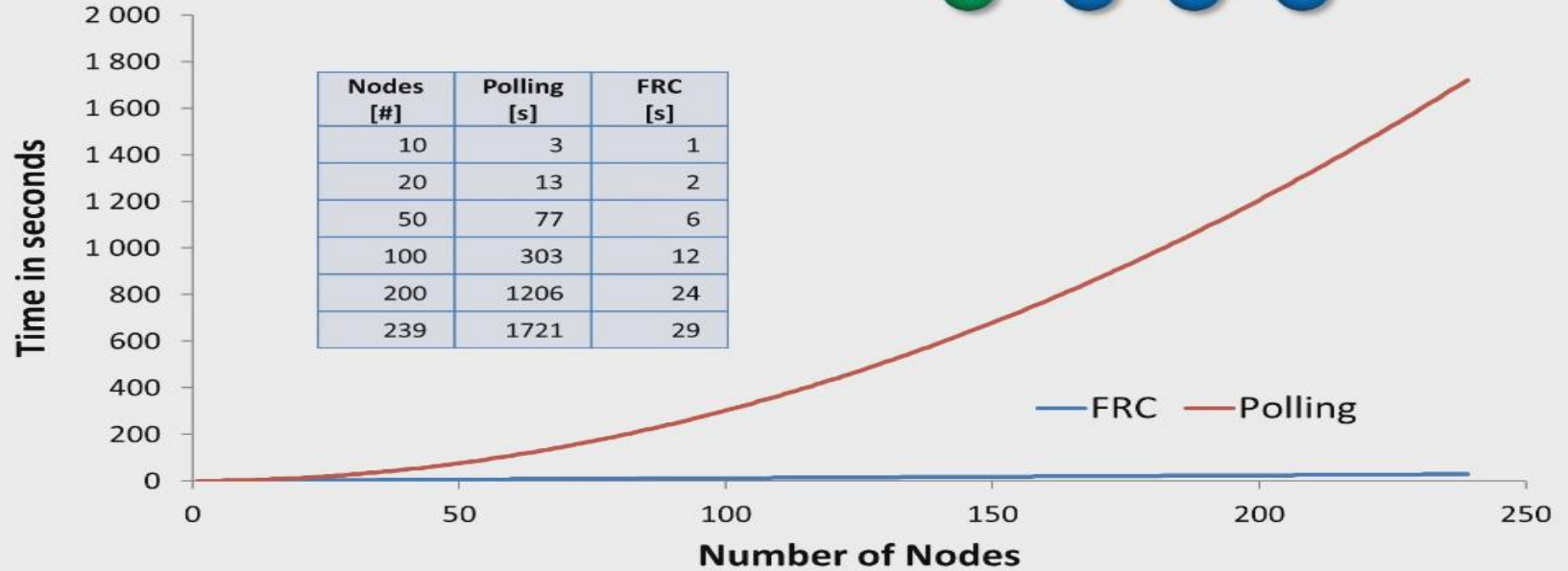
NETWORKING				ROUTING								Crypt Info		Direct Peripheral Access			AUX0	AUX1
RX=FF	TX	NETID0	NETID1	PID	RTOTX	RTDEF	RTHOPS	RTSLOT	RTDID	RTAUX	CRYPT0	CRYPT1	PNUM	PCOM	PPAR	---	---	
NETWORKING AND SYSTEM																		

FRC – Fast Response Commands



FRC – Fast Response Commands

FAST RESPONSE COMMAND





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

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
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(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

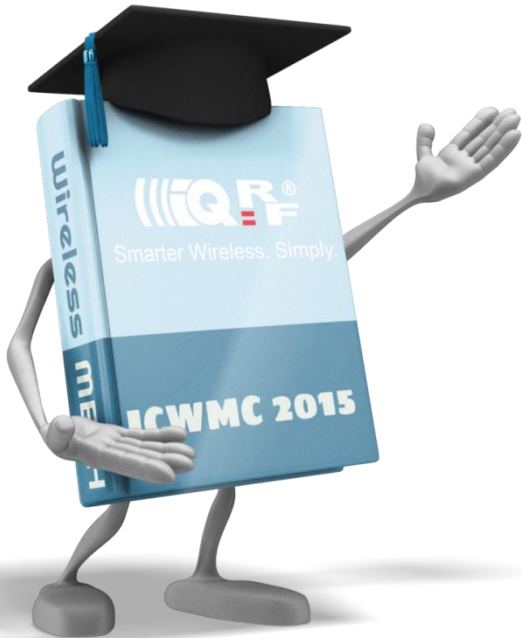


FRC – Fast Response Commands

- 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

- ❑ 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

- ❑ 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.







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