SKY CONTROL: A novel concept for a vendor-agnostic multi-cloud framework to optimize cost control and risk management for small and medium-sized enterprises

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Introduction

- Larger enterprises increasingly use cloud computing.
- However small and medium-sized enterprises (SME) are not likely to adopt cloud computing[a].
- However multi-cloud setups have the following benefits:
  - **Multiple Provider Selection**
  - **Avoiding Vendor Lock-in**
  - **Best-of-Breed Services**
  - **Workload Optimization Possibilities**

[a] Source: Digital Ocean

Questions?

- How to make cloud computing setups attractive and adoptable for SMEs?
- How to make the costs for SMEs manageable?
- How to leverage the benefits of multi-cloud setups for SMEs and find answers to the questions posed in this section?

Idea!

Develop a framework which incorporates tools for the management, the analysis of costs and the overview of complex infrastructures for SMEs! ⇒ **SKY CONTROL**

Computing of the future? – Quote from 1961

- The following section presents the foundation for the SKY CONTROL framework.
- The SKY CONROL project originates in **Sky Computing**.

> *"computation may someday be organized as a public utility, just as the telephone system is a public utility. We can envisage computer service companies whose subscribers are connected to them [...]. Each subscriber needs to pay only for the capacity that he actually uses, but he has access to all programming languages characteristic of a very large system."* – John McCarthy

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Interoperability of cloud services – A historical view

The Internet

- In the early 1960s several groups were developing packet switching technology.
- The early networks lacked interoperability and therefore only niche technologies developed.
- Robert Kahn introduced the ARPANET with open architecture, that formed TCP/IP networks.
- The ARPANET developed to the Internet as we know it now $\Rightarrow$ *The Network of networks*

Question

What does this mean in the context of cloud computing? Can we build *The Cloud of clouds*?

Sky Computing – Analogy to the Internet

Internet	Sky Computing
Router	Server
Autonomous System	Datacenter / Availability Zone
Internet Service Provider	Cloud Provider
Enterprise Network	Private Cloud
Internet Protocol	Compatibility Layer
BGP	Intercloud Layer

Sky Computing

Sky Computing is a new paradigm for interoperable cloud services, enabling applications to run on any provider and realizing the vision of utility computing.

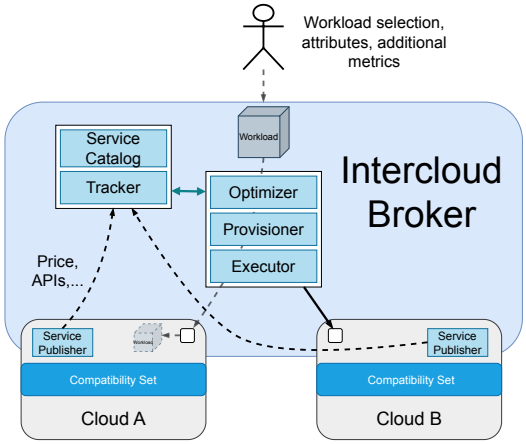
How to reach the goal?

Sky Computing builds on infrastructure spanning multiple heterogeneous, competing cloud providers — *No standardization of the clouds!*.

Source

Stoica, Ion, and Scott Shenker. "From cloud computing to sky computing". *Proceedings of the Workshop on Hot Topics in Operating Systems*. 2021.

Sky Computing – Intercloud Broker (1/2) Yang et al.



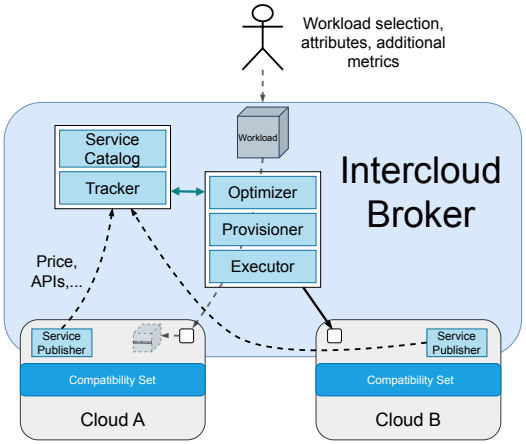
Intercloud Broker

- **Service Catalog**
  - Contains location and API information of services.
- **Tracker**
  - Tracks resource availability across clouds and their locations.
- **Optimizer**
  - Checks instance and service availability with their prices.
  - Computes an optimal placement of the applications and may perform re-optimization.

Source

Yang, Z.,et al. "SkyPilot: An intercloud broker for sky computing". *In 20th USENIX Symposium on Networked Systems Design and Implementation* (pp. 437-455), 2023.

Sky Computing – Intercloud Broker (2/2) Yang et al.



Intercloud Broker

- **Provisioner**
  - Allocating the resources with all dependencies automatically (Terraform, etc.).
- **Executor**
  - Packages each application's tasks and runs them on the resources allocated by the provisioner.

How to implement this in practice?

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SKY CONTROL

We are faced with a twofold problem for users of hybrid multi-cloud infrastructures:

1. **Effective cost control, monitoring (preferably in real time) and management in hybrid infrastructures**
2. **Security of information assets, information security management**

We present **SKY CONTROL**, a novel framework addressing SMEs' challenges in multi-cloud deployments. It simplifies cost oversight and enhances security risk analysis and asset governance.

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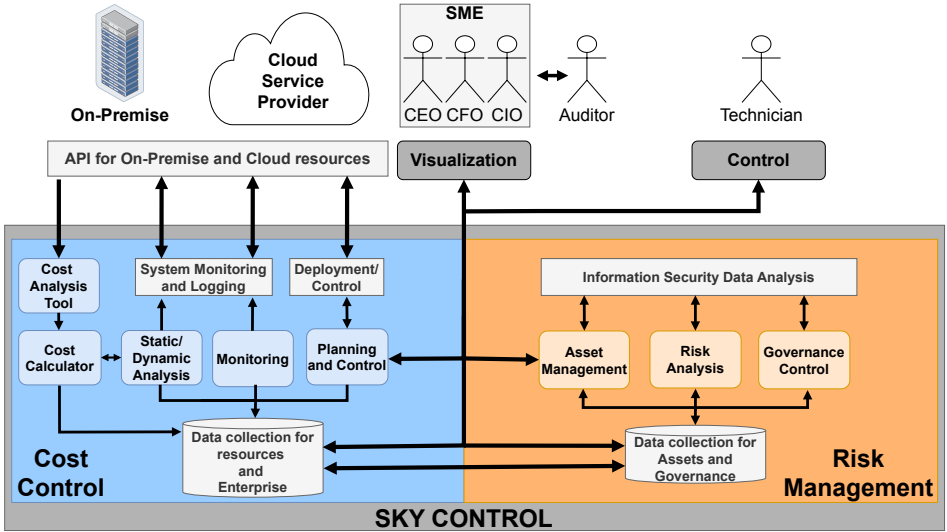
SKY CONTROL – Architecture



Expected impact of the project

- SKY CONTROL holistically assesses digital asset value alongside storage and processing costs.
- Cost analysis and critical data protection extend beyond traditional performance evaluation.
- SKY CONTROL aims to optimize costs and risks, implementing solutions in real time when possible.
- Long-term, SKY CONTROL could have a macroeconomic impact.

SKY CONTROL is the first practical implementation of Sky Computing for SMEs. If it creates a market, cloud resources could be traded like stocks, allowing companies to monetize idle resources securely.

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