SKY COMPUTING
WHITEPAPER

New future for cloud computing

Safi
• Previous research
• Services in compatibility set;
• Architecture (how does it work?)
• Example; Cost (is it worth it ?)

• Reasons to use sky;
• Conjectures / Assumptions / Predictions / Rationals about the proposal
• Impact Opportunities / Advantages

• Objections / Criticism
• Risks

• SkyPilot & SkyPlane, and other projects
• Summary
Multi-cloud or not?
Case 1: **Partitioned** multicloud each workload on a single cloud

- **Team A**
  - data analytics
  - Azure Synapse

- **Team B**
  - ML workload
  - AWS SageMaker

- **Team C**
  - Another ML
  - on-premise Tensorflow workstation
Case 2: **Portable** multicloud
Same app can be deployed on any cloud
Case 3: **Portable** multicloud
Same workload can potentially run on any cloud

- **AWS**
  - Containers on Kubernetes cluster

- Google Anthos
  - (Third-party service to manage Kubernetes nodes)

- Company
  - Azure
  - GCP

↑ manage
Case 4: **Transparent multicloud**
Same workload transparently run on any cloud

- User
- "Deployment manager"
- Third-party software service
- $v_1$
- $v_2$
- Azure Container instance
- Amazon ECS Docker service
- Lower cost? New feature req.?
<table>
<thead>
<tr>
<th></th>
<th>Partitioned multi-cloud</th>
<th>Portable multi-cloud</th>
<th>Sky (transparent multi-cloud)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same app running on different clouds?</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Cloud transparent?</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Universal APIs (do all clouds provide the same APIs)?</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Deep APIs (are APIs at different levels)?</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
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**Table 1:** *Comparison between existing types of multi-cloud and Sky.*
What is SKY-COMPUTING...

A set of software tools/services that make it easy to run apps across multiple clouds (ideally transparent).
Sky Computing Lab (2022- )

Successor of RISELab, AMPLab
- 8 faculty
- ~50 students & postdocs
- Sponsored by
  - Google
  - IBM
  - Intel
  - Samsung SDS
  - VMware
  - ASTRONOMER
  - Lacework
Prof. Ion Stoica
@ Berkley, CA

- Research: Distributed sys., Cloud, Networks
- “Sky computing” lab
- Databricks co-founder
- Video presentation: useunix.org/conference/atc23/presentation/joint-keynote
Current computing **market**: Proprietary-service-oriented business model

![Cloud Provider Market Share Trend](image-url)

**Source**: Synergy Research Group
Issues with current cloud computing market:

• Non-compatible proprietary interfaces
• Market model discourages competition
  lock-in strategy (egress cost, proprietary API, volume offer/contracts, etc.)
• Difficult to compare services (burden of choice)
  Customers must choose which clouds to use for which workloads
• Complex to setup (configs) & optimize (tuning) the service → high operational cost
  Ever-increasing set of services/configs/parameters; Migration complexity
  e.g. users worry about: resource allocation, query optimization, or excessive configuration and tuning decisions..
Compatibility

Ecosystem actors seek cross-cloud compatibility:

- Corporate users: ability to leverage a combination of services across clouds.
- Third-party software services: need to support multiple clouds as users already make cross-clouds compatibility a requirement.
- Cloud providers: offer service interfaces compatible with other clouds’ proprietary interfaces.

OSS drive compatibility
serves as standard (at different layers of the software stack)
Previous proposals: comprehensive compatibility standard supported by all clouds
Standardization problem:

- Not feasible (given the amount of interfaces - unlikely to happen)
- Dominant cloud would resist (lessen their competitive advantage)
- Impedes innovation (rigid set of interfaces)
  
  At what abstraction level? Tradeoff between user-flexibility & operator-innovation.
- Perfect-compatibility of cloud is not necessary (no need for every service to run on all clouds)
New proposal: introduce inter-cloud broker

• Sky is cloud-computing mediated by an **Inter-cloud Broker**.
  = managed mediated multi-cloud

• Inter-cloud broker matches app **demands** & user **preferences** to clouds;

• compatibility set: similar services provided by many clouds (hosted or managed)
  e.g. OSS: Kubernetes, Apache Spark, Apache Kafka
  e.g. cloud-specific: AWS Inferentia, BigQuery
Two-sided Market:

Supply
Merchants, sellers, and service providers

Platform

Demand
Buyers, customers, and clients

App Layer

Compatibility Set

Instead of a portability layer, a two-sided market
- One side: existing services running on one or more clouds (aka compatibility set)
- Other side: apps using one or more of these services
New proposal: Flexible workload placement
Goals of new proposal:

- Greater/Partial compatibility (encourage expanding of compatibility set)
- Flexible workload placement (through intermediation)
  Allow customers to move/shift workloads between clouds.
- Thriving competitive market (platform serves as marketplace)
- Fully-managed (rely on brokers to optimize desired criteria)
  Self-tuning & self-managing — only need to submit a job description.
Architecture:

- User identity, access credentials
- Job API (e.g., job’s DAG specification)
- Billing
- Executor
- Provisioner
- Data Orchestration
- Optimizer
- Service Catalog
- Identity Management
- Intercloud Broker
- Compatibility Set
- Cloud A
- Cloud B
- Service publisher
- APIs, cost
- APIs, cost
Business model:

• Service fees as intermediator.
• Telemetry data on jobs' execution patterns and providers market share (e.g. frequency of services use).
Sky Example

ML Pipeline + Optimize cost

- Use Azure Confidential Computing (ACC) for secure data processing
- Use Google Cloud for training on TPUs
- Use AWS for serving on Inferentia

Objective

Data set

Azure Blob store

Remove PII

1GB

NL model

Inference: predict rate from text (cost-performance)

Low cost
Does it Work?

- BERT on user review data set
- 10K queries
- Requirement: process data confidentially
- Preference: reduce cost

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<thead>
<tr>
<th></th>
<th>proc</th>
<th>train</th>
<th>infer</th>
<th>egress</th>
<th>Total</th>
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<td>8.4</td>
<td>1.8</td>
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<td>10.8</td>
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<tr>
<td>(hr.) Sky 0.6</td>
<td>4.0</td>
<td>1.1</td>
<td>0.03</td>
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<td>Reduce both latency and cost</td>
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<td>Transfer costs</td>
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Benefits/Opportunities of cross-cloud deployments

• Low barriers to cloud usage → greater cloud adoption
• Easy access to specialized services → Rapid technical innovations
• Integration of various computational options — on-premise, edge, zones, etc.
  • E.g. Massive cost savings of repatriating cloud workloads (to private clouds).
• Enhancing compliance, security, and resilience/reliability.
Conjectures

• Compatibility set: There are enough easy cases to benefit users from Sky computing.
  • Killer apps: DS/ML pipelines (DAG model) & data sovereignty trends;
• No help needed from existing cloud providers.
• Constant evolution: once initiated market forces will create self-reinforcing cycle:
  • More compatibility → Greater supported workloads.
  • More workloads → Larger compatibility set (Clouds offer more services)
• Data transfer cost will drop — offering reciprocally-free data peering
Risks:

• Market devolve in dysfunctional ways: **Collusion** & predatory pricing.
• Inaccurate catalog information.
• Shim layers have a significant drawback: provide the lowest common denominator functionality across services. (remedy: “bolt-on” layers which extend a service’s functionality);
• Sky may remain only a niche market.
• Requires new debugging, monitoring, & profiling tools.
Thoughts?
How large Sky market would become?
will it gain traction?