

# The Current State of C++ Unikernels

The background of the image is a dramatic, dark, swirling cloud formation, possibly a whirlwind or a stormy sky, rendered in shades of grey and black.

whirlwind tour of  
unikernels

I looked up ‘standard’ in  
the dictionary. There are  
eleven different  
definitions.

- Dave Winer

Einstein



cross-compile existing  
applications down into small light-  
weight secure virtual machines

A close-up portrait of Mr. Spock from Star Trek. He has his signature dark brown hair with a flat-top style and a prominent forehead. His eyes are dark and focused. He is wearing a dark blue Starfleet uniform with a black turtleneck and a gold Starfleet insignia on his left chest. The background is dark, showing some illuminated panels and equipment, typical of the USS Enterprise's interior.

but why?

# Massive Consolidation



10 VMs



10k VMs

A photograph of a cheetah in mid-stride, running from left to right across a green, slightly hilly landscape. The cheetah's body is blurred horizontally, emphasizing speed. The background consists of dark, streaked horizontal bands.

**10ms Boot**

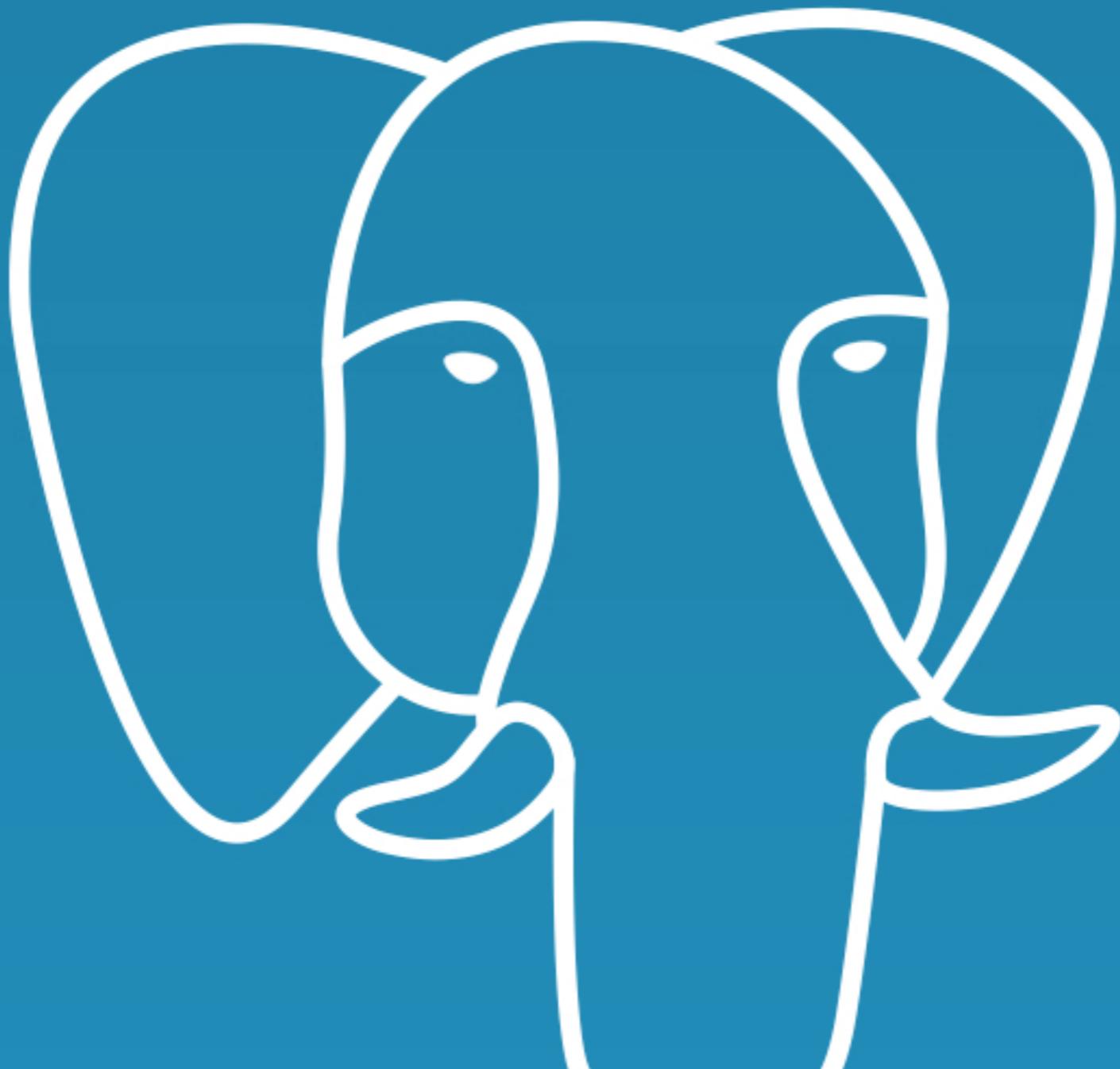
# single process

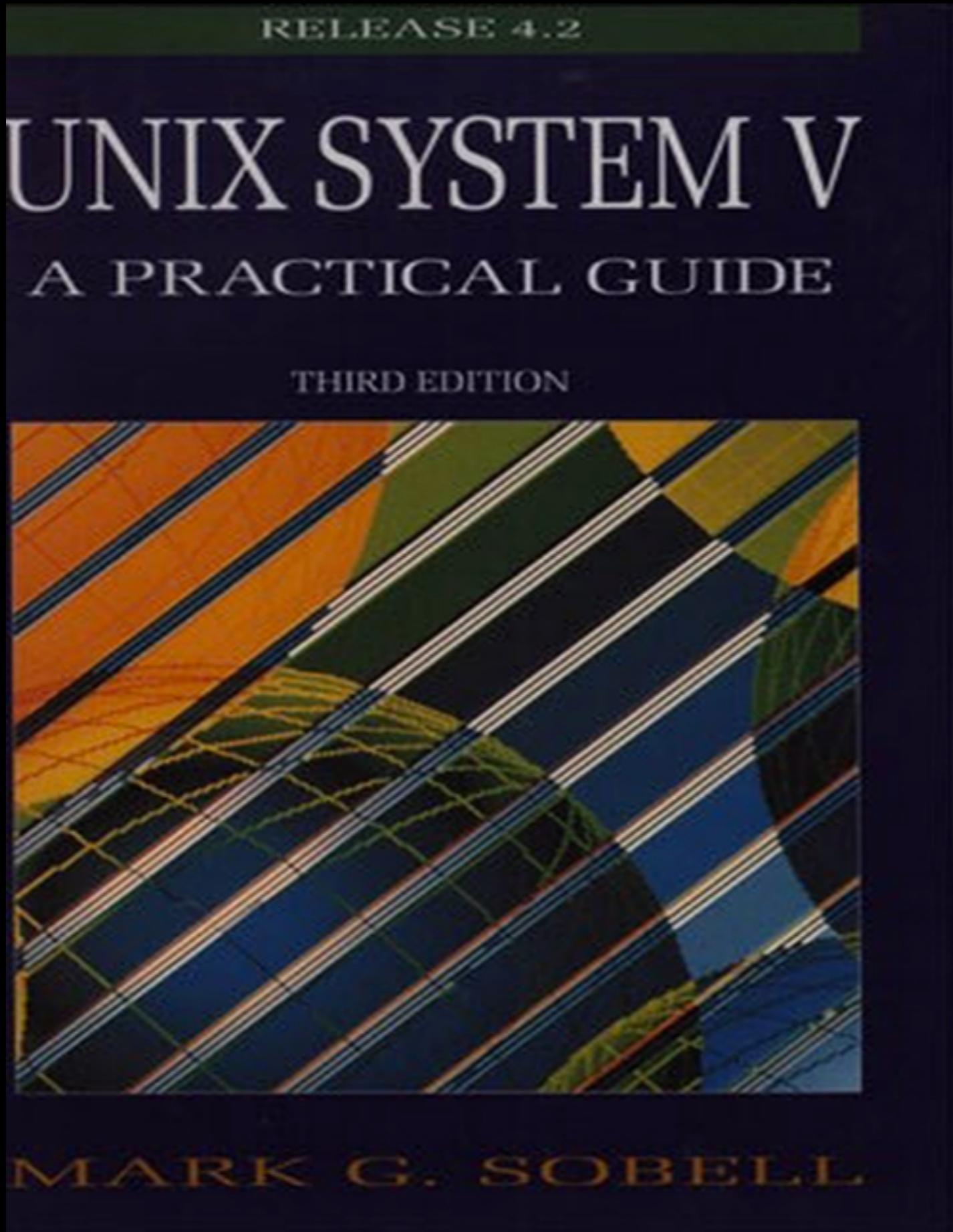




no fork

# PostgreSQL





fork

shared memory

semaphores

shared libraries

multiple processes

signals

IPC

AlgoDash

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

Unsigned char shellcode[] = \
"\xd9\xe9\xd9\x74\x24\xf4\xbd\x7e\xe2\xc4\xb4\x58\x29\xc9\xb1" \
"\x12\x31\x68\x17\x83\xc0\x04\x03\x16\xf1\x26\x41\xd7\x2e\x51" \
"\x49\x44\x92\xcd\xe4\x68\x9d\x13\x48\x0a\x50\x53\x3a\x8b\xda" \
"\x6b\xf0\xab\x52\xed\xf3\xc3\x6e\x0d\x04\x24\x07\x0f\x04\x5b" \
"\x8b\x86\xe5\xeb\x55\xc9\xb4\x58\x29\xea\xbf\xbf\x80\x6d\xed" \
"\x57\x34\x41\x61\xcf\x22\xb2\xe7\x66\xdd\x45\x04\x2a\x72\xdf" \
"\x2a\x7a\x7f\x12\x2c" \
"\x90";

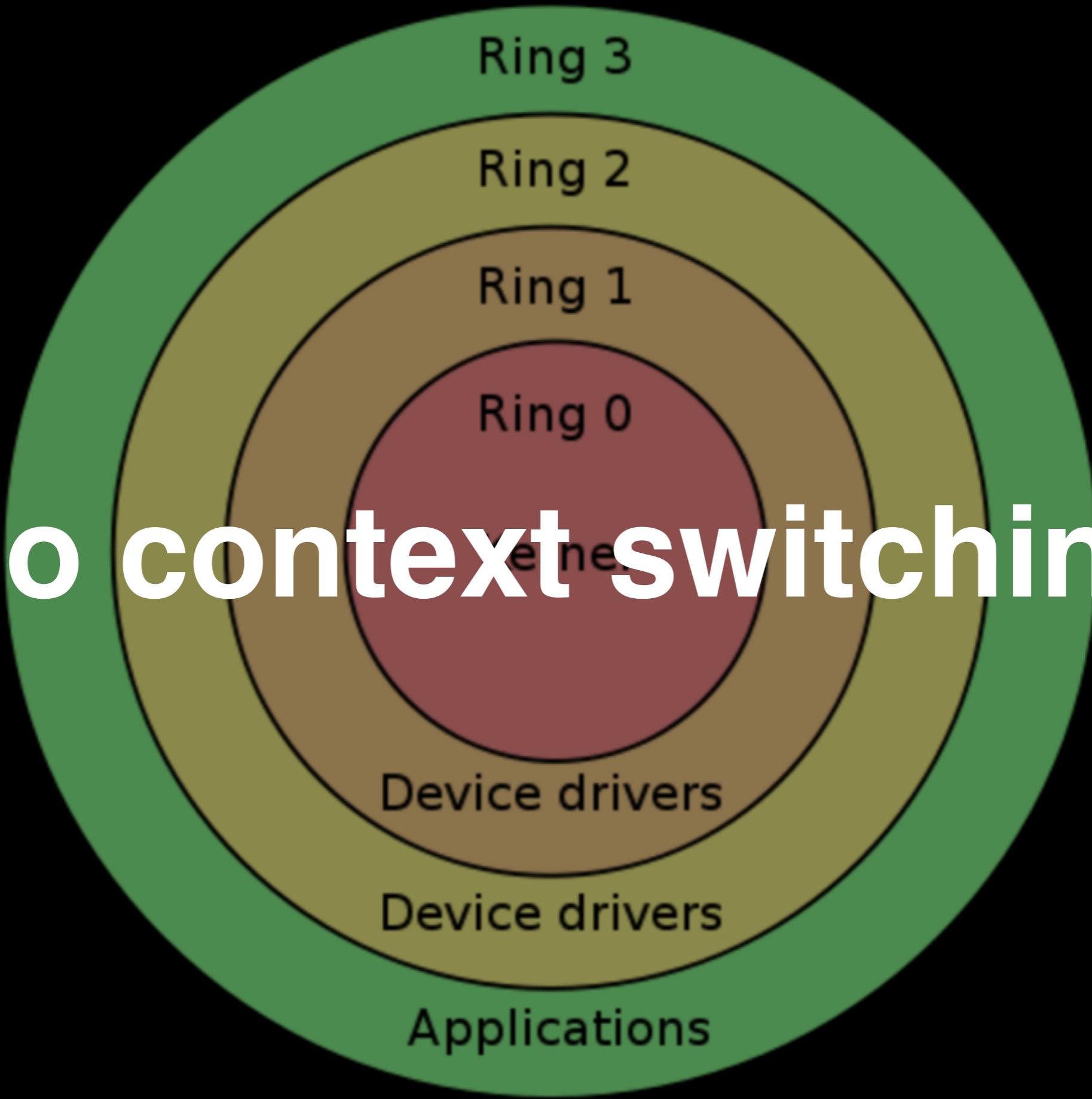
int shellcode_len=96;
```

L  
E  
S

OMG!  
*DEVOPS*



# no context switching





single address space

unsafe code tax for  
multiple address  
space systems is  
30-40%

# no virtual memory

## VIRTUAL ADDRESS SPACE FOR 4

A photograph of three people in a control room. Two individuals are seated at a desk, facing away from the camera, while a third person stands behind them. They are surrounded by a wall of computer monitors displaying various data visualizations, graphs, and operational information. The scene suggests a high-stakes environment like a power plant or industrial facility.

**coupled with SR-IOV**

JOHN R. LEVINE

# Linkers & Loaders

no  
dynamic  
linking

MARIO  
005400

• x22

WORLD  
1-1

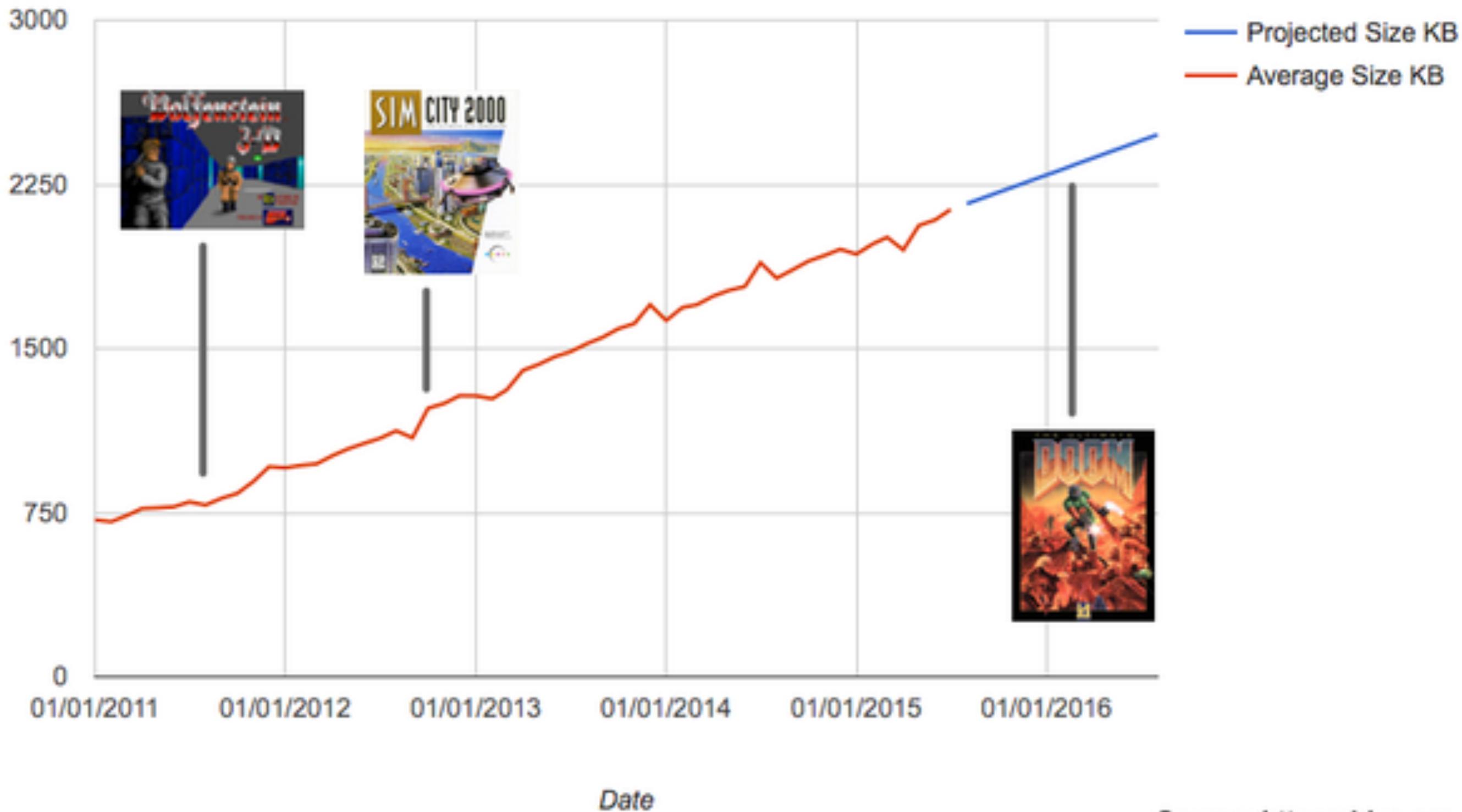
TIME  
367

The entire Super Mario  
Brothers game was only  
40 kilobytes.

This image is  
283 kilobytes.



## Web Page Size KB



A photograph of a group of soldiers in a field. One soldier in the foreground is shouting with his mouth open. They are wearing camouflage uniforms and helmets. The background shows a hilly landscape under a cloudy sky.

**1-10 Bugs/1000 LOC**



> 100 Processes  
> 10,000 Files



**300-400M LOC**

A dark, cluttered scene featuring a green jeep, a red car, and various household items like a television, a clock, and a wicker chair.

token ring  
wireless  
usb  
cdrom  
floppy disk



EXIT



A photograph of a middle-aged man with dark hair and glasses, wearing a dark suit jacket over a light-colored shirt. He is smiling and gesturing with his hands, which are clasped together in front of him. A small microphone is clipped to his shirt. The background is dark and out of focus.

# Shit VCs Say

**"I don't think server sales are growing."**

A photograph of three men in a server room. They are leaning forward, looking down at something on a table or floor. The man on the left has light brown hair and blue eyes, wearing a dark blue sweater over a patterned shirt. The man in the center has glasses and dark hair, wearing a dark t-shirt. The man on the right has dark hair and is wearing a red hoodie. In the background, there are rows of server racks with many green and red indicator lights. The lighting is low, with a blue tint at the bottom.

400 Million New  
Servers Needed by  
2020

v1

vmware®

A wide-angle photograph of a large warehouse or distribution center. The entire scene is filled with floor-to-ceiling shelving units packed tightly with various office supplies. In the lower-left foreground, a man wearing a light blue t-shirt and dark pants stands facing away from the camera, holding a handheld barcode scanner and looking up at a shelf. In the lower-right foreground, another man wearing a red t-shirt and dark pants is also facing away, reaching up towards a higher shelf. The shelves are organized into several distinct sections, each containing different types of products like paper, binders, and boxes. The lighting is bright and even, typical of an industrial interior.

V2



v3

# unikernel spectrum

"posix"		language specific	domain specific
osv	rump kernel	mirage	clickos



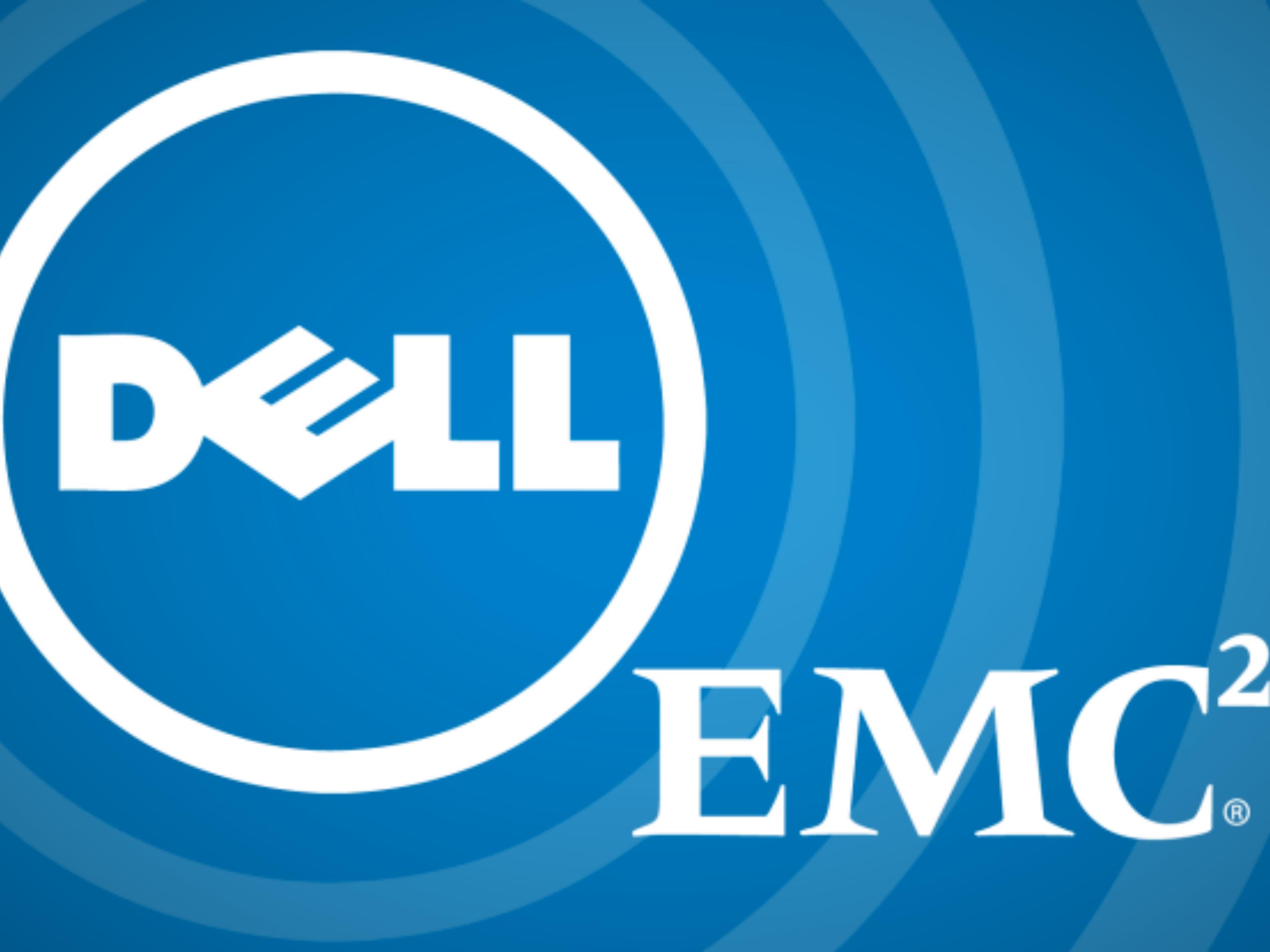
whose using  
unikernels?

# ERICSSON





GENERAL ELECTRIC



**NFC**



CISCO



WIND RIVER

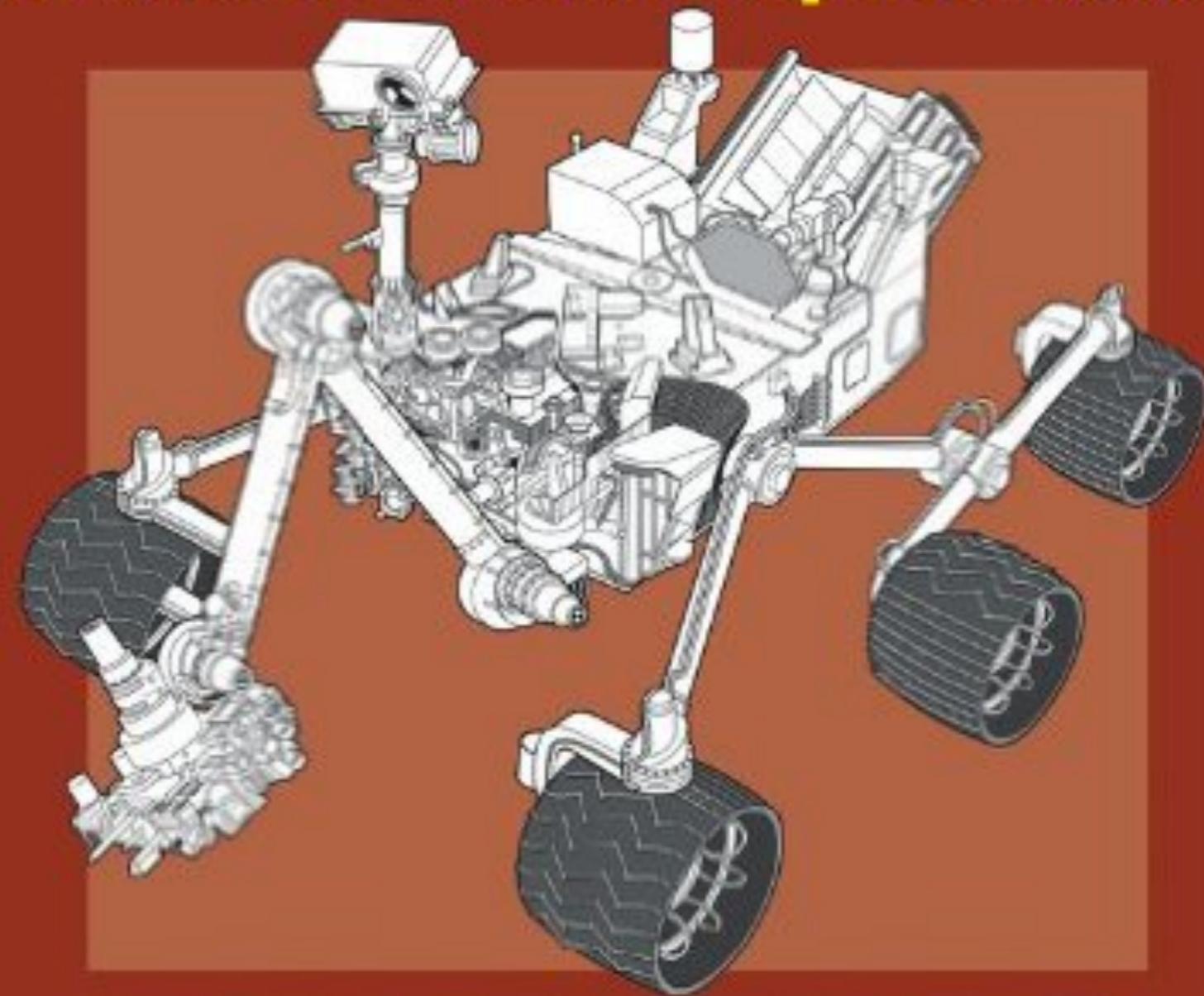
isn't this  
an old  
idea?

- ✓ single process
- ✓ single address space

# NASA MARS ROVERS

1997–2013 (Sojourner, Spirit, Opportunity and Curiosity)

## Owners' Workshop Manual

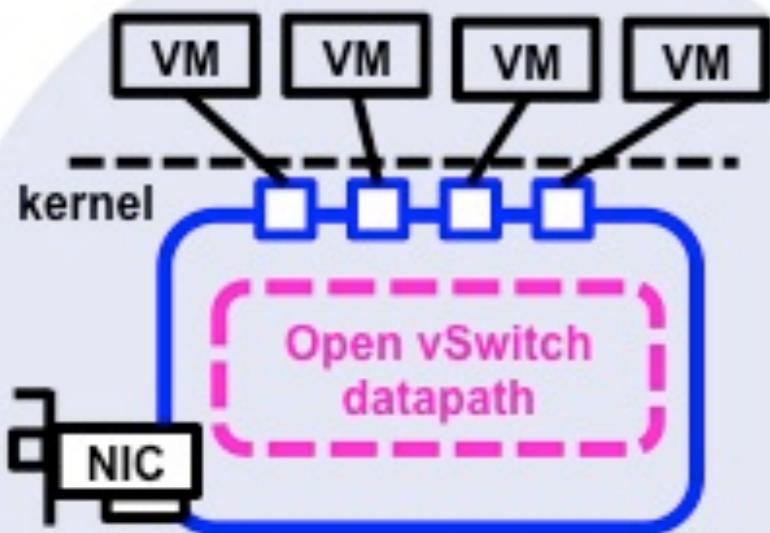


An insight into the technology, history and development  
of NASA's Mars exploration roving vehicles

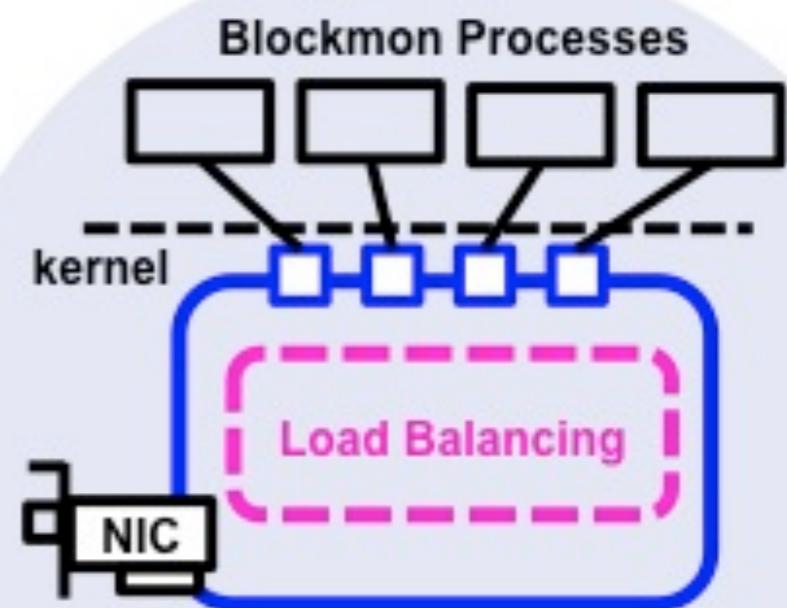
# NFV



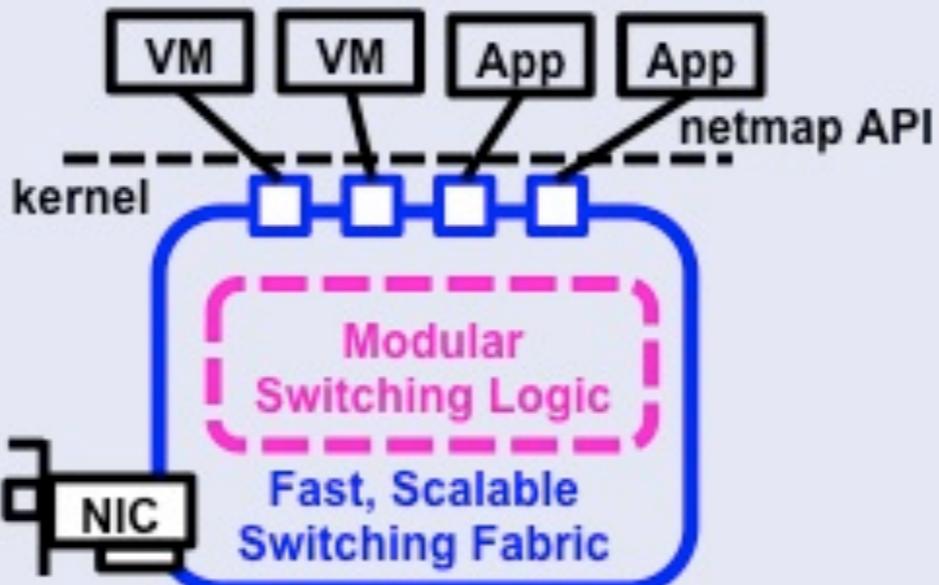
# CLICKOS



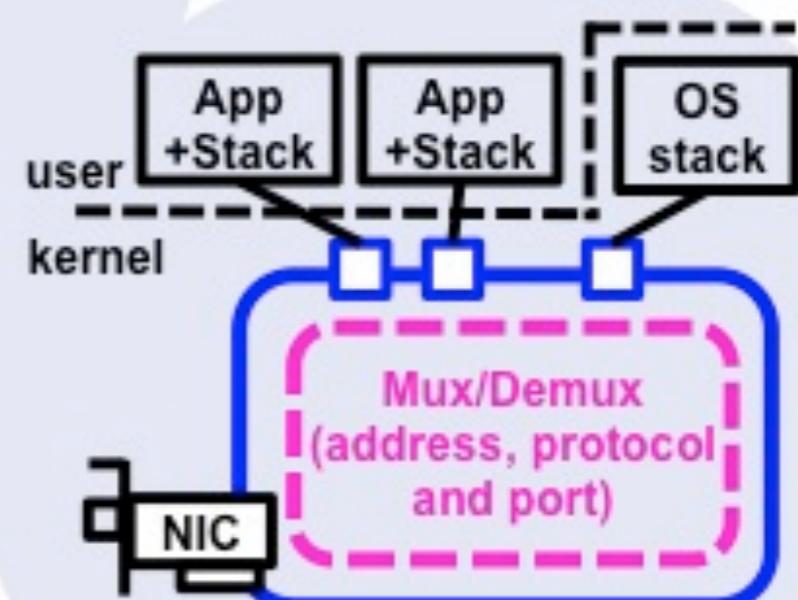
OVS-VALE: Seamless  
Open vSwitch Acceleration



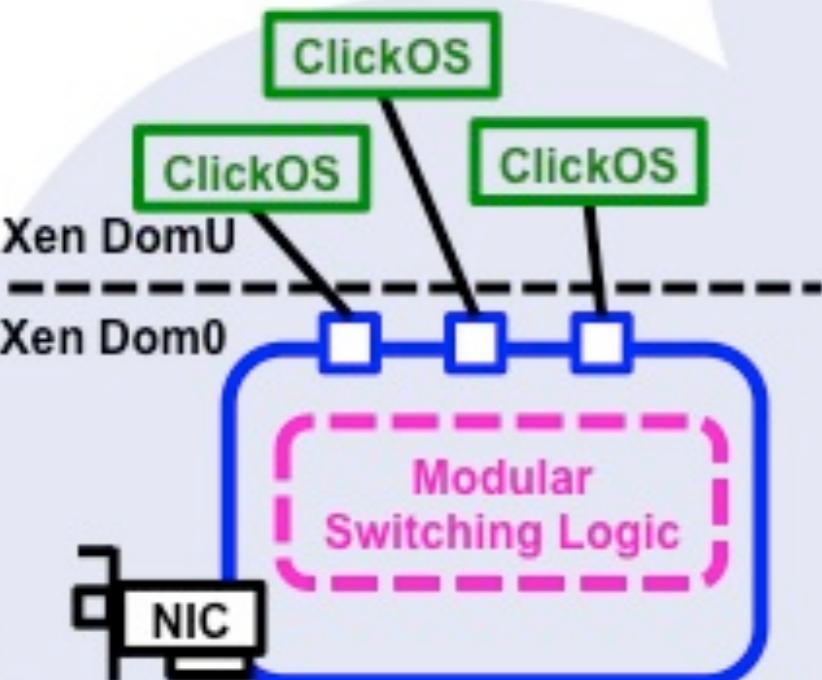
Blockmon: Distributed  
Monitoring and Data Analysis  
Solution



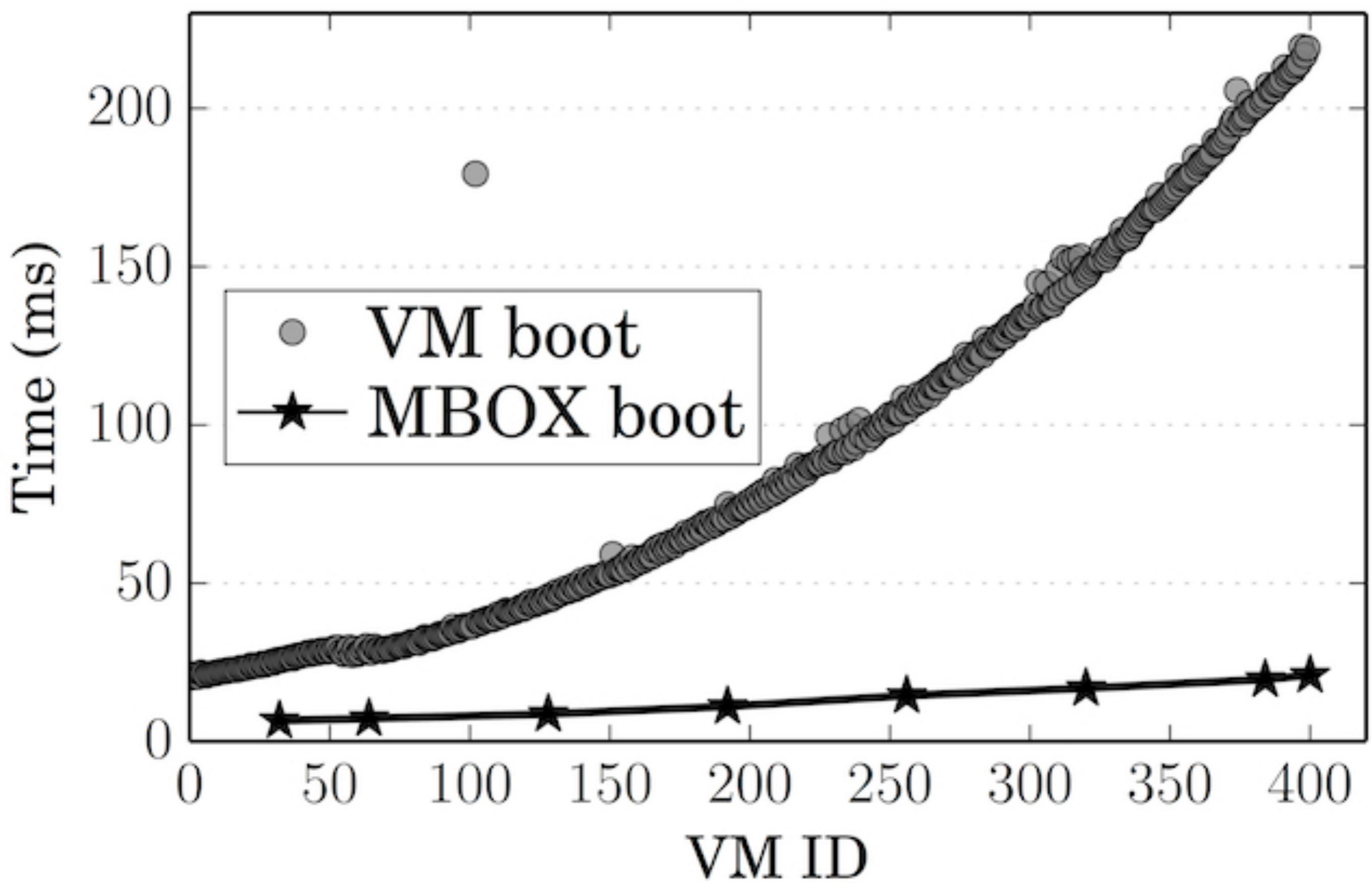
VALE Extensions: A Blazingly Fast  
Software Switch



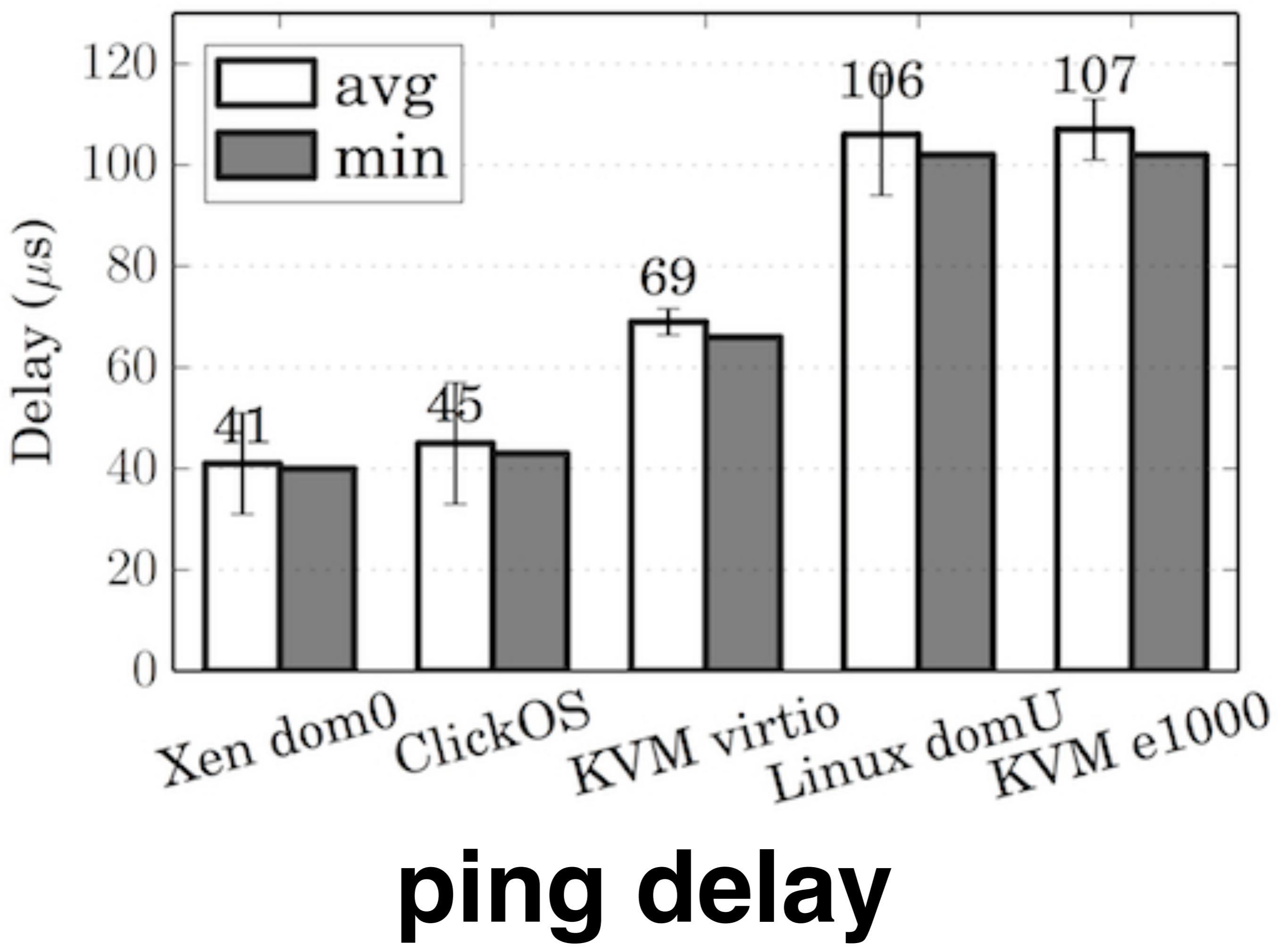
MultiStack: Support for User-  
Space Network Stacks

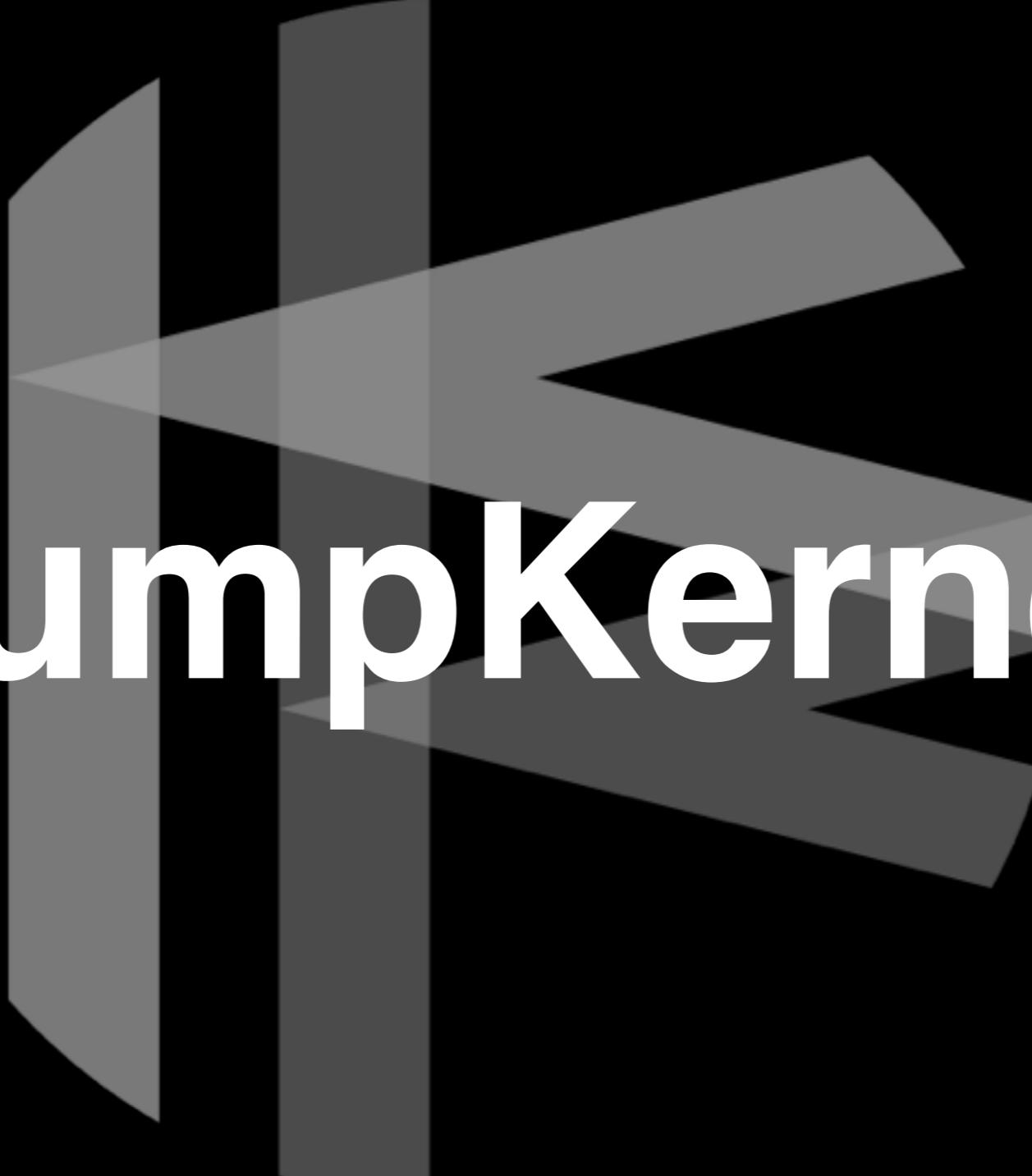


ClickOS: Tiny, Agile Virtual  
Machines for Network  
Processing



# Boot Time





# RumpKernel



The first 30 years were just the beginning.  
Welcome to 2007.



# debugging kernel drivers



# Portable Operating System Interface

```
INIT: version 2.86 booting
Starting the hotplug events dispatcher: udevd.
Synthesizing the initial hotplug events...done.
Waiting for /dev to be fully populated...done.
Setting the system clock.
Activating swap...done.
Checking root file system...fsck 1.41.3 (12-Oct-2008)
/dev/sda1: clean, 22168/258400 files, 463600
directories.
Setting the system clock.
```



Unmodified drivers  
from netbsd

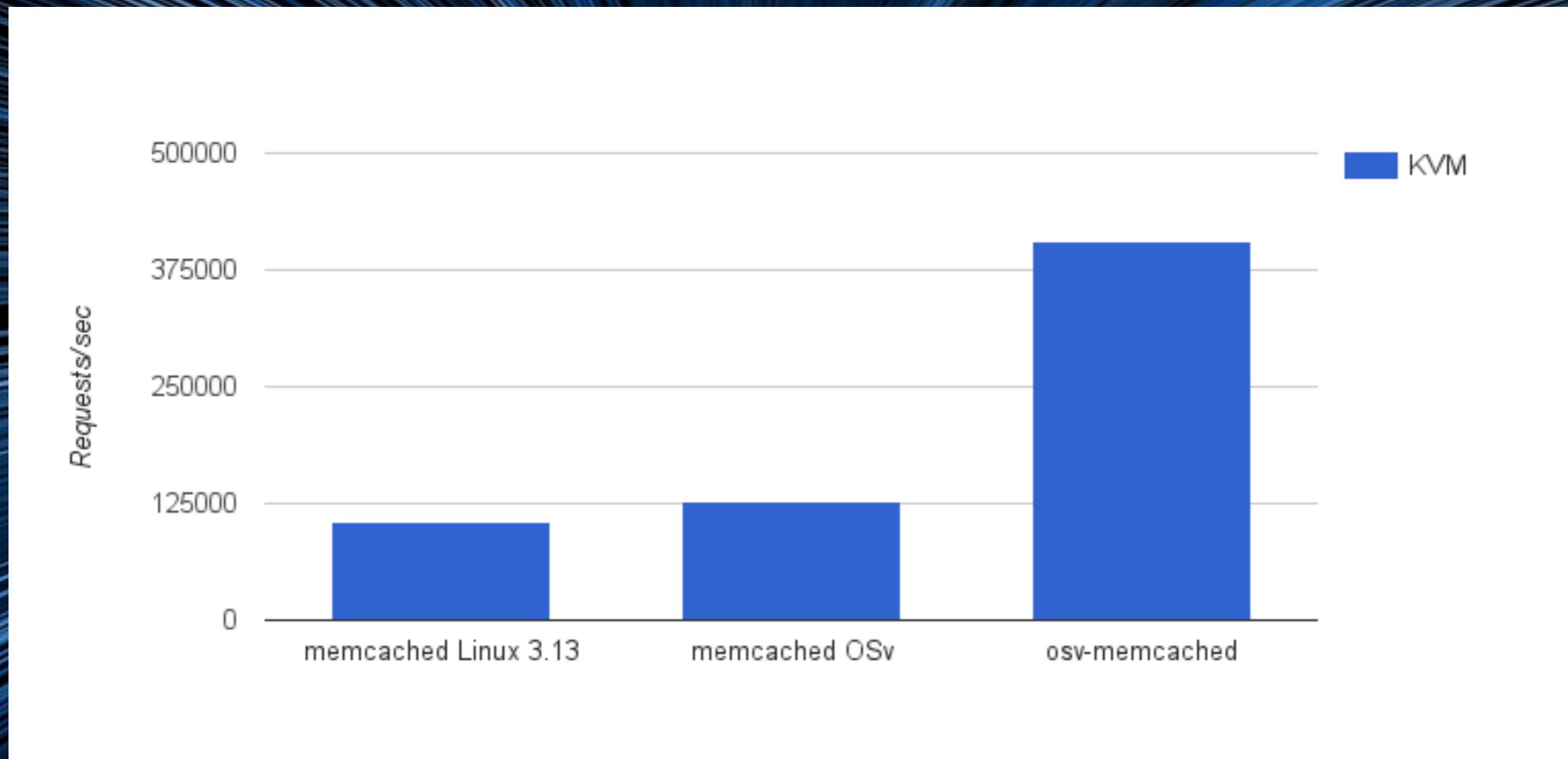


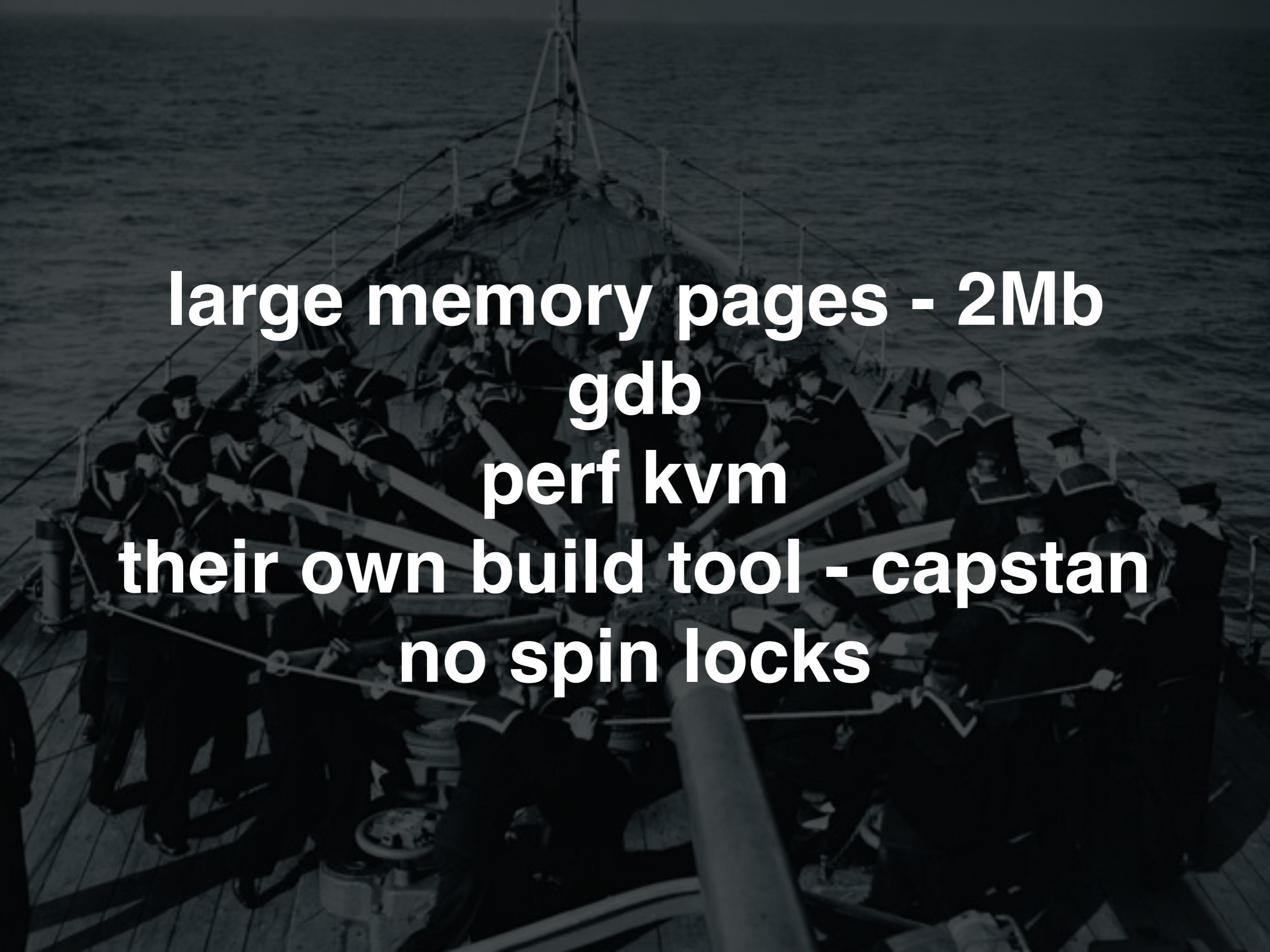
OSv



.so

# 406k Requests/Second



A black and white photograph showing the deck of a tall ship, likely a three-masted sailing vessel. Several sailors are visible, some standing at the helm and others along the deck. The ship is on the water, with its masts and rigging visible against a dark sky.

**large memory pages - 2Mb  
gdb  
perf kvm  
their own build tool - capstan  
no spin locks**

# IncludeOS

#include <os> // Literally

# Alfred



booted 110,000  
instances on a 48 core  
host, before memory  
was exhausted



Images

Instances

Networks

Usage

Storage

Resources

DNS

Volumes

Hosts

## Instance Execution Log - 381

```
=====
#include<os> // Literally

=====
[ Kernel ] Heap start: @ 0x2f9000
[ Kernel ] Current end is: @ 0x2f8000
[ IRQ manager ] Creating interrupt handlers
    + Exception gates set for irq < 32
    + Default interrupt gates set for irq >= 32
    + Enabling IRQ 0, mask: 0xffff
[ PCI Manager ] Probing PCI bus
    |
    +--- Host Bridge (0x0)
    |
    +--- ISA Bridge (0x1)
    |
    +--- Mass Storage Controller
    |
    +--- Other Bridge (0x80)
    |
    +--- Ethernet Network Controller (0x0)
    |
    o
[ Kernel ] Starting IncludeOS Demo Service
=====
[ Virtio ] Attaching to PCI addr 0x10
[x] Vendor ID is VIRTIO
[x] Device ID 0x1000 is in a valid range (Virtio LEGACY)
```

A photograph of a person standing on a sandy beach, facing the ocean. Waves are crashing onto the shore around their feet. The background shows more waves and a clear blue sky.

**pure play**

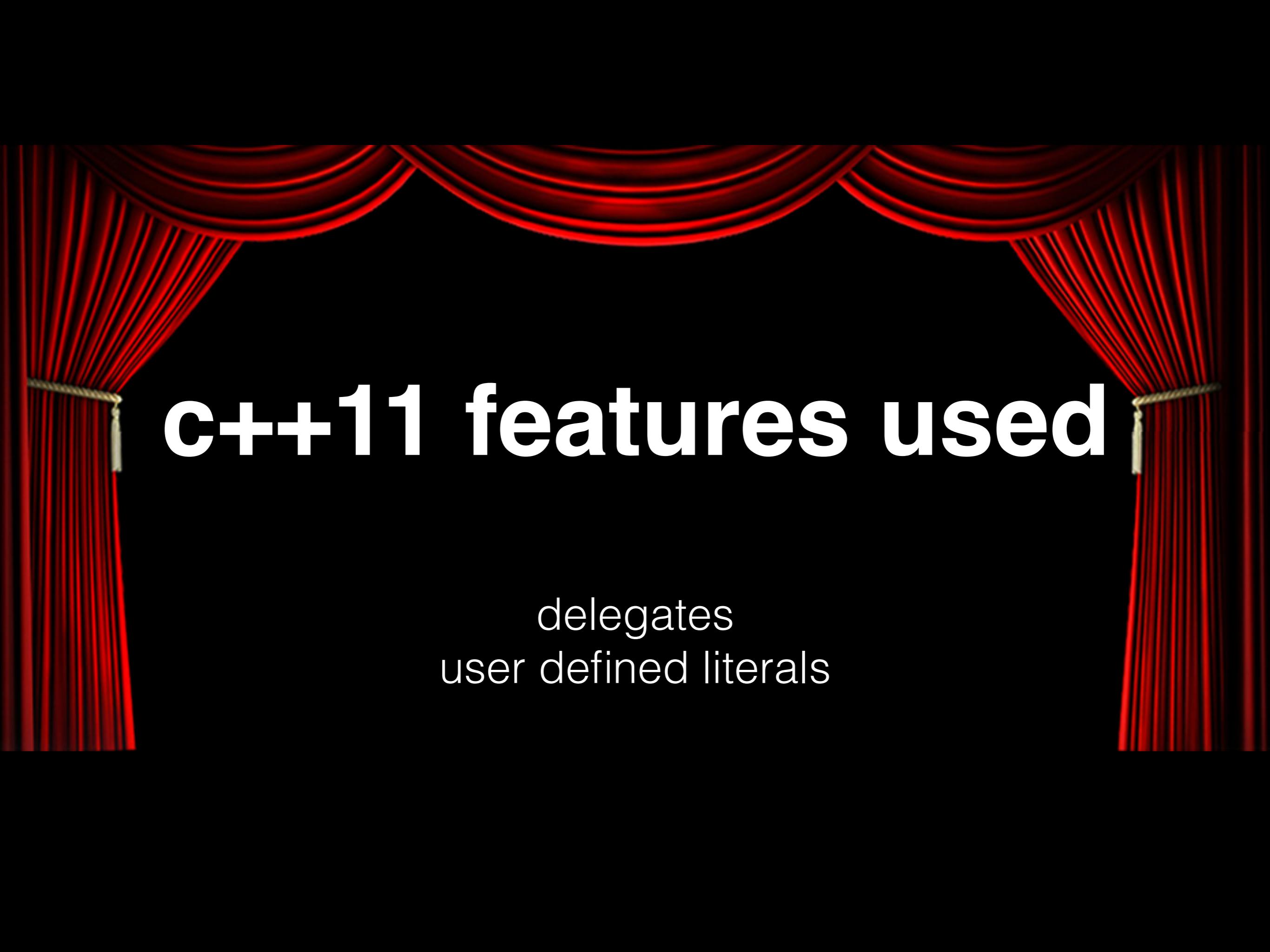
C++ runtime running  
directly on x86



**BRAND NEW**

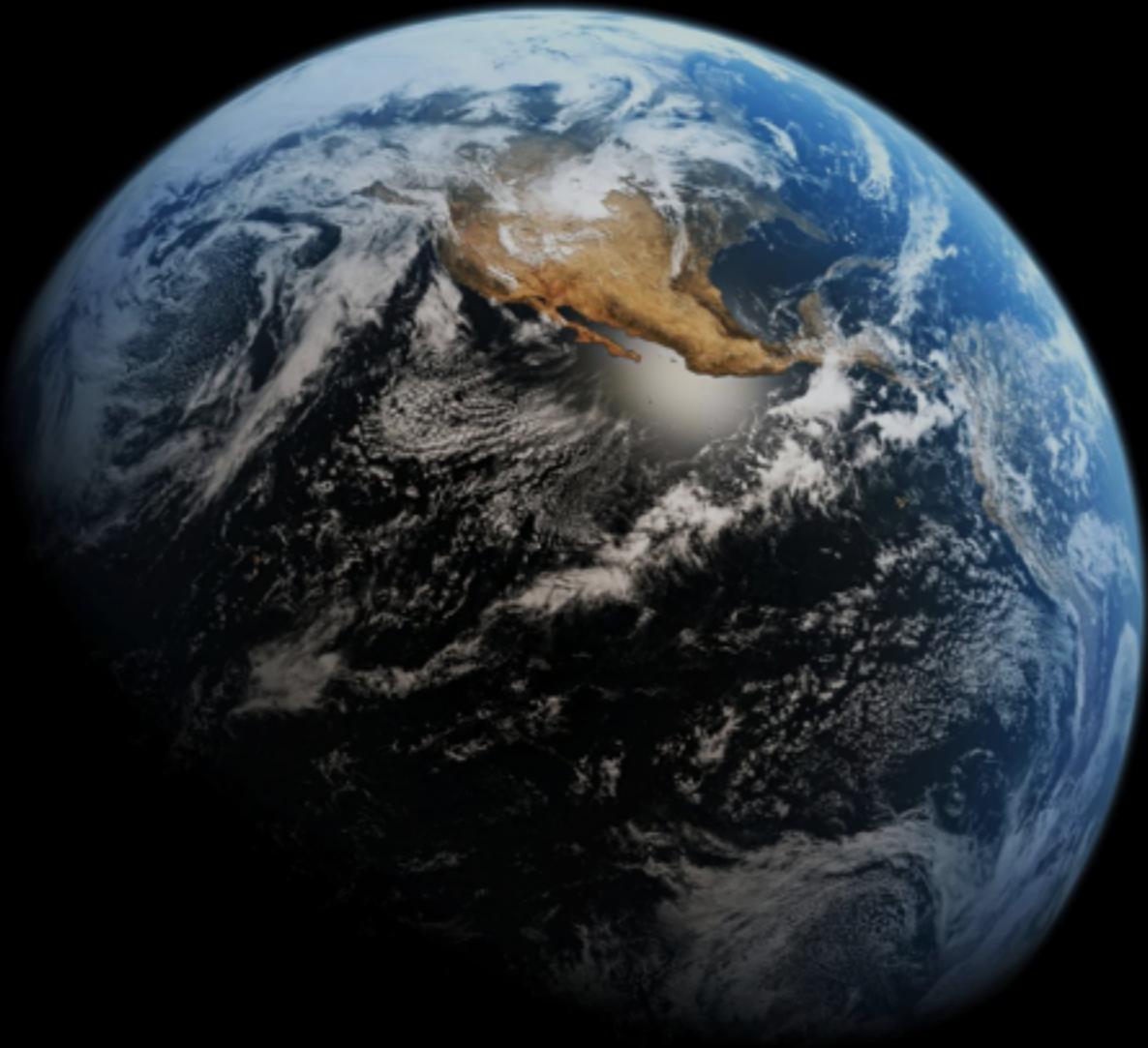
C++ 11/14

clang v3.8+

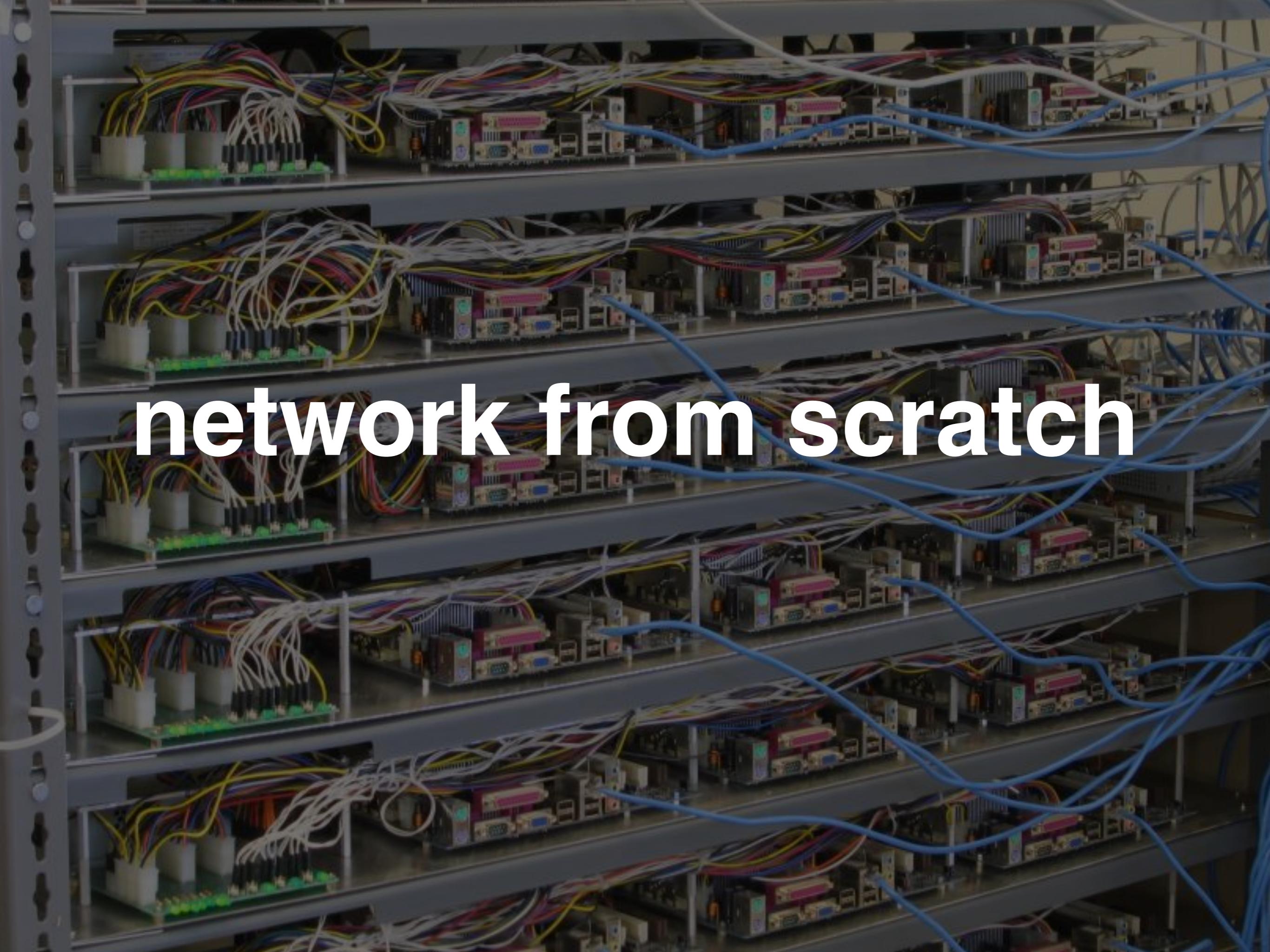
A red curtain is drawn back to reveal a white title. The curtain has gold-colored metal rings at the top and bottom.

# c++11 features used

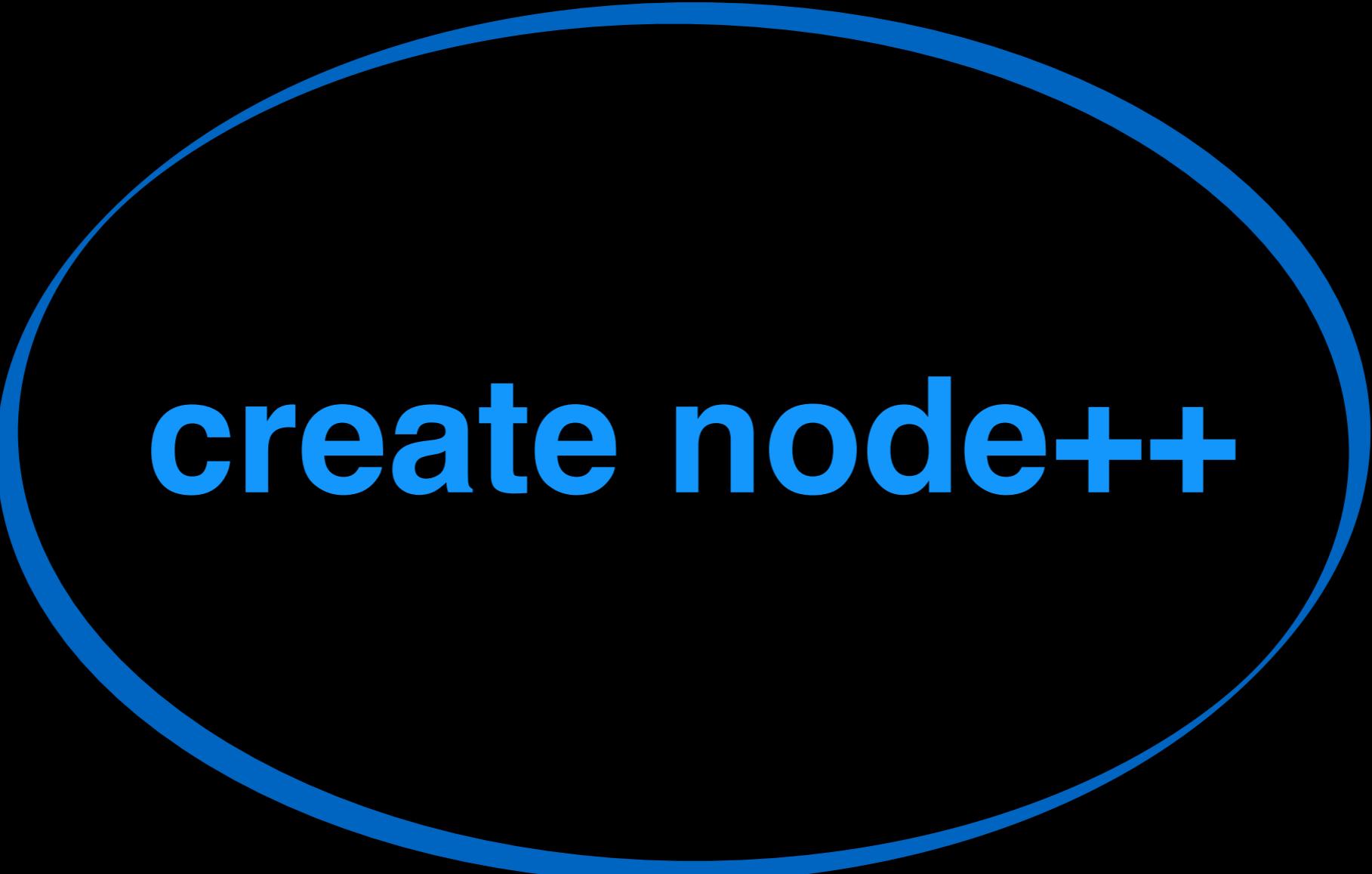
delegates  
user defined literals



**hello world is 1/3 the  
size of JVM hello world  
even with hypervisor**

A photograph showing a multi-tiered server rack filled with various electronic components and a complex web of colored cables, primarily blue and yellow.

**network from scratch**



**create node++**

# OS.a

irq manager  
pic manager  
pit-timer  
device drivers



overbooking  
75k VMs on One Host



redhat.

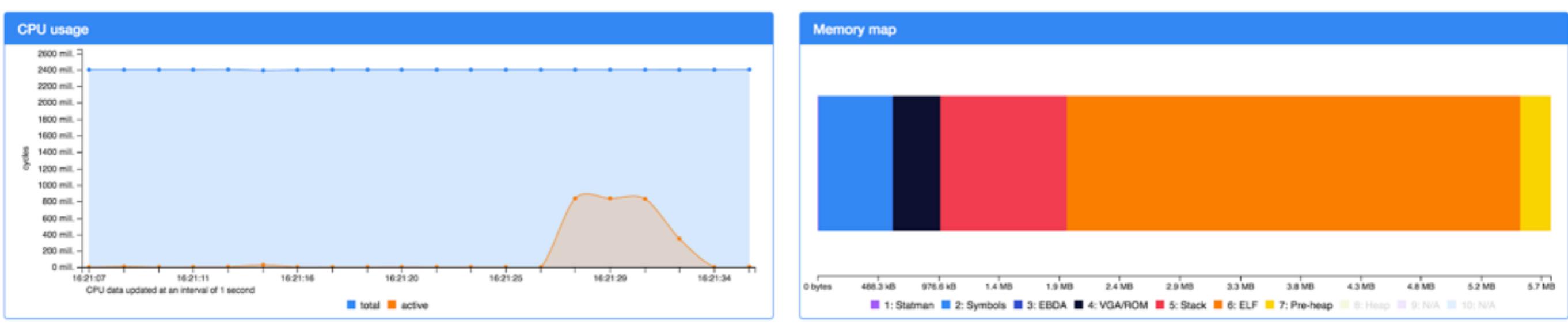
**newlib**

The background of the slide features a dark blue space-themed image. It includes a large, swirling nebula with shades of purple, blue, and yellow, and a bright green planet on the right side, partially visible.

**Stats**

**Profiling**

**Memory map**



### Statman

Name	Value
cmos.now	2
timers.oneshot_started	126671
timers.oneshot_stopped	126622
timers.periodic_started	4
timers.periodic_stopped	0
syscalls.sbrk	46
cpu0.cycles_hit	262491871133
cpu0.cycles_total	278033047561
irq.126	0
irq.0	113552
eth0.packets_rx	190060
eth0.packets_tx	127014
irq.64	63987
irq.65	63557
irq.66	0
irq.67	63392
memdisk0.reads	85216
eth0.ethernet.packets_rx	190061
eth0.ethernet.packets_tx	127014
eth0.ethernet.packets_dropped	0
eth0.arp.requests_rx	3
eth0.arp.requests_tx	0
eth0.arp.replies_rx	0
eth0.arp.replies_tx	3
eth0.ip4.packets_rx	190058
eth0.ip4.packets_tx	127011
eth0.ip4.packets_dropped	0
eth0.tcp.bytes_rx	1554572
eth0.tcp.bytes_tx	91556011
eth0.tcp.packets_rx	190058

### TCP 10.0.0.42 (eth0)

Local	Remote	Recv	Sent	State
10.0.0.42:8081	195.159.159.10:56578	138.9 kB	683.6 kB	ESTABLISHED
10.0.0.42:8081	195.159.159.10:56598	28.7 kB	17.5 kB	ESTABLISHED
10.0.0.42:8081	195.159.159.10:56599	17.4 kB	5.7 kB	ESTABLISHED
10.0.0.42:8081	195.159.159.10:56600	60.4 kB	212.1 kB	ESTABLISHED

### Stack Sampler

Active: 3.40 % Asleep: 96.60 %

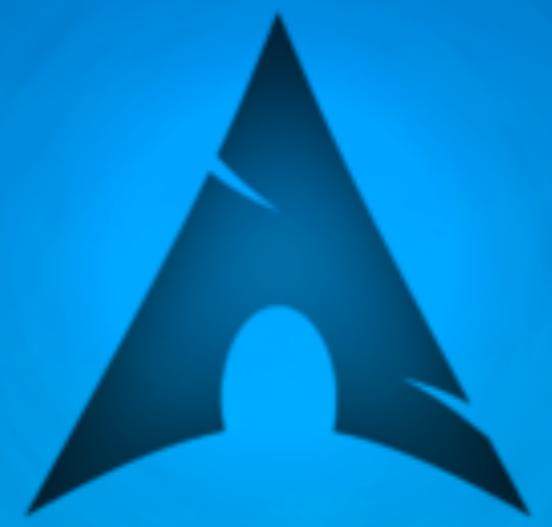
Percent	Total	Addr	Function
20.46	791	0x237920	Virtio::Queue::kick()
6.49	251	0x28d280	_malloc_r
4.16	161	0x239f90	net::TCP::checksum(std::__l::shared_ptr<net::tcp::Packet>)
3.96	153	0x28c2c0	_free_r
3.23	125	0x225840	VirtioNet::msix_recv_handler()
2.51	97	0x28dedc	
2.48	96	0x300460	std::__l::__shared_weak_count::__release_shared()
2.28	88	0x2b5460	bool std::__l::basic_regex<char, std::__l::regex_traits<char>>::__match_at_start_ecma<std::__l::allocator<std::__l::sub_match<char const*> >>(char const*, char const*, std::__l::match_results<char const*, std::__l::allocator<std::__l::sub_match<char const*> >>, std::__l::regex_constants::match_flag_type, bool) const
1.66	64	0x293970	_svfprintf_r
1.55	60	0x23e110	net::tcp::Connection::rtx_start()
1.03	40	0x233c40	hw::Serial::write(char)
1.01	39	0x3398e5	operator new(unsigned int)

### Logger

```

GET /api/squirrels/
GET /api/users/
GET /api/users/:id(\d+)/:name/something/:something([a-z]+)

```



**few tweaks**

	include OS	rump kernel	OSv	clickOS
“Posix”	X	✓	✓	X
Size	2Mb	16Mb	29MB	6MB
Multiple Languages	X	✓	✓	X

<http://rumpkernel.org/>

<http://www.includeos.org/>

<http://osv.io/>

<https://deferpanic.com>

<https://github.com/deferpanic/virgo>

<http://www.meetup.com/San-Francisco-Unikernels/>