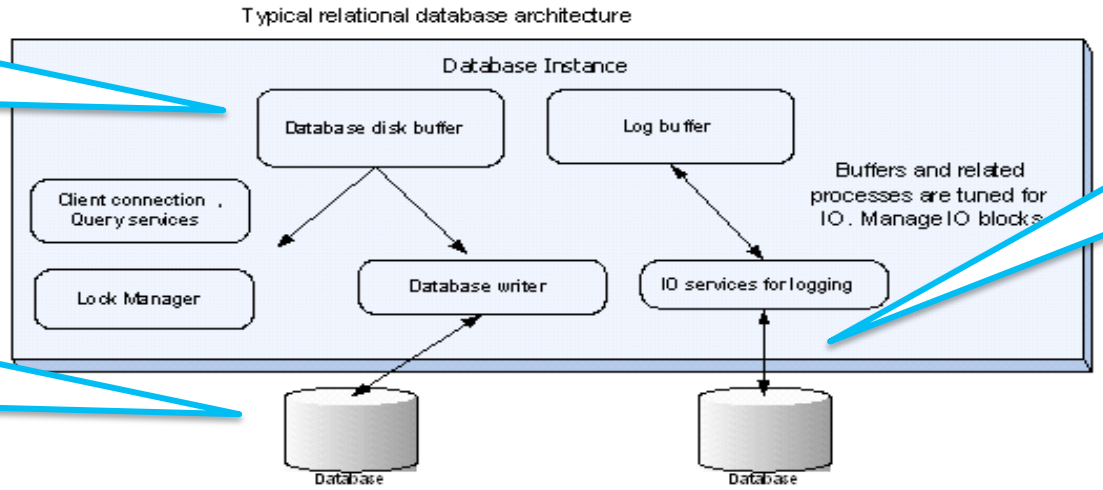

Pivotal
BUILT FOR THE SPEED OF BUSINESS

Eliminate disk access in the real time path

We Challenge the traditional RDBMS design NOT SQL

Buffers primarily tuned for IO



First write to Log

Second write to Data Files

Too much I/O

Design roots don't necessarily apply today

- **Too much focus on ACID**
- **Disk synchronization bottlenecks**

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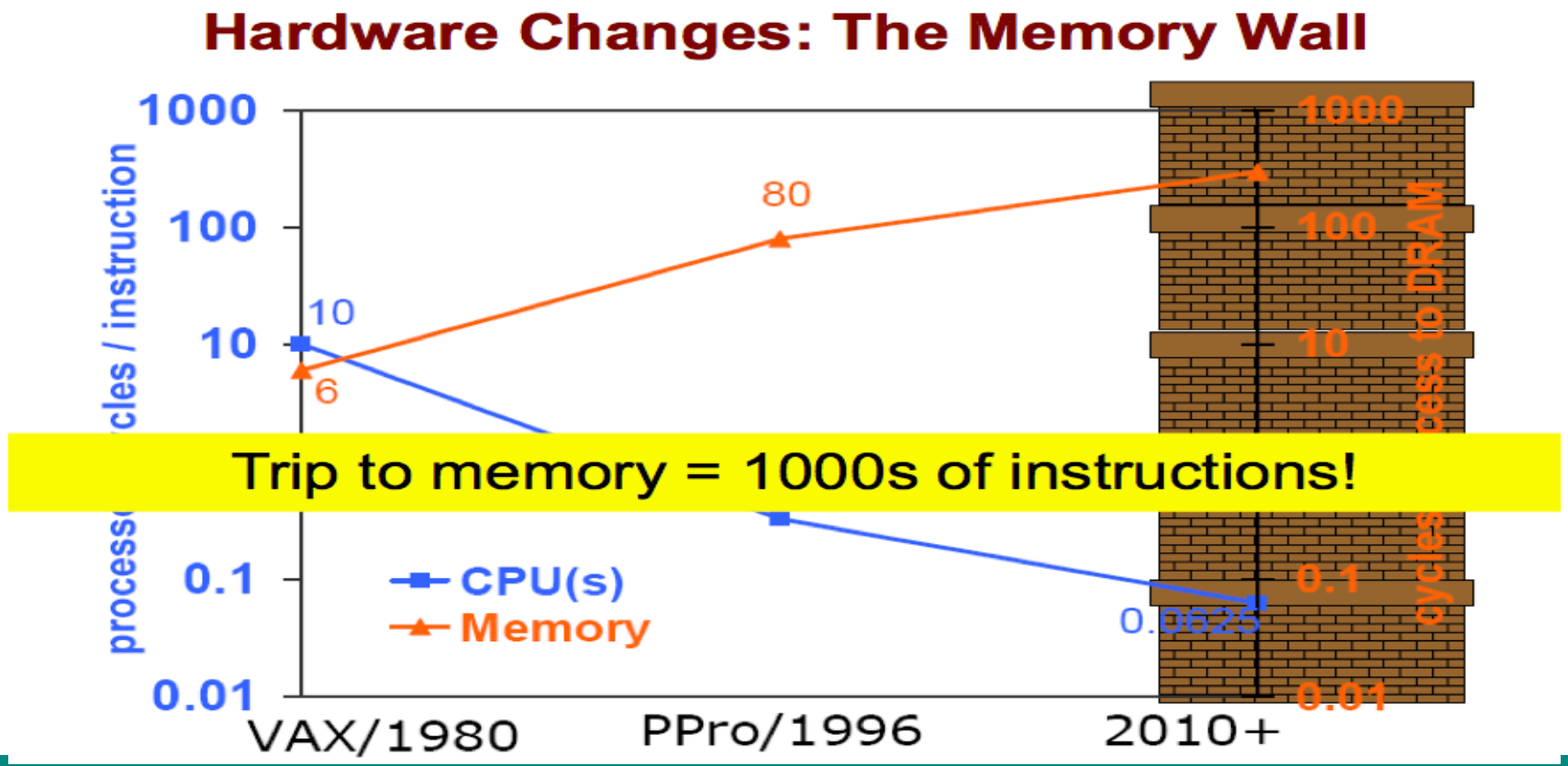
‘Memory is the new bottleneck’



Source: MonetDB

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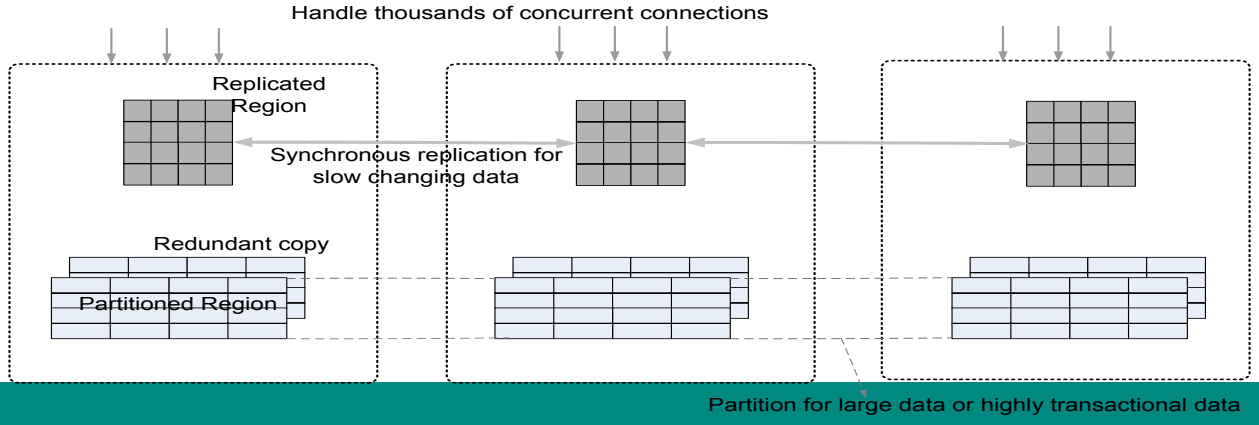
IMDG basic concepts

- Distributed memory oriented store
  - KV/Objects or JSON
  - Queryable, Indexable and transactional
- Multiple storage models
  - Replication, partitioning in memory
  - With synchronous copies in cluster
  - Overflow to disk and/or RDBMS

- Parallelize Java App logic
- Multiple failure detection schemes
- Dynamic membership (elastic)

- Vendors differentiate on
  - Query support, WAN, events, etc

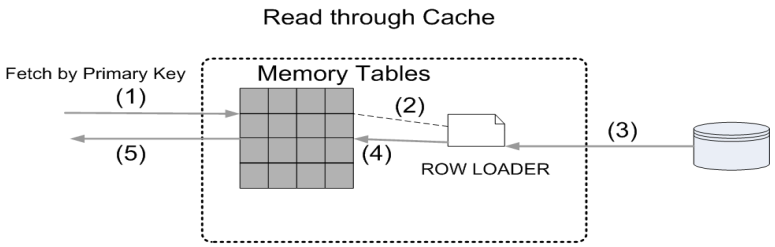


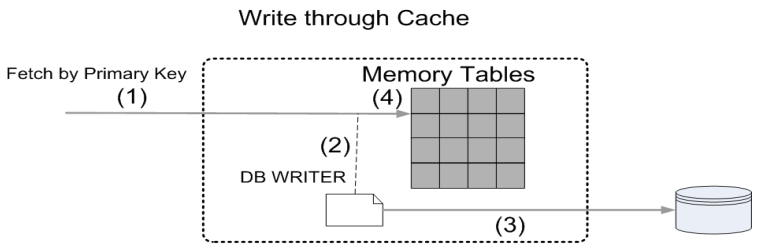
Low latency for thousands of clients

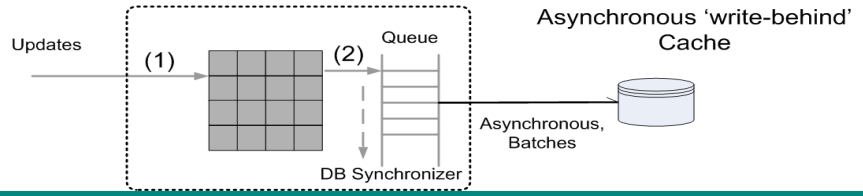
4

Key IMDG pattern - Distributed Caching

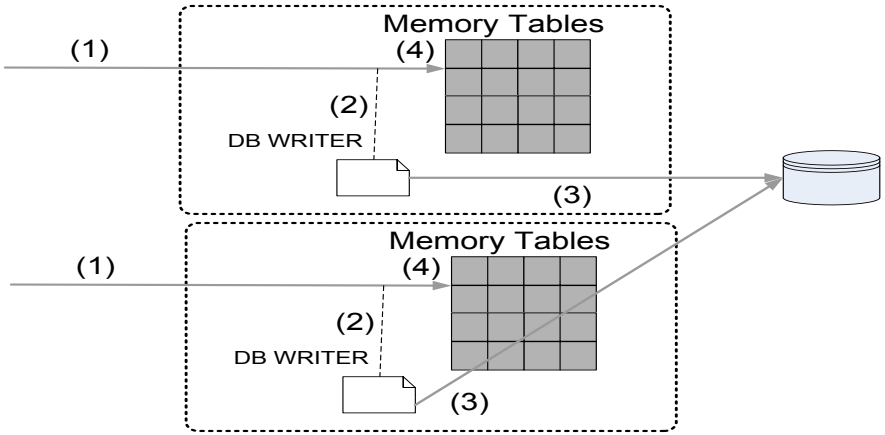
- Designed to work with existing RDBs
  - Read through: Fetch from DB on cache miss
  - Write through: Reflect in cache IFF DB write succeeds
  - Write behind: reliable, in-order queue and batch write to DB

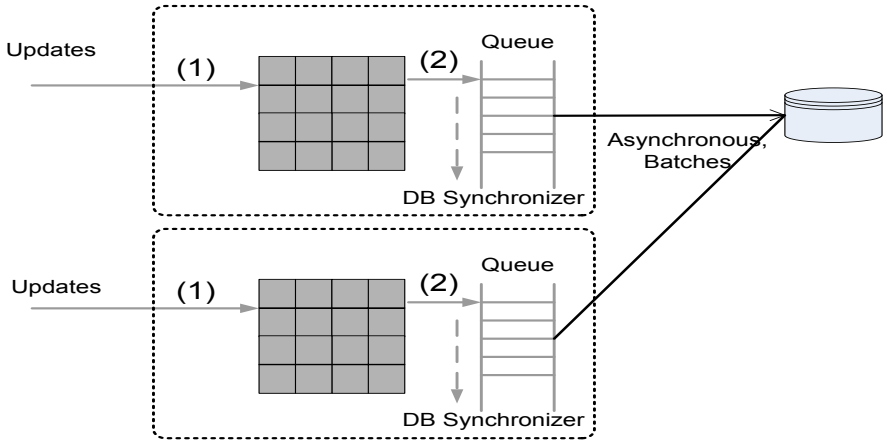






Traditional RDB integration can be challenging





Synchronous "Write through"

Single point of bottleneck and failure
Not an option for "Write heavy"
Complex 2-phase commit protocol
Parallel recovery is difficult

Asynchronous "Write behind"

Cannot sustain high "write" rates
Queue may have to be persistent
Parallel recovery is difficult

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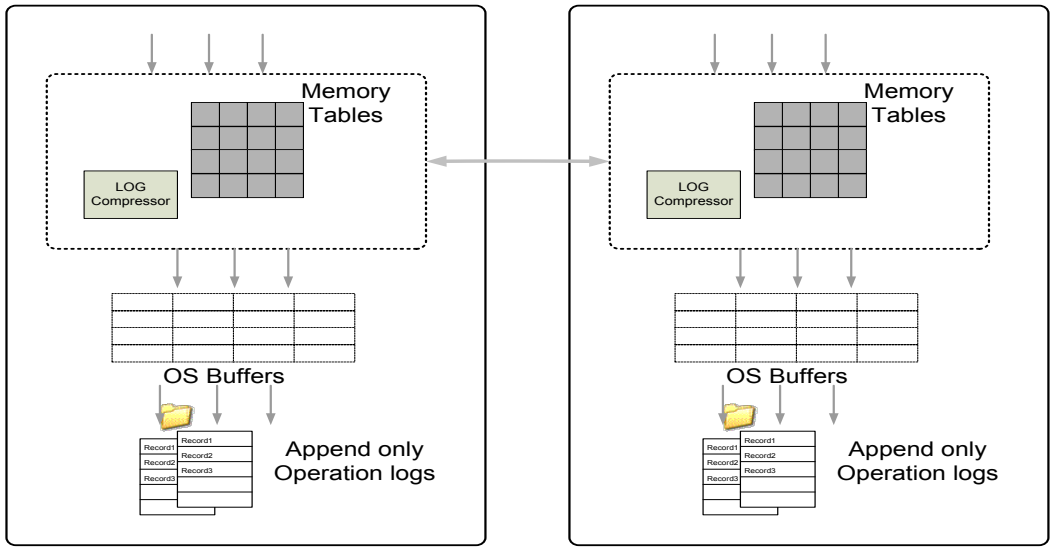
Some IMDG, NoSQL offer ‘Shared nothing persistence’



- Append only operation logs
- Fully parallel
- Zero disk seeks

- But, cluster restart requires log scan

- Very large volumes pose challenges

GemFire

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GemFire – How we got here

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GemFire – The world as we see it

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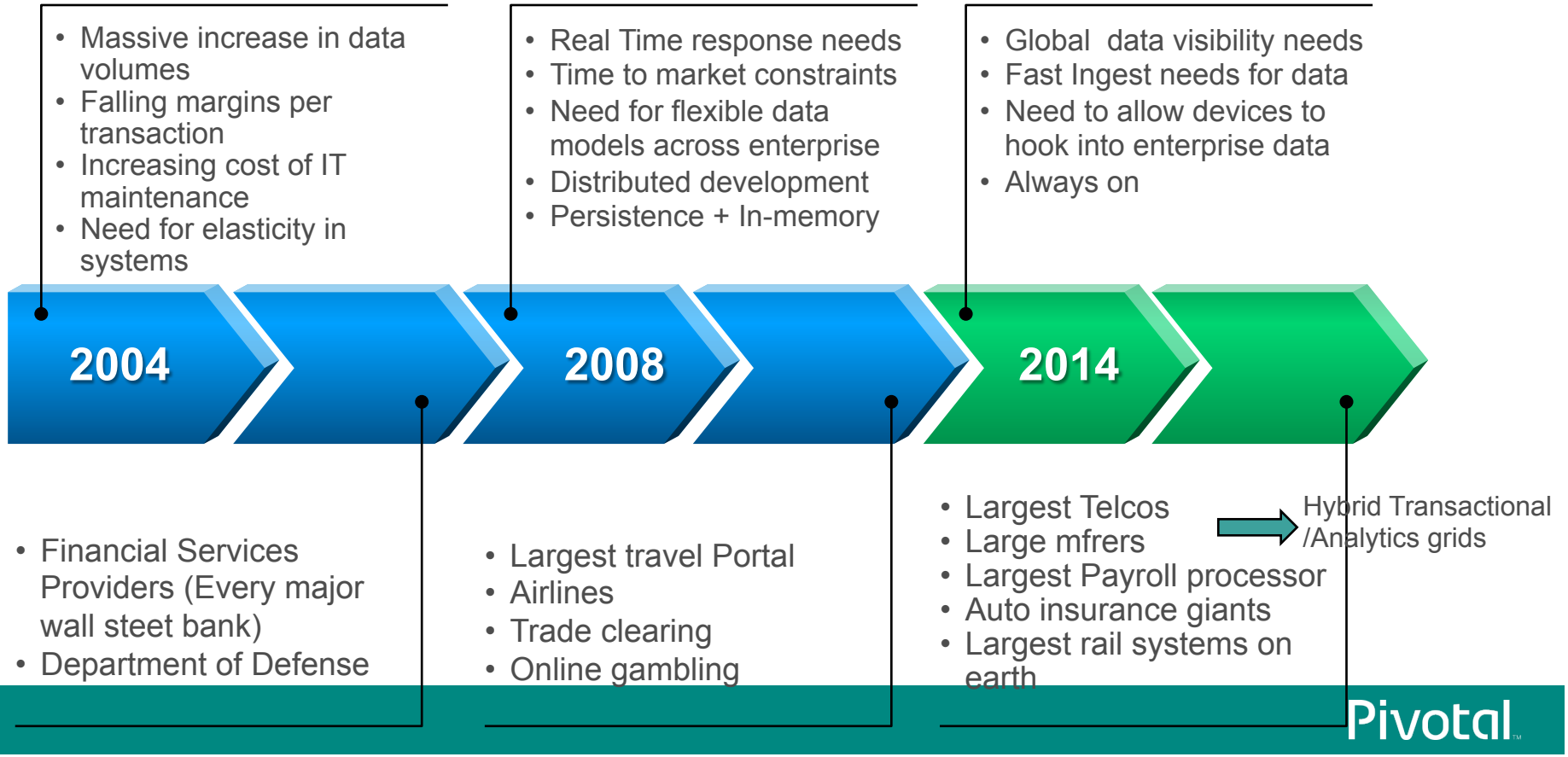
Our GemFire Journey Over The Years



Why OSS? Why Now? Why Apache?

- Open Source Software is fundamentally changing buying patterns
  - Developers have to endorse product selection (No longer CIO handshake)
  - Community endorsement is key to product visibility
  - Open source credentials attract the best developers
  - Vendor credibility directly tied to street credibility of product
- Align with the tides of history
  - Customers increasingly asking to participate in product development
  - Resume driven development forces customers to consider OSS products
  - Allow product development to happen with full transparency
- Apache is where you go to build Open Source street cred
  - Transparent, meritocracy which puts developers in charge
  - Roman keeps shouting “Apache!” every few hours

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Geode Will Be A Significant Apache Project

- Over a 1000 person years invested into cutting edge R&D
- Thousands of production customers in very demanding verticals
- Cutting edge use cases that have shaped product thinking
- Tens of thousands of distributed , scaled up tests that can randomize every aspect of the product
- A core technology team that has stayed together since founding
- Performance differentiators that are baked into every aspect of the product

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GemFire – Architecture Designed For Speed & Scale

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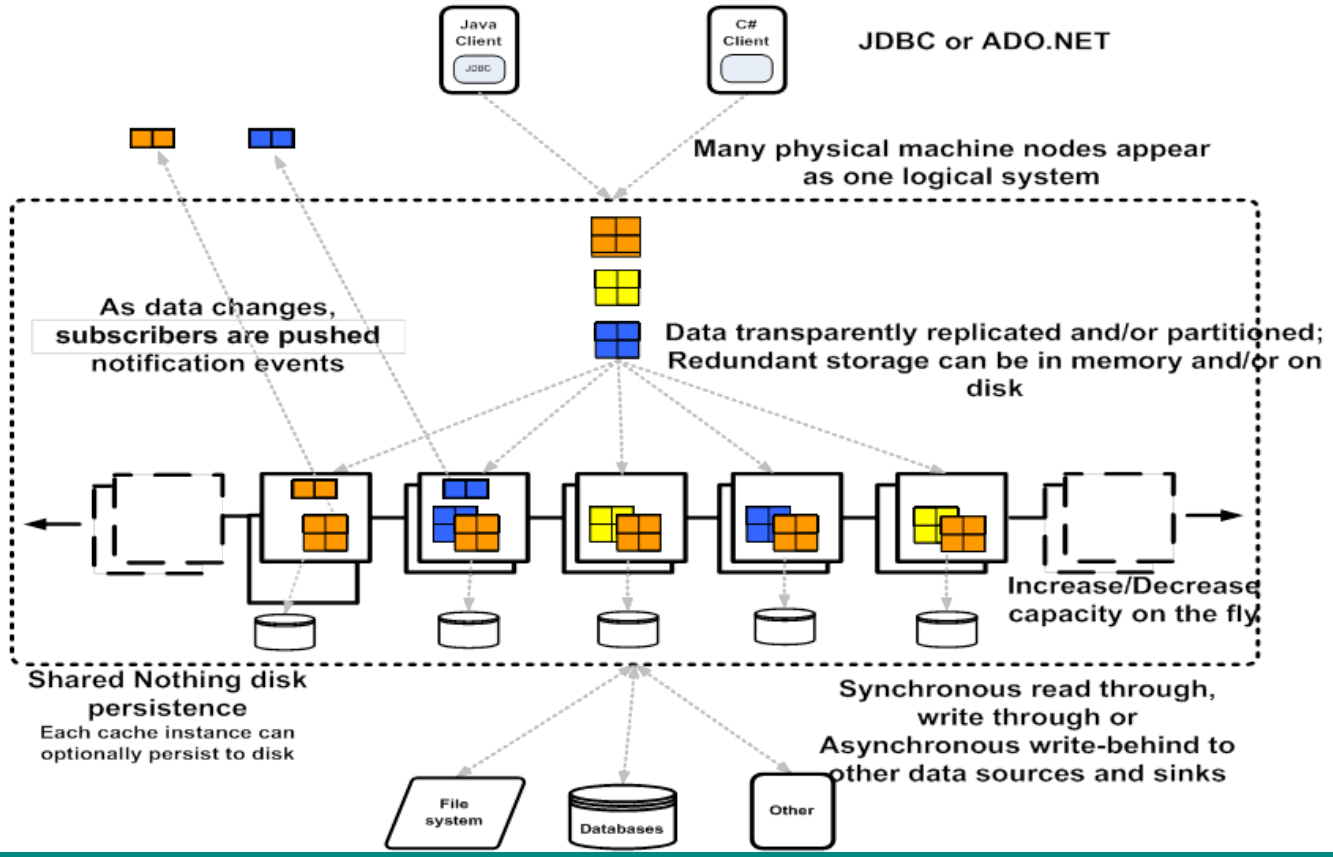
Gemfire High Level Architecture



What makes it fast?

- Minimize copying
  - Clients dynamically acquire partitioning meta data for single hop access
  - Avoid JVM memory pools to the extent possible
- Minimize contention points .. avoid offloading to OS scheduler
  - Highly concurrent data structures
  - Efficient data transmission – Nagle's Algorithm
- Flexible consistency model
  - FIFO consistency across replicas but NO global ordering across threads
  - Promote single row transactions (i.e no transactions)
  - No lock escalation strategies … no *Serializable* transactions

What makes it fast?

- Avoid disk seeks
  - Data kept in Memory – 100 times faster than disk
  - Keep indexes in memory, even when data is on disk
  - Direct pointers to disk location when offloaded (single IOP fetch)
  - Flush only to OS buffers
    - Mitigate failure risks by concurrent disk write on replicas
- Tiered Caching
  - Eventually consistent client caches
  - Avoid Slow receiver problems
- Partition and parallelize everything
  - Data. Application processing (procedures, callbacks), queries, Write behind, CQ/Event processing

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GemFire – Common Usage Patterns

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“low touch” Usage Patterns

HTTP Session management

Simple template for TCServer, TC, App servers

Shared nothing persistence, Global session state

Hibernate L2 Cache plugin

Set Cache in hibernate.cfg.xml

Support for query and entity caching

Memcached protocol

Servers understand the *memcached* wire protocol

Use any *memcached* client

Spring Cache Abstraction

```
<bean id="cacheManager"
class="org.springframework.data.gemfire.support.GemfireCacheManager"
```

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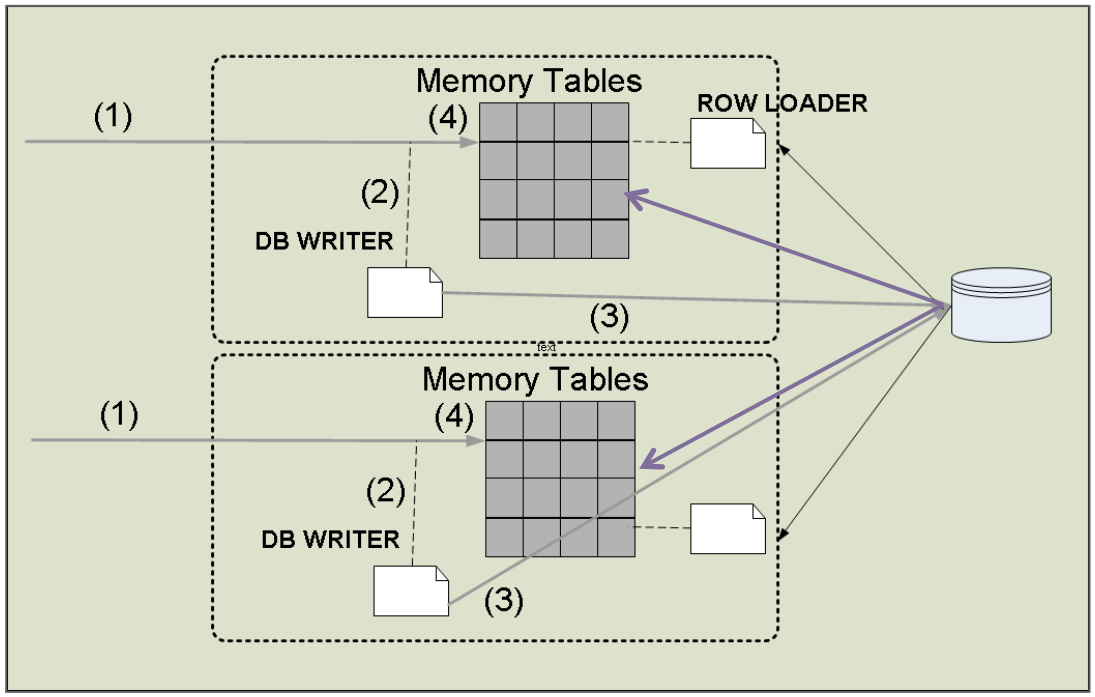
“Write thru” Distributed caching



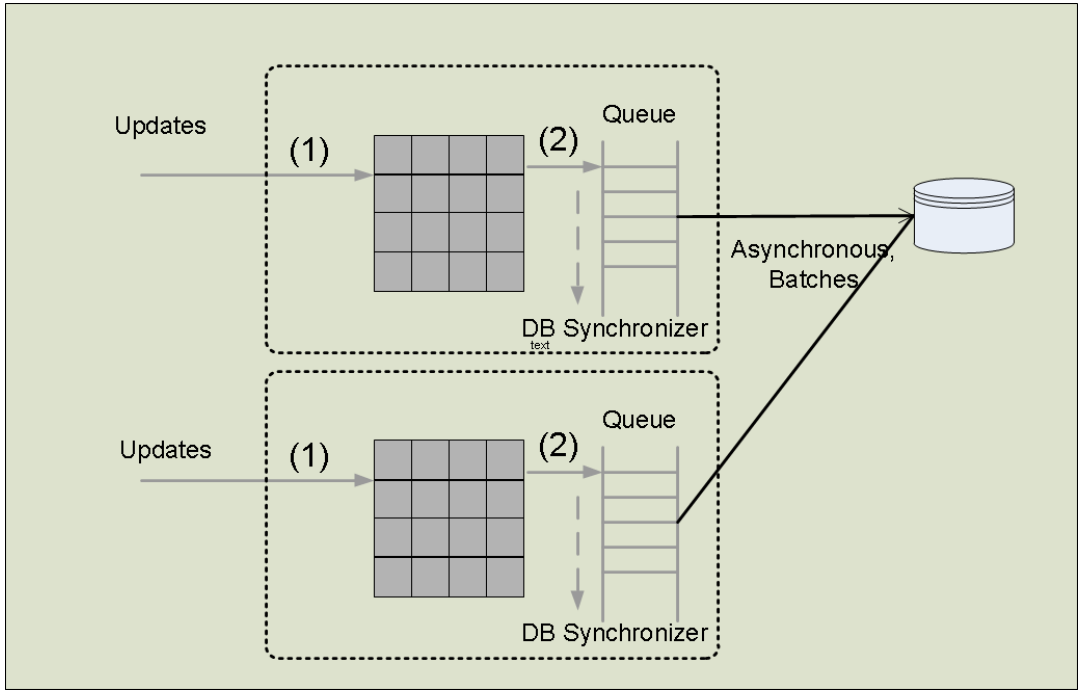
Pre-load data into system

Lazily load cache misses

Configure LRU eviction or expiry for large data

“Write thru” – participate in container transaction

Distributed caching with Async writes to DB



Buffer high write rate from DB

Writes can be enqueued in memory redundantly on multiple nodes

Or, also be persisted to disk on each node

Batches can be conflated and written to DB

Pattern for “high ingest” into Data Warehouse

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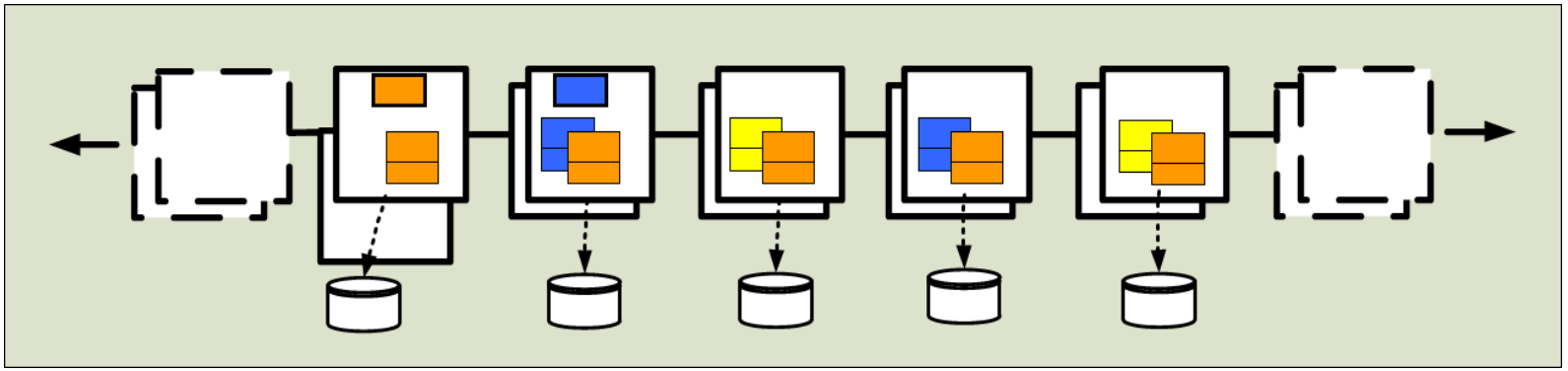
As a scalable OLTP data store



Shared nothing persistence to disk
Backup and recovery

No Database to configure and be throttled by

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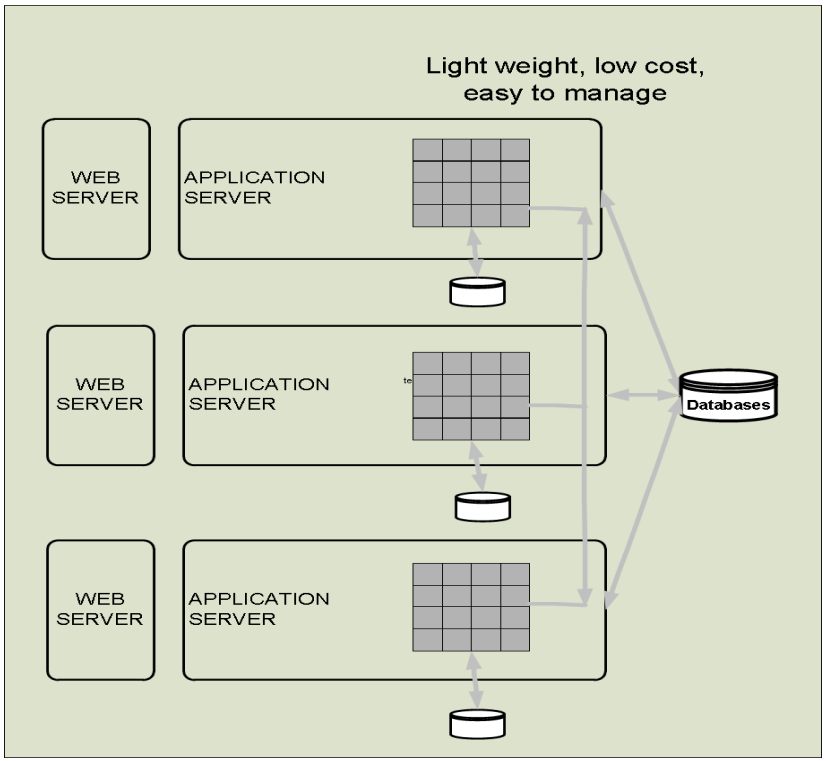
As embedded, clustered Java database



Just deploy a JAR or WAR into clustered App nodes

Data can be sync'd with DB is partitioned or replicated across the cluster

Low cost and easy to manage

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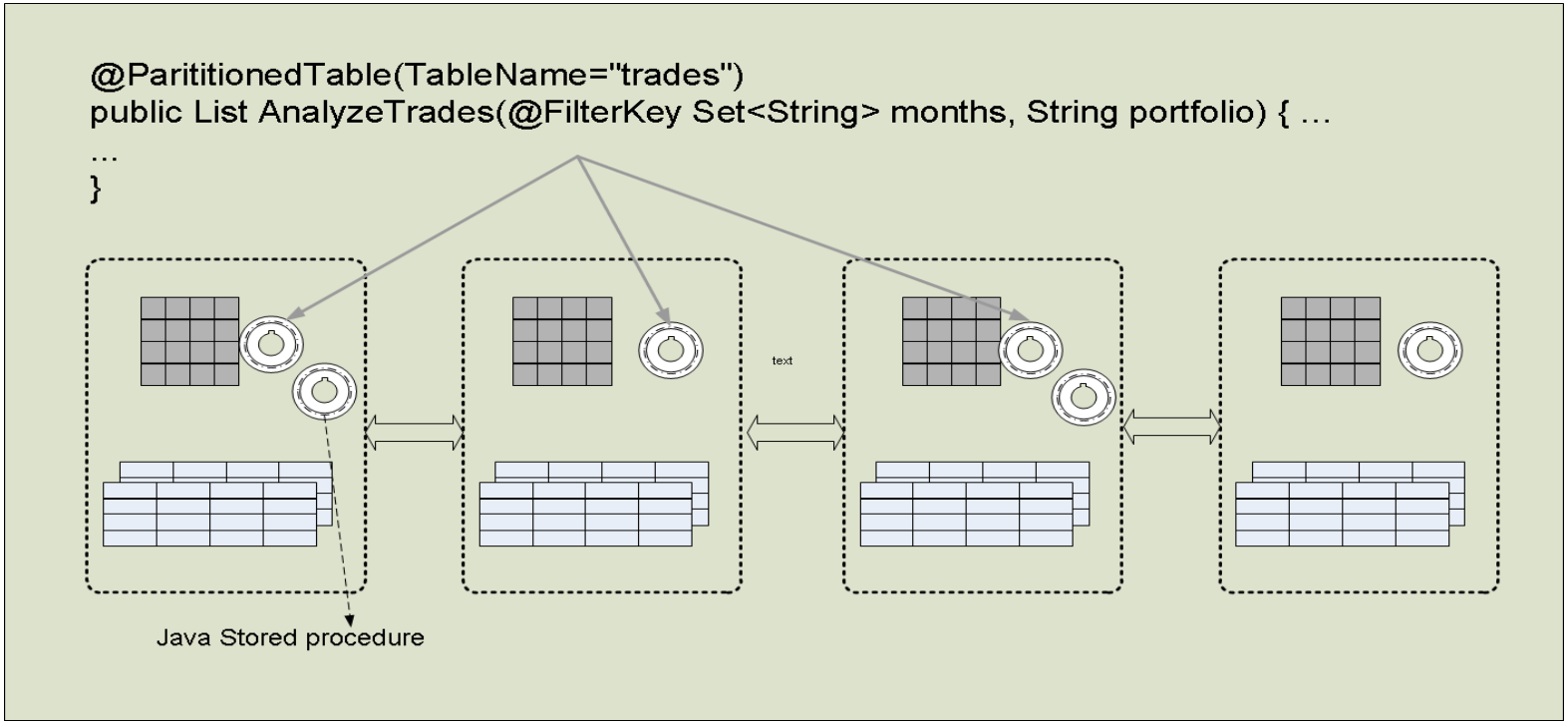
To process app behavior in parallel



Map-reduce but based on simpler RPC

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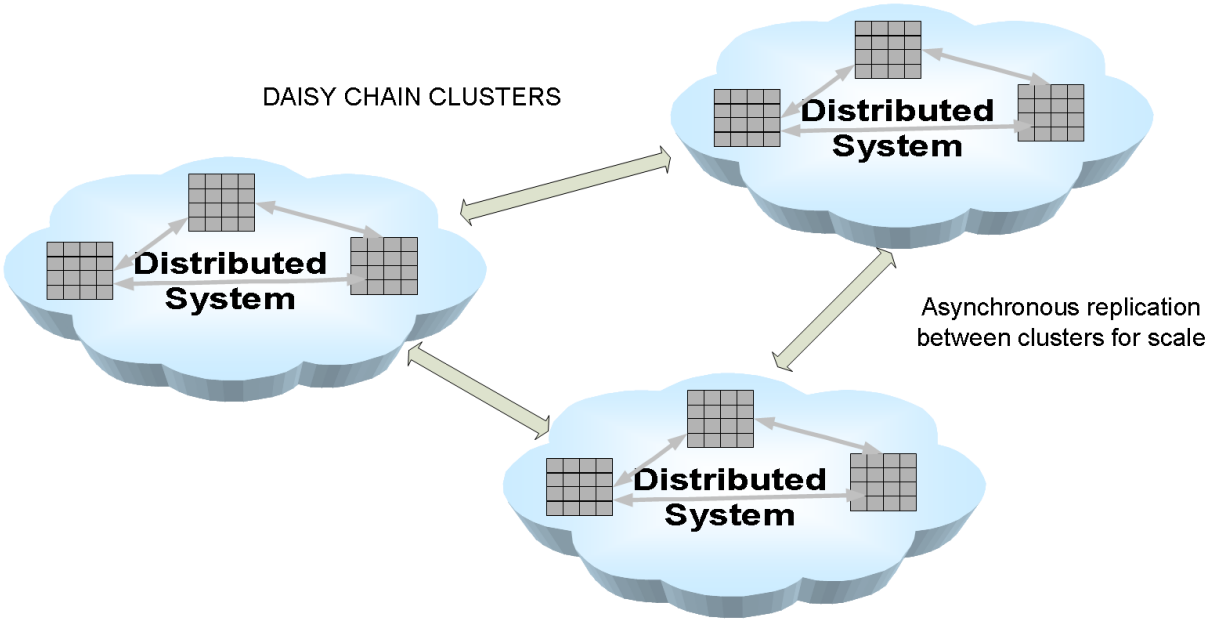
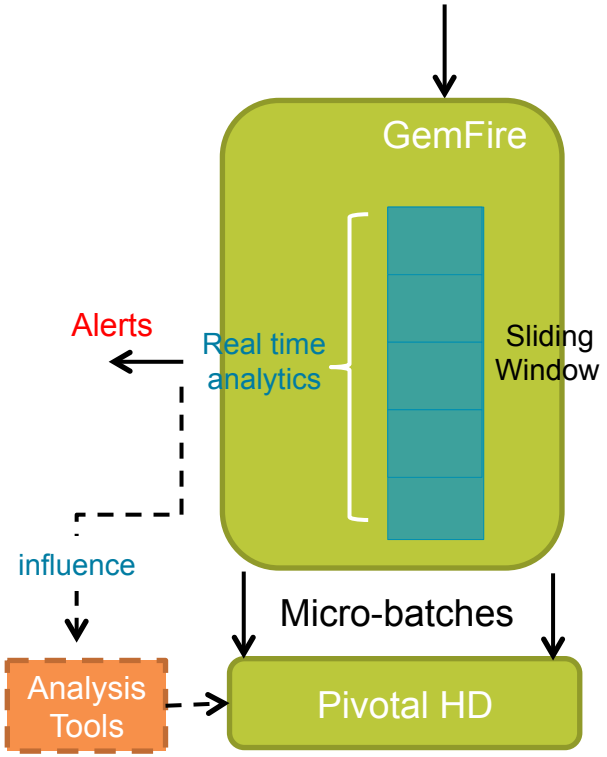
To make data visible across sites in real time



Real Time Analytics With GemFire

- Data stored within GemFire in a “sliding window”
- GemFire map-reduce style in-memory analytics can be performed with data locality
  - Ex: Violation of known trading patterns
- **Benefit**: Early-warning indicators can be identified faster than waiting for analysis on just Pivotal HD
- **Benefit**: Real-time analytics can better influence what kind of big data analytics need to be performed



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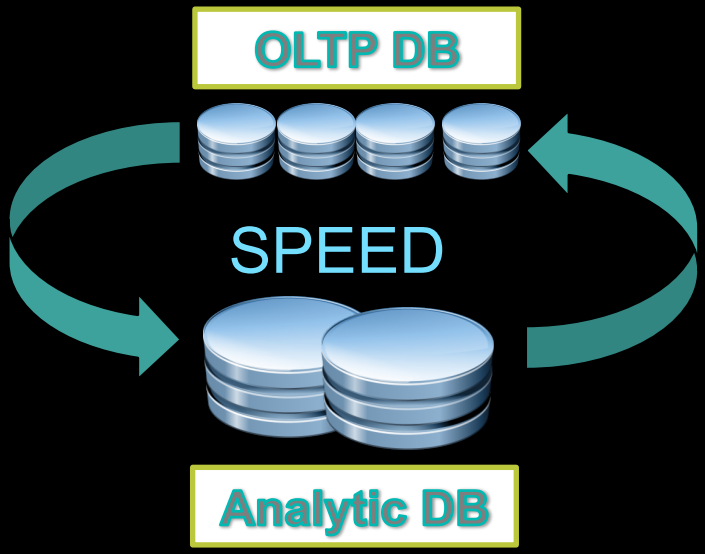
Analytics on HDFS



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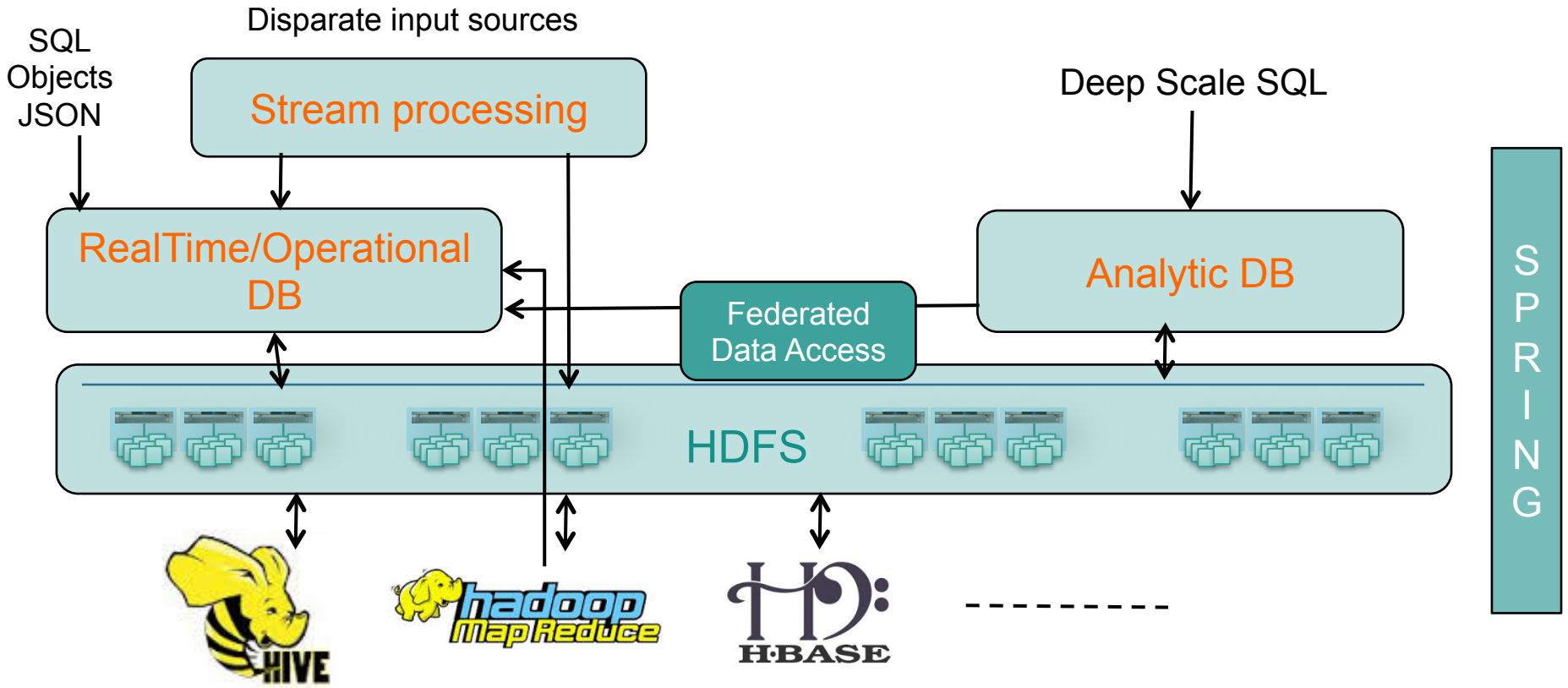
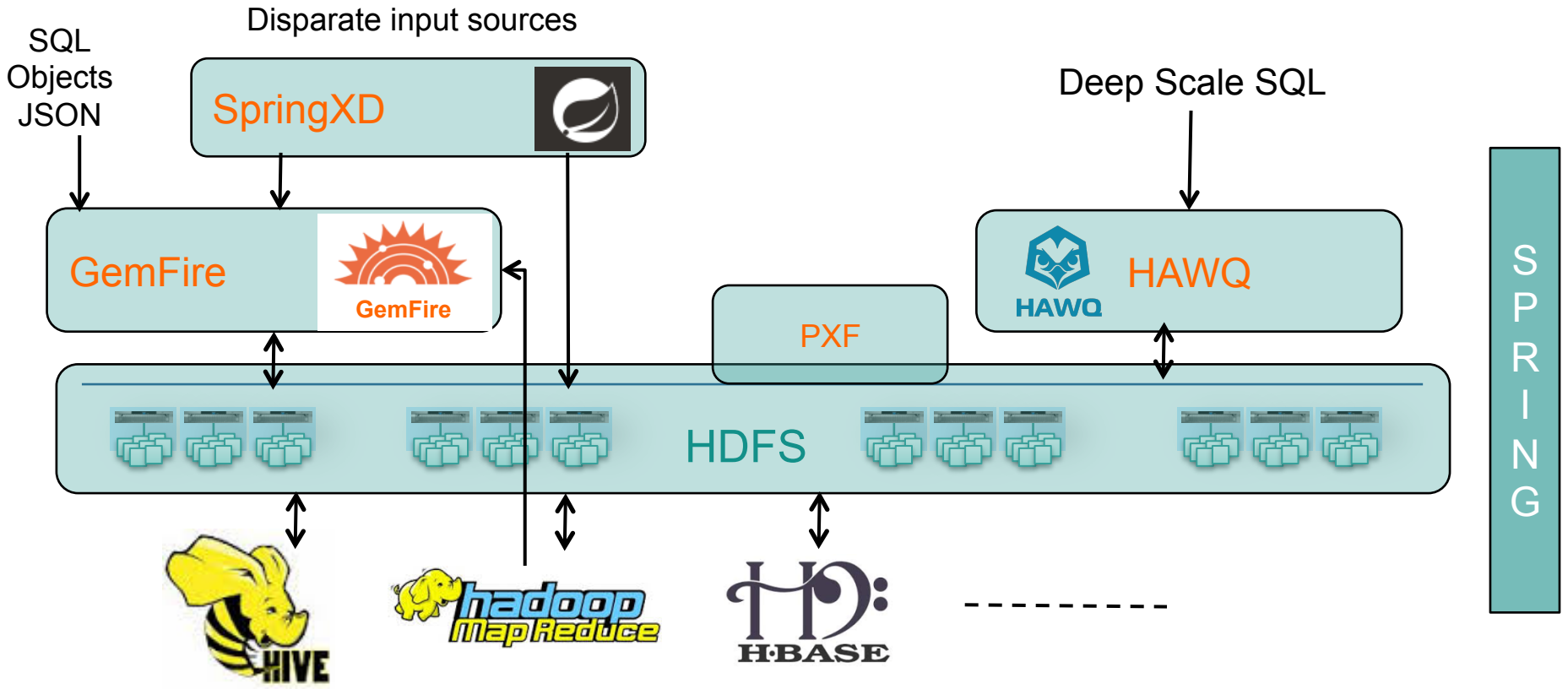
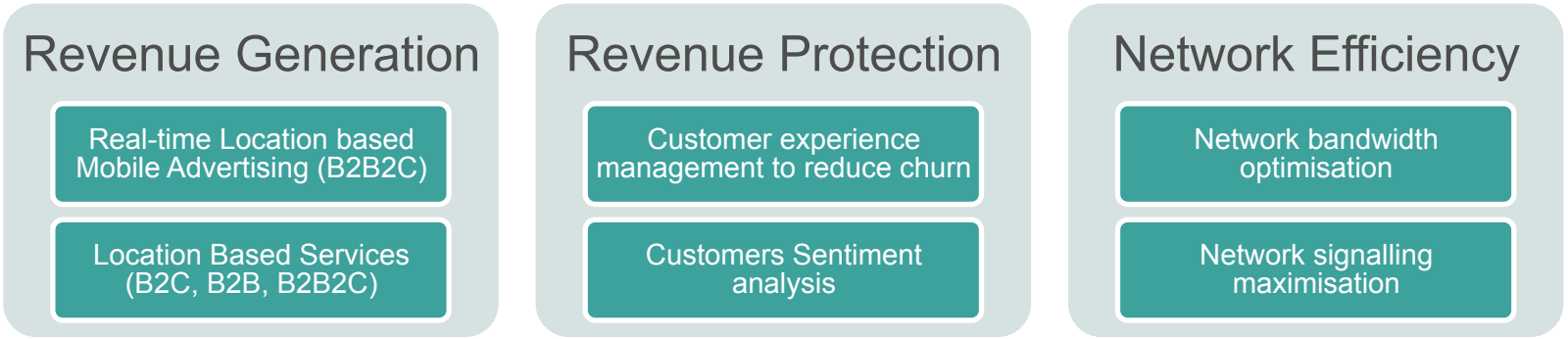
The Pivotal Data Fabric (core platform)



Mapping to Products



Use case: Telemetry – Net optimization, Location based Svc



- Network optimization
  - E.g. re-reroute call to another cell tower if congestion detected
- Location based Ads
  - Match incoming event to Subscriber profile; If 'Opt-in' show location sensitive Ad
- Challenge: Too much streaming data
  - Many subscribers, lots of 2G/3G/4G voice/data
  - Network events: location events, CDRs, network issues

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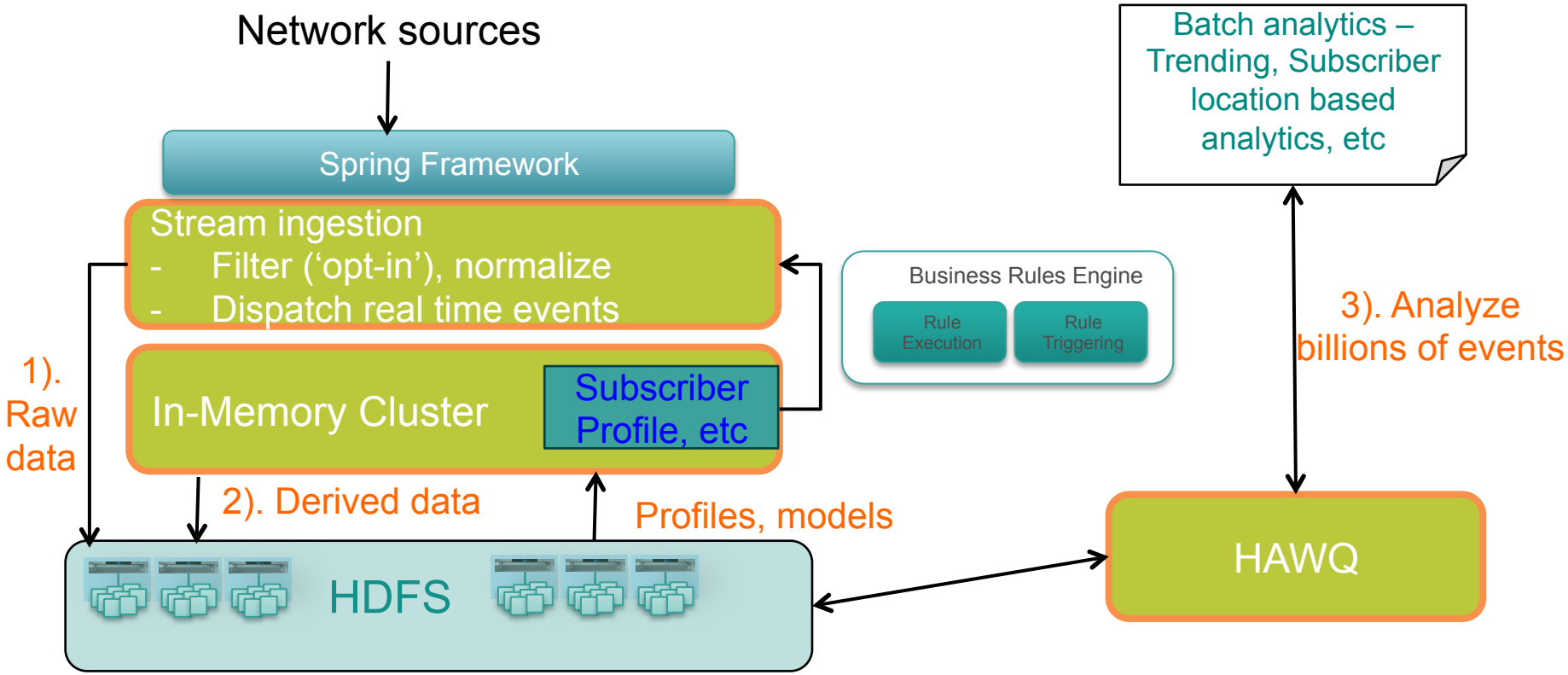
Scalable Big Data Architecture for Real time Network analytics



Demo

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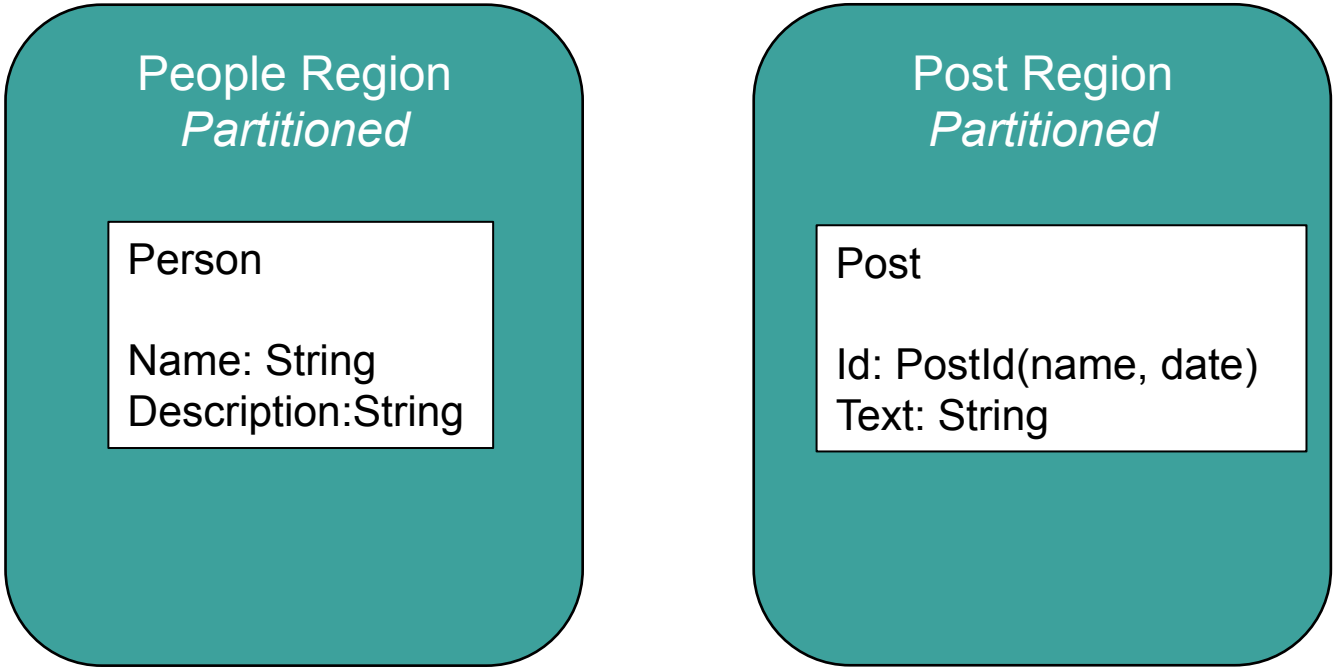
Social Network



Basic Save Code

```
public interface PersonRepository extends CrudRepository<Person, String> {
}
```

```
@Autowired
PersonRepository people;

Public static void main(String[] args) {
{
   people.save(new Person(name));
}
```

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Configuration

```
<bean id="pdxSerializer"
class="com.gemstone.gemfire.pdx.ReflectionBasedAutoSerializer">
        <constructor-arg value="io.pivotal.happysocial.model.*"/>
</bean>

<gfe:cache pdx-serializer-ref="pdxSerializer"/>

<gfe:partitioned-region id="people" copies="1"/>
```

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Queries

```
public interface PostRepository extends
                GemfireRepository<Post, PostId> {

    @Query("select * from /posts where id.person=$1")
    public Collection<Post> findPosts(String personName);
}
```

Query Nested Objects

```
Collection<Post> posts = postRepository.findPosts(personName);
```

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Indexes

```
public interface PostRepository extends
        GemfireRepository<Post, PostId> {

    @Query("select * from /posts where id.person=$1")
```

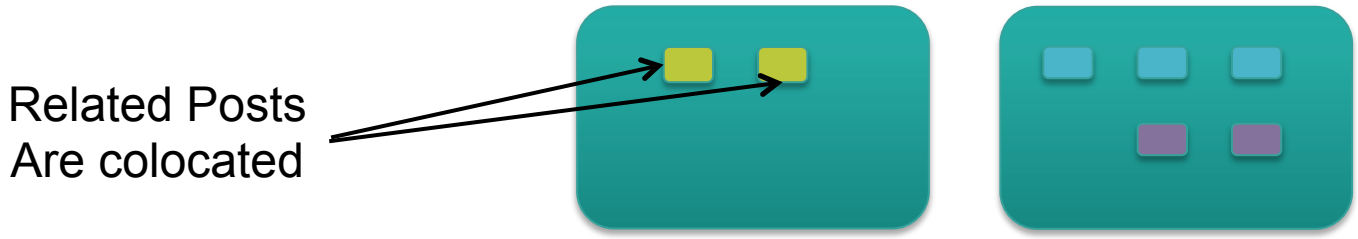
Query Nested Objects

```
<gfe:index id="postAuthor" expression="id.person" from="/posts"/>
```

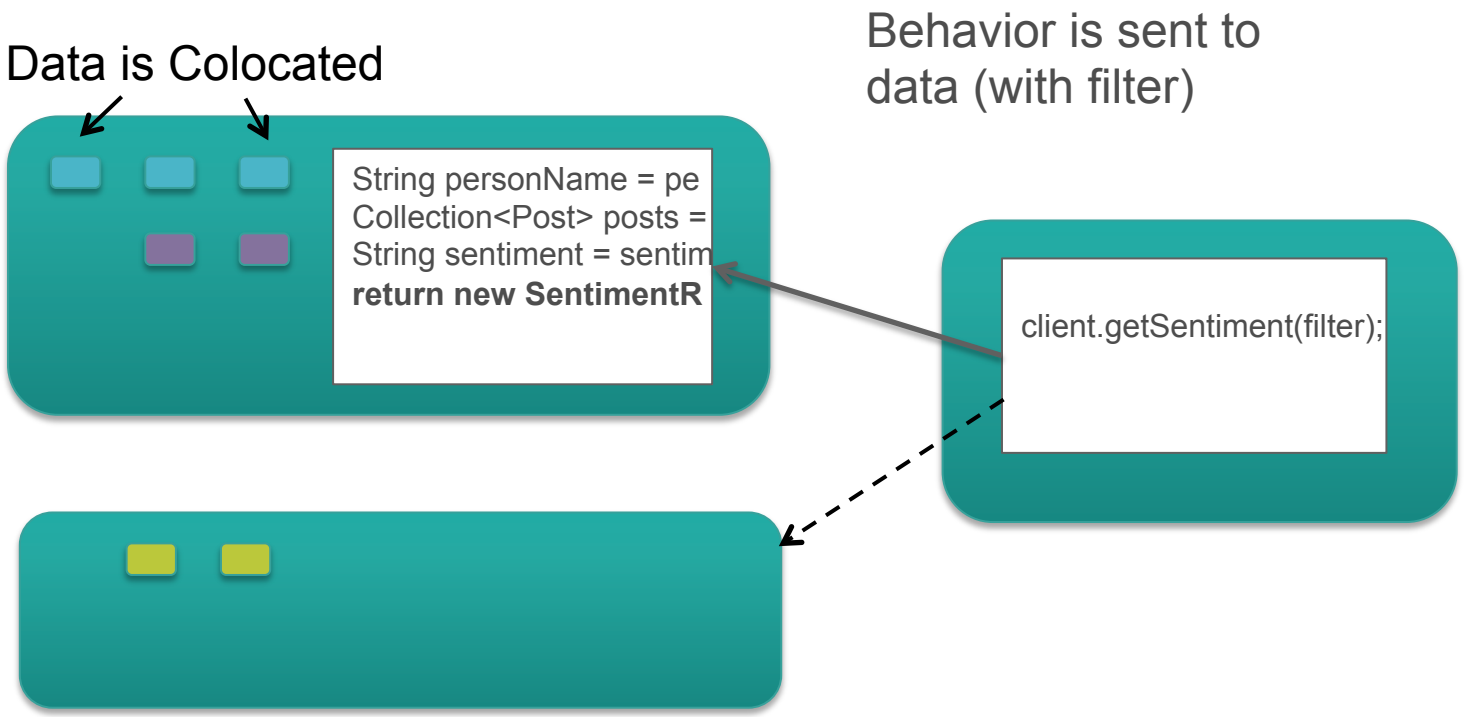
```
Collection<Post> posts = postRepository.findPosts(personName);
```

Colocation

```
<gfe:partitioned-region id="posts" copies="1" colocated-with="people">
        <gfe:partition-resolver ref="partitionResolver"/>
</gfe:partitioned-region>
```



Functions



Sample Function – Client Side

```
@Component
@OnRegion(region = "posts")
public interface FunctionClient {
  public List<SentimentResult> getSentiment(@Filter Set<String> people);
}
```

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Sample Function – Server Side

```
@Autowired private PostRepository postRepository;
@Autowired SentimentAnalyzer sentimentAnalyzer;

@GemfireFunction
public SentimentResult getSentiment(@Filter Set<String>
                                    personNames) {
   String personName = personNames.iterator().next();
   Collection<Post> posts = postRepository.findPosts(personName);
   String sentiment = sentimentAnalyzer.analyze(posts);
   return new SentimentResult(sentiment, personName);
 }
```

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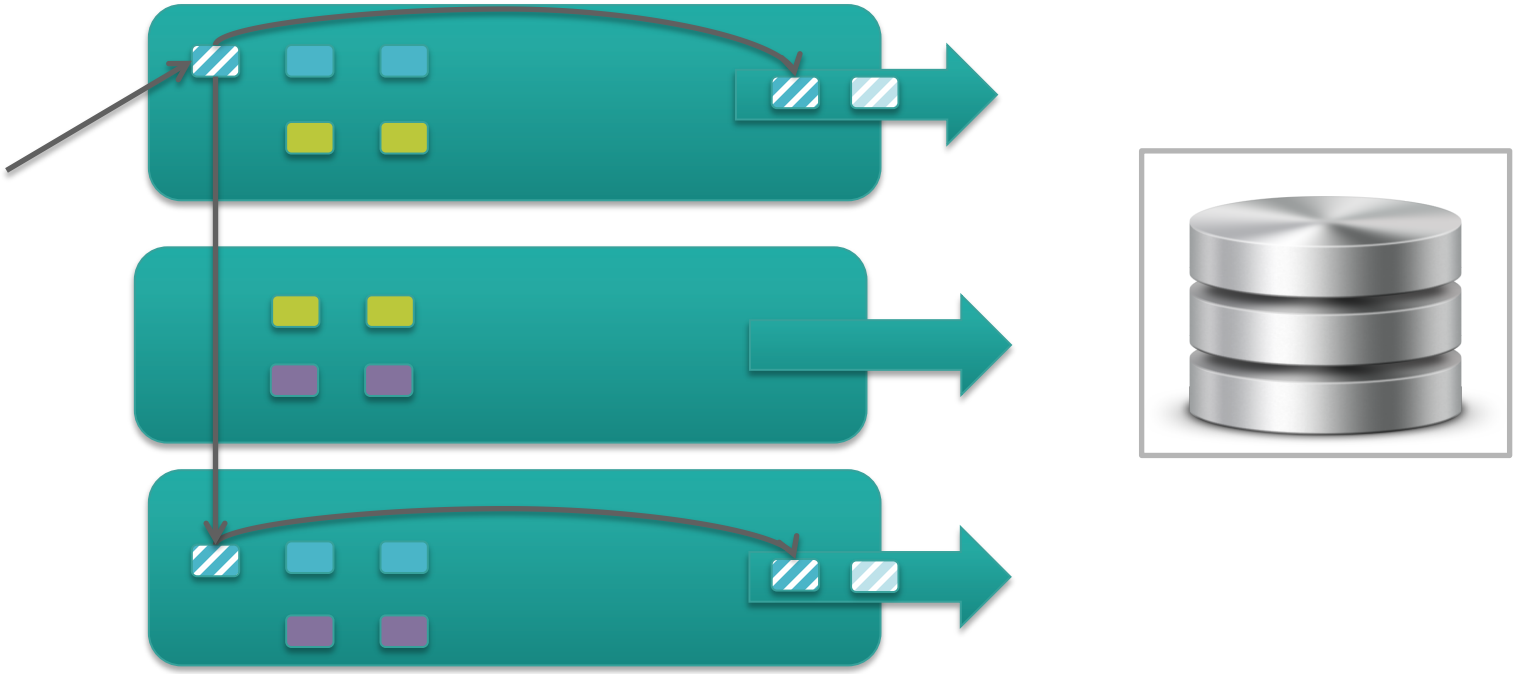
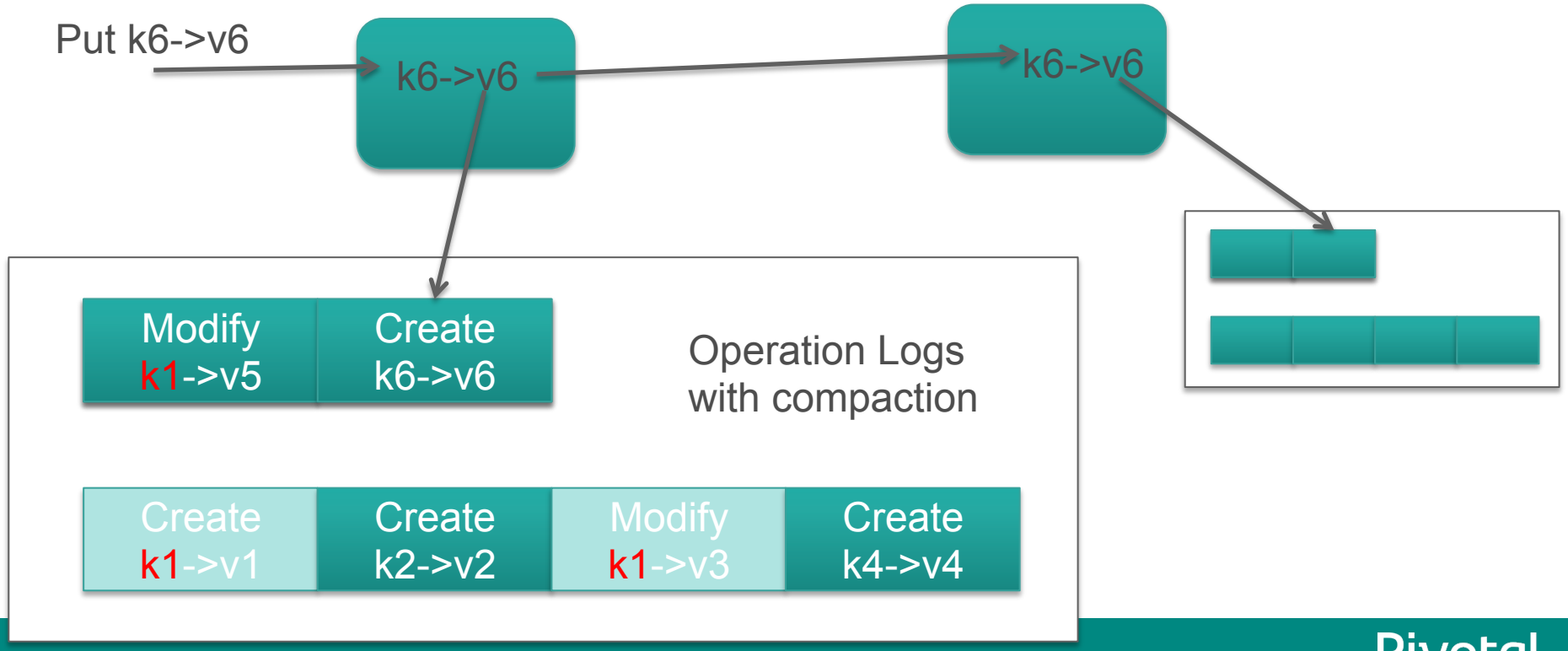
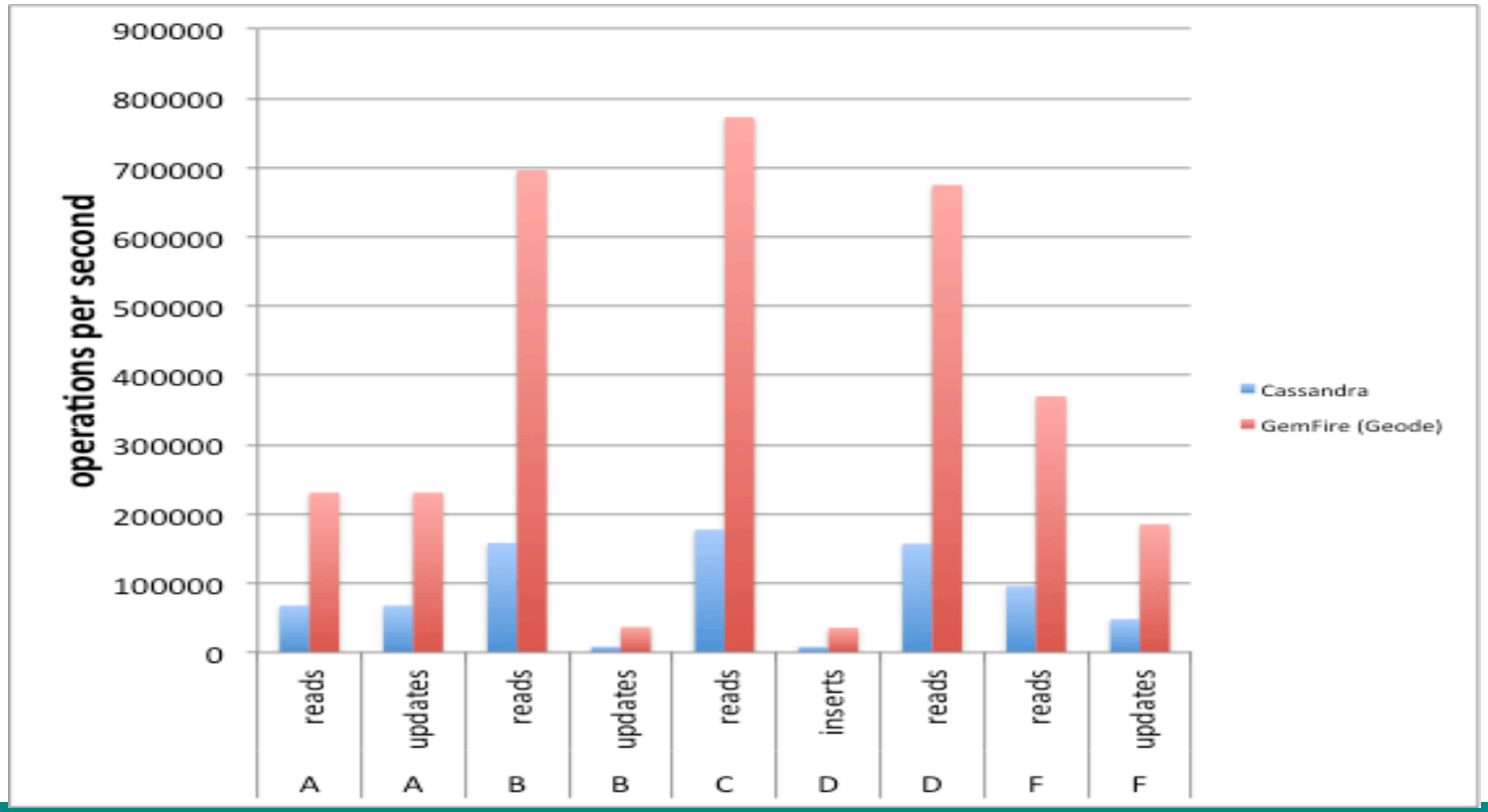
Parallel, Highly Available Queues



Shared Nothing Persistence



GemFire (Geode) 3.5-4.5X Faster Than Cassandra for YCSB



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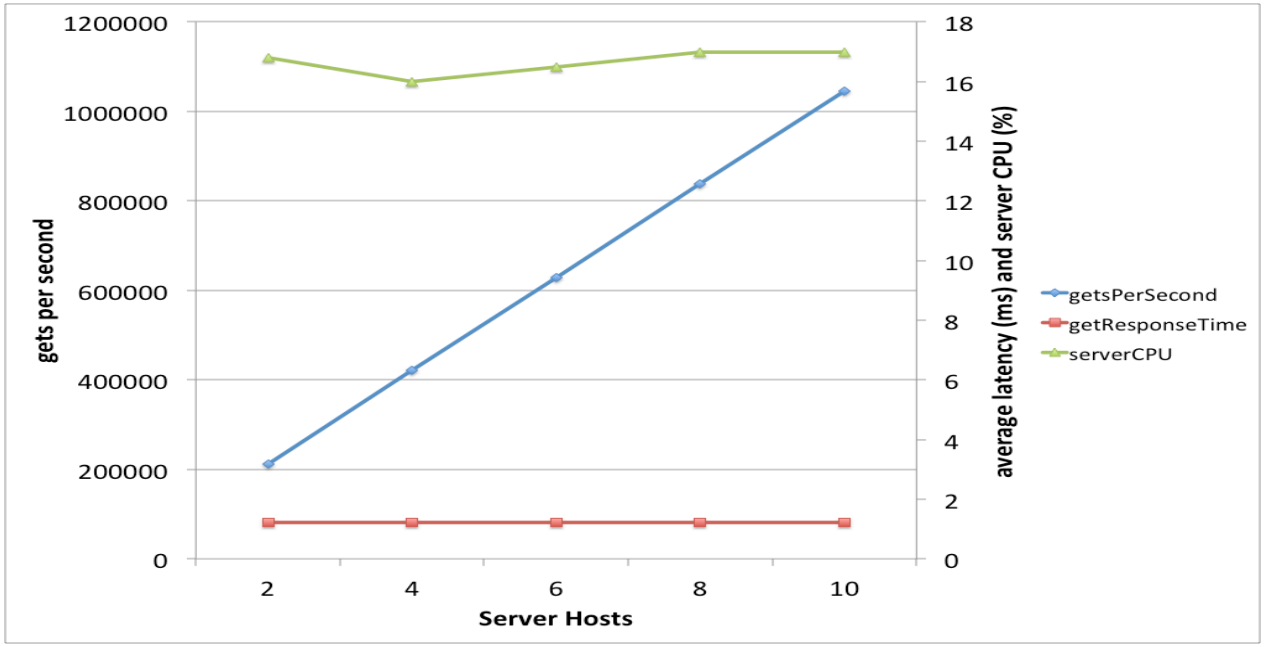
Horizontal Scaling for GemFire (Geode) Reads With Consistent Latency and CPU



- Scaled from 256 clients and 2 servers to 1280 clients and 10 servers
- Partitioned region with redundancy and 1K data size

Southwest Airlines Technology

Fueling Fast Data At Southwest Airlines : Adopting Gemfire and Cross-Domain Integration

Integrated Data =

Better Decisions

If we had **fast access** to **more information**, could we make better gate assignments?

Yes!

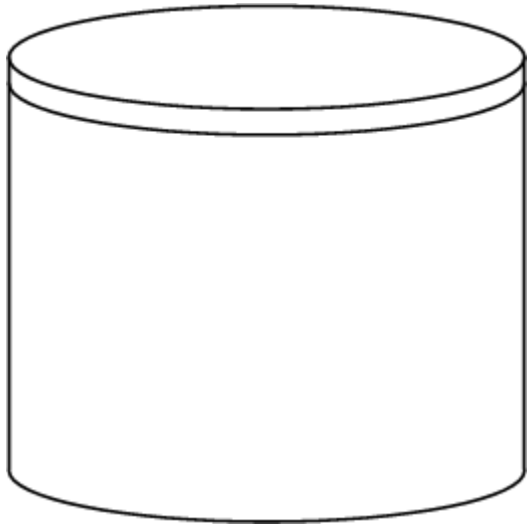
Flight Times
Passenger Connections
Crew Connections
Connecting Bags
Gate Proximity
Aircraft Maintenance

NETWORK OPERATIONS CONTROL (NOC)

From

RELATIONAL

ONE ACTIVE DB
NORMALIZED TABLES
ROW LOCKS
SQL JOINS



To

DATA FABRIC

KEY, VALUE STORE
NO JOINS
CAP
DISTRIBUTED GRID
PARTITIONED DATA
BUCKETS
ACTIVE / ACTIVE

Tips: Adopting Gemfire

DATA PLACEMENT

Spread across multiple availability zones
Multiple data centers
Number of copies

CAP THEOREM (insights on choose 2)

Partitions = Slow or no ACKS
(usually not the network)
Consistency = Your use case wins
(you probably have several different ones)
Convergence = Some write wins

Tips: Adopting Gemfire

DATA LOCKING

"This lock does not mean what you think it means."

TRANSACTIONS

Data on the same node only

PUT

BEWARE! Stale reads on concurrent puts!

Tips: Adopting Gemfire

PDX

Use it.

Don't rename enumerated options

SNAPSHOTS

In 7.0.x, you can't **mix** PDX IDs between caches

FILESYSTEMS

Shared less = Good!

Cross-Domain Integration

COMPLEX

DATA DOMAINS

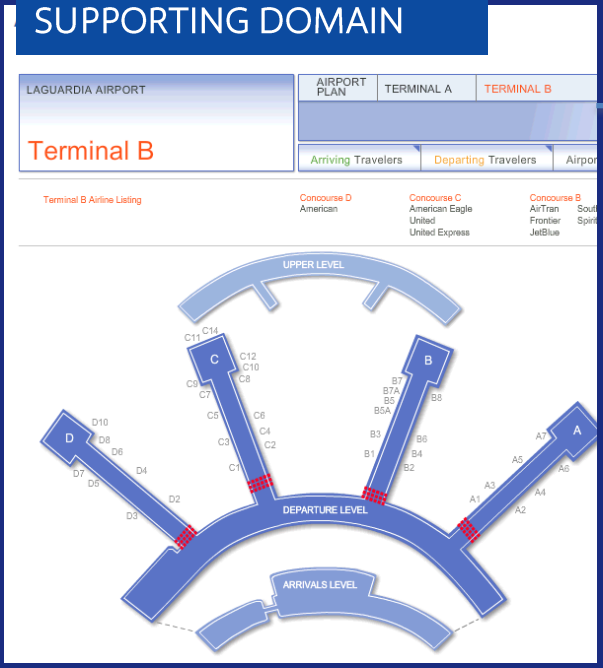
10M

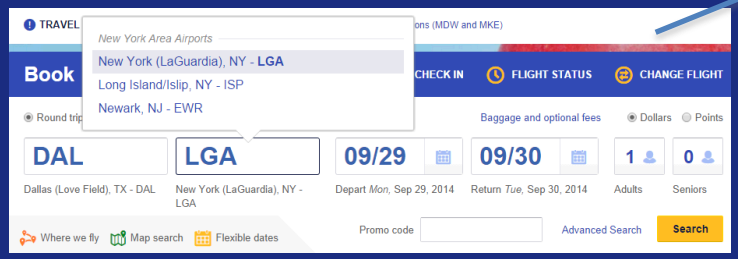
EVENTS DAILY

CREW
FLIGHTS
PASSENGERS
MAINTENANCE

Cross-Domain Integration

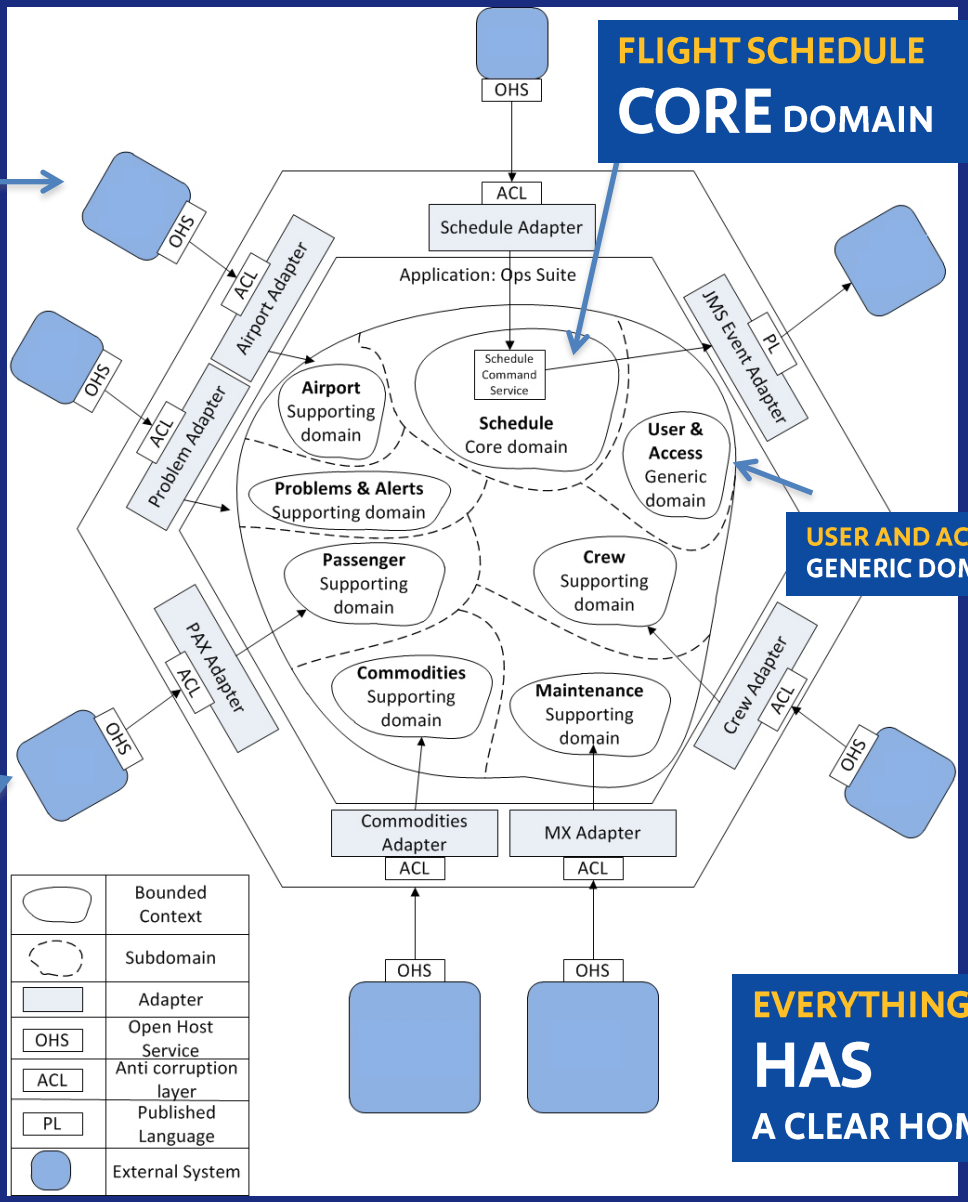
AIRPORT
SUPPORTING DOMAIN





PASSENGER
SUPPORTING DOMAIN

FLIGHT SCHEDULE
CORE DOMAIN



USER AND ACCESS
GENERIC DOMAIN

EVERYTHING
HAS
A CLEAR HOME

Resources

Google:

Implementing Domain-Driven Design by Vaughn Vernon

Reactive Enterprise by Vaughn Vernon (published this summer)

CAP Theorem

The Dynamo Paper

Reactive Streams

Questions

Thank You!

Brian Dunlap
Technical Lead

bdunlap22@gmail.com

@brianwdunlap