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# Why is Cloud-Native Application Development Still So Hard ?



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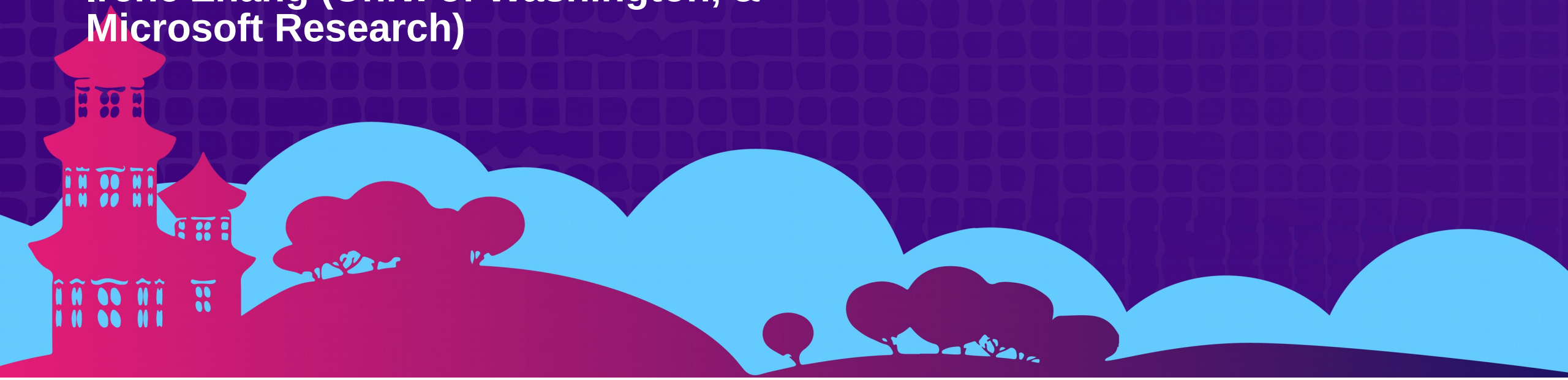


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*Integrating the Amino OS Distributed Cloud-native Programming Platform with Kubernetes ([github.com/Amino-OS](https://github.com/Amino-OS))*

**Venugopal Reddy K (Lead Architect, Huawei)**  
**Irene Zhang (Univ. of Washington, & Microsoft Research)**





# Overview



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A brief history of the  
(microservice)  
universe



App devs  $\neq$   
Sys devs  $\neq$   
SREs



Amino OS from  
30,000'



Demo,  
Remaining  
Challenges +  
Q&A



Amino.Run:  
Evaluation and  
some Data



Amino.Run: How  
it Works



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# 1. A Brief History of the (Microservice) Universe

# Once upon a time, applications were..



- single user
- single platform
- single node

# Life was good for mere mortal app devs...



- Single-machine OS's work well
- Local procs, virtual memory, files, locks...
- Pick one (or two?) good programming languages
- App devs could understand their platform

# Then “Suddenly” Everything Changed...



- Cloud Computing
- “Mobile-first”
- Ubiquitous Connectivity (Wifi... 3G... 4G... 5G...)



# So Now Today's Applications are Very Different...



- Multi-user,
- Multi-platform,
- Multi-language,
- Multi-node,
- Always-on,
- Autoscaling,
- **Distributed Systems Nightmares!**



# So Containers, Kubernetes and Microservices Saved the Day

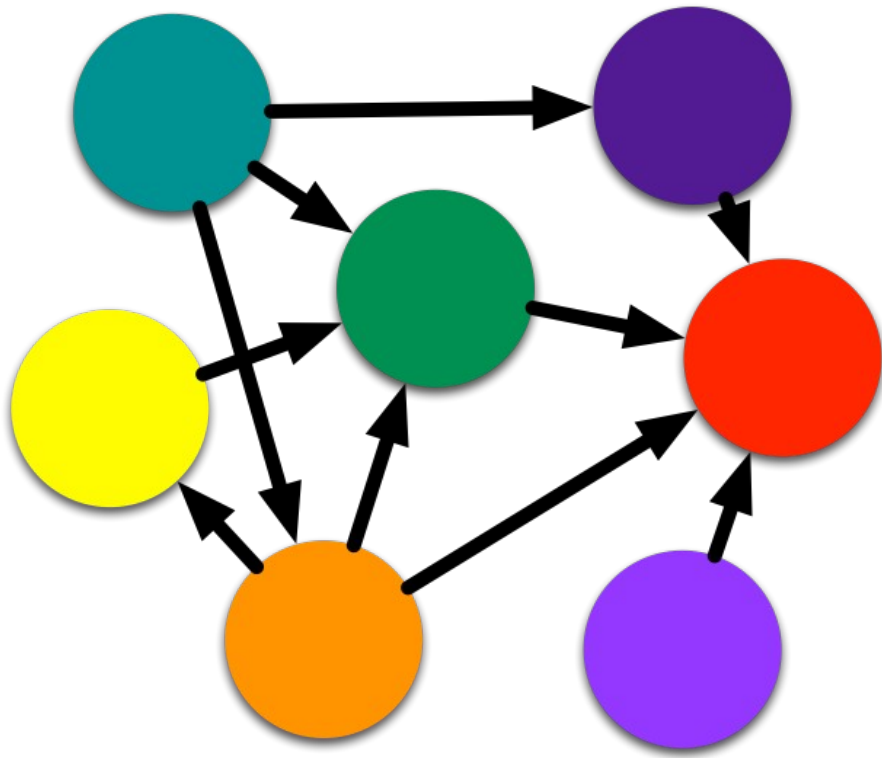


## Apps could be:

- Decomposed into independently deployable Containers
- Programmatically orchestrated, driven by declarative configuration
- Developed in many different languages  
Java/Kotlin for Android, ObjC/Swift for IOS,  
Go/Java/Python/C/C++/... for Linux/Windows...
- Hooked together using service meshes  
Linkerd, Envoy, Istio...
- Configured, deployed, monitored and upgraded by expert devops/SREs (basically Ninjas).

# Turns out, it's still really, really difficult...

**Developers still have to write the (really hard) stuff in the containers:**



- distributed concurrency, synchronization,
- reliable RPC, fault tolerance,
- replication, leader election, sharding,
- code and data migration,
- observability, fault diagnosis
- As well as all the obvious
- remote invocation, load balancing, etc...

These sound like  
distributed systems  
problems!



**PROFESSIONAL SYSTEMS  
PROGRAMMER REQUIRED.  
DO NOT ATTEMPT AT HOME.**



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2.

App devs  $\neq$

Sys devs  $\neq$

SREs



# Specialization..

## App Devs

- Know their app domain very well.
  - Social Networking
  - Travel
  - Finance
  - ...
- Need to move really fast.
- Don't give a hoot about distributed systems algorithms, exponential backoff, PAXOS/Raft,...

## Sys Devs

- Are really interested in understanding and solving hard distributed systems problems.
- Are in very short supply.
- Typically don't understand your specific business needs.

## SREs/DevOps Engineers

- Understand what happens when your specific customers hit your specific app, e.g.
  - Capacity/scaling requirements
  - Optimal sharding schemes
  - What breaks and why.
  - What needs to be replicated, updated etc and how.



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# 3. Amino OS from 30,000'



# What is Amino OS?

**Amino OS** is an umbrella project, the goal of which is to create a distributed platform for coding and running distributed (cloud, edge and mobile) microservice-based applications. It has four main components:



- **Amino.Run**: A distributed microservice runtime (we'll focus on this today).
- **Amino.Sync**: A reactive data synchronization service that provides configurable consistency guarantees
- **Amino.Store**: A distributed transactional storage service
- **Amino.Safe**: A distributed privacy and security manager



# Amino OS

## Distributed Cloud-native Application Programming Platform

Users (often  
mobile)



Distributed Cloud-native Application

**Amino.Run**  
(Process  
Manager)

**Amino.Sync**  
(Memory  
Manager)

**Amino.Store**  
(Storage  
System)

**Amino.Safe**  
(Security  
System)

Distributed Cloud-native Application Programming Platform

OS

OS

OS

OS

OS

OS

**Central  
Cloud  
Server**

**Central  
Cloud  
Server**

**Edge  
Cloud  
Server**

**Edge  
Cloud  
Server**

**Mobile  
Device  
(Phone)**

**Mobile  
Device  
(IoT)**



# What is Amino OS?



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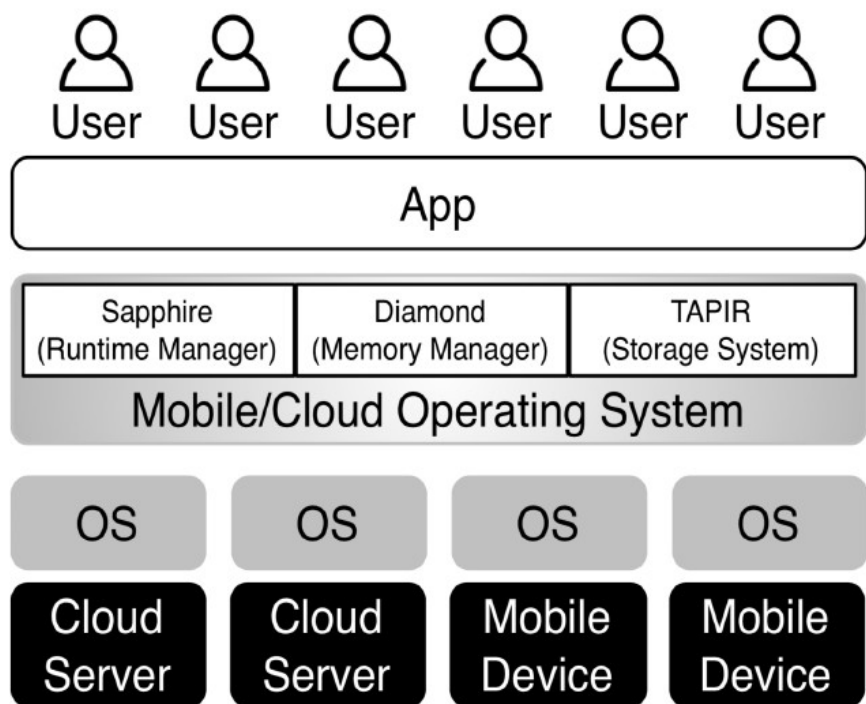
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- Amino OS is based on several years of distributed systems research done by Irene and her team at the University of Washington Systems Lab in Seattle, WA.
- Amino OS is the result of 2 years of collaboration between Quinton, Venu and Irene's teams.



	AminoRun	AminoSync	AminoStore
	Sapphire	Diamond	Tapir
Requirement	Run-time Manager	Memory Manager	Storage Manager
Availability	Auto-restart on crash	Auto-sync w/ storage	Replication
Responsiveness	Automatic process migration	In-memory caching	Storage caching
Scalability	Automatic process spin-up	In-memory caching	Partitioning
Consistency	Distributed locks	Atomic memory operations	Transactions
Fault-tolerance	Periodic process checkpoint	Auto-sync w/ storage	Log to disk
Reactivity	Notifications	Sync across address spaces	Triggers

# We'll Focus on Amino.Run in this Talk

- Goals
- Architecture and How it Works
- Deployment Managers
- Experience and Evaluation
- Demo
- Q&A

# Amino.Run Goals

1. Separate application logic from deployment code.
2. Make application code very simple and intuitive
3. Allow devs and SRE's to easily make, combine and change automated application deployment choices across arbitrary servers and devices (cloud, edge, mobile, IoT etc)
4. Support arbitrary programming languages
5. Performance!
6. Optionally integrate with external infrastructure systems (like Kubernetes, Istio etc) in a very natural way.

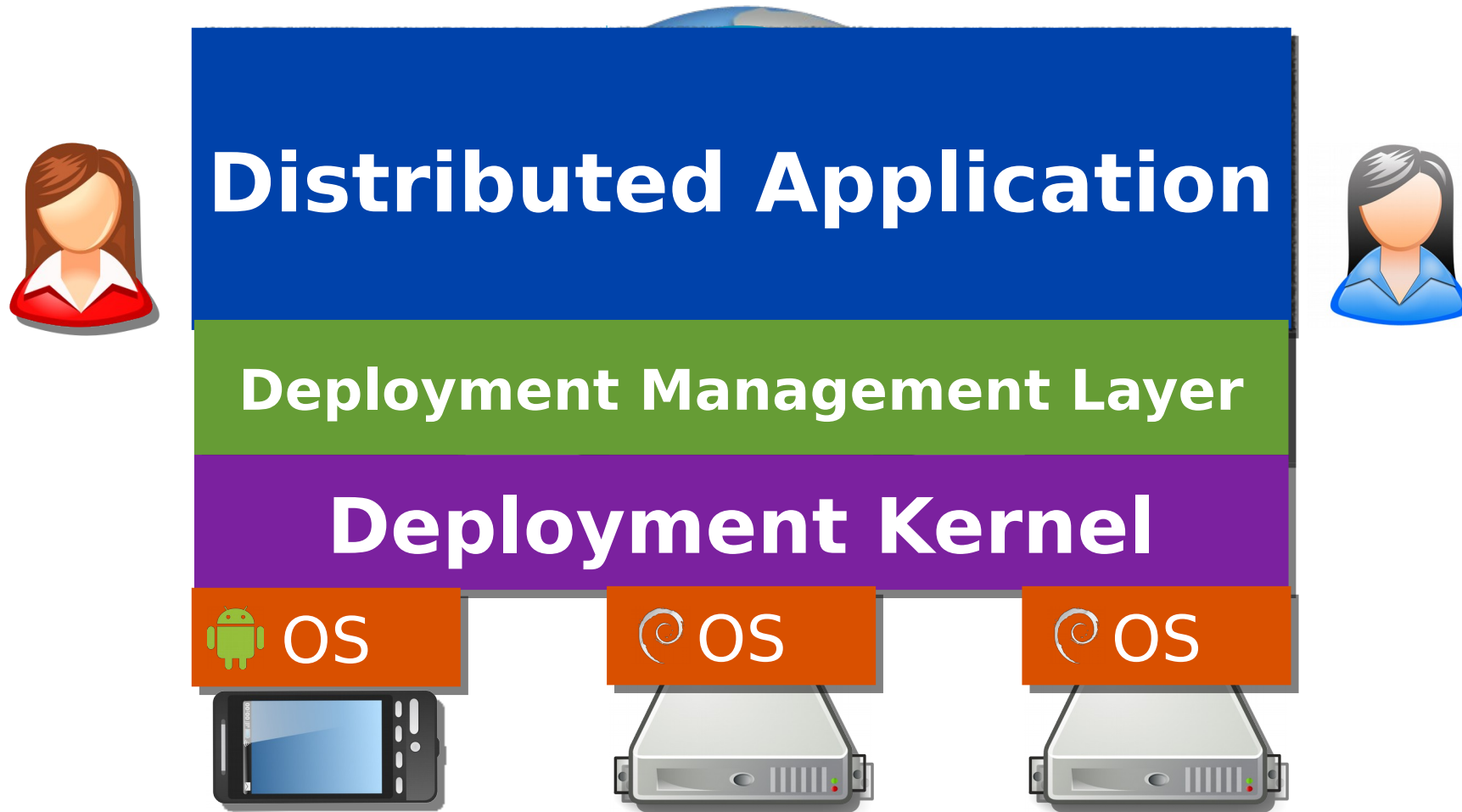
# Our Solution

A new system architecture that supports:

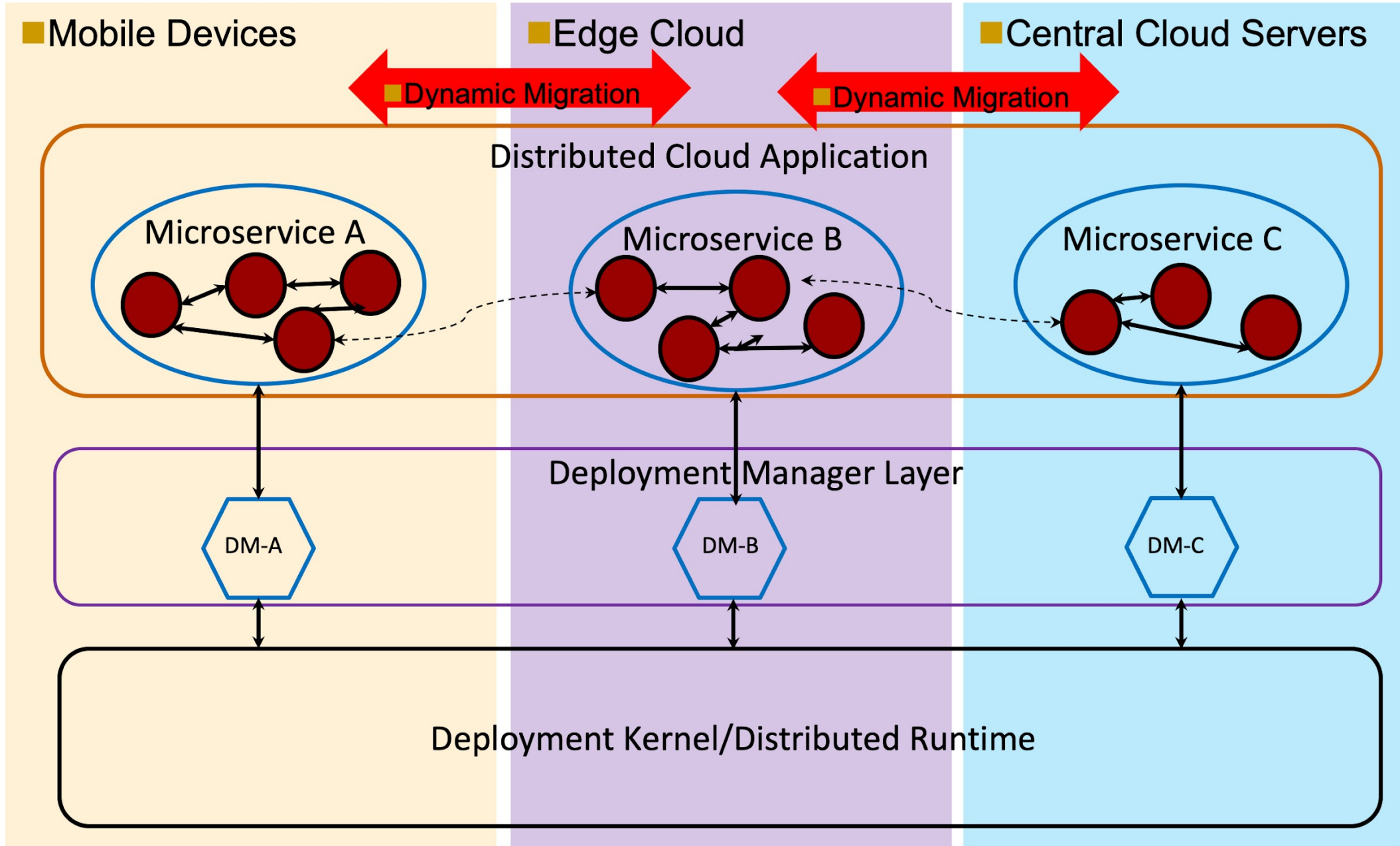
- pluggable and extensible deployment managers
- across arbitrary programming languages
- and operating systems



# Amino.Run Architecture



# Example Deployment – Edge Cloud

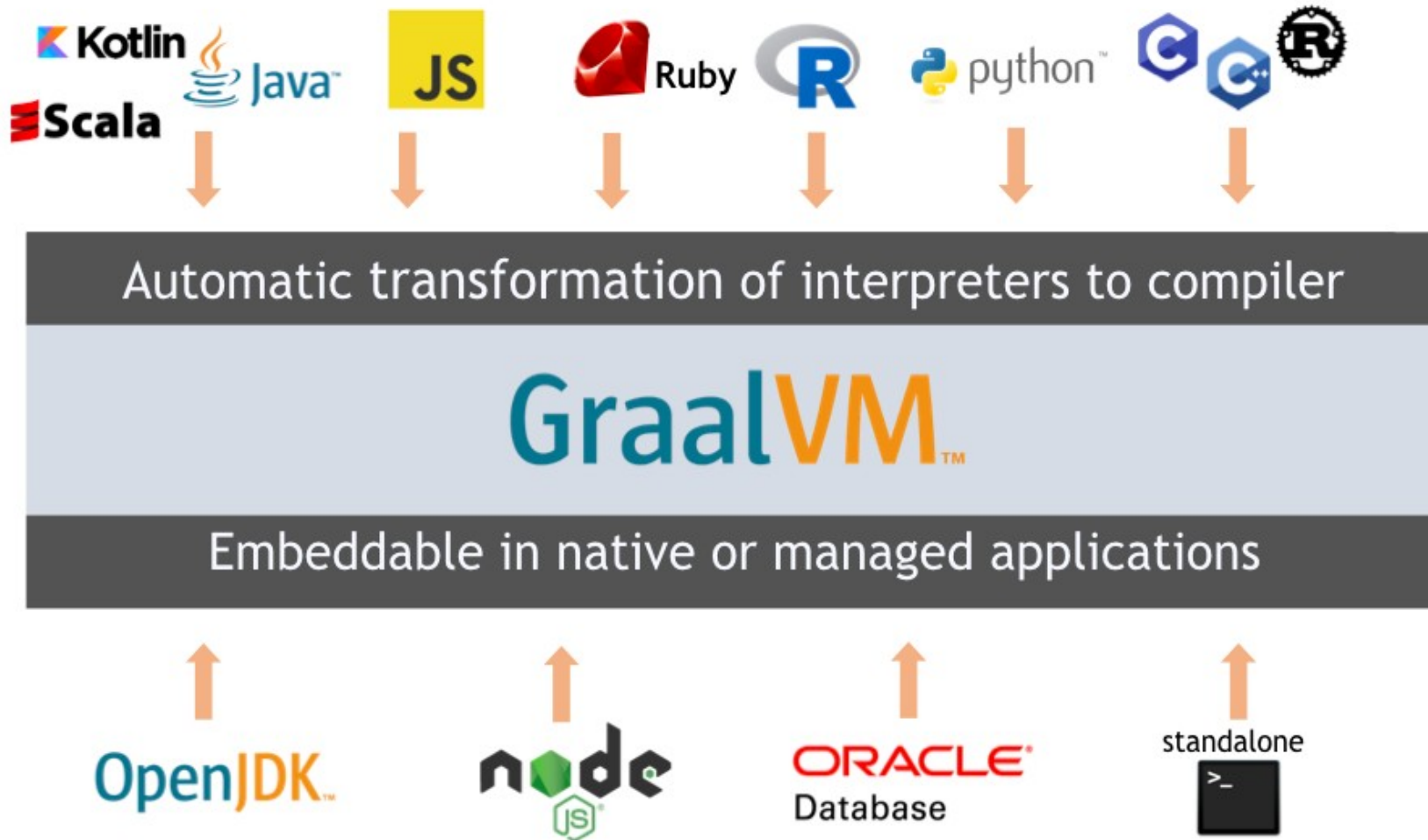


# Amino.Run Application

Partitioned into ***Microservices***, which:

- Run in a single address space with RPC.
- Execute anywhere and move transparently.
- Provide a unit of distribution for deployment managers.
- May be written in any programming language (using GraalVM)
- Can pass data structures transparently between programming languages (using GraalVM Polyglot)

# A brief word about multi-language and GraalVM



- High-performance polyglot VM (think JVM)
- Native via Ahead-of-Time compilation, or JIT
- Embeddable
- Allows Microservices, Amino Kernel and DMs all in different languages



# Amino.RunArchitecture

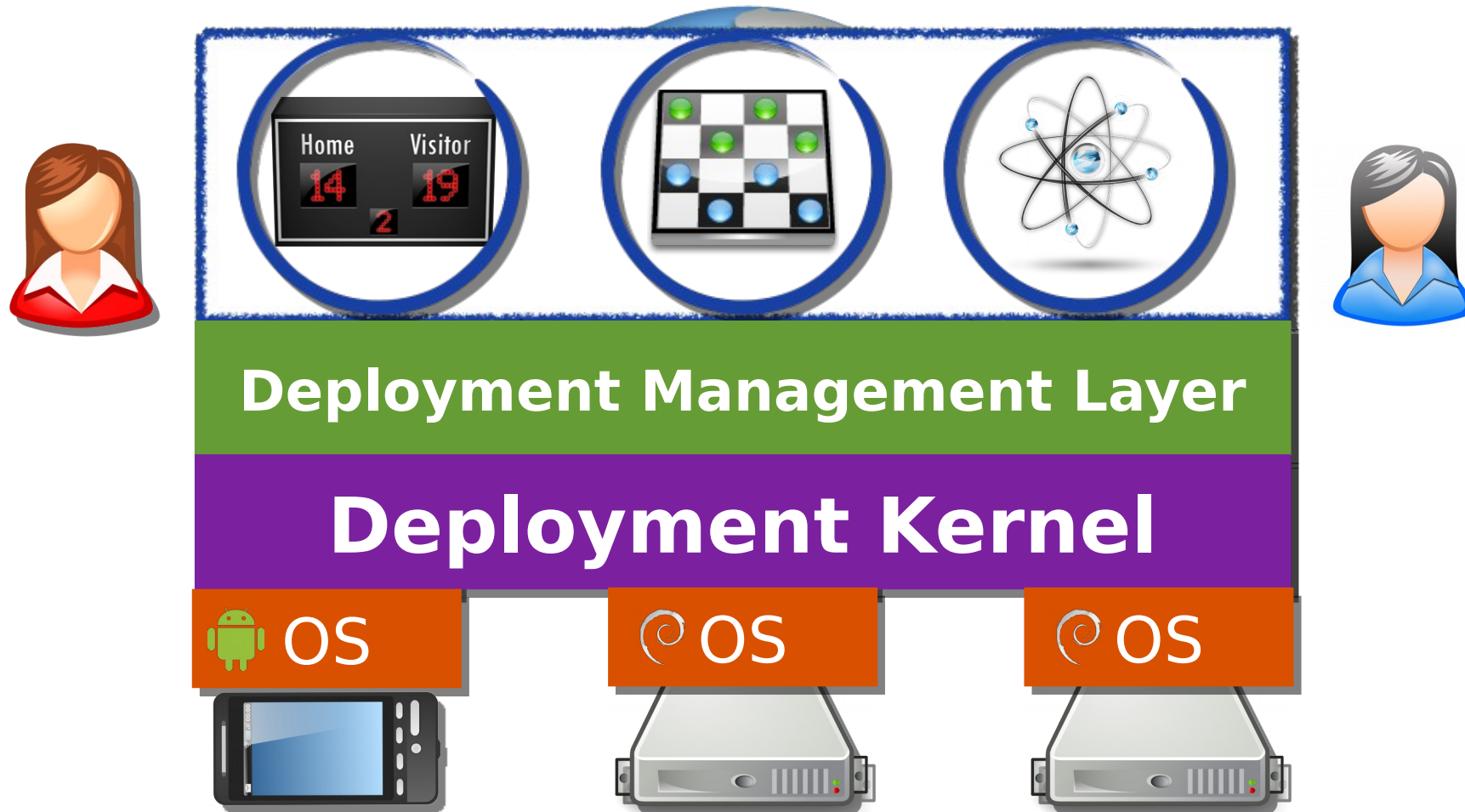


# Deployment Kernel

Provides ***best-effort distribution services***, including:

- Microservice instantiation, tracking, mobility and replication.
- Making and routing RPC to Microservice replicas.
- Managing, distributing and running deployment managers.

# Amino.Run Architecture

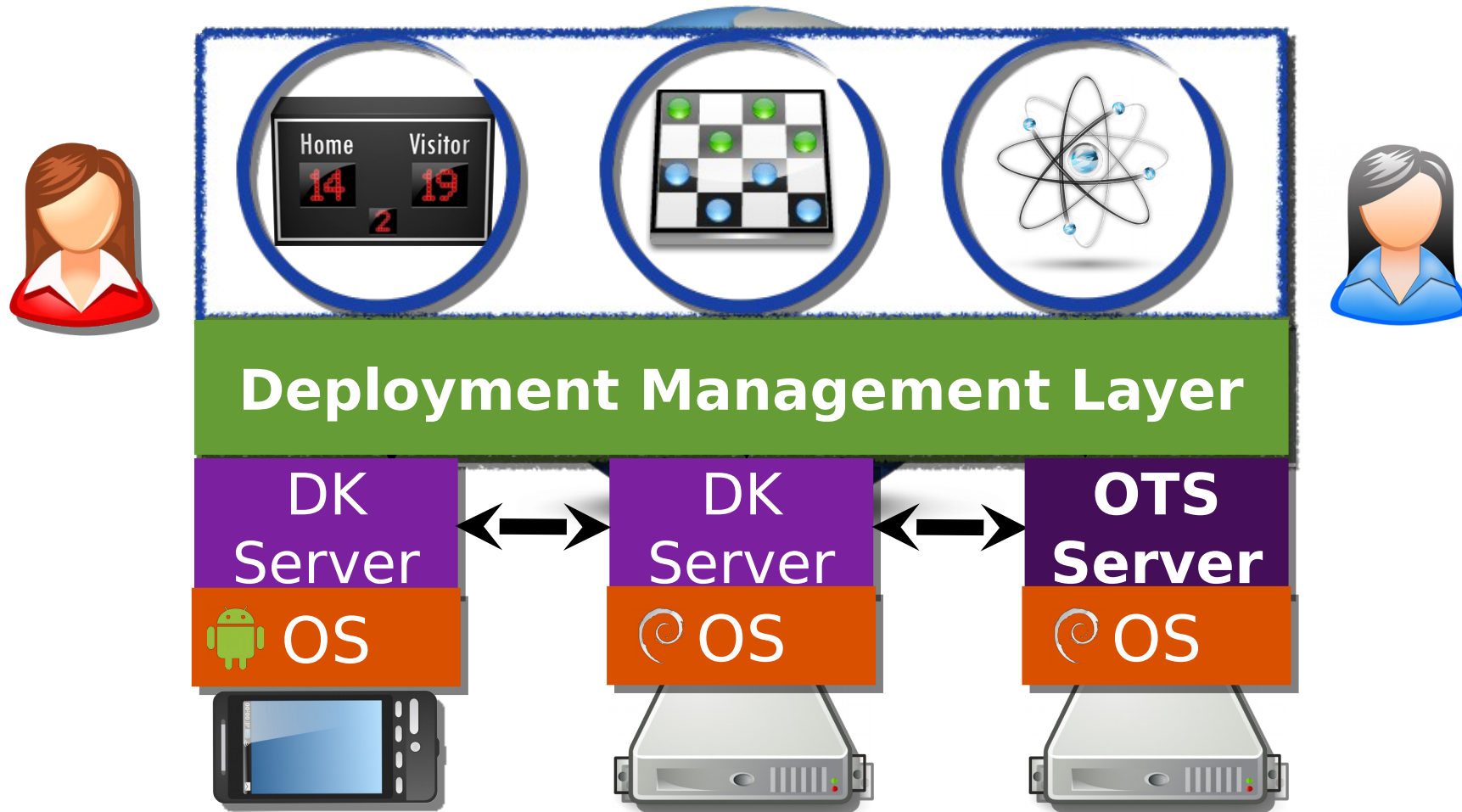


## Deployment Management Layer

Consists of ***deployment managers***, which:

- Extend the functions and guarantees of the deployment kernel.
  - Sharding, Method Replication, Caching etc
- Interpose on Microservice calls and events.
- Easy to choose and change without modifying the application.
- Can be arbitrarily combined! (with some obvious restrictions)
  - E.g. Replicated shards, Transactional replicas, Retries over sharded transactions, etc...

# Amino.Run Architecture





# Deployment Managers



Caching



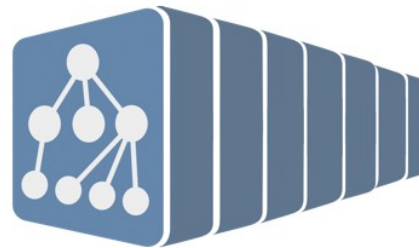
Distributed Transaction  
Management



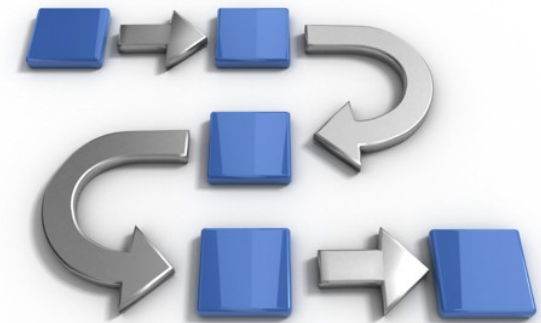
Checkpointing



Replication



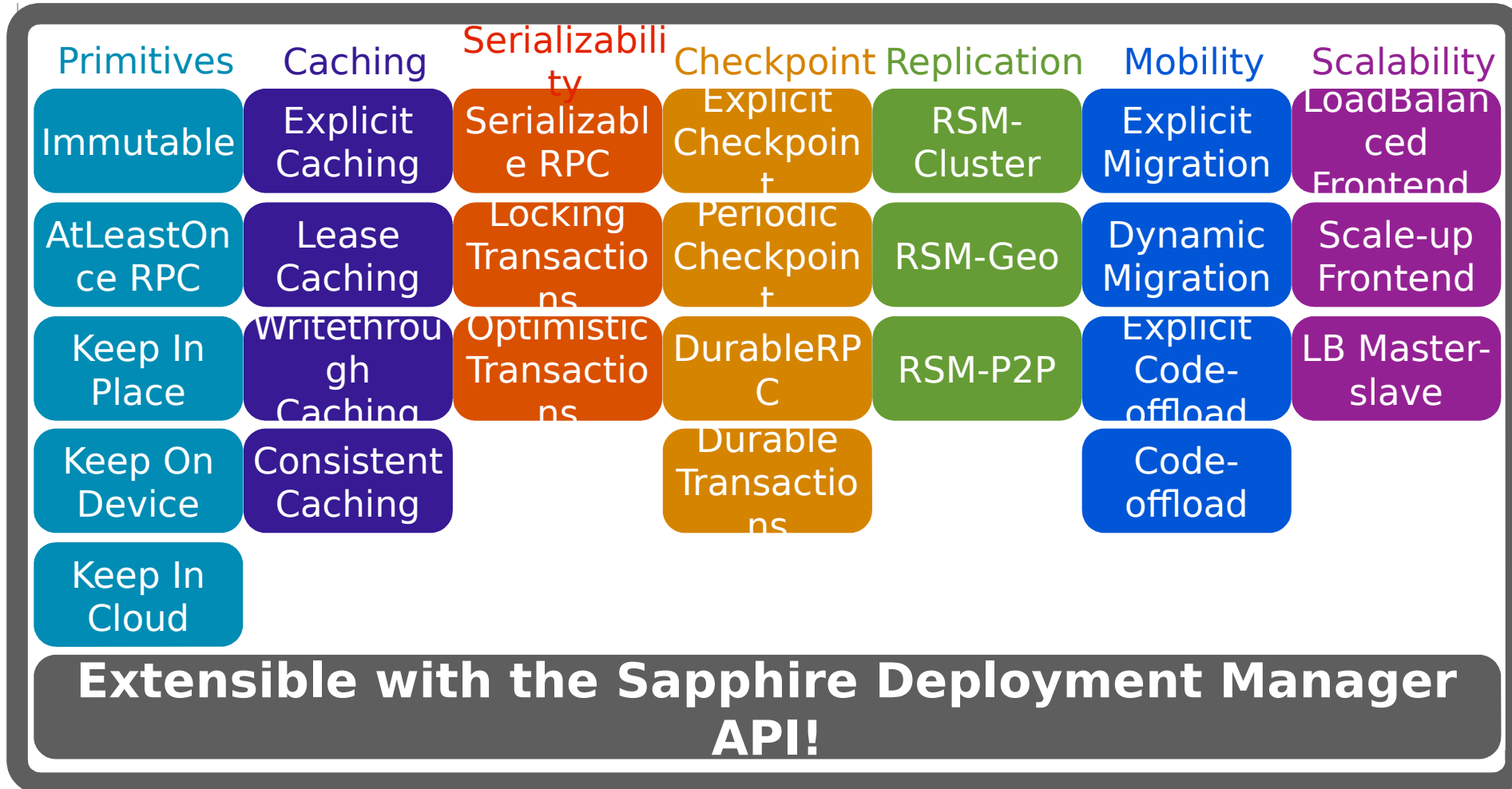
Autoscaling



Dynamic Code and  
Data Migration

**And many more...**

# Sapphire Deployment Manager Library



# Outline

**1. Architecture**

**2. Deployment  
Managers**

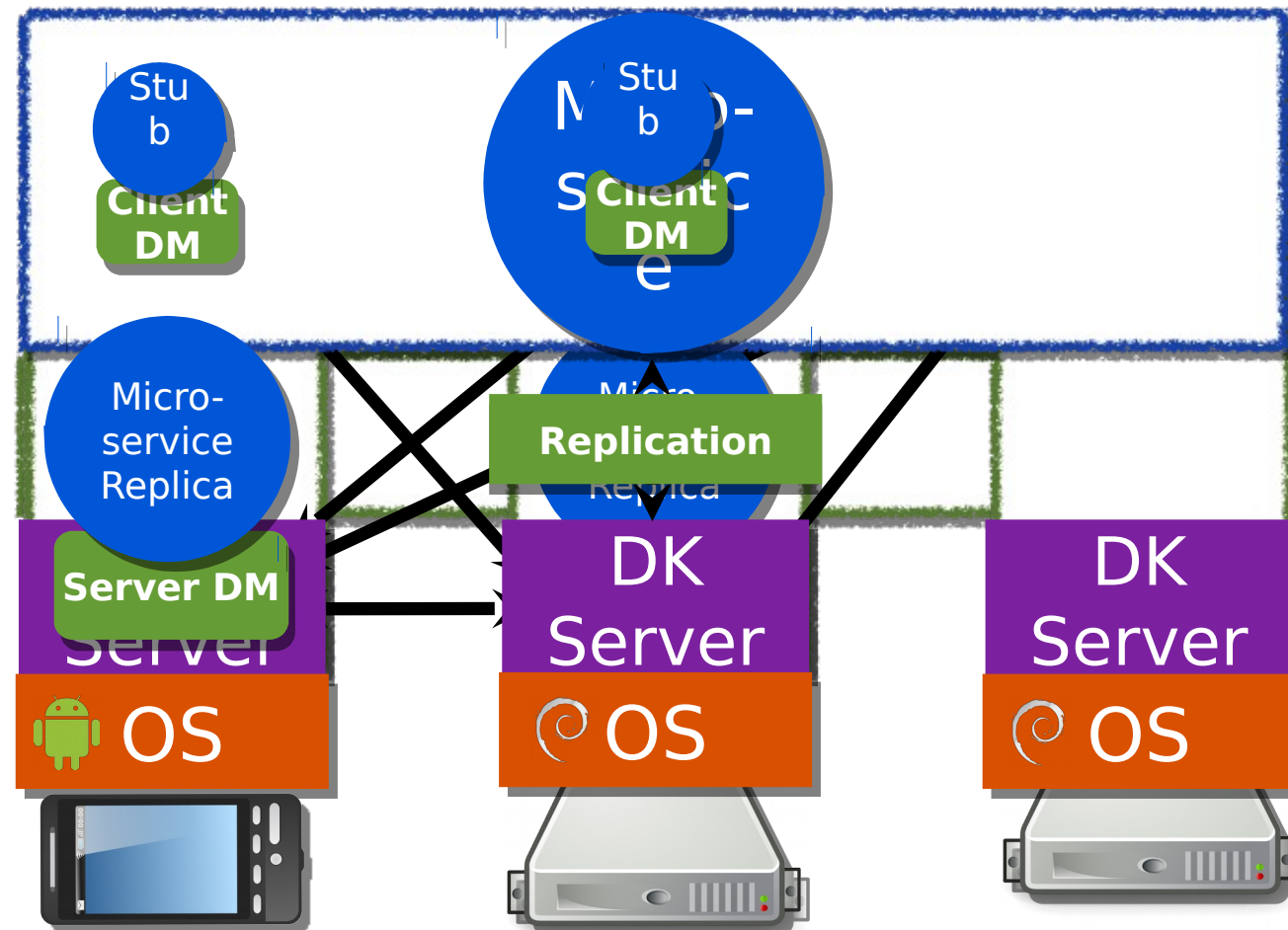
**3. Experience and  
Evaluation**

# Deployment Manager API

Deployment Manager (“DM”) components, which the Amino.Run kernel creates, deploys and invokes automatically:

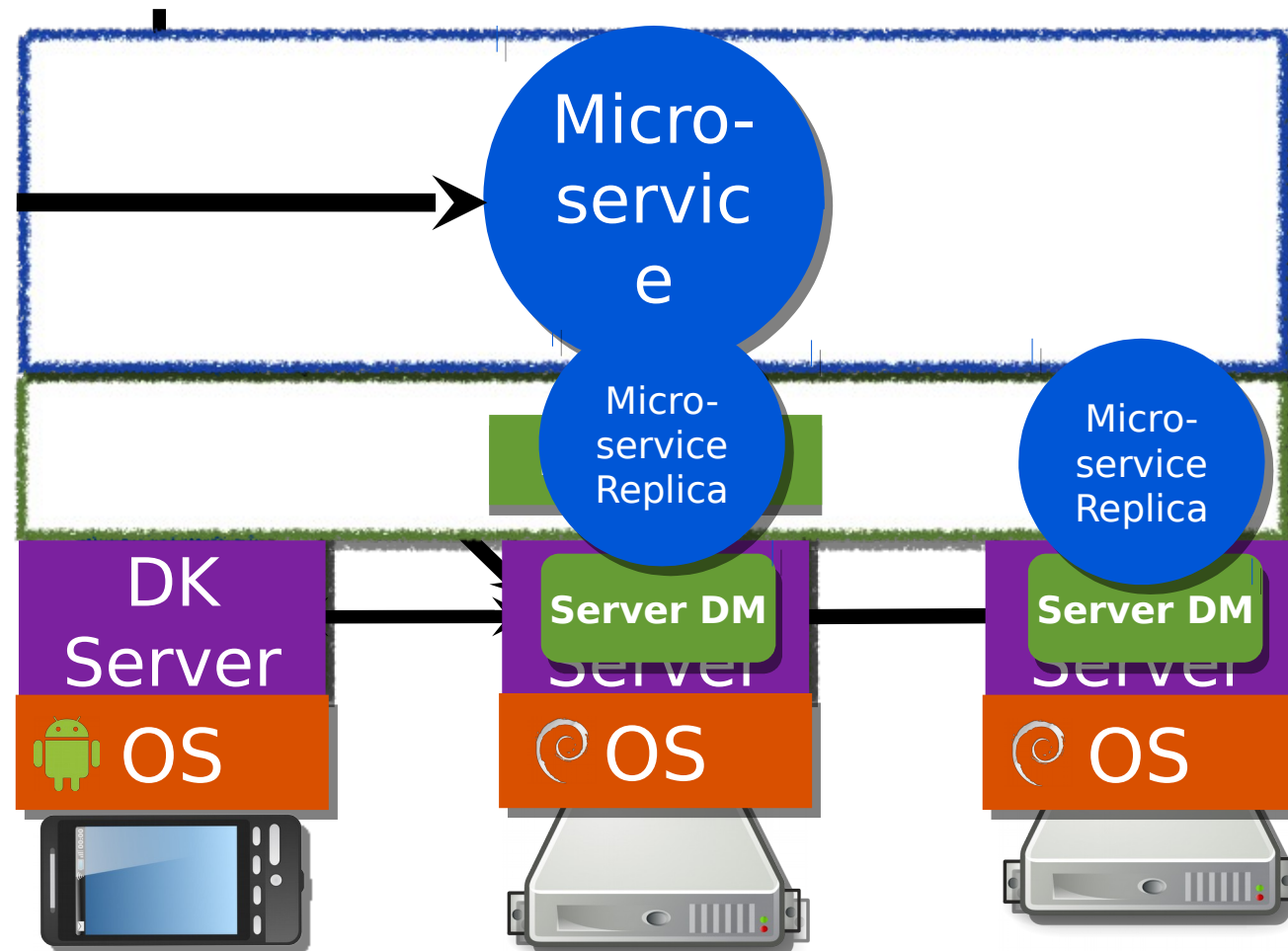
- Server-Side DMs: Co-located with the Microservice Replica (i.e. process).
- Client-Side DMs: Co-located with remote references to the Microservice.
- Group Coordinator DMs: Co-located with fault-tolerant Microservice Management Service (MMS aka OMS).

# Deployment Manager Architecture

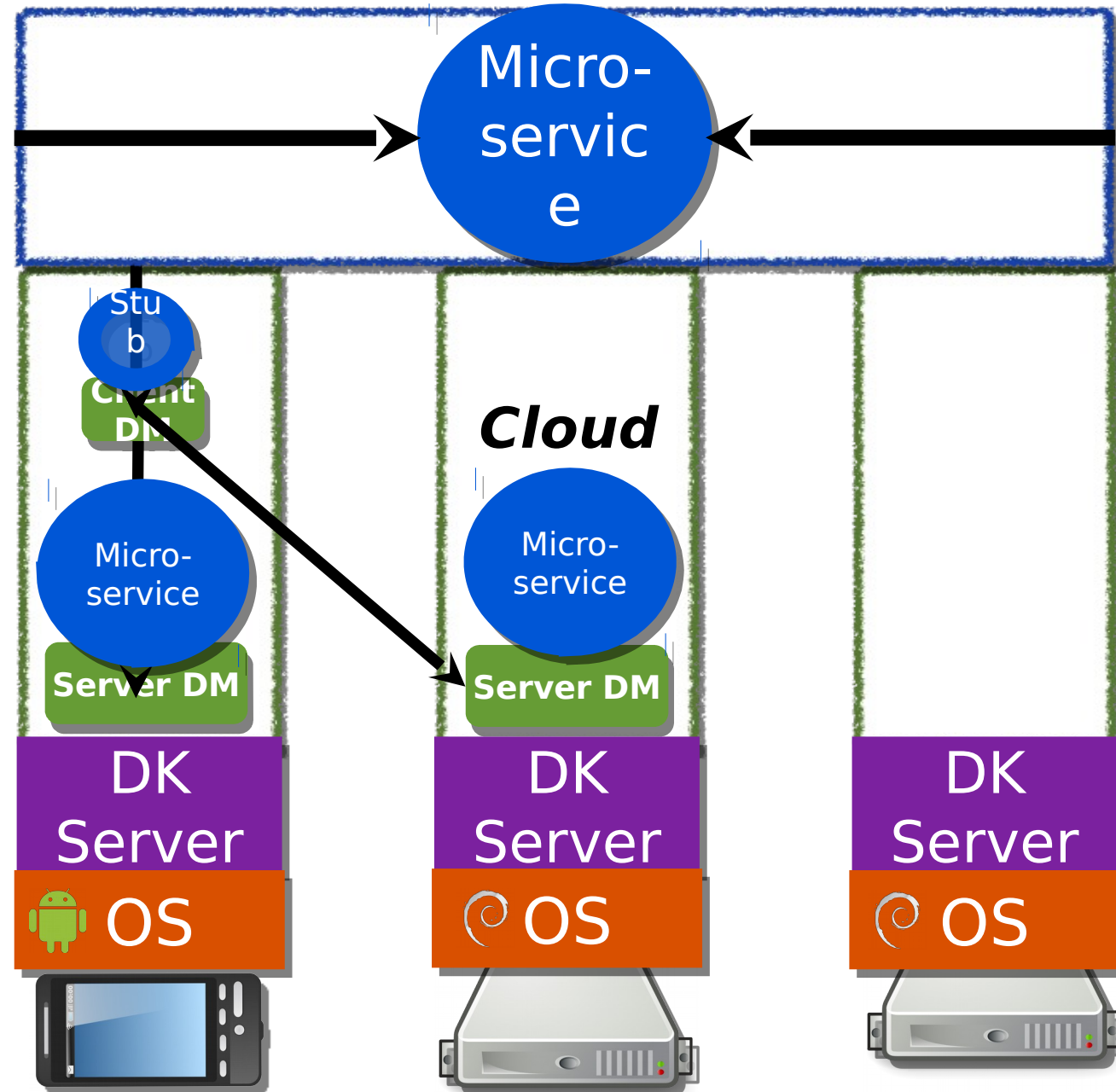




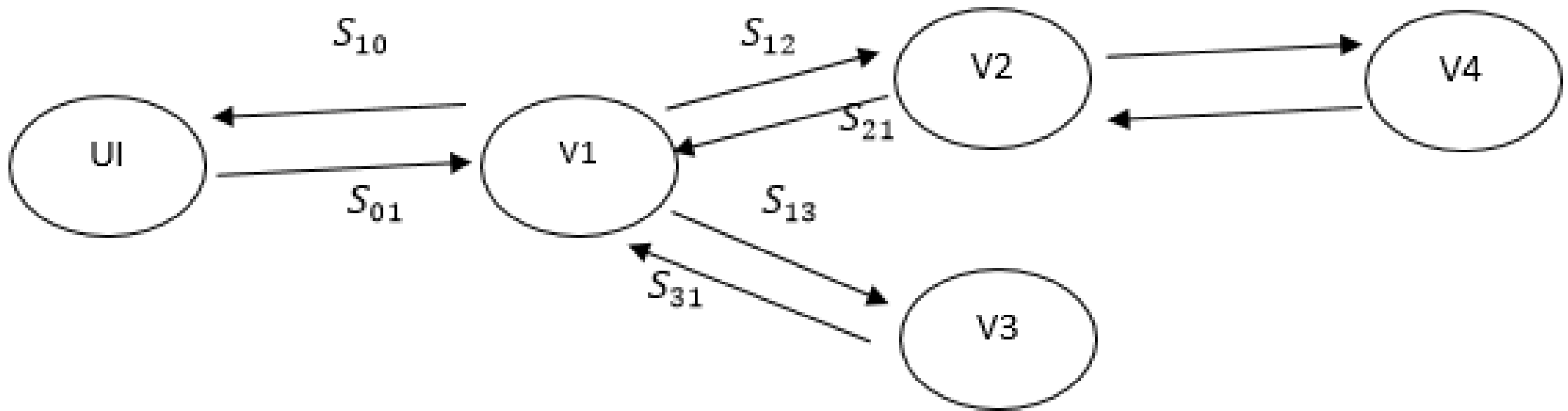
# Replicating a Microservice



# Offloading a Microservice

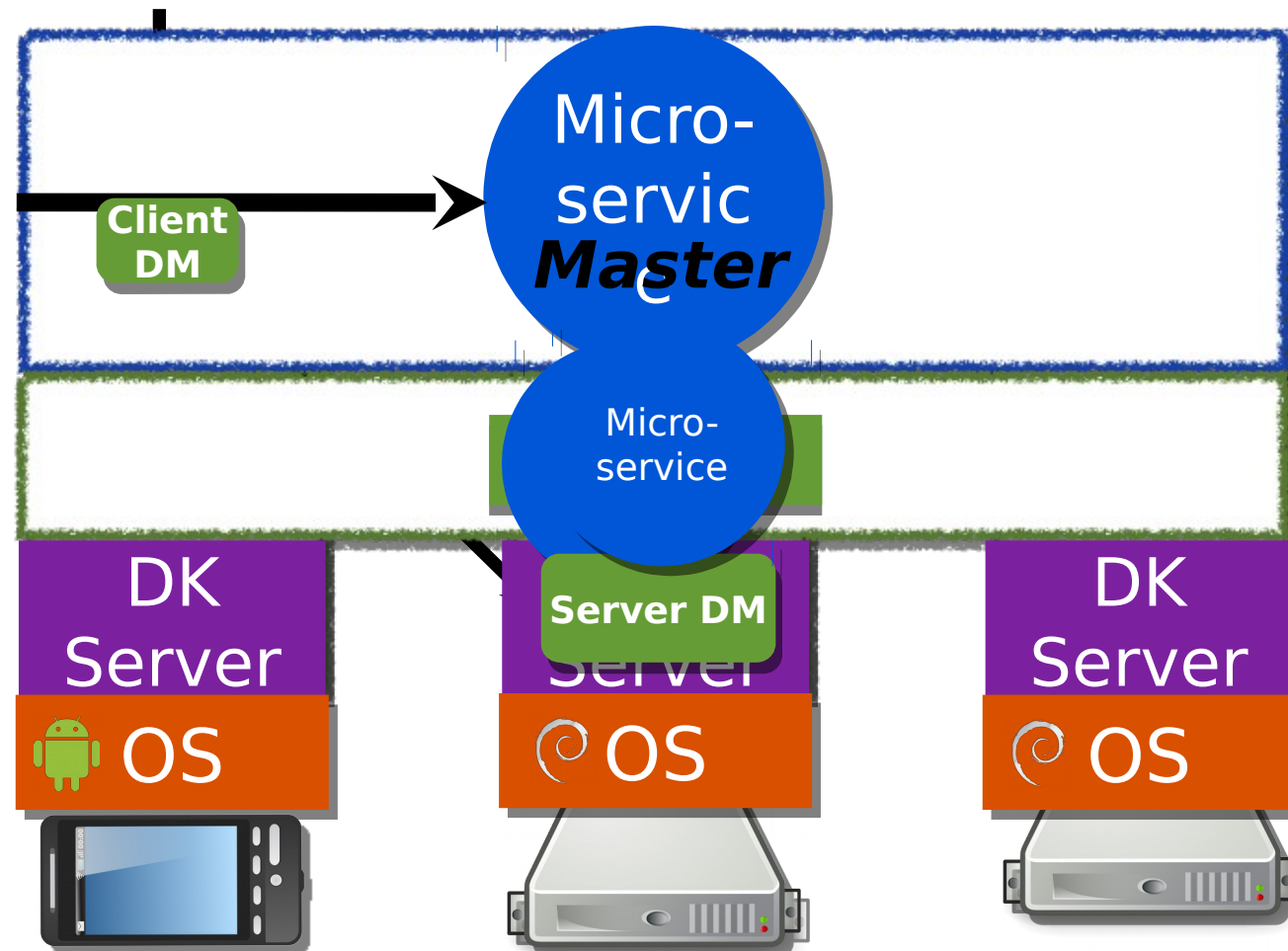


- Automatic Object Migration – Stateful Offloading



- See more in the demo later.

# Caching a Microservice state



# Outline




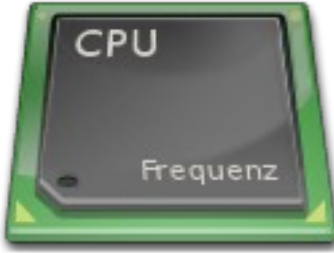
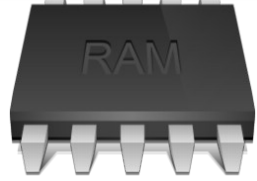



**1. Sapphire  
Architecture**

**2. Deployment  
Managers**

**3. Experience and  
Evaluation**



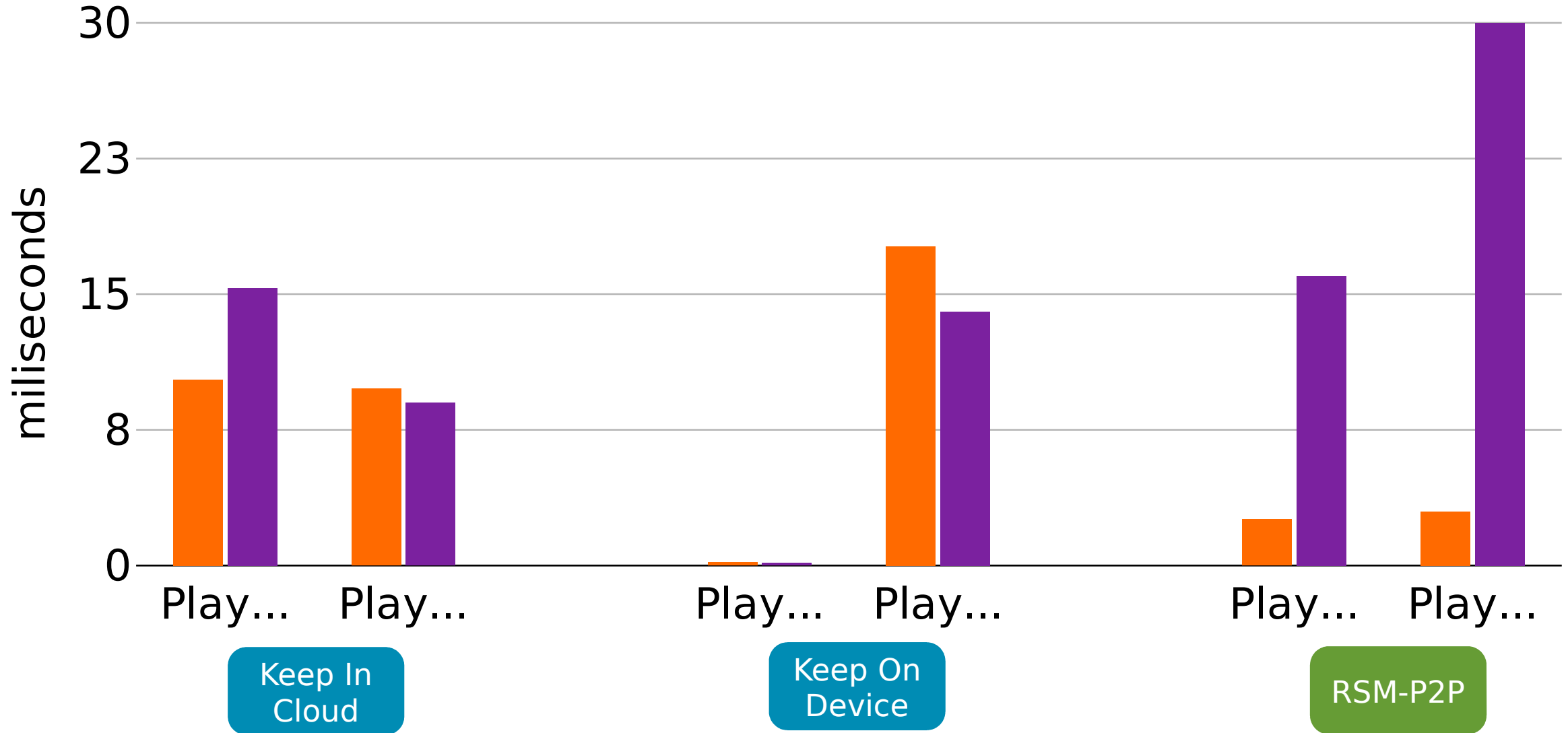
# Experimental Setup

			
	Dell Server	Nexus 7	Nexus S
	8-core Intel Xeon 2GHz	4-core ARM Cortex A9 1.3GHz	1-core ARM Cortex A8 1GHz
	8GB	1GB	512MB
  OS			

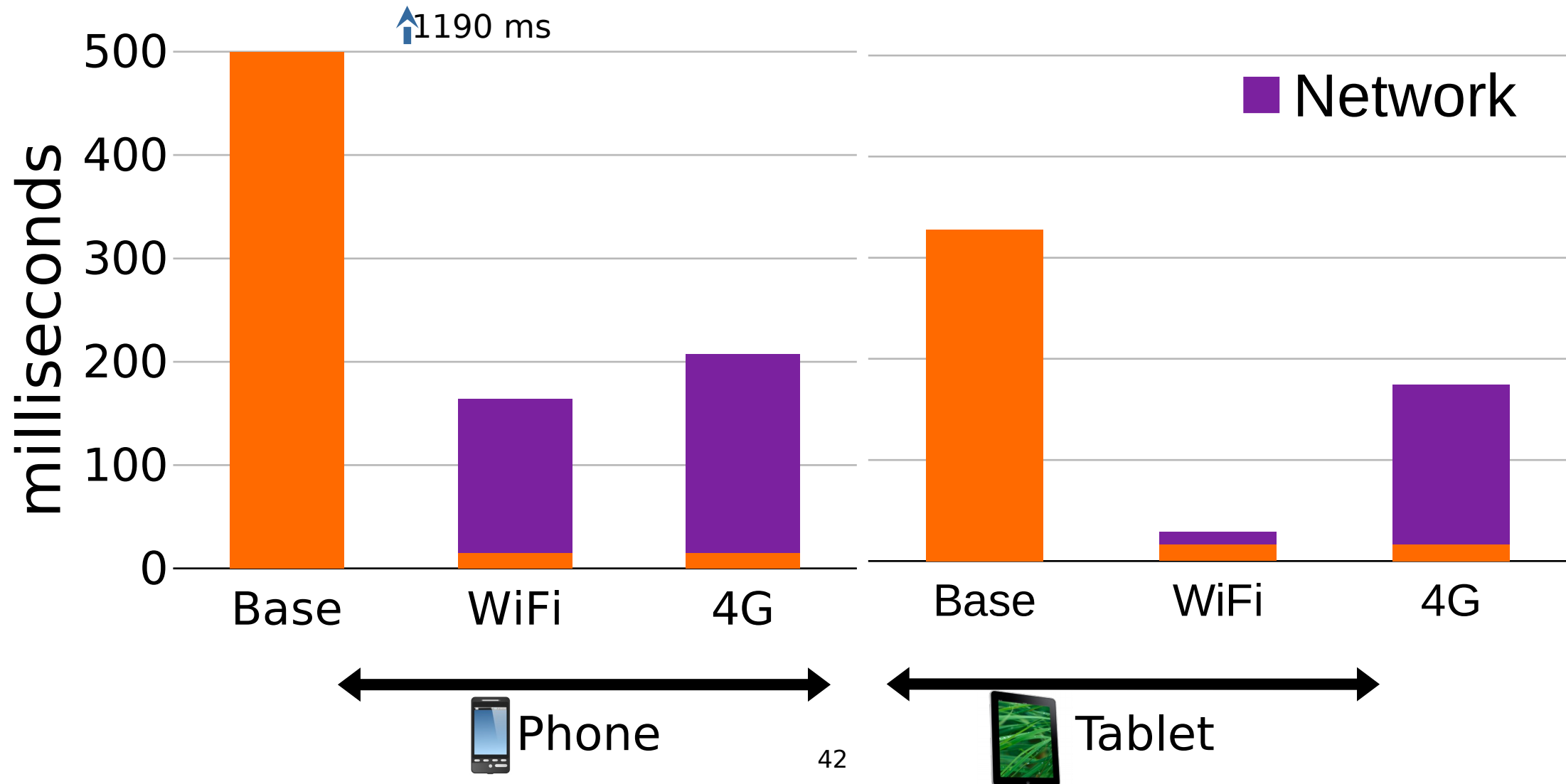
# Peer-to-Peer Multiplayer Game

Read

Write



# Code-offloading for Physics Engine



# Summary

**Modern applications implement difficult distributed deployment tasks.**

**Amino.Run** is a new programming system for deploying interesting distributed applications including cloud-native, mobile/cloud, edge/cloud.

**Deployment managers** makes it easy to choose, combine, and customize deployment options.

# Next Steps?

- Migrating state that's not inside the application or Amino system (e.g. local files, Linux timers etc).
- Some rough edges between certain language combinations.
- Additional plugins for external systems (Istio, etcd, TiKV, etc)
- Federations and disconnected Edge scenarios.



# Get Involved



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- Slack Channel: [Amino-OS.slack.com](https://amino-os.slack.com)
- Web site: [www.Amino-OS.io](http://www.Amino-OS.io)
- Contributions most welcome
- Repo: [github.com/Amino-OS/Amino.Run](https://github.com/Amino-OS/Amino.Run)



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# Demo

## Q & A