USB System Design in Sitara Devices Using Linux
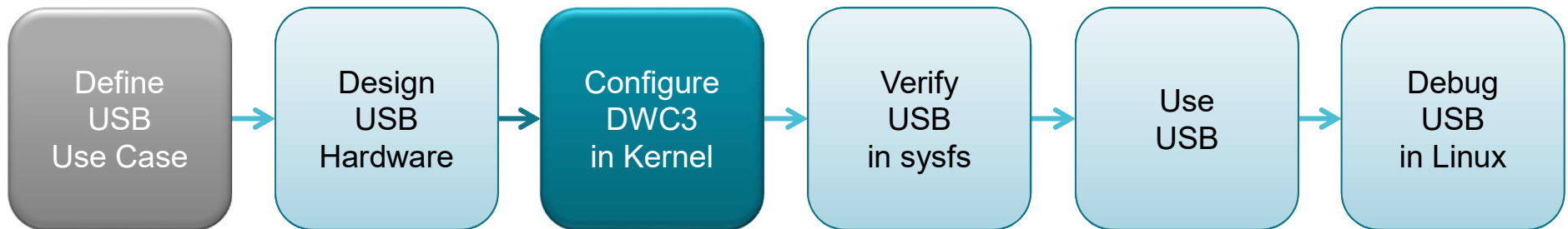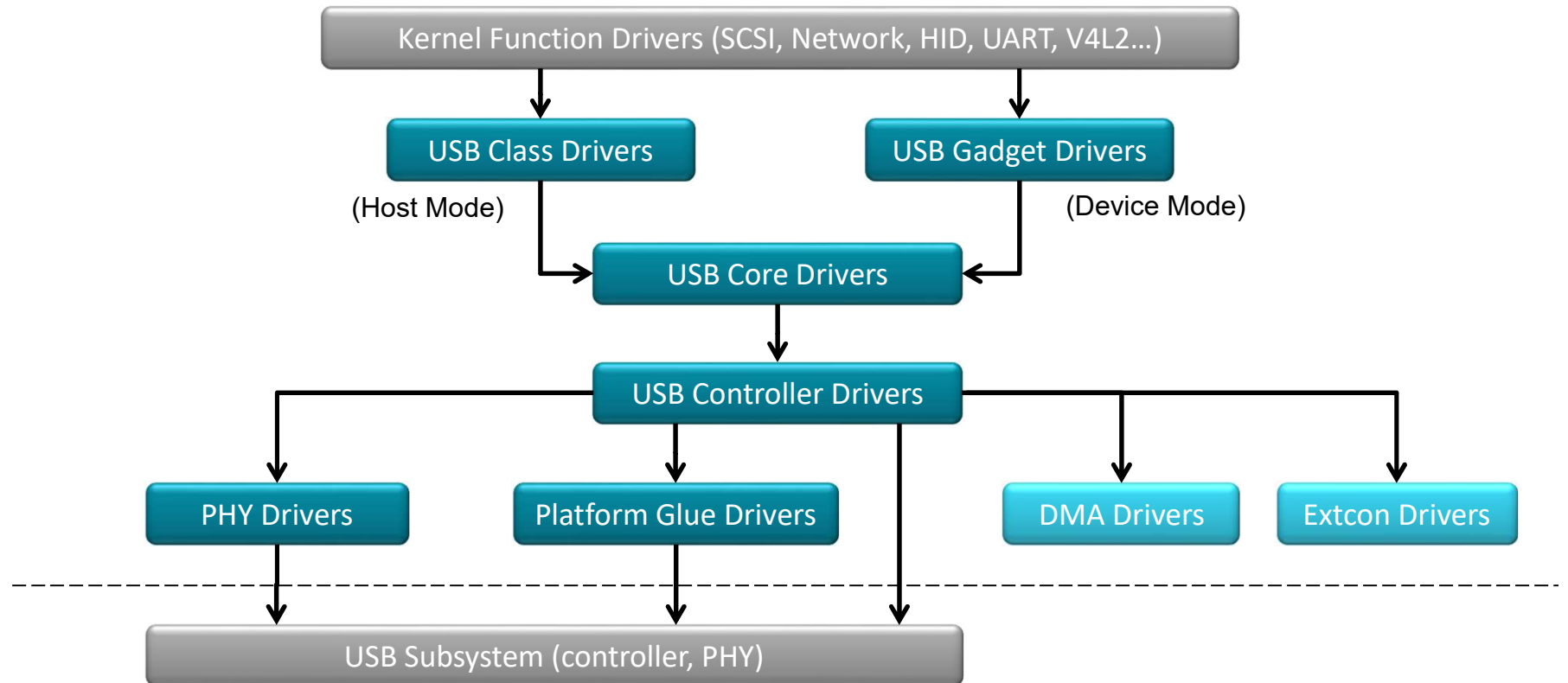
[Part 3]: Configure DWC3 in Linux Kernel

Bin Liu (EP, Processors)
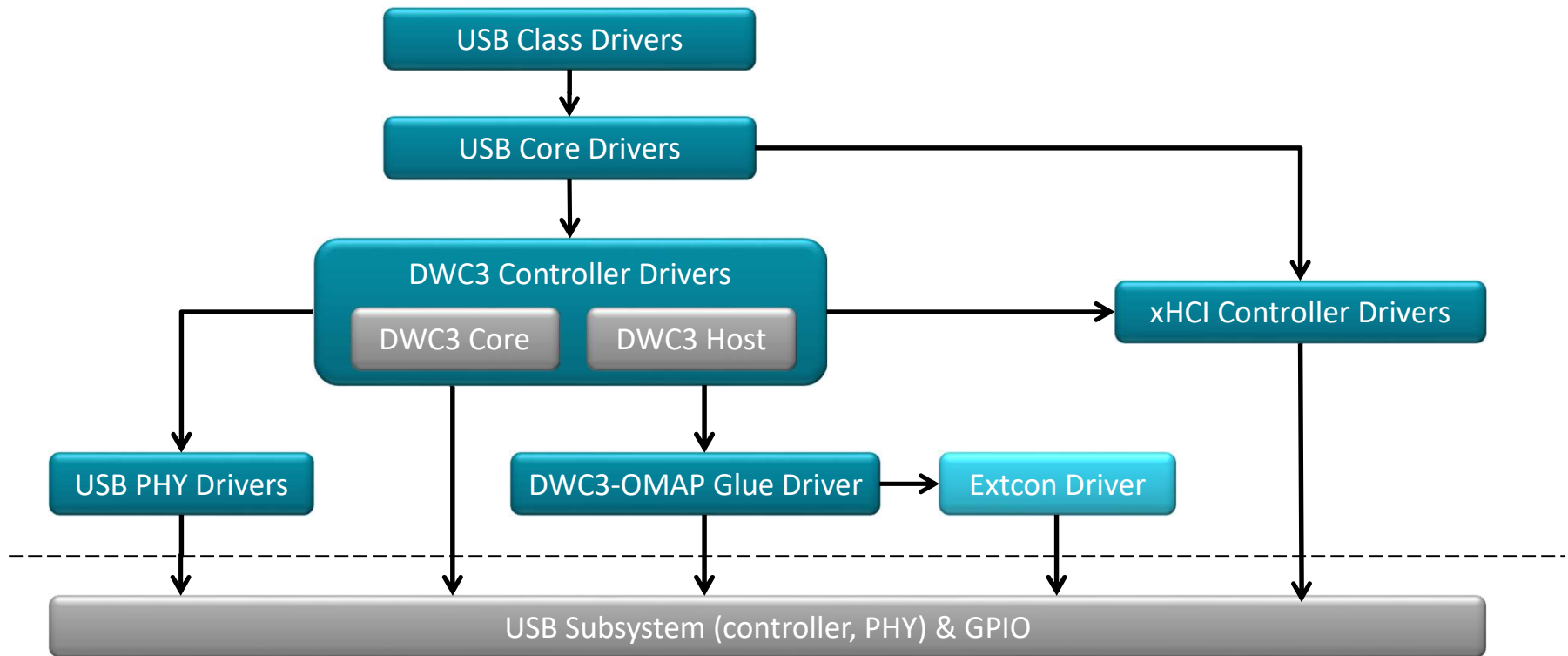
TEXAS INSTRUMENTS

Agenda

```
┌─────────────┐   ┌─────────────┐   ┌─────────────┐   ┌─────────────┐   ┌─────────────┐   ┌─────────────┐
│   Define    │   │   Design    │   │  Configure  │   │   Verify    │   │     Use     │   │    Debug    │
│   USB       │ → │   USB       │ → │   DWC3      │ → │   USB       │ → │     USB     │ → │    USB      │
│   Use Case  │   │  Hardware   │   │  in Kernel  │   │  in sysfs   │   │             │   │   in Linux  │
└─────────────┘   └─────────────┘   └─────────────┘   └─────────────┘   └─────────────┘   └─────────────┘
```

- Overview of Kernel USB Stack

- DWC3 Driver Structure

- DWC3 Kernel Config Options

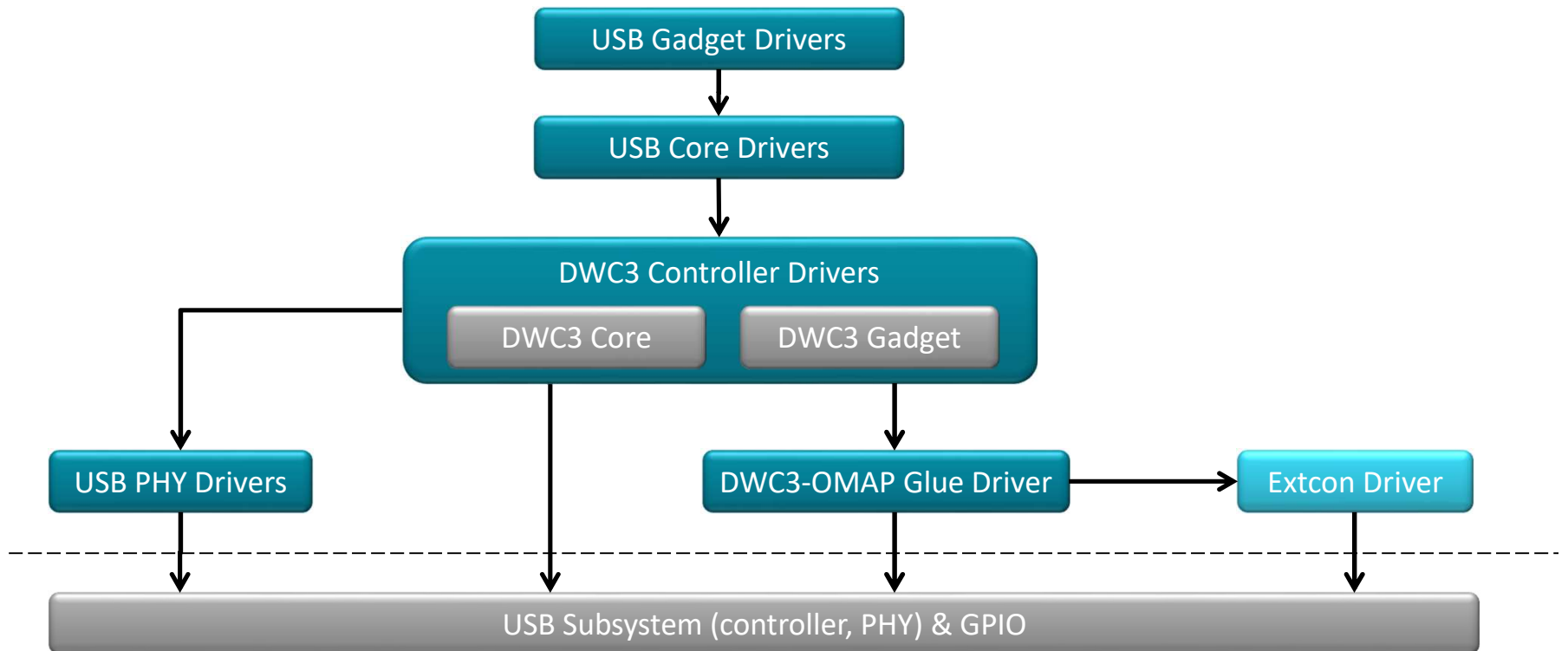- DWC3 Device Tree Binding

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Kernel USB stack

Kernel Function Drivers (SCSI, Network, HID, UART, V4L2...)

USB Class Drivers (Host Mode) → USB Core Drivers ← USB Gadget Drivers (Device Mode)

USB Core Drivers → USB Controller Drivers

USB Controller Drivers → PHY Drivers, Platform Glue Drivers, DMA Drivers, Extcon Drivers

USB Subsystem (controller, PHY)

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DWC3 host mode driver structure

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DWC3 device mode driver structure

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DWC3 kernel config options

- USB Core

- xHCI Controller

- DWC3 Core

- DWC3-OMAP Glue

- USB PHY

- Extcon

- USB Class

- USB Gadget

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USB class driver kernel config

- USB Device Classes
  - Identifies the functionality of a USB device
  - For example: UAC (Audio), MSC (Mass storage)
  - Each class has an ID defined by USB-IF
- Kernel config options for USB classes are not in a centralized place
- Under each kernel function module
- Kernel defconfig has all/most class options enabled
  - tisdk_am437x-evm_defconfig
  - tisdk_am57x-evm_defconfig

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USB gadget driver kernel config

- Options are all located under:

    Device Drivers -->

       USB support -->

          USB Gadget Support

```
.config - Linux/arm 4.9.69 Kernel Configuration
> Device Drivers > USB support > USB Gadget Support -----------------------
                        USB Gadget Support                              +
 Arrow keys navigate the menu.  <Enter> selects submenus ---> (or empty |
 submenus ----).  Highlighted letters are hotkeys.  Pressing <Y>        |
 includes, <N> excludes, <M> modularizes features.  Press <Esc><Esc> to |
 exit, <?> for Help, </> for Search.  Legend: [*] built-in  [ ]         |
+-----------------------------------------------------------------------+
| --- USB Gadget Support                                                 |
| [*]     Debugging messages (DEVELOPMENT)                               |
| [ ]       Verbose debugging Messages (DEVELOPMENT)                     |
| [*]     Debugging information files (DEVELOPMENT)                      |
| [*]     Debugging information files in debugfs (DEVELOPMENT)           |
| (2)     Maximum VBUS Power usage (2-500 mA)                            |
| (2)     Number of storage pipeline buffers                            |
|         USB Peripheral Controller  --->                               |
| <M>     USB functions configurable through configfs                   |
| [*]       Generic serial bulk in/out                                  |
| [*]       Abstract Control Model (CDC ACM)                            |
| [*]       Object Exchange Model (CDC OBEX)                            |
| [*]       Network Control Model (CDC NCM)                             |
| [*]       Ethernet Control Model (CDC ECM)                            |
| [*]       Ethernet Control Model (CDC ECM) subset                    |
| [*]       RNDIS                                                        |
+   v(+)                                                                 |
+-----------------------------------------------------------------------+
      <Select>    < Exit >    < Help >    < Save >    < Load >
```

USB core kernel config

Config Option Symbol:
    CONFIG_USB_SUPPORT
    CONFIG_USB

xHCI controller kernel config

- For DWC3 in host mode
- Config Option Symbol:
  CONFIG_USB_XHCI_HCD
  CONFIG_USB_XHCI_PLATFORM

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DWC3 core kernel config

Config Option Symbol:

    CONFIG_USB_DWC3

    CONFIG_USB_DWC3_DUAL_ROLE

DWC3-OMAP glue kernel config

Config Option Symbol:

    CONFIG_USB_DWC3_OMAP

```
.config - Linux/arm 4.9.69 Kernel Configuration
> Device Drivers > USB support ---------------------------------------------
+------------------------- USB support -------------------------------------+
|  Arrow keys navigate the menu.  <Enter> selects submenus ---> (or empty    |
|  submenus ----).  Highlighted letters are hotkeys.  Pressing <Y>           |
|  includes, <N> excludes, <M> modularizes features.  Press <Esc><Esc> to    |
|  exit, <?> for Help, </> for Search.  Legend: [*] built-in  [ ]            |
| +----^(-)------------------------------------------------------------+     |
| |     [*]        TUSB 6010                                           |     |
| |     <M>     DesignWare USB3 DRD Core Support                       |     |
| |               DWC3 Mode Selection (Dual Role mode)  --->           |     |
| |               *** Platform Glue Driver Support ***                 |     |
| |     <M>       Texas Instruments OMAP5 and similar Platforms        |     |
| |     <M>       Generic OF Simple Glue Layer                         |     |
| |     < >     DesignWare USB2 DRD Core Support                       |     |
| |     < >     ChipIdea Highspeed Dual Role Controller               |     |
| |     < >     NXP ISP 1760/1761 support                             |     |
| |               *** USB port drivers ***                             |     |
| |     <M>     USB Serial Converter support  --->                    |     |
| |               *** USB Miscellaneous drivers ***                    |     |
| |     < >     EMI 612m USB Audio interface support                  |     |
| |     < >     EMI 216 USB Audio interface support                   |     |
| |     < >     ADU devices from Ontrak Control Systems               |     |
| |     < >     USB 7-Segment LED Display                             |     |
| +    v(+)                                                           +     |
| ------------------------------------------------------------------------- |
|       <Select>     < Exit >     < Help >     < Save >     < Load >         |
+---------------------------------------------------------------------------+
```

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USB PHY kernel config

Config Option Symbol:
    CONFIG_GENERIC_PHY
    CONFIG_OMAP_USB2
    CONFIG_TI_PIPE3

* AM437x only requires USB2.0 PHY,
  which option is CONFIG_OMAP_USB2.

```
.config - Linux/arm 4.9.69 Kernel Configuration
> Device Drivers > PHY Subsystem
+-------------------------- PHY Subsystem ----------------------------+
| Arrow keys navigate the menu.  <Enter> selects submenus ---> (or empty |
| submenus ----).  Highlighted letters are hotkeys.  Pressing <Y> |
| includes, <N> excludes, <M> modularizes features.  Press <Esc><Esc> to |
| exit, <?> for Help, </> for Search.  Legend: [*] built-in  [ ] |
| +-----------------------------------------------------------------+ |
| |    -*- PHY Core                                                 | |
| |    <M> TI dm816x USB PHY driver                                 | |
| |    < > Marvell USB HSIC 28nm PHY Driver                         | |
| |    < > Marvell USB 2.0 28nm PHY Driver                          | |
| |    -*- OMAP CONTROL PHY Driver                                  | |
| |    <M> OMAP USB2 PHY Driver                                     | |
| |    <*> TI PIPE3 PHY Driver                                      | |
| |    < > Broadcom Kona USB2 PHY Driver                            | |
| |                                                                 | |
| |                                                                 | |
| |                                                                 | |
| |                                                                 | |
| |                                                                 | |
| |                                                                 | |
| |                                                                 | |
| |                                                                 | |
| +-----------------------------------------------------------------+ |
+---------------------------------------------------------------------+
|    <Select>     < Exit >     < Help >     < Save >     < Load >     |
+---------------------------------------------------------------------+
```

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Extcon kernel config

- Only required for AM57x
  - For detecting VBUS & ID events
- Config Option Symbol:
  CONFIG_EXTCON
  CONFIG_EXTCON_PALMAS
  CONFIG_EXTCON_USB_GPIO

Kernel defconfig

Kernel defconfig which has DWC3 config options enabled:

	AM437x	AM57x
Processor SDK Kernel	tisdk_am437x-evm_defconfig	tisdk_am57x-evm_defconfig
Community Kernel	omap2plus_defconfig	omap2plus_defconfig

 * Use the defconfig as the base of the config, then fine tune for your project.

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AM437x DWC3 device tree binding

- USB-related DT nodes are defined in *am4372.dtsi*
  - *am4372.dtsi*: AM437x SoC DT definition
- USB node **status** property:
  - In *am4372.dtsi,* default is set to **"disabled"**
  - Set to **"okay"** in board DT file to enable the node
- USB port **dr_mode** property:
  - In *am4372.dtsi,* default is set to "otg" (dual-role)
  - Override it in the board DT file for non-otg mode:
    - Host-only mode:
      - **dr_mode = "host"**
    - Device-only mode:
      - **dr_mode = "peripheral"**

```
am437x-gp-evm.dts:

&usb2_phy1 {
        status = "okay";
};

&usb1 {
        dr_mode = "otg";
        status = "okay";
};

&usb2_phy2 {
        status = "okay";
};

&usb2 {
        dr_mode = "host";
        status = "okay";
};
```

TEXAS INSTRUMENTS

AM57x DWC3 device tree binding

- USB-related DT nodes are defined in *dra7.dtsi*
  - *dra7.dtsi*: AM57x SoC DT definition

> **Different from AM335x/AM437x**

- USB node **status** property:
  - Not set in *dra7.dtsi*, which implies "okay" (enabled)
  - Set to **"disabled"** in board DT file if not to use

- USB port **dr_mode** property:
  - In *dra7.dtsi,* default is set to "**otg**" (dual-role)
  - Override it in the board DT file for non-otg mode:
    - Host-only mode:
      dr_mode = "host"
    - Device-only mode:
      dr_mode = "peripheral"

> **AM335x/AM437x do not need Extcon**

- Extcon node:
  - To specify the input of VBUS & ID events
  - Define in the board DT file

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AM57x DWC3 device tree binding - example

am57xx-beagle-x15-common.dtsi	am571x-idk.dts

```
extcon_usb2: tps659038_usb {
    compatible = "ti,palmas-usb-vid";
    ti,enable-vbus-detection;
    vbus-gpio = <&gpio4 21 GPIO_ACTIVE_HIGH>;
};

&omap_dwc3_2 {
    extcon = <&extcon_usb2>;
};

&usb1 {
    dr_mode = "host";
};

&usb2 {
    dr_mode = "peripheral";
};
```

```
extcon_usb2: {
    id-gpio = <&gpio5 7 GPIO_ACTIVE_HIGH>;
    vbus-gpio = <&gpio7 22 GPIO_ACTIVE_HIGH>;
};

&omap_dwc3_2 {
    extcon = <&extcon_usb2>;
};
```

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DWC3 in USB2.0-only config

- DWC3 in device mode
  - maximum-speed = "full-speed"

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For more information

- DWC3 Linux Driver Configuration:
http://processors.wiki.ti.com/index.php/Linux_Core_DWC3_User%27s_Guide#Driver_Configuration

- USB Generic DT Bindings Kernel Documentation
https://www.kernel.org/doc/Documentation/devicetree/bindings/usb/generic.txt

- OMAP DWC3 DT Bindings Kernel Documentation
https://www.kernel.org/doc/Documentation/devicetree/bindings/usb/omap-usb.txt

- DWC3 Core DT Bindings Kernel Documentation
https://www.kernel.org/doc/Documentation/devicetree/bindings/usb/dwc3.txt

- For questions about this training, refer to the E2E Community Forums at
http://e2e.ti.com

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