unikernel

Technologies

3 juillet 2017, RMLL St-Etienne, Michael Bright

@mjbright
Agenda

- What are Unikernels?
  - What they are not.
- Why Unikernels?
  - Advantages / Characteristics
  - Application domains
- Implementations & Tools
- Demos
- Usage: Baremetal anyone?
- Where’s it all heading?

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What's it all about?

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What are Unikernels?

“Unikernels are specialized, single-address-space machine images constructed by using library operating systems”

“What are Unikernels”, unikernel.org
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“Unikernels are specialized, single-address-space machine images constructed by using library operating systems”

“What are Unikernels”, unikernel.org

“VMs aren't heavy, OSes are”

Alfred Bratterud, #includeOS
What are Unikernels? - They are "Library OS"

Specialized applications built with only the "OS" components they need.

A Unikernel is an image able to run directly as a VM
(on bare metal?)

"OS" components such as Network stack, Filesystem, Device drivers are optional

typically, there is no filesystem.

So configuration is stored in the unikernel application binary

A unikernel application containing only selected OS components
Unikernels: What they are not ... General Purpose

OS kernels with unneeded features e.g. floppy drivers, designed to run any software on any hardware are huge - lines of code

Unikernels are not "top-down" minified versions of General Purpose OSes ...
Unikernels: What they are not ... minified OS

Container hosts

Minimal Linux distributions have been created with similar goals to Unikernels, aimed to be minimal host OS for container engines, e.g.

- CoreOS Linux
- Project Atomic
- RancherOS

They aim to be

- Secure
  - Less features/lines of code: reduced attack surface
  - Atomic updates of system (not quite immutable)
- Fast to boot: Small binary size
- Specialized to run containers

But these are still reduced versions of general purpose OSes and so have many unnecessary features.

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Unikernels: What they are not … minified OS

In April 2017 Docker open sourced LinuxKit a way of building minimal Linux distributions for hosting containers.
Unikernels: What they are not ... minified OS

**LinuxKit**

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LinuxKit is also a specialized Container Host with

- declarative specification of the system components to include
- services and applications encapsulated in containers
- MirageSDK ... looks interesting ...
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It's just one step closer to Unikernels ...
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... who knows what Docker will do next ?? ...

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Unikernels: What they are not ... summary

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- Not µ-kernels
- Not minified Linux kernels or Container OS
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- Multi-kernels (though HermitCore is !)
- Multi-process (though Graphene is !)

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Building a specialized application with only the "OS" components needed

==> a "bottom-up" approach

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Unikernels: Are...

Very small compared to an application + OS

- use few resources
- immutable, suitable for micro-services
- No legacy drivers
- No unneeded shell - did I mention this?
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Fast to boot

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More difficult to develop

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- libraries, languages, debugging limitations
Unikernels: Application Domains

Cloud Computing and NFV

- Fast to boot: On demand services
- Secure immutable images
Unikernels: Application Domains

Cloud Computing and NFV

- Fast to boot: On demand services
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IoT / Embedded

- Small images for OTA updates
- Secure immutable images
Unikernels: Application Domains

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HPC

- Secure in the cloud
- Very efficient (no context switches, just 1 process)

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Unikernel implementations

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## Unikernel Implementations: 2 families

<table>
<thead>
<tr>
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<th>Legacy</th>
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We can see that Legacy Unikernels trade off some principles for ease of use ...
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<td>... others ? ...</td>
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There's some collaboration going on across projects especially to use some common underlying layers such as Minio, Solo5/ukvm.
MirageOS "Library OS" components and apps are written in Ocaml, a type-safe functional (& OO) language with extensive libraries.

The mirage tool is used to build Unikernels for various backends:

- Xen Hypervisor (PV)
- Unix (Linux or OS/X binaries)
- MirageOS 3 (/Solo5) supports kvm (/ukvm) and xhyve

Building applications for unix or xen

```
mirage configure -t [unix|xen|ukvm]
make depend
make
./mir-console
```

Use cases: BNC Pinata, E/// Research NFV, PayGarden
Unikernel Implementations: HalVM

halvm.org

- Clean Slate
  Runs on Xen

- Open Source
  Considering port to Solo5 for HalVM v3.

- Backing (Galois)
  [2012] HalVM is a "nifty platform" for
  - developing simple cloud services
  - creating critical, isolated services

  Aimed at highly secure network appliances such as CyberChaff

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Unikernel Implementations: IncludeOS

Written in C++.

Create Unikernel from an application by including 
#include <os>

Runs on hypervisors (KVM, VMWare) maybe baremetal ...

Single-threaded, single-process, single-memory space

Delegates to route messages between TCP/IP stack components.

No blocking POSIX calls implemented yet, only async i/o.

Recent developments:

- Working with Mender (mender.io) for OTA updates
- 64-bit
- ARM?
- Solo5 (ukvm)

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Unikernel Implementations: OSv

Written in C++ but with "POSIX" compatibility

- includes threads, tcp/ip, ZFS filesystem
- support for other languages and memory-managed platforms (JVM, Go, Lua)
- used in Mikelangelo EU Project (OpenStack+Unikernels)

Runs on KVM, Xen, VBox, VMWare

The OSv Manifesto

- Run existing Linux apps, run them faster
- Boot time ~ Exec time
- Leverage memory-managed platforms
- Stay open

Single process, address space

TCP/IP stack components (C++ classes) communicate via net channels

Possibility for MMU to handle garbage collection
Unikernel Implementations: Rumprun

A refactoring of the NetBSD kernel allowing to select OS modules as needed.

Unikernel base in C/C++, supports many languages

- C/C++, Lua, PHP, Python, Ruby, Node.js, Erlang, Go

Workflow is

- cross-compile against NetBSD libc (modified)
- bake in the hypervisor choice (not KVM ...)
- launch VM

Baremetal "Hypercall" implementation.

Many available packages: apache2, nginx, haproxy, redis, mysql, sqlite, leveldb, tor, mpg123

NOTE: LKL (Linux Kernel Libraries) an experimental Linux version since 2015

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Unikernel Implementations: Runtime.js

runtimejs.org
Legacy
Open Source

Implementation of v8 Javascript engine as a Unikernel
Supports Node.js on KVM Hypervisor
Ongoing discussions about supporting WebAssembly ..
Unikernel Implementations: HermitCore

Experimental unikernel from University of Aachen, initial performance results are promising.

Supports SMP in multi-kernel mode.

Modes:

- "classical unikernel" - runs on a VM
- multikernel on VM: proxy "Linux" kernel on one core, separate applications on other cores
- multikernel on BM: proxy "Linux" kernel on one core, separate applications on other cores

Uses Intel OpenMP runtime.

Languages:

- C++, Fortran, Go (all via gcc)

hermitcore.org

Legacy

Open Source

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Unikernel Tools

Open Source tools help to advance the various projects.

Unik: Unikernel Compiler

Cloud Foundry project (Dell-EMC) compiles several Unikernel Technologies

- Supports: RumpRun, OSv, IncludeOS, MirageOS

'VboxUnikInstanceListener' VM handles requests from the 'unik' cli.

Solo5/ukvm

A common Unikernel (Solo5) base and (ukvm) library hypervisor developed by IBM.

Integrated into MirageOS v3 to extend to KVM support. Other projects (HalVM, IncludeOS) are also considering this approach. Ongoing port to ARM64.

Deferpanic

Web and cli tool allow to test deploy Unikernels.
Demo

- MirageOS
  - compilation for unix
  - compilation/run for Solo5/ukvm
- Runtime.js
- Deferpanic.net

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What's coming?

Docker bought Unikernel Systems (main MirageOS developers) in Jan 2016

- Unikernel technology used in Docker for Mac, Docker for Windows

MirageOS v3 released in March 2017

- improves MirageOS implementation (less code, more func)
- New Solo5 backend: kvm via Solo5/ukvm

Unikernels are becoming easier to use

- Adoption of existing backends: Minios/Xen, Solo5/ukvm
- LinuxKit/MirageSDK synergies with MirageOS?
- Docker facilitates Build Ship and Run for Unikernel technologies
- Unik project facilitates use of different Unikernel technologies
- Cloud Foundry and Kubernetes look to deploy Unikernels
- Solo.io "Squash" project producing debugger for µ-services and Unikernels

Many Unikernel projects are advancing quickly ... and specialized deployment trials ongoing

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Unikernels: Usage? Baremetal?

Specific applications (network appliances - Hybrid solutions)

Well-suited for very specific applications such as target networking components

- DNS, DHCP, NAT, Firewall, TLS, Chaff

Can be used as standalone appliances or as secure network front-end.

But what about Baremetal?

Some Unikernels target baremetal, but not appropriate for all use cases

- requires maintaining h/w specific device drivers
- may not support more than 1 core!

You won’t want to dedicate your latest Proliant server to one Unikernel (flea on an elephant’s back), but rather to a Hypervisor running Unikernels

May be appropriate for the smallest IoT devices (webcam, sensor)
Unikernels: Conclusions ...

A very active research area

- many active projects, several with commercial backers
- mostly Open Source
- healthy collaboration - common tooling possible
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Some projects adopt a "Clean-Slate" approach building up capabilities.

- impose a particular language
- smallest, most secure Unikernels
- potentially harder to develop

Other projects trade off some of the Unikernel advantages for "ease of use".
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We will start to hear of deployments for specific use cases

Unlikely to become a mainstream approach

- competition from VMs, containers, serverless
- unless someone surprises us ...
Q&A

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## Resources - General

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