June 2017

DC/OS AND FAST DATA (THE SMACK STACK)

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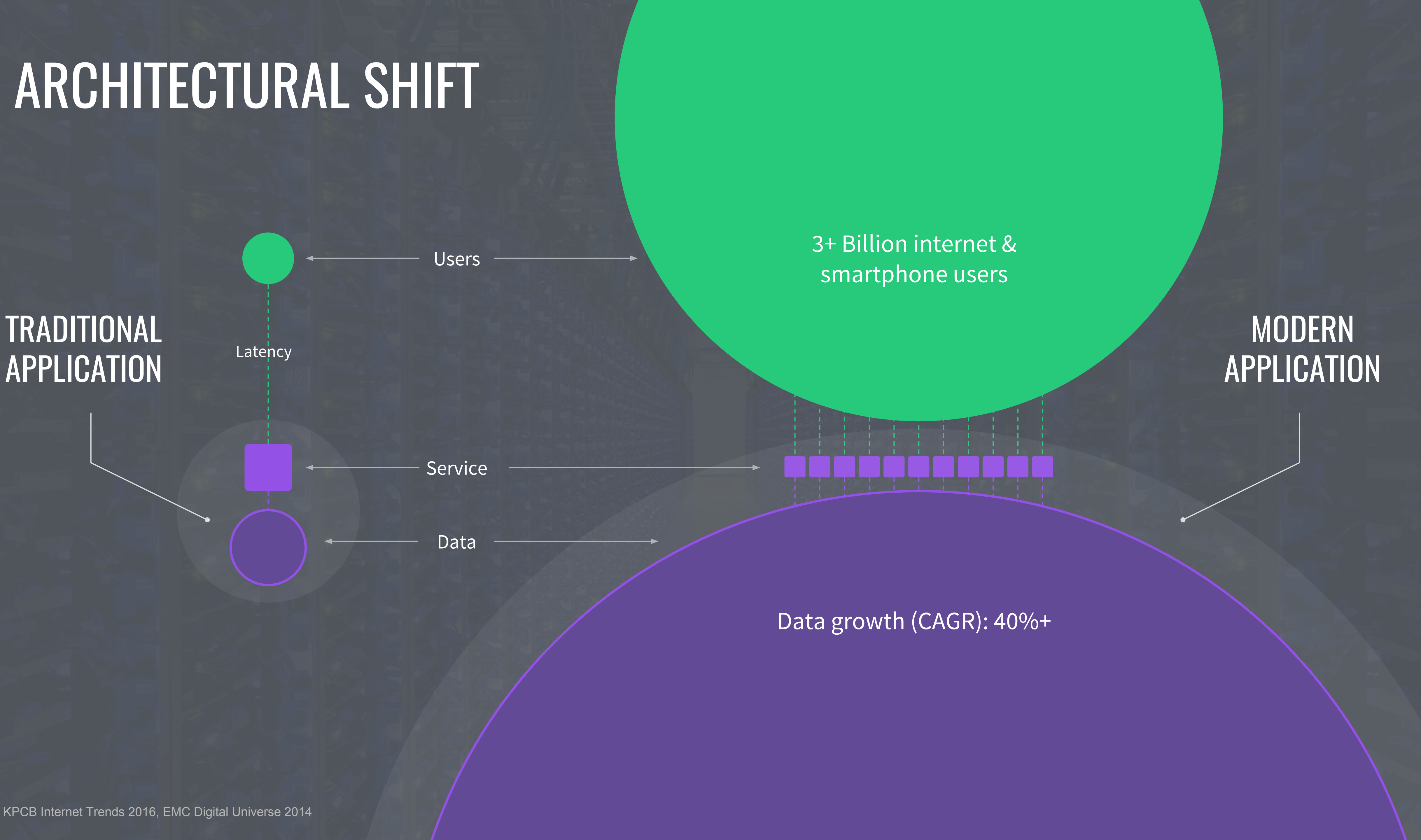
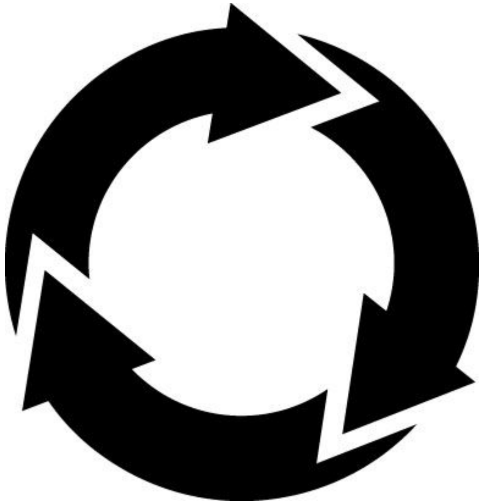
ARCHITECTURAL SHIFT



Source: KPCB Internet Trends 2016, EMC Digital Universe 2014

TODAY'S REINFORCING TRENDS

CONTAINERIZATION



MICROSERVICES

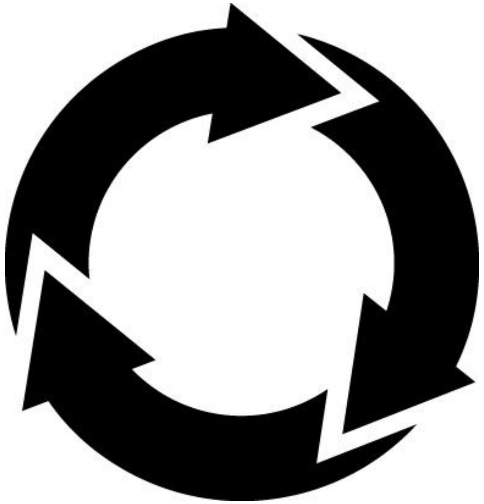
CONTAINER ORCHESTRATION

BIG DATA & ANALYTICS

TODAY'S REINFORCING TRENDS

CONTAINERIZATION

MICROSERVICES



CONTAINER ORCHESTRATION

FAST ~~BIG~~ DATA & ANALYTICS

FROM BIG DATA TO FAST DATA

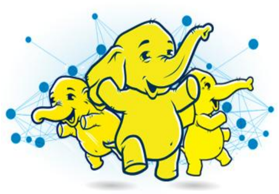
Days *Hours* *Minutes* *Seconds* *Microseconds*

Batch → **Micro-Batch** → **Event Processing**

Reports what has happened using descriptive analytics

Solves problems using predictive and prescriptive analytics

Billing, Chargeback



Product recommendations

Customers Who Bought This Item Also Bought

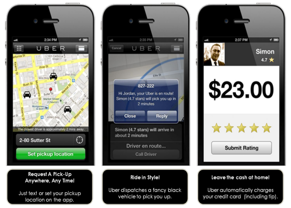
TV Mount 32"-70" Loctek

Black Friday! Loctek Curved Panel UHD HD TV Wall Mount Bracket Articulating Arm Swivel & ★★★★☆ 37

AmazonBasics High-Speed HDMI Cable - 6.5 Feet (2 Meters) Supports Ethernet, 3D, 4K and Audio Return ★★★★☆ 34,529

Cheetah Mounts APTMM2B TV Wall Mount for 32-65" TVs (Many from 20-75") Specifically fits up ★★★★☆ 10,239

Real-time Pricing and Routing



2:34 PM UBER

The closest driver is approximately 2 mins away

2-80 Sutter St

Set pickup location

2:35 PM Cancel UBER

827-222

Hi Jordan, your Uber is en route! Simon (4.7 stars) will pick you up in 2 minutes

Close Reply

Simon (4.7 stars) will arrive in about 2 minutes

Driver en route...

Call Driver

2:37 PM Simon 4.7 ★

$23.00

★★★★★

Submit Rating

Request A Pick-Up Anywhere, Any Time!

Just text or set your pickup location on the app.

Ride in Style!

Uber dispatches a fancy black vehicle to pick you up.

Leave the cash at home!

Uber automatically charges your credit card (including tip).

Real-time Advertising

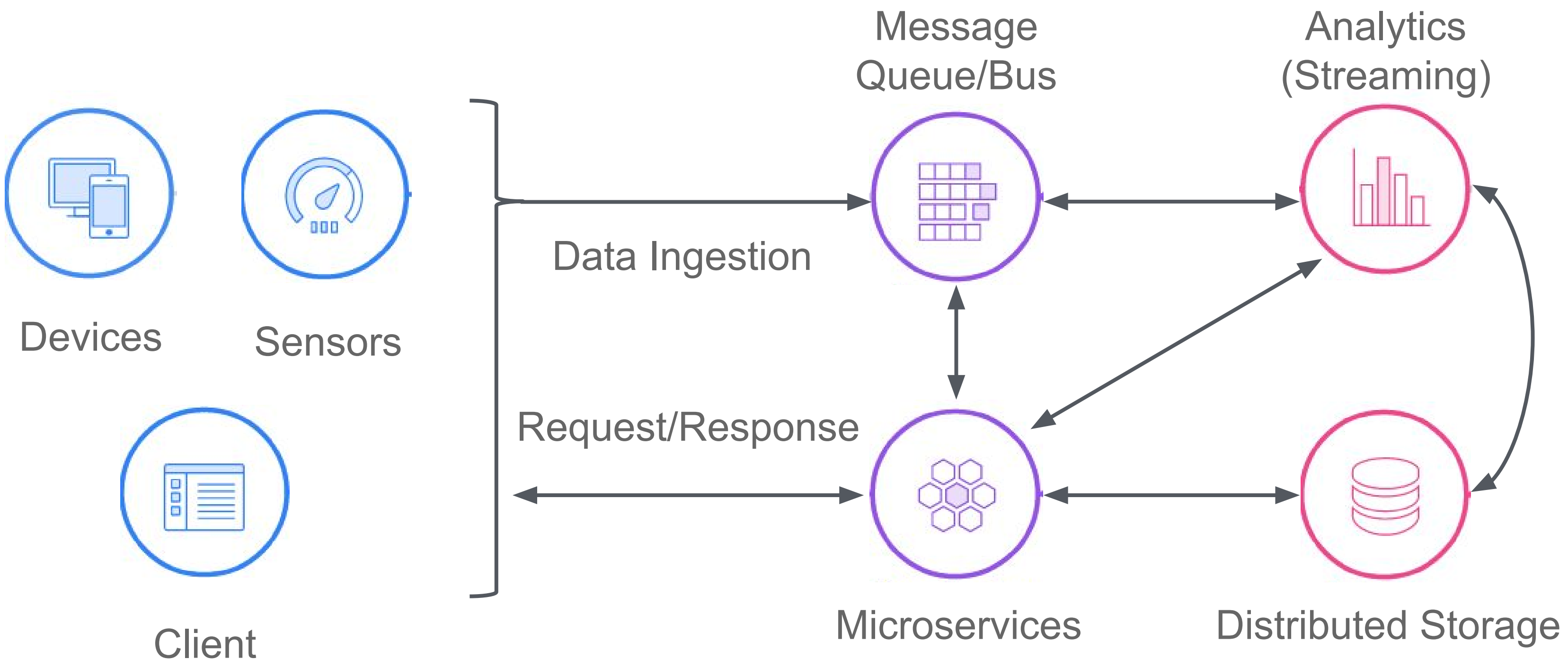
Predictive User Interface

ON THE EDGE, AND STILL REALLY BIG!

A380-1000: 10,000 sensors in each wing; produces more than 7Tb of IoT data per day

[1] https://goo.gl/2S4q5N

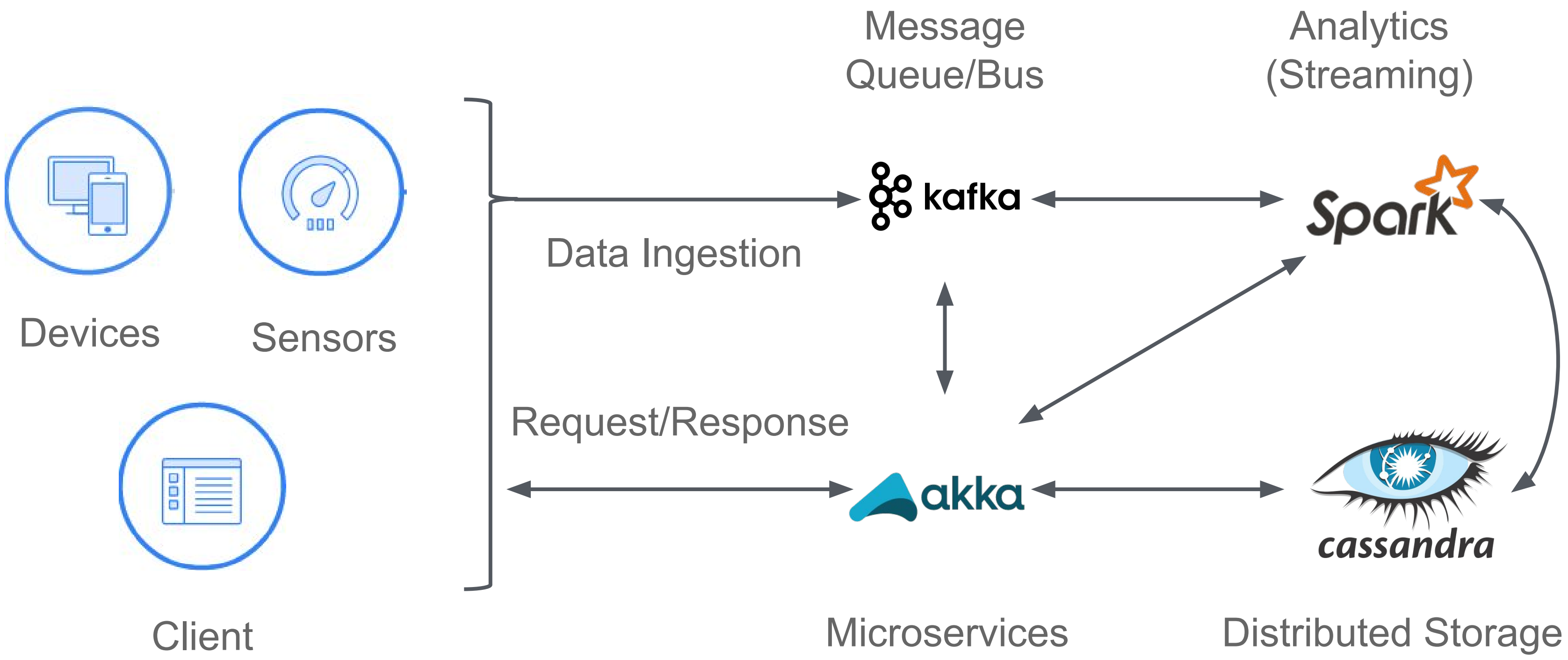
MODERN APPLICATION -> FAST DATA BUILT-IN



Use Cases:

- Anomaly detection
- Personalization
- IoT Applications
- Predictive Analytics
- Machine Learning

A GOOD STACK ...



Use Cases:

- Anomaly detection
- Personalization
- IoT Applications
- Predictive Analytics
- Machine Learning

MESSAGE QUEUES

Message Brokers

- Apache Kafka
- ØMQ, RabbitMQ, Disque

Log-based Queues

- fluentd, Logstash, Flume

see also queues.io

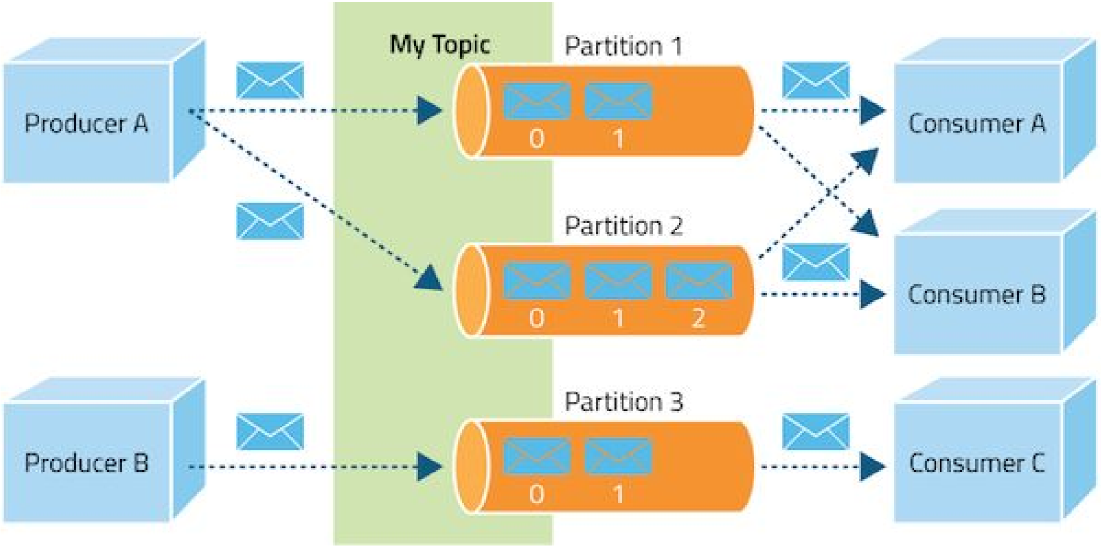
kafka

RabbitMQ

fluentd

logstash

APACHE KAFKA



Typical Use: A reliable buffer for stream processing

Why Kafka?

- High-throughput, distributed, persistent publish-subscribe messaging system
- Created by LinkedIn; used in production by 100+ web-scale companies [1]

[1] https://cwiki.apache.org/confluence/display/KAFKA/Powered+By

DELIVERY GUARANTEES

- **At most once**—Messages may be lost but are never redelivered
- **At least once**—Messages are never lost but may be redelivered (Kafka)
- **Exactly once**—Messages are delivered once and only once (this is what everyone actually wants, but no one can deliver!)

Murphy's Law of Distributed Systems:

Anything that can go wrong, will go wrong … partially!

STREAMING ANALYTICS

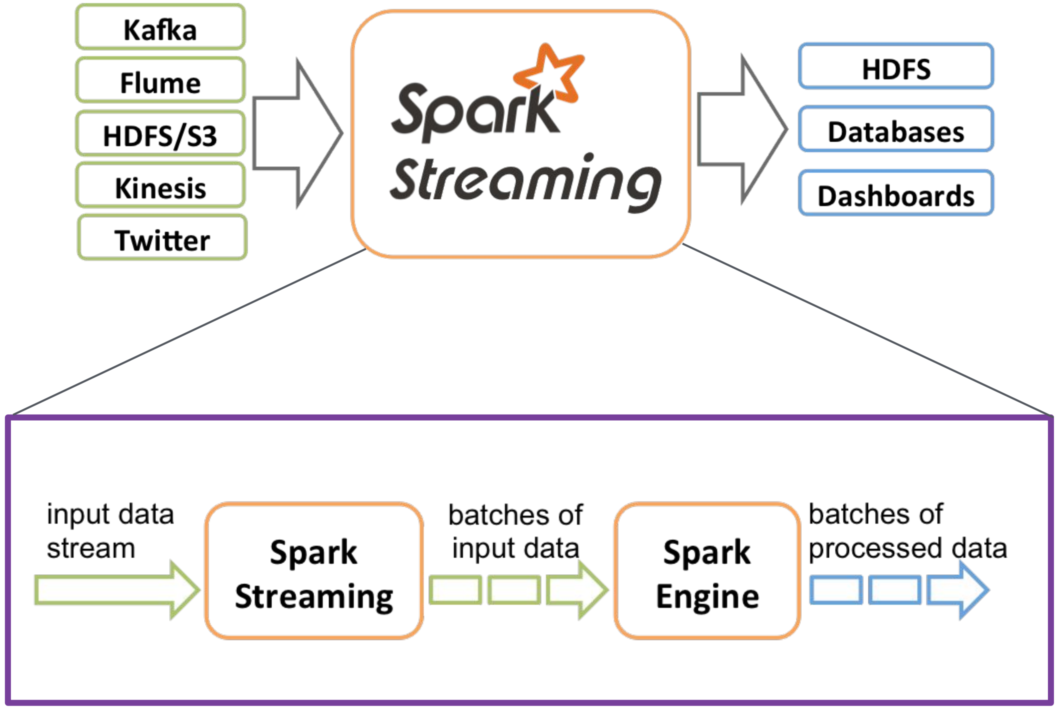
Microbatching

- Apache Spark (Streaming)

Native Streaming

- Apache Flink
- Apache Storm/Heron
- Apache Apex
- Apache Samza

APACHE SPARK (STREAMING)



Typical Use: distributed, large-scale data processing; micro-batching

Why Spark Streaming?

- Micro-batching creates very low latency, which can be faster
- Well defined role means it fits in well with other pieces of the pipeline

DISTRIBUTED STORAGE

NoSQL

- ArangoDB
- mongoDB
- Apache Cassandra
- Apache HBase

SQL

- MemSQL

Filesystems

- Quobyte
- HDFS

Time-Series Datastores

- InfluxDB
- OpenTSDB
- KairosDB
- Prometheus

see also iot-a.info

APACHE CASSANDRA

Typical Use: No-dependency, time series database

Why Cassandra?

- A top level Apache project born at Facebook and built on Amazon’s Dynamo and Google’s BigTable
- Offers continuous availability, linear scale performance, operational simplicity and easy data distribution

how do we operate these distributed systems?

most organizations have many stateless independent (micro)services, the *distributed systems* I’m talking about here are …

state latency

consensus

tolerance synchronous high

tor idempotence

rate consistency dynamic

fault unreliable cap

clients network backpressure limiting replication eventual

switch

topology partial nondeterministic

asynchronous partition failure

theorem paxos

performance

scalability administrators availability

insecure bandwidth power

stateful multiple

how do we *scale the operations* of distributed systems?

SMACK STACK

Apache Spark: distributed, large-scale data processing

Apache Mesos: cluster resource manager

Akka: toolkit for message driven applications

Apache Cassandra: distributed, highly-available database

Apache Kafka: distributed, highly-available messaging system

distributed systems
are *hard* to operate

DATA & ANALYTICS DAY 2 OPS CHALLENGES

- Bare metal storage (or someone else’s problem)
- Drive down job latency and drive up utilization
- Run multiple versions simultaneously
- Upgrade complicated data systems

1: download

2: deploy

3: monitor

4: maintain

5: upgrade → goto 1

1: download

2: deploy

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fault tolerance

+ high availability

+ latency

+ bandwidth

+ CPU/mem resources

+ …

= configuration

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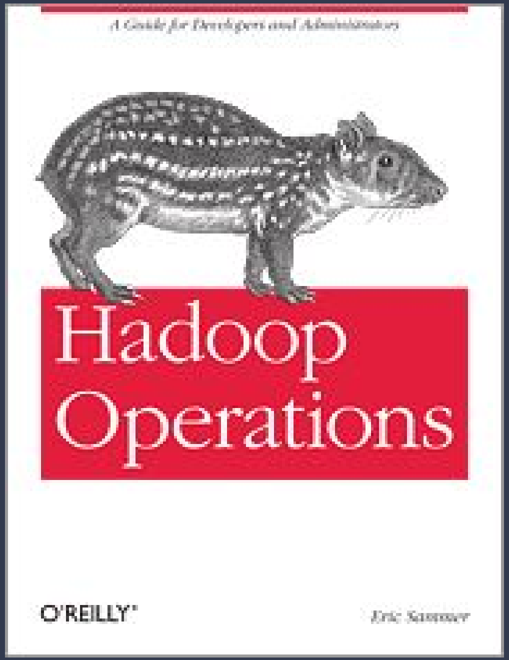

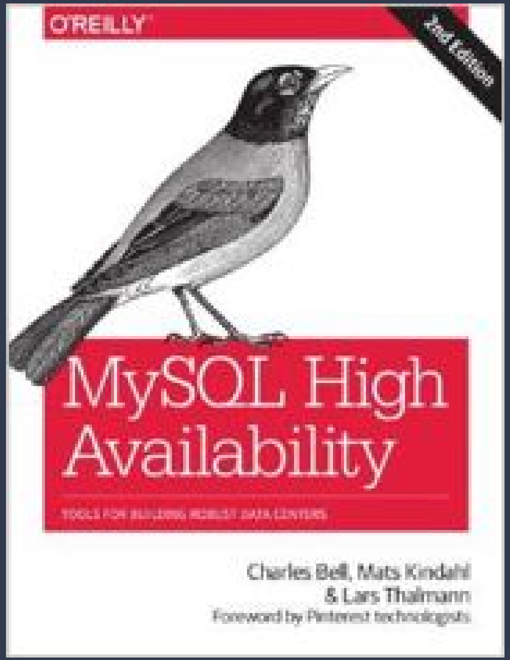
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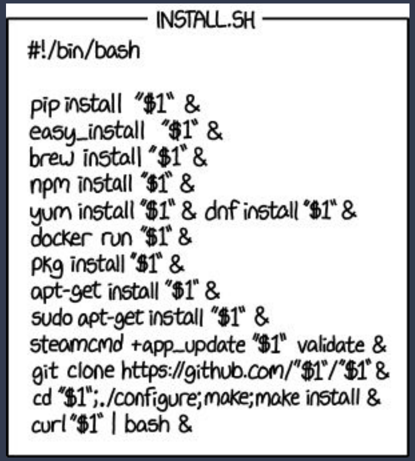

INSTALL.SH

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sudo apt-get install "$1" &
steamcmd +app_update "$1" validate &
git clone https://github.com/"$1"/"$1" &
cd "$1";./configure;make;make install &
curl "$1" | bash &
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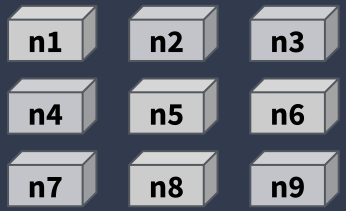

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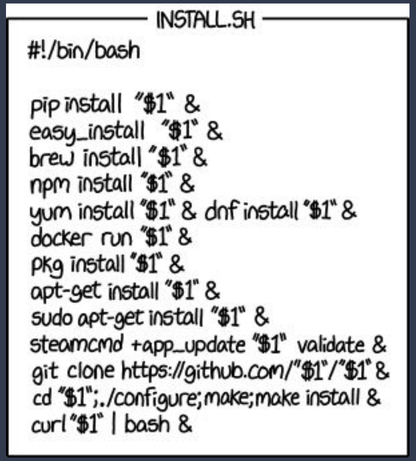

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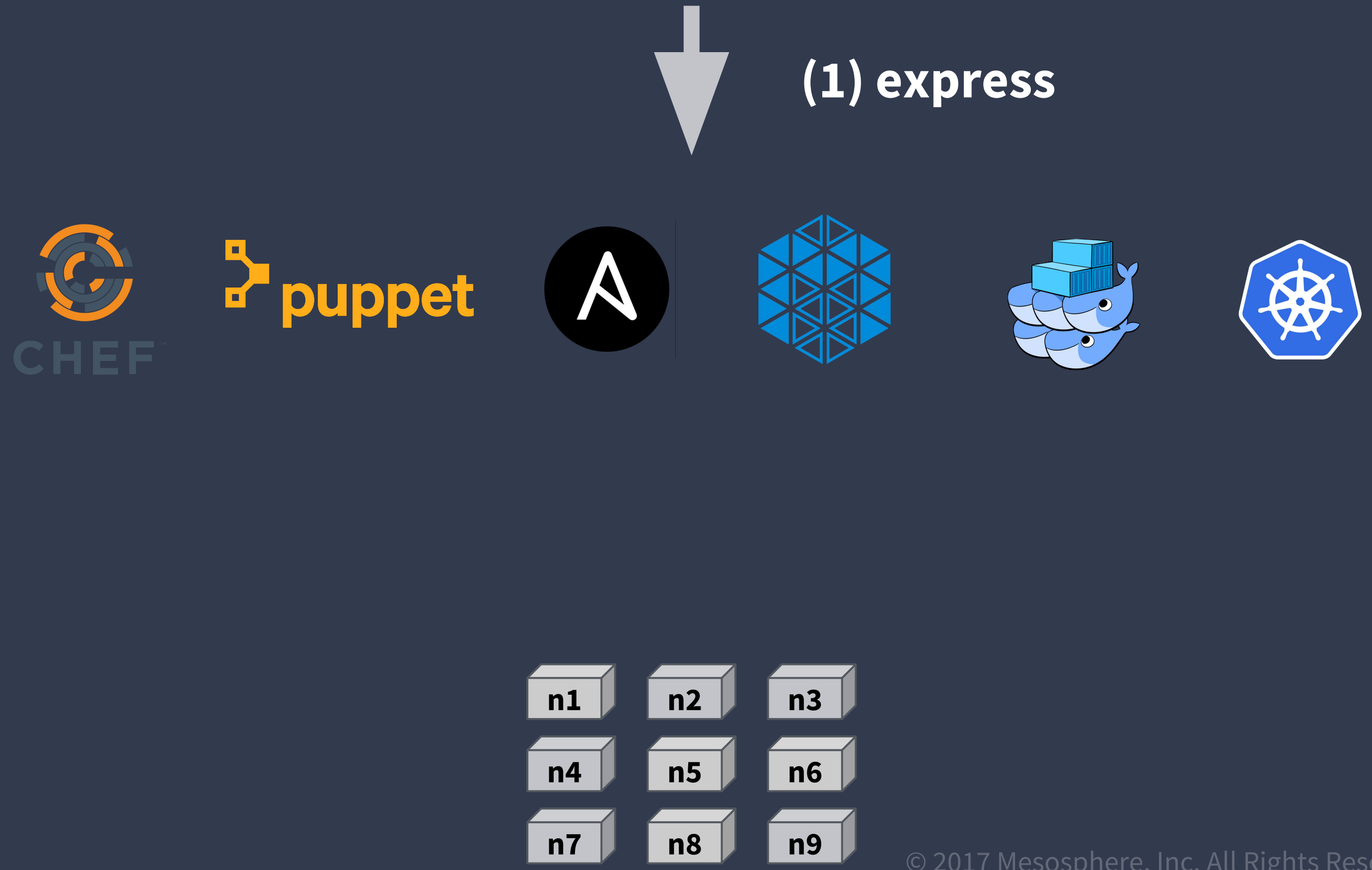


(1) express

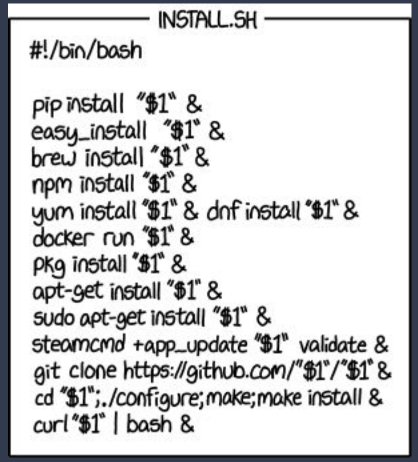
1: download

2: deploy

3: monitor

4: maintain

5: upgrade → goto 1



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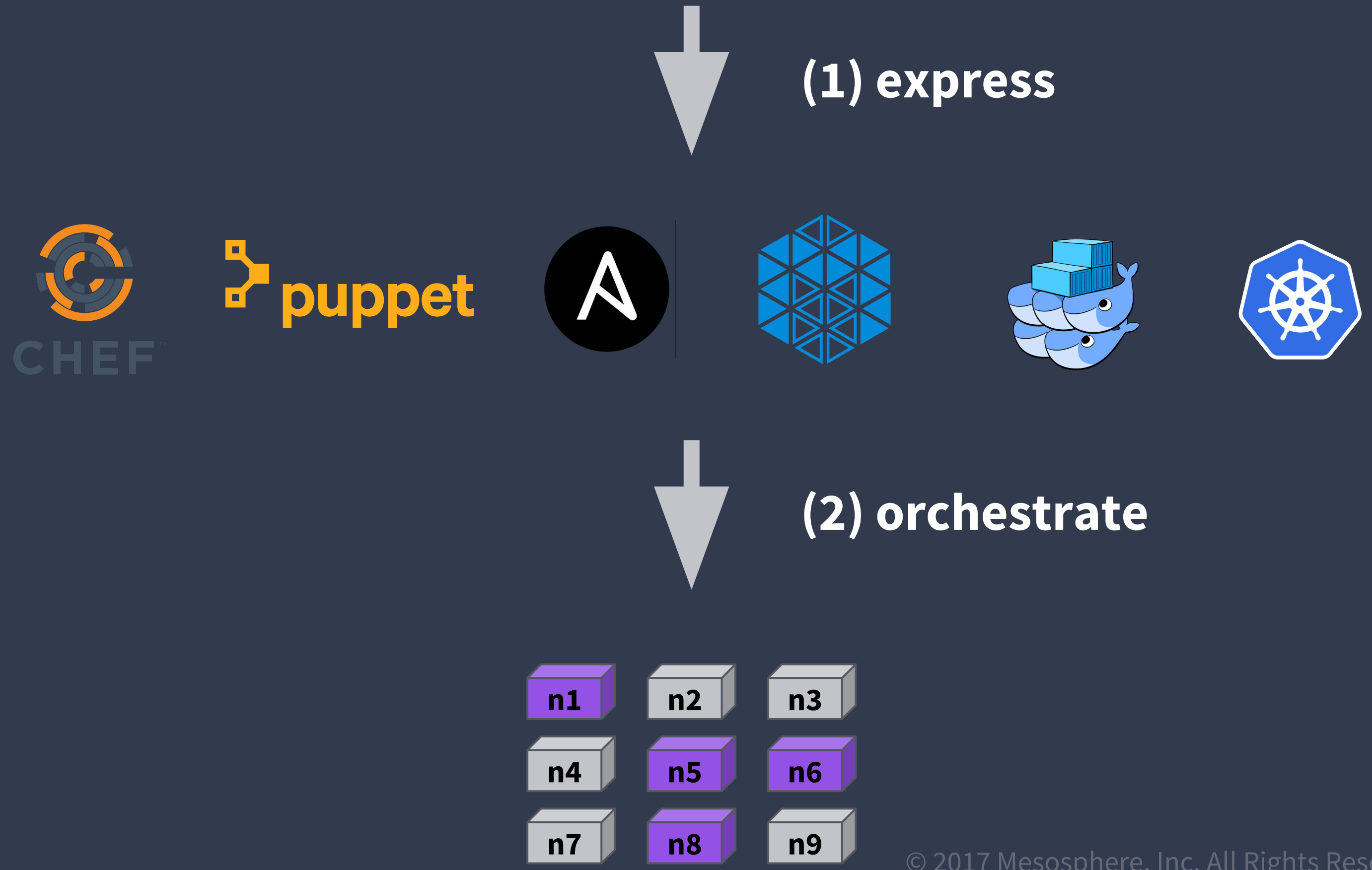

(1) express

(2) orchestrate

n1 n2 n3
n4 n5 n6
n7 n8 n9

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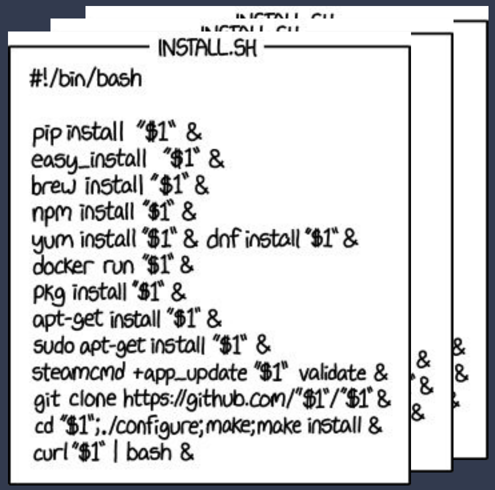

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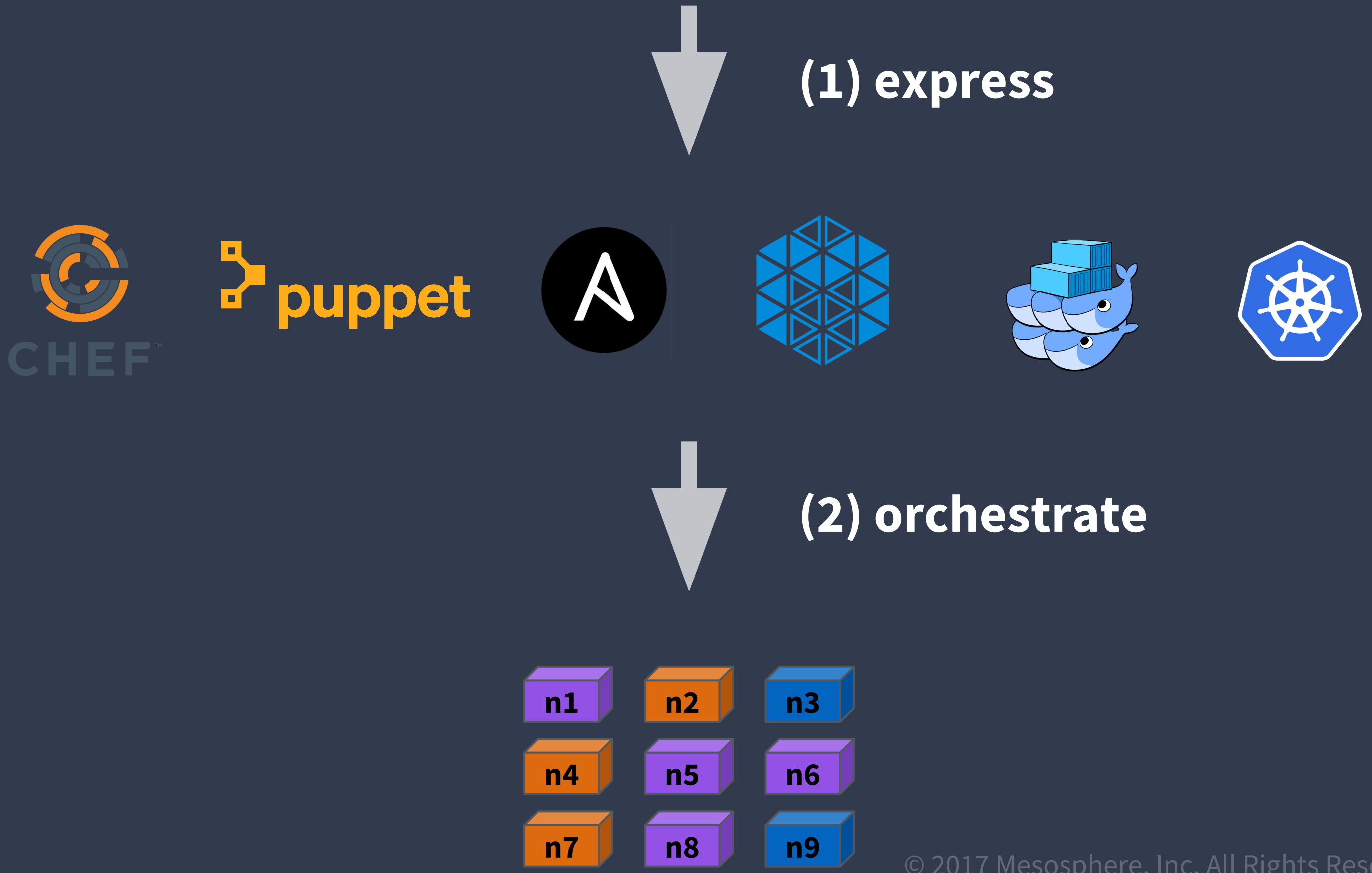

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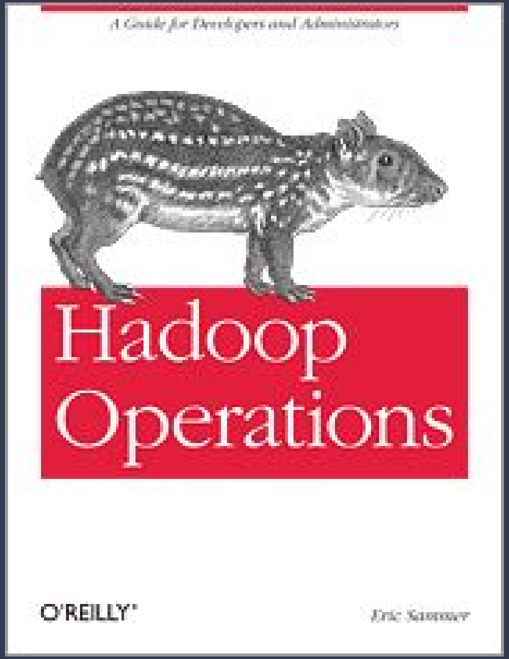

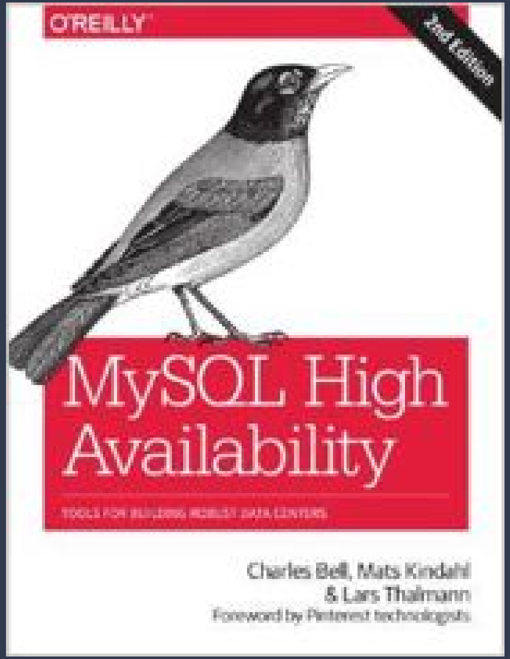
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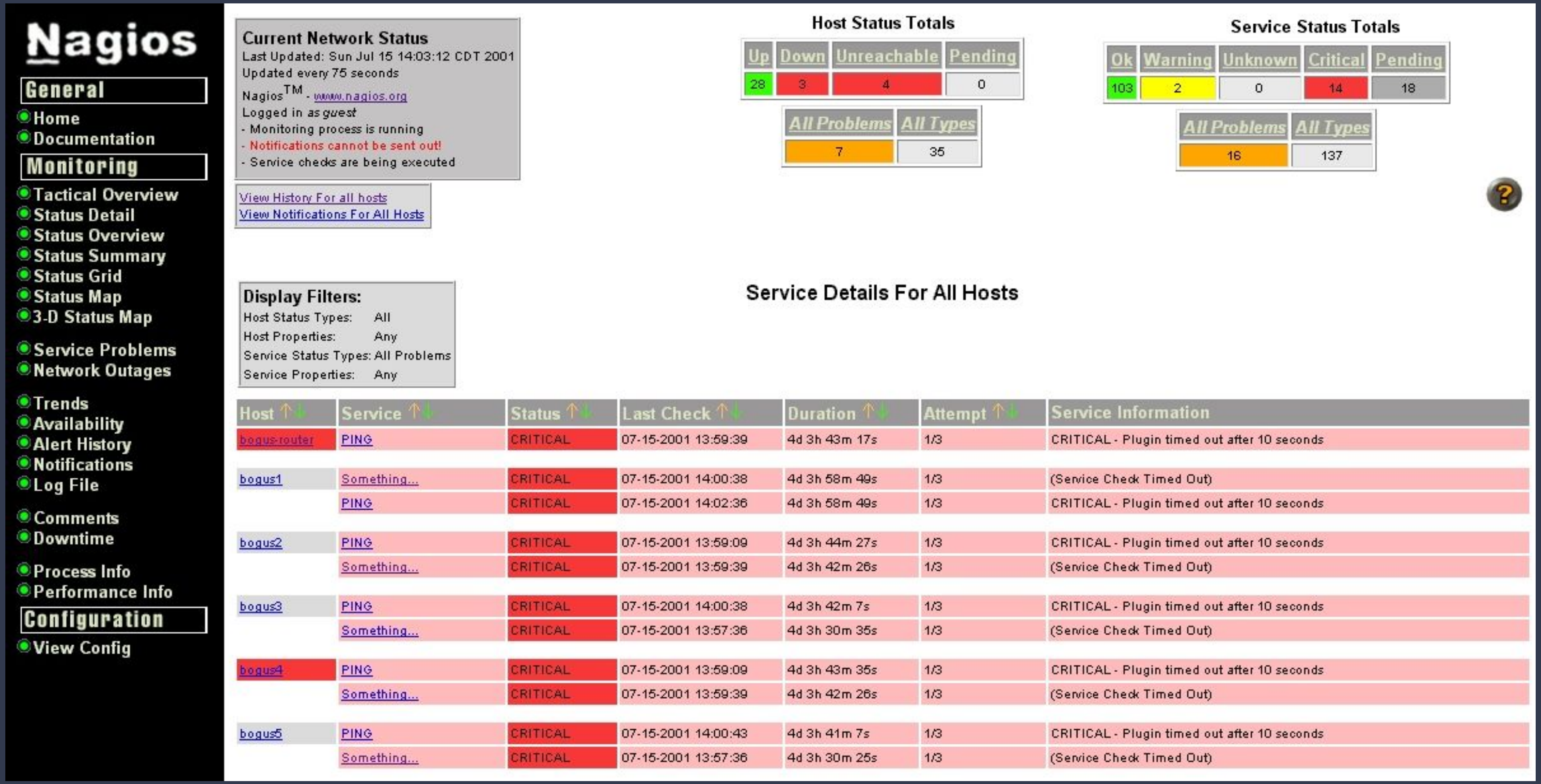

Current Network Status
Last Updated: Sun Jul 15 14:03:12 CDT 2001
Updated every 75 seconds
Nagios^{TM} - www.nagios.org
Logged in as *guest*
- Monitoring process is running
- Notifications cannot be sent out!
- Service checks are being executed

View History For all hosts
View Notifications For All Hosts

Host Status Totals

Up	Down	Unreachable	Pending
28	3	4	0

All Problems	*All Types*
7	35

Service Status Totals

Ok	Warning	Unknown	Critical	Pending
103	2	0	14	18

All Problems	*All Types*
16	137

Display Filters:
Host Status Types: All
Host Properties: Any
Service Status Types: All Problems
Service Properties: Any

Service Details For All Hosts

Host	Service	Status	Last Check	Duration	Attempt	Service Information
bogus-router	PING	CRITICAL	07-15-2001 13:59:39	4d 3h 43m 17s	1/3	CRITICAL - Plugin timed out after 10 seconds
bogus1	Something...	CRITICAL	07-15-2001 14:00:38	4d 3h 58m 49s	1/3	(Service Check Timed Out)
	PING	CRITICAL	07-15-2001 14:02:36	4d 3h 58m 49s	1/3	CRITICAL - Plugin timed out after 10 seconds
bogus2	PING	CRITICAL	07-15-2001 13:59:09	4d 3h 44m 27s	1/3	CRITICAL - Plugin timed out after 10 seconds
	Something...	CRITICAL	07-15-2001 13:59:39	4d 3h 42m 26s	1/3	(Service Check Timed Out)
bogus3	PING	CRITICAL	07-15-2001 14:00:38	4d 3h 42m 7s	1/3	CRITICAL - Plugin timed out after 10 seconds
	Something...	CRITICAL	07-15-2001 13:57:36	4d 3h 30m 35s	1/3	(Service Check Timed Out)
bogus4	PING	CRITICAL	07-15-2001 13:59:09	4d 3h 43m 35s	1/3	CRITICAL - Plugin timed out after 10 seconds
	Something...	CRITICAL	07-15-2001 13:59:39	4d 3h 42m 26s	1/3	(Service Check Timed Out)
bogus5	PING	CRITICAL	07-15-2001 14:00:43	4d 3h 41m 7s	1/3	CRITICAL - Plugin timed out after 10 seconds
	Something...	CRITICAL	07-15-2001 13:57:36	4d 3h 30m 25s	1/3	(Service Check Timed Out)

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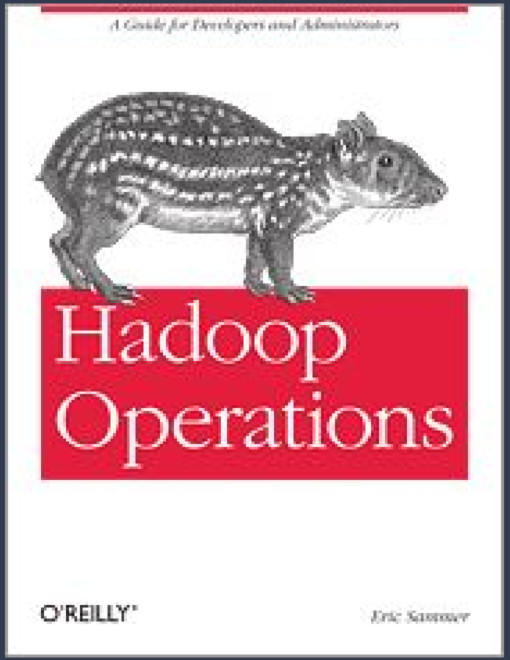
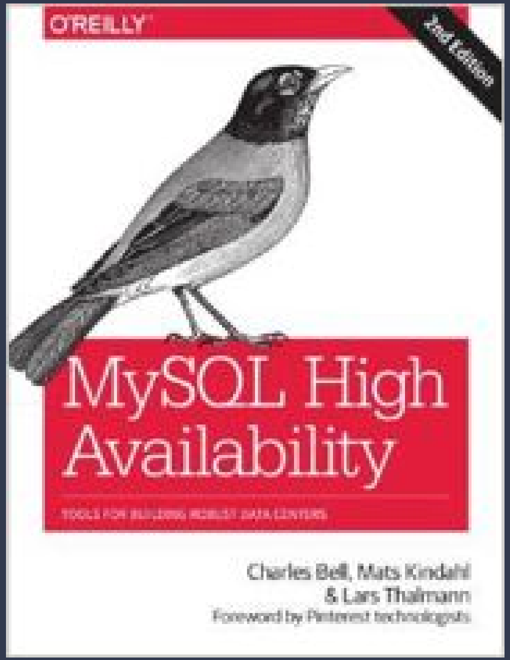
first, debug ...

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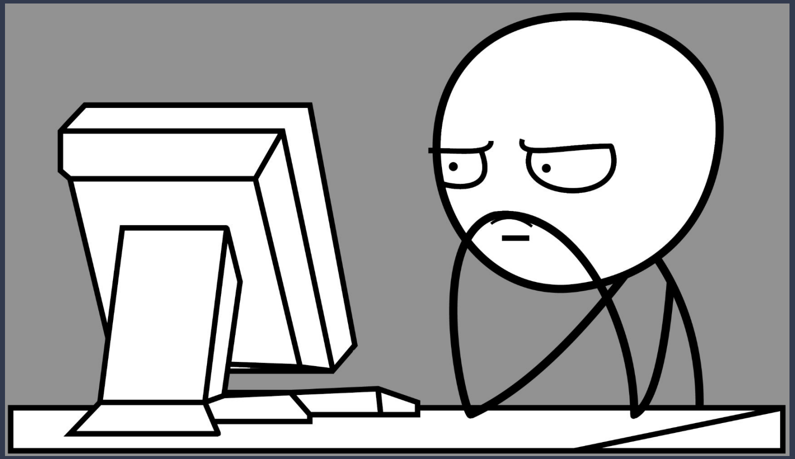

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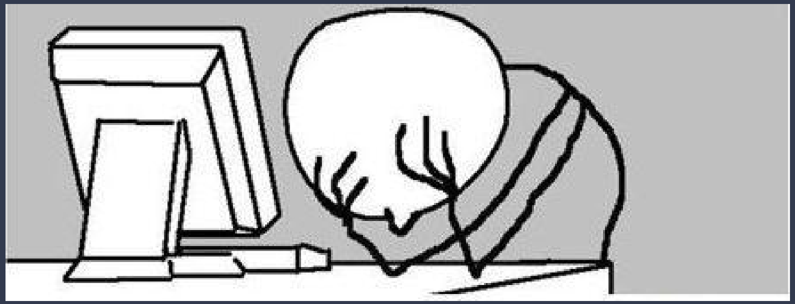
second, fix (scale, patch, etc)

…

1: download
2: deploy
3: monitor
4: maintain
5: upgrade → goto 1

then, debug again ...



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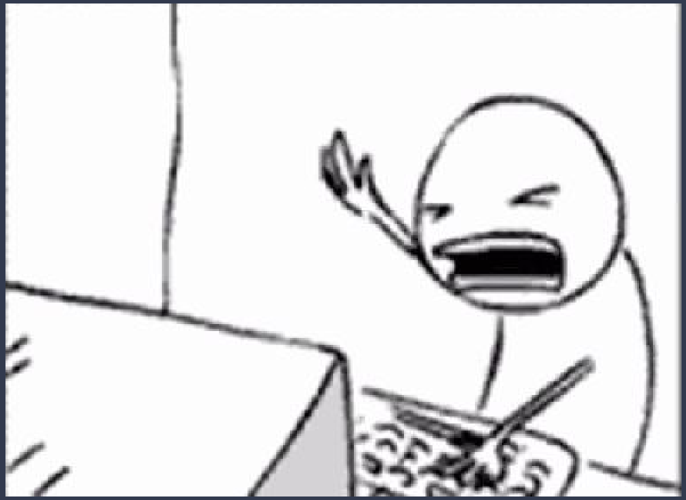
finally, write code so it never happens again ...



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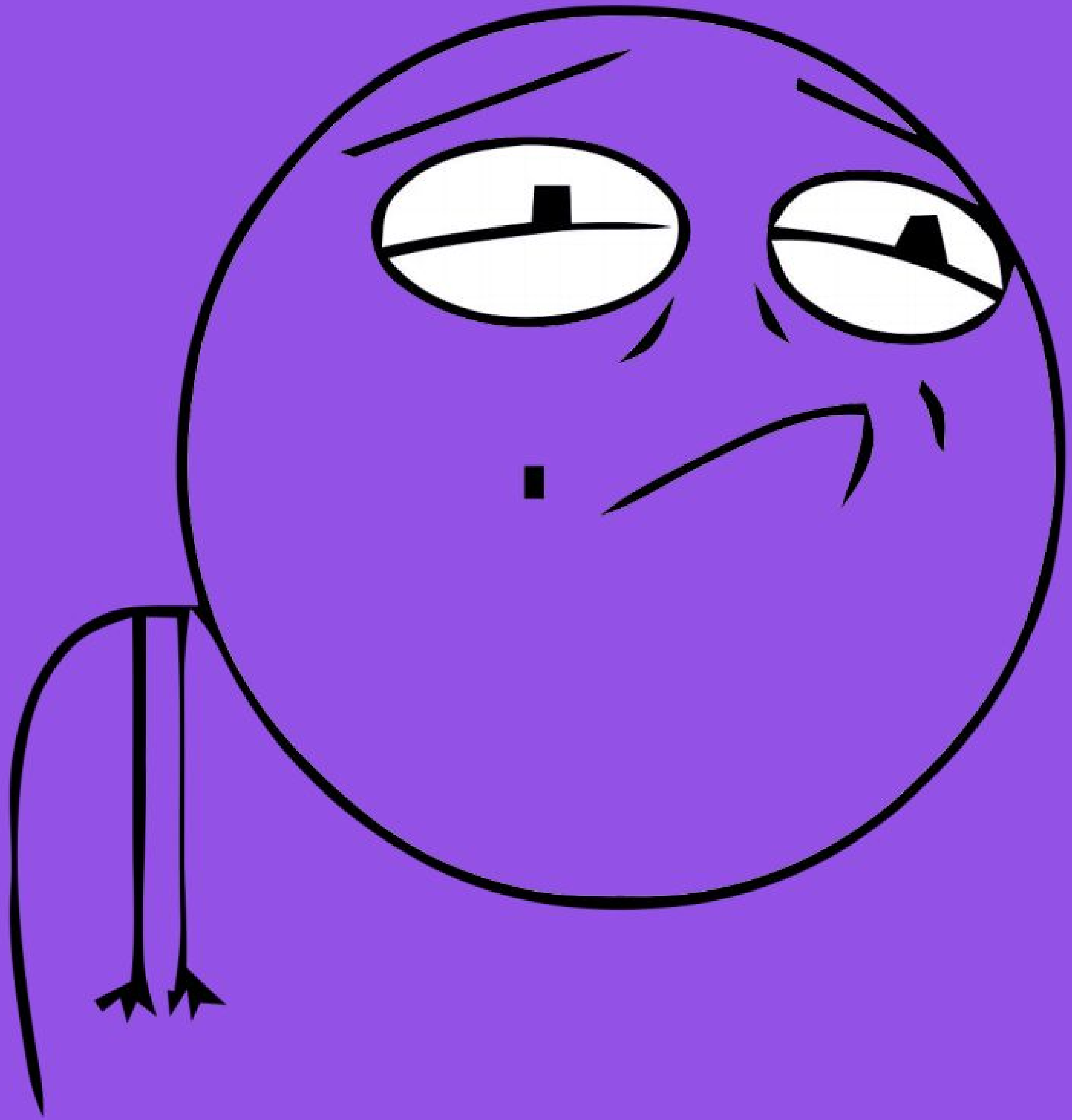


thesis:

**distributed systems should
(be able to) operate themselves;
deploy, monitor, upgrade …**

why:

(1) operators have *inadequate knowledge* of distributed system needs/semantics
to make optimal decisions

why:

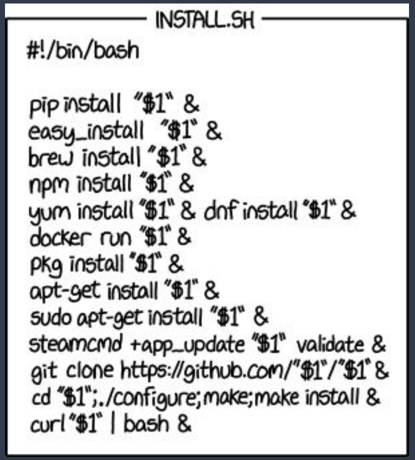
(1) operators have *inadequate knowledge* of distributed system needs/semantics
to make optimal decisions
(even after reading the book)

why:

(2) execution needs/semantics *can’t easily or efficiently be expressed* to underlying system, and vice versa

hadoop Map Reduce

(1) express



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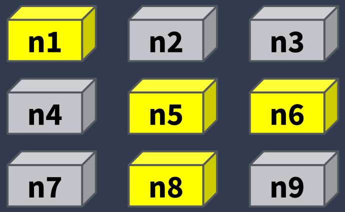
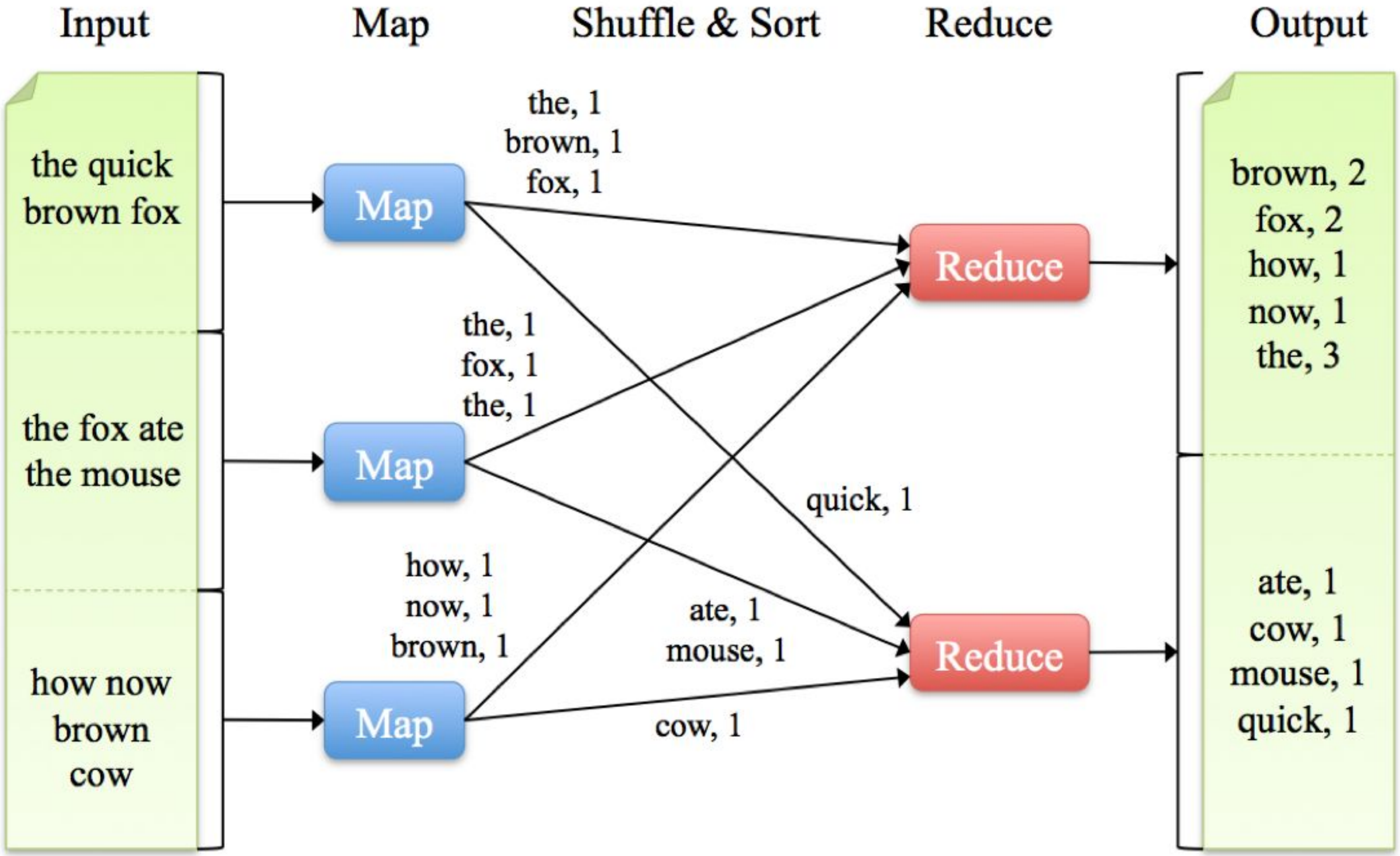
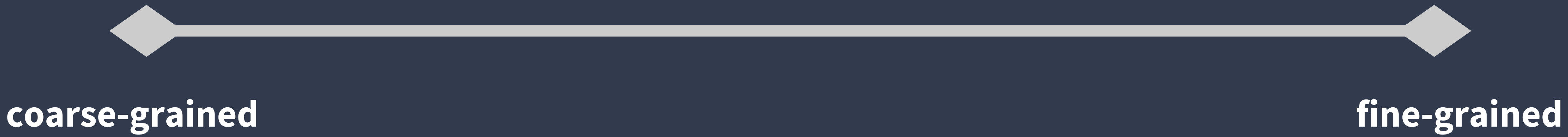
```

(2) orchestrate




Input
Map
Shuffle & Sort
Reduce
Output
the quick brown fox
the fox ate the mouse
how now brown cow
Map
Map
Map
the, 1
brown, 1
fox, 1
the, 1
fox, 1
the, 1
how, 1
now, 1
brown, 1
quick, 1
ate, 1
mouse, 1
cow, 1
Reduce
Reduce
brown, 2
fox, 2
how, 1
now, 1
the, 3
ate, 1
cow, 1
mouse, 1
quick, 1

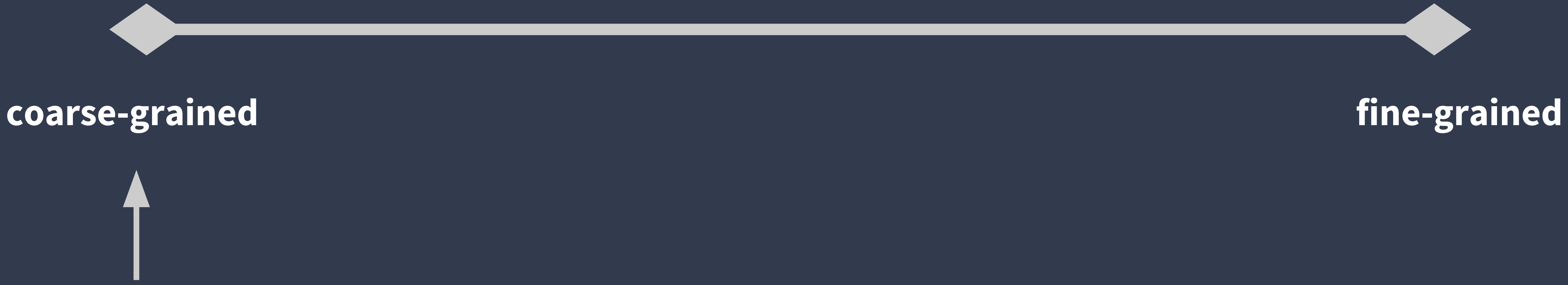
configuration spectrum:



coarse-grained

fine-grained

configuration spectrum:

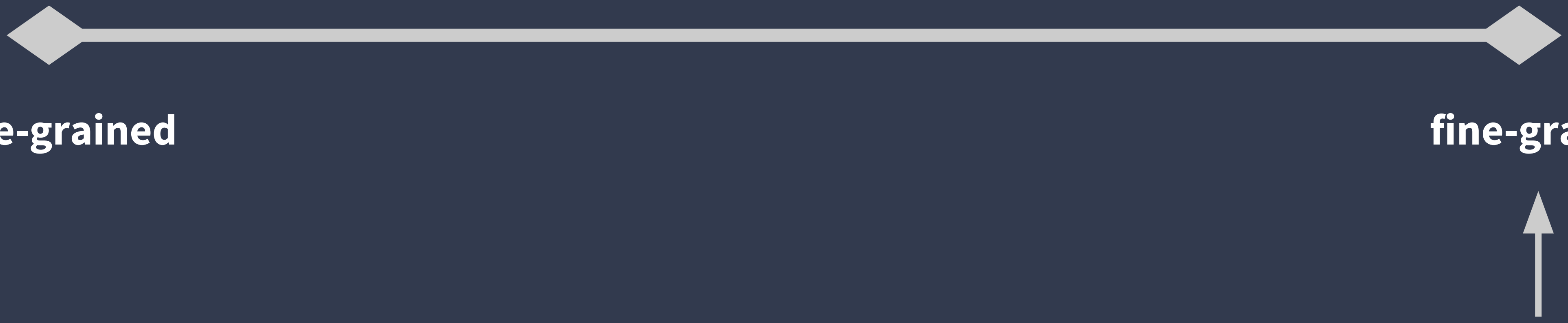


coarse-grained

fine-grained

easiest to express (how most of us would do it),
but worst resource utilization

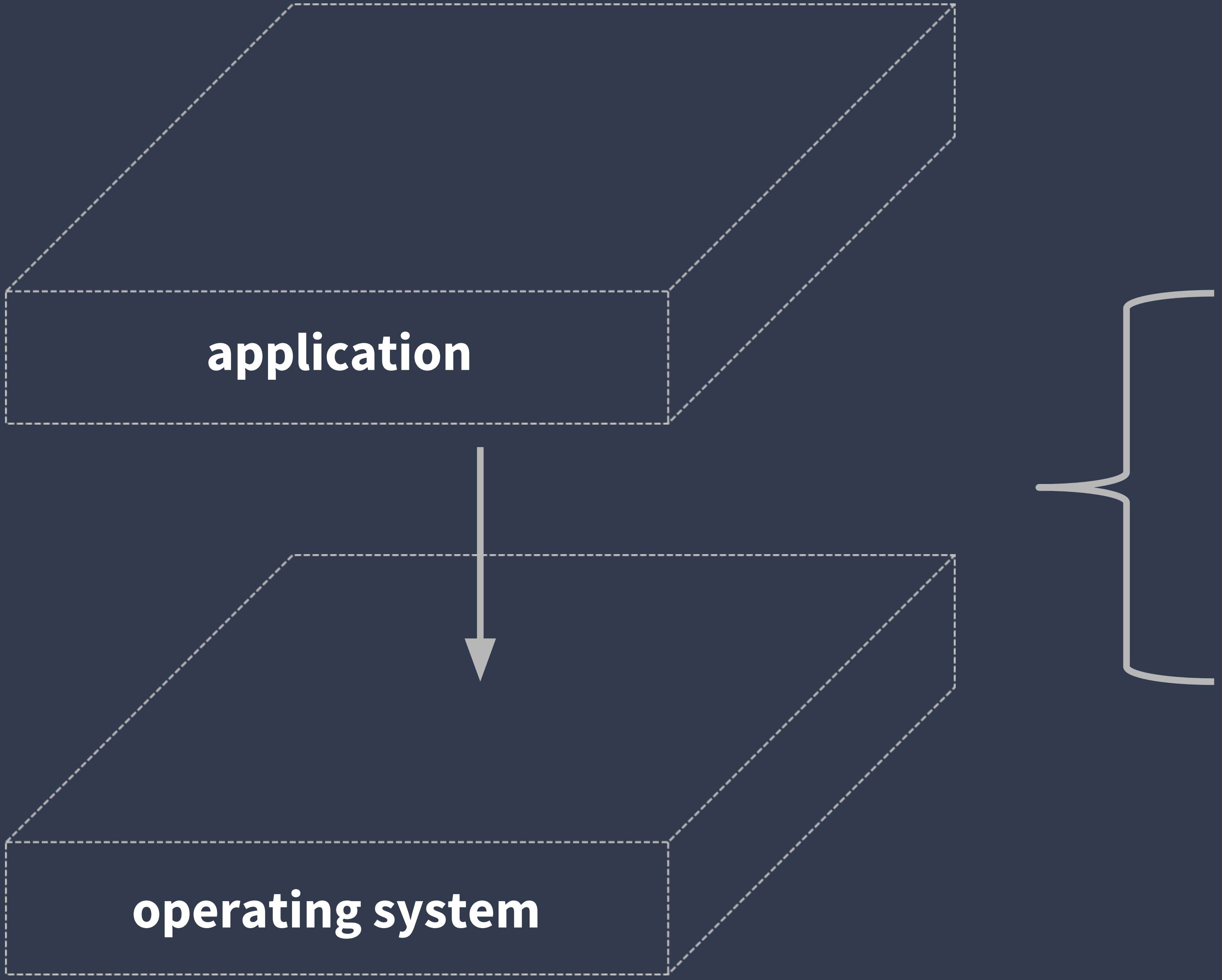
configuration spectrum:



hardest to express (if even possible),
but best resource utilization

why can’t Hadoop decide this for me?

applications “operate” themselves on Linux; when an application needs to “scale up” it asks the operating system to allocate more memory or create another thread …



application

operating system

<u>syscall interface:</u>
memory allocate
clone/fork
create file
read, write
…

once upon a time … before virtual memory

0x0 0x8

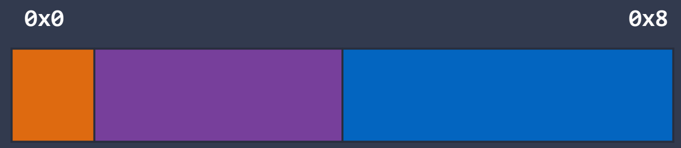
physical memory

+

configuration:

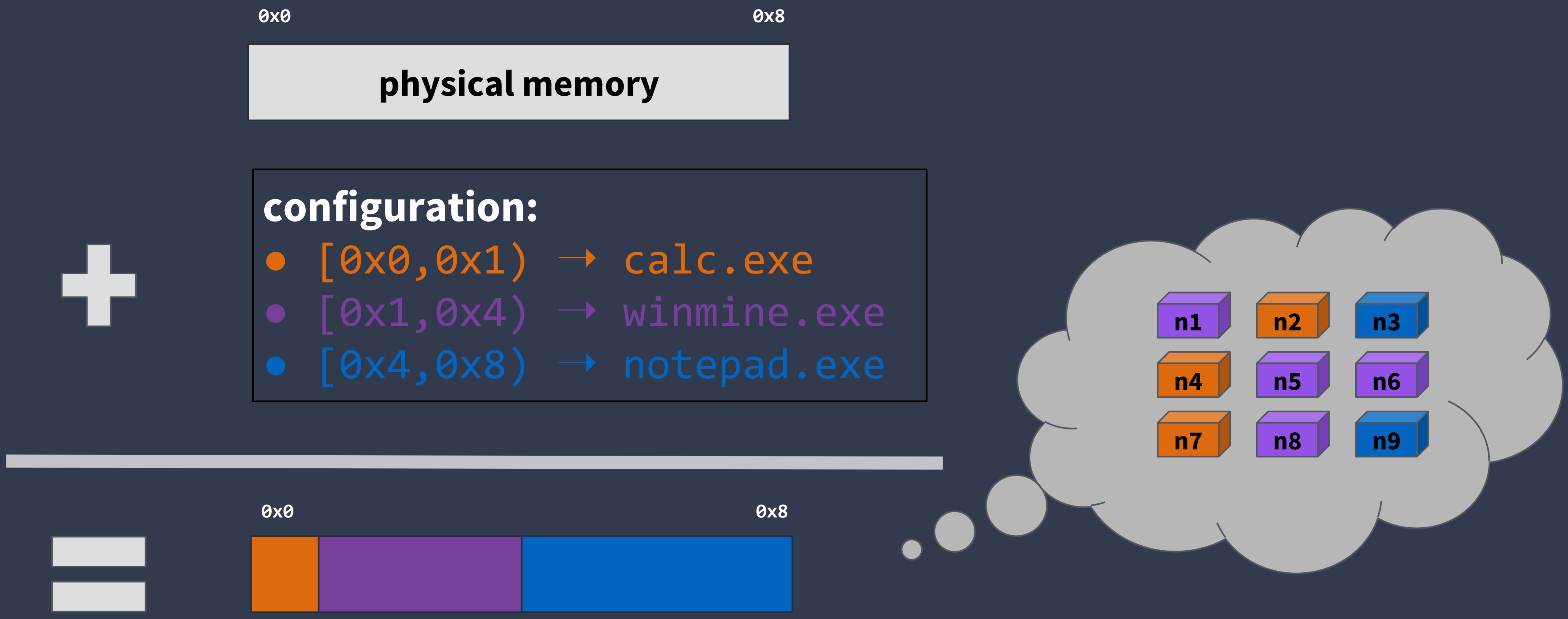
- [0x0,0x1) → calc.exe
- [0x1,0x4) → winmine.exe
- [0x4,0x8) → notepad.exe

=



applications take physical memory address range as an **input**

once upon a time … before virtual memory

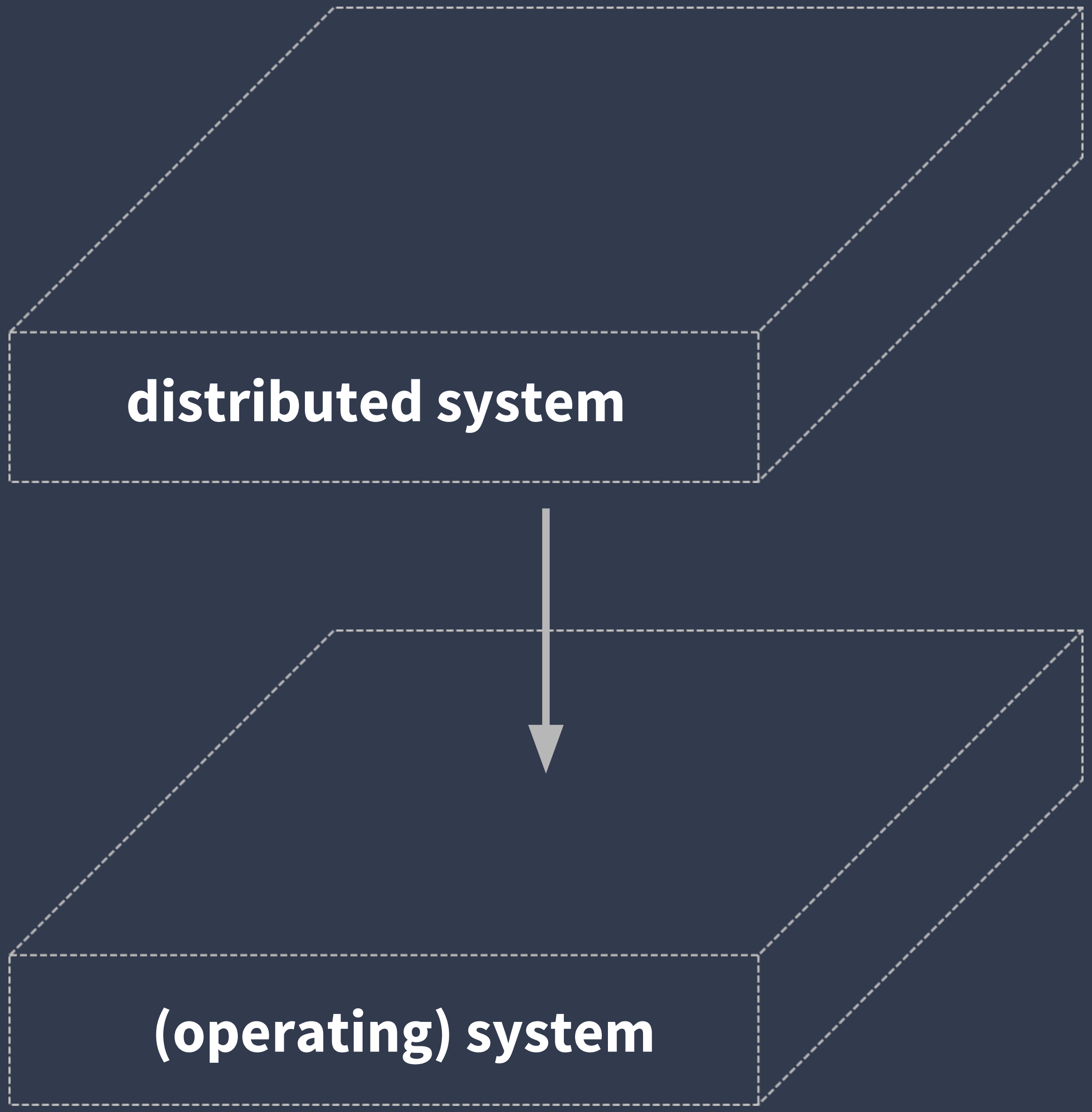


configuration:

- [0x0,0x1) → calc.exe
- [0x1,0x4) → winmine.exe
- [0x4,0x8) → notepad.exe

how:

distributed systems need *interface* to *communicate* with underlying system, ***and vice versa***



distributed system

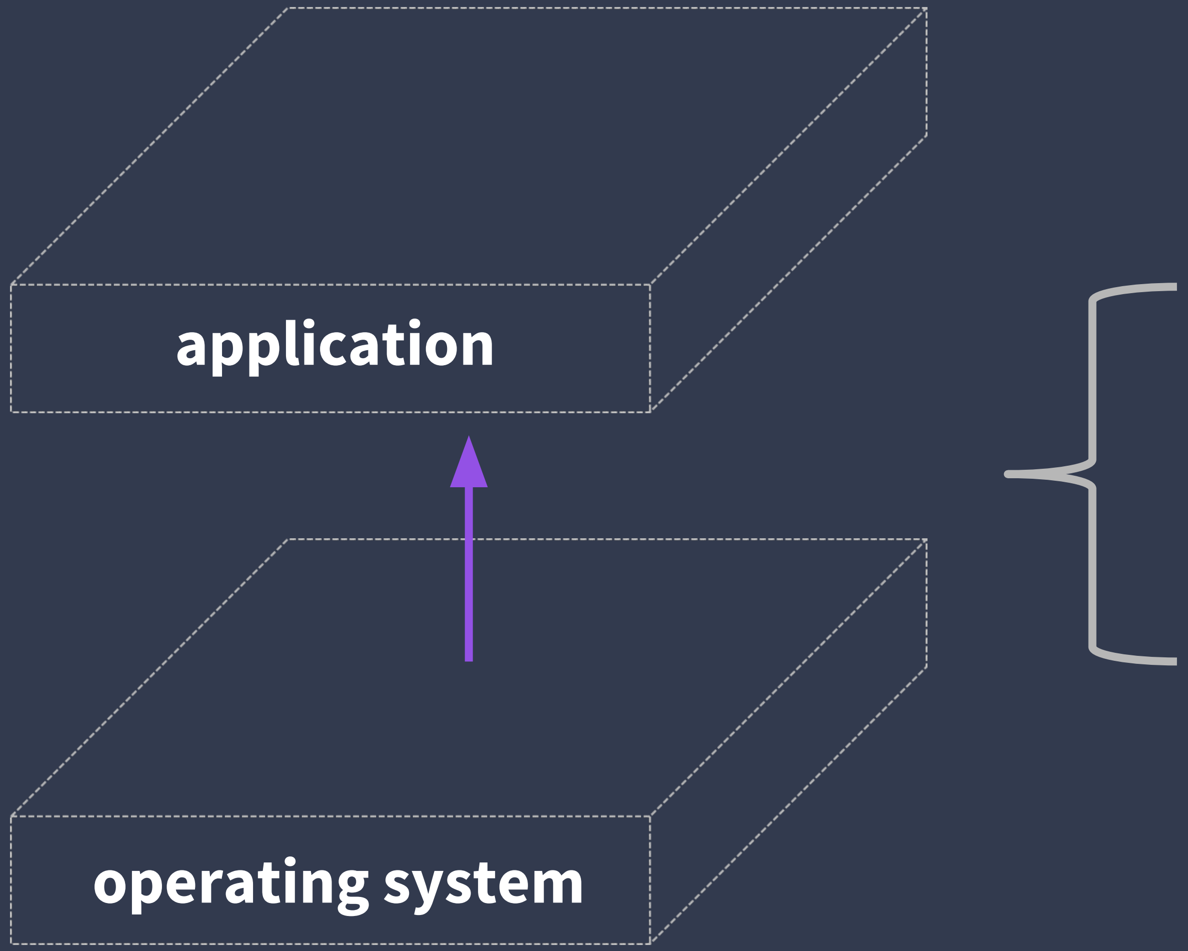
(operating) system

<u>interface:</u>

resource allocation
launch container/VM
create storage
attach/detach storage
…

vice versa:
operating system should be able to *callback* into application

learning from history … bidirectional interface



callback interface:
paging/swapping
CPU deallocation
…

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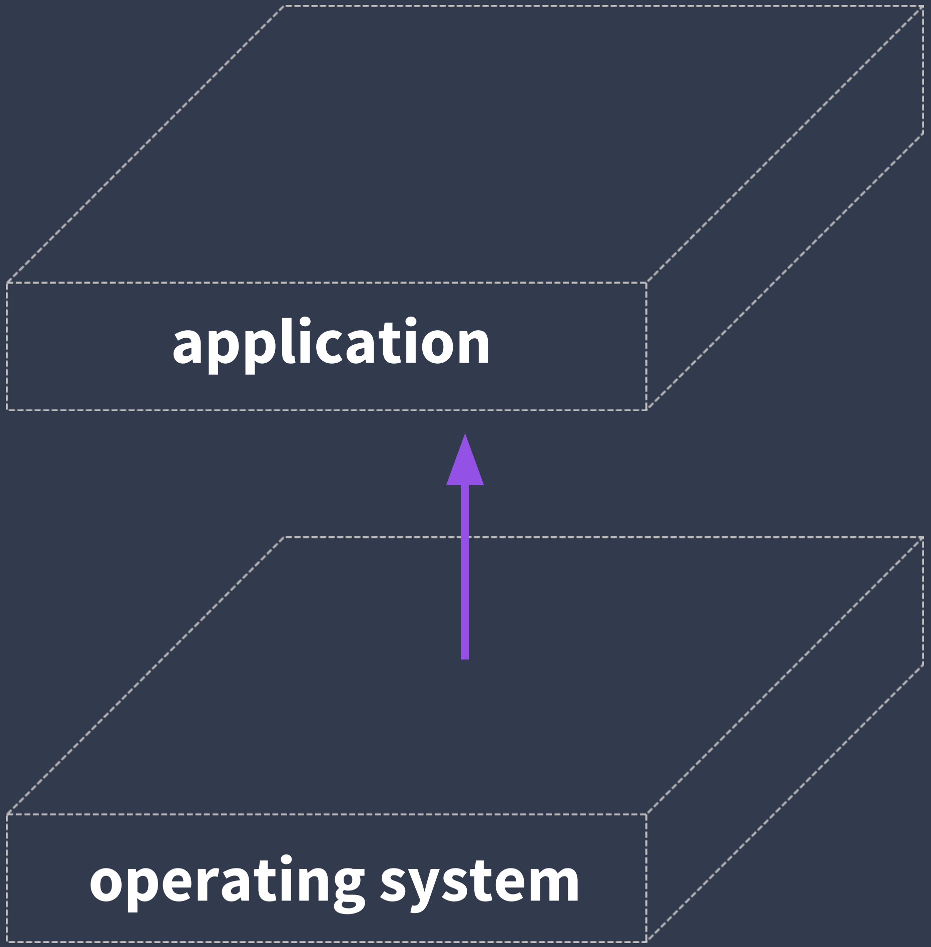


callback interface:

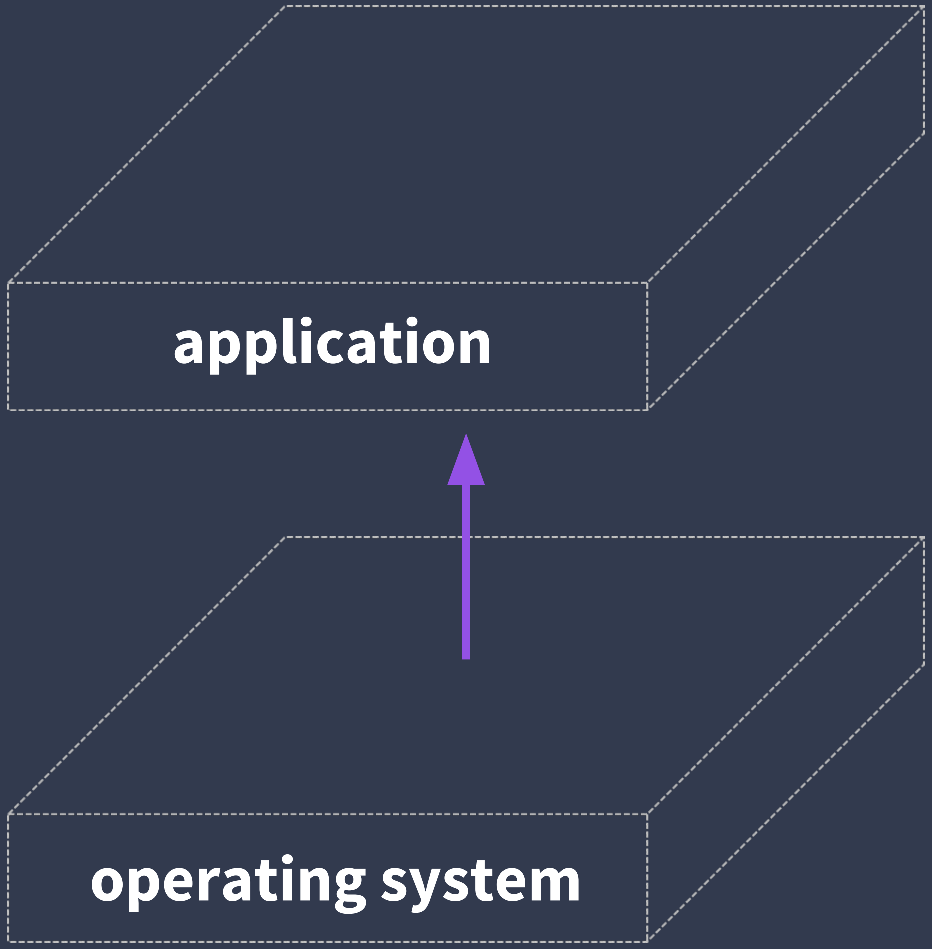
paging/swapping

CPU deallocation

…

better than LRU, ask the application what pages to swap!

learning from history … bidirectional interface

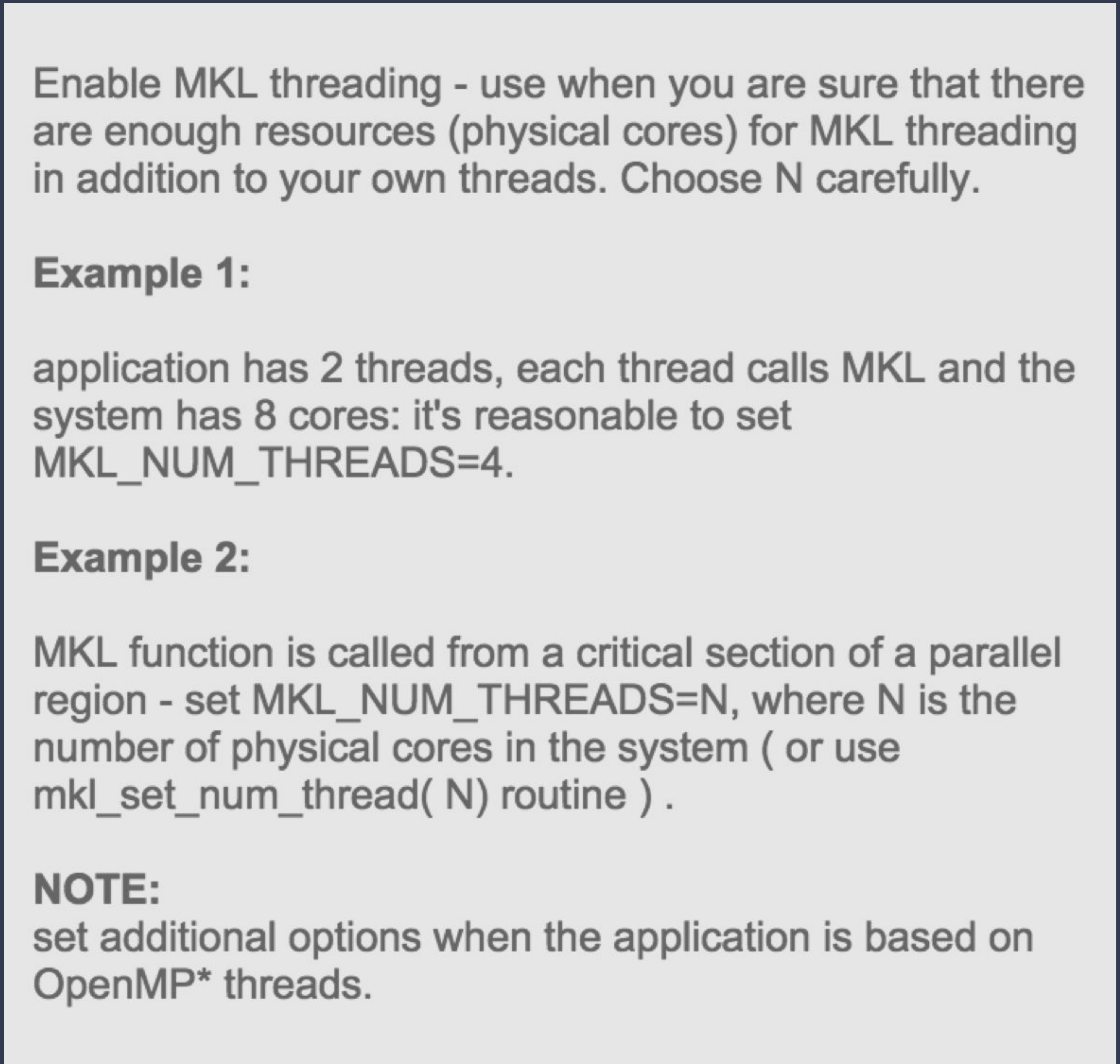


callback interface:
paging/swapping
CPU deallocation
…

search for ‘scheduler activations’ and ‘Lithe composition’ intel®

intel
Intel
Threading
Building
Blocks
intel
Intel
Math Kernel
Library

consequences of inadequate interfaces for parallel software ...



Enable MKL threading - use when you are sure that there are enough resources (physical cores) for MKL threading in addition to your own threads. Choose N carefully.

Example 1:

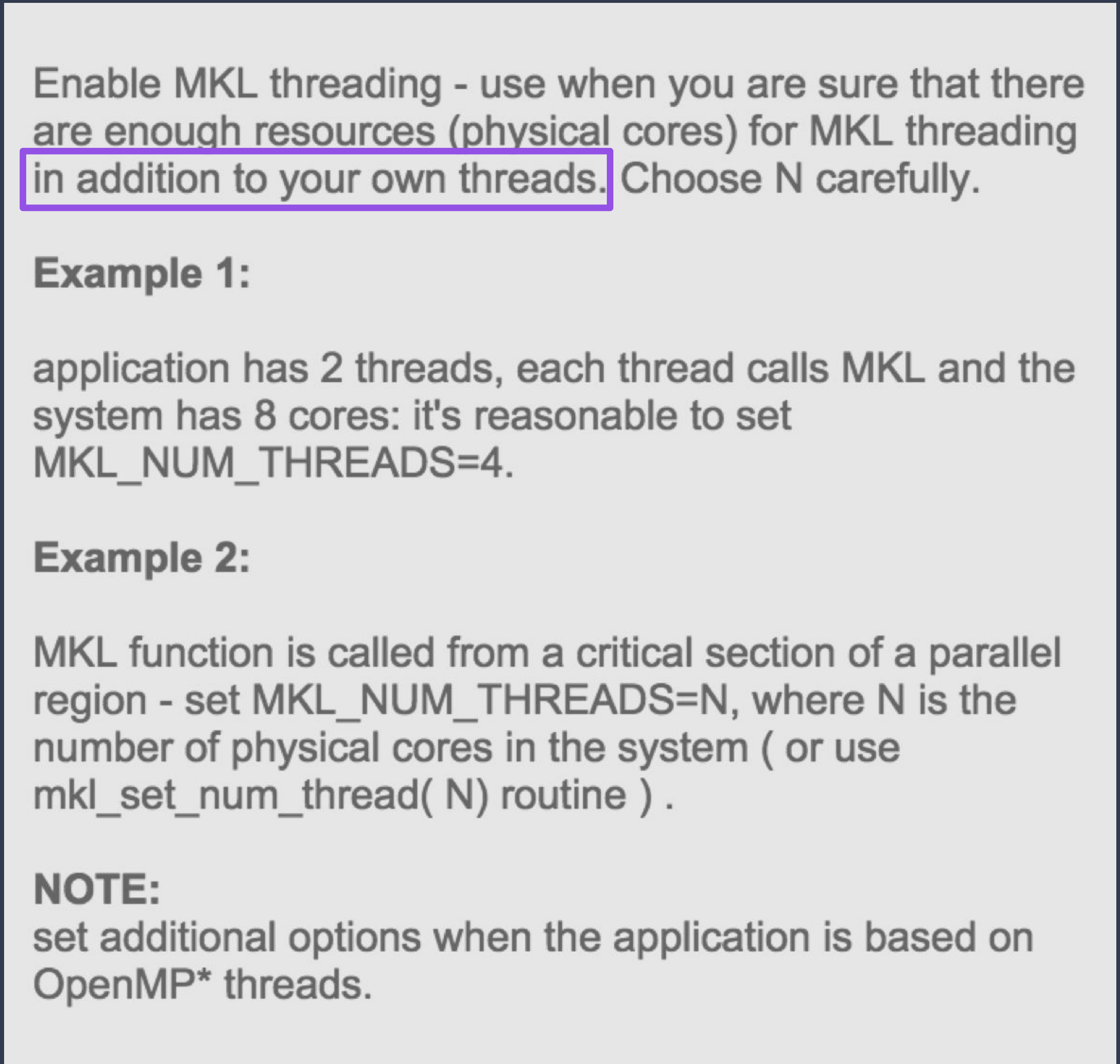
application has 2 threads, each thread calls MKL and the system has 8 cores: it's reasonable to set MKL_NUM_THREADS=4.

Example 2:

MKL function is called from a critical section of a parallel region - set MKL_NUM_THREADS=N, where N is the number of physical cores in the system (or use mkl_set_num_thread(N) routine) .

NOTE:
set additional options when the application is based on OpenMP* threads.

consequences of inadequate interfaces for parallel software …



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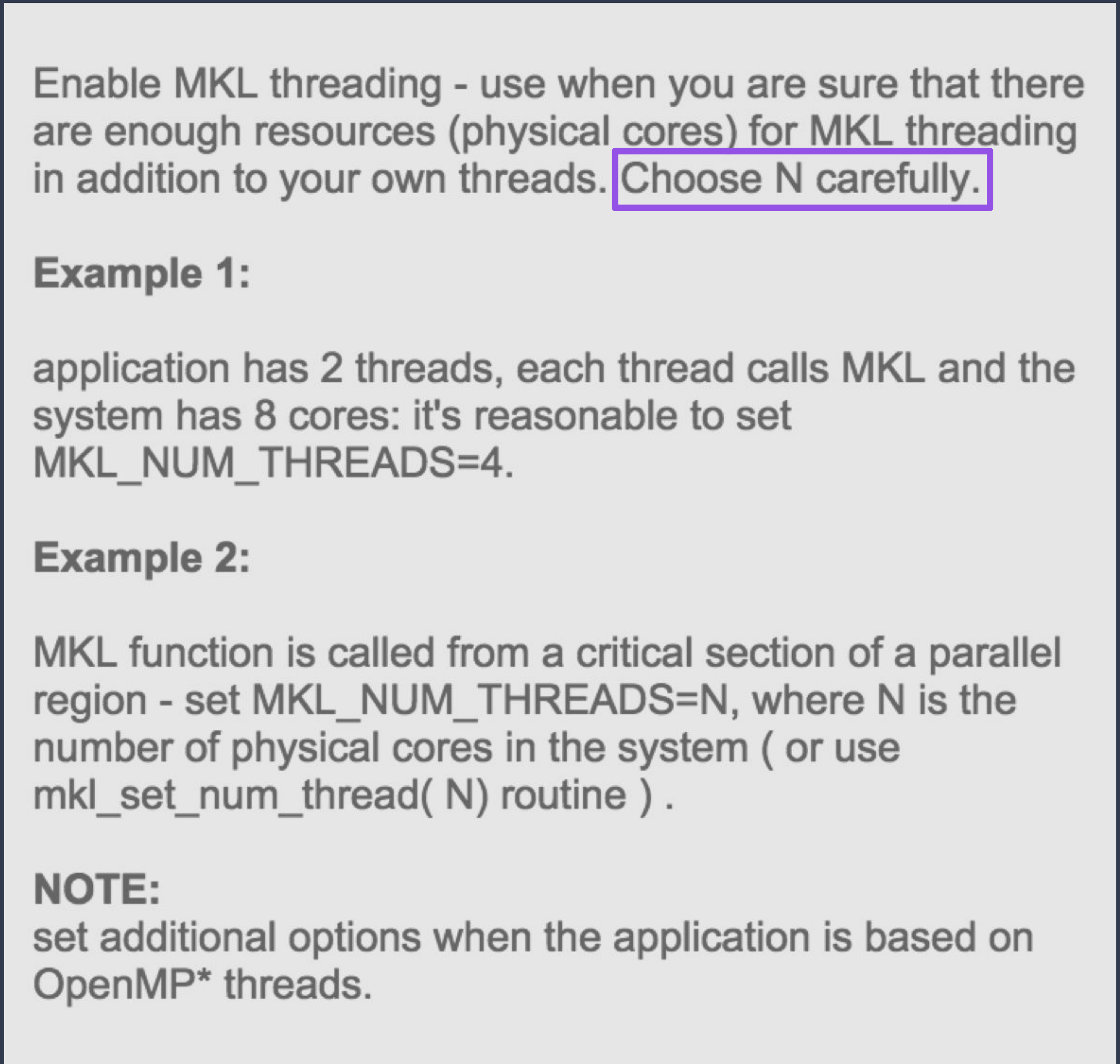

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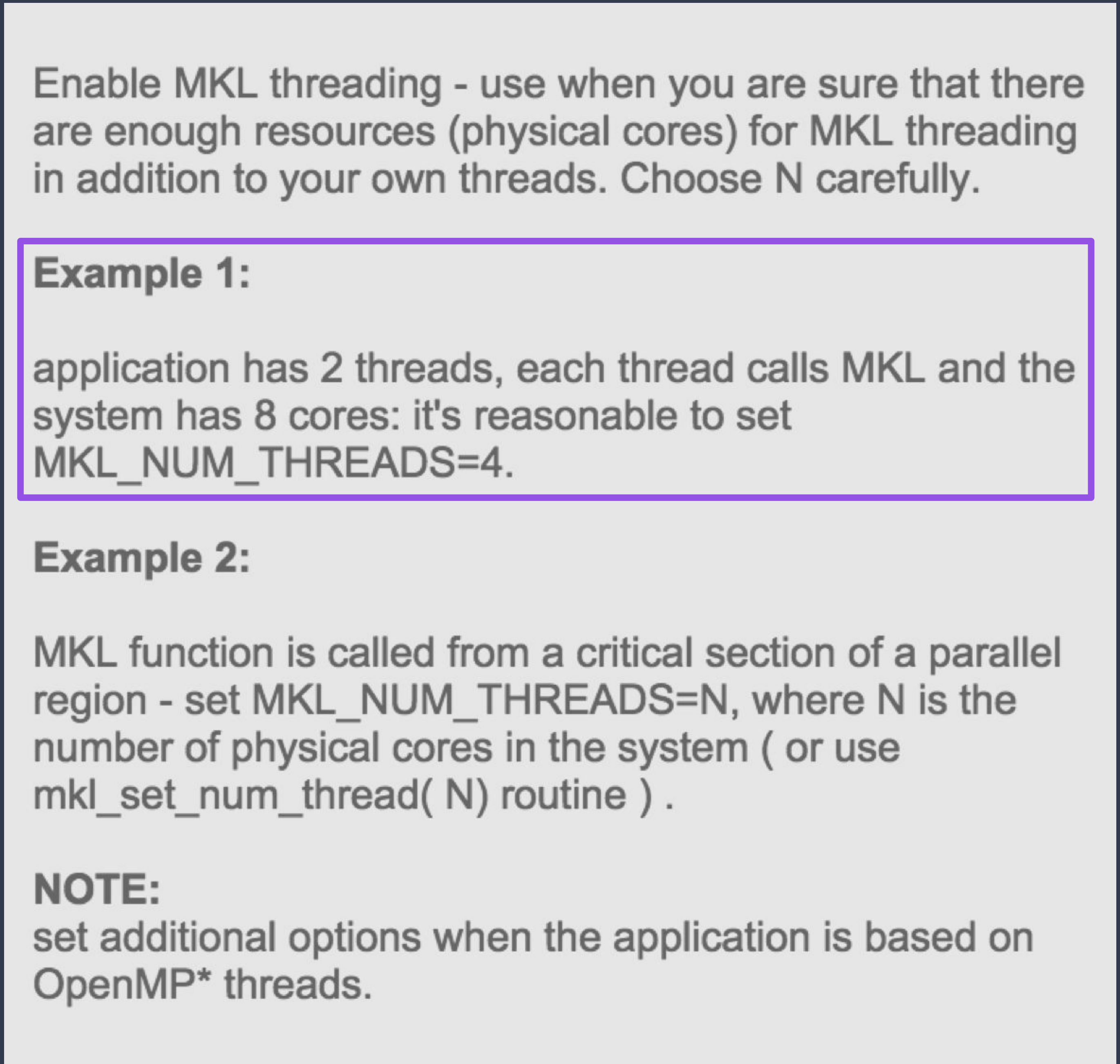

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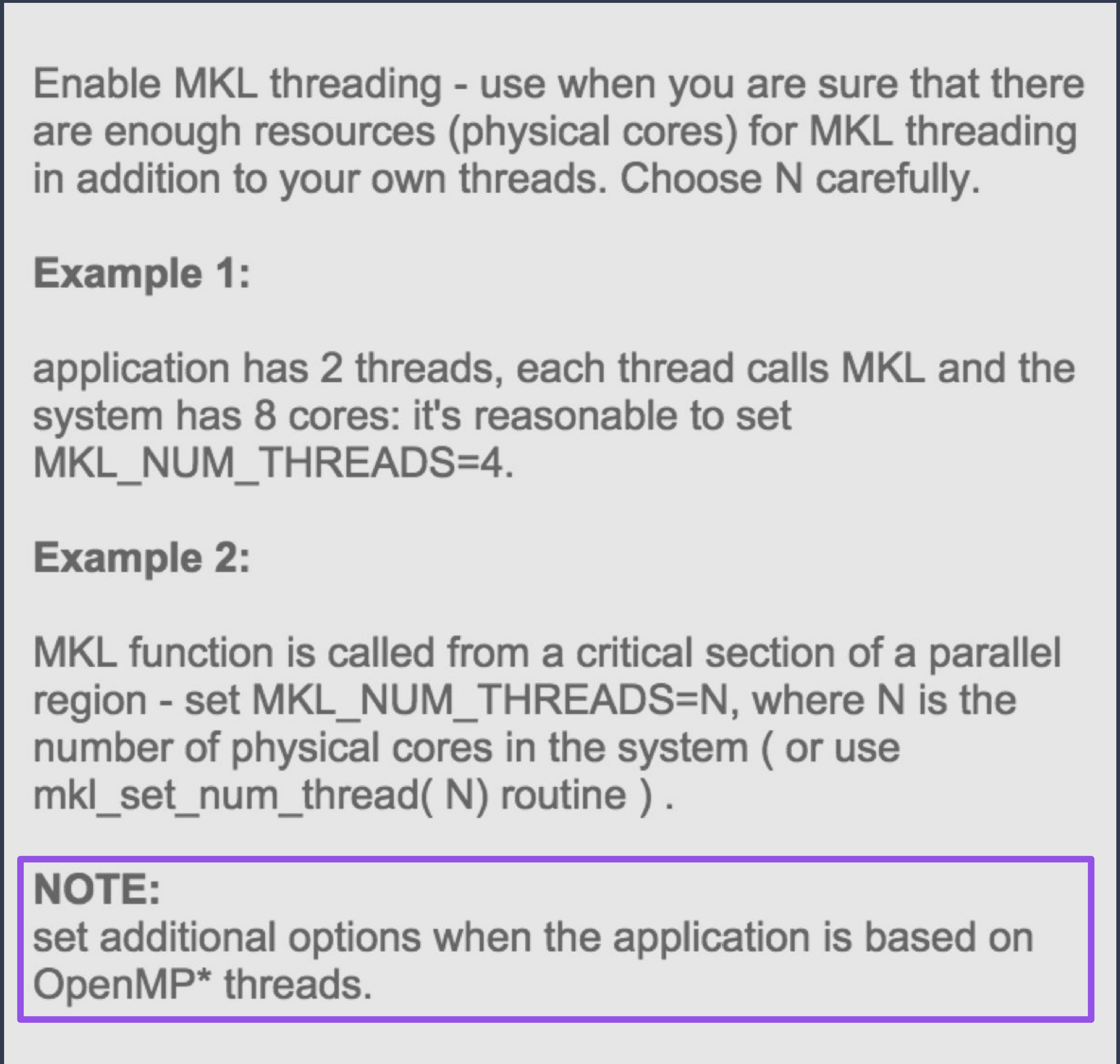

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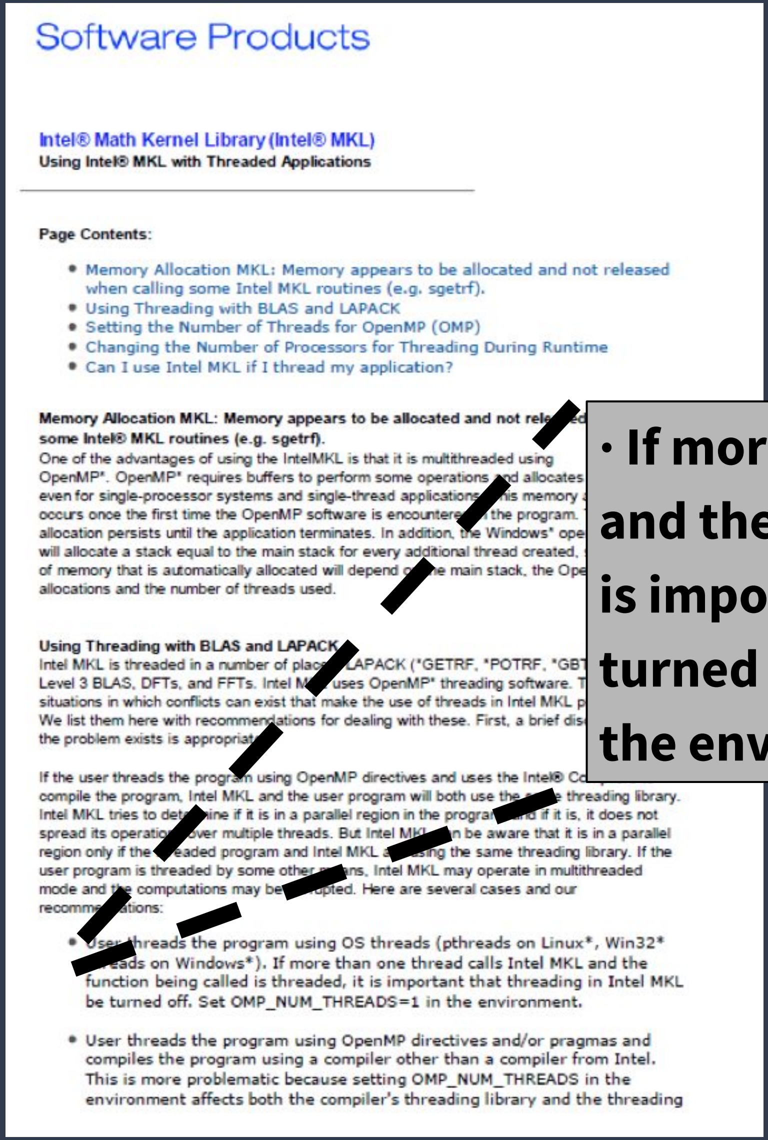

Software Products

Intel® Math Kernel Library (Intel® MKL)
Using Intel® MKL with Threaded Applications

Page Contents:

- Memory Allocation MKL: Memory appears to be allocated and not released when calling some Intel MKL routines (e.g. sgetrf).
- Using Threading with BLAS and LAPACK
- Setting the Number of Threads for OpenMP (OMP)
- Changing the Number of Processors for Threading During Runtime
- Can I use Intel MKL if I thread my application?

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Using Threading with BLAS and LAPACK
Intel MKL is threaded in a number of places: LAPACK (*GETRF, *POTRF, *GBT
Level 3 BLAS, DFTs, and FFTs. Intel MKL uses OpenMP* threading software. T
situations in which conflicts can exist that make the use of threads in Intel MKL p
We list them here with recommendations for dealing with these. First, a brief dis
the problem exists is appropriate.

If the user threads the program using OpenMP directives and uses the Intel® Co
compile the program, Intel MKL and the user program will both use the same threading library. Intel MKL tries to determine if it is in a parallel region in the program and if it is, it does not spread its operations over multiple threads. But Intel MKL can be aware that it is in a parallel region only if the threaded program and Intel MKL are using the same threading library. If the user program is threaded by some other means, Intel MKL may operate in multithreaded mode and the computations may be corrupted. Here are several cases and our recommendations:

- User threads the program using OS threads (pthreads on Linux*, Win32* threads on Windows*). If more than one thread calls Intel MKL and the function being called is threaded, it is important that threading in Intel MKL be turned off. Set OMP_NUM_THREADS=1 in the environment.
- User threads the program using OpenMP directives and/or pragmas and compiles the program using a compiler other than a compiler from Intel. This is more problematic because setting OMP_NUM_THREADS in the environment affects both the compiler's threading library and the threading

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http://www.intel.com/support/performancetools/libraries/mkl/sb/CS-017177.htm

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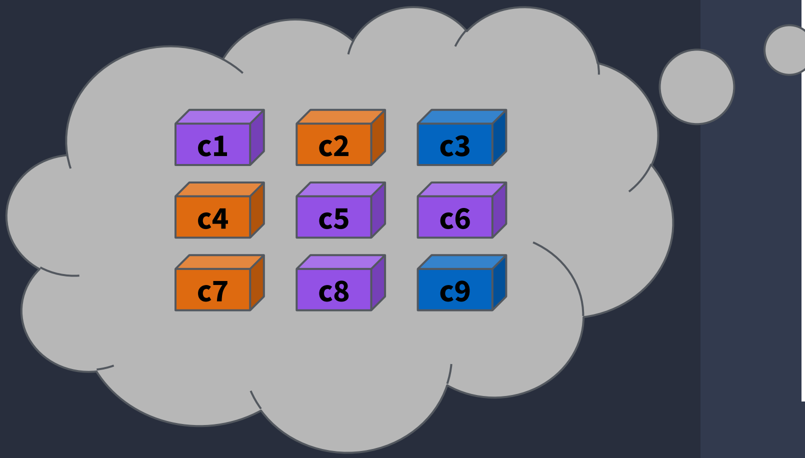

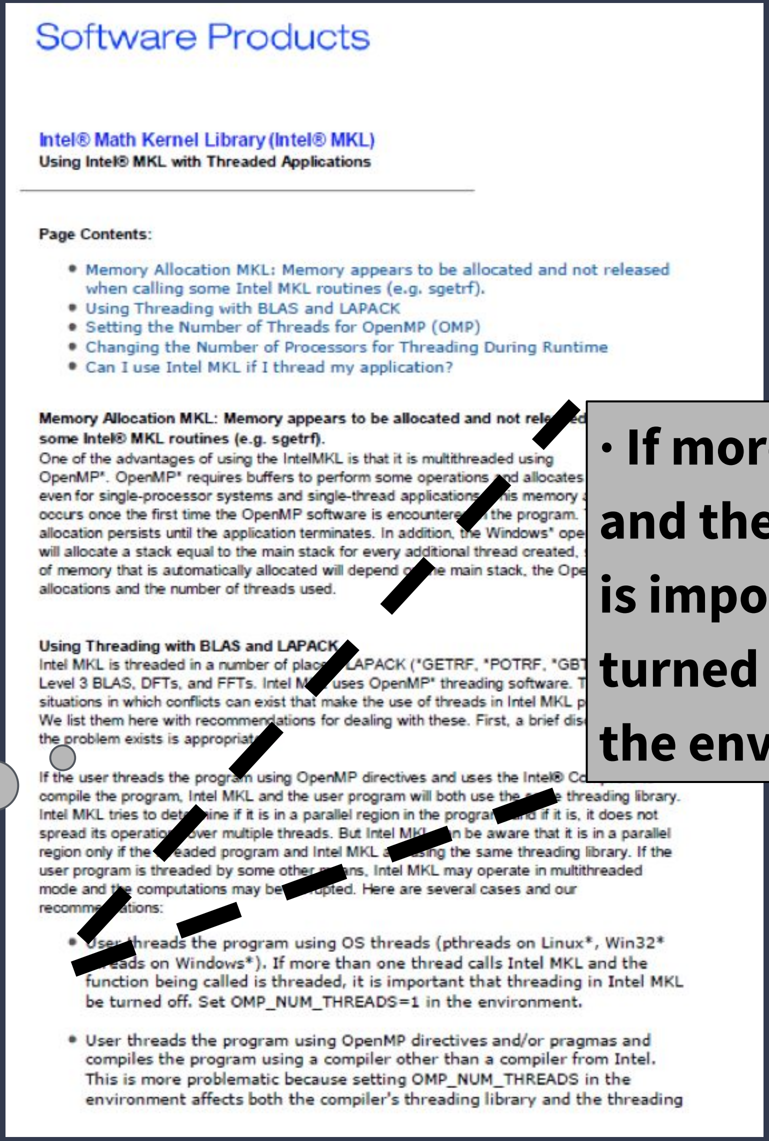

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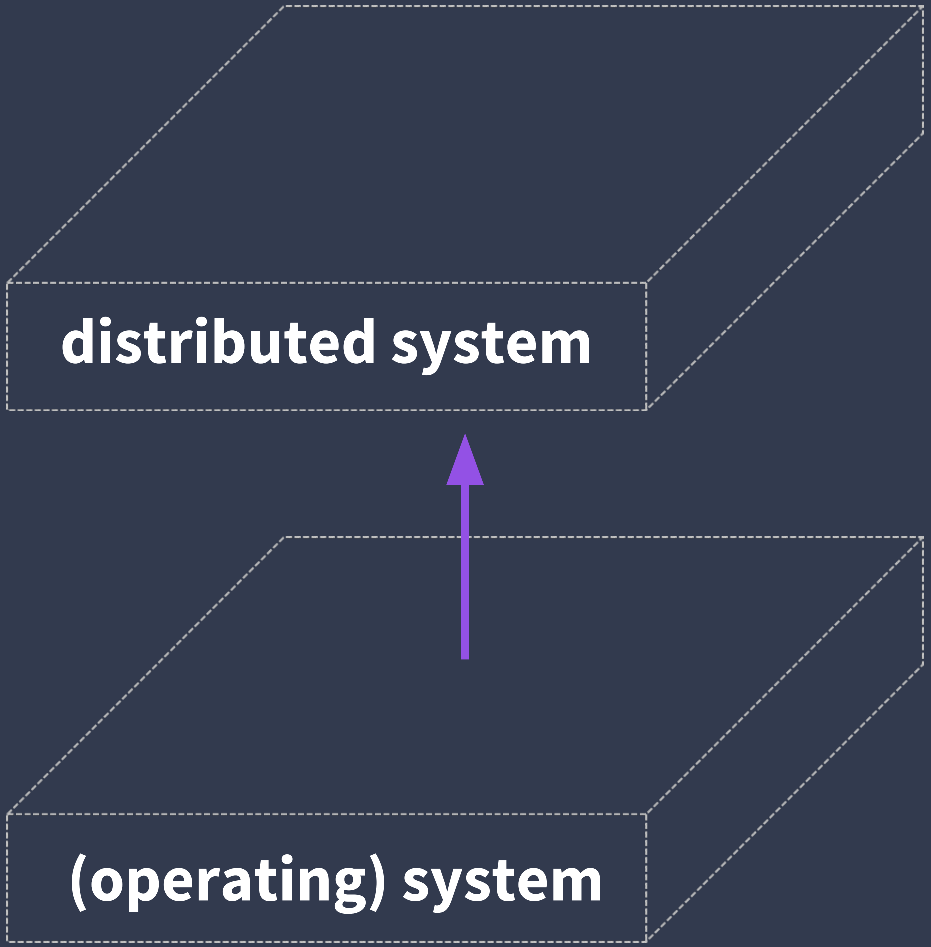
application execution needs/semantics *can’t easily or efficiently be expressed* to operating system, and vice versa

distributed systems need bidirectional interface too



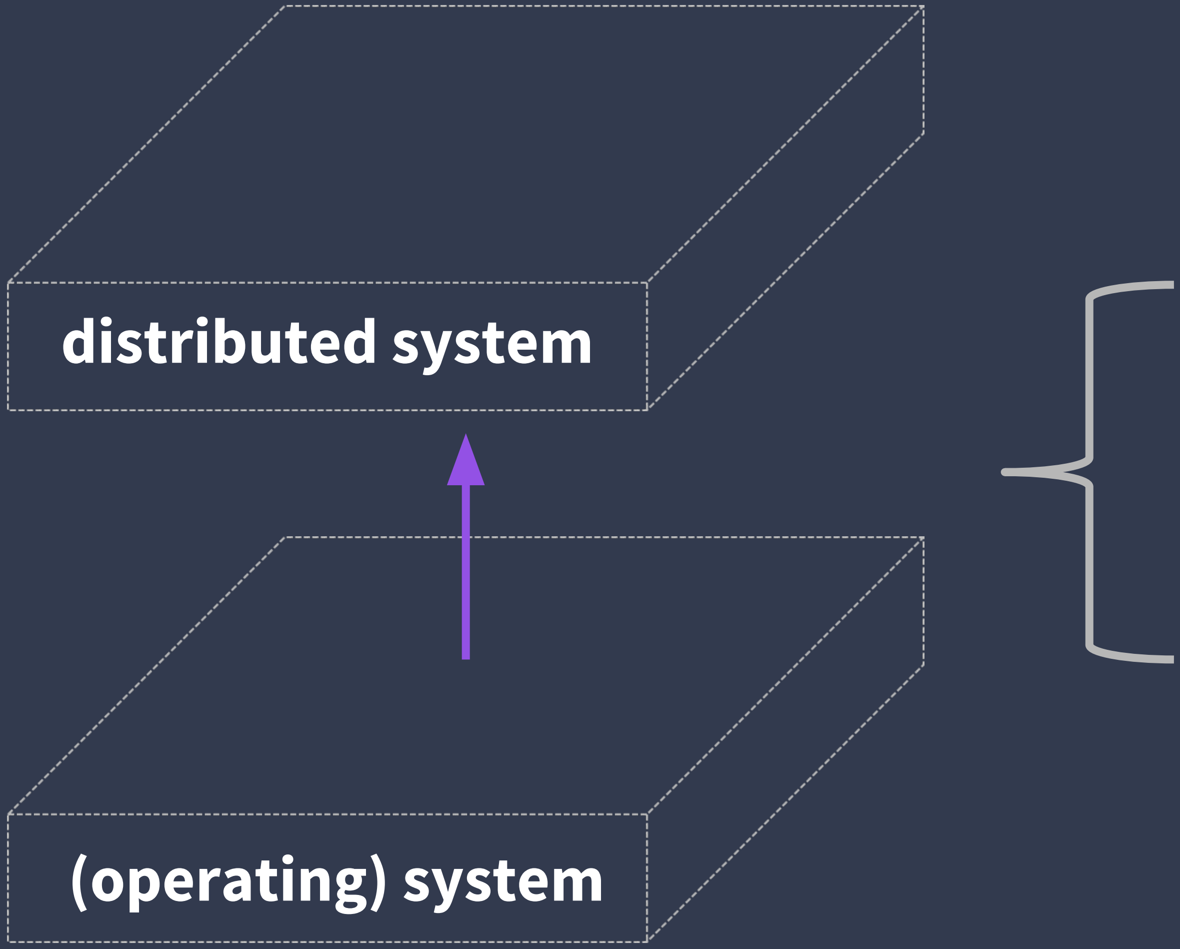
callback interface:

container/VM failed

resource deallocation

…

distributed systems need bidirectional interface too



<u>callback interface:</u>

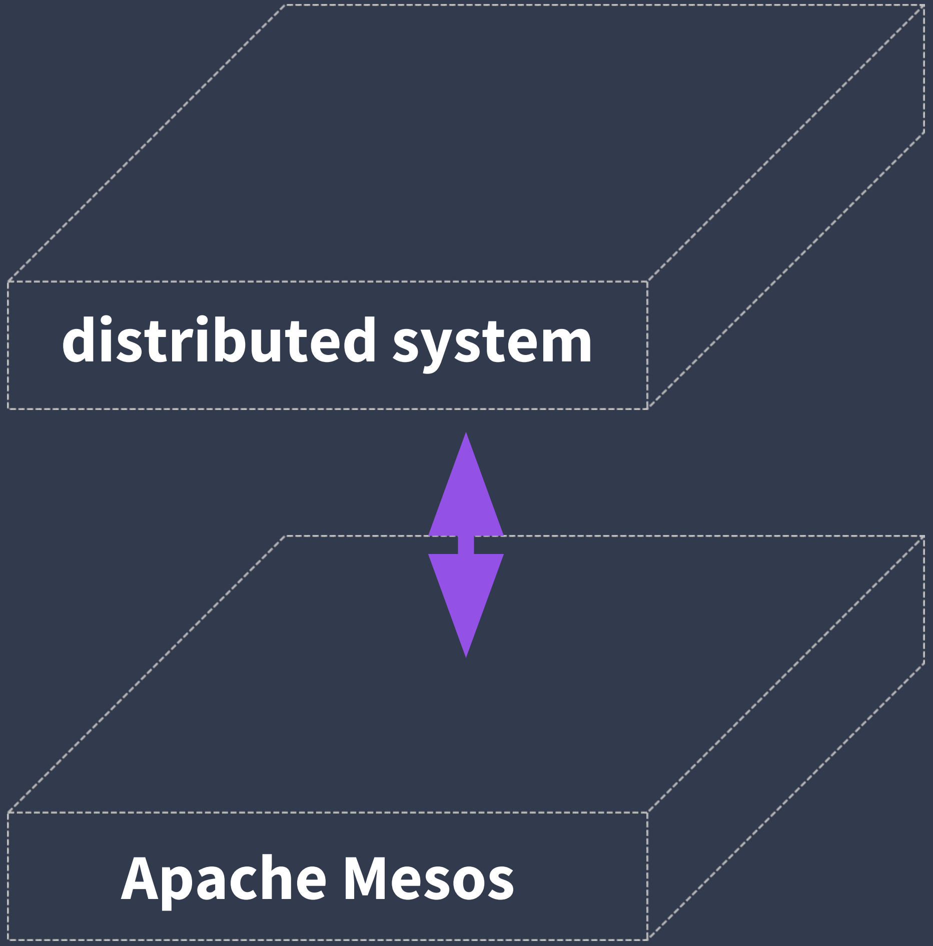
container/VM failed

resource deallocation

…

tell the distributed system about “planned failures” (i.e., maintenance)

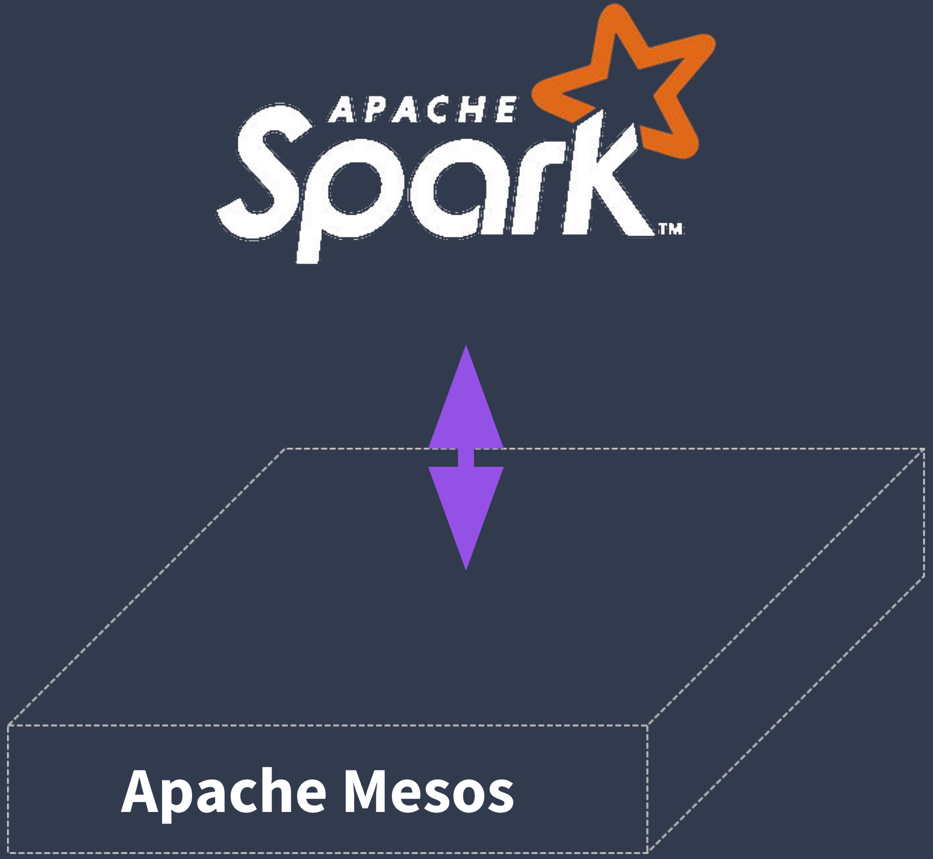
Apache Mesos



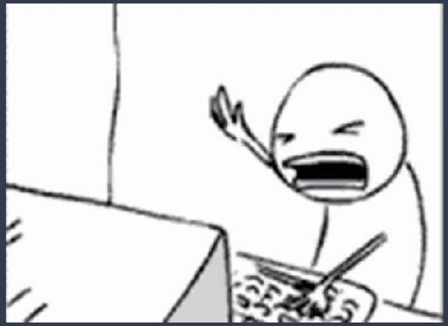
distributed system

Apache Mesos

Dogfooding: Apache Spark



reality is people are (already) building software that *operates* distributed systems …

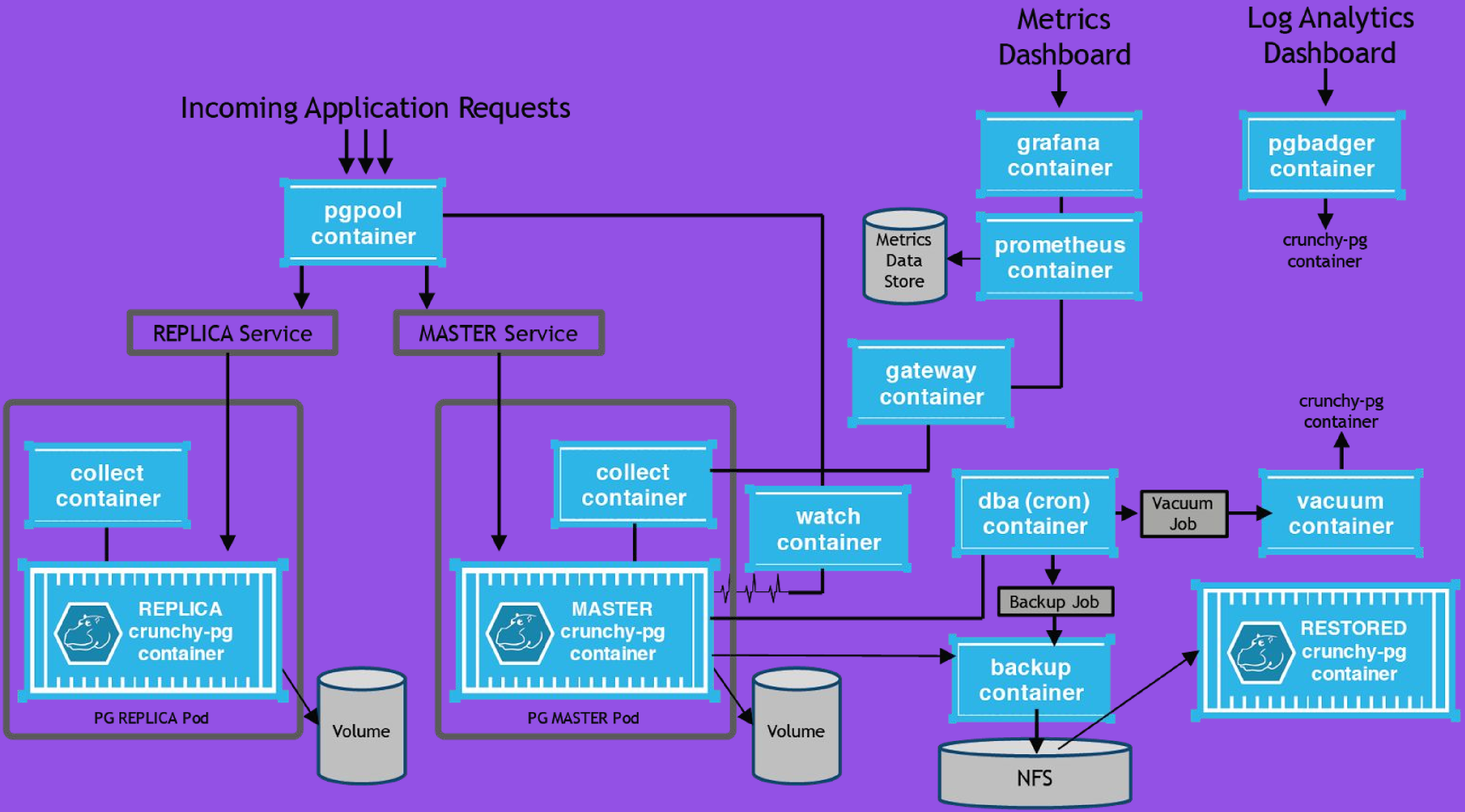


common pattern: ad hoc control planes

goal: provide *distributed system** as software as a service (SaaS) to the rest of your internal organization or to sell to external organizations

solution: a *control plane* built out of ad hoc scripts, ancillary services, etc, that deploy, maintain, and upgrade said SaaS

* e.g., analytics via Spark, message queue via Kafka, key/value store via Cassandra



https://github.com/crunchydata/crunchy-containers

```
$ kubectl create -f $LOC/kitchensink-master-service.json
$ kubectl create -f $LOC/kitchensink-slave-service.json
$ kubectl create -f $LOC/kitchensink-pgpool-service.json
$ envsubst < $LOC/kitchensink-sync-slave-pv.json | kubectl create -f -
$ envsubst < $LOC/kitchensink-master-pv.json | kubectl create -f -
$ kubectl create -f $LOC/kitchensink-sync-slave-pvc.json
$ kubectl create -f $LOC/kitchensink-master-pvc.json
$ envsubst < $LOC/kitchensink-master-pod.json | kubectl create -f -
$ envsubst < $LOC/kitchensink-slave-dc.json | kubectl create -f -
$ envsubst < $LOC/kitchensink-sync-slave-pod.json | kubectl create -f -
$ envsubst < $LOC/kitchensink-pgpool-rc.json | kubectl create -f -
$ kubectl create -f $LOC/kitchensink-watch-sa.json
$ envsubst < $LOC/kitchensink-watch-pod.json | kubectl create -f -
```

https://schd.ws/hosted_files/cnd2016/8d/Containerizing%20PostgreSQL%20and%20Making%20it%20Cloud%20Native%20Ready%20-%20Jeff%20McCormick.pdf

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```

https://schd.ws/hosted_files/cnd2016/8d/Containerizing%20PostgreSQL%20and%20Making%20it%20Cloud%20Native%20Ready%20-%20Jeff%20McCormick.pdf

what happens if there’s a bug in the control plane?

what if my control plane has diverged from yours?

what happens when a new release of the distributed system invalidates an assumption the control plane previously made?

a better world ...

control planes should be built into the distributed systems itself by the experts who built the distributed system in the first place!

as an industry we should strive to build a standard interface that distributed systems can leverage

vice versa:

abstractions exist for good reasons, but without sufficient communication they force sub-optimal outcomes …

a better world ...

control planes should be built into distributed systems themselves by the experts who built the distributed system in the first place!

as an industry we should strive to build a standard interface distributed systems can leverage

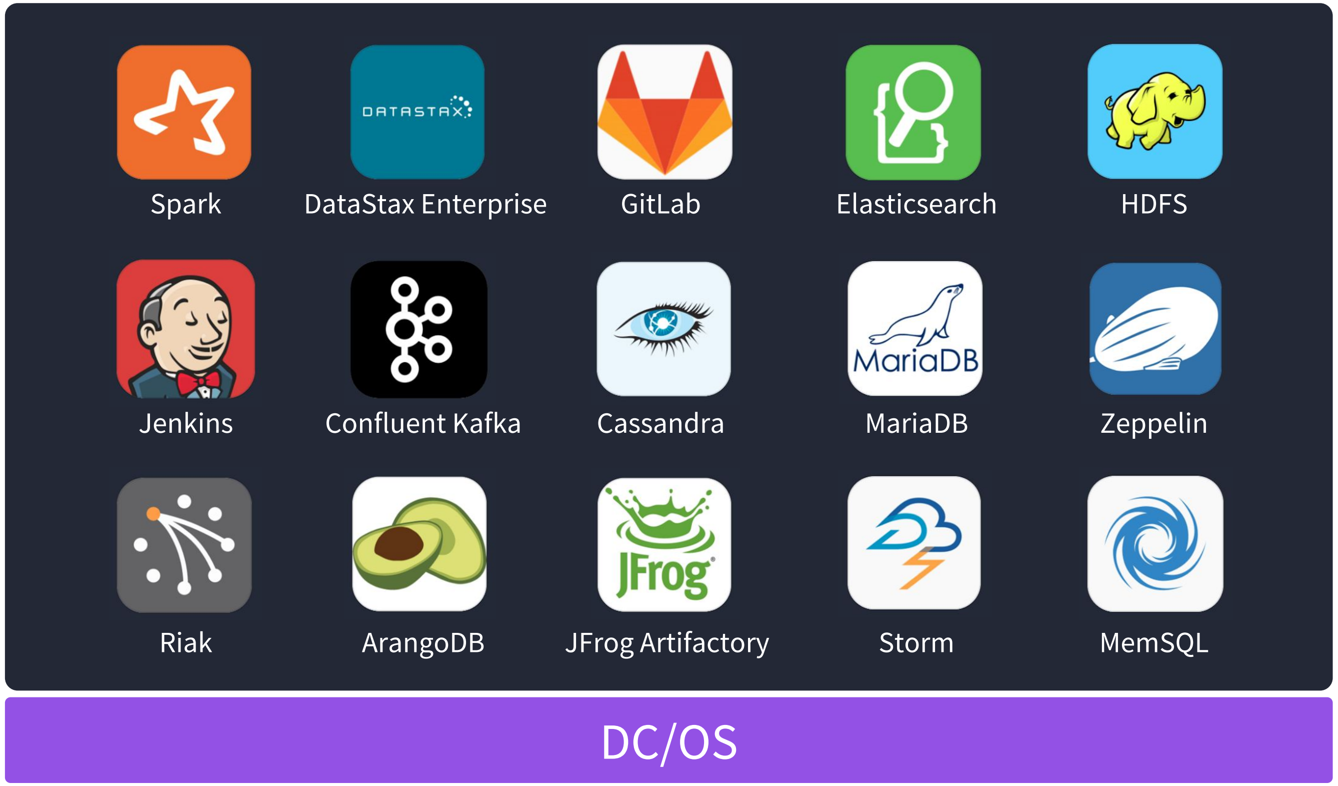
our standard interface should be bidirectional to avoid sub-optimal outcomes

how do we scale the operations of distributed systems?

let them *scale* themselves!

OPERATING SYSTEMS ARE FOR APPLICATIONS

"SaaS" Experience using DC/OS



Spark

DataStax Enterprise

GitLab

Elasticsearch

HDFS

Jenkins

Confluent Kafka

Cassandra

MariaDB

Zeppelin

Riak

ArangoDB

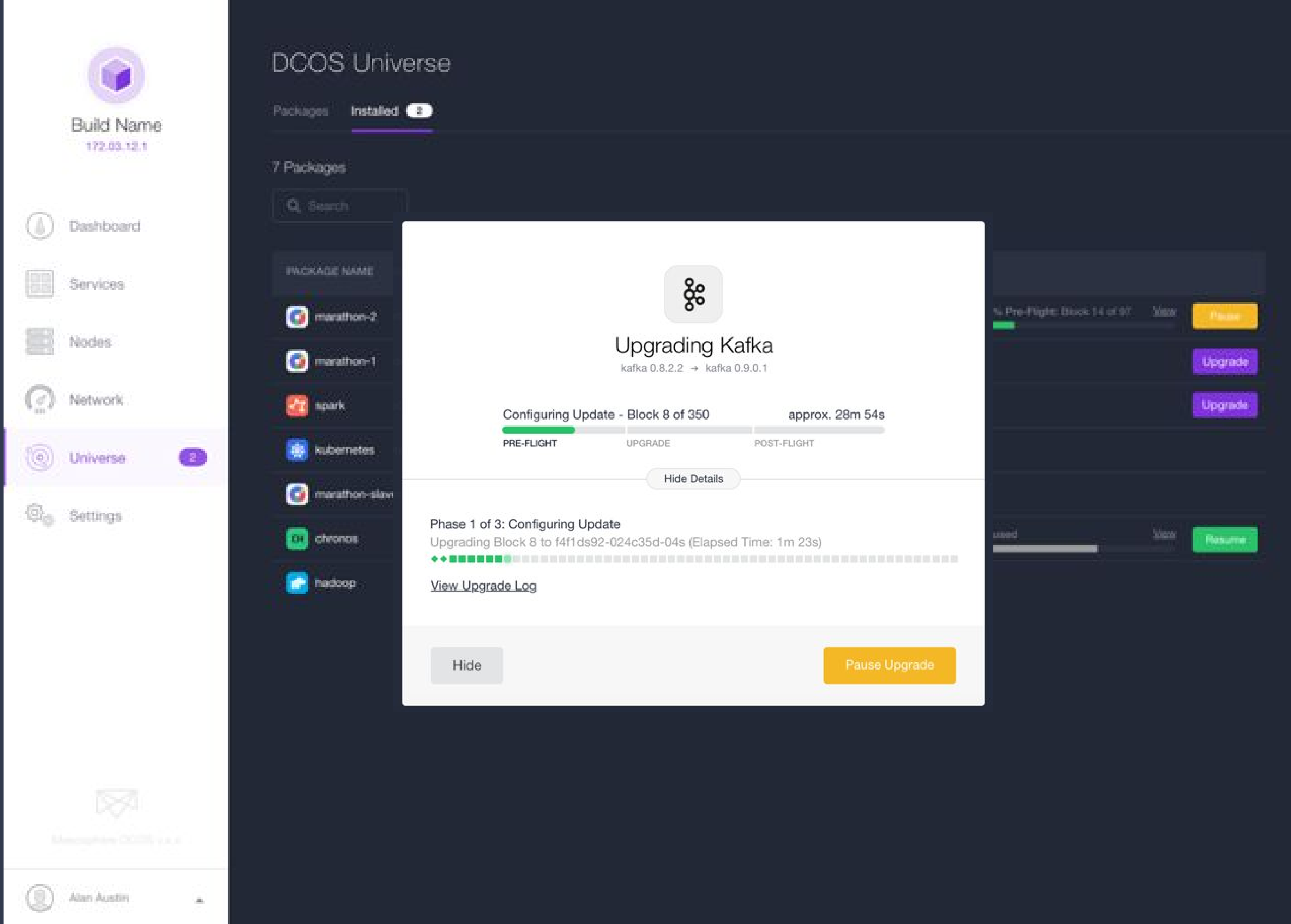
JFrog Artifactory

Storm

MemSQL

DC/OS

DC/OS SERVICE MANAGES IT'S OWN UPGRADES



Upgrading Kafka

kafka 0.8.2.2 → kafka 0.9.0.1

Configuring Update - Block 8 of 350 approx. 28m 54s

Phase 1 of 3: Configuring Update

Upgrading Block 8 to f4f1ds92-024c35d-04s (Elapsed Time: 1m 23s)

DC/OS: AVOIDING CLOUD LOCK-IN #2

	CAPABILITY	AWS	AZURE	GCP	DC/OS
Storage	**Object Storage**	S3	Blob Storage	Cloud Storage	Quobyte
	Block Storage	Elastic Block Storage (EBS)	Page Blobs, Premium Storage	GCE Persistent Disks	EMC² ScaleIO
	File Storage	Elastic File System	File Storage	ZFS / Avere	EMC² ScaleIO
DB	**Relational**	RDS	SQL Database	Cloud SQL (MySQL)	MariaDB CRATE.IO MEMSQL MySQL
	NoSQL	DynamoDB	DocumentDB	Datastore, Bigtable	cassandra ArangoDB riak
Data & Analytics	**Full Text Search**	CloudSearch	Log Analytics, Search	N/A	elastic
	Hadoop / Analytics	Elastic Map Reduce (EMR)	HDInsight	Dataproc, Dataflow	hadoop HDFS Spark
	Stream Processing / Ingest	Kinesis	Stream Analytics, Data Lake	Kinesis	kafka Spark Streaming
	Data Warehouse	Redshift	SQL Data Warehouse	BigQuery	citusdata Impala APACHE DRILL
Other	**Monitoring**	CloudWatch	Application Insights, Portal	Stackdriver Monitoring	DATADOG netsil ruxit sysdig
	Serverless	Lambda	Azure Functions	Google Cloud Functions	GALACTIC FOG

THANK YOU!

DEMO!

QUESTIONS?

@dcos

chat.dcos.io

users@dcos.io

/groups/8295652

/dcos
/dcos/examples
/dcos/demos

bigger picture:

abstractions exist for good reasons, but without sufficient communication they force sub-optimal outcomes …