

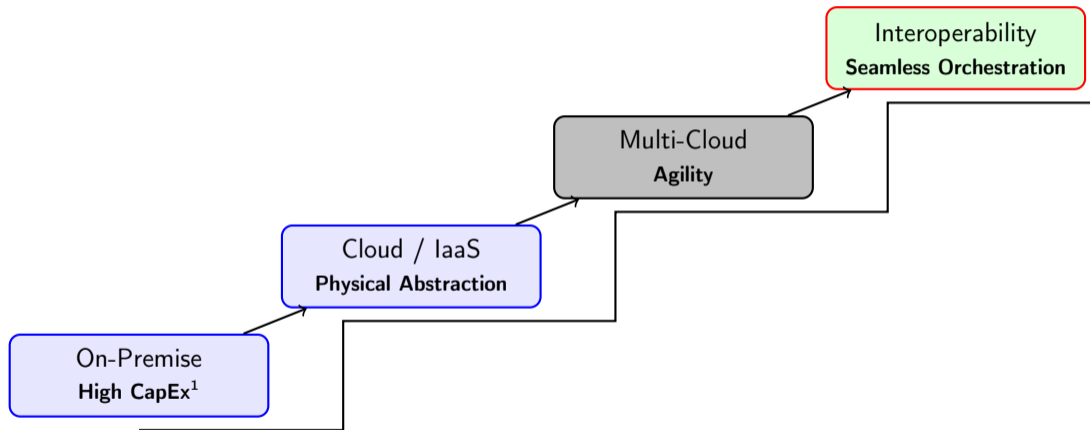
# Sky Computing in Practice: A Framework for Unified Vendor Agnostic Multi-Cloud Management and the Lessons Learned

11th International Congress on Information and Communication Technology  
24th - 27th February 2026  
London, United Kingdom

Henry-Norbert Cocos, Christian Baun,  
Andreas U. Schmidt, Thorsten Luft, Abo El Hage  
{cocos,baun}@fra-uas.de  
{a.schmidt,T.Luft,a.elhage}@systrade.de

Computer Science  
Department of Computer Science and Engineering  
**Frankfurt University of Applied Sciences**

# Infrastructure Evolution: From Iron to Abstraction



<sup>1</sup>Capital expenditure (CapEx): funds to acquire, upgrade, and maintain physical, long-term assets like property, buildings, machinery, or technology.

# From Fragmentation to Federation

## The Challenge

Hybrid multi-cloud is the standard, but brings:

- Cost opacity
- Inconsistent APIs
- Security silos

Small and Medium-sized Enterprises (SME) lack the resources of large corporations.

## The Solution

**SKY CONTROL** – A vendor-neutral framework as **Intercloud Broker** combines

- Cost control,
- Risk management,
- Secure Access and Service Edge (SASE) and
- Free and Open Source (FOSS) software

in a single abstraction layer.

## The Market

The market is very heterogeneous:

- Tools for Cloud Cost Management
- Security via Firewalls, Identity and Access Management (IAM), etc.

A unified abstraction layer is **technically essential**.

# Sky Computing – Interoperability 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.

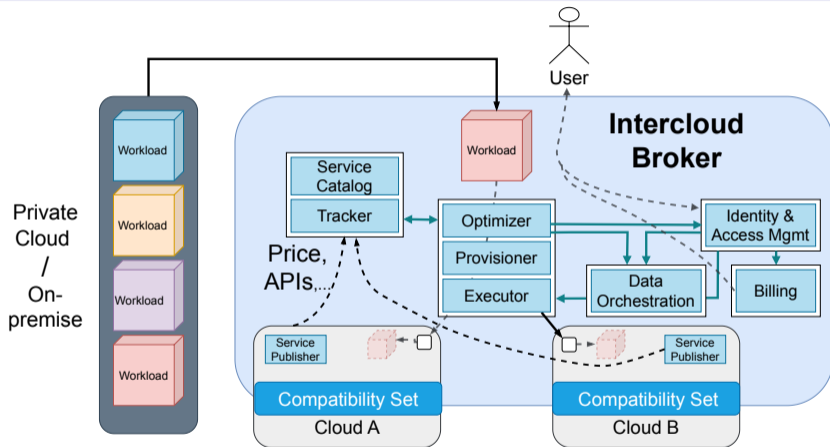
## How to reach this goal?

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



## Source

Stoica, I. "Sky computing: Opportunities and challenges". *In Studies in Systems, Decision and Control* (pp. 15–27), 2024.

# Market Analysis: Why Existing Tools Fail

Tool	Cost Structure	Automated Provisioning	Security (Identity/Role)	SME Suitability
CloudHealth	Expensive (~3% of spend)	No	Limited	Low
Flexera One	Enterprise fixed price	No	Limited	Low
Densify	€2.50 per instance	No	No	Medium
<b>SKY CONTROL</b>	<b>FOSS / Low</b>	<b>Yes</b>	<b>Yes (SASE)</b>	<b>High</b>

## CONCLUSION

The market needs a cost-efficient, Open Source-based solution. Existing tools lack the combination of provisioning and security modules.

# Module 1: Intelligent Cost Control

## PRE-DEPLOYMENT: Static Analysis

- Analyzes resource metadata (ID, CPU, RAM)
- Checks price catalogs before launch
- Prevents "*Bill Shock*" through forecasting



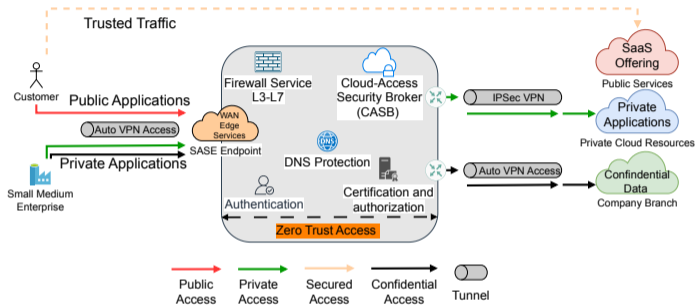
Optimized Cost  
Decision



## RUNTIME: Dynamic Analysis

- Real-time monitoring of CPU load & RAM
- Monitoring of Ingress/Egress bandwidth
- Identifies hidden data transfer costs

## Module 2: Risk & SASE Integration



- **SD-WAN:** Connection optimization (MPLS, 5G)
- **SWG:** Secure Web Gateway - Filtering
- **CASB:** Cloud Access Security Broker - Policies
- **ZTNA:** Zero Trust - *"Never trust, always verify"*

### The FOSS Strategy

Layer	Technology
Governance	Cloud Custodian
ZTNA	OpenZiti / Tailscale
Firewall	OPNsense / pfSense
Routing / SD-WAN	OpenWrt

- No expensive licenses (e.g. Zscaler, Cisco)
- Maximum cost efficiency for SMEs

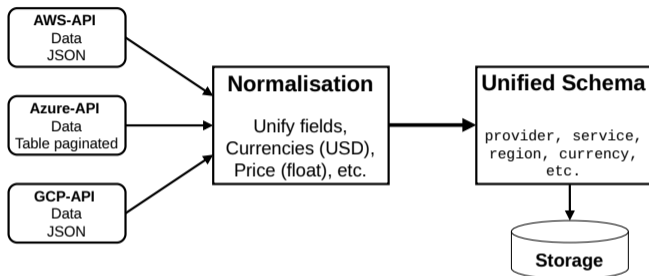
# Cost API Analysis

## Tools

- Python (boto3)
- Terraform

## Cost-API

- **AWS:** AWS Price List Query
- **GCP:** Cloud Billing Catalog
- **Azure:** Azure Retail Prices



## Methodology

Development of a prototype for normalizing price and service data from heterogeneous API structures.

## Challenge

**No standard:** AWS delivers structured JSONs, while GCP requires complex Service-ID mappings.

## Goal

Creation of a unified data basis for SKY CONTROL.

# Test Results: Performance & Payload Discrepancy

## API Response Time (Seconds)

- **AWS:** < 0.96s
- **GCP:** < 0.89s
- **Azure:** ~36.47s

## API Payload Size

- **AWS:** 3.62 KB
- **GCP:** 316.05 KB
- **Azure:** **84.33 MB**

### Insight

Even with high-speed connections, Azure creates significant latency through massive data volumes.

### Conclusion

Direct API management is inefficient. A caching layer (**SKY CONTROL**) is technically mandatory.

# Conclusion & Outlook

- **Feasibility**

**Validated:** Cost analysis is technically possible but requires normalization.

**Validation ongoing:** Deployment analysis through Terraform (static) and Monitoring tools (dynamic).

- **Security**

**Validated:** SASE via FOSS is the only economical path for SMEs.

**Next step:** Incorporation of FOSS SASE technologies in SKY CONTROL.

## Final Thought

SKY CONTROL enables SMEs to finally treat cloud resources like electricity or water – **simple, transparent, and essential.**

The complexity belongs in the framework, not in the business.

## Vision: Cloud as a "Public Utility"

*"Computation may someday be organized as a public utility, just as the telephone system is a public utility."*

— *John McCarthy, 1961*

### Analogy

Just as the telephone network connects without the user knowing the switchboard, Sky Computing connects clouds. The user pays for **capacity**, not infrastructure management.

The project is realized in cooperation with the company **Systrade GmbH**.



This project is funded by the **Federal Ministry for Economic Affairs and Climate Action** ('**Bundesministerium für Wirtschaft und Klimaschutz**') in the framework of the central innovation programme for small and medium-sized enterprises ('**Zentrales Innovationsprogramm Mittelstand**').



Bundesministerium  
für Wirtschaft  
und Energie



**Henry-Norbert Cocos, M.Sc**  
Frankfurt University of Applied Sciences  
Room 1-230

📞 +49 69 1533-2699

✉️ [cocos@fra-uas.de](mailto:cocos@fra-uas.de)

🌐 [www.henrycocos.de](http://www.henrycocos.de)

