UniKernels and Friends

Advanced Operating Systems

Luca Abeni

luca.abeni@santannapisa.it

The Cloud Revolution

- Cloud computing: large usage of VMs
  - Even 1 VM per application!!!
  - Single-application OSs?
  - Not general-purpose OSs...
- Traditional approach: run a GPOS in the VM, and install the application
- Dynamic workloads: some times, VMs must boot very quickly...
  - Optimization of VM and OS for virtual environments, quick boot, ...

An OS for the Cloud — I

- GPOS in a VM: simple solution
  - But maybe it is overkill...
  - Do we really need a whole OS just to run an application???
  - Lots of unneeded user-space applications and libraries...
  - Lots of unneeded kernel features / drivers / functionalities...
- A VM provides a protection domain
  - So, do we need address-space protection inside the VM?
- The OS kernel abstracts the hardware
  - Why do we want to abstract a VM?

An OS for the Cloud — II

- The OS kernel provides virtual filesystem, network stack, etc...
  - Do we need these subsystems even if the application does not use network or filesystems?
- The OS provides flexible boot scripts, shells, many commands, etc...
  - Do we need all of them just to run a single application?
- Result: we might need a $1GB$ filesystem image just to run a web server...
  - Not to talk about memory footprint, CPU usage, etc...

The Unikernel Idea

- Very simple idea: remove all the unneeded stuff!
  - Redesign the whole OS to be special-purpose, for our application
- Application directly linked to the kernel code (library OS)
  - Does it sound familiar? Uh... What is the difference with a real-time executive?
  - Also, remember the “vertically structured OSs” (exokernels)
- Everything runs in the guest kernel space (protection is provided by the VM / hypervisor)
- Do not link / include unneeded kernel components and drivers

Taking it to the Limit...

- Unikernel: designed to run in a VM
  - Application directly linked to the kernel (only the needed parts!)
  - Drivers only for virtual devices
  - Paravirtualization
  - ...
- What about (re)designing a VMM / hypervisor to only run unikernels?
  - Simplified host / guest interface
  - Do not virtualize unneeded devices
  - ...
- Advantages: simpler code, reduced boot time, better performance, ...