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STM32WL LoRa 例程介绍

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STM32WLCube 开发包



STM32Cube_FW_WL开发包目录



STM32WL 例程









- STM32WL Cube 开发包提供的4个 应用例程:
 - LoRaWAN_AT_Slave
 - 可以使用AT 指令和STM32WL 的LoRa 调制 通信
 - AN5481: LoRaWAN® AT commands for STM32CubeWL
 - LoRaWAN_End_Node
 - STM32WL作为节点传输传感器数据到LoRaWAN 服务器
 - SubGHz_Phy_PingPong
 - STM32WL作为两个节点基于LoRa 调制进行点对点通信
 - LocalNetwork
 - STM32WL 基于LoRa调制搭建本地私有网络,一个STM32WL concentrator,多个STM32WL 节点 sensor





STM32WL 节点开发环境



STM32WL的生态系统

完全集成到经过市场验证的STM32丰富的生态系统中







・ 硬件:

- STM32WLWL55JC Nucleo 板
 - NUCLEO-WL55JC1: 高频板, 865 MHz 930 MHz
 - •NUCLEO-WL55JC2: 低频板, 433MHz-520 MHz

・软件

- STM32Cube_FW_WL_V1.0.0(<u>STM32CubeWL</u>)
- STM32CubeIDE(1.5or later) /IAR(EWARM8 and laters)/Keil (MDK-ARM v5.25 or later installed)
- EWARMv8_STM32WLxx_V4.6 补丁
 - 提取: STM32Cube_FW_WL_V0.2.0\Utilities\PC_Software
 - 运行EWARMv8_STM32WLxx_V4.6.exe, 默认安装路径是C:\Program Files\IAR Systems\Embedded Workbench \
- Keil.STM32WLxx_DFP.1.0.7补丁
 - 提取: STM32Cube_FW_WL_V0.2.0\Utilities\PC_Software
 - 运行Keil.STM32WLxx_DFP.1.0.7.pack, 默认安装到keil 的安装路径
- 串口工具: 比如Tera Term



IAR 设置举例 (1/2)

- 打开 三个例程中的IAR工程:
 - STM32Cube FW WL V1.0.0\Projects\NUCLEO-• WL55JC\Applications\LoRaWAN\LoRaWAN End Node\EWARM / Project.eww
 - STM32Cube FW WL V1.0.0\Projects\NUCLEO-• WL55JC\Applications\LoRaWAN\LoRaWAN AT Slave\EWARM\Project.eww
 - STM32Cube FW WL V1.0.0\Projects\NUCLEO-WL55JC\Applications\SubGHz_Phy\SubGHz_Phy_PingPong\EWARM\Project.

- 选择M4内核:
 - ST STM32WL55JC M4





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IAR 设置举例 (2/2)

• 检查是否使用ST-LINK调试

• 检查 ST-Link 配置

- Connect during reset
- Interface: SWD





STM32WL Nucleo Board

- 连接STM32WL Nucleo Board , 烧录软件
 - <u>UM2592: STM32WL Nucleo-64 board (MB1389)</u>







- 打开串口工具 Tera Term监控
- 三个例程串口配置参考工程目录下对应的readme.txt
- 波特率

AT Slave End Node	Ping Pong		
9600 115200	115200	💆 COM16 - Tera Term VT —	
110200	110200	File Edit Setup Control Window Help	<u>^</u>
Tera Term: Serial port setup	×	AT+TRLRA=10 1475s665:PRE OK	
<u>P</u> ort: COM19 →	οκ	14758682:HDK OK 14758705:OnRxDone 14758705:RssiValue=-111 dBm, SnrValue=-8	
<u>B</u> aud rate: 9600 ▼		1475s705:Rx 1 of 10 >>> PER= 0 % 1475s719:PRE OK 1475c724:HDB OK	
<u>D</u> ata: 8 bit ▼	Cancel	1475s756:OnRxDone 1475s756:RssiValue=-111 dBm, SnrValue=-8	
P <u>a</u> rity: none 🔻		1475s756:Rx 2 of 10 >>> PER= 0 % 1475s771:PRE OK 1475s786:HDR OK	
Stop: 1 bit	Help	1475s808:OnRxDone 1475s808:RssiValue=-112_dBm, SnrValue=-8	
Elow control:		1475s808:Rx 3 of 10 >>> PER= 0 % 1475s823:PRE OK 1475s837:HDR OK	
Transmit delay		1475s860:OnRxDone 1475s860:RssiValue=-111 dBm, SnrValue=-8	
0 msec/char 0	mseclline	1475s860:Rx 4 of 10 >>> PER= 0 % 1475s875:PRE OK 1475s888:HDR OK	~
	noodino		1.4

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LoRaWAN 网关和网络服务器搭建



LoRaWAN 网络结构





P-NUCLEO-LRWAN 网关





P-NUCLEO-LRWAN 网关配置

- 通过USB线给网关供电(如图示)
- 通过主板ST-Link连接串口
 - 通过串口使用AT 指令配置MAC 地址:
 - AT+MAC= 0800270DXXXX
 - 通过串口使用AT 指令配置LoRaWAN 网络服务器地址 和 端口
 - AT+PKTFWD: eu1.loriot.io, 1780, 1780
- 网关的网络通信
 - 无线热点:
 - 网关通过网线连接热点上网
 - 有线网络





注册网关(1/2)

- <u>登入https://eu1.loriot.io</u>
 - 建议使用Chrome 浏览器
- 注册账号
- 选择网络和网络名称
- 在网络服务器添加网关
 - 选择 ST packet Forwarder







注册网关(2/2)

- 填入网关MAC地址
 - 通过串口读取MAC 地址或使用 AT+MAC修改
- 注册网关
 - 在网络服务器填入MAC地址,以及网关所在地 理位置

VERSION:	2.1.7, Nov 6 2018
LOG:	OFF
AT ECHO:	ON
BAUDRATE:	115200bps
MACADDR:	xx:xx:xx:xx:xx
ETHERNET:	DHCP
DNS1:	114.114.114.114
DNS2:	8.8.8
NTP SERVER:	1.ubuntu.pool.ntp.org
EUI PADDING:	{3, FF}, {4, FF}
GATEWAY ID:	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
LORAWAN:	Public
LORAWAN SERVER:	cn1.loriot.io
UPLINK UDP PORT:	1780
DOWNLINK UDP PORT:	1780
CHANNEL0:	471500000, A, SF7/SF12, BW125KHz (LORA_MULTI_SF)
CHANNEL1:	471700000, A, SF7/SF12, BW125KHz (LORA_MULTI_SF)
CHANNEL2:	471900000, A, SF7/SF12, BW125KHz (LORA_MULTI_SF)
CHANNEL3:	472100000, A, SF7/SF12, BW125KHz (LORA_MULTI_SF)
CHANNEL4:	472300000, A, SF7/SF12, BW125KHz (LORA_MULTI_SF)
CHANNEL5:	472500000, B, SF7/SF12, BW125KHz (LORA_MULTI_SF)
CHANNEL6:	472700000, B, SF7/SF12, BW125KHz (LORA_MULTI_SF)
CHANNEL7:	472900000, B, SF7/SF12, BW125KHz (LORA_MULTI_SF)
CHANNEL8:	OFF (LORA_STANDARD)
CHANNEL9:	OFF (FSK)







- 选择网关工作频段
- 使用 SampleApp application





在应用添加节点

- 在 LoRiot 工具栏, 选择 "Enroll Device"
 - 检查LoraWAN version 1.0.x 版本
 - 检查入网方式,比如<u>OTAA</u>
- 填入配置好的节点参数(OTAA)(见下 一章节点配置部分):
 - DevEUI :

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- Application Key
- Application EUI:
- 本章节网关详细操作可参考UM2587
 <u>UM2587 Getting started with the P-NUCLEO-LRWAN3 starter</u> packs 1.0





LoRaWAN_End_Node例程



LoRaWAN节点入网参数配置

1.在STM32Cube_FW_WL_V1.0.0 lora_app.h

- 配置工作频段
 - #define ACTIVE_REGION LORAMAC_REGION_CN470,
- 配置入网方式 OTAA 或 APB
 - #define LORAWAN_DEFAULT_ACTIVATION_TYPE ACTIVATION_TYPE_OTAA (OTAA)
 - #define LORAWAN_DEFAULT_ACTIVATION_TYPE ACTIVATION_TYPE_ABP (ABP)

2.在STM32Cube_FW_WL_V1.0.0 se-identity.h 文件 配置LoRaWAN_End_Node入网参数

- 配置 DEVEUI
 - #define LORAWAN_DEVICE_EUI { 0x01, 0x01

0

- #define STATIC_DEVICE_EUI
 - When set to 1 DevEui is LORAWAN_DEVICE_EUI
 - When set to 0 DevEui is automatically generated based on MCU ID
- OTAA参数
 - 配置LORAWAN_JOIN_EUI. 即 APPEUI
 - 配置 LORAWAN_APP_KEY. 即 APPKEY
- ABP参数
 - #define LORAWAN_DEVICE_ADDRESS



#define LORAWAN_DEVICE_ADDIX #define LORAWAN_NWK_S_KEY #define LORAWAN_APP_S_KEY (uint32_t)0x0100000A

2B,7E,15,16,28,AE,D2,A6,AB,F7,15,88,09,CF,4F,3C

2B,7E,15,16,28,A& 22,A6,AB,F7,15,88,09,CF,4F,3C



- 在"sys_conf.h" 打开调试:
 - #define DEBUGGER_ON 1
- 在"sys_conf.h" 可关闭或打开低功耗 模式:
 - #define LOW_POWER_DISABLE 0
- 使Nucleo 板上ST_LINK 进行调试

/orkspace 🔻 🕈 🗙	sys_conf.h * x main.c app_lorawan.c sys_app.c lora_app.h Region.h [Read-Only] radio.c [Read-Only] cmsis_compiler.h [Read-Only] lorawan_con se-identity.
.oRaWAN_End_Node ~	
Files Image: Constraint of the second se	<pre>53 - */ fdefine APP_LOG_ENABLED 1 55 56 - /** * @brief Enable Debugger mode * @note 1:0N it enables the debbugger plus 4 dgb pins, 0:0FF the debugger is OFF (lower consumption) */ fdefine DEBUGGER_ON 1 61 62 - /** * @brief Disable Low Power mode * @note 0: LowPowerMode enabled. MCU enters stop2 mode, 1: LowPowerMode disabled. MCU enters sleep mode only */ fdefine LOW_POWER_DISABLE 1 66 67 68 7 * USER CODE BEGIN EC */ 70 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7</pre>
LoRaWAN_End_Node	(



Project - JAR Embedded Workbench IDE - Arm 8 50 9

LoRaWAN_End_Node(1/2)

- 打开IAR 工程:
 - STM32Cube_FW_WL_V1.0.0\Projects\NUCLEO-• WL55JC\Applications\LoRaWAN\LoRaWAN End Node\ EWARM \Project.eww
- 编译工程并烧写到STM32WL Nucleo 板上 •
- 通过串口可以观察工作状态信息: ٠
 - "Joined": devices joins Network •
 - "MAC txDone": Tx sent •
 - "U/L Frame X": Frame X sent & received •

Ba EndNode SingleCore	aninc x
the second se	- magn
	PLLN = 1
Project - LoBa EndN	FLL R = 2
E Application	* PLL_P = 7
Doc	PLL Q = 4
Middlewarac	* rlasr latency(#S) = 4 * @param None
Utilities	* fretval None
Cutput	attic and Supremiles Cartiel raid by
	Static vold Jystemstock_control vold //
	/* USER CODE BEGIN PFP */
	/* USER CODE END PFF */
	/* Private user code+/ /* USER CODE BEGIN 0 */
	/* USER CODE END 0 */
	<pre>/** * @prief The application entry point</pre>
	• gentral ince • gentral inc
	+/ int main(void)
	/* USER CODE END 1 */
	/* MCU Configuration*/
	/* Reset of all peripherals, Initializes the Flash interface and the Systick. */
	BAL_Init();
	/ USER COOL EL Fait Schure Control Window Halp
	The For Serve Courton Millagow Lieb
	V* Configure OTAR
	10 Section 1991 22 12 13 10 20 10 10 17 13 00 07 11 30
roject	0s022: MAC_UERSION= 04.04.02.01
	0s026: TX on freq 868100000 Hz at DR 0
d	1s511: MAC txDone
Messages	6s545: RX on freq 868100000 Hz at DR 0
Building configuration: Project - LoRa	a_EndNode_SingleCore 853535 THC FXDONE
Updating build tree	Se358- JOINED
Configuration is up-to-date	1 Merce - Broutes
configuration to up to date.	UDDO- CONTRACTOR
	10s032: IX on freq 867700000 Hz at DR 0
	10681: MAC txDone
	12s715: KA ON IFEQ SUFFEEDED NZ AT DR Ø
	12:515: MHC rxlimeOut
	138/13- NA ON TPEQ 80/525000 HZ AT UK 0
	LICOMIN MULTIMOLIUT
	135115: THG FX11meUut 135917: APP> MensCanfirm STATUS: OK
d Debug Log	13syl5: THG FX1ImeUut 13syl7: APP> McpsConfirm STATUS: OK
id Debug Log	135915: THG FX1ImeUut 135917: APP> McpsConfirm STATUS: OK 13-917: #= U/L FRAME 1 =# Class A, Port 99, data size 17, pwr 0, Channel Mask 00FF
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LoRaWAN_End_Node(2/2)



1/18/2022

- 开启之前配置好的网关,打开网络服务 器
- 节点配置完成,,节点就可以自动加入 对应的网关,
- 网络节点将传感器信息传输到Loriot LoRaWAN 网络服务器



LoRaWAN_End_Node(2/2)

• LoRaWAN 网络服务器Loriot 收到 数据后,还可以将网络服务器收到 的数据转发给应用服务器Cayenne.

•本章节详细操作可参考UM2587

UM2587 Getting started with the P-NUCLEO-LRWAN2 and P-NUCLEO-LRWAN3 starter packs 1.0







LoRaWAN_AT_Slave例程



LoRaWAN_AT_Slave(1/3)

- 打开 IAR工程 :
 - STM32Cube_FW_WL_V1.0.0\Projects\NUCLEO-WL55JC\Applications\LoRaWAN\LoRaWAN_AT_Slave\EWARM\ Project.eww
- 将编译好的软件烧写到STM32WL NUCLEO 板
- 打开串口工具,可使用AT指令对入网参数进行配:具体 AT指令操作可以参考 <u>AN5481: LoRaWAN® AT commands for</u> <u>STM32CubeWL</u>
 - AT+APPEUI=<Param>
 - AT+APPKEY=<Param>
 - AT+DEUI=<Param>
 - AT+JOIN: Join the Network
 - AT+SEND=PortNb:my_value



1		
Messages	COM19:9600baud - Tera Term VT File Edit Setup Control Window Help	
ild Debug Log	File Edit Setup Control Window Help ATtention command interface OTAA Mode enabled DevEuie 01-01-01-01-01-01-04-01 JoinEuie 01-01-01-01-01-01-01-01 JoinEuie 01-01-01-01-01-01-01-01-01-01 01-01-01-01-01-01 01-01-01 01-01-01 AppKey= 2B 7E 15 16 28 AE D2 A6 AB F7 15 88 09 CF 4F 3C PRE 0K TX on freq 868300000 Hz at DR 0 13s682: PHY txDone 0 RX on freq 868300000 Hz at DR 0 18s919: PHY rxTimeOut No RX on freq 869525800 Hz at DR 0 2ssore PHY rxDone Mon freq 8677000000 Hz at DR 0 18s919: PHY rxTimeOut No Massore PHY rxDone 0 0 Massore PHY rxDone 0 0 Massore PHY rxTimeOut 1 0 Massore PHY rxTimeOut	



LoRaWAN_AT_Slave(2/3)

- 开启之前配置好的网关,打开网 • 络服务器
- 节点配置完成, , 节点就可以自 动加入对应的网关,
- 网络节点将传感器信息传输到 • Loriot LoRaWAN 网络服务器





4

LoRaWAN_AT_Slave(3/3)

- 通过串口工具输入AT 指令也可以做LoRa RF 性能的测试
- 比如执行下面的指令测试RF Tx:
 - AT+TTONE







SubGHz_Phy_PingPong例程



Ping Pong (1/2)

- 打开 IAR 工程编译:
 - STM32Cube_FW_WL_V1.0.0\Projects\NUCLEO-WL55JC\Applications\SubGHz_Phy\SubGHz_Phy_PingPong\ EWARM\Project.eww
- 在两块STM32WL Nucleo 板上分别烧录软件
- 两块板中先上电的会做master发出PING 信息,另一 块收到PING信息的板会做slave,并回一个PONG信 息给master。
- 打开两个串口工具分别监控两块板的工作状态

Addressing Image: State in the state intervence inter	Ra_PingPong_SingleCore				
<pre>http://www.setures.com/public for the system lock // system l</pre>					
<pre>lest</pre>			* PLL M	= 1	
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<pre>weite Void System.lose_control (void);</pre>	🖽 📹 Output	L.	*/		
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Project INC_SystemCommon_Thit(); INC_SystemCom		- I T	/* USER CODE BEGIN SysInit */		
Neglect m Md Messages Building configuration: Project - LoRa_PingPong_SingleCore Updating build tree Configuration is up-to-date.			MX_SystemCommon_Init();		
Messages Building configuration: Project - LoRa_PingPong_SingleCore Updating build tree Configuration is up+to-date.	roject	•			m
Messages Bullding configuration: Project - LoRa_PingPong_SingleCore Updating build tree Configuration is up-to-date.	Id				
Messages Building configuration: Project - LoRa_PingPong_SingleCore Updating build tree Configuration is up-to-date.					
Building configuration. Hroject - LoHa_PingPong_SingleCore Updating build tree Configuration is upHo-date.	Messages				
Configuration is up-to-date.	Building configuration: Project - Li Updating build tree	oRa_PingPo	ong_SingleCore		
Comguration is up-to-dete.	Configuration is up to data				
	configuration is up to dote.				



Ping Pong (2/2)

- 做master的板串口显示如右上图:
- 做slave的板串口显示如右下图:
- 收到PONG消息时,红灯闪
- 收到PING消息时,蓝灯闪烁

COM102:115200baud - Tera Term VT		
<u>File Edit Setup Control Window H</u> elp		
3s769:PING 3s914: OnTxDone		
4s107: RssiValue=-17 dBm, SnrValue= 4s111:PING		
4s255- duluenc 4s448: OnRxDone 4s449: RssiValue=-17 dBm. SnrValue=:	12	
4s453:PING 4s597: OnTxDone		
48790: UNRXJONE 48791: RssiValue=-17 dBm, SnrValue= 48794:PING 48939: OnTxDone	12	
5s131: OnRxDone 5s132: RssiValue=-17 dBm, SnrValue=: 5s136:PING 5s291: OnTxDone	12	
5s473: OnRxDone 5s474: RssiValue=-17 dBm, SnrValue=: 5s478:PING	12	
5s623: OnTxDone 5s815: OnRxDone 5s816: RssiValue=-16 dBm, SnrValue=:		
5s820:PING 5s965: OnTxDone 6s159: OnTxDone	<u>File Edit Setup Control Window H</u> elp	
6s163:PING	13 6s234:PONG 6s354: OnTxDone	*
6s302: OnTxDone 6s500: OnRxDone 6s500: RssiValue=-14 dBm, SnrValue=:	6s549: Residulue=-18 dBm, SnrValue=13 6s577:PONG	
6s504:PING 6s649: OnTxDone	6sB91: OnRxDone 6s891: OnRxDone 6s892: Bssivalue=-18 dBm, SprValue=12	
-	6s918:PONG 7s039: OnTxDone	
	78234: RssiValue=-18 dBm, SnrValue=12 78260:PONG	
	7s380: OnlxDone 7s575: OnRxDone 7s576: RssiUalue=-18 dBm. SnrValue=12	
	7s602:PONG 7s722: OnTxDone 7s916: OnByDone	
	7s917: RssiValue=-18 dBm, SnrValue=13 7s944:PONG	
	8s064: UnixDone 8s258: OnRxDone 8s259: RssiValue=-18 dBm, SnrValue=13	
	8s287:PONG 8s407: OnTxDone 8s601: OnTxDone	
	8s602: RssiValue=-17 dBm, SnrValue=13 8s629:PONG 8s629:PONG	
	85944: OnRxDone 85944: OnRxDone 85945: RssiValue=-15 dBm, SnrValue=12	
	8s971:PONG 9s092: OnTxDone	₽ B5
1/18/2022	2	





LocalNetwork例程



LocalNetwork(1/2)

本例程可支持一个STM32WL concentrator,和14个STM32WL sensor组成的私有网络







LocalNetwork(2/2)

- 比如,有四块STM32WL Nucelo 板,选其中一块作为 Concentrator,烧写LocalNetwork_Concentrator 工程软件。 其余3块烧写LocalNetwork Sensor 工程软件作为节点。
- 将四块STM32WL Nucleo 板分别上电,让节点加入concentrator
- 使用串口工具,或者STM32CubeMonitor1.1.0 监控 节点传输传感器数据到Concentrator。
- 关于STM32CubeMonitor 详细操作请参考链接: https://wiki.stmicroelectronics.cn/stm32mcu/wiki/STM32CubeMonitor: How_to_start_with_STM32_Wireless_Long_Range_demo



÷ EUI								
- EUI						COUNTER RES	ET	5 RESTART
	÷ 1	Packets		Signal quality		Measurement	Measurements	
		Received ~	Missed -	RSSI -	PER - SNR	- Temp -	Voltage	*
0 0x	00004b8d	2	0	-98 dBm	0 % 7	+27.00 °C		3.30 V
1 0x	00004bdd	2	0	96 dBm	0 %	+28.00 °C	De	3.30 V
2 0x	0500b9bf	1	0	-72 dBm	0 % 7	+25.00 °C	0	3.30 V
Social Is	a				Sensor 0			
Senairu								





- 1. 开发包
- 2. STM32WL 开发环境
- 3. LoRaWAN_End_Node例程
- 4. LoRaWAN_AT_Slave例程
- 5. SubGHz_Phy_PingPong例程
- 6. LocalNetwork例程



Thank you

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