

## MPLAB<sup>®</sup> Harmony 3 之基础篇(10)

-- 轻松创建 TCP/IP 应用

Microchip Technology Inc. MCU32 产品部

一、 简介

本文主要介绍如何利用 MPLAB X IDE 创建一个工程,利用 MPLAB Harmony 3 Configurator(MHC)添加所需要的硬件驱动,TCP/IP 协议栈,其他服务等,在 SAM V71 Xplained Ultra Evaluation Kit 开发板上轻松创建一个完整的 TCP/IP Server 端的 例程。

# 二、 硬件工具和软件平台

硬件: SAM V71 Xplained Ultra Evaluation Kit https://www.microchip.com/DevelopmentTools/ProductDetails/ATSAMV71-XULT



*软件(开发工具和环境的安装和使用,见"MPLAB® Harmony 3 之基础篇(01) --Harmony 3 开发环境搭建")*: MPLAB<sup>®</sup> X: v5.15 或者更新



XC32:v2.15 或者更新Harmony 3:v3.10 或者更新



### 三、 详细步骤

首先我们来了解一下我们需要用到的这一块 SAM V71 Xplained Ultra Evaluation Kit。 这块开发板,使用的主控 MCU 是 SAMV71Q21。这是一颗 ARM Cortex-M7 内核的 MCU,主频高达 300MHz,带有 2MB 的 Flash, 384KB 的 SRAM。拥有 10/100 Mbps 的 Ethernet Media Access Controller (GMAC),支持 MII, RMII 接口。开板上带有一 颗 KSZ8061 网络 PHY 芯片。该开发板同时自带了 EDBG,可以直接通过 Micro USB 连接电脑,用 MPLAB 进行下载,或者在线调试。同时还有一个虚拟串口,可供 打印调试信息。

接下来我们就用 MPLAB X IDE 和 MHC 一步步地创建和配置基于 TCPIP 的应用。 SAM V71 Xplained Ultra Evaluation Kit 采用的是 RMII 接口,搭配的 PHY 芯片就是 板子上自带的 KSZ8061。

- 注:以下MHC 配置里没有特别标注出来的地方,说明使用的是默认选项。
- (一) 新建一个 MPLAB Harmony 3 的工程

在 MPLAB X IDE 里点击 File > New Project:

🗴 New Project		×
Steps	Choose Project	
1. Choose Project	Q, Filter:	
	Categories:	Projects: 32-bit MPLAB Harmony 3 Project Standalone Project Existing MPLAB IDE v8 Project Prebuilt (Hex, Loadable Image) Project User Makefile Project Library Project Import START MPLAB Project Import Atmel Studio Project
	Description:	
	MPLAB(8) Harmony Project Wizard	
	< <u>B</u> ack	Next > Einish Cancel Help

选择"32-bit MPLAB Harmony Porject", 然后点击"Next"按钮。



🔀 New Project			×
Steps	Manage Framework		
Choose Project     Framework Selection     Project Settings     Configuration Settings	Use the Framework Dow Launch Framew	vnloader tool to download or configure a local framework. work Downloader	
	Framework Path:	C:\HarmonyFramework3\	1
		Convert to Relative Path for Configuration	
		< Back Next > Enish Cancel	<u>H</u> elp

选择"Harmony Framework"路径,然后点击"Next"按钮。



🔀 New Project		×
Steps	Name and Loc	cation
Choose Project     Framework Selection     Project Settings	Location:	D:\tcpip_server
4. Configuration Settings	Folder:	tcpip_server
	Name:	
	Path:	D:\tcpip_server\firmware\tcpip_server.X
	Show	Visual Help
		< Back Next > Einish Cancel Help

在这里输入需要的项目名称,项目代码的存放位置,然后点击"Next"按钮。



🔀 New Project					×
Steps	Configuration Set	ttings			
Choose Project     Framework Selection     Project Settings     Configuration Settings	Name:	tcp_server	配置的名称		
	Device Family:	ATSAM	Target Device:	ATSAMV71Q21B	
	Device Filter:		心万突加		一心斤具体型号
	Show Visua	al Help			
			< <u>B</u> a	dk Next > Ein	ish Cancel <u>H</u> elp

这个页面最主要是选择我们需要使用的芯片,我们用的这个开发板的 MCU 是 ATSAM 的 ATSAMV71Q21B。另外需要设置当前配置的名称,用于保存配置文件。 然后点击"Finish"按钮。

(二) 添加所需要的基础软件包



Juau	Name	Version	Dependencies
	- venice	version	Dependencies
	dutio	V3.1.0	core(3.0)
$\sim$	bsp	V3.2.0	core(3.0)
<u> </u>	bt	V3.1.0	core(3.0)
$\leq$	core	v3.2.0	csp(3.0)
	crypto		core(3.0)
$\sim$	csp	v3.2.0	
<u> </u>	gfx	v3.1.0	core(3.0)
	micrium_ucos3	v3.0.0	core(3.0)
$\leq$	net		core(3.0)
	toucn	v3.1.0	csp(3.0)
$\checkmark$	usb	v3.1.3	core(3.0)
nfigure P:	e Device Family and CMSIS Pack Paths: .\dev_packs\Microchip\SAMV71	DFP\3.0.2\samv71b\atdf\ATSAMV71Q21B	8.atdf

这个页面是选择我们需要加入使用的基础的 Harmony 软件 package。在这里我们 选择 bsp, core, net 三个主要的 package。其他几个在本例程中不需要使用。点 击 "Launch"完成。

(三) 往当前新建工程里面添加所需要的功能

从 MPLAB X IDE 的 Tools 菜单,选择 Embedded,MPLAB Harmony3 Configurator。

MPLAB X IDE v5.15 - tcp_server : tcp_server		
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当前已经加入的部件列表		e Por
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Graphics		
Harmony		
🖽 Input	Console	
🖶 Libraries		
🖶 Peripherals	<harmony database="">[Info]: create component: USB Device Ve</harmony>	ndor
Third Party Libraries	<harmony database="">[Info]: create component: USB Device Au</harmony>	idio
I Tools	<pre><harmony database="">[Info]: create component: USB Device H]</harmony></pre>	D ID

从 MPLAB X IDE 左下角的 Available Components 页面中,选择添加当前使用开发



### 板的 BSP。

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Board Support Packages (BSPs)			
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Core			1
Drivers	Console		
Harmony Networking			
System Services	<pre><harmony database="">[Info]: create component: USB Device Vendor</harmony></pre>		
CONSOLE 双击添加CONSOLE	(Harmony Database>[Info]: create component: USB Device Audio		
FILE SYSTEM	<harmony database="">[Info]: create component: USB Device HID  <harmony database="">[Info]: create component: USB Device MSD</harmony></harmony>		
TIME	<pre>{Harmony Database&gt;[Info]: create component: USB Host</pre>		
🖽 Input	<harmony database="">[into]: create component: USB Host MSD   <harmony database="">[Info]: create component: USB Host CDC</harmony></harmony>		
🖽 Libraries	<pre><harmony database="">[Info]: create component: USB Host HID</harmony></pre>		
III Bautakausta	II-Uanmony Databases IInfol: create component: IISR Wost Audio	_	

从左下角的 Available Components 页面中,选择添加 Harmony3 的服务 CONSOLE。 这个主要是后面通过串口来打印调试信息。然后选中 Active Components 中的 CONSOLE,在 MPLAB X IDE 右上方的列表中勾选 Enable Debug 使能该功能。

X MPLAB X IDE v5.15 - tcp_server : tcp_server		
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		E
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	The database is requesting auto-activation of the following components:	
	Core (HarmonyCore)	
	Are you sure you want to activate these components?	
tcp_server Navigator Available Co		
*	Yes No	
Board Support Packages (BSPs)		
Graphics		
Harmony		
Core		
🕀 Drivers	Console	
Harmony Networking		
System Services	<harmony database="">[Info]: create component: USB Device Vendor</harmony>	
	<pre><harmony database="">[info]: create component: USB Device Audio <harmony database="">[info]: create component: USB Device HID</harmony></harmony></pre>	
FILE SYSTEM	-Warmony Datahasas[Trifo], create component: USB Davice MSD	

在添加 CONSOLE 的时候, MPLAB X IDE 同时提示, 是否需要加入 Core。选择 Yes 添加进去。



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	Confirm Component Auto-Activation? ×		
	The database is requesting auto-activation of the following components:		
	FreeRTOS (FreeRTOS)		
ton convor - Navigator Available Co	Are you sure you want to activate these components?		
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Default Board (BSP)			
Graphics			
Harmony			
Core			
🖶 Drivers	Console		
Harmony Networking			
System Services	<harmony database="">[Info]: create component: USB Device Vendor</harmony>		
CONSOLE	<pre> </pre>		
FILE SYSTEM	<harmony database="">[Info]: create component: USB Device MSD</harmony>		
	<pre>  <harmony database="">[Info]: create component: USB Host</harmony></pre>		

同时 MPLAB X IDE 还会提示,是否需要添加 FreeRTOS。因为当前例程不需要 OS 的支持,所以选择 No 跳过。







下面接着添加 CONSOLE 所需要用到的串口。从左下角的 Available Components 页面中, Peripherals 列表,选择添加 USART1。同时把串口的波特率改为 115200。 同时把 CONSOLE 跟 UART1 连接起来。

#### (四) 逐步添加 TCP/IP 相关的功能

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Graphics		
Cryptographic (Crypto) Library		
➡ TCPIP		
CORE		
🖶 Layer3-NETWORK		
🖶 Layer4-TRANSPORT		
Layer7-APPLICATION		
TCP/IP Application Layer Configurator		
TCP/IP Basic Configurator XII/II/	Console	
ICP/IP Driver Layer Configurator		
TCP/IP Transport Layer Configurator	<pre><harmony database="">[Info]: create component: USB Device MSD</harmony></pre>	
	<harmony database="">[Info]: create component: USB Host</harmony>	
Peripherals	<harmony database="">LINTO]: Create component: USB HOST MSD  <harmony database="">[Info]: create component: USB Host CDC</harmony></harmony>	
Third Party Libraries	<pre><harmony database="">[Info]: create component: USB Host HID</harmony></pre>	
Tools	<pre>  <harmony database="">[into]: Create component: USB HOST AUG10   <init>[Info]: Startup tasks complete.</init></harmony></pre>	
	[ <statusmessage>[Info]: Drag into the Design Graph Window and release to add this component.</statusmessage>	

首先在 Libraries 类别下的 TCP/IP 项,选择添加 TCP/IP Driver Layer Configurator。





过程中会要求加入 TIME,选择 Yes 添加。







然后选中添加进去的 TCP/IP Driver Layer Configurator,在 MPLAB X IDE 的右上方勾选 GMAC,系统提示的时候选择 Yes 添加。后面 MPLAB X IDE 还会提示会自动连接相关部件,选择 Yes 继续。





选中 TCP/IP Driver Layer Configurator,在 MPLAB X IDE 的右上方勾选 MIIM\_Driver,系统提示的时候选择 Yes 添加。



选中 TCP/IP Driver Layer Configurator,在 MPLAB X IDE 的右上方勾选 KSZ8061,系 统提示的时候选择 Yes 添加。



X MPLAB X IDE v5.15 - tcp\_server : tcp\_server



这个时候我们可以看到, MPLAB X IDE 左上方的 Active Components 页面,系统已 经自动为我们添加了 TCP/IP 相关的几个 Layer 的一些配置。

🔀 MPLAB X IDE v	5.15 - tcp_	server : tcp	o_server												
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Proje Files	Servi	Classes	Acti	Project Gra	ph*										Configu
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CMSIS Pack CONSOLE Core Device Family SAW V71 Xpla System TC0 ➡ TCP/IP STACK TIME USART1	r Pack (D ined Ultra	FP) a BSP		Device P US Periphe Periphe	amily Pack (DFP) ART1 I Library UART al Library CO al Library TMR	System CONSOLE System Servic O Core Servic UART Sys_CONSOL TIME System Service Sys_TIME TMR	CMSIS Pack	SAM	V71 Xplained ACK SOLE	Ultra BSP) 史,拖动道	Harmon O RTOS Cor	Core y Core Service S e Service	•		
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因为添加的过程中,加入了 TIME,所以这里我们需要从左下的 Available Components 的 Peripherals 中添加一个 TCO。然后在 Project Graph 的 Root 页面中 把相应的 service 跟 peripheral 连接起来。

(五) 逐步配置当前工程 TCP/IP 相关的功能





- <Harmony Database>[Info]: MIIM Driver Component
  <Harmony Database>[Info]: KSZ8061 PHY Driver Component
  <Harmony Database>[Info]: Running TC0





选中 Active Components 中 TCP/IP STACK 下的 APPLICATION LAYER 里面的 TCP/IP Application Layer Configurator,在 MPLAB X IDE 右上方的列表中,选择添加我们需要用到的 DHCP CLIENT 和 DNS CLIENT。在添加的过程中,系统还会提示需要同时加入的 ARP, UDP 服务。我们也需要选择 Yes 一并加入。

MPLAB X IDE v5.15 - tcp\_server : tcp\_server File Edit MHC View Navigate Source Refactor Pr oduction Debug Team Tools Window Help ٩ 🕾 🔚 📲 🦏 🧶 🤄 top\_server 💿 👔 - 🦉 - 🕨 - 🤽 - 🔽 - 🏹 🚯 - 🕨 🖻 🏓 🕬 🕬 🕬 👘 🖬 🖬 How do 12 Proje... Files Servi... Classes Acti... 
Project Graph\* Configuration Options\* He View: Root CMSIS Pack CONSOLE C  $\mathbf{Y}$ Core Core RTOS Core Se Device Family Pack (DFP) System TCP/IP STACK TC0 TCP/IP STACK TIME USART1 tcp\_server - ... Navigator Available Co... Board Support Packages (BSPs)
 Graphics
 Harmony
 Unput
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 Peripherals
 Third Party Libraries
 Tools Console cHarmony Databases[Info]: Running TC0
cHarmony Databases[Info]: Running TC0
cHarmony Databases[Info]: TCPIP DHCP Client Com
cHarmony Databases[Info]: TCPIP HV4 Component
cHarmony Databases[Info]: TCPIP Menu Invisible.
cHarmony Databases[Info]: TCPIP Menu Invisible.

选中 Active Components 中 TCP/IP STACK 下的 BASIC CONFIGURATION 的 TCP/IP Basic Configurator。勾选 TCPIP CMD 添加进来。





选中 Active Components 中 TCP/IP STACK 下的 NETWORK LAYER 的 TCP/IP Network Layer Configurator。勾选 ICMPv4 添加进来。



选中 Active Components 中 TCP/IP STACK 下的 TRANSPORT LAYER 的 TCP/IP Transport Layer Configurator。勾选 TCP 添加进来。

(六)检查当前配置,连接相关的服务和驱动





在 Project Graph 的 root view 中, 检查确保我们已经把 USART1, CONSOLE, TCP/IP STACK 的 SYS\_CONSOLE 连接起来。

(七) 配置 MCU 的相关 GPIO, 与 Ethernet PHY 的相关 GPIO

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ic		-	16	PC29		Available	$\sim$	In	n/a		Disabled	$\sim$			Disabled	$\sim$
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		DMA Configurat	on 28	PD3	GMAC_GTX1	GMAC_GTX1	~	n/a	n/a		Disabled	~			Disabled	~
	Utilities	MDULCarformet	26	PD4	GMAC_GRXDV	GMAC_GRXDV	~	n/a	n/a	$\vdash$	Disabled	~			Disabled	~
		MPO Configurati	on 25	PDS	GMAC_GRX0	GMAC_GRXU	~	n/a	n/a		Disabled				Disabled	
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			110	PD9	GMAC GMDIO	GMAC GMDIO	~	n/a	n/a		Disabled	~	H		Disabled	~
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rd S	upport Packages	(BSPs)	88	PD 13		Available	$\sim$	In	n/a		Disabled	~			Disabled	$\sim$
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ines	5		69	PD 18		Available	$\sim$	In	n/a		Disabled	$\sim$			Disabled	$\sim$
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接下来我们需要打开菜单 MHC -> Tools -> Pin Configuration,在 Pin Settings 页面根 据 V71 Xplained Ultra Evaluation Kit 的硬件配置,把相应的 GPIO 配置好。下面是 一个列表:

PA21 -> USART1\_RXD1 PB4 -> USART1 TXD1



PD0 -> GMAC\_GTXCK PD1 -> GMAC\_GTXEN PD2 -> GMAC\_GTX0 PD3 -> GMAC\_GTX1 PD4 -> GMAC\_GRXDV PD5 -> GMAC\_GRX0 PD6 -> GMAC\_GRX1 PD7 -> GMAC\_GRXER PD8 -> GMAC\_GMDC PD9 -> GMAC\_GMDIO

(八) 编译器的相关配置





MPLAB X IDE v5.15 - tcp_server : tcp_server	
File Edit MHC View Navigate Source Refactor Produ	uction Debug Team Tools Window Help * • • • • • • • • • • • • • • • • • • •
Proj × Files Servi Classes Activ	Project Graph* Pin Diagram × Pin Table × Pin Settings ×
Control C	Pin       Pin ID       Custom Name       Function       Direction       Latch       Open       PIO Interrupt       Pull Up       Glitch/Deboun         76       Project       Project       Project       Pint       Direction       Latch       Open       PIO Interrupt       Pull Up       Pull       Glitch/Deboun         78       Project       Project       Project       Project       Pille       Inclusion/Exclusion         131       •       General       Option categories:       Option categories:       Poteo       Reset         132       •       Fille Inclusion/Exclusion       Option categories:       Option categories:       Poteo       Reset         133       •       EbBG       Minimum stek circle (bytes)       44950       Allow overlapped sections       Poteo         133       •       EbBding       Use response file to link       Poteo       Poteo       Poteo       Poteo         133       •       v:22:as       Additional driver options       Poteo       Pot
tcp_server SYS_Tasks( Available	Additional options:
Board Support Packages (BSPs)     Graphics     Harmony     Input     Libraries     Dordhorale	20     Option Description Generated Command Line User Comments       306     78       78     69
	67 Manage Configurations
AFEC	Search I
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在编译之前,还需要手动选择一下编译工具。该例程是使用 XC32 进行编译。另外,请确保在 xc32-ld 项的配置中,把 Heap size 设置位 44960。

#### (九) MHC 产生代码

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经过一系列的添加配置之后,我们就可以点击 MHC 菜单下的 Generate Code 来产 生基础代码。

(十) 在 APP Task 添加相应的 TCP Server 逻辑代码



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系统 Generate Code 完成之后可以看到, MPLAB X IDE 已经自动为我们生成了大部分的代码以及应用框架。我们只需要修改其中的 APP 部分代码(对应 APP.c, APP.h) 来实现 TCP/IP 的 server 应用。APP 部分的代码,可以直接参考 Harmony3 Framework 安装目录, HarmonyFramework\net\apps\tcpip\_tcp\_server\firmware\src 目录的应用代码实现。

(十一) 连接开发板调试





在连接开发板进行调试的时候,需要选择当前的开发板作为调试目标。

在这个例程里面,系统启动之后,就会初始化一系列相关的硬件,然后等 IP 获取到之后,就会创建一个 TCP 的 Server,然后等待连接。



用串口工具连接开发板的虚拟调试信息口,波特率就是我们之前配置的 115200。 系统启动之后会看到一下打印信息。最后的打印信息表示已经拿到 IP 地址 10.161.8.56,并且 TCP Server 在端口 9760 等待 Client 的连接。





 → 期抵流循环发送
 发送间隔 1000 毫秒
 文件载入 雪跷输入

 本地主机: 10.161.8.72 本地端口: 54804

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这个时候我们可以利用网络调试工具,连接到开发板上的 TCP Server。并且往 Server 发送一些字符串。Server 会把其中的小写字母都转换成相应的大写字母, 然后回发给 Client。另外,用 escape 字符来断开与 Server 的连接。

### 四、 总结

本文通过 MPLAB X IDE 的 MHC 一步步的配置,最后生成代码,完成了一个 TCP/IP 的简单应用。基本的应用框架以及所有的底层驱动代码都是系统自动生成了。用 户只需要实现 Server 功能相应的逻辑代码就可以。所以利用 MPLAB X IDE 的 MHC 来创建工程是非常简单的,大部分的代码都能自动生成。用户只需要集中精力处 理自己需要实现的功能代码就可以了。

