ELC-Europe 2009 - Grenoble

Philippe GERUM - SourceTrek

Introduction

The context

- Linux about to be natively real-time
  - PREEMPT_RT close to mainline

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- Linux about to be natively real-time
  - PREEMPT_RT close to mainline
- Legacy applications knocking on Linux's door
  - Traditional, embedded RTOS
  - Non-POSIX core API
  - Flat / physically addressed memory
  - Typically: VxWorks, pSOS, VRTX etc.

The issue

- Porting them to Linux currently means
  - Rebasing on Linux, changing design

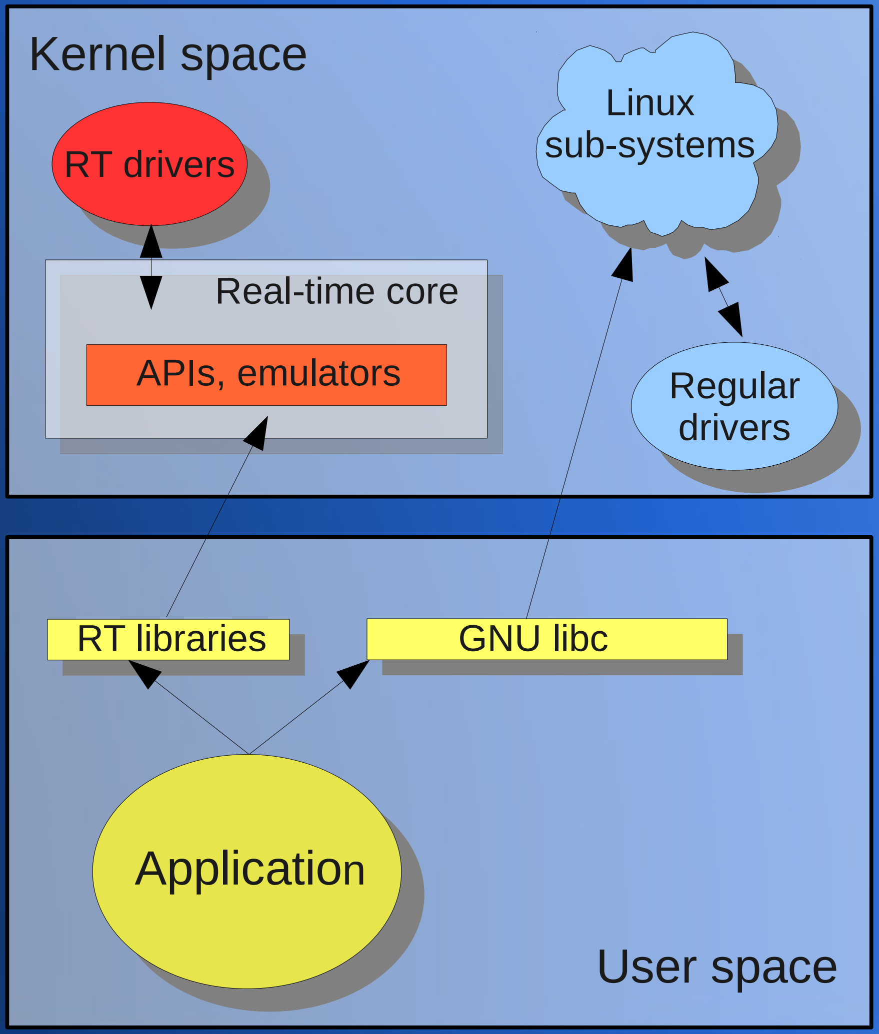
    or,
  - Keeping design, keeping proprietary RTOS
- How to go the Linux way?
  - Keeping design, using Linux technologies

Possible solution

- Combine existing Linux technologies
  - Native real-time support
  - Linux-native virtualization
  - RTOS emulation

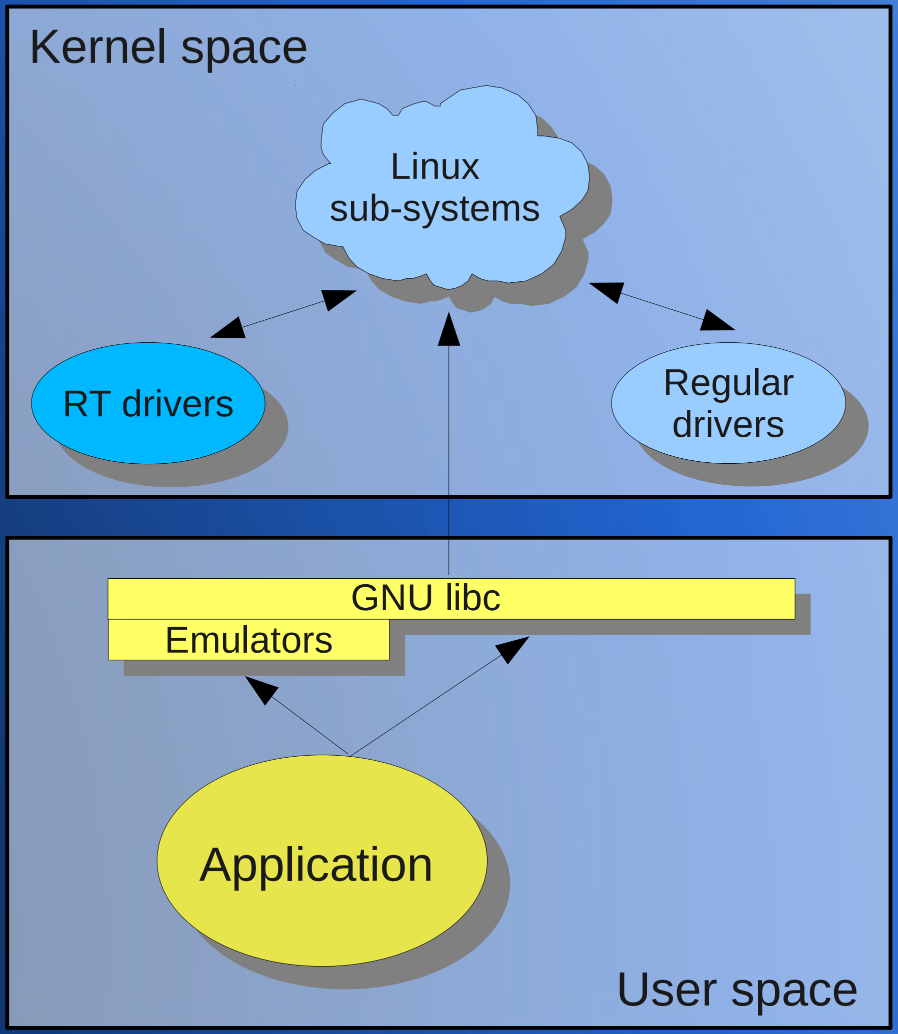
Common porting strategies

- Port to dual kernel
  - Over POSIX API
  - Over API emulator
  - Over *ad hoc* API



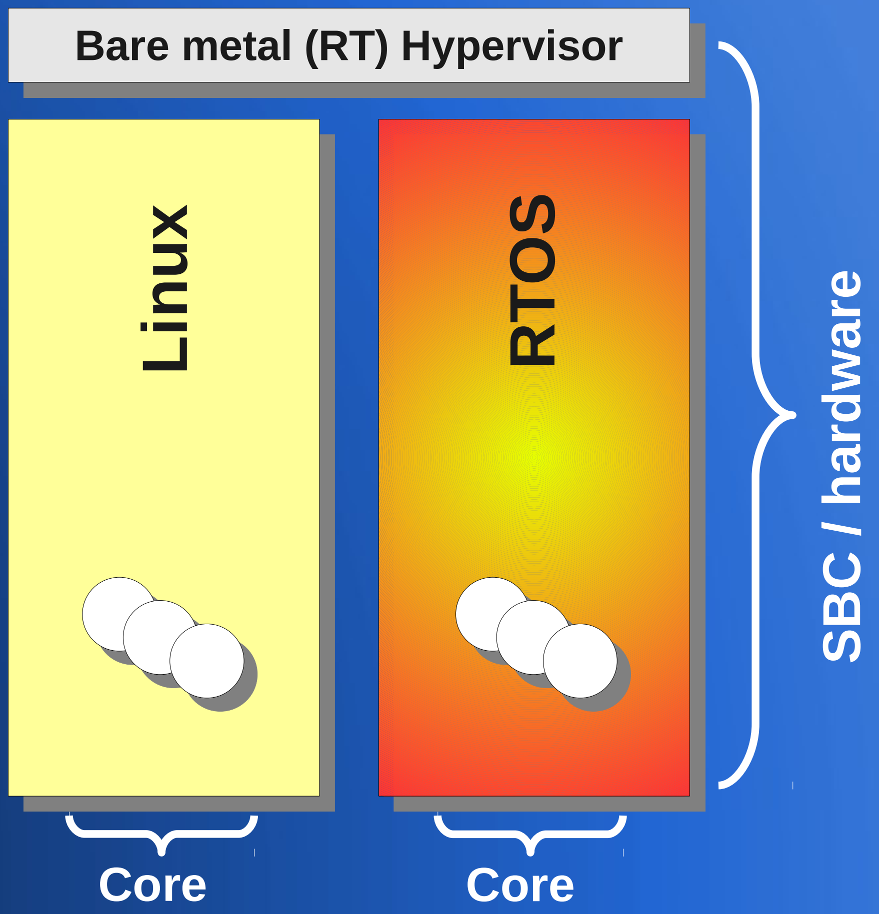
Common porting strategies

- Go Linux native
  - Over POSIX API
  - Over API emulator



Common porting strategies

- Introduce virtualization
  - Original RTOS guest
  - Vendor-specific
- Bare metal hypervisor
  - Leverage multi-core



Approaches are challenging

- Dual kernel Linux architecture is complex

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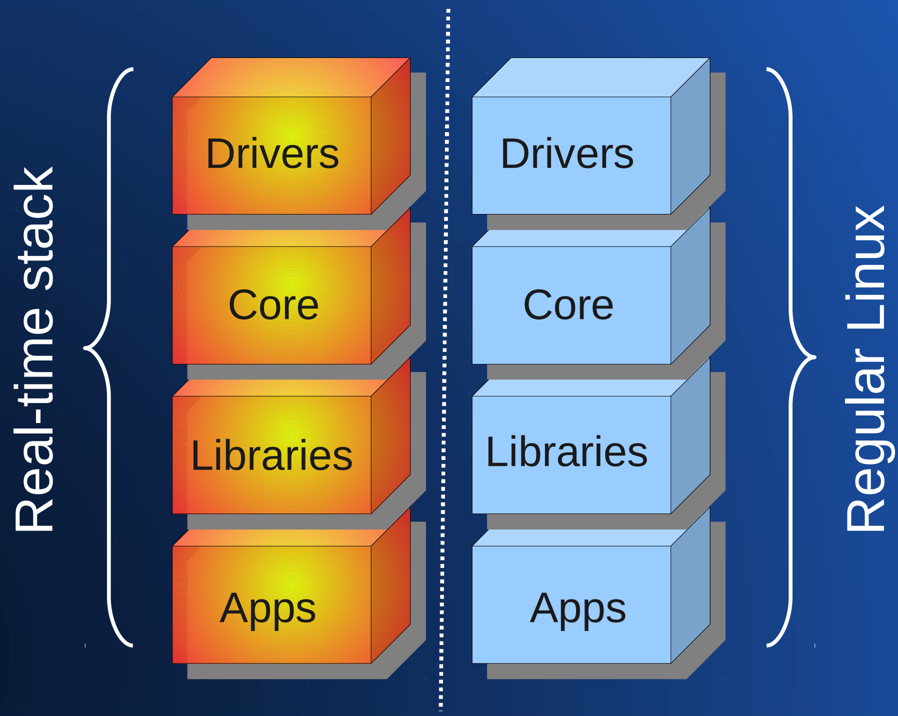

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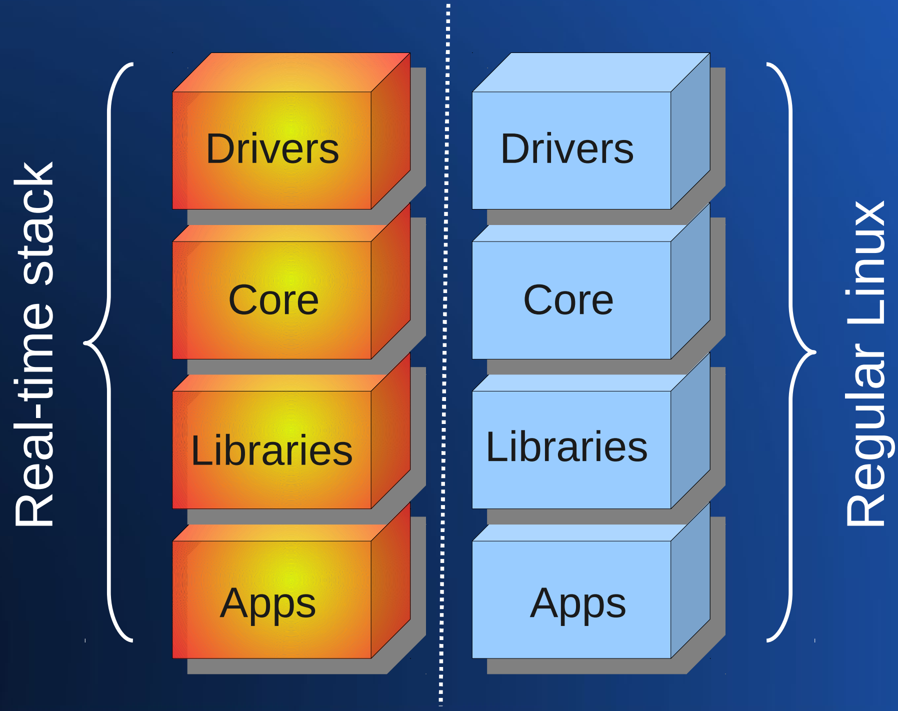
- Dual kernel Linux architecture is complex
  - Pressure on application design



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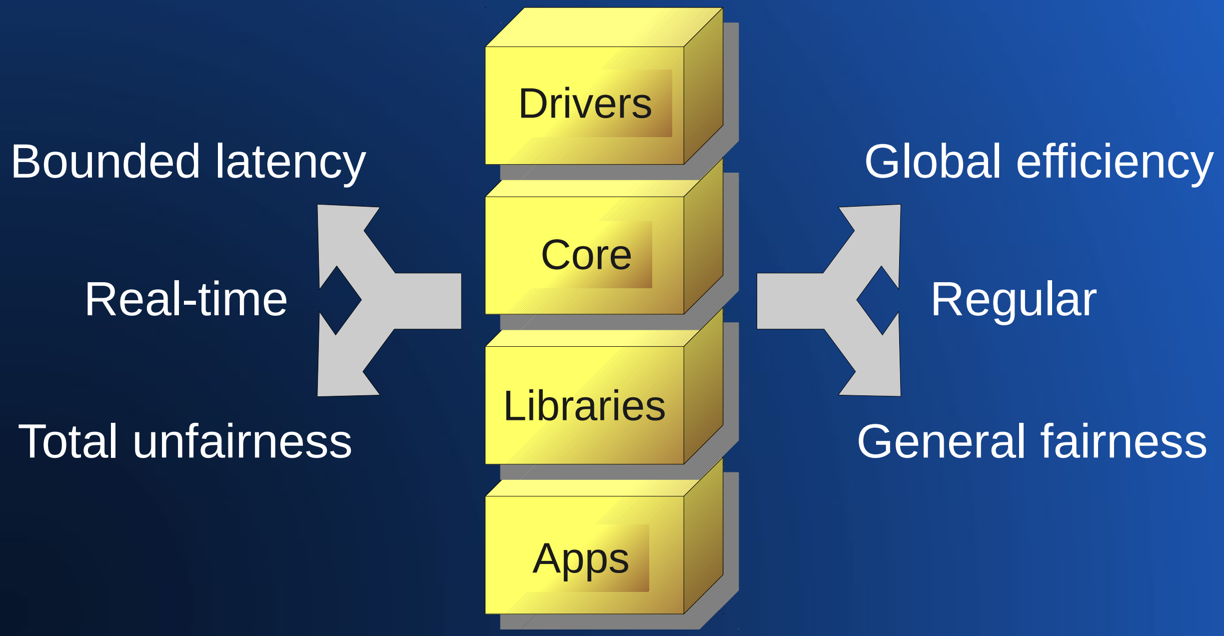
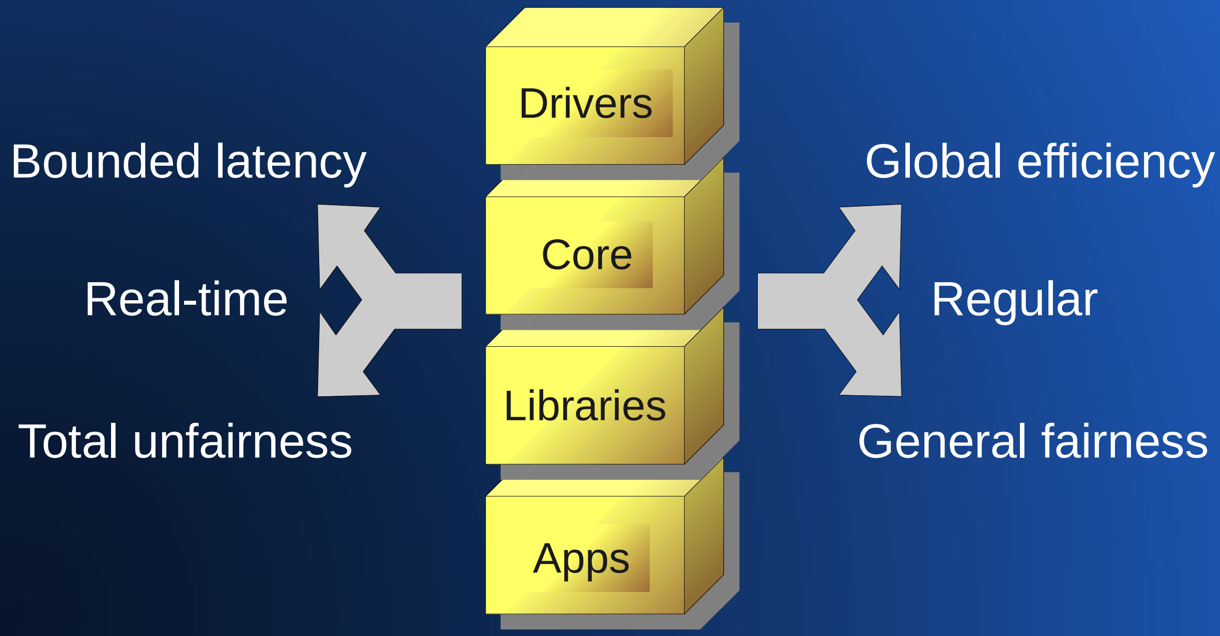


Approaches are challenging

- Native real-time Linux is complex
  - Pressure on system configuration



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    - Private (PV) Linux kernel
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    BUT,
  - Do not help the Linux real-time effort

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  - Over-emulation of missing calls
  - Pitfalls in mapping common calls

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- Driver model
  - Weak vs strong
  - Linux kernel API is more complex
- Protocol stacks
  - Keep “as is” or offload to Linux?

Legacy issues

- Software architecture
  - BSP code exposed
  - Application and driver code entangled
  - Non-public API sometimes used

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- Software architecture
  - BSP code exposed
  - Application and driver code entangled
  - Non-public API sometimes used
- Programming model
  - Flat / physically addressed memory assumed
  - Supervisor mode assumed
  - CPU architecture assumed

About RTOS emulators

RTOS API emulation?

- A way to mimic the RTOS interfaces
  - Evades the BSP issue
  - Source-level approach
- Has real-time requirements
  - Must run over a deterministic core
  - Must exhibit real-time properties itself

Myths and Reality

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  - Based on public, dependable interfaces
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Should your code <u>rely on undocumented</u> features?	**NO**
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Therefore, you don't need the original API implementation to emulate it properly.

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    - Optimized building blocks can be made
    - Efficient “window-dressing” follows
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- Isn't API emulation slower?
  - Traditional RTOS share basic semantics
    - Optimized building blocks can be made
    - Efficient “window-dressing” follows
    - Leveraging single address space helps
  - Naive emulation over POSIX not enough
    - POSIX semantics do not map 1:1
    - POSIX-based <u>building blocks</u> may work better

RTOS emulators shortcomings

- Limited emulation coverage
  - noarch/generic core services

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- Limited emulation coverage
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- Require Application / Driver split
  - BSP code not accessible from user-space
  - I/O resources live in kernel space
- Restricted by Linux protections
  - No supervisor actions from user-space

Our assets

PREEMPT-RT

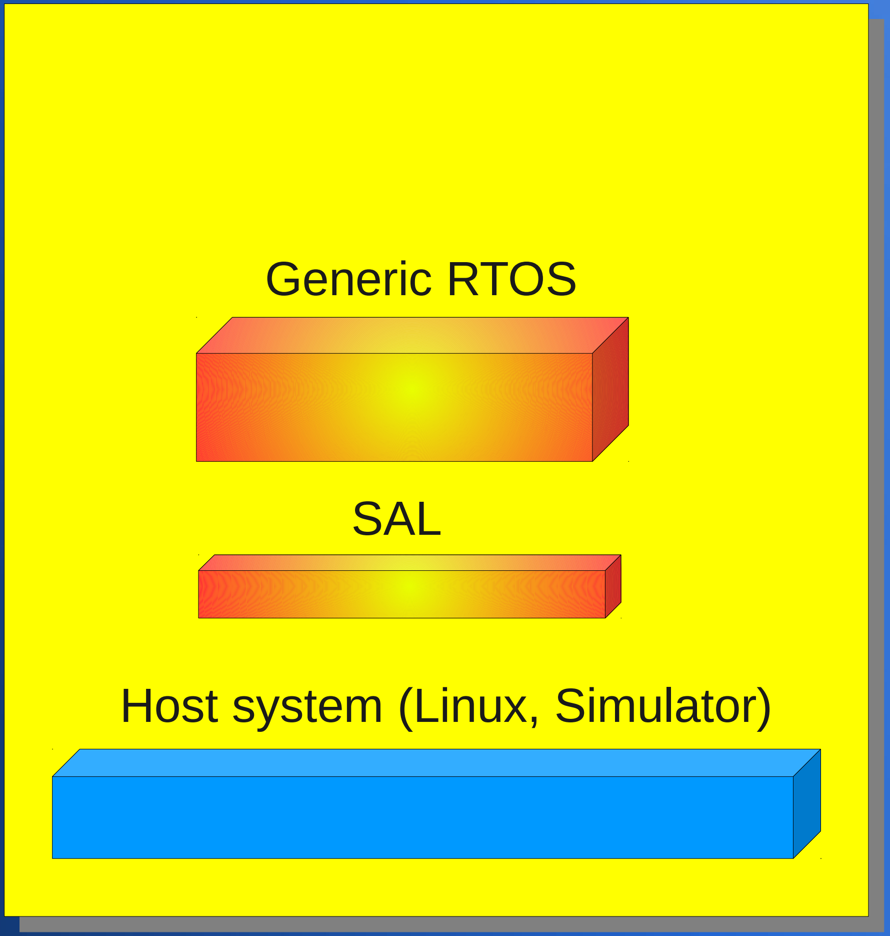
- Fully native real-time support
  - Enables real-time virtualization
- Promise of embedded multi-core scalability
  - Sophisticated locking model
  - Sophisticated scheduling

KVM

- Complete sandboxing
- Compatible memory spaces
- Device virtualization through host
  - *virtio*
- Device emulation through VM
  - *Qemu*-based modelling

Introducing Xenomai

- Generic RTOS core
- Host abstraction
  - Dual kernel
  - Simulator
  - (Single image *)



(*) Xenomai/SOLO

Introducing Xenomai

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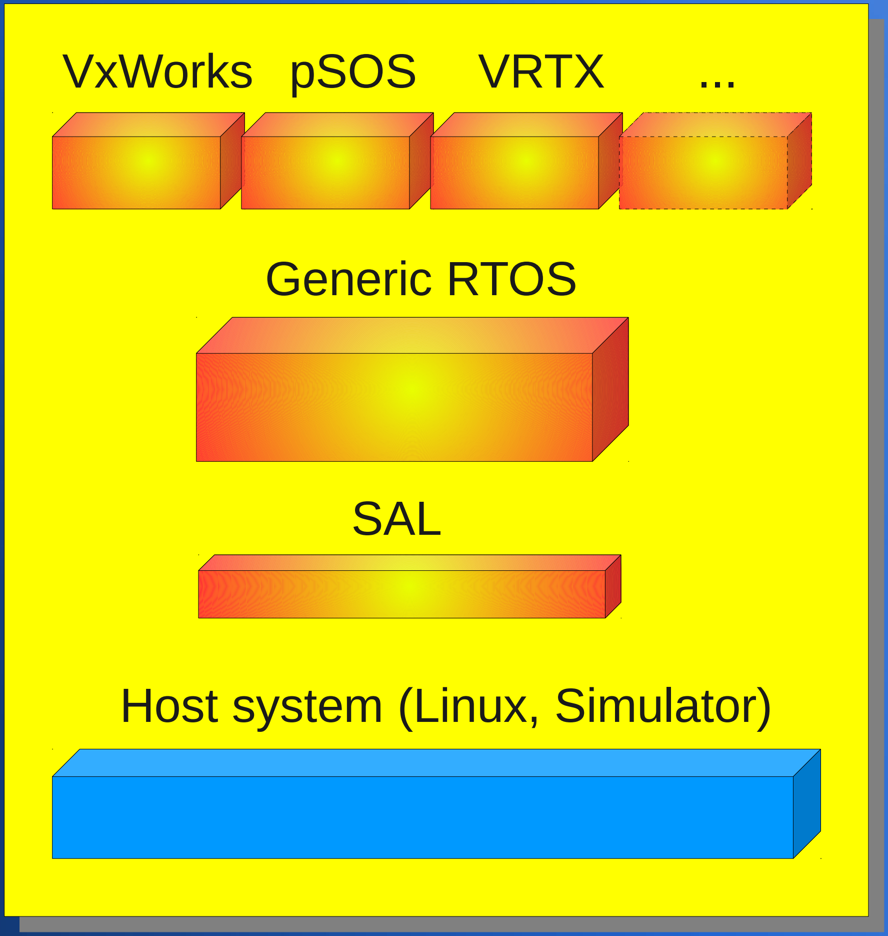
- Host abstraction
  - Dual kernel
  - Simulator
  - (Single image *)
- RTOS personalities



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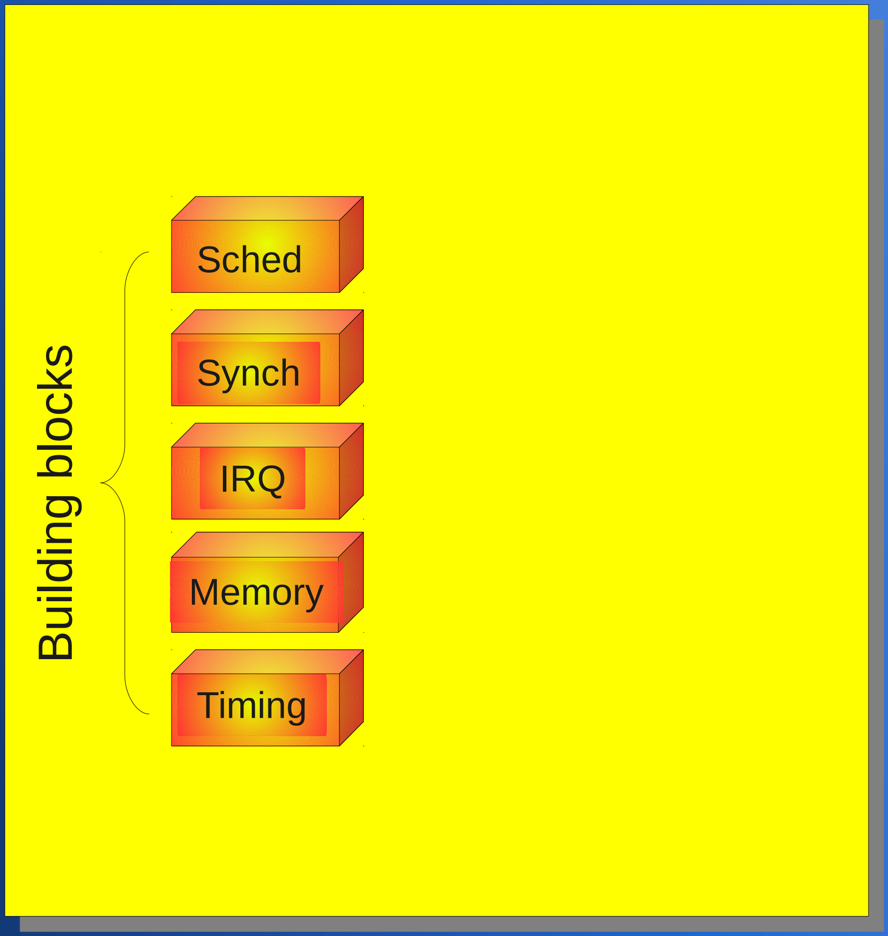
- RTOS building blocks
  - Thread scheduling
  - Synchronization
  - Interrupt handling
  - Memory allocation
  - Timing services



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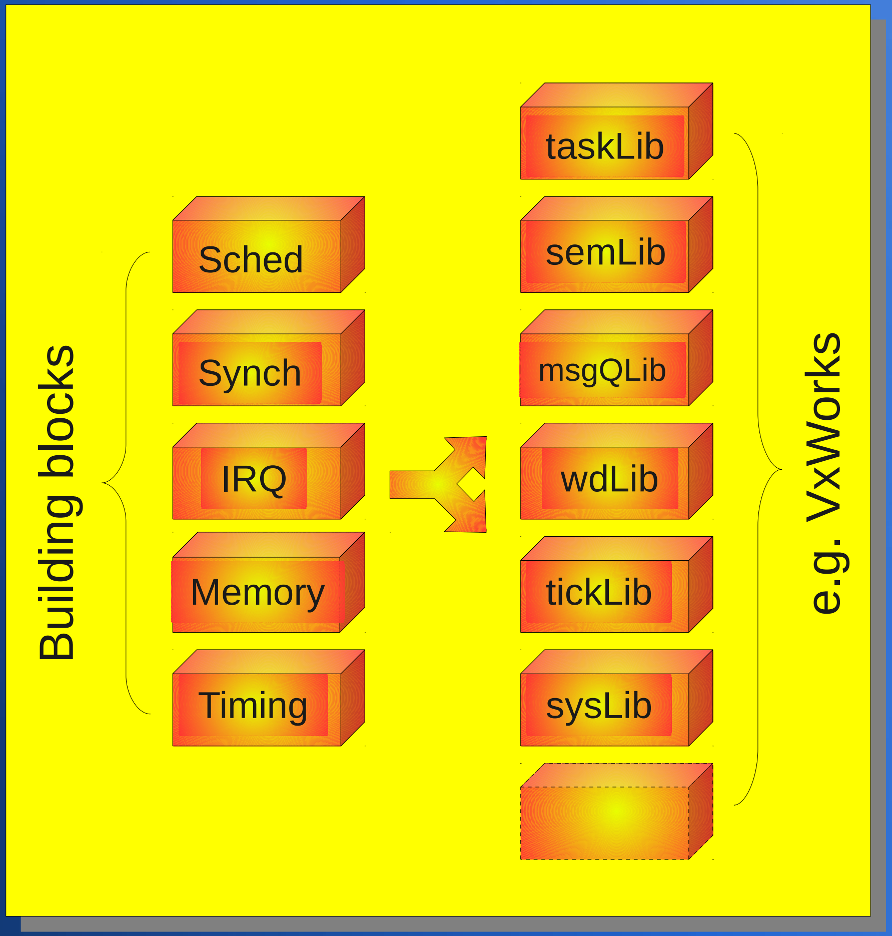
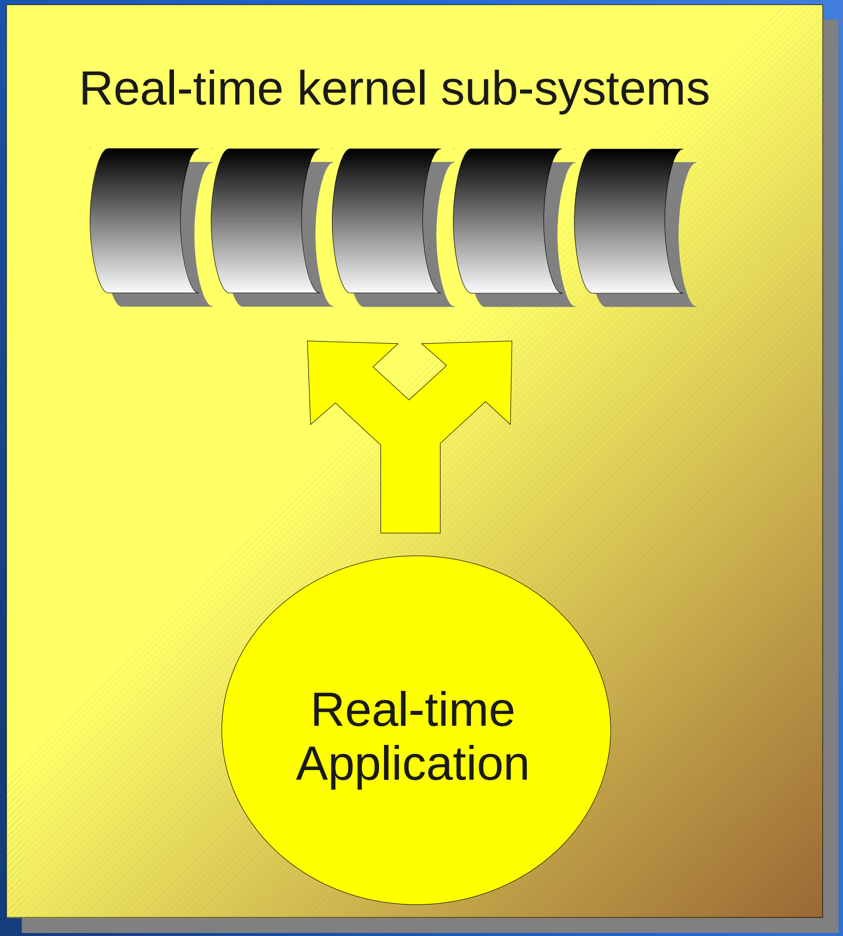


What about combining?

- Real-time host kernel
  - PREEMPT-RT



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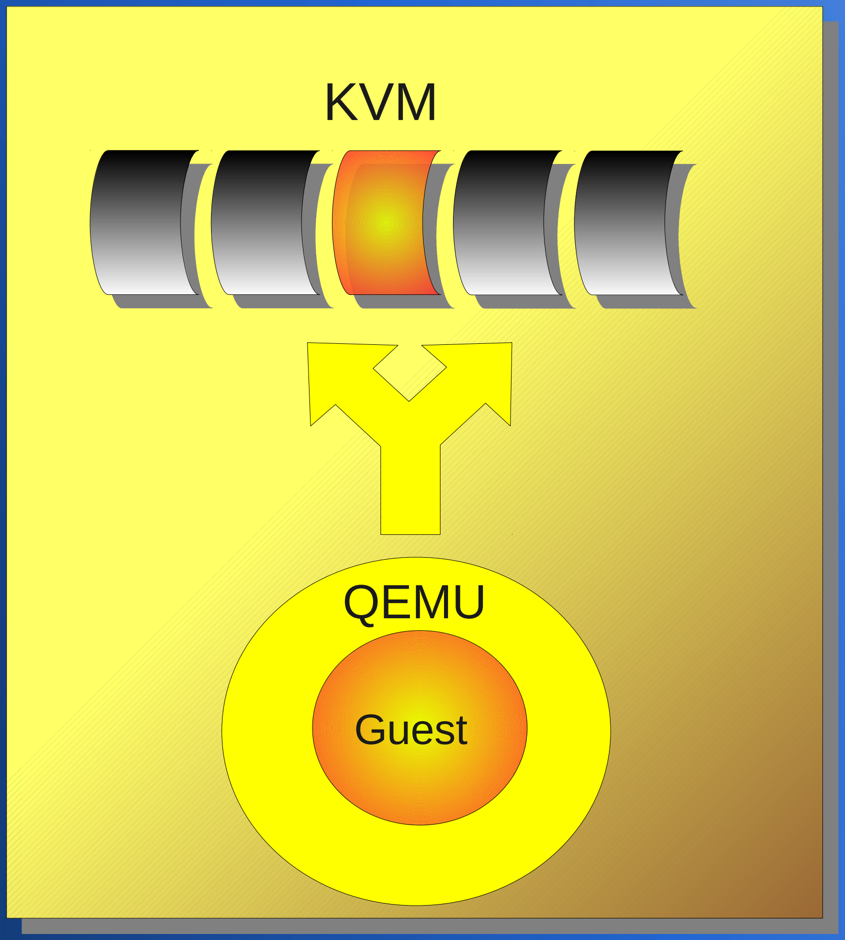
  - QEMU



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- Real-time host kernel
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- Virtualization core
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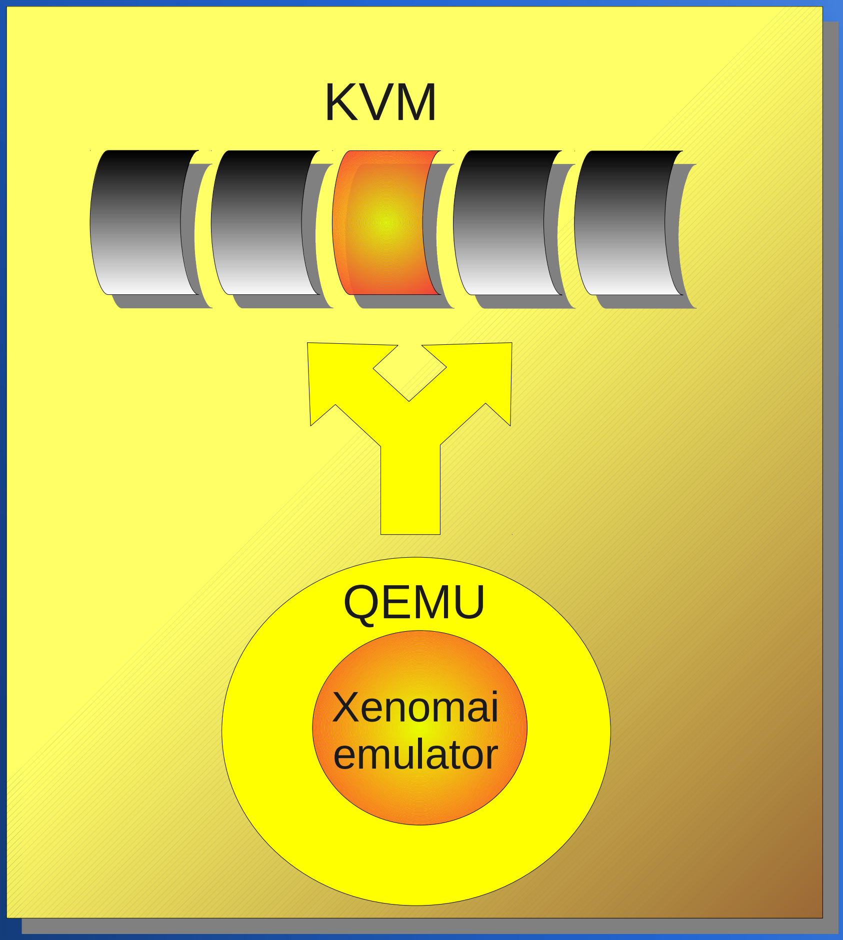
- RTOS emulation
  - Xenomai



Virtualization + RTOS emulation

Improvements

- Native real-time
- Original programming model
- Better emulation coverage
- Sandboxing
- Legacy device emulation

Virtualization + RTOS emulation

Restrictions

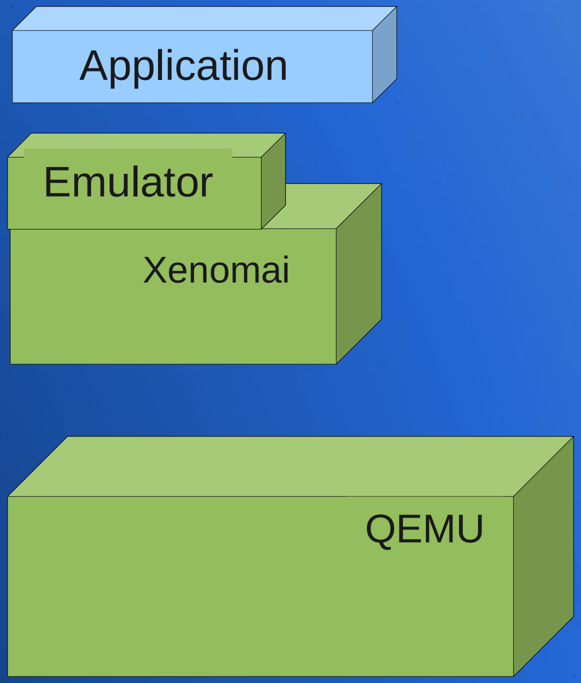
- No ABI compatibility
- Still not 100% source compatible
- Reworking the device driver layer still required

Virtualize & Emulate

Improved emulation engine

Emulation core

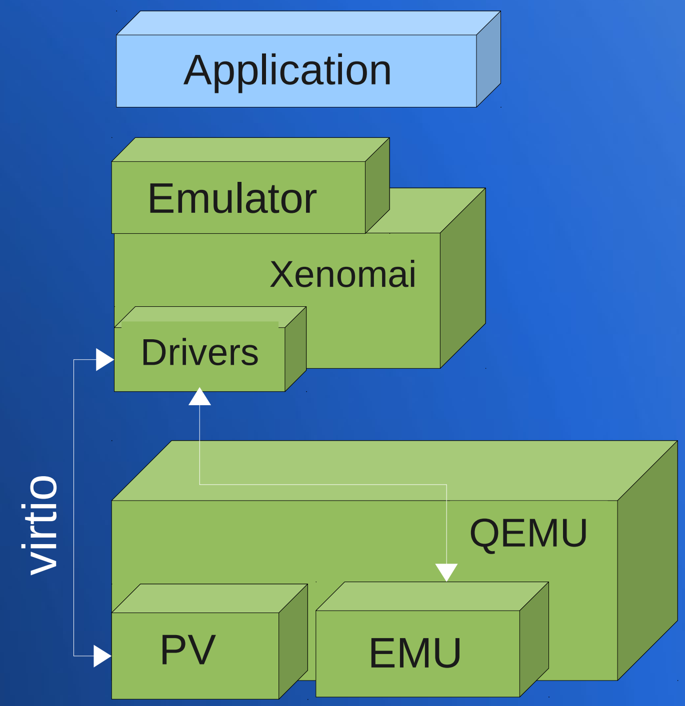
- Xenomai guest
  - Freestanding mode
  - RTOS personality
- QEMU
  - Virtual machine



Improved emulation engine

Handling I/O

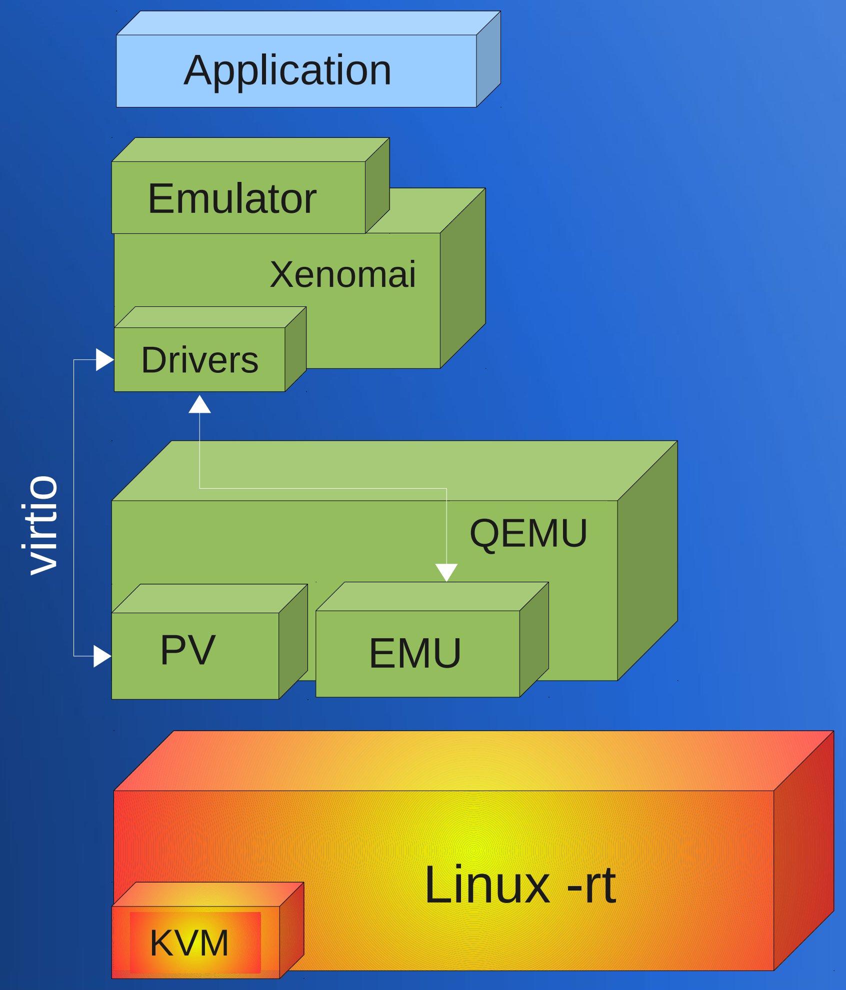
- Paravirtualized
  - Common hw
  - High bandwidth
- Emulated
  - Precise emulation
  - Low bandwidth



Improved emulation engine

Native real-time VMM

- PREEMPT-RT host
  - KVM-enabled



TODO list

- Real-time aware KVM
  - Guest scheduling
- Real-time aware QEMU
  - I/O emulation
- Guest mode Xenomai core
- Extended emulation coverage

More applications

Could also be used for...

- Application-specific virtual RTOS
  - Virtual RT appliance (sort of)

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- Transition path for in-house RTOS
  - Consolidate & extend via virtualization

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- Application-specific virtual RTOS
  - Virtual RT appliance (sort of)
- Transition path for in-house RTOS
  - Consolidate & extend via virtualization
- Simulation of complex architectures
  - e.g. modeling Arinc653 systems

Conclusion

Legacy RT application to Linux

Today

- Rebase on Linux, change design
- Keep design, keep proprietary RTOS

Legacy RT application to Linux

Today

- Rebase on Linux, change design
- Keep design, keep proprietary RTOS

Tomorrow

- Combine existing technologies
  - Rely on real-time capable virtualization
  - Couple with accurate RTOS emulation

The End

Thank you for attending