

### Unikraft NFV

## Extremely Fast and Efficient NFV with Unikraft

Sharan Santhanam Felipe Huici

**NEC Laboratories Europe GmbH** 

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## Overview



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## VNF with DPDK Ecosystem



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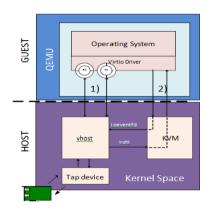
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## VNF with DPDK Ecosystem



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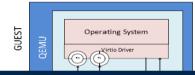
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## Can we do better?

- → Boot Time
- → Isolation within the guest

. Kerner space

## VNF with DPDK Ecosystem



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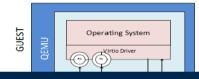
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### Can we do better?

- → Guest OS specialization
- → Boot Time
- → Isolation within the guest



Let's discuss Unikernel...



# Unikernel - Do One Thing and Do It Well

#### Unikraft NFV

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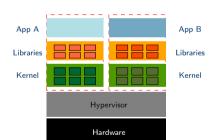
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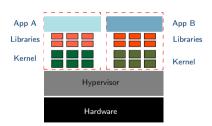
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### Virtual Machine







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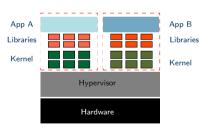
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- ► Unikernel are purpose built
  - Thin kernel layer
  - Single image with application, specific kernel primitives



# $\overline{Uni}$ kernel - Do One Thing and Do It Well

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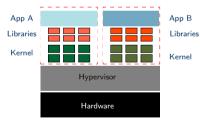
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- ► Unikernel are purpose built
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- No isolation within a Unikernel
  - Flat address space



# Unikernel - Do One Thing and Do It Well

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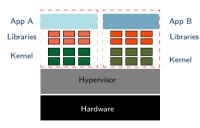
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- No isolation within a Unikernel
  - Flat address space
- ► Software Stack Specialization



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- ► Fast instantiation, destruction and migration times
  - 10 milliseconds or less (LightVM [Manco SOSP 2017], Jitsu [Madhvapeddy, NSDI 2015])



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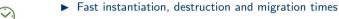


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- 10 milliseconds or less (LightVM [Manco SOSP 2017], Jitsu [Madhvapeddy, NSDI 2015])
- ► Low memory footprint
  - Few MBs of RAM or less (ClickOS [Martins NSDI 2014])



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  - Few MBs of RAM or less (ClickOS [Martins NSDI 2014])
- ► High Deployment Density
  - 8k guests on a single x86 server (LightVM [Manco SOSP 2017])



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- ► High Deployment Density
  - 8k guests on a single x86 server (LightVM [Manco SOSP 2017])
- High Performance
  - 10-40Gbit/s Ethernet throughput with a single guest CPU (ClickOS [Martins NSDI 2014], Elastic CDNs [Kuenzer VEE 2017])





#### Unikraft NFV



#### What we saw





### Fast instantiation, destruction and migration times

10 milliseconds or less (LightVM [Manco SOSP 2017], Jitsu [Madhvapeddy, NSDI 2015])



Few MBs of RAM or less (ClickOS [Martins NSDI 2014])



8k guests on a single x86 server (LightVM [Manco SOSP 2017])



• 10-40Gbit/s Ethernet throughput with a single guest CPU (ClickOS [Martins NSDI 2014], Elastic CDNs [Kuenzer VEE 2017])



Small trusted compute base

Strong isolation by hypervisor



## La-la Land



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- ♦ High Performance
- Isolation and reduced attack surface.
- ♦ Faster Instantiation Time
- Smaller image size

### La-la Land



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### So. Unikernel

- ♦ High Performance
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- ♠ Faster Instantiation Time
- Smaller image size

### The problem with Unikernel development:

- Building take several months or longer
- Potentially repeat the process for each target application
- "Specialization" is hard to build

### La-la Land



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### So. Unikernel

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- ♠ Faster Instantiation Time
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### The problem with Unikernel development:

- P Building take several months or longer
- Potentially repeat the process for each target application
- "Specialization" is hard to build

## Ooops!!

That's not an effective way of doing things!

## What is Unikraft?



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### Objectives

- → Support wide range of use cases
- → Simplify building and optimizing
- → Common and shared code base
- → Support different hypervisors
- → CPU architectures

## What is Unikraft?



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### **Objectives**

- → Support wide range of use cases
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### Unikraft

- "Everything is a library"
- ▶ Decomposed OS functionality
- ▶ Unikraft's two components:
  - Library Pool
  - Build Tool

## What is Unikraft?



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### Unikraft

- "Everything is a library"
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## Unikraft says Hi!!

Source is BSD-licensed

Kconfig based build system



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## Appln I2fwd PyAPP

- ► Take an existing application
  - For example, a Python application or a I2fwd



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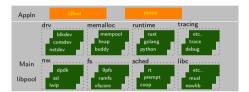
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- ► Take an existing application
  - For example, a Python application or a I2fwd
- ► Pick Unikraft functionality
  - Pool of drivers and standard libraries



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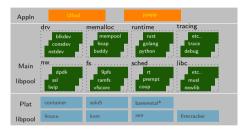
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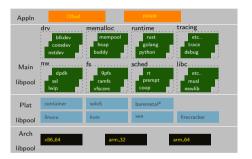
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- ► Pick a platform and architecture
  - Pool of drivers and standard libraries
- ► Build Unikraft application



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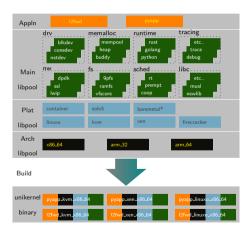
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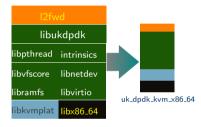
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## Unikraft - DPDK Target Arch?



#### Unikraft NFV

#### Unikraft meets DPDK



## Unikraft - DPDK Target Arch?



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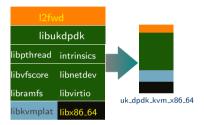
#### Unikraft meets DPDK

Unikraft within DPDK

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C....

between Unikraft and



## Challenges!!

- ► Build System Integration
- ► Specialization of Guest OS
- Minimize modification to DPDK library



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## Unikraft Build system

- ► Config.uk (Kconfig based)
  - Handles dependencies across library
  - Enable/Disable Function

## DPDK Build System

- ► Automatic config generation
  - CPU feature flags





### Unikraft NEV

Unikraft meets DPDK

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- Config.uk (Kconfig based)
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- Automatic config generation
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  - Makefile (gmake)
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Process DPDK Makefile



### Unikraft NFV

Unikraft meets

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## DPDK Build System

- Automatic config generation
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## libukdpdkbuild

- Process DPDK Makefile.
  - Add DPDK library



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## | libukdpdkbuild

- Process DPDK Makefile.
  - Add DPDK library
  - Support newer version of DPDK



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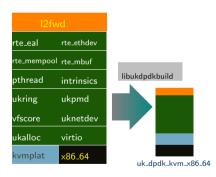
- ► Process DPDK Makefile
  - Add DPDK library
  - Support newer version of DPDK
- ▶ Add dpdk specific configuration file.

## Unikraft - DPDK Target Arch



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#### Unikraft meets DPDK



## Unikraft as EAL in DPDK



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## Specialize the Guest OS

- ▶ Memory management
- ► Bus/Device Management
- ► CPU Scheduling and CPU Features

### Unikraft as EAL in DPDK



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#### Specialize the Guest OS

- ▶ Memory management
- ▶ Bus/Device Management
- ► CPU Scheduling and CPU Features

### Memory Management

- ♦ Unikraft: flat page table since boot
- ♦ Huge pages based 2MB sized pages
- Memory region can be explicitly assigned to the Application
- Custom memory allocator per memory region

### Unikraft as EAL in DPDK



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#### Specialize the Guest OS

- Memory management
- ► Bus/Device Management
- ► CPU Scheduling and CPU Features

#### Bus/Device Management

- ♠ A simpler bus/device interface
- Directly attached device and usable by DPDK with unikraft

### Unikraft as EAL in DPDK



#### Unikraft NEV

Unikraft within DPDK

### Specialize the Guest OS

- Memory management
- **Bus/Device Management**
- CPU Scheduling and CPU Features

### CPU Scheduling and CPU Features

- Application decides on scheduling on the core.
- Minimal interference / resource usage for other purpose within guest.



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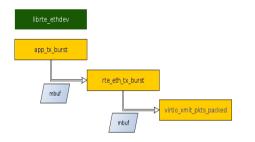
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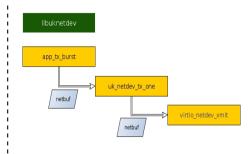
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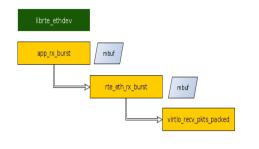
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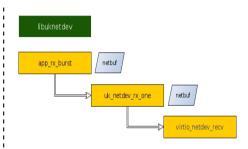
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uk_netbuf
user private_data
packet header
packet data
packet data
packet data
packet data
pacres data
parter data
patrion data
pacras una
pactor una
pacras una
pacros una
packet trailer



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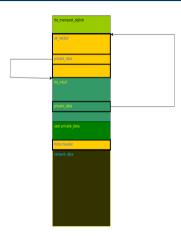
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## Test Setup



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#### Unikraft/Linux GuestVM Setup

- ► CPU Family: Sandy Bridge (Server) (Family: 6 and Model: 45)
- CPU Model: Intel(R) Xeon(R) CPU E5-1650 0 @ 3.20GHz
- ▶ Nr of Cores: 6
- ► RAM : 16GB
- ▶ Nr of NUMA nodes: 1
- ► Host Linux Kernel: Debian 4.19
- ► Guest Linux Kernel: Debian 4.19
- ▶ Qemu Version: 4.0.0
- ▶ DPDK Version (vhost-user): 19.08

### Packet Generator/Receiver Setup

- CPU Family: Ivy Bridge (Server) (Family: 6 and Model: 62)
- CPU Model: Intel(R) Xeon(R) CPU E5-1620 v2 @ 3.70GHz
- ► Nr of Cores: 4
- ► RAM : 16GB
- ► Nr of NUMA nodes: 1
- ► Host Linux Kernel: Debian 4.19
- ▶ DPDK Version (vhost-user): 19.08

### Packet Send: Unikraft vs LinuxVM



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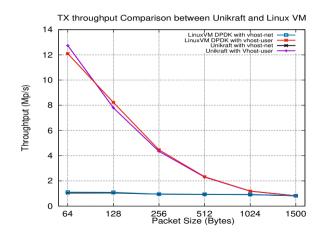
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### Packet Receive: Unikraft vs LinuxVM



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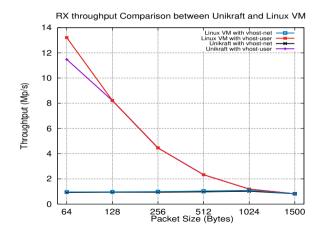
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# Key Value: Unikraft vs LinuxVM



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Linux Guest VM	Unikraft using DPDK(mbuf)	•
6.1Mp/s	6.1Mp/s	6.0Mp/s

# Resource Usage: Unikraft vs LinuxVM



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Parameters	Unikraft	Linux VM
Memory	1GB	6GB
<b>Boot Times</b>	87ms	12s
Image Size	1.4MB	2.5GB

### Future Work



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- ► Add SMP support
- ► Add NUMA support
- ► Use DPDK drivers directly

## Join us!



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#### Project Home Page

http://unikraft.org

#### Documentation

http://docs.unikraft.org/

#### Sources

https://github.com/unikraft

http://xenbits.xen.org/gitweb/ (Namespace: Unikraft)

#### What we think



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#### Unikraft DPDK

- Support multiple platforms
- Specialized Guest OS
- Simpler Management Device
- ♦ Increased control for an application

- ♦ Performance of Network stack
- Specialized VNF
- ♦ Wealth of knowledge DPDK driver
- ♦ Increased application base

#### What we think



#### Unikraft NEV

Synergy between Unikraft and DPDK

#### Unikraft **DPDK**

- ♠ Specialized Guest OS
- ▲ Simpler Management Device
- ♦ Increased control for an application

- - ♠ Performance of Network stack
  - Specialized VNF
  - ♦ Wealth of knowledge DPDK driver
  - ♦ Increased application base

## What do you think?