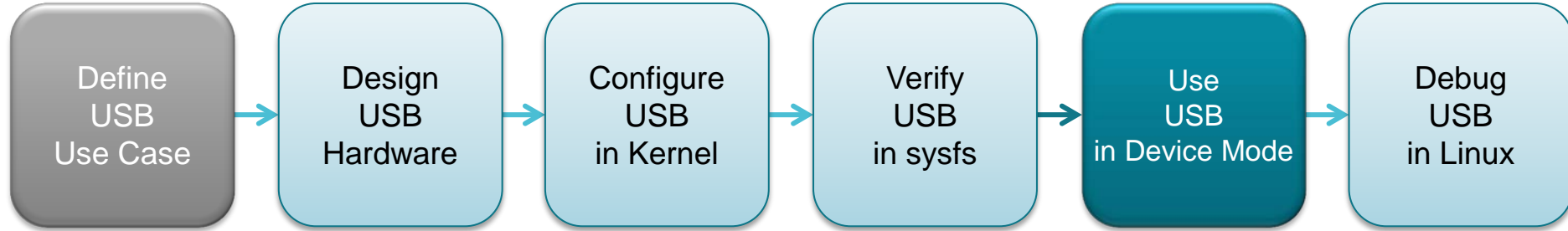


# USB System Design in Sitara Devices Using Linux

**[Part 6]: Use USB in Device Mode**

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# Agenda



- USB Device Mode Overview
  - Functions supported in Linux
- Device Functions
  - Legacy
  - configs
- `/sys/class/udc/`

# USB device mode overview

- USB device mode (a.k.a., USB Gadget mode):
  - Presented as a USB device (dongle) to attach to a USB host port
  - Linux/Kernel implements the USB device firmware
- USB devices:
  - Hubs
  - Functions
- Supported USB functions in Linux (as of Kernel v4.9):
  - Ethernet Gadget (CDC NCM/ECM/EEM, RNDIS)
  - Serial Gadget (CDC ACM/OBEX)
  - Printer Gadget
  - Audio Gadget (Class 1.0 & 2.0)
  - Mass Storage Gadget
  - HID Gadget
  - Webcam Gadget
  - Composite Gadget – multiple functions

# Methods of loading USB gadget drivers

## 1. Legacy method:

- For example, “modprobe g\_ether”
- Suitable for the following:
  - Ethernet Gadget
  - Mass Storage Gadget
  - Serial Gadget
  - Printer Gadget
  - Audio Gadget
- Deprecated

## 2. Through USB configs:

- /sys/kernel/config/usb\_gadget
- Suitable for all gadgets
- But beneficial for the following:
  - Webcam Gadget
  - HID Gadget
  - Composite Gadget

# Legacy method of using USB Ethernet Gadget

```
root@am57xx-evm:~# modprobe g_ether
```

```
[ 25.025947] using random self ethernet address
```

```
[ 25.030412] using random host ethernet address
```

```
[ 25.037596] usb0: HOST MAC 2a:cc:4a:1b:71:86
```

```
[ 25.042203] usb0: MAC 12:b9:3f:c8:7f:53
```

```
[ 25.046267] using random self ethernet address
```

```
[ 25.050845] using random host ethernet address
```

```
[ 25.055539] g_ether gadget: Ethernet Gadget, version: Memorial Day 2008
```

```
[ 25.062285] g_ether gadget: g_ether ready
```

# Legacy method of using USB Ethernet Gadget

```
root@am57xx-evm:~# modprobe g_ether
[ 25.025947] using random self ethernet address
[ 25.030412] using random host ethernet address
[ 25.037596] usb0: HOST MAC 2a:cc:4a:1b:71:86
[ 25.042203] usb0: MAC 12:b9:3f:c8:7f:53
[ 25.046267] using random self ethernet address
[ 25.050845] using random host ethernet address
[ 25.055539] g_ether gadget: Ethernet Gadget, version: Memorial Day 2008
[ 25.062285] g_ether gadget: g_ether ready
```

Connecting USB Gadget to a USB host port, the gadget UART console prints:

```
root@am57xx-evm:~# [32.992247] g_ether gadget: high-speed config #1: CDC Ethernet (ECM)
```

# Legacy method of using USB Ethernet Gadget

```
root@am57xx-evm:~# modprobe g_ether
[ 25.025947] using random self ethernet address
[ 25.030412] using random host ethernet address
[ 25.037596] usb0: HOST MAC 2a:cc:4a:1b:71:86
[ 25.042203] usb0: MAC 12:b9:3f:c8:7f:53
[ 25.046267] using random self ethernet address
[ 25.050845] using random host ethernet address
[ 25.055539] g_ether gadget: Ethernet Gadget, version: Memorial Day 2008
[ 25.062285] g_ether gadget: g_ether ready
```

- Connecting USB gadget to a USB host port, the gadget UART console prints:  
root@am57xx-evm:~# [32.992247] g\_ether gadget: high-speed config #1: CDC Ethernet (ECM)
- Both gadget and host sides now have **usb0** network interface.

# Legacy method of using USB Mass Storage Gadget (MSG)

```
root@am57xx-evm:~# modprobe g_mass_storage file=/dev/mmcblk0p1
```

```
[ 461.652129] Mass Storage Function, version: 2009/09/11  
[ 461.657541] LUN: removable file: (no medium)  
[ 461.662170] LUN: file: /dev/mmcblk0p1  
[ 461.665952] Number of LUNs=1  
[ 461.668941] g_mass_storage gadget: Mass Storage Gadget, version: 2009/09/11  
[ 461.676088] g_mass_storage gadget: userspace failed to provide iSerialNumber  
[ 461.683218] g_mass_storage gadget: g_mass_storage ready  
[ 462.044258] g_mass_storage gadget: high-speed config #1: Linux File-Backed Storage
```

The USB host now enumerated the gadget as a block storage device.



# Legacy method of using USB Serial Gadget

```
root@am57xx-evm:~# modprobe g_serial
```

```
[ 800.169665] g_serial gadget: Gadget Serial v2.4
```

```
[ 800.174732] g_serial gadget: g_serial ready
```

```
[ 800.535731] g_serial gadget: high-speed config #2: CDC ACM config
```

This creates:

- /dev/ttyGS0 on the gadget side
- /dev/ttyACM0 on the host side

# Legacy method of using USB Printer Gadget

```
root@am57xx-evm:~# modprobe g_printer
```

```
[ 981.388465] printer gadget: printer ready
```

```
[ 981.746183] printer gadget: high-speed config #1: printer
```

This creates:

- /dev/g\_printer0 on the gadget side
- /dev/usb/lp0 on the host side

# Legacy method of using USB Audio Gadget

- On the Sitara device board:

```
root@am335x-evm:~# modprobe g_audio
```

```
root@am335x-evm:~# aplay -l
```

```
card 1: UAC2Gadget [UAC2_Gadget], device 0: UAC2 PCM [UAC2 PCM]
```

```
root@am335x-evm:~# arecord -l
```

```
card 1: UAC2Gadget [UAC2_Gadget], device 0: UAC2 PCM [UAC2 PCM]
```

# Legacy method of using USB Audio Gadget

- On the Sitara device board:

```
root@am335x-evm:~# modprobe g_audio
```

```
root@am335x-evm:~# aplay -l
```

```
card 1: UAC2Gadget [UAC2_Gadget], device 0: UAC2 PCM [UAC2 PCM]
```

```
root@am335x-evm:~# arecord -l
```

```
card 1: UAC2Gadget [UAC2_Gadget], device 0: UAC2 PCM [UAC2 PCM]
```

- Connect its USB device port to USB host port.

- On USB host:

```
test@host:~$ aplay -l
```

```
card 2: Gadget [Linux USB Audio Gadget], device 0: USB Audio [USB Audio]
```

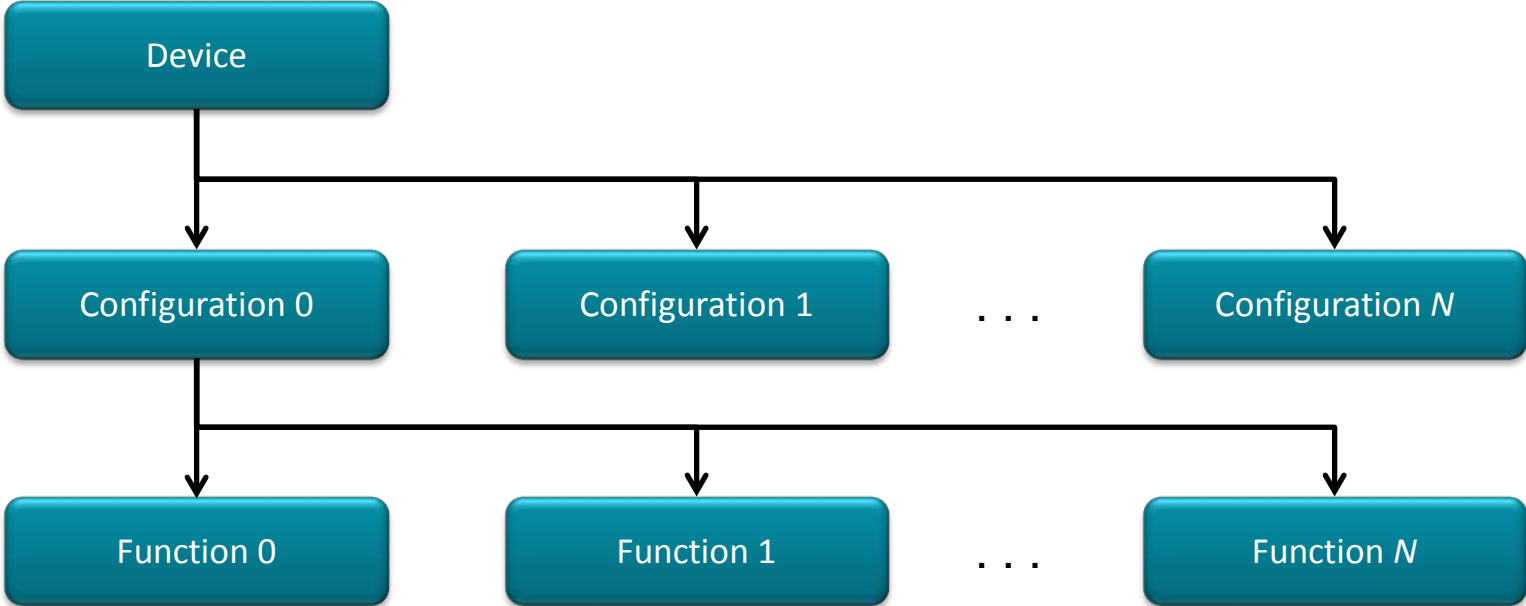
```
test@host:~$ arecord -l
```

```
card 2: Gadget [Linux USB Audio Gadget], device 0: USB Audio [USB Audio]
```

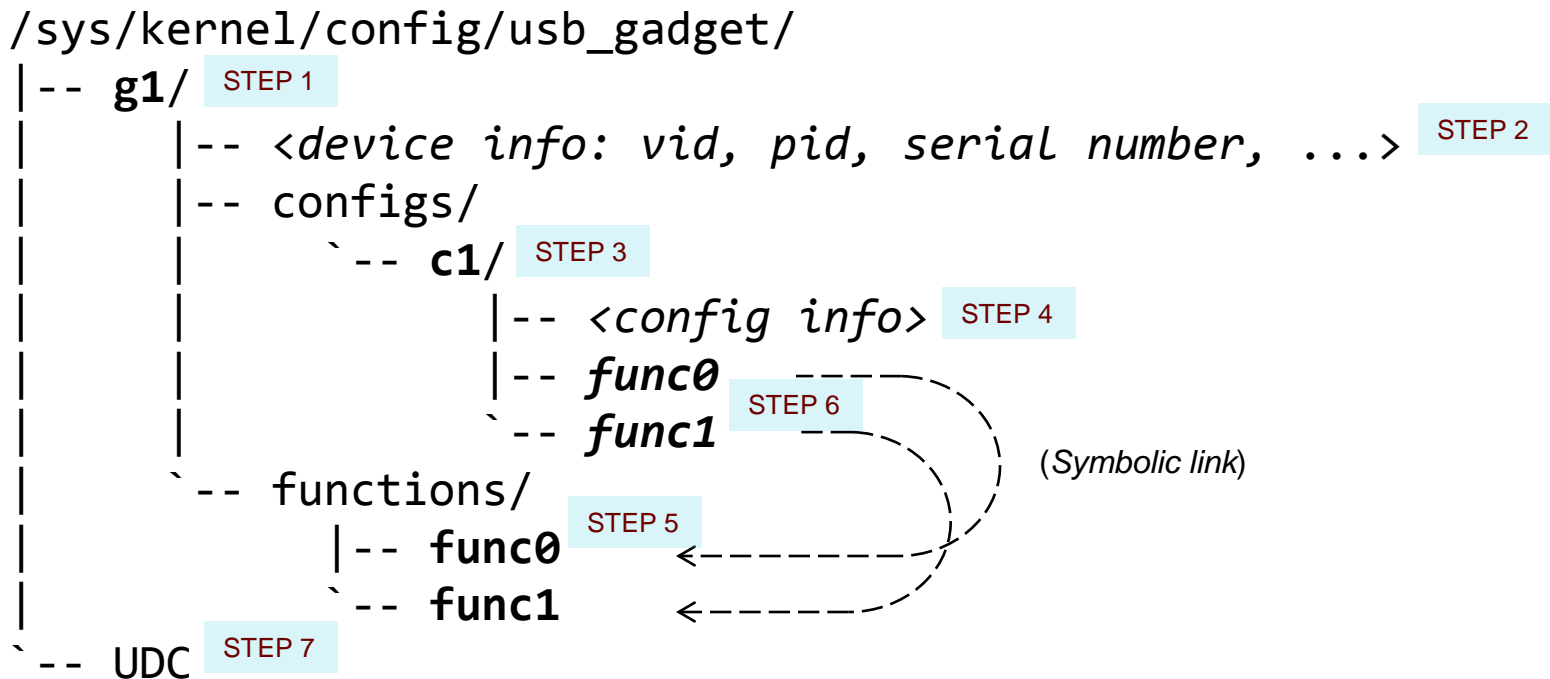
# USB Gadget configs

- An sysfs entry for creating an USB gadget:
  - Single USB function
  - Multiple USB functions
- Easy to customize a single function:
  - HID
  - Webcam
- No longer need to create customized USB composite gadget drivers.

# USB device structure



# USB Gadget configs structure



# USB Gadget configs example: ACM Serial Gadget

## # create gadget

```
mkdir /sys/kernel/config/usb_gadget/g1
cd /sys/kernel/config/usb_gadget/g1
echo "0x1d6d" > idVendor
echo "0x0104" > idProduct
```

```
mkdir strings/0x409
echo "0123456789" > strings/0x409/serialnumber
echo "Foo Inc" > strings/0x409/manufacturer
echo "Bar gadget" > strings/0x409/product
```

## # create config

```
mkdir configs/c.1
mkdir configs/c.1/strings/0x409
echo "conf1" > configs/c.1/strings/0x409/configuration
```

## # create function

```
mkdir functions/acm.usb0
ln -s functions/acm.usb0 configs/c.1
```

## # activate

```
echo "musb-hdrc.0" > UDC
```



# Additional information of USB Gadget configs

- USB Gadget Configs Kernel Documentation:  
[https://www.kernel.org/doc/Documentation/usb/gadget\\_configs.txt](https://www.kernel.org/doc/Documentation/usb/gadget_configs.txt)  
Explains what USB gadget configs is and how to use it.
- USB Gadget Testing Kernel Documentation:  
<https://www.kernel.org/doc/Documentation/usb/gadget-testing.txt>  
Explains how to test each USB function.

# USB Gadget configs setup

- Compile kernel with CONFIG\_CONFIGFS\_FS enabled:
  - Enabled by default in Processor SDK filesystems
- Mount configs into the root filesystem /sys
  - `modprobe libcomposite`
  - `mount -t configfs none /sys`
  - Done in Processor SDK filesystems
  - Now the rootfs has entry: `/sys/kernel/config/usb_gadget/`

# Use HID Gadget in configs

Define the following entries under configs hid function:

protocol                      # 1 for keyboard, 2 for mouse

subclass

report\_length                # 8 for keyboard

report\_desc                  # HID specific

Details are in the HID Specification

# Use Webcam Gadget in configs

- Define the following entries under configs uvc function:

streaming\_interval      streaming\_maxburst      streaming\_maxpacket

- And the following entries for each streaming video format:

dwFrameInterval      dwMinBitRate

dwMaxBitRate      wHeight

dwMaxVideoFrameBufferSize      wWidth

# Kernel UDC interface

```
/sys/class/udc/<UDC>
```

```
root@am57xx-evm:~# ls /sys/class/udc/  
48890000.usb
```

```
root@am335x-evm:~# ls /sys/class/udc/  
musb-hdrc.0
```

# Check loaded gadget driver

```
root@am57xx-evm:~# cat /sys/class/udc/48890000.usb/uevent
```

```
USB_UDC_NAME=dwc3-gadget
```

```
root@am57xx-evm:~# cat /sys/class/udc/48890000.usb/state
```

```
not attached
```

# Check loaded gadget driver

```
root@am57xx-evm:~# cat /sys/class/udc/48890000.usb/uevent
```

```
USB_UDC_NAME=dwc3-gadget
```

```
root@am57xx-evm:~# cat /sys/class/udc/48890000.usb/state
```

```
not attached
```

```
root@am57xx-evm:~# modprobe g_ether
```

# Check loaded gadget driver

```
root@am57xx-evm:~# cat /sys/class/udc/48890000.usb/uevent
```

```
USB_UDC_NAME=dwc3-gadget
```

```
root@am57xx-evm:~# cat /sys/class/udc/48890000.usb/state
```

```
not attached
```

```
root@am57xx-evm:~# modprobe g_ether
```

```
root@am57xx-evm:~# cat /sys/class/udc/48890000.usb/uevent
```

```
DRIVER=g_ether
```

```
USB_UDC_NAME=dwc3-gadget
```

```
USB_UDC_DRIVER=g_ether
```



# Check loaded gadget driver

```
root@am57xx-evm:~# cat /sys/class/udc/48890000.usb/uevent
```

```
USB_UDC_NAME=dwc3-gadget
```

```
root@am57xx-evm:~# cat /sys/class/udc/48890000.usb/state
```

```
not attached
```

```
root@am57xx-evm:~# modprobe g_ether
```

```
root@am57xx-evm:~# cat /sys/class/udc/48890000.usb/uevent
```

```
DRIVER=g_ether
```

```
USB_UDC_NAME=dwc3-gadget
```

```
USB_UDC_DRIVER=g_ether
```

<connect the gadget USB port to a USB host>

```
root@am57xx-evm:~# cat /sys/class/udc/48890000.usb/state
```

```
configured
```

# For more information

- USB Gadget Configs Kernel Documentation  
[https://www.kernel.org/doc/Documentation/usb/gadget\\_configs.txt](https://www.kernel.org/doc/Documentation/usb/gadget_configs.txt)
- USB Gadget Testing Kernel Documentation  
<https://www.kernel.org/doc/Documentation/usb/gadget-testing.txt>
- USB HID Gadget Kernel Documentation  
[https://www.kernel.org/doc/Documentation/usb/gadget\\_hid.txt](https://www.kernel.org/doc/Documentation/usb/gadget_hid.txt)
- USB Serial Gadget Kernel Documentation  
[https://www.kernel.org/doc/Documentation/usb/gadget\\_serial.txt](https://www.kernel.org/doc/Documentation/usb/gadget_serial.txt)
- USB Printer Gadget Kernel Documentation  
[https://www.kernel.org/doc/Documentation/usb/gadget\\_printer.txt](https://www.kernel.org/doc/Documentation/usb/gadget_printer.txt)
- For questions about this training, refer to the E2E Community Forums at <http://e2e.ti.com>



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