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Introducing RISC-V Platform Management Interface (RPMI)

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Agenda

1. RPMI Specification
2. librpmi
3. SBI Message Proxy Extension (MPXY)
4. RPMI Demo

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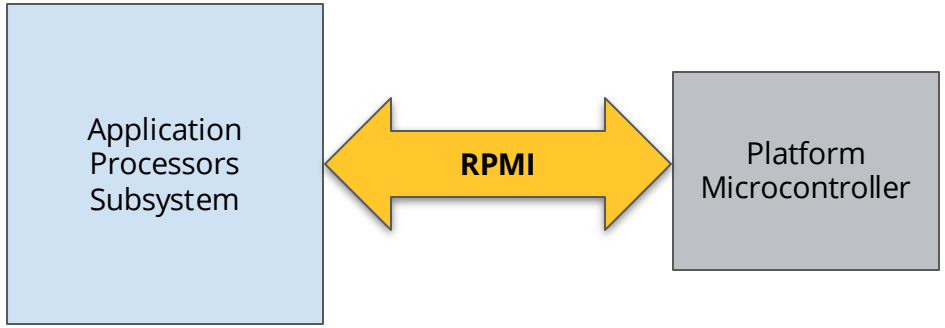
Part 1: RPMI Specification

Introduction

- Systems today may contain one or more Platform Microcontrollers that perform various platform-specific system management and control related tasks.
- This requires a standard interface for communication between Application Processors and Platform Microcontrollers.
- The RISC-V Platform Management Interface (RPMI) specification **defines a standard messaging-based interface** to enable communication between the Application Processors and the Platform Microcontrollers on RISC-V platforms.



Why RPMI?

Standardization

- RPMI provides a standardized interface for communication between the OS and firmware components, ensuring consistency across different RISC-V based platforms.

Scalability

- Supports multiple Application Processors and Platform Microcontrollers.
- Extensible transports and services

Efficiency

- Enable efficient management of system resources, including power, performance, and temperature.

Abstraction

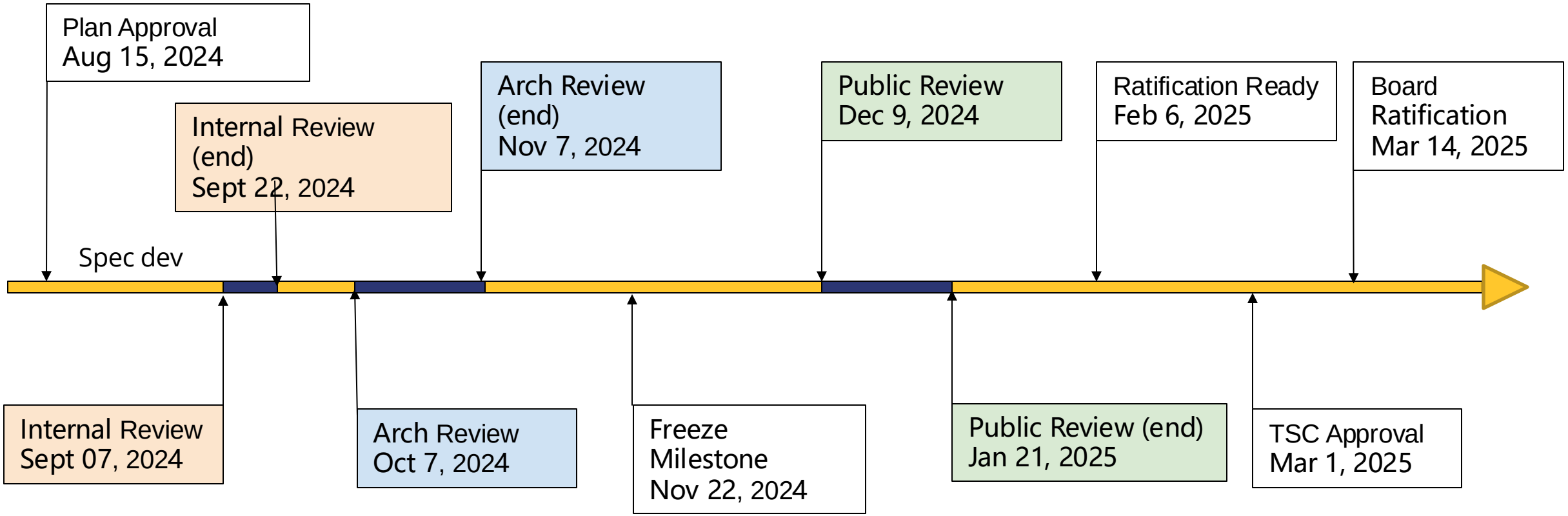
- Abstracts the underlying hardware details, making it easier for developers to write portable and scalable code
- Platform-agnostic OS

RPMI - Status and Plan

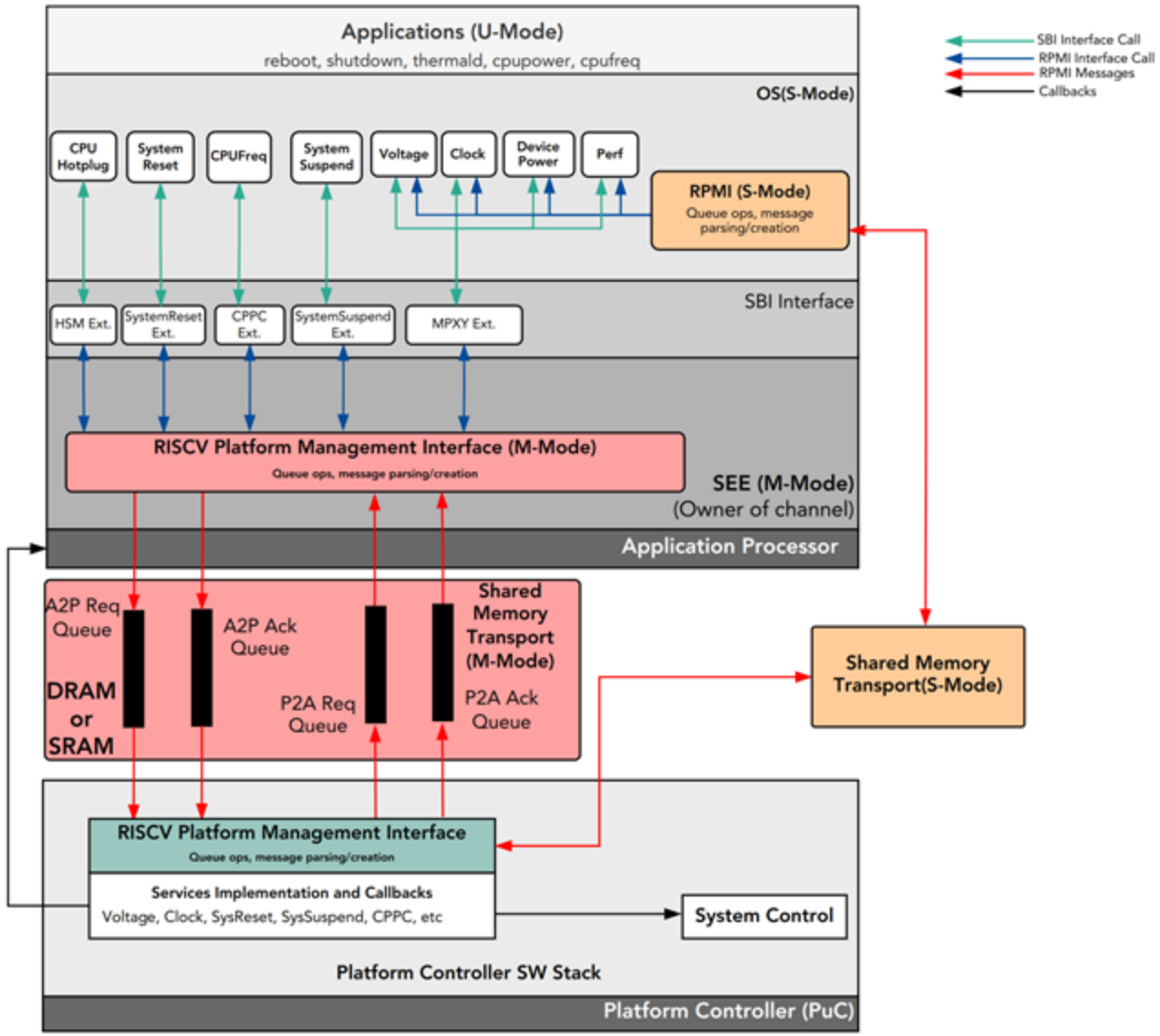
- Under charter of Platform Management Interface Task Group (TG)
- Current state: Specification development
- RPMI TG Meeting: Bi-weekly Thursday (7.00am PST)

Items	Links
TG Charters	https://github.com/riscv-admin/rpmi/blob/main/charter.adoc
Specification	https://github.com/riscv-non-isa/riscv-rpmi
Mailing List	https://lists.riscv.org/g/tech-rpmi
Plan (Jira)	https://jira.riscv.org/browse/RVG-151
PoC	https://lists.riscv.org/g/tech-rpmi/message/90

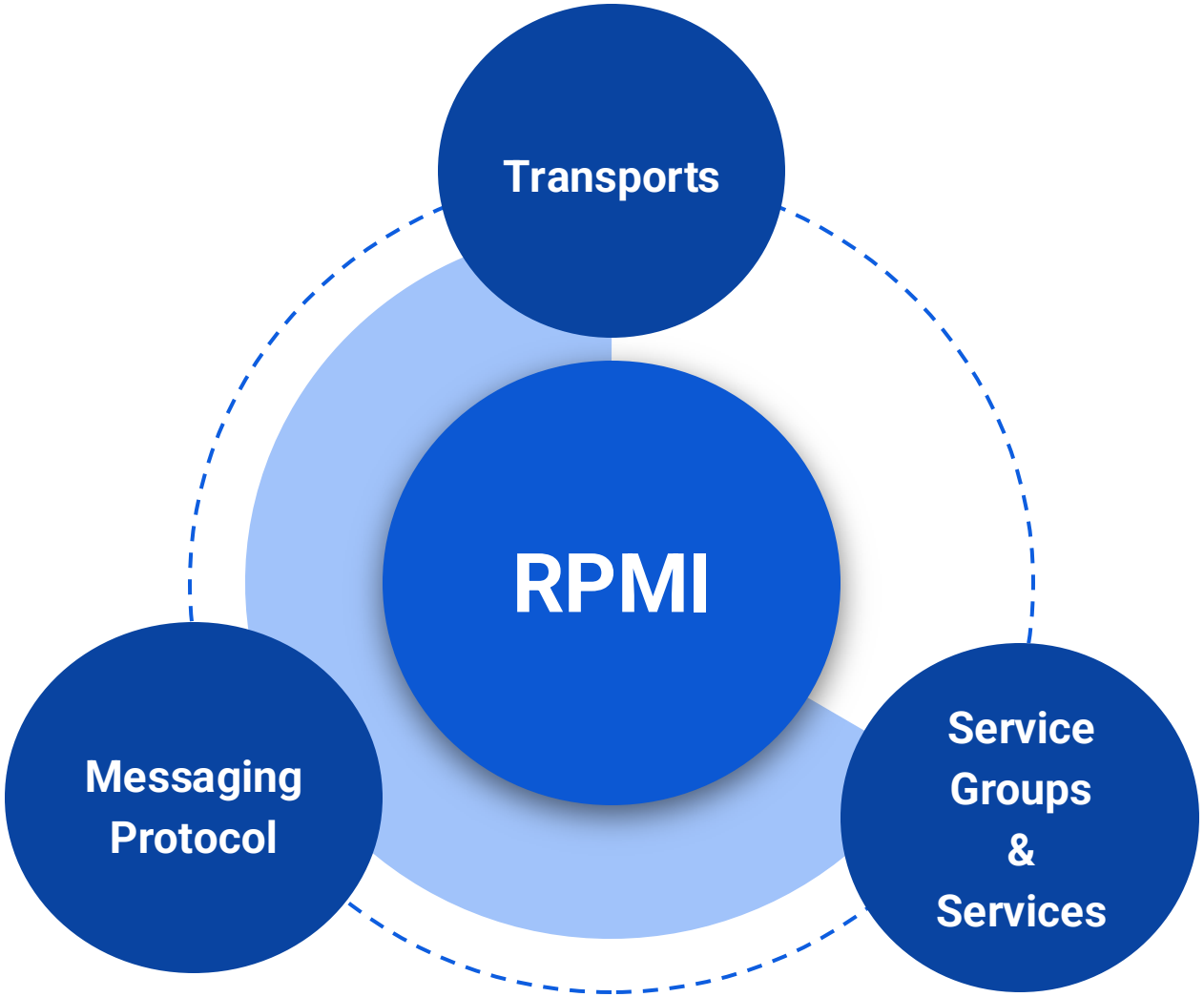
Key Milestones



Overview of RPMI based System Architecture



RPMI Components

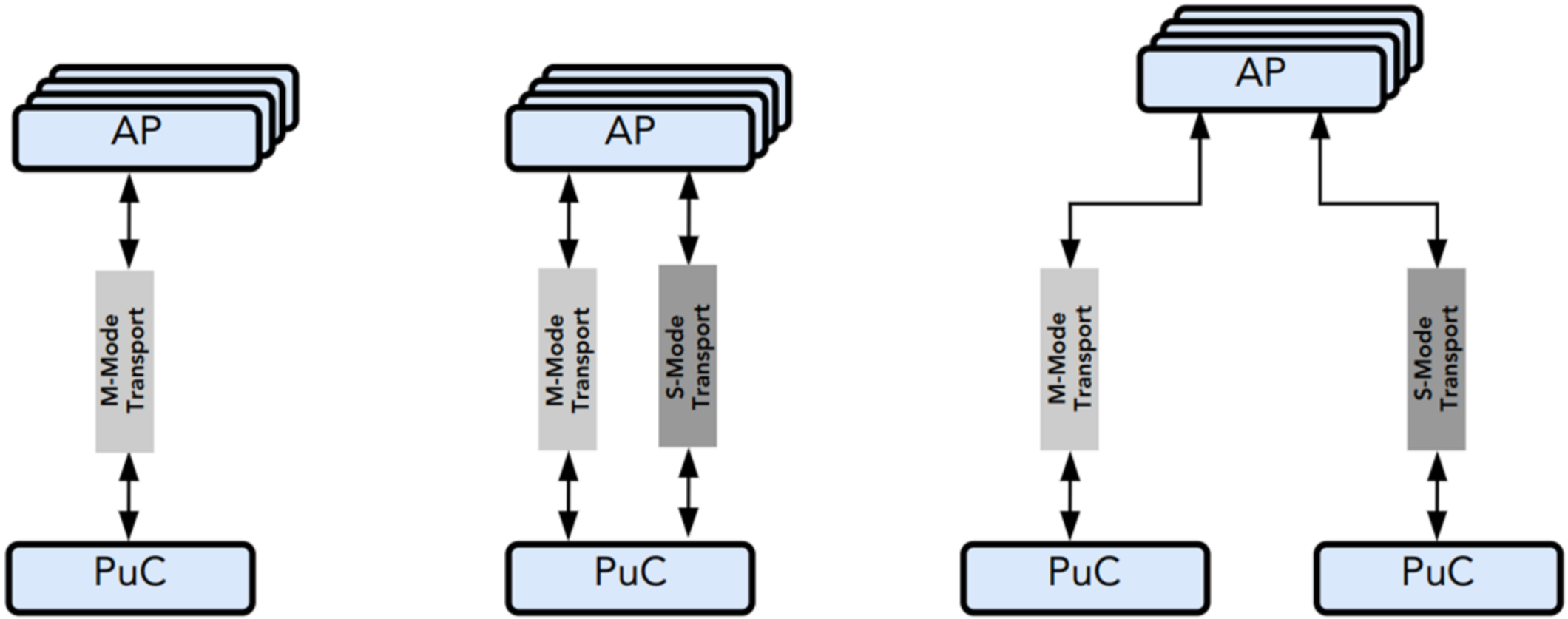


Transports

- RPMI Transport = Mechanism by which the messages are exchanged between the Application Processors and the Platform Microcontrollers
- Supports bi-directional communication
- The RPMI specification currently only defines a shared memory based transport
  - This could be extended in the future.
- Shared memory based transport
  - Accessible by Application Processor and Platform Microcontroller.
  - Non-cacheable memory region
  - Supports both polling and doorbell interrupt modes

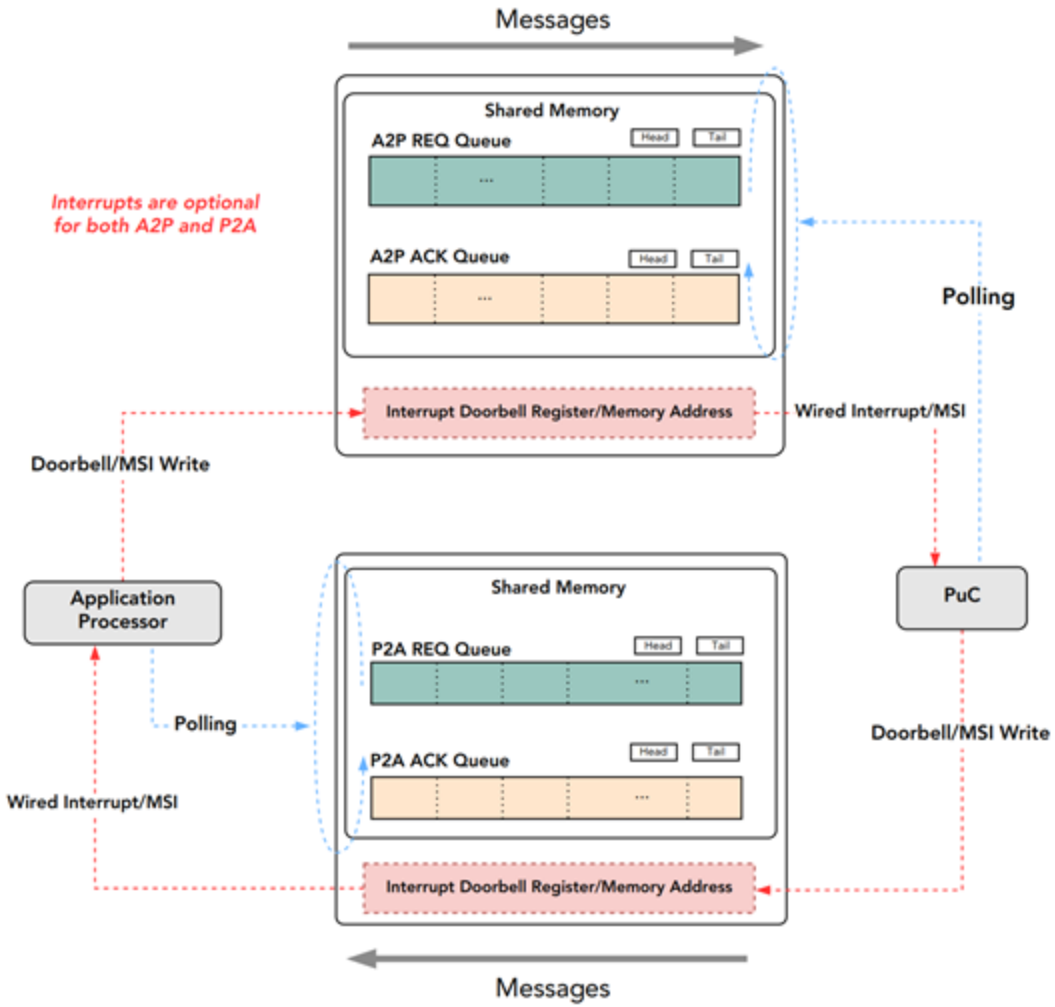
Transports

AP *- Application Processor*
PuC *- Platform MicroController*

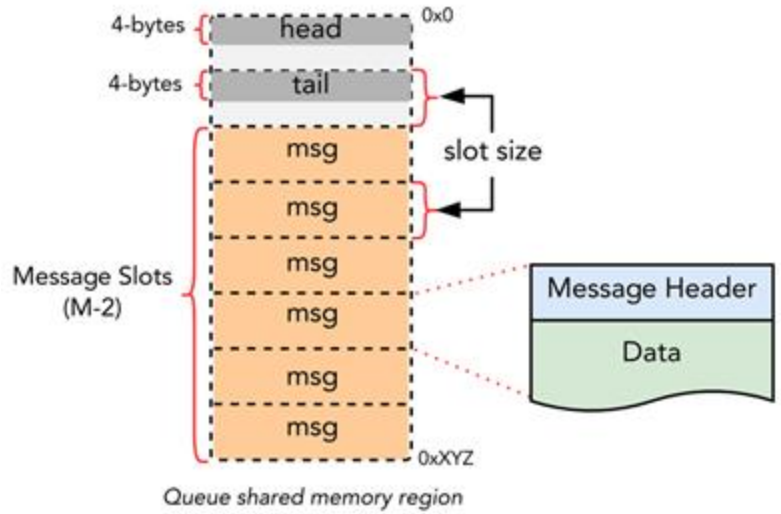


Transport in Different System Topologies

Shared Memory based Transport



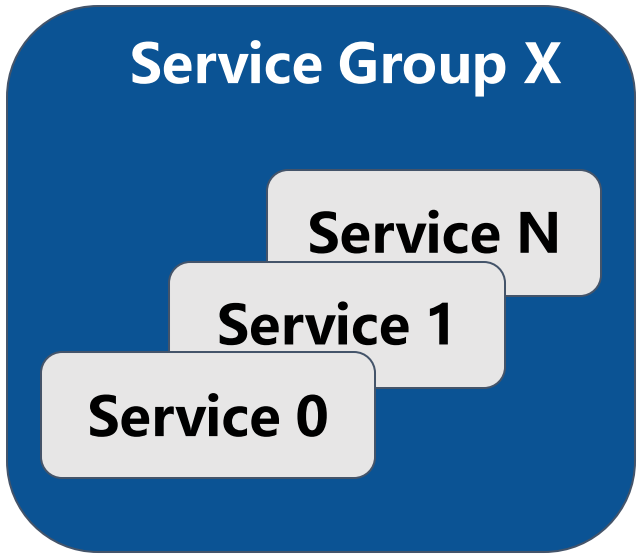
Shared Memory Based Transport



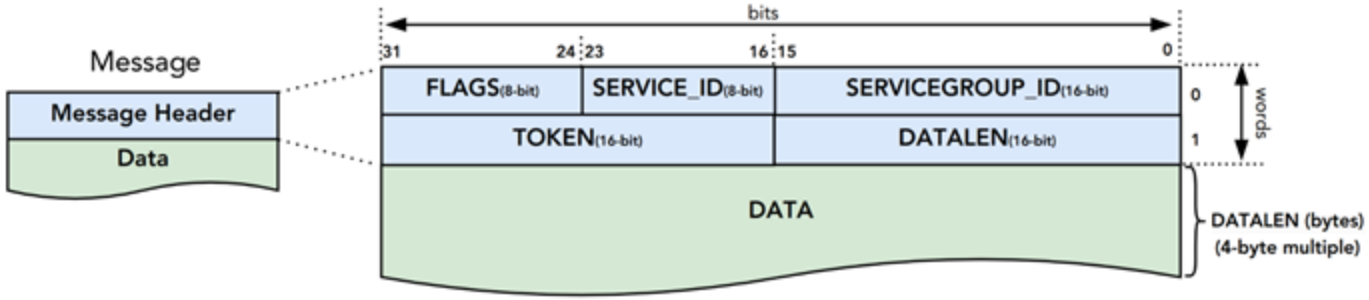
Message Queue

Messaging Protocols

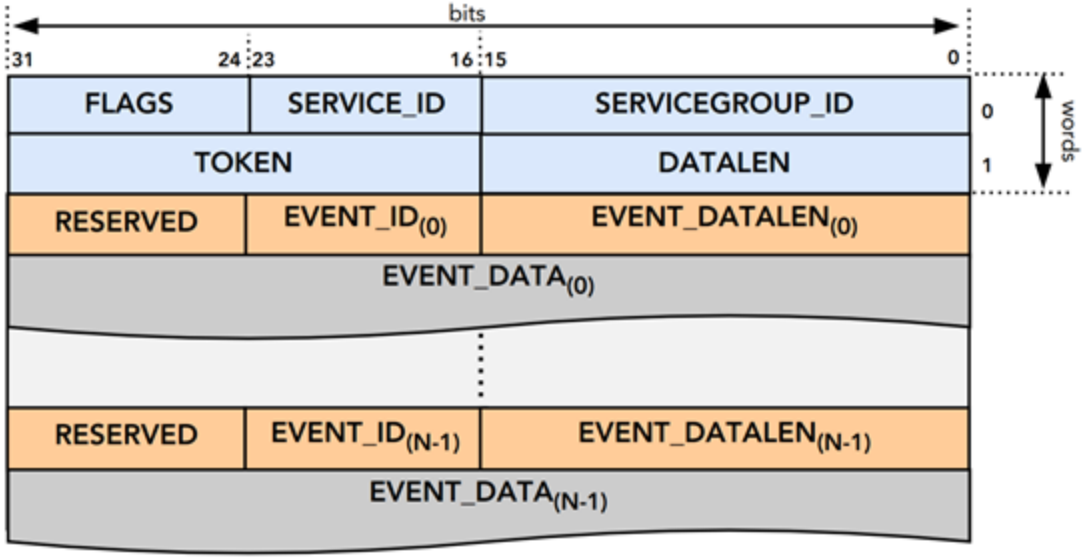
- Defines **Message Types** and **Message Formats**
- Each message performs a specific task called **Service**
- Multiple Services are grouped into **Service Groups**
- Message Types:
  - **Request**
    - Normal Request
    - Posted Request
  - **Acknowledgement**
  - **Notification**
- Message Formats:
  - Request and Acknowledgement
  - Notification



Message Formats



Request & Acknowledgment



Notification

Service Groups

Service Group ID	Service Group Name
0x00001	BASE
0x00002	SYSTEM_RESET
0x00003	SYSTEM_SUSPEND
0x00004	HART_STATE_MANAGEMENT
0x00005	CPPC
0x00006	VOLTAGE
0x00007	CLOCK
0x00008	DEVICE_POWER
0x00009	PERFORMANCE
0x0000A	MANAGEMENT_MODE
0x0000B	RAS_AGENT
0x0000A - 0x7FFFF	*Reserved for Future Use*
0x80000 - 0xFFFFF	*Implementation specific service groups*

Service Groups and Services

BASE

- BASE_ENABLE_NOTIFICATION
- BASE_GET_IMPLEMENTATION_VERSION
- BASE_GET_IMPLEMENTATION_ID
- BASE_GET_SPEC_VERSION
- BASE_GET_HW_INFO
- BASE_PROBE_SERVICE_GROUP
- BASE_GET_ATTRIBUTES
- BASE_SET_MSI

SYSTEM_RESET

- SYSRST_ENABLE_NOTIFICATION
- SYSRST_GET_ATTRIBUTES
- SYSRST_RESET

SYSTEM_SUSPEND

- SYSSUSP_ENABLE_NOTIFICATION
- SYSSUSP_GET_ATTRIBUTES
- SYSSUSP_SUSPEND

Service Groups and Services

HART_STATE_MANAGEMENT	CPPC	VOLTAGE
• HSM_ENABLE_NOTIFICATION • HSM_HART_START • HSM_HART_STOP • HSM_HART_SUSPEND • HSM_GET_HART_STATUS • HSM_GET_HART_LIST • HSM_GET_SUSPEND_TYPES • HSM_GET_SUSPEND_INFO	• CPPC_ENABLE_NOTIFICATION • CPPC_PROBE_REG • CPPC_READ_REG • CPPC_WRITE_REG • CPPC_GET_FAST_CHANNEL_ATTRIBUTES • CPPC_POKE_FAST_CHANNEL • CPPC_GET_HART_LIST	• VOLT_ENABLE_NOTIFICATION • VOLT_GET_NUM_DOMAINS • VOLT_GET_ATTRIBUTES • VOLT_GET_SUPPORTED_LEVELS • VOLT_SET_CONFIG • VOLT_GET_CONFIG • VOLT_SET_LEVEL • VOLT_GET_LEVEL

Service Groups and Services

CLOCK	DEVICE_POWER	PERFORMANCE
• CLK_ENABLE_NOTIFICATION • CLK_GET_NUM_CLOCKS • CLK_GET_ATTRIBUTES • CLK_GET_SUPPORTED_RATES • CLK_SET_CONFIG • CLK_GET_CONFIG • CLK_SET_RATE • CLK_GET_RATE	• DPWR_ENABLE_NOTIFICATION • DPWR_GET_NUM_DOMAINS • DPWR_GET_ATTRIBUTES • DPWR_SET_STATE • DPWR_GET_STATE	• PERF_ENABLE_NOTIFICATION • PERF_GET_NUM_DOMAINS • PERF_GET_ATTRIBUTES • PERF_GET_SUPPORTED_LEVELS • PERF_GET_LEVEL • PERF_SET_LEVEL • PERF_GET_LIMIT • PERF_SET_LIMIT • PERF_GET_FAST_CHANNEL_ATTRIBUTES

Service Groups and Services

MANAGEMENT_MODE	RAS_AGENT
• MM_ENABLE_NOTIFICATION • MM_VERSION • MM_COMMUNICATE • MM_COMPLETE	• RAS_ENABLE_NOTIFICATION • RAS_GET_NUM_ERR_SRCS • RAS_GET_ERR_SRCS_ID_LIST • RAS_GET_ERR_SRC_DESC

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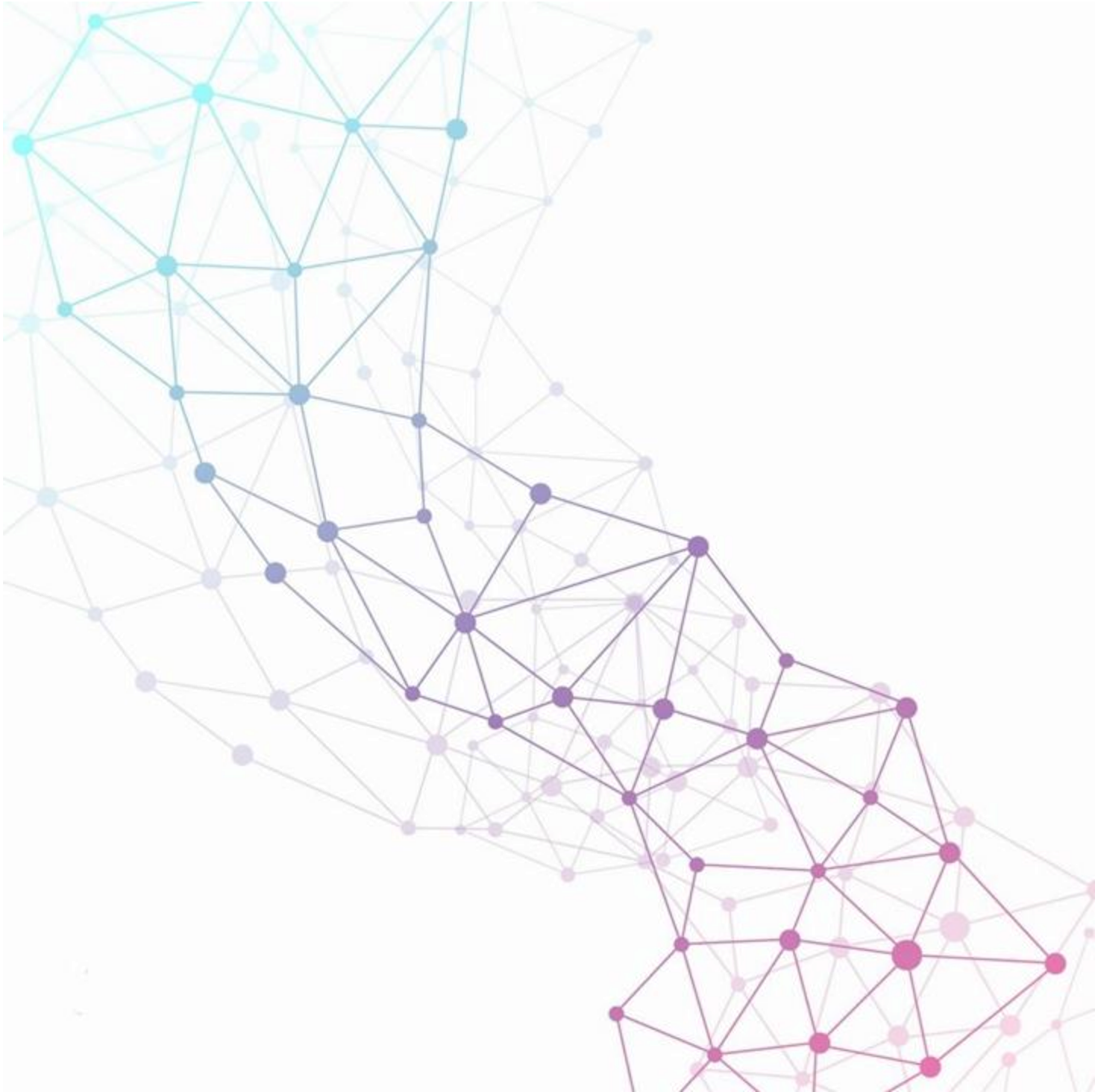
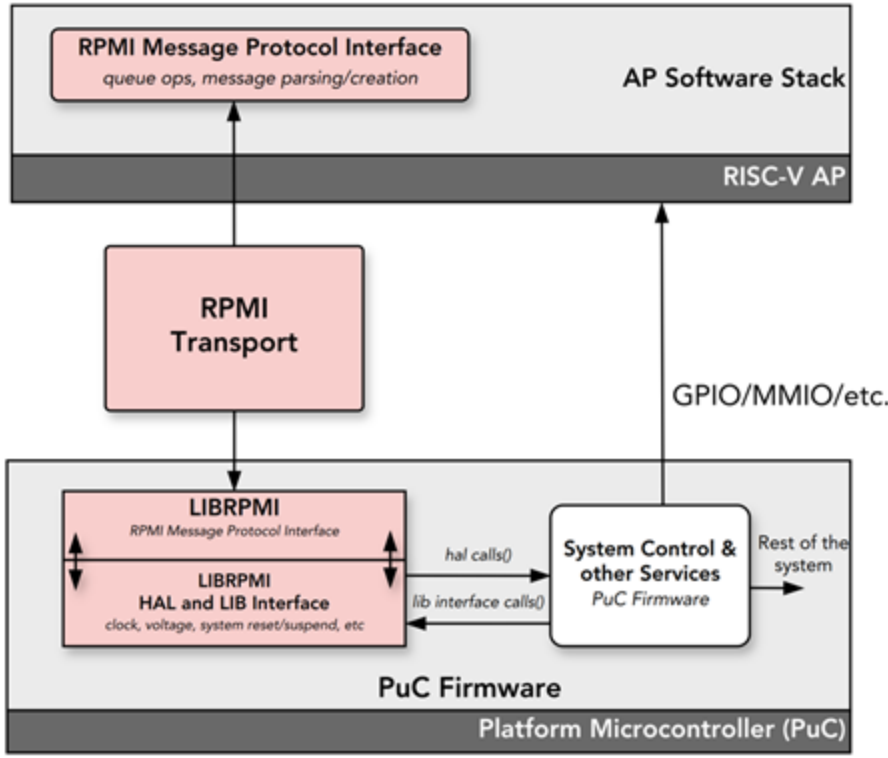
Part 2: librpmi



librpmi

- https://github.com/riscv-software-src/librpmi.git
- The librpmi is an reference implementation of the RPMI specification.
- Implements RPMI Transport (shared memory), Message Protocol and multiple Service Groups and Services as defined by RPMI.
- The librpmi can be used by:
  - RISC-V platform vendors to implement RPMI services in their platform microcontroller firmware.
  - System-level partitions to implement RPMI services running as separate OpenSBI domain
  - Hypervisors/emulators/simulators to emulate RPMI services for the Guest/VM
- Announcement of librpmi project
  - https://lists.riscv.org/g/tech-rpmi/message/102



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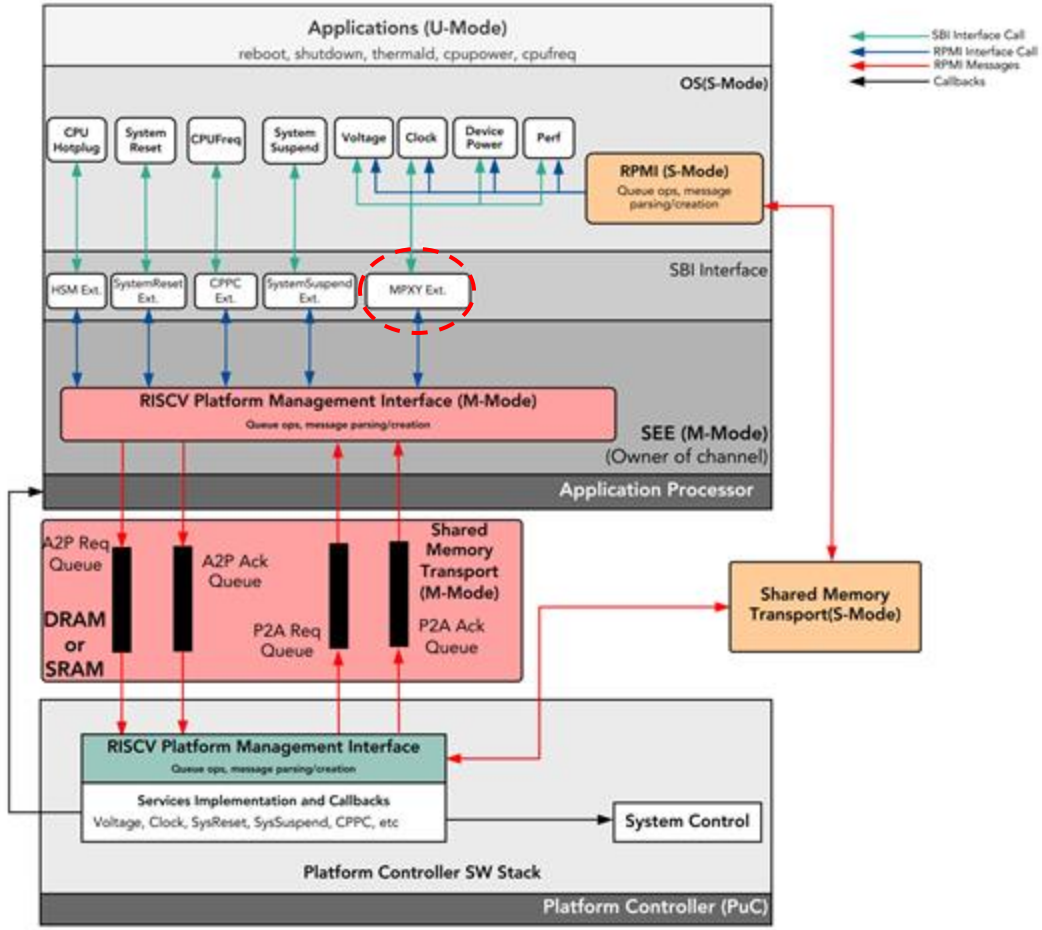
Part 3: SBI Message Proxy Extension (MPXY)

SBI MPXY - Introduction

- A SBI extension for sending/receiving messages via the SBI implementation.
- Defines a **protocol-agnostic interface** between supervisor software (S-Mode) and SBI implementation (M-Mode) when message protocol is implemented in M-Mode.
- RPMI uses this SBI MPXY extension for some service groups, such as voltage, clock, etc.
- Status
  - SBI MPXY Extension specification is under review in PRS TG mailing list.
  - https://lists.riscv.org/g/tech-prs/message/974
  - PoC: https://lists.riscv.org/g/tech-rpmi/message/90



SBI MPXY - Functions

Functions	Description
struct sbiret **sbi_mpxy_set_shmem**(unsigned long shmem_size, unsigned long shmem_phys_lo, unsigned long shmem_phys_hi, unsigned long flags)	Set shared memory
struct sbiret **sbi_mpxy_get_channel_ids**(uint32_t start_index)	Get Channel IDs
struct sbiret **sbi_mpxy_read_attributes**(uint32_t channel_id, uint32_t base_attribute_id, uint32_t attribute_count)	Read Channel Attribute
struct sbiret **sbi_mpxy_write_attributes**(uint32_t channel_id, uint32_t base_attribute_id, uint32_t attribute_count)	Write Channel Attribute
struct sbiret **sbi_mpxy_send_message_with_response**(uint32_t channel_id, uint32_t message_id, unsigned long message_data_len)	Send Message with Response
struct sbiret **sbi_mpxy_send_message_without_response** (uint32_t channel_id, uint32_t message_id, unsigned long message_data_len)	Send Message without Response
struct sbiret **sbi_mpxy_get_notification_events**(uint32_t channel_id)	Get Notifications

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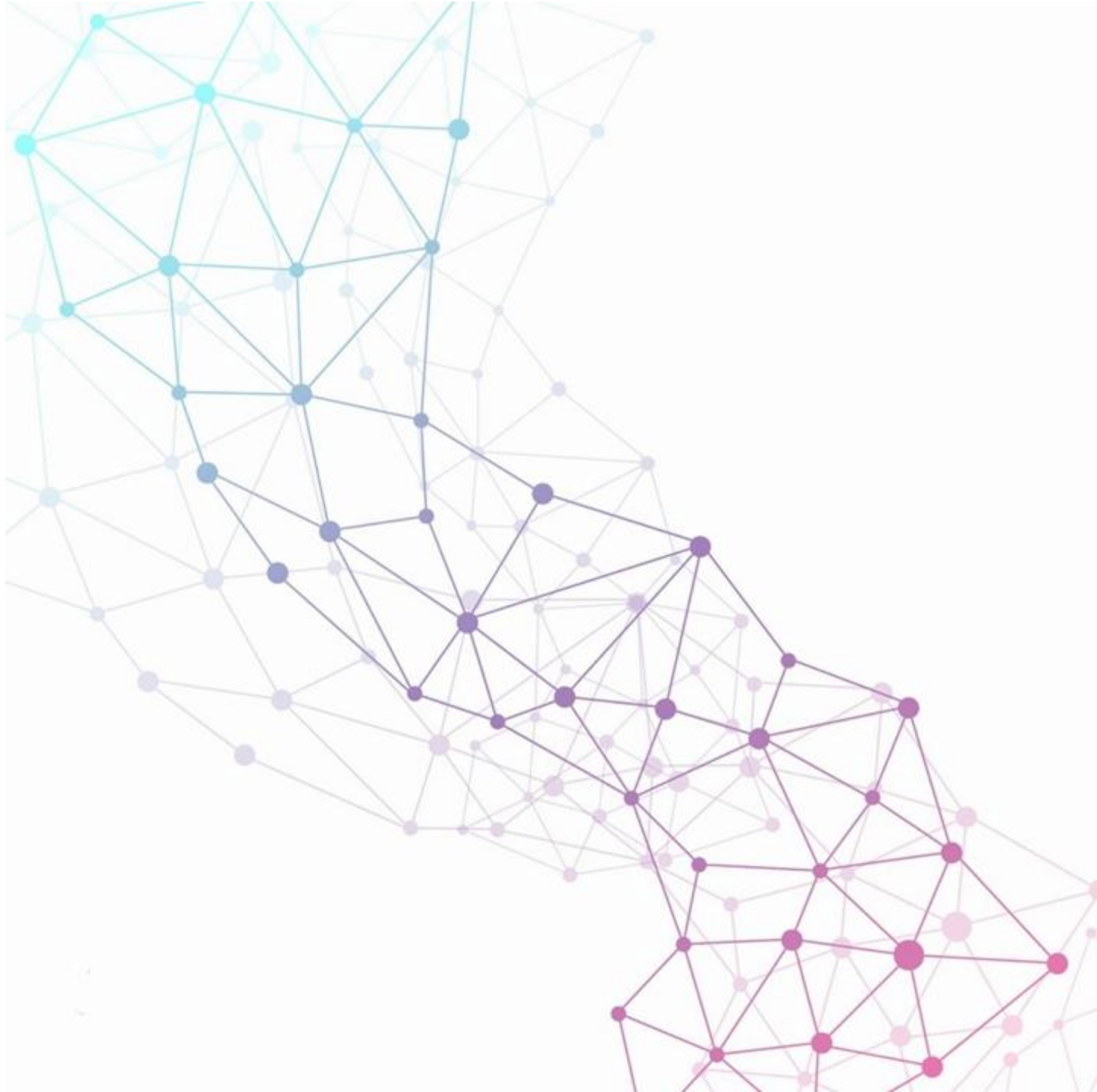
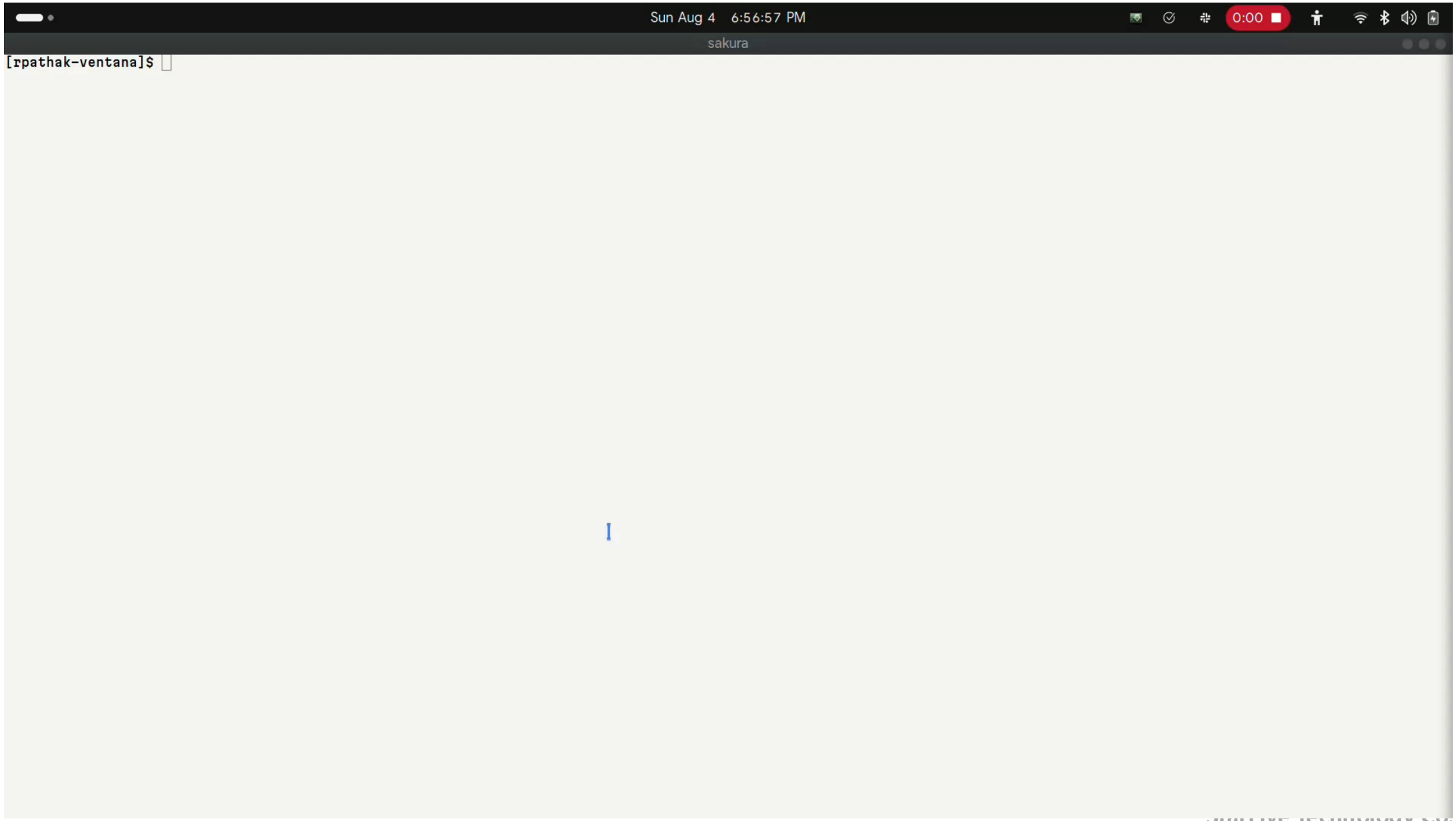
Part 4: RPMI Demo



RPMI Demo

- Run on Qemu platform
- Uses SBI MPXY extensions path to send RPMI messages
- Demonstrates Clock, Hart State Management, System Suspend, System Reset services.

RPMI Demo



Summary

- StarFive will continue to work with the RISC-V community to advance the development of RISC-V RPMI, and will continue to contribute to the RPMI specification and the RISC-V software ecosystem.

- Goal is to freeze the RPMI specification by Q4 2024 and ratify by Q1 2025.

- Acknowledgments
  - To all contributors to the RPMI Specification.
  - Special thanks to Rahul Pathak for preparing the RPMI demo video.

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