Tessellation: Space-Time Partitioning in a Manycore Client OS

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Client Device

- Single-user device
- Runs a heterogeneous mix of interactive, real-time and batch applications simultaneously
- Generally battery constrained

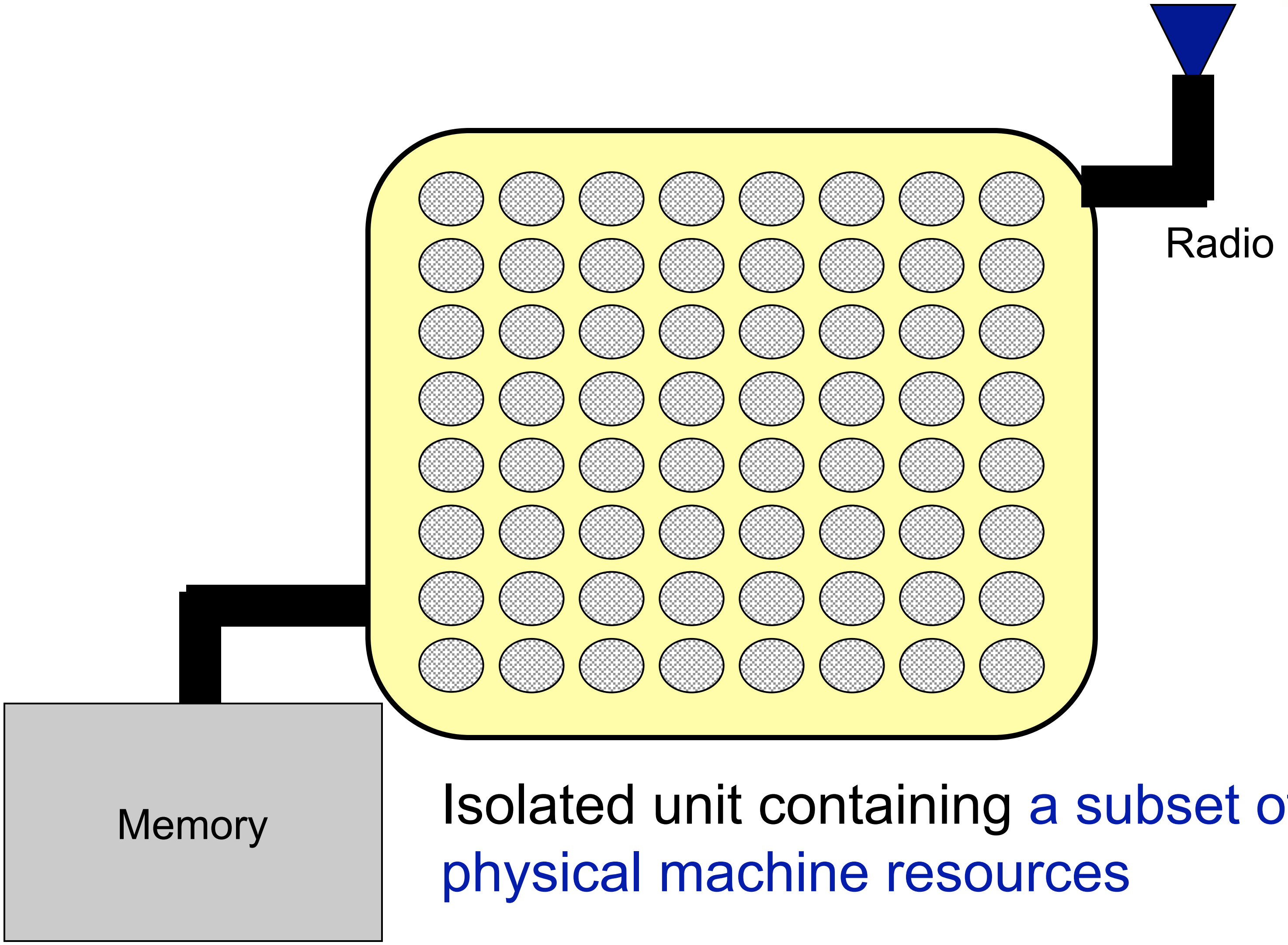
Why a new Client OS?

- Enter the Manycore world → Must address parallelism
  - Current client OSs weren't designed for parallel applications
- Existing OSs addressing parallelism targets servers or HPC contexts, not clients
  - Servers – emphasis on throughput vs.
  - Client – emphasis on user experience/responsiveness
  - HPC – machine dedicated to one parallel application vs.
  - Client – runs many heterogeneous parallel applications
  - Client - Longer battery life

Outline

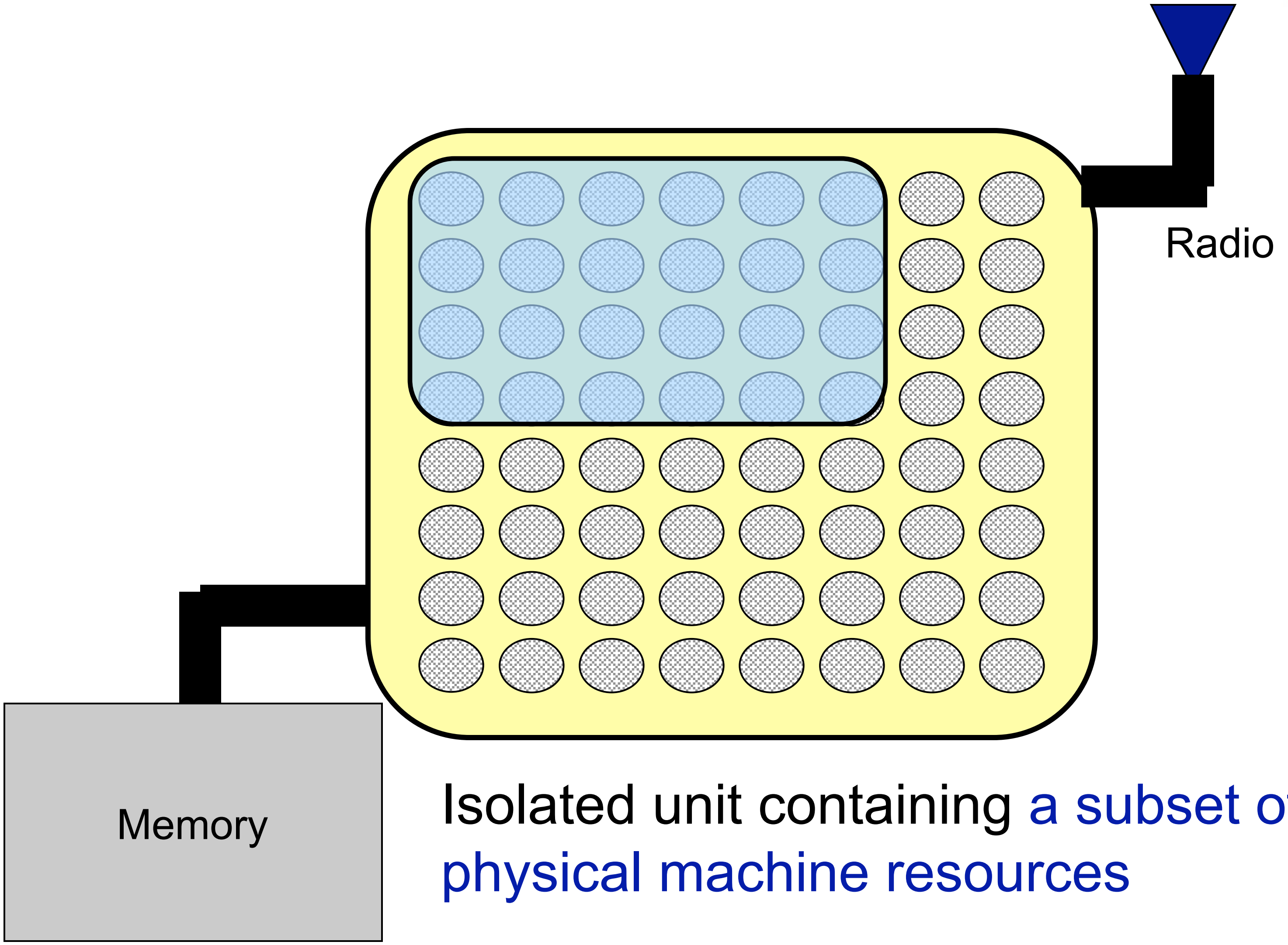
- Why a new OS for Manycore Clients?
- A Case for Space-time Partitioning
  - Define space-time partitioning
  - Use cases for space-time partitioning
- Implementing Space-Time Partitioning in a Manycore OS
- Status

Spatial Partitions



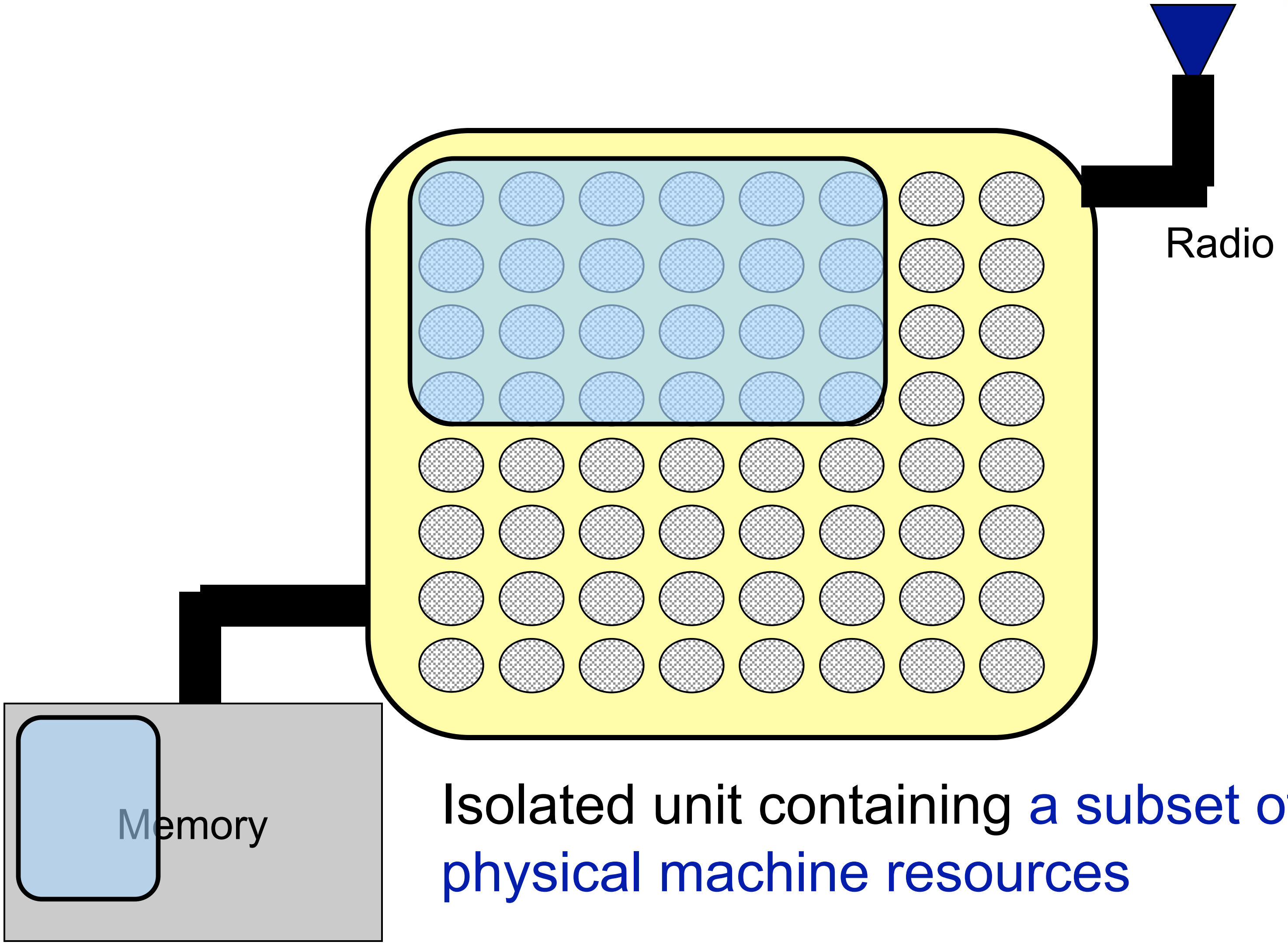
Isolated unit containing a subset of physical machine resources

Spatial Partitions



Isolated unit containing a subset of physical machine resources

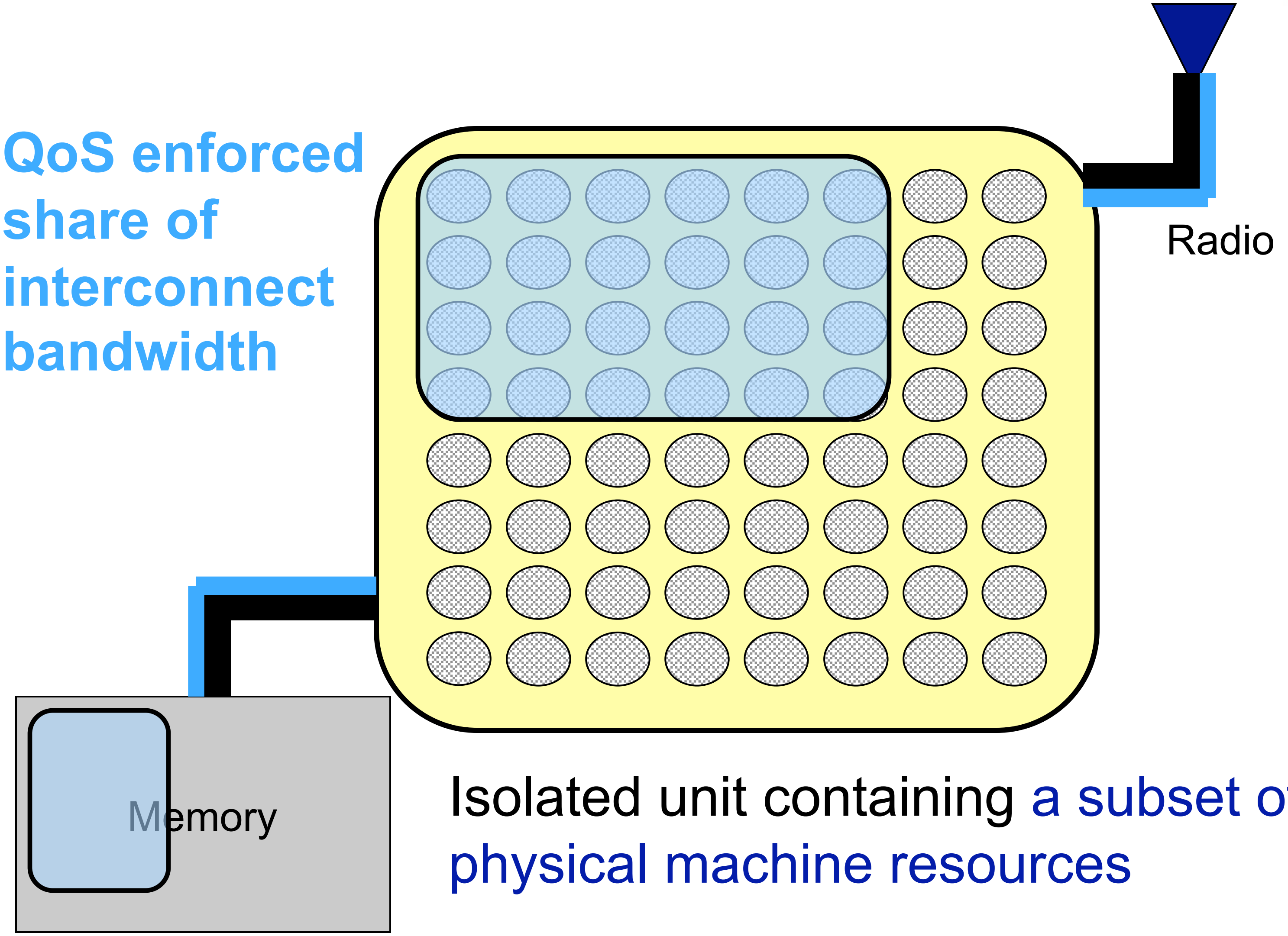
Spatial Partitions



Isolated unit containing a subset of physical machine resources

Spatial Partitions

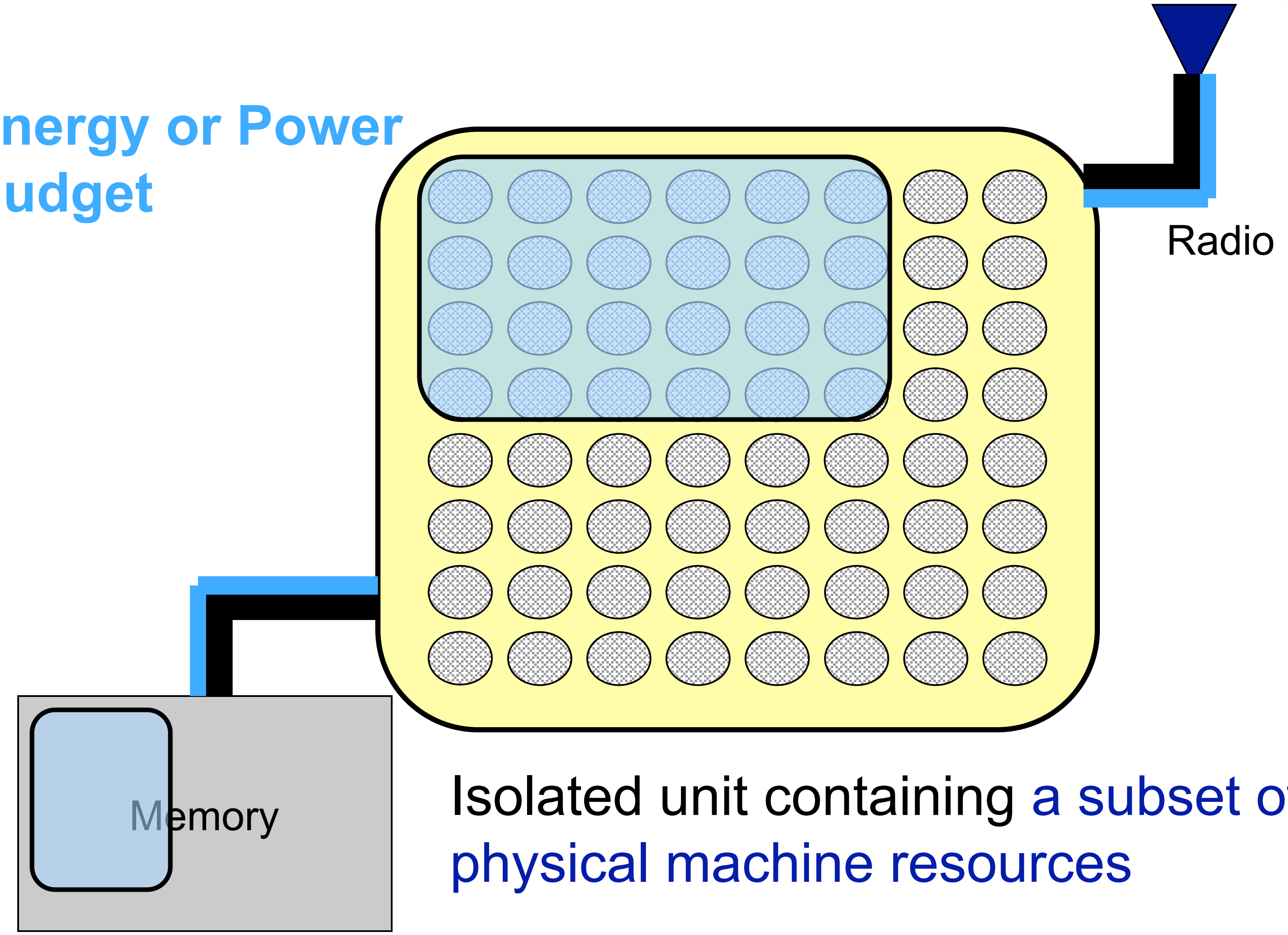
QoS enforced share of interconnect bandwidth



Isolated unit containing a subset of physical machine resources

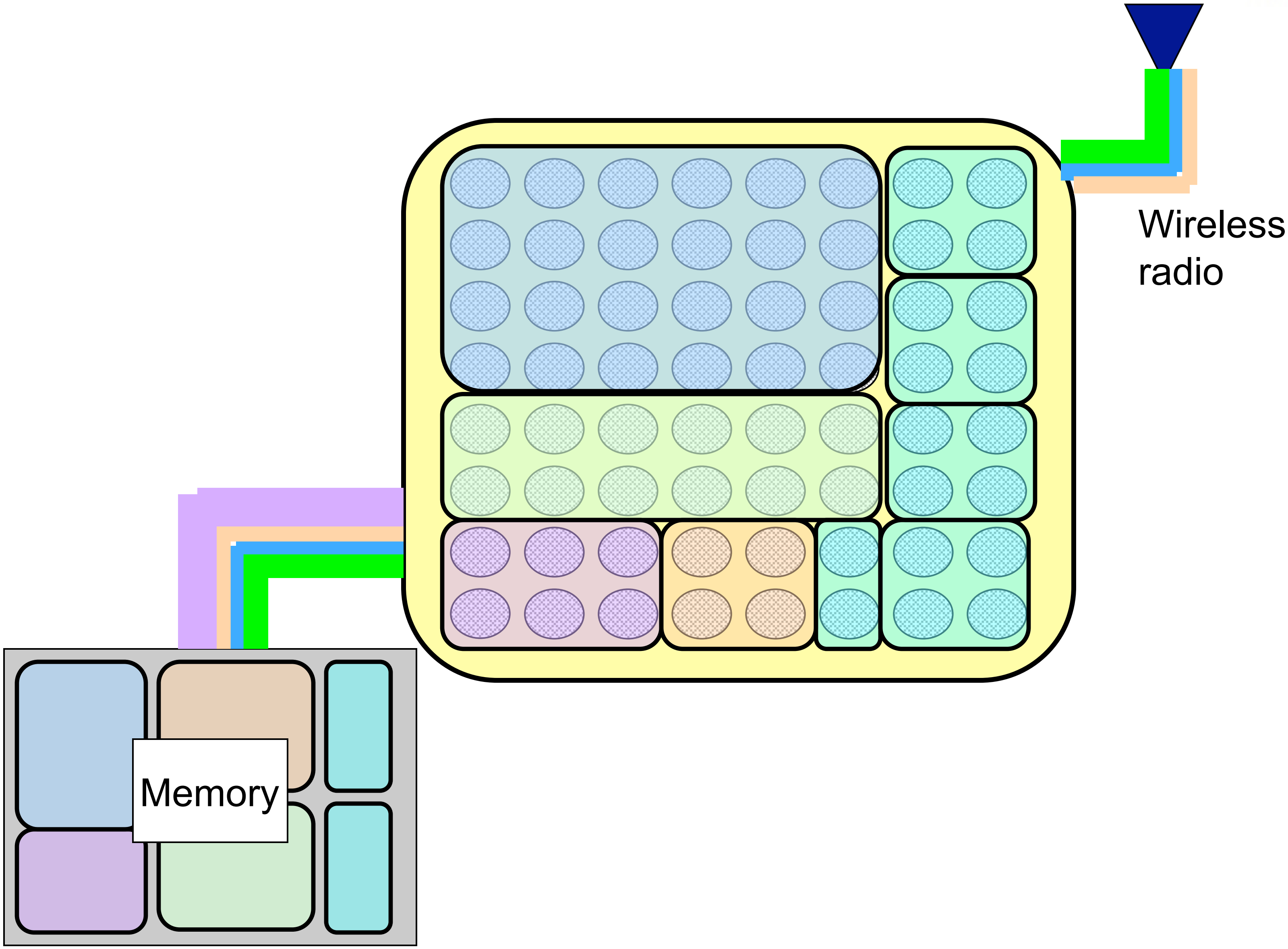
Spatial Partitions

Energy or Power Budget

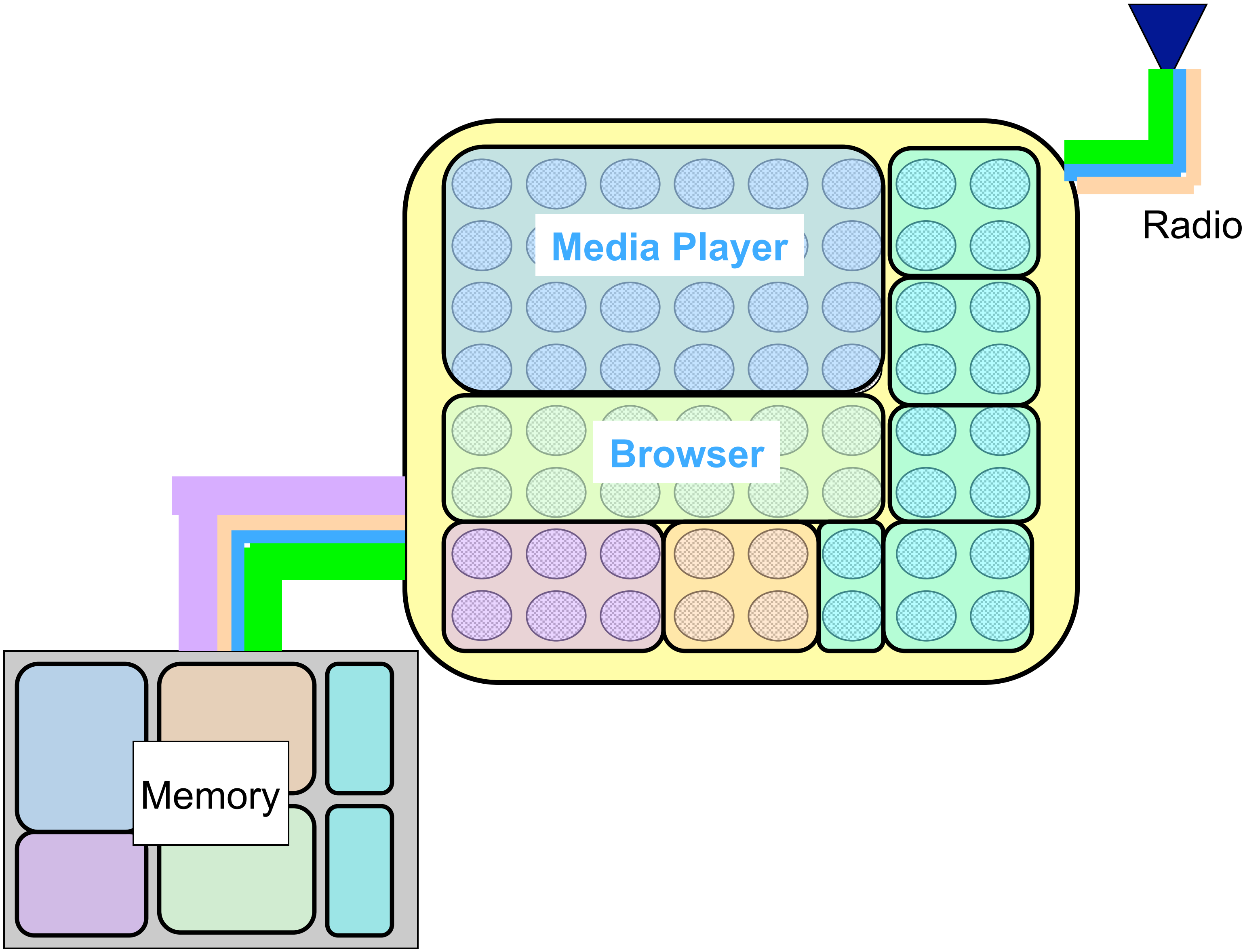


Isolated unit containing a subset of physical machine resources

Machine divided into spatial partitions

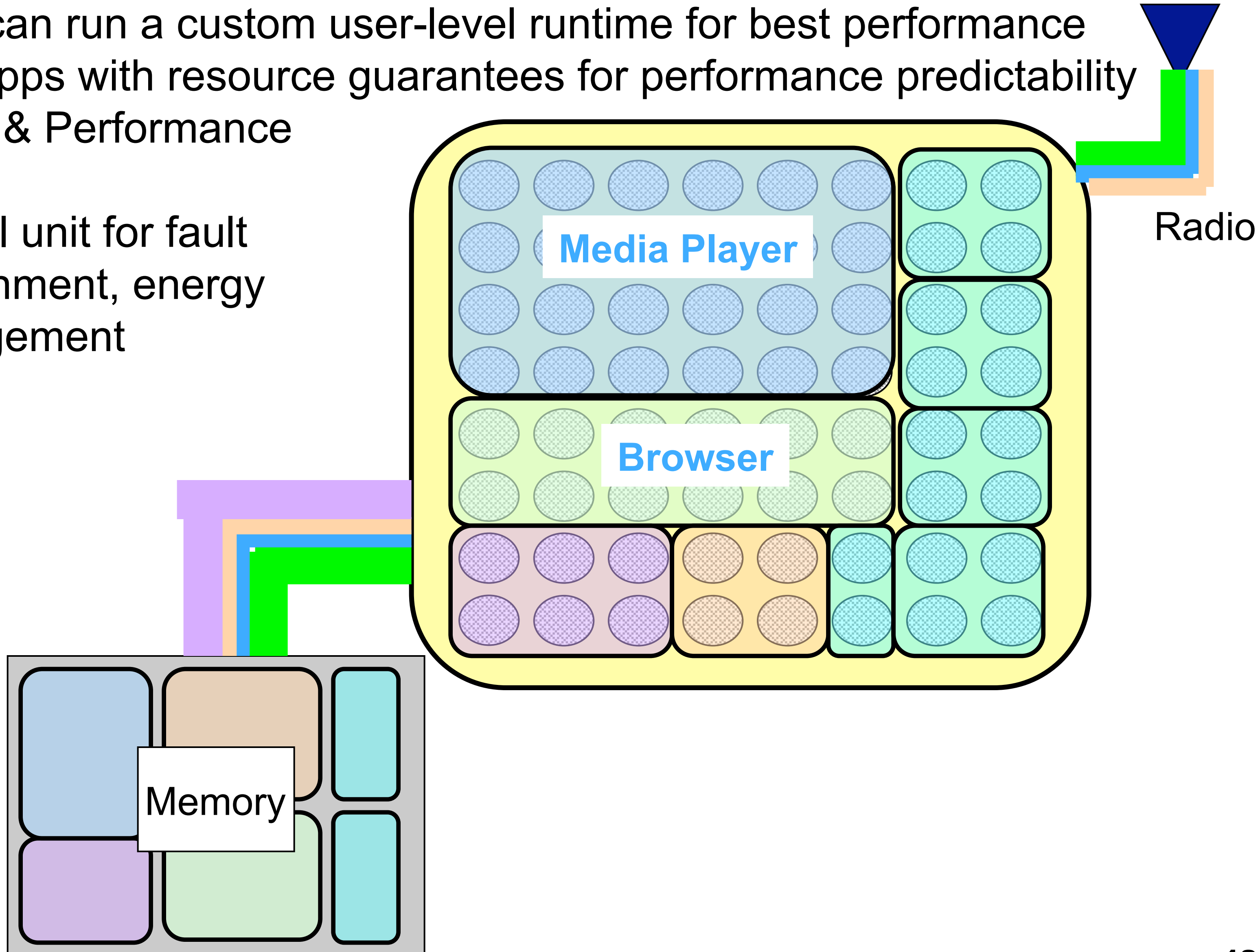


Put applications in spatial partitions

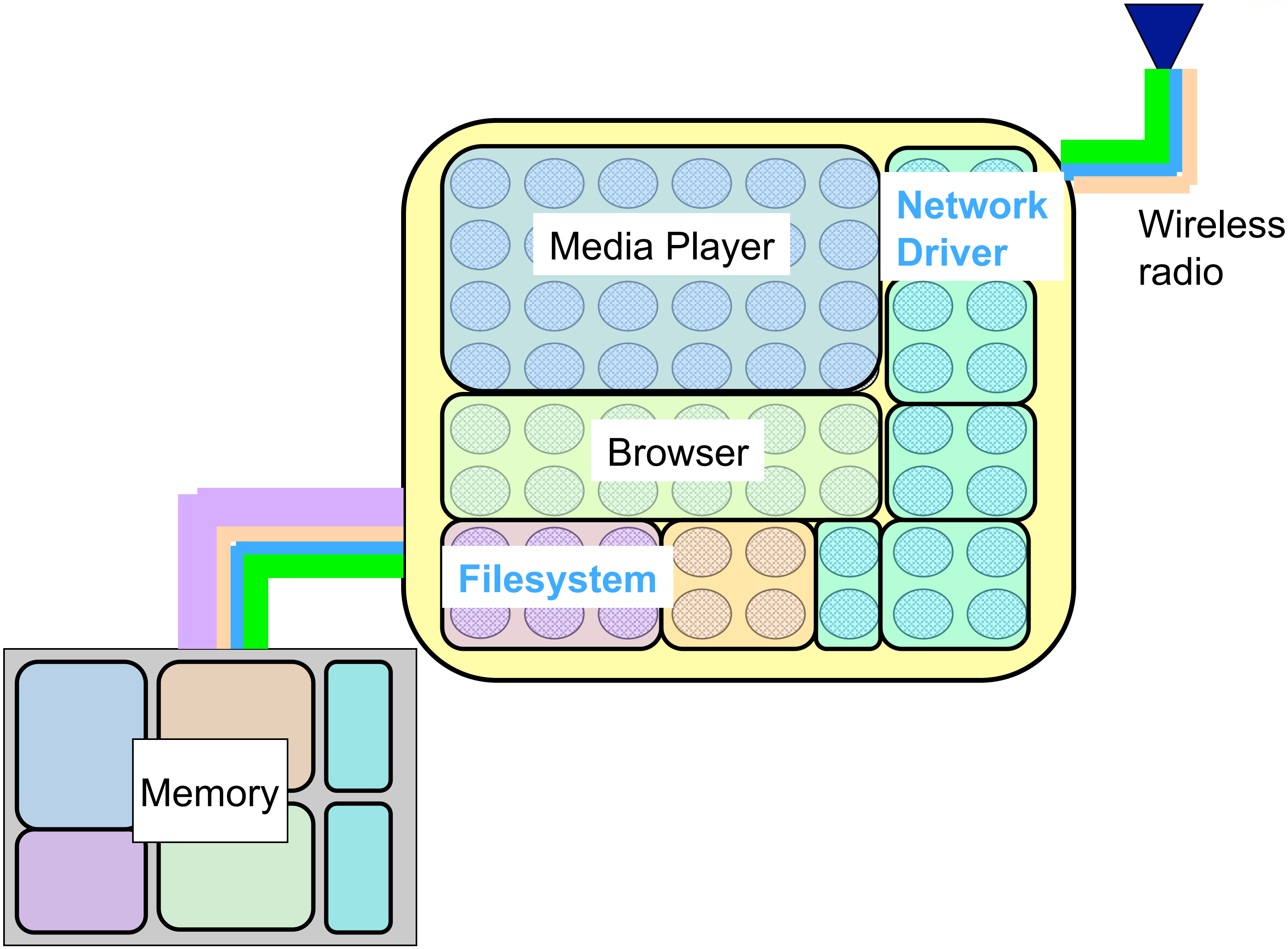


Benefits of spatial partitions

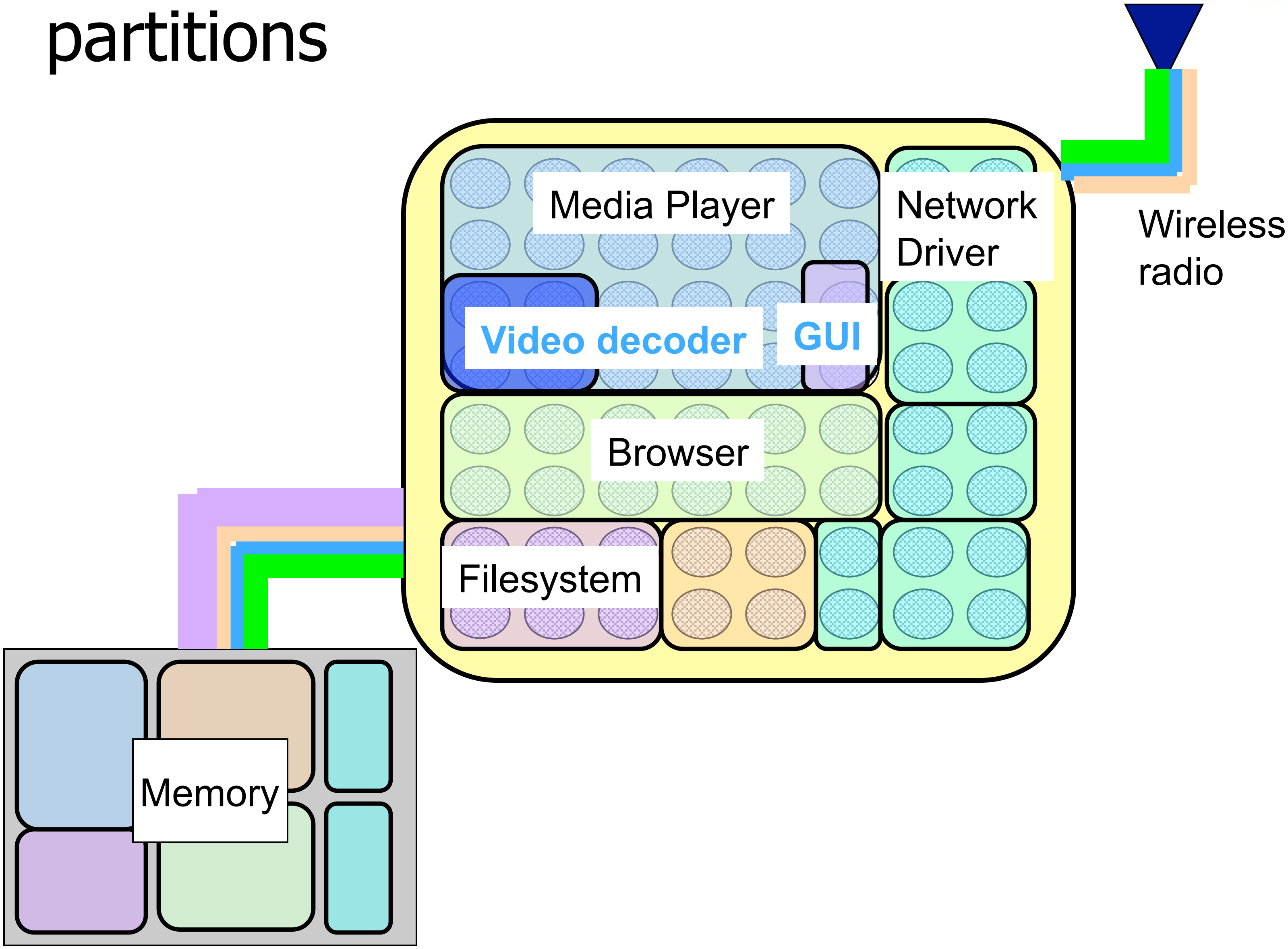
- Each app can run a custom user-level runtime for best performance
- Provides apps with resource guarantees for performance predictability
- Functional & Performance Isolation
  - Natural unit for fault containment, energy management



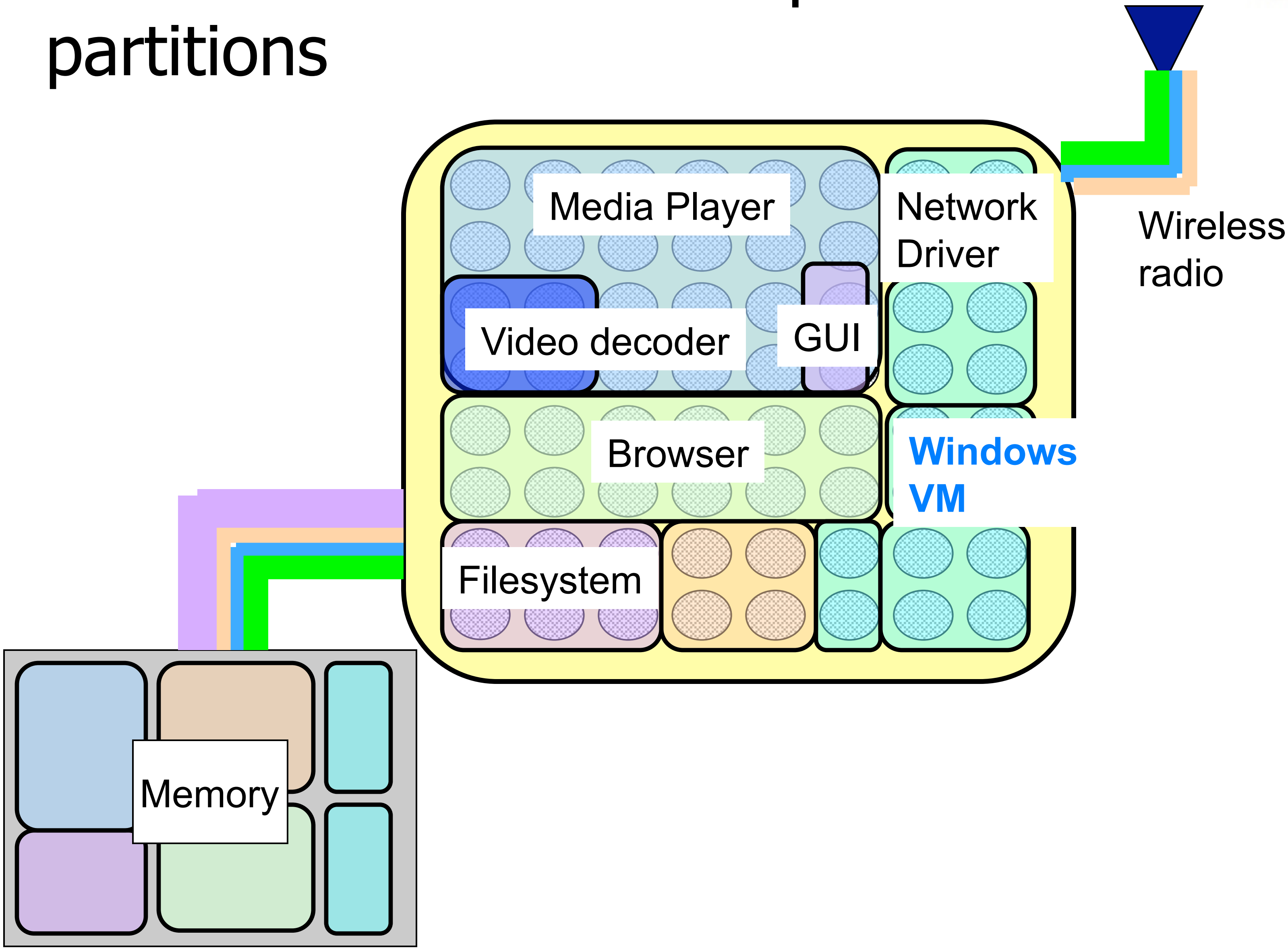
Put OS Services in spatial partitions



Put sub-components in spatial partitions

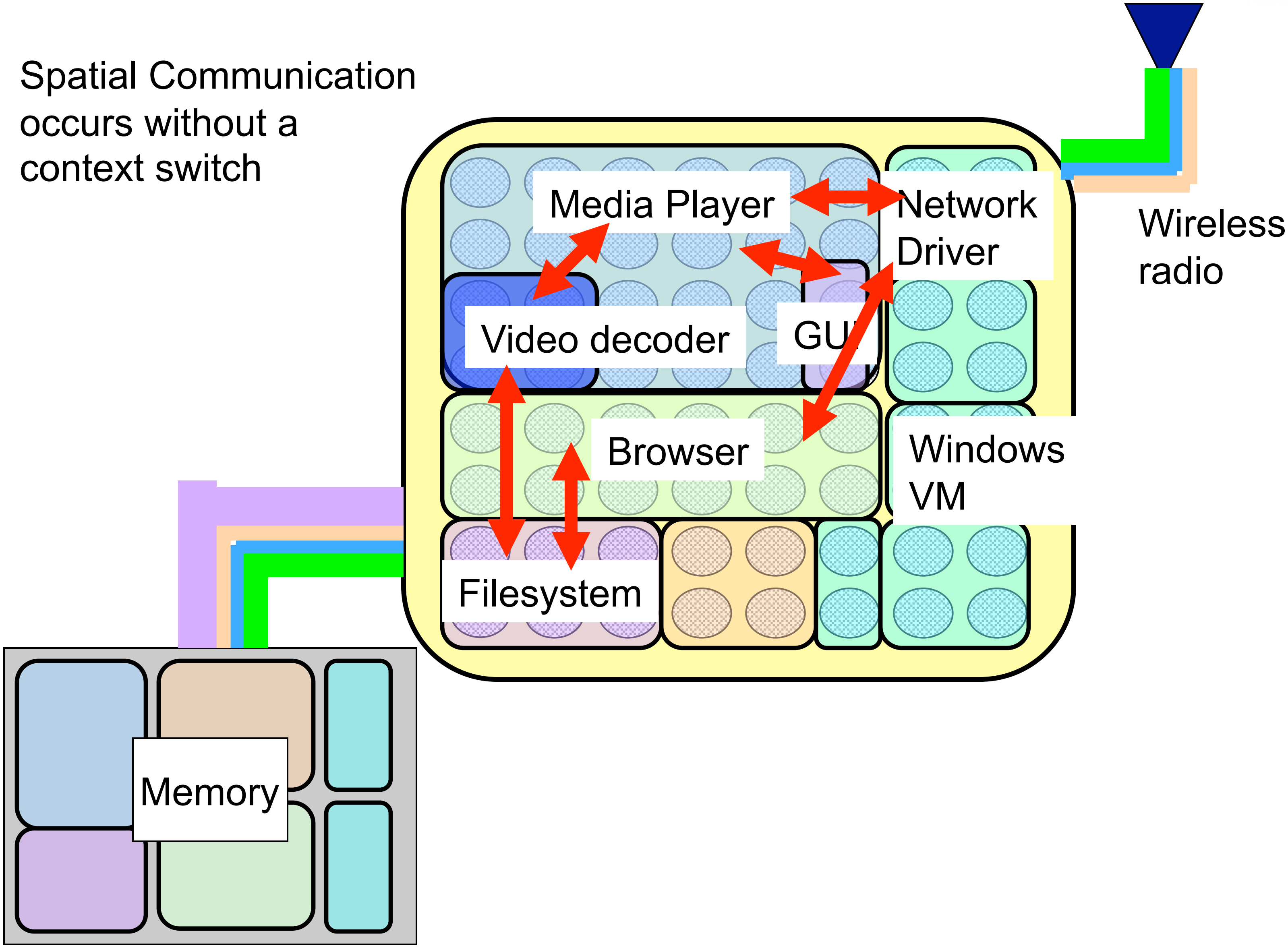


Put virtual machines in spatial partitions



Partitions need to communicate

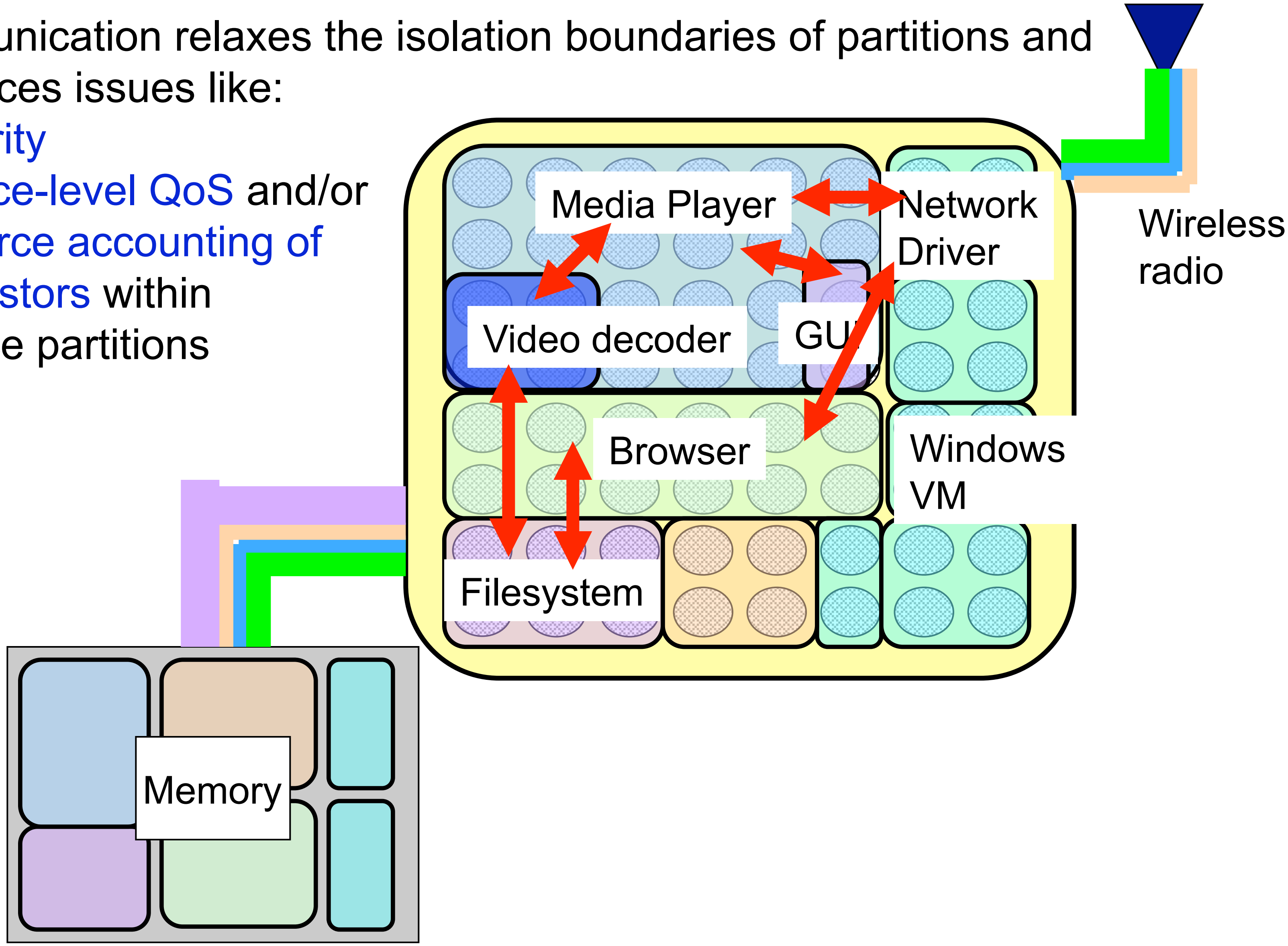
Spatial Communication occurs without a context switch



Communication Challenges

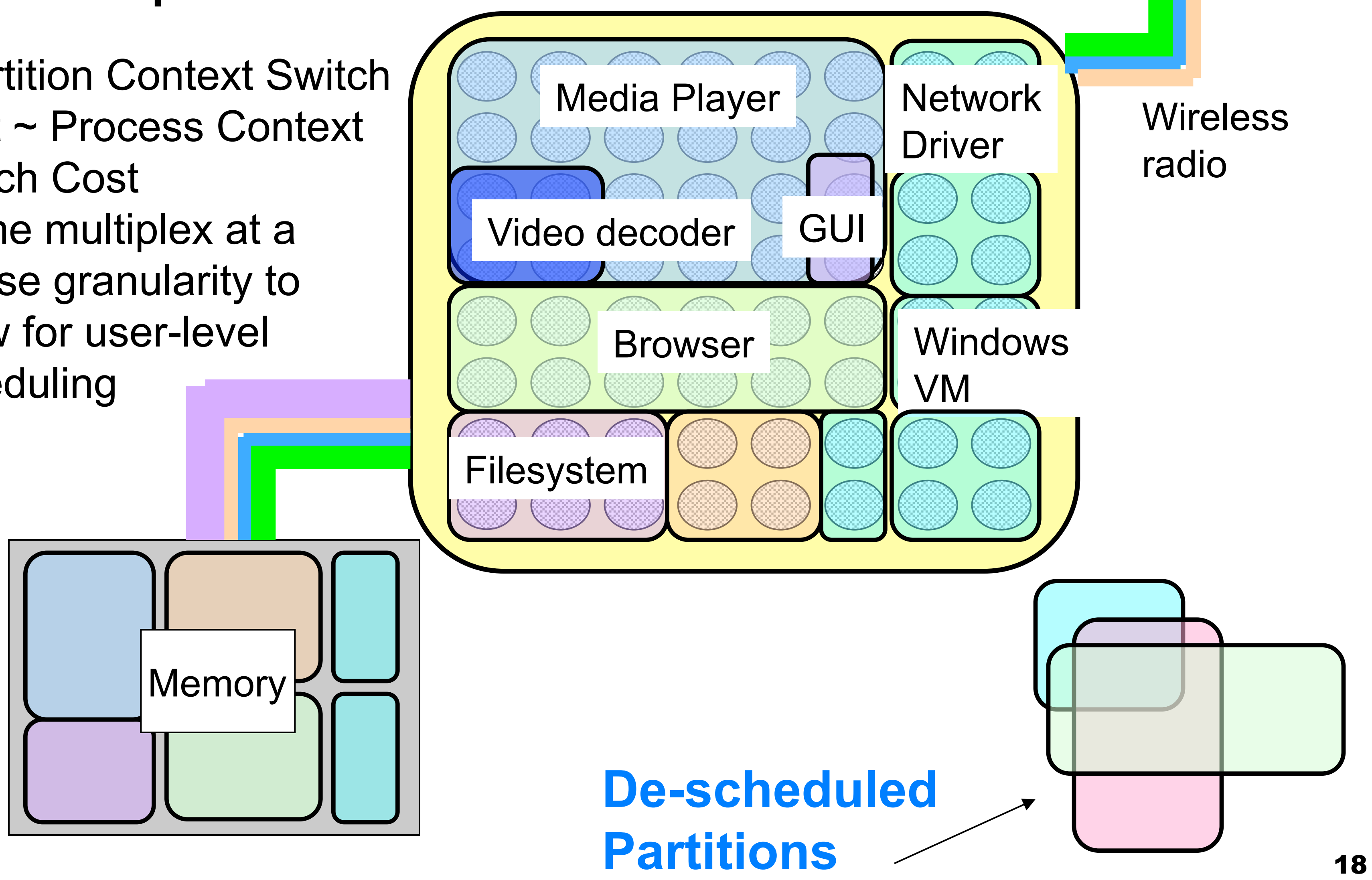
Communication relaxes the isolation boundaries of partitions and introduces issues like:

- Security
- Service-level QoS and/or resource accounting of requestors within service partitions

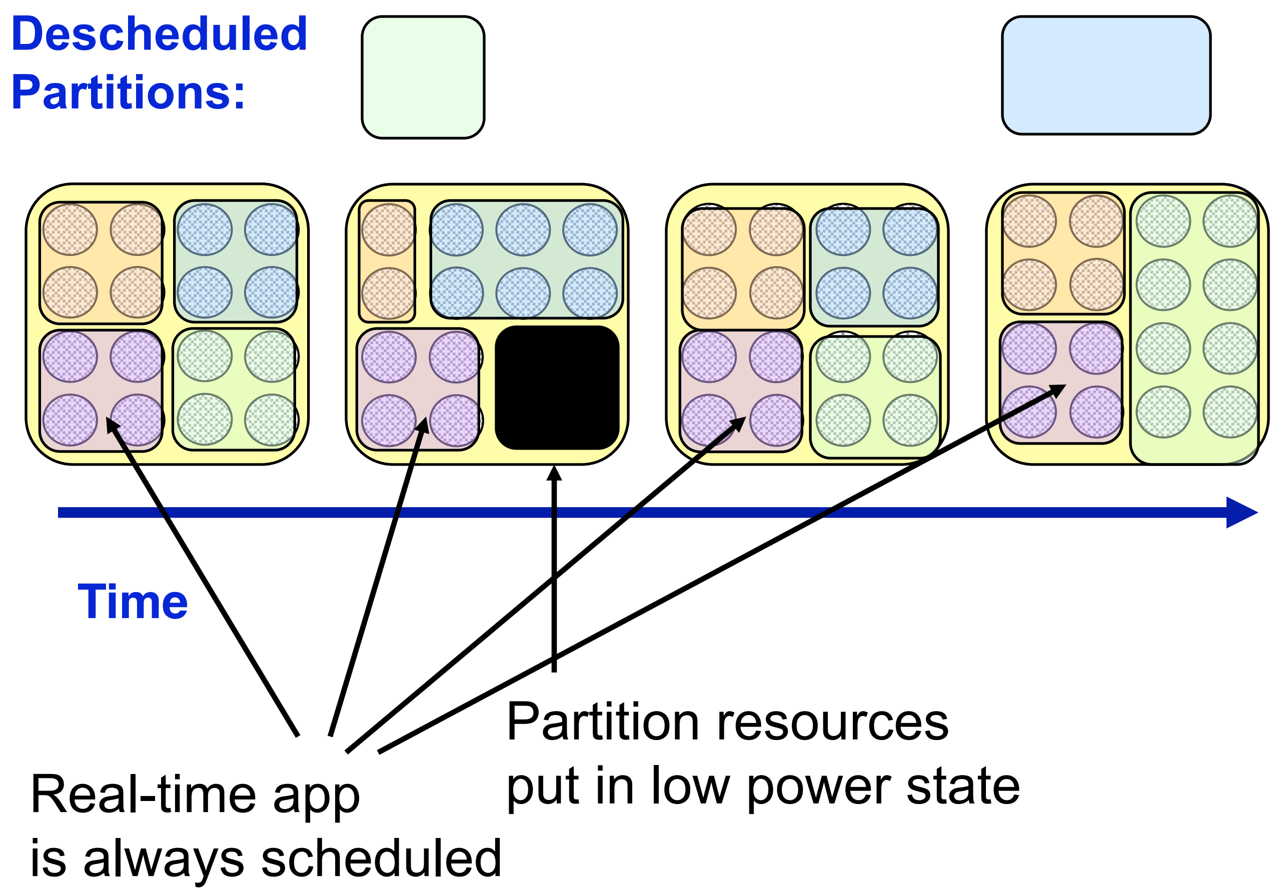


Space-time partitioning virtualizes spatial partitions

- Partition Context Switch Cost ~ Process Context Switch Cost
- Time multiplex at a coarse granularity to allow for user-level scheduling



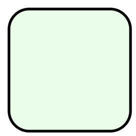
Space-Time Partition Scheduling

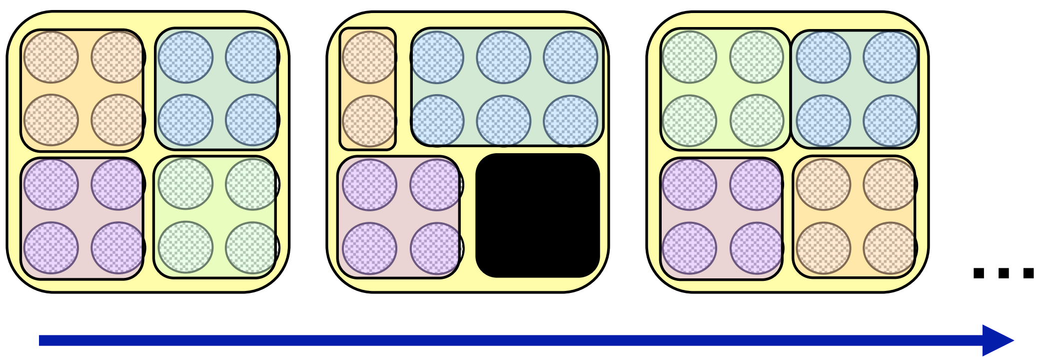


Partitions are dynamically resized while running without a reboot or application restart

Space-Time Partition Scheduling

Descheduled Partitions:





Time

Partitions are dynamically resized while running without a reboot or application restart

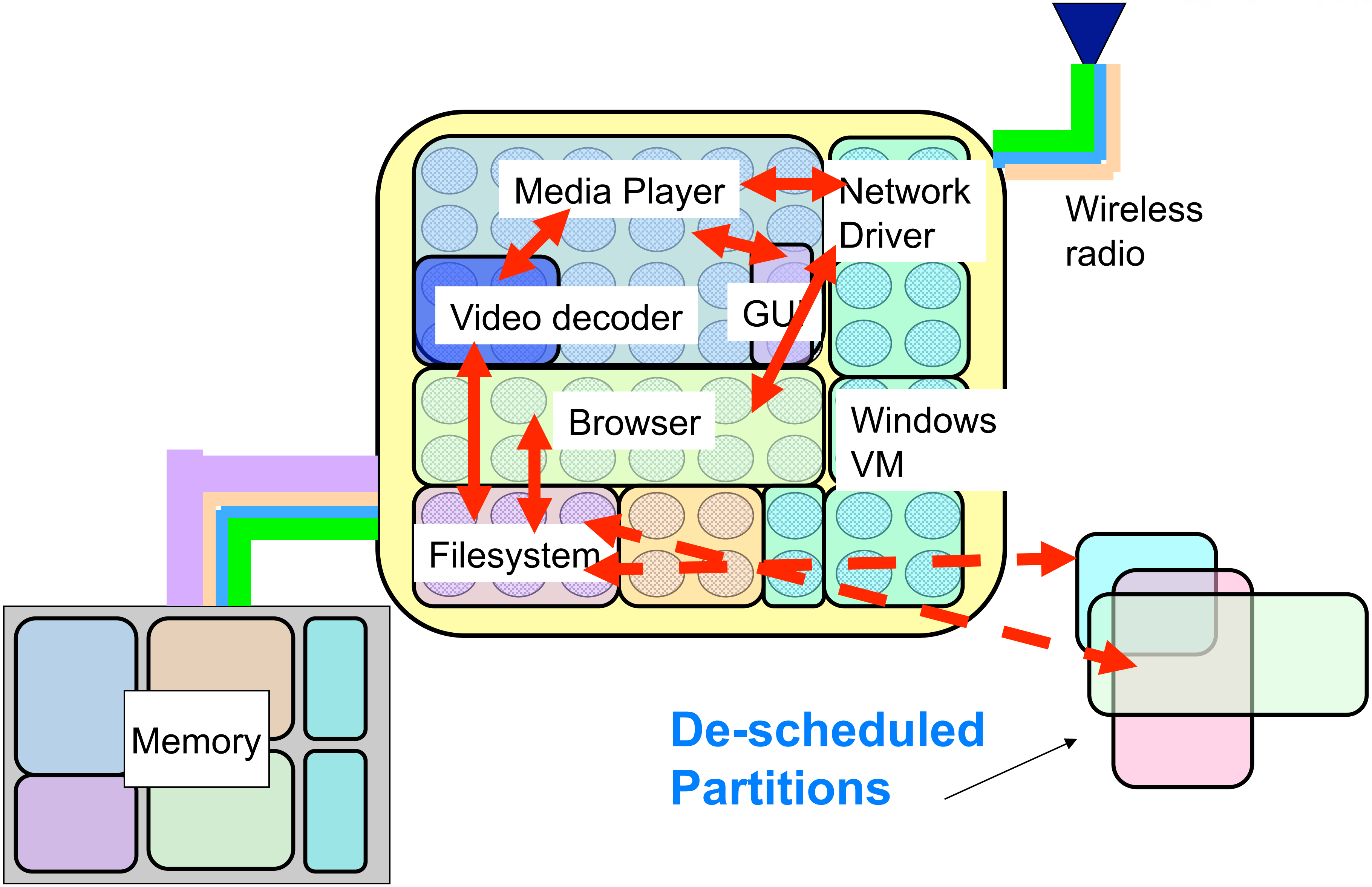
Challenges:

1. How to determine the right resource allocation for a partition?

2. What granularity to time multiplex each partition? Don't need to use same time quanta for all partitions.

3. We can deschedule partitions from each type of resource independently. E.g. time multiplex off cores more frequently than multiplex partition data off caches. How to determine 'best' policy?

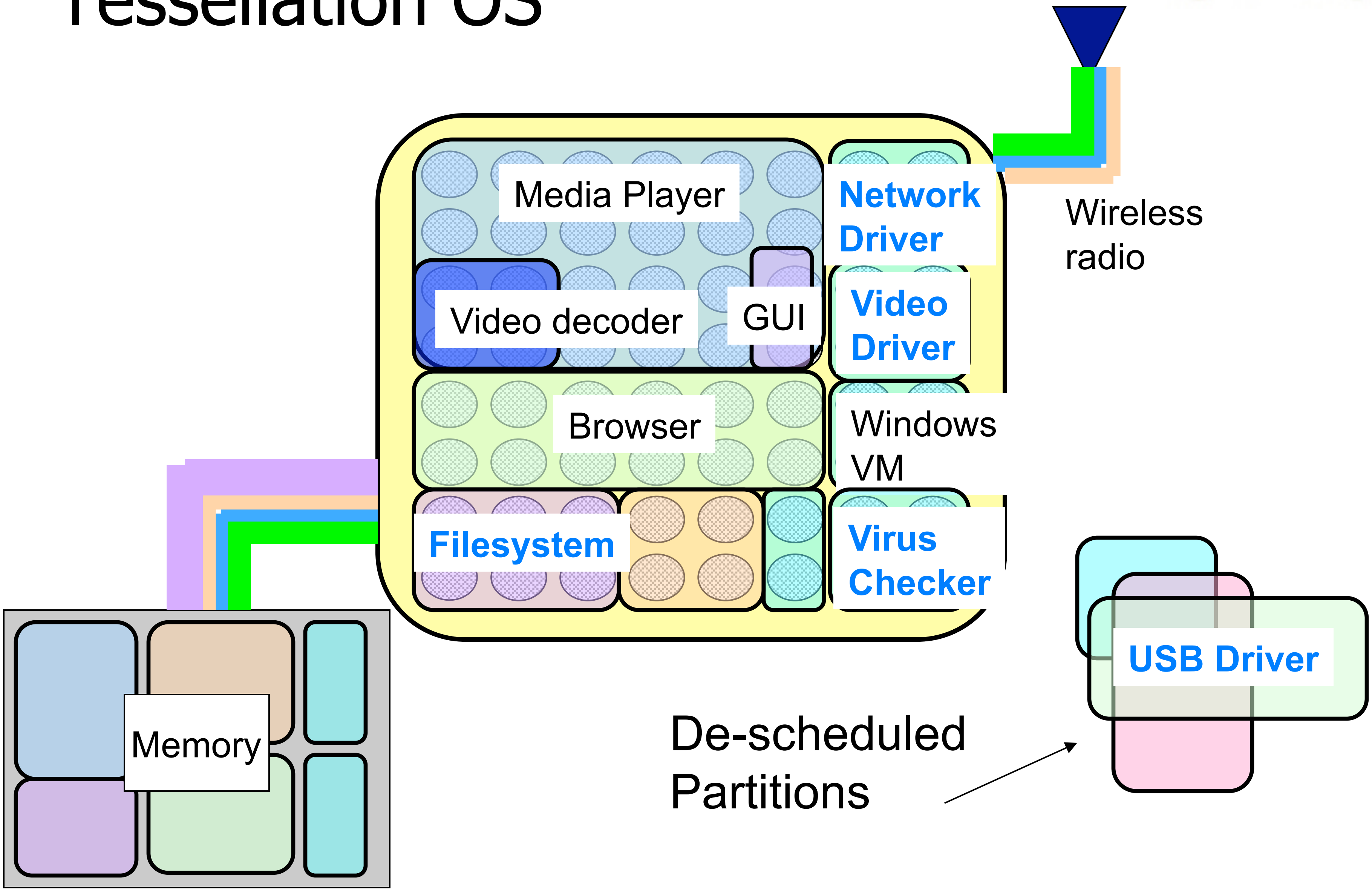
Communication in space and time



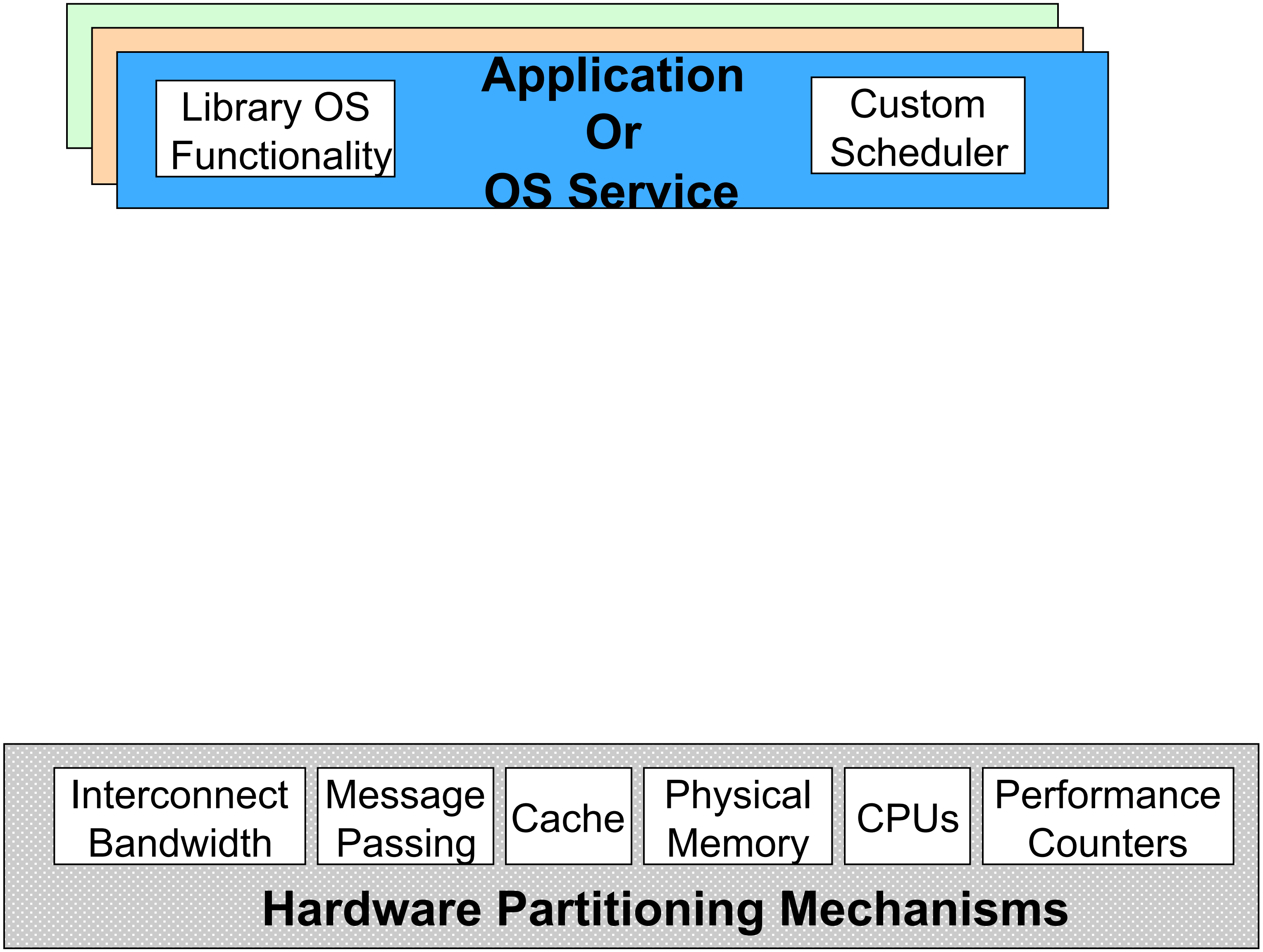
Outline

- Why a new OS for Manycore Clients?
- A Case for Space-time Partitioning
- Implementing Space-Time Partitioning in a Manycore OS (Tessellation)
- Status

Tessellation OS



Tessellation Kernel



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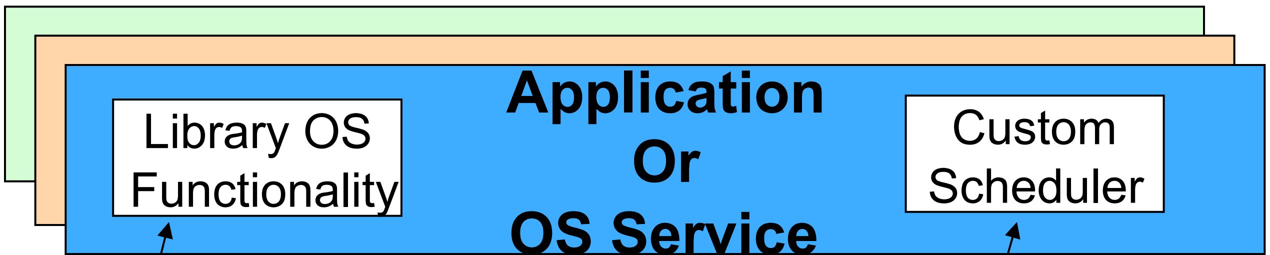
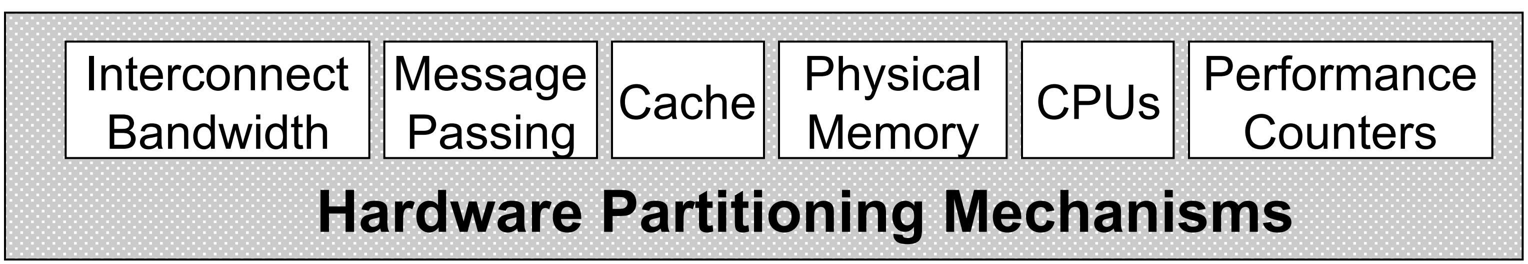


Marshalls syscalls into messages for the respective OS Service Partition

App-specific scheduler for best parallel performance. (See Lithe talk on user-level scheduling.)



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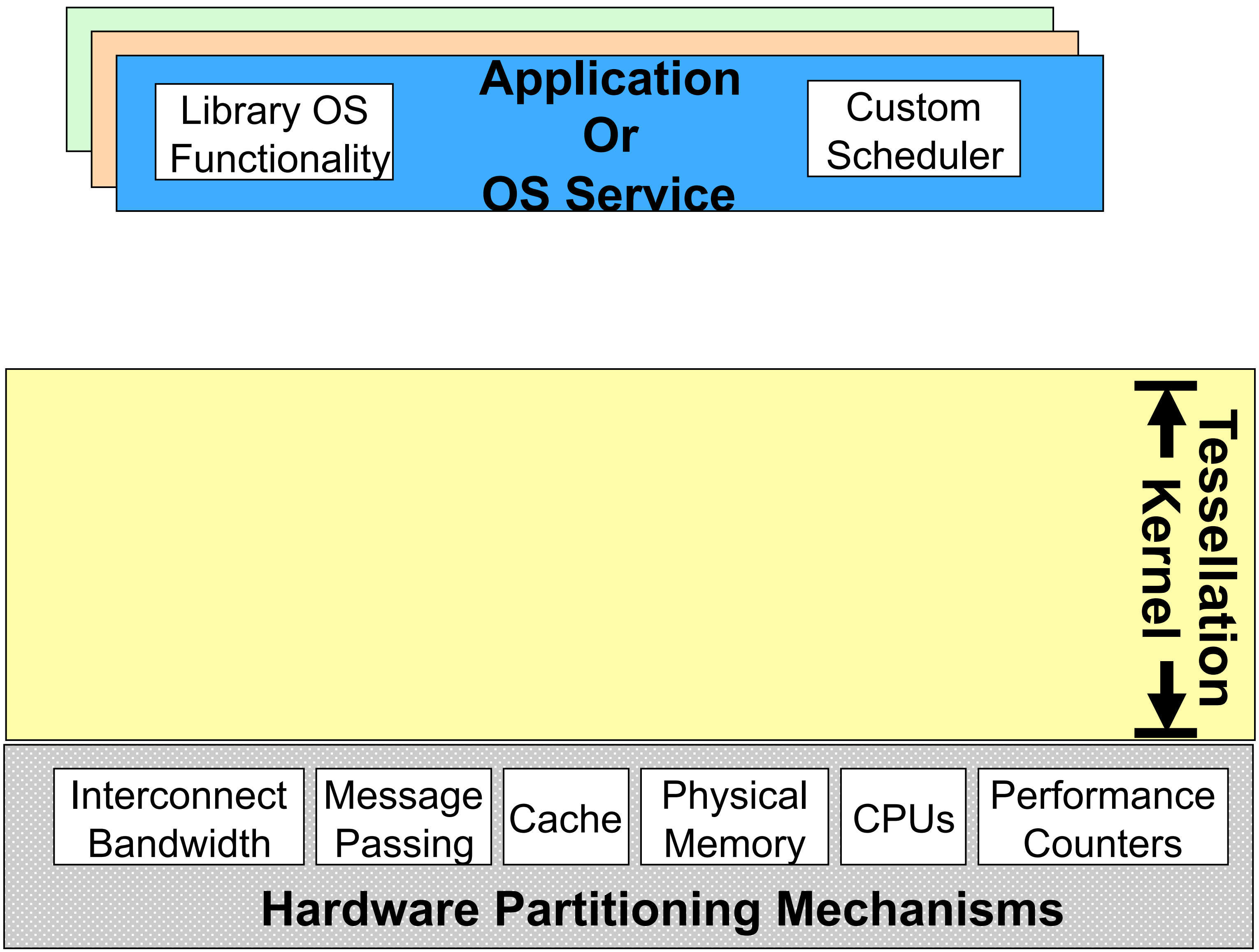

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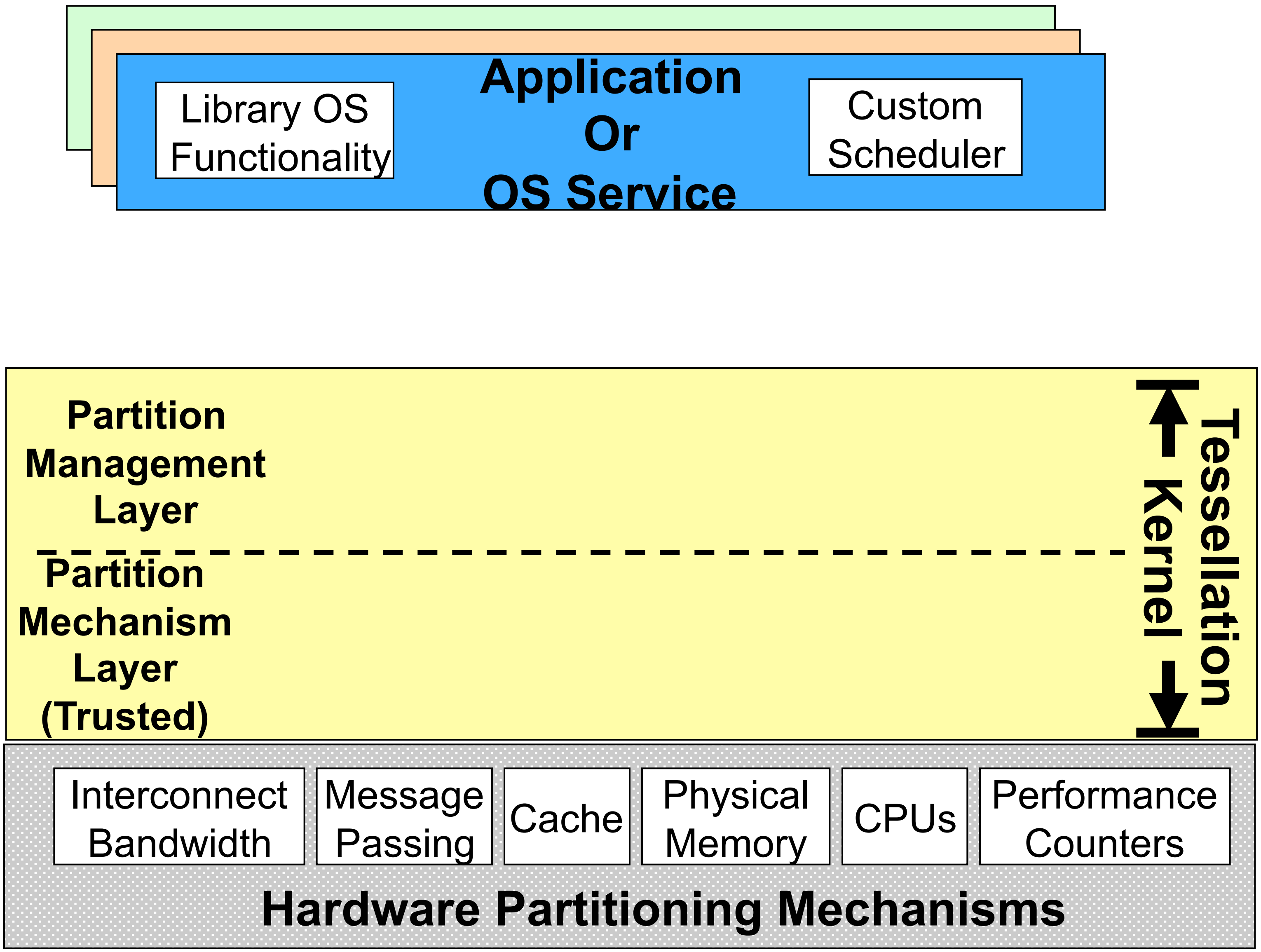
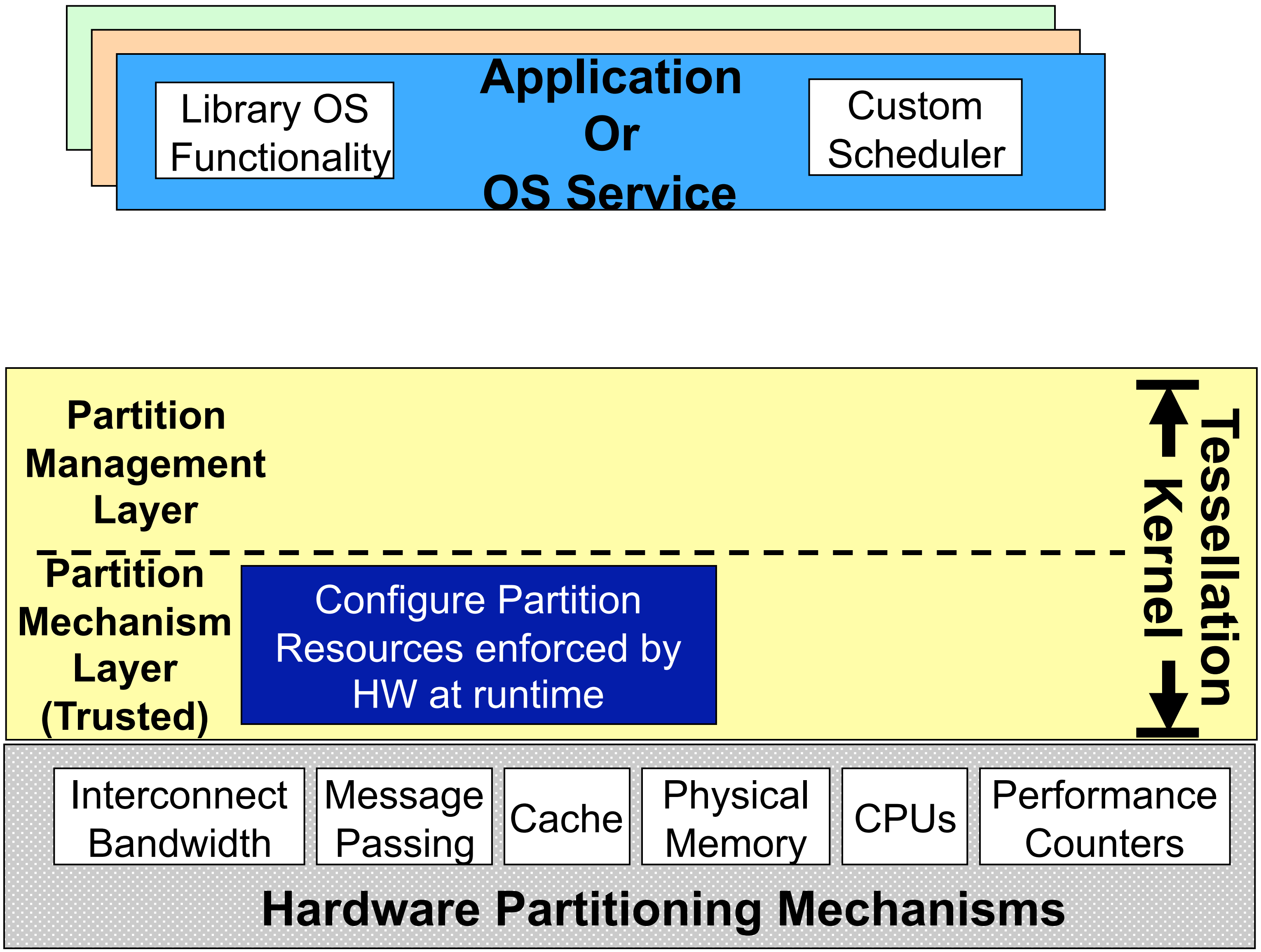


Partition Mechanism Layer



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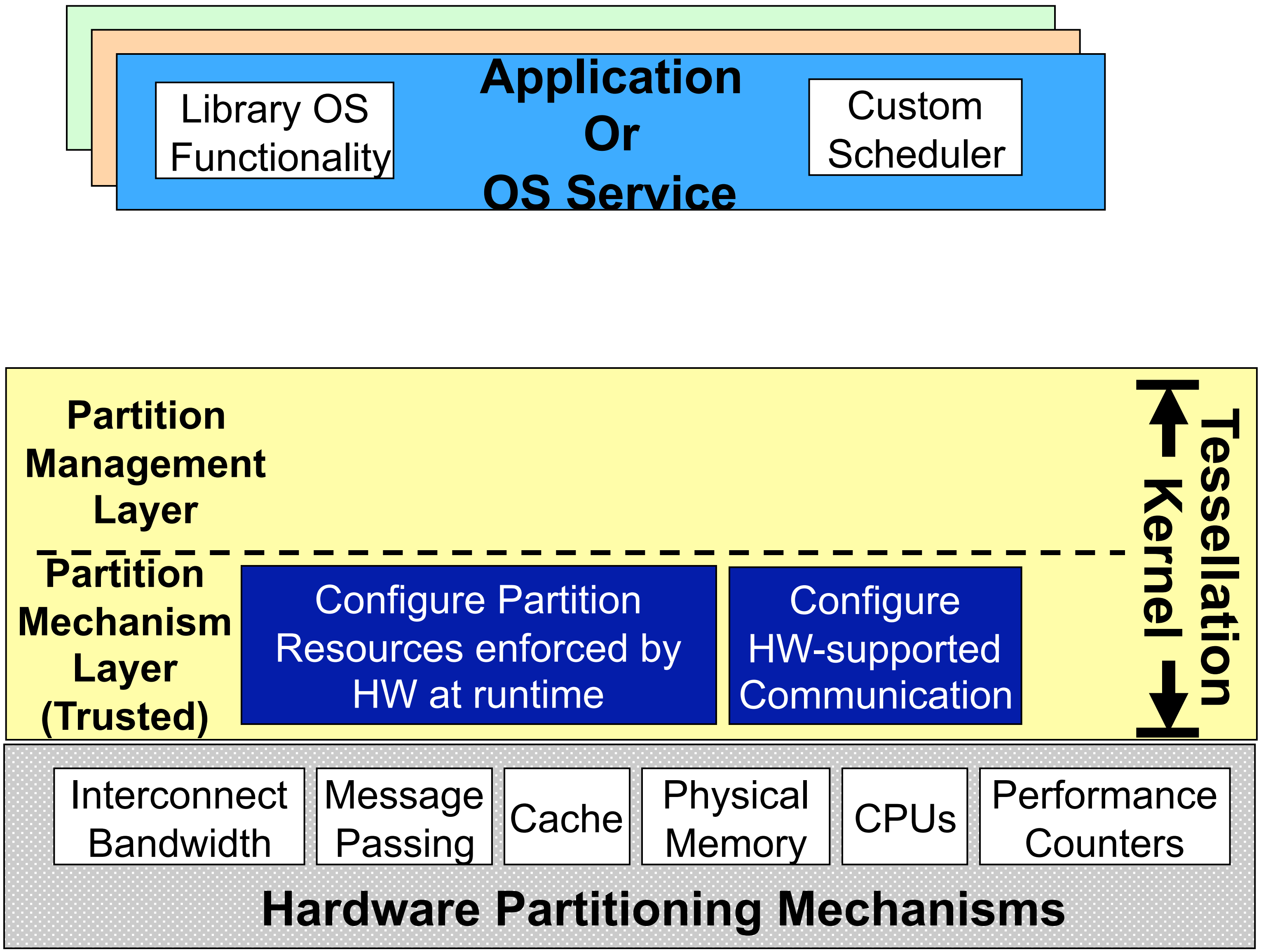
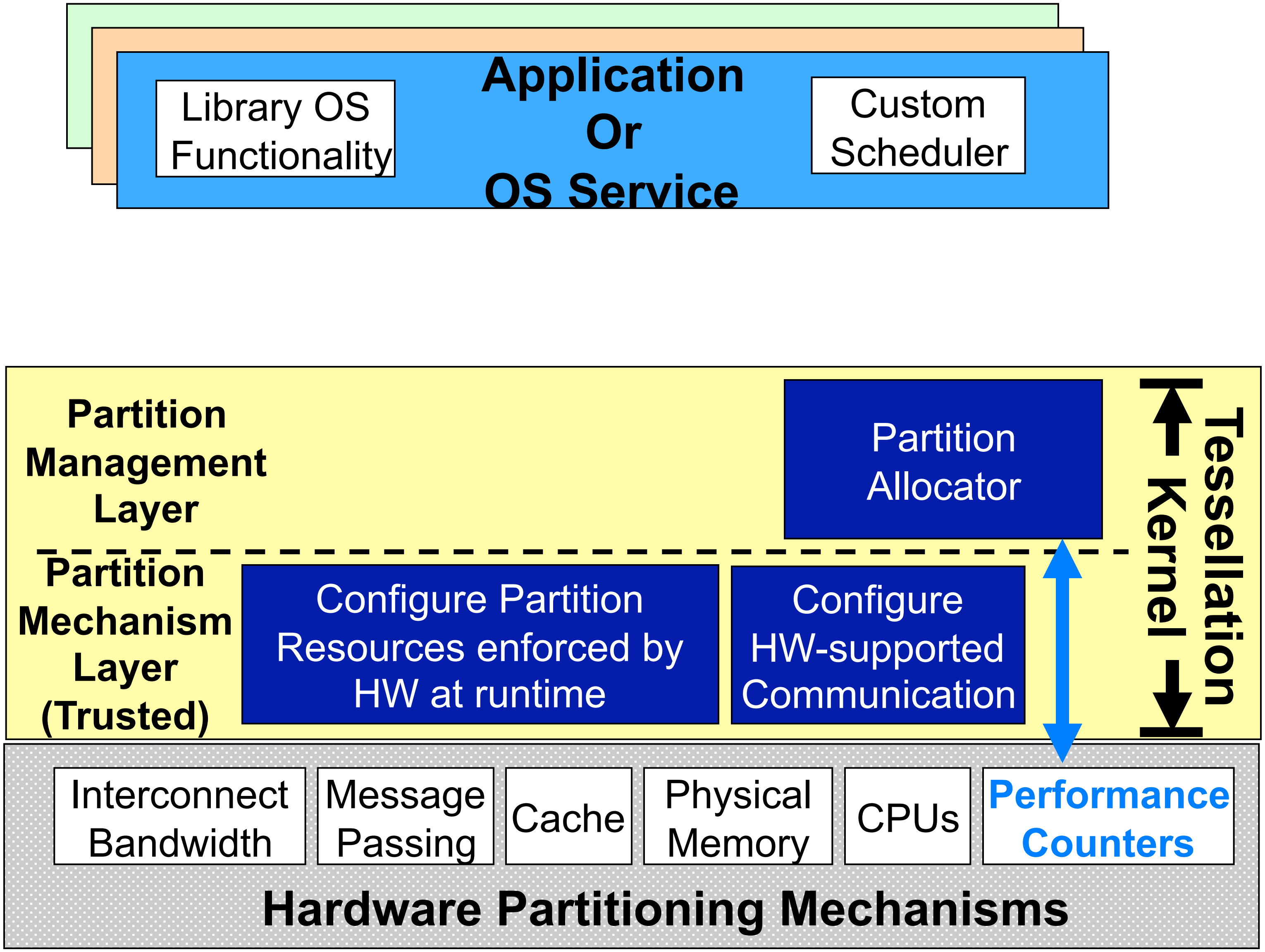


Partition Management Layer



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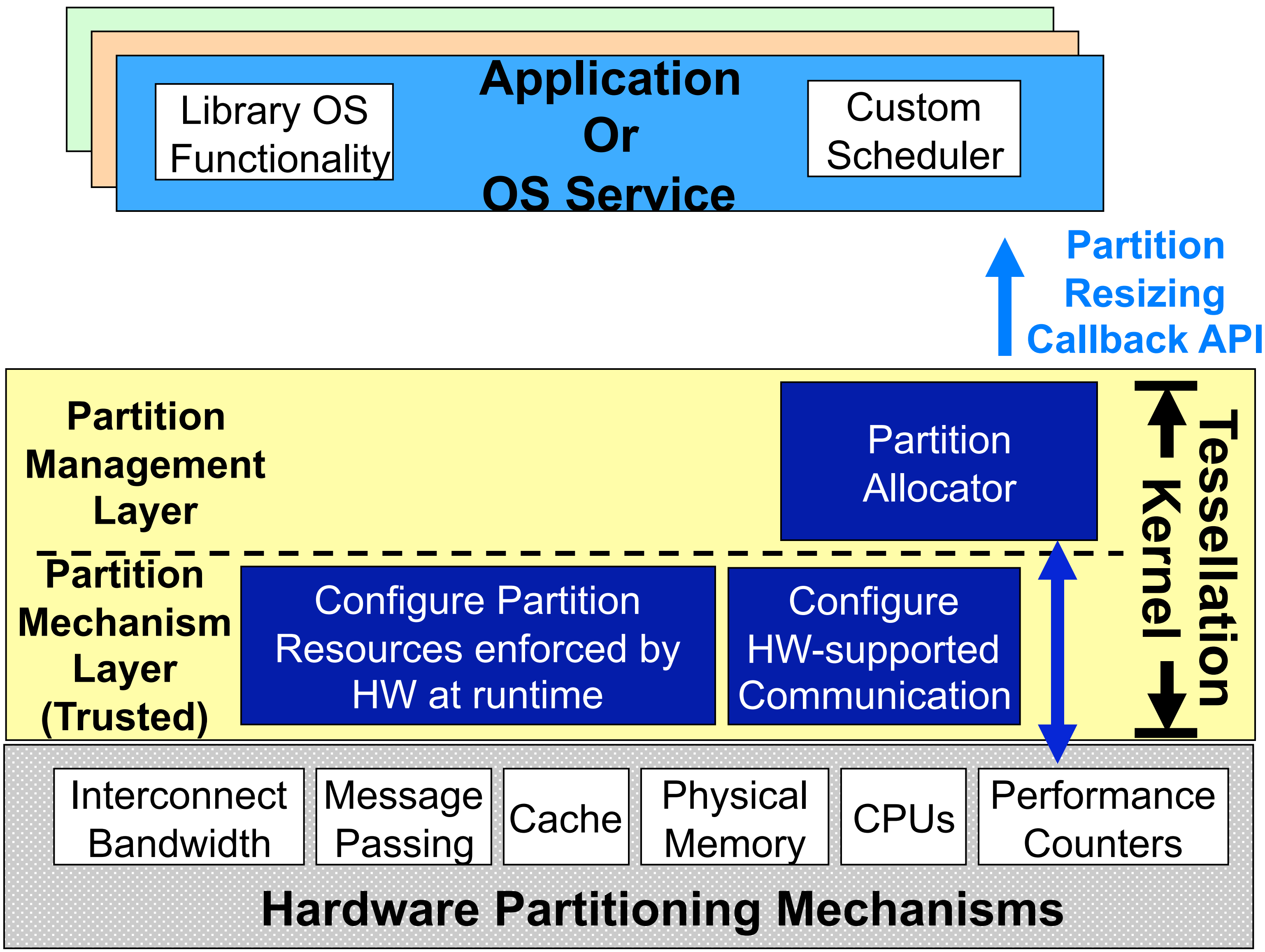

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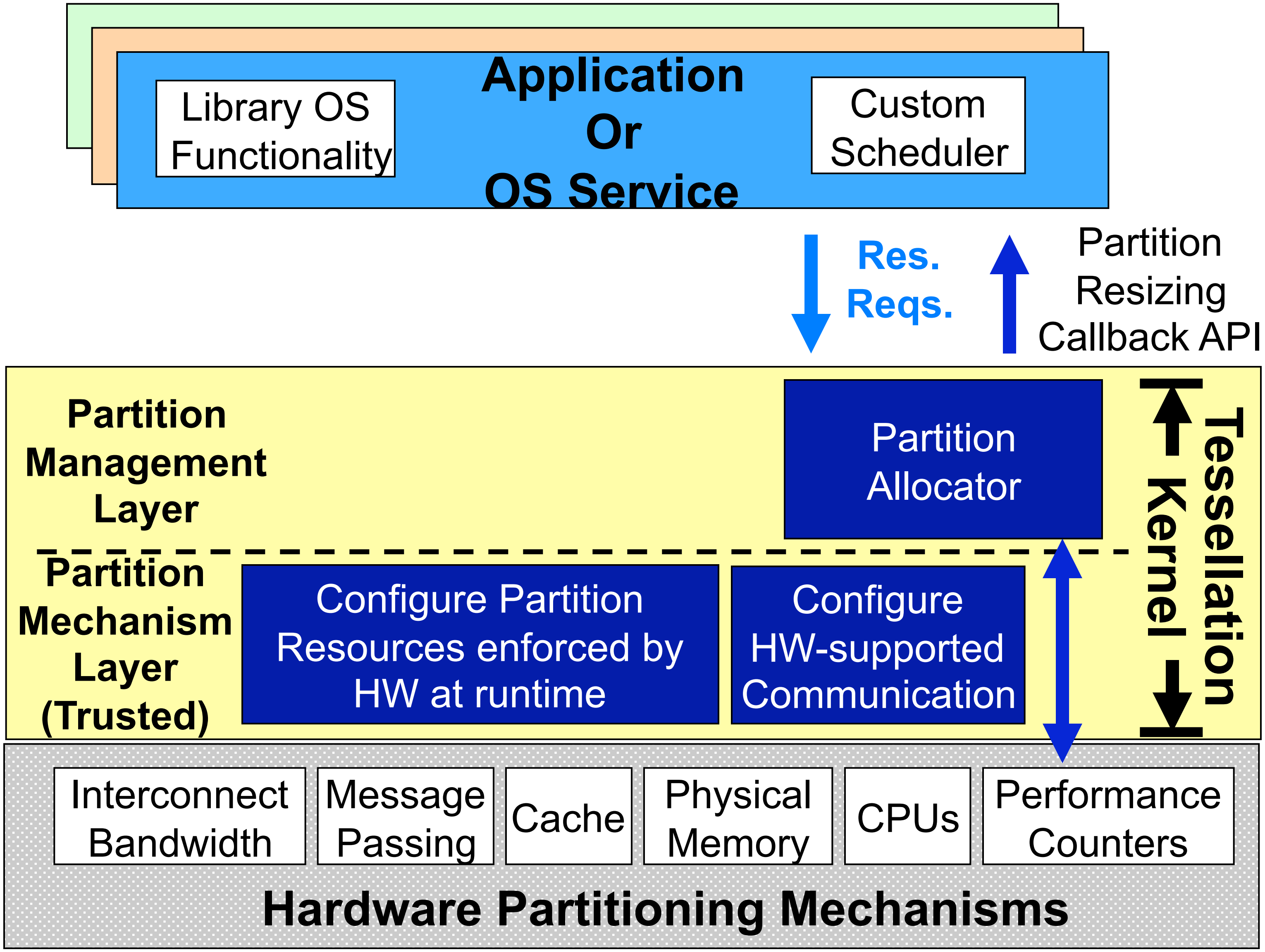

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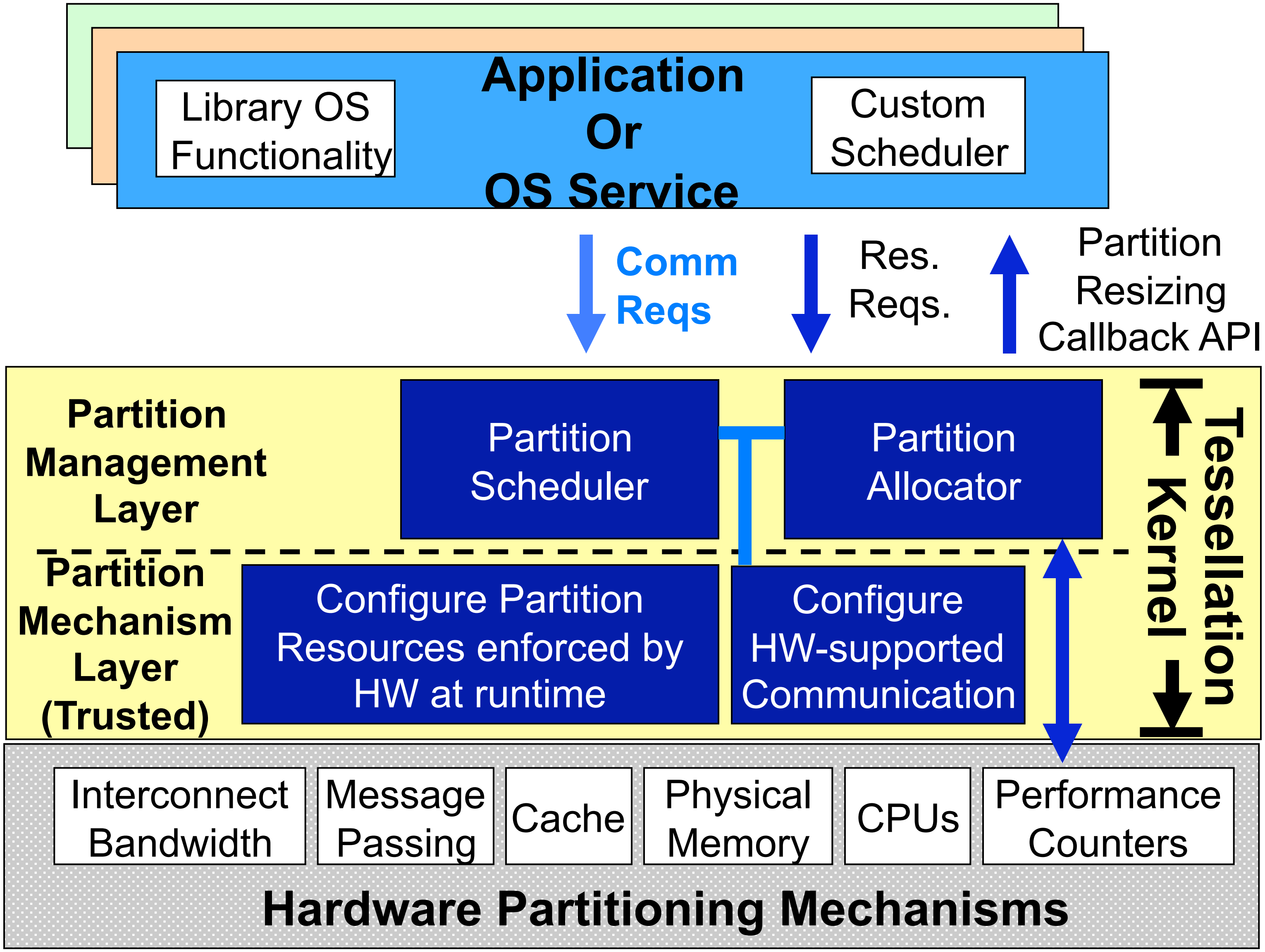

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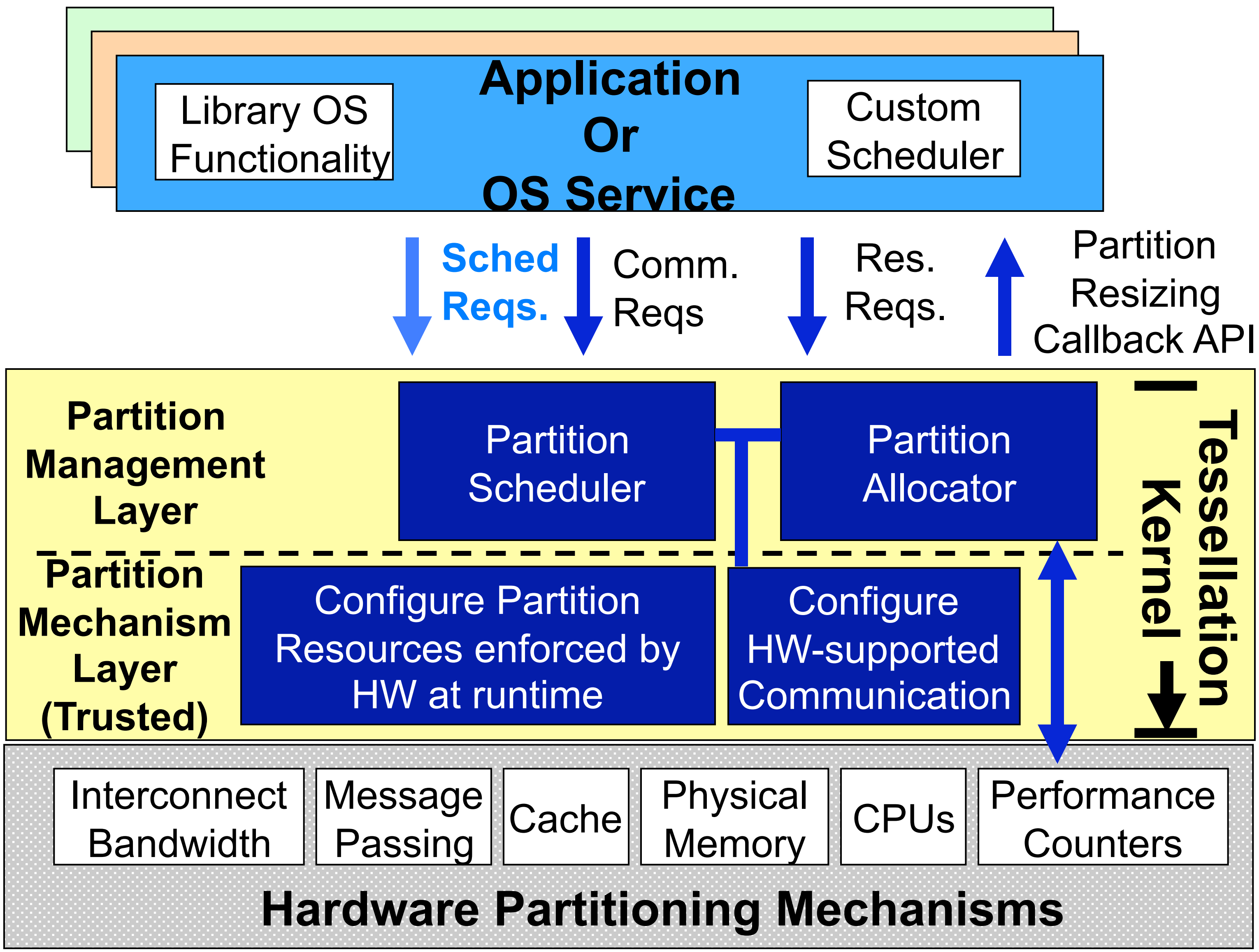

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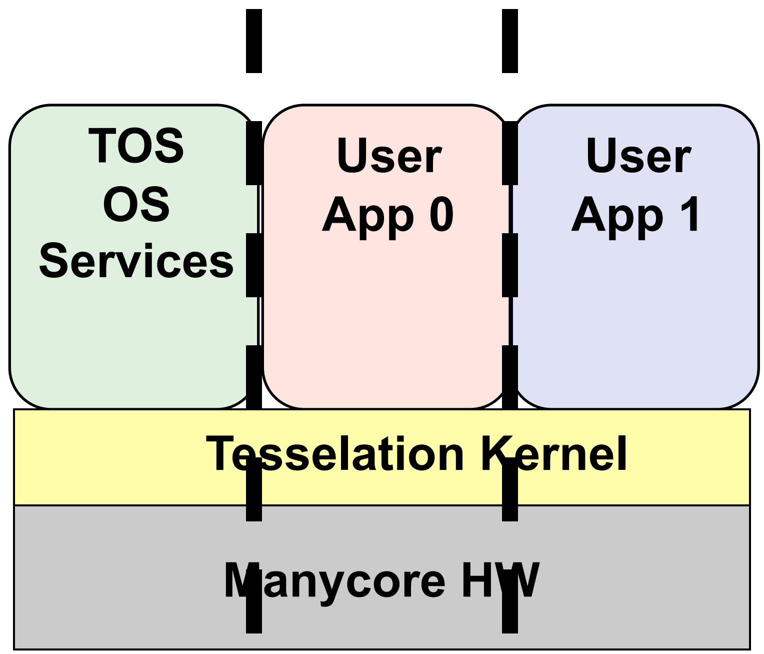
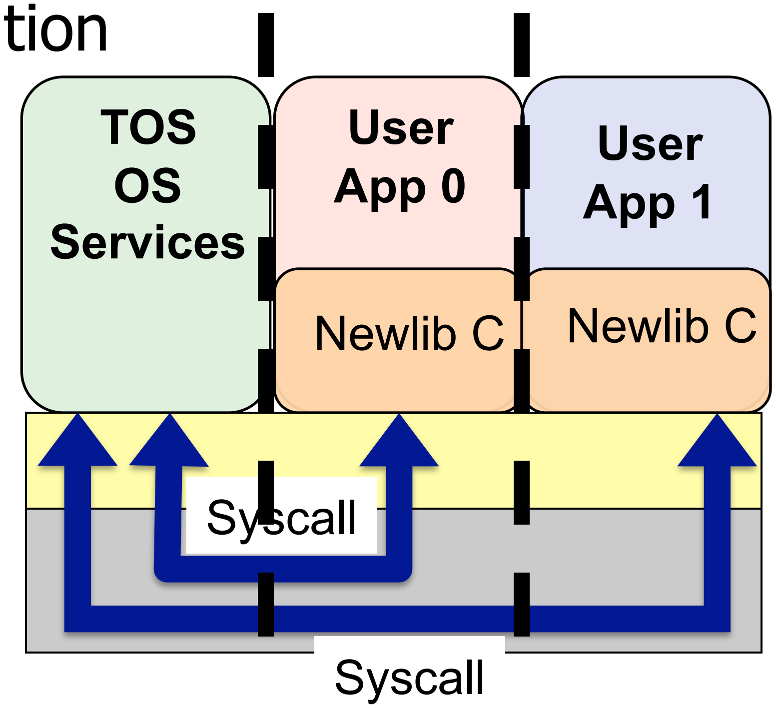
Implementation status

- Basics of Tessellation kernel and primitive OS service up and running
  - Provides rudimentary partition interface
  - Boots on standard x86 hardware
  - No I/O yet – statically linked applications and kernel



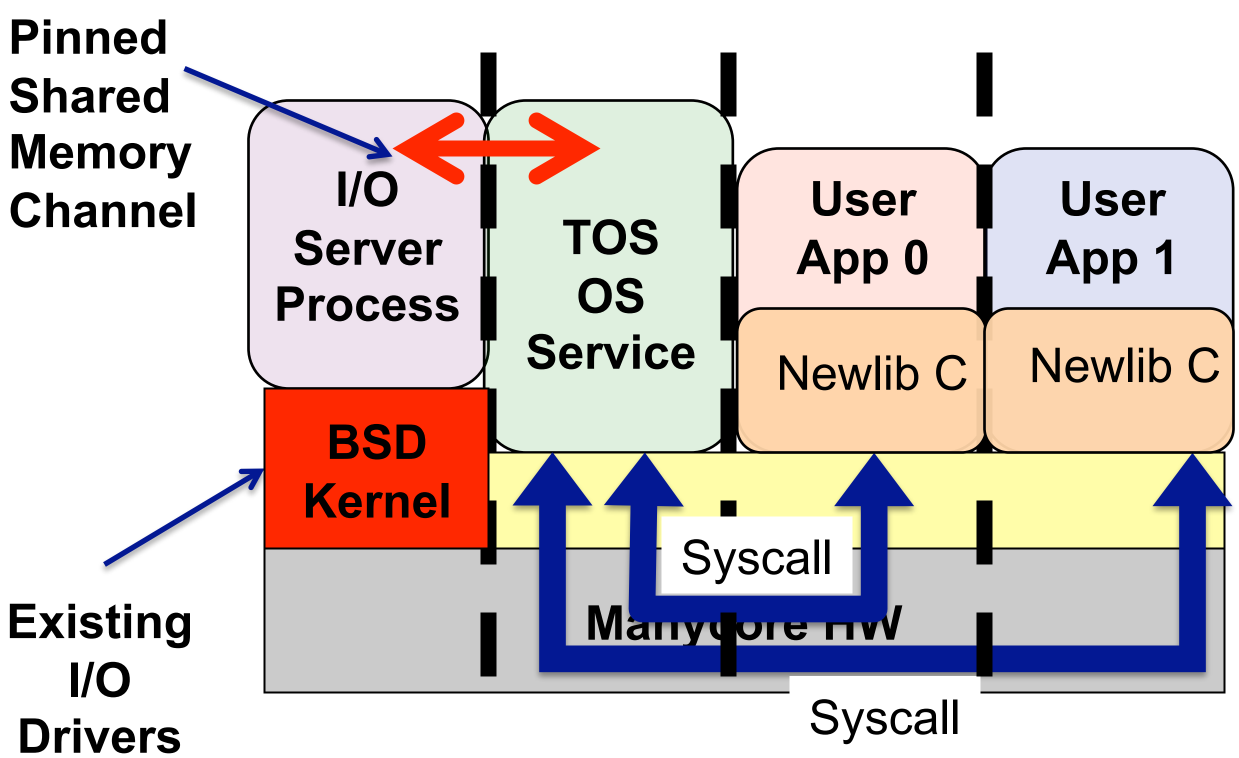
Next Steps

- Build fast cross-core communication mechanisms for system calls
  - Context-switch free system calls
  - APIC driven message notification with shared memory
- Add support for the 19 newLib system calls in TOS OS Service partition



Intermediate Infrastructure

- TOS OS Service doesn't have all drivers, so run BSD with existing drivers on one core to service I/O from TOS OS Service
- Tessellation runs on rest of the cores



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Thanks! Questions?