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OSs for low-power devices (in particular mobile phones) are a huge source of research

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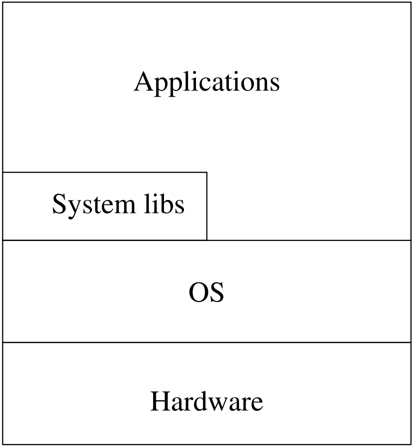
Originally, OSs were the software closest to the hardware: with OS virtualisation, this is no longer necessarily true

Conclusion of OS



Traditional OS

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So the solution is to have multiple, simultaneous OSs on a single machine

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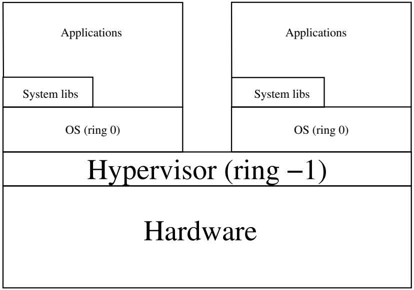


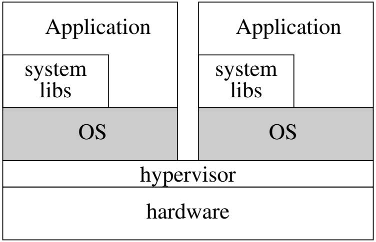
Virtualised OSs

Hypervisors appeared in IBM mainframes in the late 1960s

Conclusion of OS

There are several ways OS virtualisation is done

Conclusion of OS



Bare metal virtualisation has a thin layer, the *hypervisor*, to manage the hardware, allowing each OS to see separate "virtual hardware" which they manage

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The OSs can be completely different, e.g., Windows and Linux, and each believe they have the whole machine

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Good for sharing the computer amongst users who have requirements for different OSs

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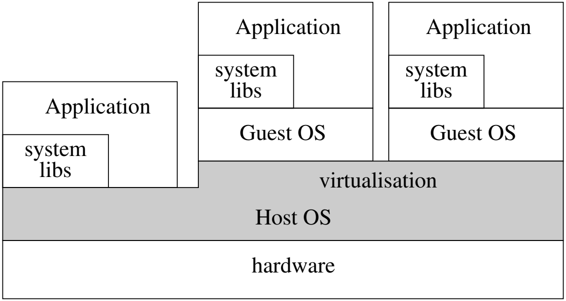

Hosted virtualisation has a normal *host* OS that runs virtualisation code. One or more *guest* OSs run on top of that

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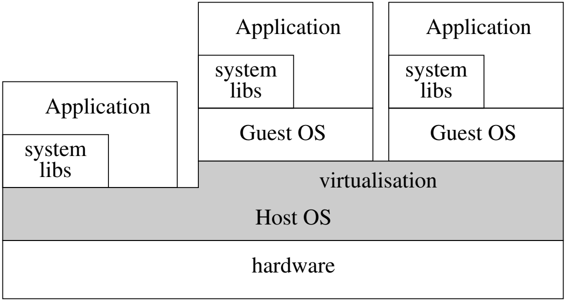

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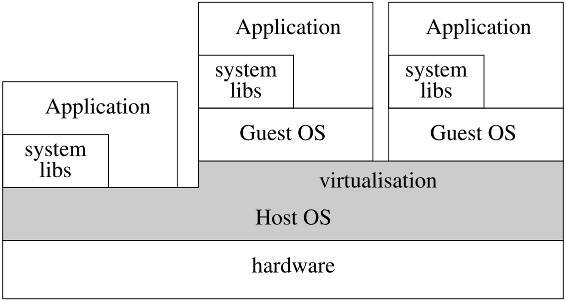

Hosted virtualisation has a normal *host* OS that runs virtualisation code. One or more *guest* OSs run on top of that

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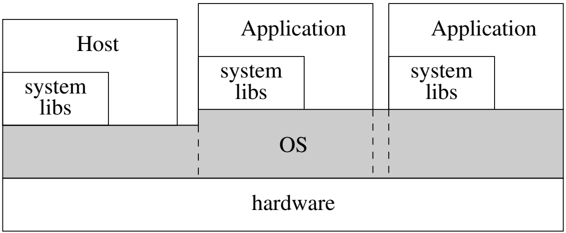
Good for when you need sophisticated management of the guest OSs by the host OS, for example in Cloud provision

Conclusion of OS



Not quite OS virtualisation, but with the same target applications is *containers*. The applications share the same OS, but the OS is rigidly partitioned so each container cannot see or influence what is happening in other containers (e.g., CPU limits)

Conclusion of OS

With containers, the applications must run on the same OS kernel, but can have different systems libraries and other software (e.g., RedHat in one and Ubuntu in another)

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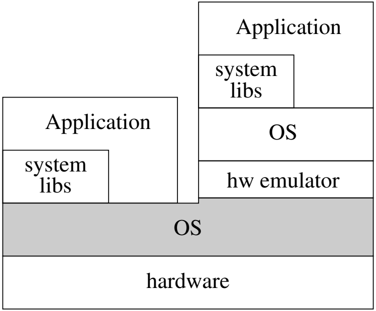
Good for application delivery, where an application needs a lot of specific system library support: so we deliver the systems libraries with the application!

Conclusion of OS



And then there are variants that do *hardware virtualisation* by emulating different kinds of hardware, e.g., we might have our OS running on an ARM emulation running on X86 hardware

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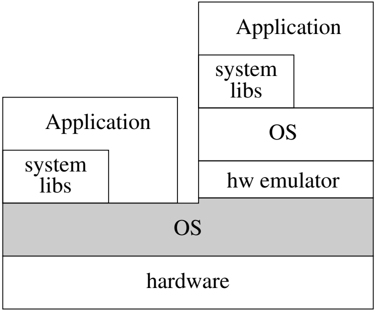

And then there are variants that do *hardware virtualisation* by emulating different kinds of hardware, e.g., we might have our OS running on an ARM emulation running on X86 hardware

Or on an X86 emulation on ARM hardware

Conclusion of OS

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Exercise Compare with Apple's new Rosetta software that allows Intel code to run on Arm hardware (only user code, though)

Conclusion of OS

Exercise Read up on Cloud Services, Software as a Service (SaaS), Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software Appliances

Conclusion of OS

All of these techniques are applied in cloud computing, where users buy time on a large, remote machine

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Welcome to the 1960s!

Conclusion of OS

Exercise On Mars, the autonomous helicopter drone Ingenuity (brought by the lander Perseverance) runs Linux on a 500Hz (not MHz!) processor. Read about this

Exercise Play with an OS you are not familiar with (Mac, Win or Lin or other) and learn the ways it does things. Write, compile and run a program

Exercise Read about the advances in persistent memory: comparable in speed to main memory, but retains data when power cycled like disk (*non-volatile*). What changes would we need from an OS to deal with such a technology?