

NES Programming and protocols

Alex Malfatti, Davide Quaglia



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Outline

- IEEE 802.15.4
- ZigBee
 - ZigBee boards
 - ZigBee tools
- Example & Exercise

IEEE 802.15.4 & ZigBee

IEEE 802.15.4

- Standard IEEE 802.15.4 defines the protocol and interconnection of devices via radio communication in a Personal Area Network (PAN).
- It defines PHY & MAC levels.
- It aims:
 - Low data rate
 - Low power
 - Low cost

ZigBee

- ZigBee is implemented over IEEE 802.15.4 PHY & MAC.
- Three different types of ZigBee devices:
 - ZigBee Coordinator (ZC)
 - ZigBee Router (ZR)
 - ZigBee End Device (ZED)

ZigBee Boards (1)

- SmartRF04EB (Evaluation Board)
 - <u>http://www.ti.com/lit/u</u>
 <u>g/swru039b/swru039b.</u>
 <u>pdf</u>
- CC2430EM (Evaluation Module)
 - <u>http://www.ti.com/tool</u> /cc2430em_refdes



ZigBee Boards (1)



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ZigBee Boards (2)

- Chipcon CC2430DB (Demonstration Board)
 - <u>http://www.ti.com/lit/ug</u> /swru125/swru125.pdf



ZigBee Boards (2)



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ZigBee Tools

• **IAR** (Ingenjörsfirman Anders Rundgren): is an embedded systems workbench IDE for building and running application on ZigBee boards.

– <u>http://www.iar.com</u>

- SmartRF[™] Studio: is a Windows application that can be used to evaluate and configure Low Power RF-ICs from Texas Instruments.
 - <u>http://www.ti.com/tool/smartrftm-</u>
 <u>studio&DCMP=hpa_rf_general&HQS=Other+OT+</u>
 <u>smartrfstudio</u>

Example & Exercise

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Example: Generic App (1)

- Open GenericApp example from Zstack Samples folder as shown below:
 - C:\Texas Instruments\Zstack-1.4.2 1.1.0\Projects\Samples\GenericApp\CC2430DB\GenericApp



Example: Generic App (2)

 Choose Coordinator or End device based on your board type (ED, DB) and ZigBee role (ZC, ZR, ZED).

IAR Embedded Work	bench IDE	
File Edit View Proj	ect Tools Window Help	
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Workspace	×	
CoordinatorEB	•	
CoordinatorDB		
CoordinatorEB RouterDB RouterEB EndDeviceDB EndDeviceEB DemoDB DemoEB		
H – ⊞ 🗀 NWK	•	
HE 🗎 OSAL	• • • • • • • • • • • • • • • • • • •	

Example: Generic App (3)

- Build the Project
 - Project -> Rebuild All
- Run the Project
 - Project -> Debug
- Reset ZigBee Board
 - S300 for EB
 - S2 for DB
- Repeat these steps to configure all the devices, setting the correct board type (ED, DB) and ZigBee role (ZC, ZR, ZED).

IAR Embedded V	Workbench IDE	
File Edit View	Project Tools Window Help	
Vorkspace VordinatorEB Files SampleA HE App HAL HE MAC	Add Files Add Group Import File List Edit Configurations Remove Create New Project	
HI INWK	Add Existing Project Options Alt+F7 Source Code Control Make F7 Compile Ctrl+F7	
Den El Constante de la constan	Rebuild All Clean	
	Stop Build Debug Ctrl+D	
	Make & Restart Debugger	

ZC - Network formation



ZC - Auto scan mode



ZED - Network binding



Red light is ON when the node joins the Network or *blinks* when it disconnects from the Network.

ZED - Send message



Push the joystick to the *top* to send the message. (the application will continue to send the message every 5s)

If the **green** light is *ON*, it means that the message has been sent.

Change IEEE address (1)

🕴 SmartRF Studio 7 - Texas Instru	ments		
SMARCOV W St Jub 1 GHz ISM band Sub 1 GHz ISM band Sub 1 GHz ISM band Sub 1 GHz System-on-Chip Wib-1 GHz Wib-1 GHz Wib-1 GHz Sub-1 GHz Sub-1 GHz Sub-1 GHz Sub-1 GHz Sub-1 GHz Sub-1 GHz Wib-1 GHz Sub-1 GHz Sub-1 GHz Sub-1 GHz Wib-1 GHz Sub-1 GHz Wib-1 GHz Wib-1 GHz Sub-1 GHz	Late 2.4 GHz CC1100E Sub-10Hz Transceiver Image: Constraint of the state Sub-10Hz Sub-10Hz Image: Constraint of the state Image: Constraint of the state Sub-10Hz Sub-10Hz Sub-10Hz Sub-10Hz Sub-10Hz Sub-10Hz Sub-10Hz Sub-10Hz Image: Constraint of the state Sub-10Hz Sub-10Hz Sub-10Hz Image: Constraint of the state Image: Constraint of the state Image: Constraint of the state Sub-10Hz Sub-10Hz Image: Constraint of the state Image: Constraint of the state	CC110L Sub-10Hz Transceiver CC1121 Sub-10Hz Transceiver	Open the SmartRF Flash Programmer tool.
List of connected devices:		Find device:	
0 Connected devic	ce(s)	🖓 Texas Instruments	

Change IEEE address (2)

N IN

• Then:

- 1. Read IEEE
- 2. Change IEEE address (8 bytes)
- 3. Write IEEE

Program CCxxxx SoC or MSP430	_
System-on-Chip MSP430	
EB ID Chip type	B type EB firmware ID EB firmware re SmartRF04EB 0400 0031 (old)
Interface:	
Flash image:	
Read IEEE Write IEEE F-128 (adr	0x1FFF8. IEEE 0x FF
Read IEEE Write IEEE F-128 (adr	0x1FFF8. IEEE 0x FF
Read IEEE Write IEEE F-128 (adr 1 IEE 3 s when repro Actions C Erase C Erase and program C Erase, program and verify C Aproand and verify	0x1FFF8: IEEE 0x FF FF FF FF FF FF FF FF FF gramming the chip 2 Flash lock (effective after program/append): Write protect: 128 kB - All pages
Read IEEE Write IEEE F-128 (adr F128 (adr F128 (adr F128 (adr F-128 (adr))	0x1FFF8: IEEE 0x FF FF FF FF FF FF FF FF FF gramming the chip 2 Flash lock (effective after program/append): 2 Write protect: 128 kB - All pages Write protect: 128 kB - All pages Write protect boot block Block debug commands (incl. read access) NB: Cannot "Append and verify" when set!
Read IEEE Write IEEE F-128 (adr F128 (adr F128 (adr F128 (adr F128 (adr F-128 (adr) F-128 (adr) F-128 (adr) F-128 (adr) F-128 (adr) F-128 (adr) F	0x1FFF8: IEEE 0x FF FF FF FF FF FF FF FF FF gramming the chip 2 Flash lock (effective after program/append): 2 Write protect: 128 kB - All pages • Write protect: 128 kB - All pages • Write protect boot block • Block debug commands (incl. read access) NB: Cannot "Append and verify" when set! • Perform actions •

RF sniffing (1)



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RF sniffing (2)

Open the SmartRF Packet Sniffer tool and choose the desidered sniffing operating frequency.

P.S. The frequency should be the same as the one in the application configuration file (*.cfg*)

SenericApp	f8wConfig	p.cfg ZMai	n			
/* Set	to 0 for	no secu	urity,	other	wise	non-0
	-0					
/* Def	ault chan	nel is (hanne.	1 11 -	0x03	B */
// Cha	nnels are	defined	i in th	he fol	lowin	ng:
11	0	: 868	MHz	0x	00000	0001
//	1 -	10 : 915	5 MHz	0x	00000	07FE
//	11 -	26 : 2.4	4 GHz	0x	07FF	F800
//						
//-DMA	X_CHANNEL	S_868MH2	2 1	0x0000	0001	
//-DMA	X_CHANNEL	3_915MH2	2	0x0000	07FE	
//-DMA	X_CHANNEL	S_24GHZ		DX07FF	1800	
//-DDE	FAULT_CHA	NLIST=09	(04000)	000 /	/ 26	- 0x1
//-DDE	FAULT_CHA	NLISI=09	02000	000 /	/ 25	- 0x1
//-DDE	FAULT CHA	MLIST-08	008000	000 /	/ 64	- 0x1
//-DDE	FAULT CHA	MLTST=0x	00.0000	000 /	1 22	- 0x1
//-DDE	FAULT CHA	NLIST=08	00200	000 /	/ 21	- 0x1
-DDEFA	ULT CHANL	IST=0x00	10000	n //	20 -	0x14
//-DDE	FAULT CHA	MLIST=0s	00080	000 /	/ 19	- 0x1
//-DDE	FAULT CHA	NLIST=0s	00040	000 /	/ 18	- 0x1
//-DDE	FAULT_CHA	NLIST=0s	00020	000 /	/ 17	- 0x1
//-DDE	FAULT_CHA	NLIST=0s	00010	000 /	/ 16	- 0x1
//-DDE	FAULT_CHA	NLIST=0s	00008	000 /	/ 15	- 0x0
//-DDE	FAULT_CHA	NLIST=0x	00004	000 /	/ 14	- 0x0
//-DDE	FAULT_CHA	MLIST=0s	00002	000 /	/ 13	- 0x0
//-DDE	FAULT_CHA	NLIST=05	00001	000 /	/ 12	- 0x0
11-DDE	FAILT CMA	MITTON-ON	00000	200	11.5	- 0v0



RF sniffing (3)

TEXAS INSTRUMEN

Start the packet capturing.

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Figure 12: Packet sniffer screenshot from the IEEE8022.15.4/ZigBee protocols

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SWRU187F

Exercise

- Configure the GenericApp based on the following requirements:
 - Change the sent message to «Ciao NES».
 - Change the operating frequency to 2415 MHz.
 - Change the IEEE address of the coordinator node to «00 11 22 33 44 55 66 77».
 - Run the application and sniff the data.