SITARA™ ARM® PROCESSORS

Boot camp

Building Blocks for PRU Broad Market Success

Module 4 – Linux Drivers

This session covers the Linux drivers to enable the PRU-ICSS sub-system.

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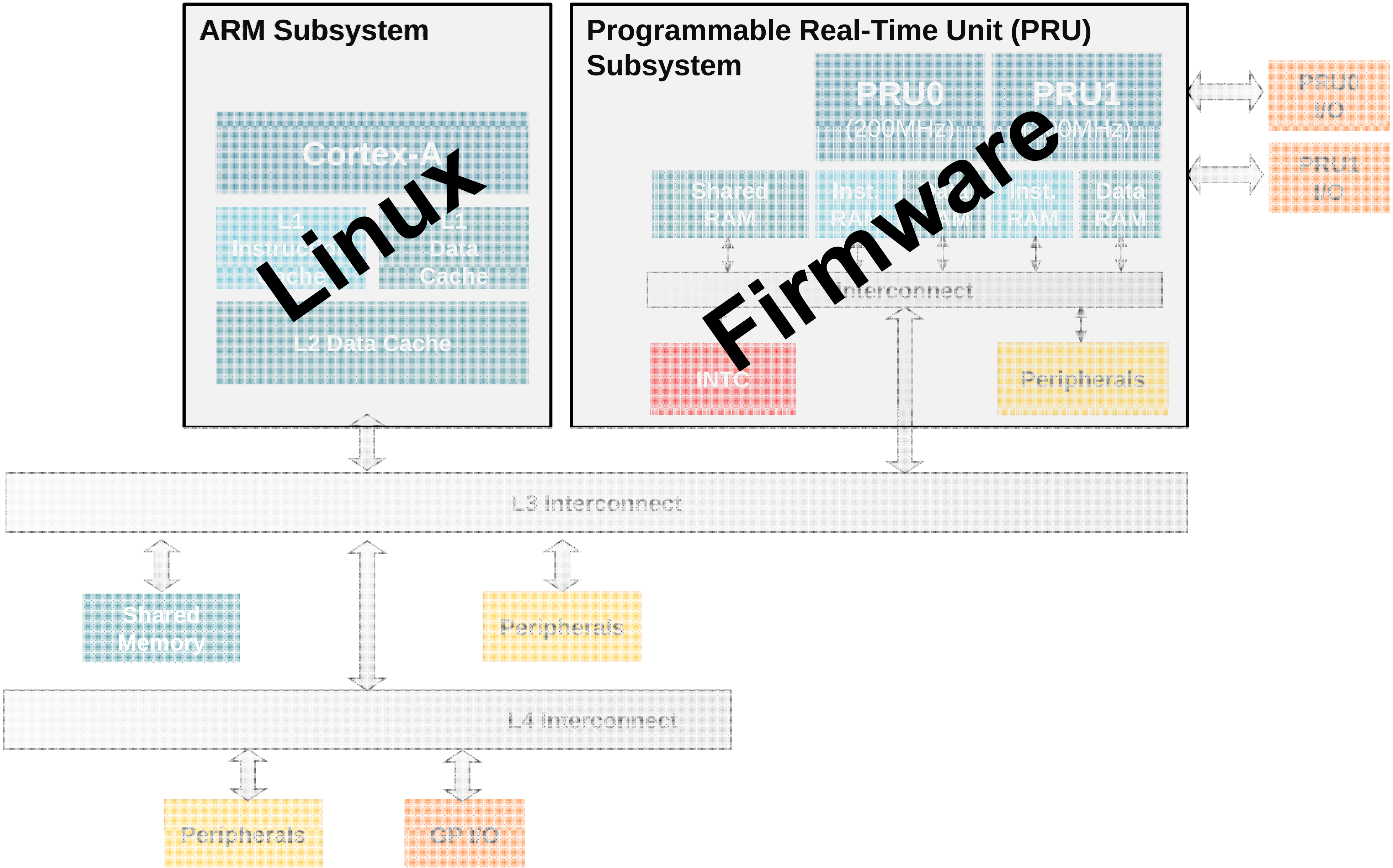
ARM + PRU SoC *Software* Architecture



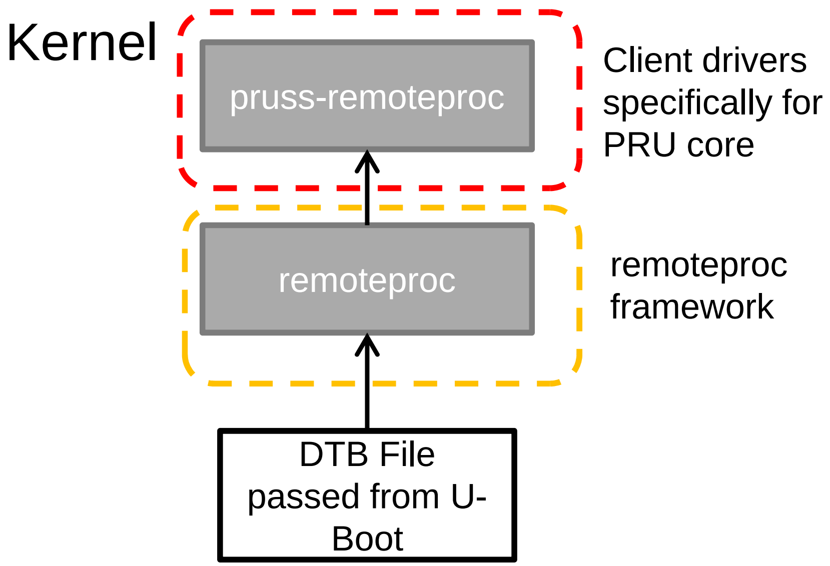
What do we need Linux to do?

- Load the Firmware
- Manage resources (memory, CPU, etc.)
- Control execution (start, stop, etc.)
- Send/receive messages to share data
- Synchronize through events (interrupts)
- These services are provided through a combination of remoteproc/rpmsg + virtio transport frameworks

Linux Drivers

Remoteproc

PRU remoteproc Stack



- The remoteproc framework allows different platforms/architectures to control (power on, load firmware, power off) remote processors **while abstracting any hardware differences**
  - Does not matter what OS (if any) the remote processor is running
- Kernel documentation available in /Documentation/remoteproc.txt

Why Use Remoteproc?

- It already exists
  - Easier to reuse an existing framework than to create a new one
- Easy to implement
  - Requires only a few custom low-level handlers in the Linux driver for a new platform
- Mainline-friendly
  - The core driver has been in mainline for a couple years
- Fairly simple interface for powering up and controlling a remote processor from the kernel
- Enables us to use rpmsg framework for message sharing

How to Use Remoteproc

- Load driver manually or build into kernel
  - Use menuconfig to build into kernel or create a module
- Probe() function automatically looks for firmware in /lib/firmware directory in target filesystem
  - rproc_pru0_fw or rproc_pru1_fw for core 0 and 1, respectively
- Interrupts passed between host application and PRU firmware
  - Application effectively registers to an interrupt

Creating a New Node

- A pruss node is created in the root am33xx Device Tree file
- This passes information about the subsystem on AM335x into the PRU rproc driver during probe() function
  - Primarily register offsets, clock speed, and other non-changing information
- Requires little-to-no interaction on a case-by-case basis
  - All project-dependent settings are configured in Resource Table

Understanding the Resource Table

- What is a Resource Table?
  - A Linux construct used to inform the remoteproc driver about the remote processor's available resources
  - Typically refers to memory, local peripheral registers, etc.
  - Firmware-dependent
- Why do I need one?
  - Allows the driver to remain generic while still supporting a number of different, often unique remote processors
    - Is flexible enough to allow for the creation of a custom resource type
  - Is not strictly required as the driver can fall back on defaults
    - This severely limits it as the driver may not understand how the PRU firmware wishes to map/handle interrupts

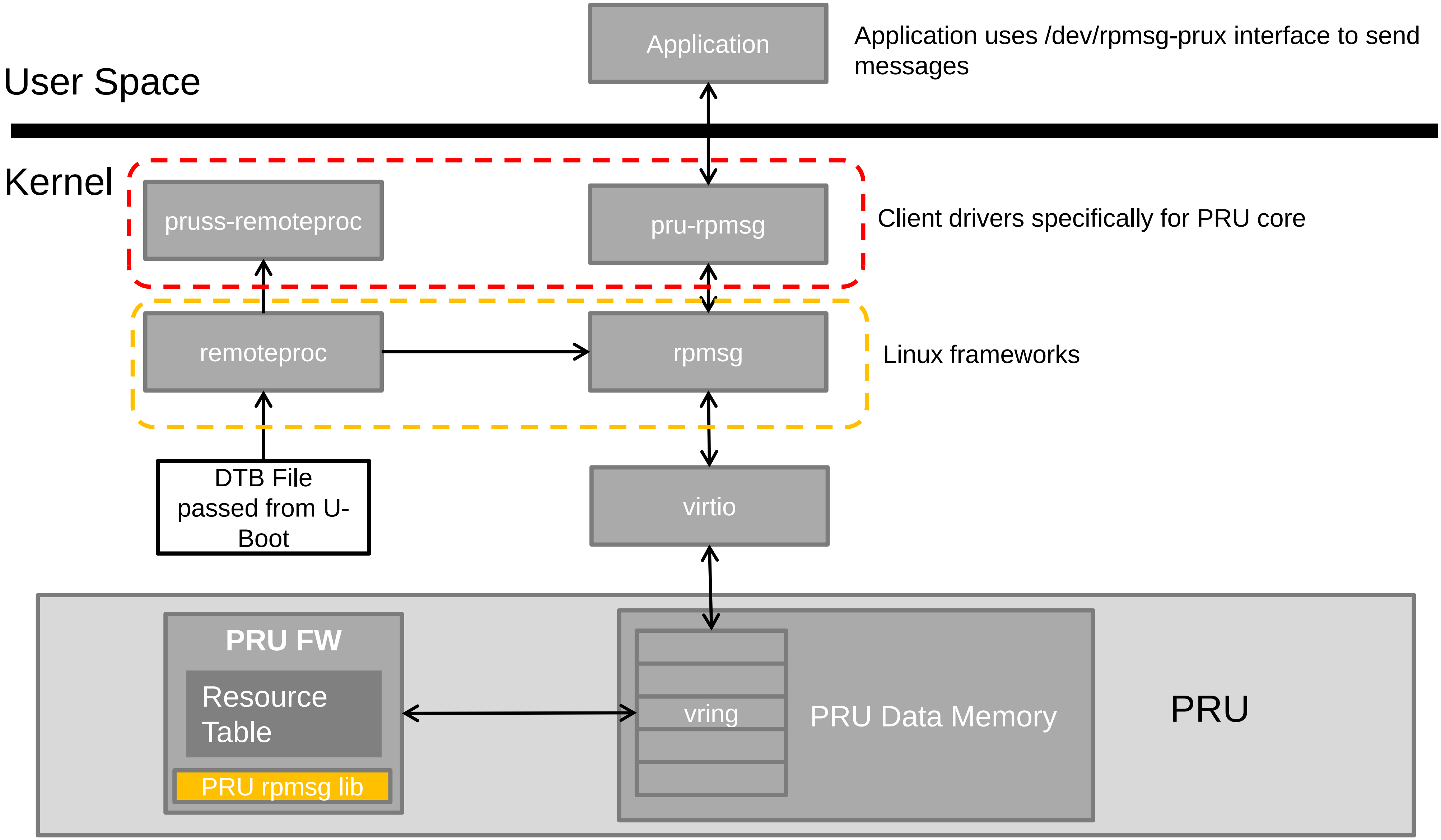
Configuring the Resource Table

- Most projects will not need to touch anything beyond the interrupt and vring configuration
- Typically only need to modify up to three things
  - Event-to-channel mapping
  - Channel-to-host mapping
  - Number and location of vrings

Linux Drivers

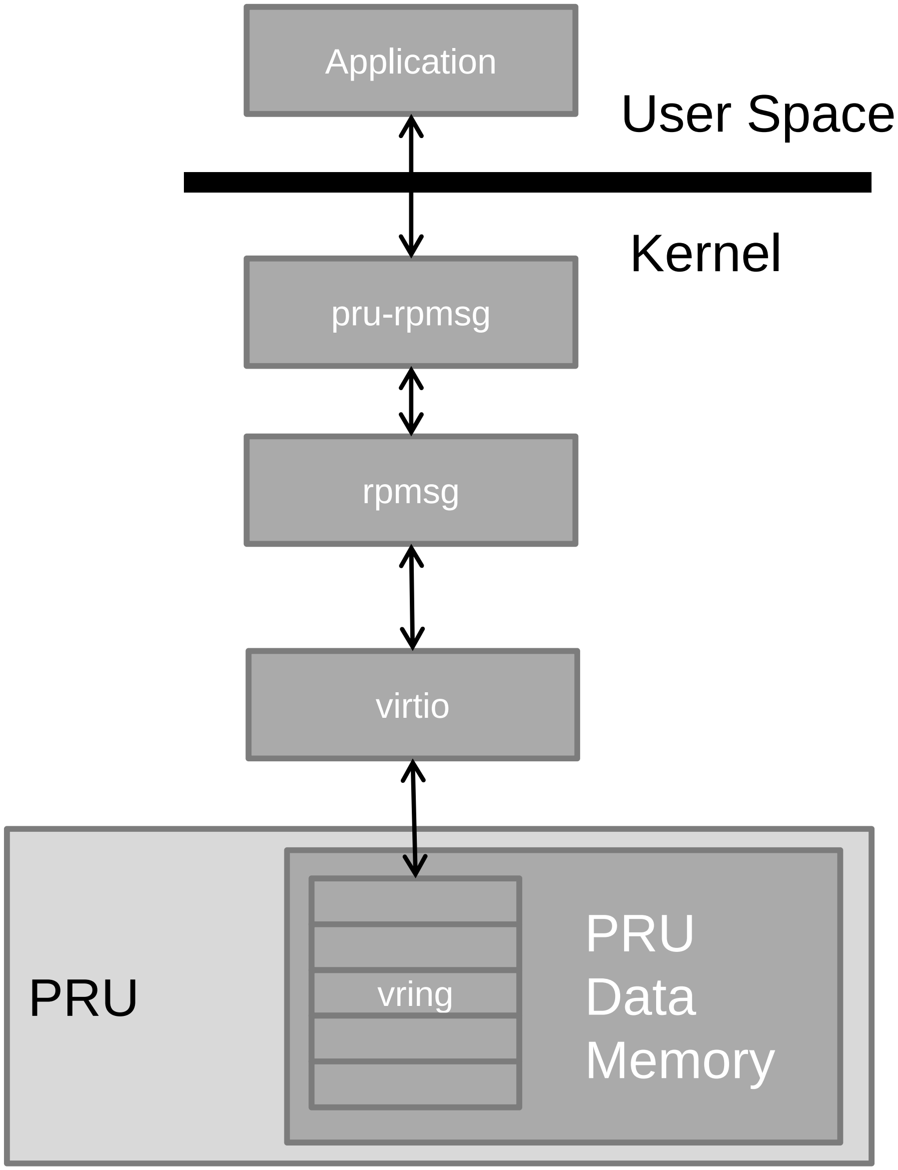
Rpmsg

PRU rpmsg Stack



What Is Rpmsg?

- Rpmsg is a Linux framework designed to allow for message passing between the kernel and a remote processor
- Kernel documentation available in /Documentation/rpmsg.txt
- Virtio is a virtualized I/O framework
  - We will use it to communicate with our virtio device (vdev)
    - There are several ‘standard’ vdevs, but we only use virtio_ring
    - Virtio_ring (vring) is the transport implementation for virtio
  - The host and PRU will communicate with one another via the virtio_rings (vrings) and “kicks” for synchronization

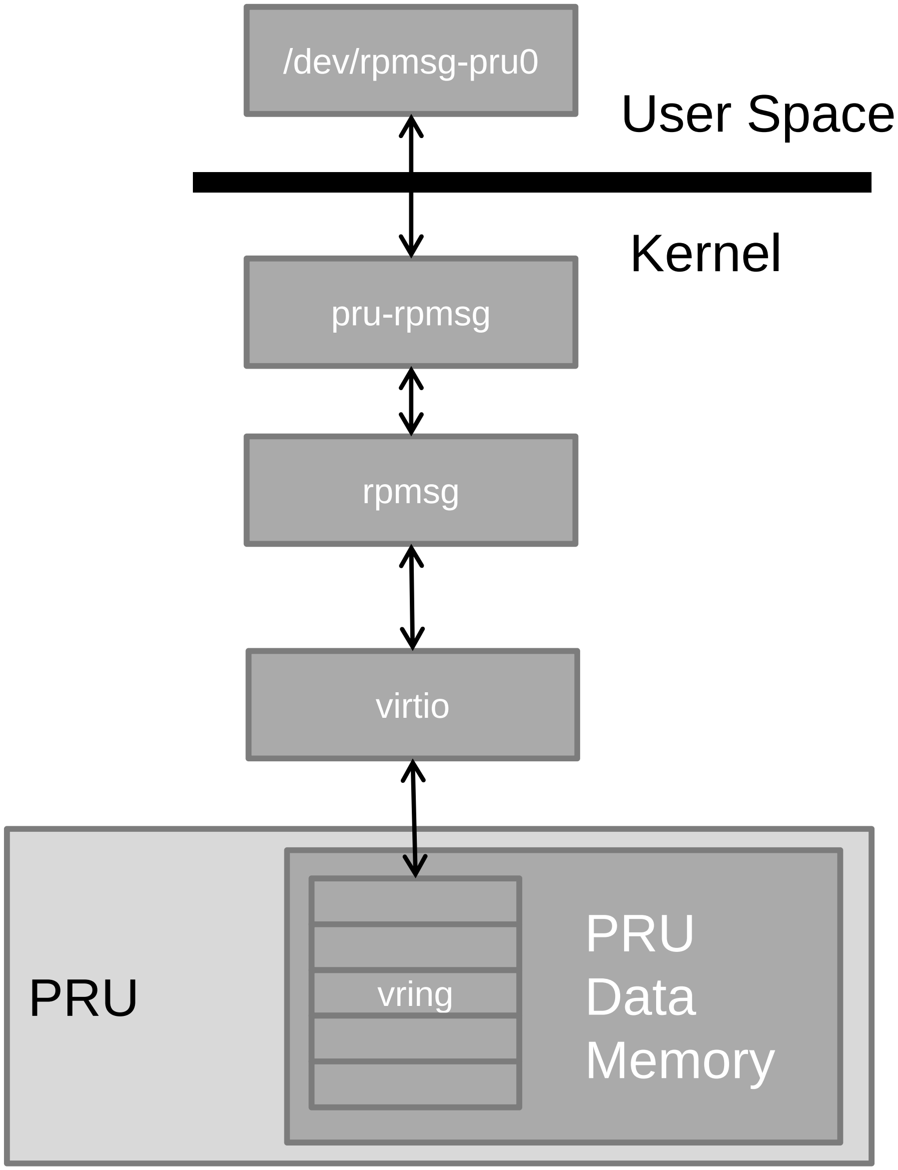


Why Use Rpmsg?

- It already exists
  - Easier to reuse an existing framework than to create a new one
- Mainline-friendly
  - The core driver has been in mainline for at least a couple years
- Ties in with existing remoteproc driver framework
- Fairly simple interface for passing messages between User Space and the PRU firmware
- Allows developers to expose the virtual device (PRU) to User Space or other frameworks
- Provides scalability for integrating individual PRU peripherals with the respective driver sub-systems.

How to Use pru-rpmsg Generic Client Driver

- User Space applications use /dev/rpmsg-prux interface to pass messages to and from PRU
- An example Generic Client Driver is under development

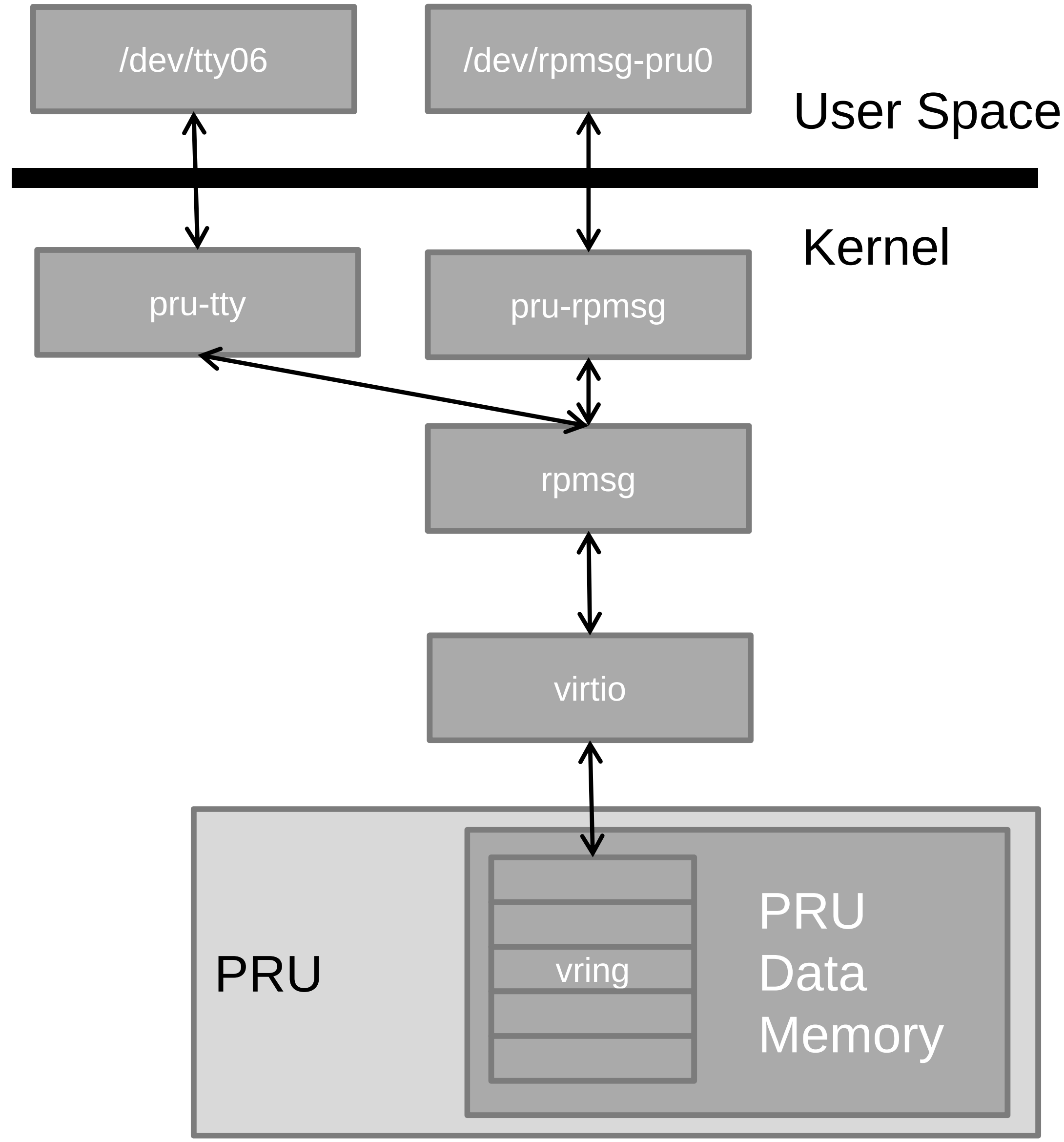


Linux Drivers

Custom Function Drivers

Custom rpmsg Client Drivers

- User Space applications use /dev/rpmsg-pru0 interface to pass messages to and from PRU
- Create different rpmsg client drivers to expose the PRU as other interfaces
  - Firmware based UART, SPI, etc.
  - Allows true PRU firmware enhanced Linux devices



Custom Function Drivers

- Some users may wish to use the PRU as another Linux Device (e.g. as another UART /dev/ttyO6)
  - This will require a custom Linux driver to work in tandem with rproc/rpmsg
  - Customer at this time will have to develop this custom driver themselves or work with a third party to do so
- TI is not initially launching any support for this mechanism
  - We have several different targets in mind (UART, I2C, I2S, SPI, etc…), but these will not be available at release
  - No target date available today, but we will start evaluating after broad market PRU launch

Thank you

Backup Slides

Virtio & Vring

- Virtio is a virtualized I/O framework
  – We will use it to communicate with our virtio device (vdev)
    - There are several ‘standard’ vdevs, but we only use virtio_ring
  – The host and PRU will communicate with one another via the virtio_rings (vrings)

Virtio & Vring

- Virtio_ring (vring) is the transport implementation for virtio
- A vring consists of three primary parts:
  - A descriptor array
  - The available ring
  - The used ring
- In our case the vring contains our list of buffers used to pass data between the host and PRU cores via rpmsg

Virtio & Vring

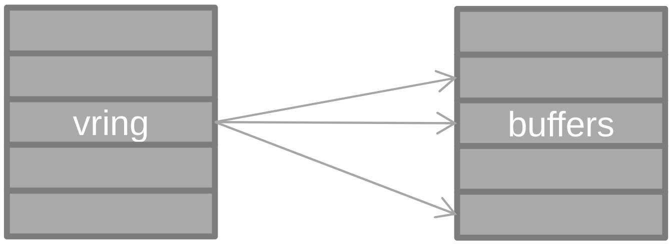
- The descriptor array
  - This is where the guest chains together length/address pairs
  - Address is the guest-physical address of the buffer
  - Length is the size of the buffer
  - There are two flags: R/W, and whether or not Next is valid
  - Next is used for chaining
    - This is generally used for packet processing (LANs)

Address	Length	Flags	Next

Virtio & Vring

- The available ring
  - This where the guest (PRU) indicates which descriptors are ready for use
  - Consists of a free-running index, an interrupt suppression flag, and an array of indices into the descriptor table (representing the heads of available buffers)
  - Available buffers do not have to be contiguous in memory

Available Buffers



Virtio & Vring

- The used ring
  - This is where the host indicates which descriptors chains it has used
  - The used ring is similar to the available ring except it is written by the host as descriptor chains are consumed
  - Consists of a free-running index, an interrupt suppression flag, and an array of indices into the descriptor table (representing the heads of used buffers)
  - Used buffers do not need to be contiguous in memory

Used Buffers