containerization: more than the new virtualization

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- Grumpy French DevOps
  - Go away or I will replace you with a very small shell script
- Runs everything in containers
  - Docker-in-Docker
  - VPN-in-Docker
  - KVM-in-Docker
  - Xorg-in-Docker
  - …

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outline

Outline

- Containers as lightweight VMs
- Containers vs VMs
- Separation of operational concerns
- Benefits
- Conclusions


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containers as lightweight VMs

It looks like a VM

- Private process space
- Can run stuff as root
- Private network interface and IP address
- Custom routes, iptables rules, etc.
- Can mount filesystems and more

Process tree in a “machine container”

```
PID TTY      STAT   TIME COMMAND
  1 ?        Ss+    0:00 /usr/bin/python3 -u /sbin/my_init --enable-insecure-key
104 ?        S+     0:00 /usr/bin/runsvdir -P /etc/service
105 ?        Ss     0:00  \_ runsv syslog-ng
108 ?        S      0:00  |   \_ syslog-ng -F -p /var/run/syslog-ng.pid --no-caps
106 ?        Ss     0:00  \_ runsv sshd
109 ?        S      0:00  |   \_ /usr/sbin/sshd -D
117 ?        Ss     0:00  |       \_ sshd: root@pts/0
119 pts/0    Ss     0:00  |           \_ -bash
135 pts/0    R+     0:00  |               \_ ps fx
107 ?        Ss     0:00  \_ runsv cron
110 ?        S      0:00      \_ /usr/sbin/cron -f
```

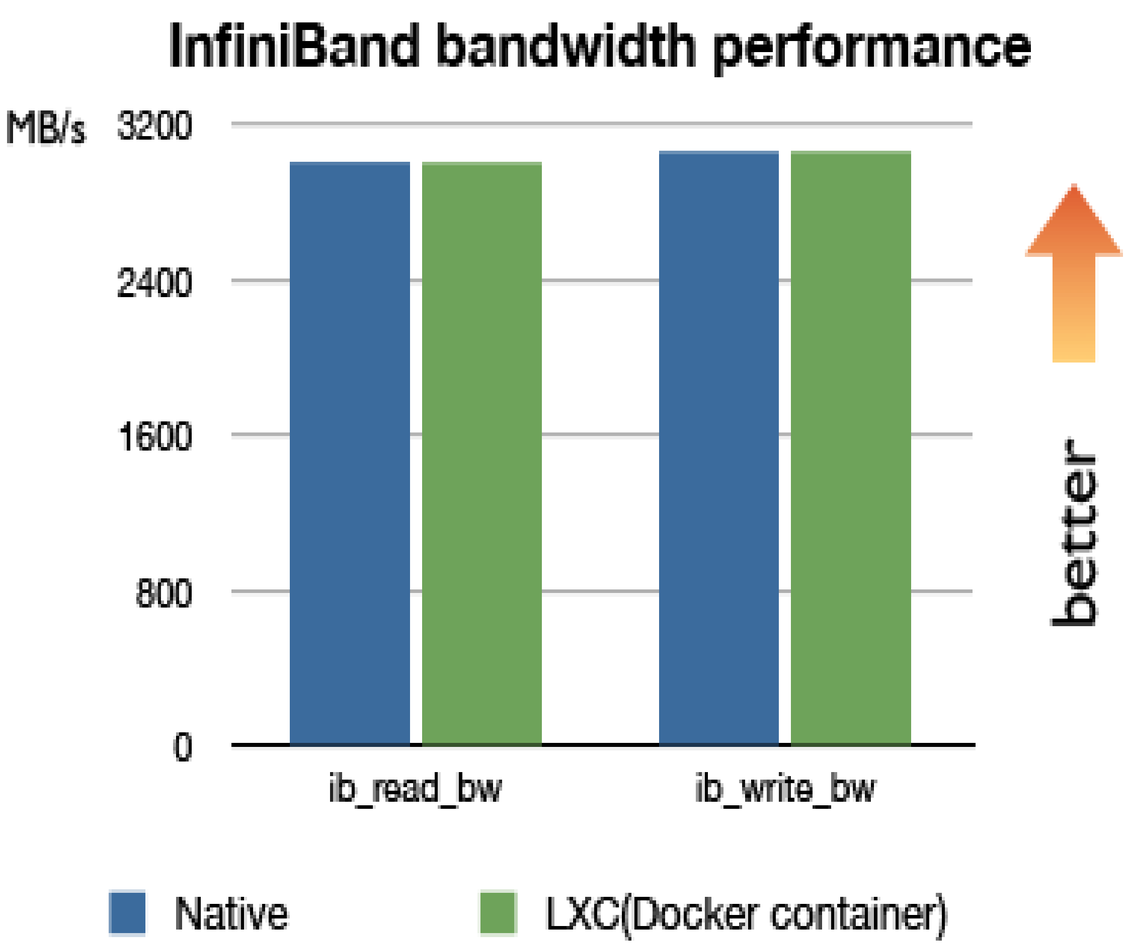
Faster to boot, less overhead than a VM

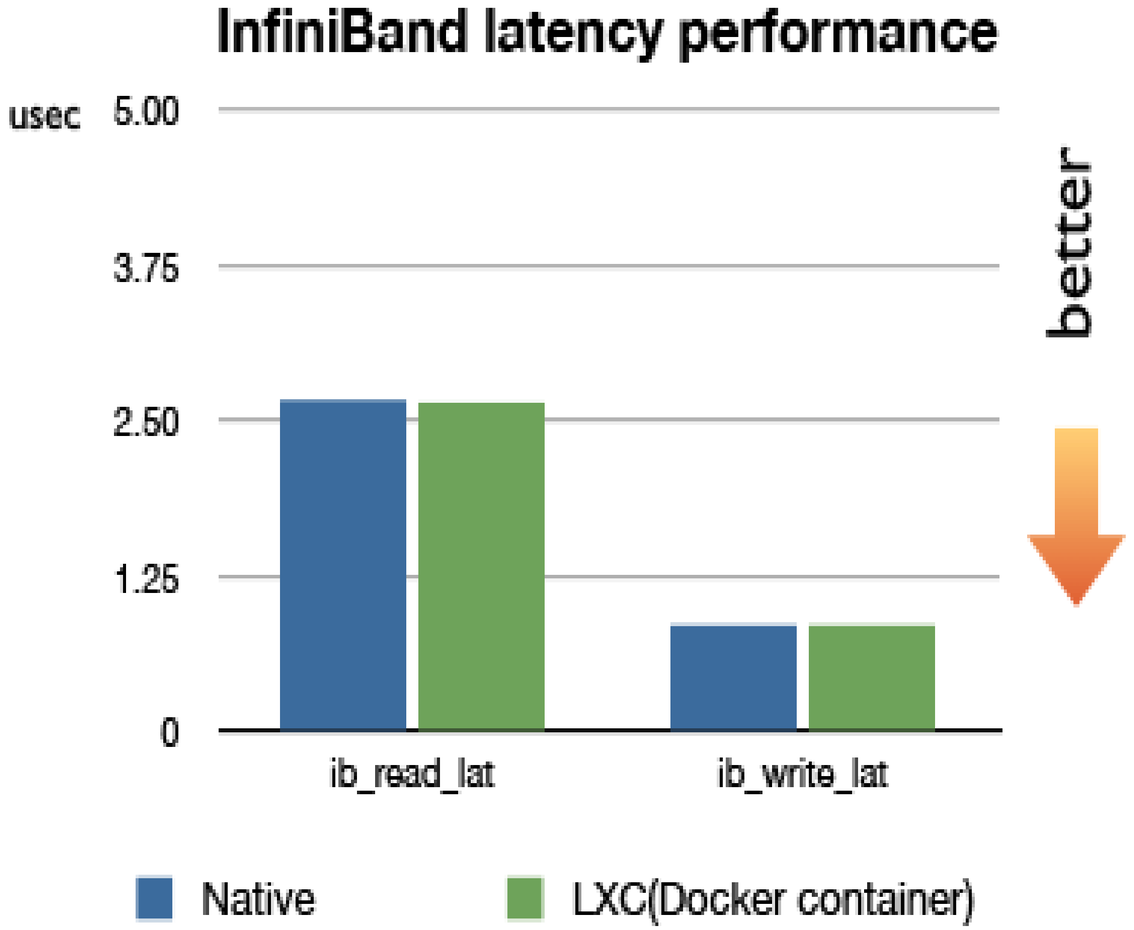
```
$ time docker run ubuntu echo hello world
hello world
real 0m0.258s
```

Disk usage: less than 100 kB

Memory usage: less than 1.5 MB

Benchmark: infiniband





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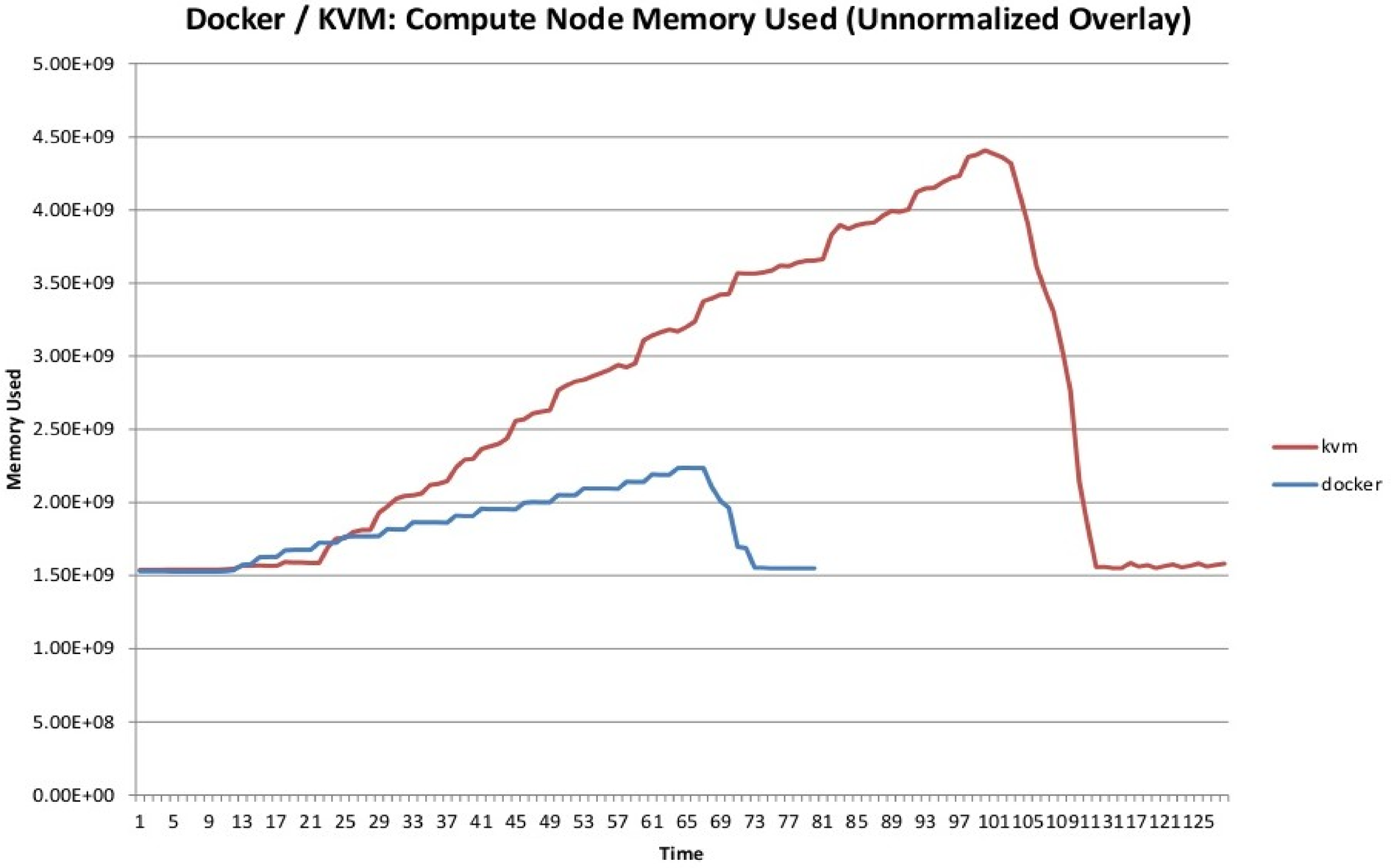
Benchmark: boot OpenStack instances



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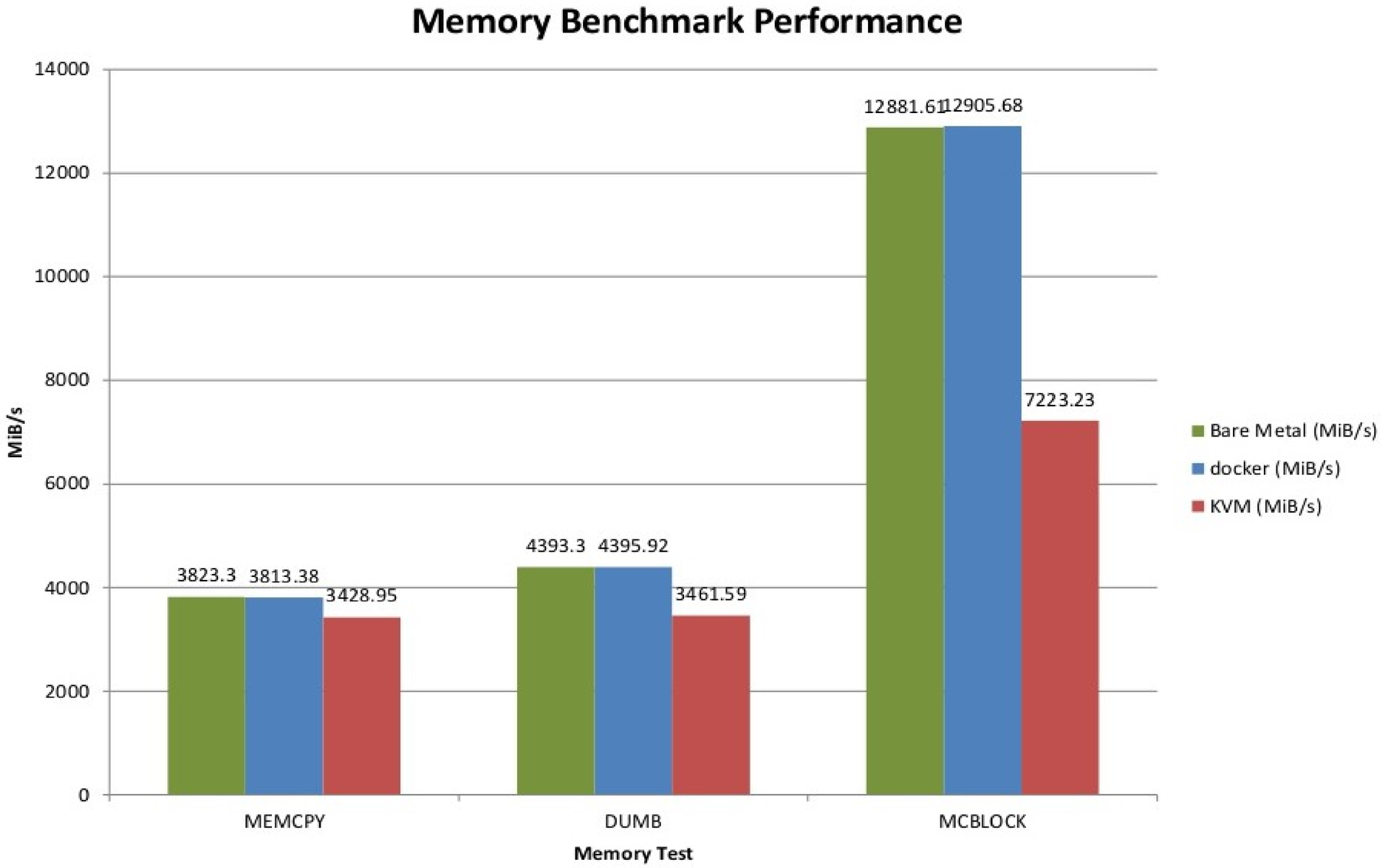
Benchmark: memory speed



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impossibru!


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containers
vs
virtual machines

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Virtual Machines

- Emulate CPU instructions
  (painfully slow)
- Emulate hardware (storage, network...)
  (painfully slow)
- Run as a userland process on top of a kernel
  (painfully slow)

Virtual Machines

- Use native CPU
  (fast!)
- Paravirtualized storage, network...
  (fast, but higher resource usage)
- Run on top of a hypervisor
  (faster, but still some overhead)

Containers

- Processes isolated from each other
- Very little extra code path
  (in many cases, it's comparable to UID checking)

Virtual Machines vs Containers

- Native CPU
- Paravirtualized devices
- Hypervisor

- Native CPU
- Native syscalls
- Native kernel

Inter-VM communication

- Strong isolation, enforced by hypervisor + hardware
  - no fast-path data transfer between virtual machines
  - yes, there are PCI pass-throughs and things like xenbus,
    but that's not easy to use, very specific, not portable
- Most convenient method: network protocols (L2/L3)
- But: huge advantage from a security POV

Inter-container communication

- Tunable isolation
  - each namespace can be isolated or shared
- Allows normal Unix communication mechanisms
  - network protocols on loopback interface
  - UNIX sockets
  - shared memory
  - IPC...
- Reuse techniques that we know and love (?)

inter-container communication

Shared localhost

- Multiple containers can share the same “localhost” (by reusing the same network namespace)
- Communication over localhost is *very very* fast
- Also: localhost is a well-known address

Shared filesystem

- A directory can be shared by multiple containers (by using a bind-mount)
- That directory can contain:
  - named pipes (FIFOs)
  - UNIX sockets
  - memory-mapped files
- Bind-mount = zero overhead

Shared IPC

- Multiple containers can share IPC resources (using the special IPC namespace)
- Semaphores, Shared Memory, Message Queues...
- Is anybody still using this?

Host networking

- Containers can share the host's network stack (by reusing its network namespace)
- They can use the host's interfaces without penalty (high speed, low latency, no overhead!)
- Native performance to talk with external containers

Host filesystems

- Containers can share a directory with the host
- Example: use fast storage (SAN, SSD...) in container
  - mount it on the host
  - share it with the container
  - done!
- Native performance to use I/O subsystem


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separation of operational concerns

…What?

- "Ops" functions (backups, logging…) can be performed in ***separate*** containers
- Application containers can run ***unchanged*** in various environments: dev, test, QA, prod…

logs

Old style

- ssh into container
- cd /var/log
- tail, grep, ack-grep, awk, sed, apachetop, perl, etc.

New style

- Create a “data container” to hold the logs

```
docker run --name logs -v /var/log busybox true
```

- Start app container sharing that volume

```
docker run --volumes-from logs myapp
```

- Inspect logs

```
docker run -ti --volumes-from logs -w /var/log ubuntu bash
```

- Use fancy tools without polluting app container

```
docker run -ti --volumes-from logs turbogrep ...
```

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Bonus points

- Ship logs to something else (logstash, syslog...)

```
docker run --volumes-from logs pipestash
```

- Change logging system independently:
  - without rebuilding app container
  - without restarting app container
  - run multiple logging systems at the same time (e.g. for migration)

backups

Old style

- Prepare the tools
  - install things like rsync, s3cmd, boto, mysqldump...
  - get backup script
- Perform one-shot manual backup
  - SSH and run the backup script
- Set up routine backups
  - edit crontab

New style: setup

- Create a “data container” to hold the files to back up

```
docker run --name mysqldata -v /var/lib/mysql busybox true
```

- Start app container sharing that volume

```
docker run --volumes-from mysqldata mysql
```

- Create a separate image with backup tools
  - Dockerfile with “apt-get install rsync s3cmd...”

New style: one-shot manual backup

- Use the special backup image

```
docker run --rm --volumes-from mysqldata mysqlbackup \
       tar -cJf- /var/lib/mysql | stream-it-to-the-cloud.py
```

- Of course, you can use something fancier than tar (e.g. rsync, tarsnap...)

New style: routine backups

- Option 1
  - run “crond” in backup image
  - start backup image and keep it running
- Option 2
  - start backup script from a crontab entry on the Docker host
- Option 3
  - have a special “cron” container
  - give it access to the Docker API
  - let it start the backup container at regular intervals

network debugging

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Old style

- ssh into container
- Install tcpdump, ngrep, …
- Run them

New style

- Make a container image with tcpdump, ngrep... (let's call it “netdebug”)
- Run it in the namespace of the application container

```
docker run -ti --net container:<app_cid> netdebug bash
```

- Now run tcpdump, ngrep, etc.
- Want to copy a dump to see it with wireshark?

```
docker run -ti --net container:... -v /tmp:/tmp netdebug \
       tcpdump -s0 -peni eth0 -w/tmp/myapp.pcap
```

configuration tweaking

Old style

- ssh into container
- vi /etc/tomcat/something.xml
- (maybe) /etc/init.d/tomcat restart

New style

- Option 1
  - set up /etc/tomcat to be a “data container”
  - start another container sharing this volume; install vi/emacs here
- Option 2
  - set up /etc/tomcat to be on the host:

    ```
    docker run -v /etc/containers/myapp:/etc/tomcat …
    ```
- If needed: restart the container
  - `docker  stop; docker start`
  - `docker kill -s HUP`

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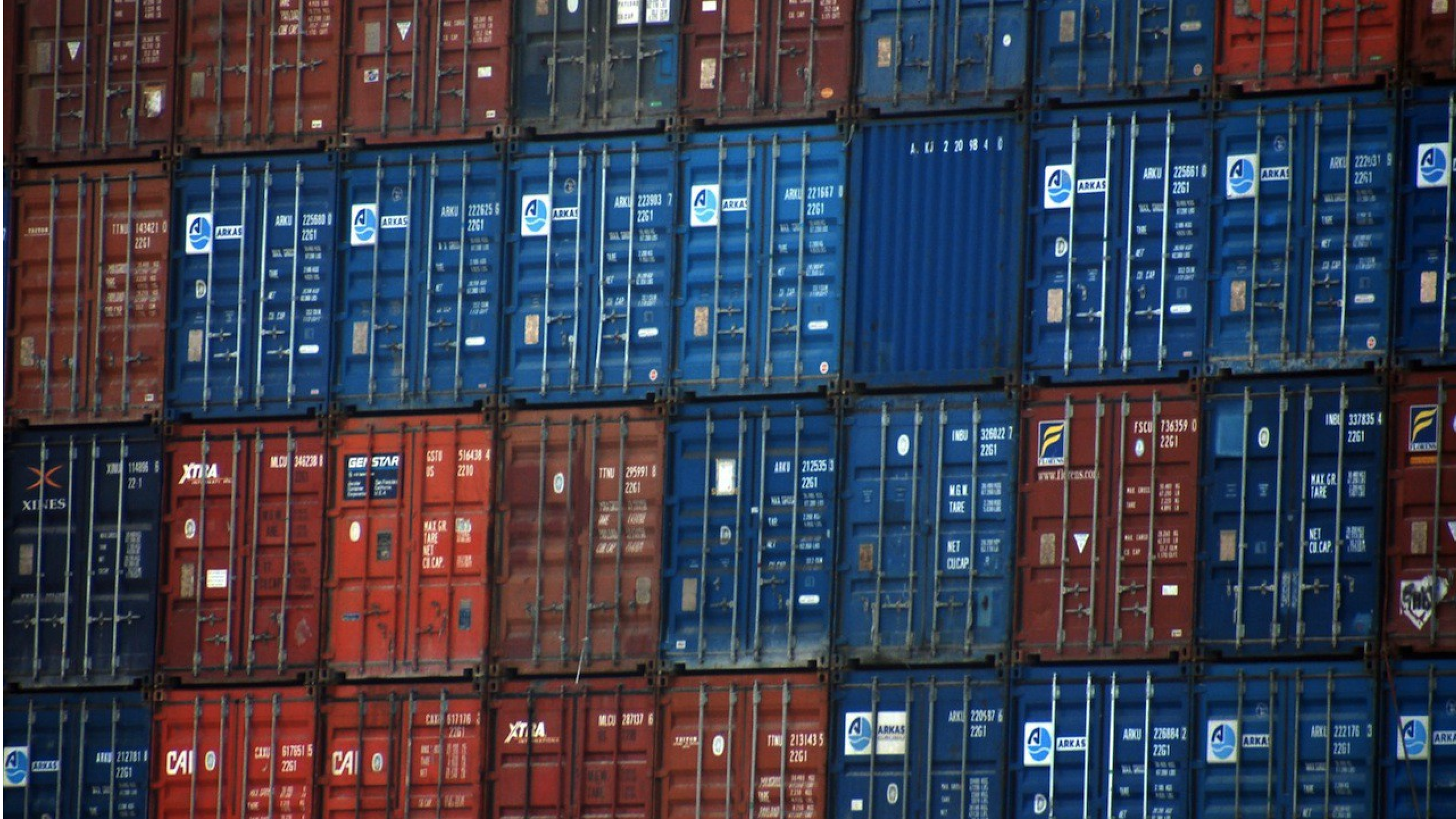
ARKAS
XTRA
GESTAR
MAX GR.
TARE
NET
CU.CAP.

epiphany


DOCKWISE
BLUE MARLIN
DOCKWISE

composition

Virtual Machine deployment

- Linux base system
- Libraries
- Application
- Logging
- Backups
- Metrics
- ...

With configuration management

```
node www {
    include common
    include web
    include logstash
    include backup
    include graphite
}
```

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Problems

- Conflicts between two components
  - example: logging and metrics systems use different Java versions
- Software certified for different distro
  - example: one component requires RHEL 6.4 but you run Ubuntu
- Migration from one component to another
  - example: from syslog to splunk

Container deployment

- Linux base system
- Docker
- Application container
- Logging container
- Backups container
- Metrics container
- …

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benefits

Immutable infrastructure

- What's an immutable infrastructure?
  - re-create images each time you change a line of code
  - prevent (or track) modifications of running images
- Why is it useful?
  - no more rebellious servers after manual upgrades
  - no more “oops, how do we roll back?” after catastrophic upgrade
  - easier security audit (inspect images at rest)
- How can containers help?
  - container images are easier to create and manage than VM images

Micro-service architecture

- What's a micro-service architecture?
  - break your big application down into many small services
- Why is it useful?
  - it's easier to upgrade/refactor/replace a small service
  - encourages to have many small teams*, each owning a service
    *(*small teams are supposedly better; see Jeff Bezos' "two-pizza rule")*
- How can containers help?
  - problem: 10 micro-services instead of 1 big application
    = 10x more work to deploy everything
  - solution: need extremely easy deployment; hello containers!


docker
docker

thank you!

questions?

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