

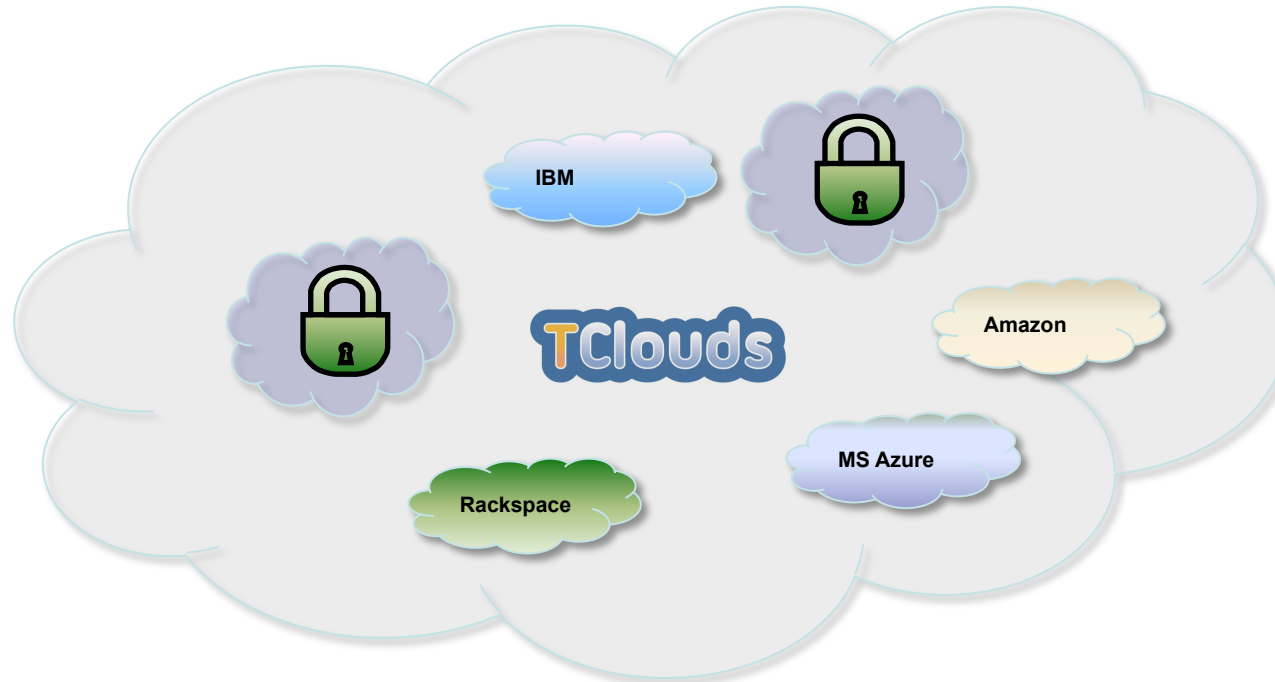


# Cloud-of-Clouds Computing for Supporting Public Utilities *A Case Study*

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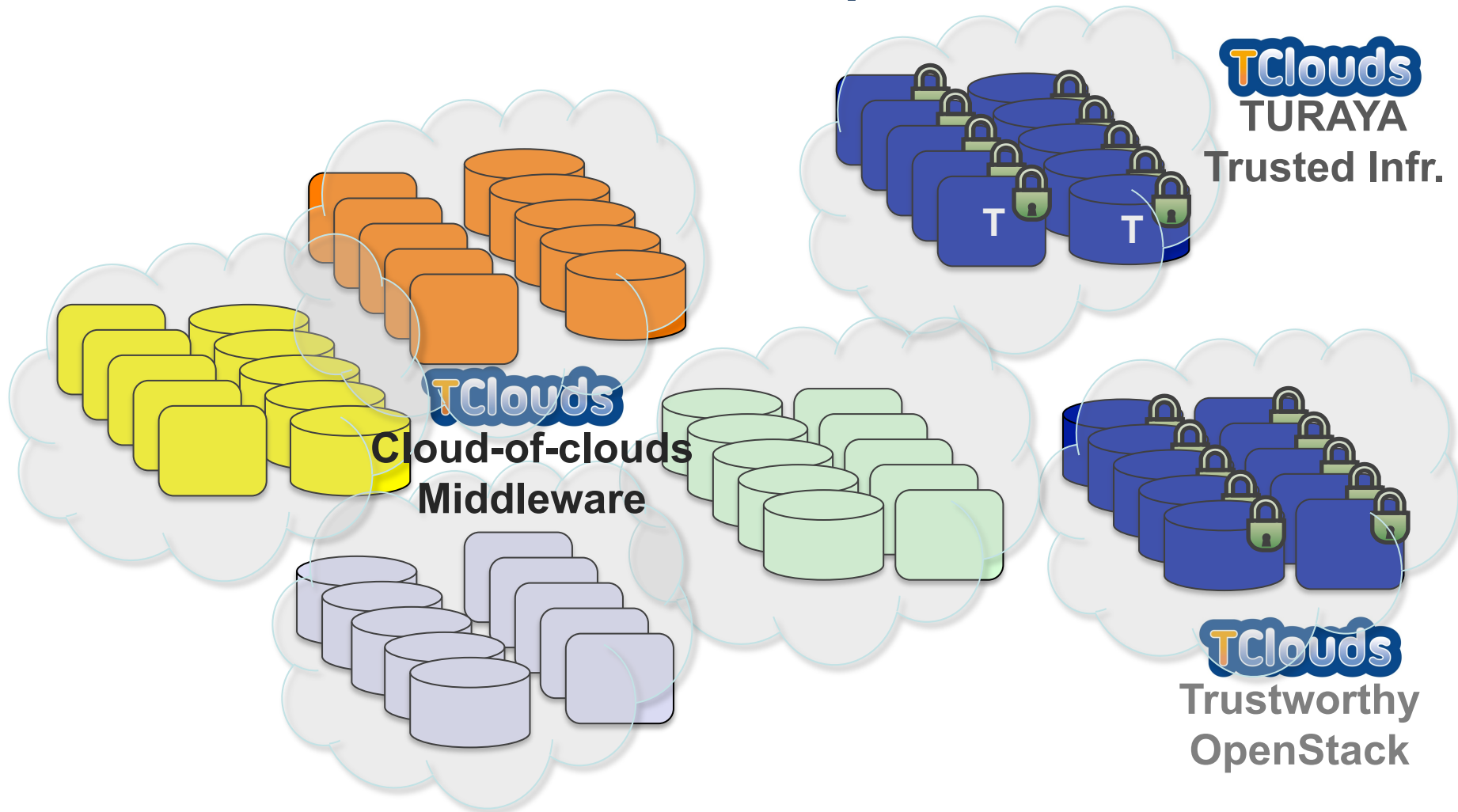
# TClouds in a Nutshell



**Cloud-of-clouds:** an ecosystem composed by public and private clouds, enhanced by **TClouds** software in several ways.

**Objective:** Improve security in several aspects of the cloud (storage, virtualization technology, computing, networking, secure platforms) as well as promote cloud security awareness.

# TClouds Ecosystem



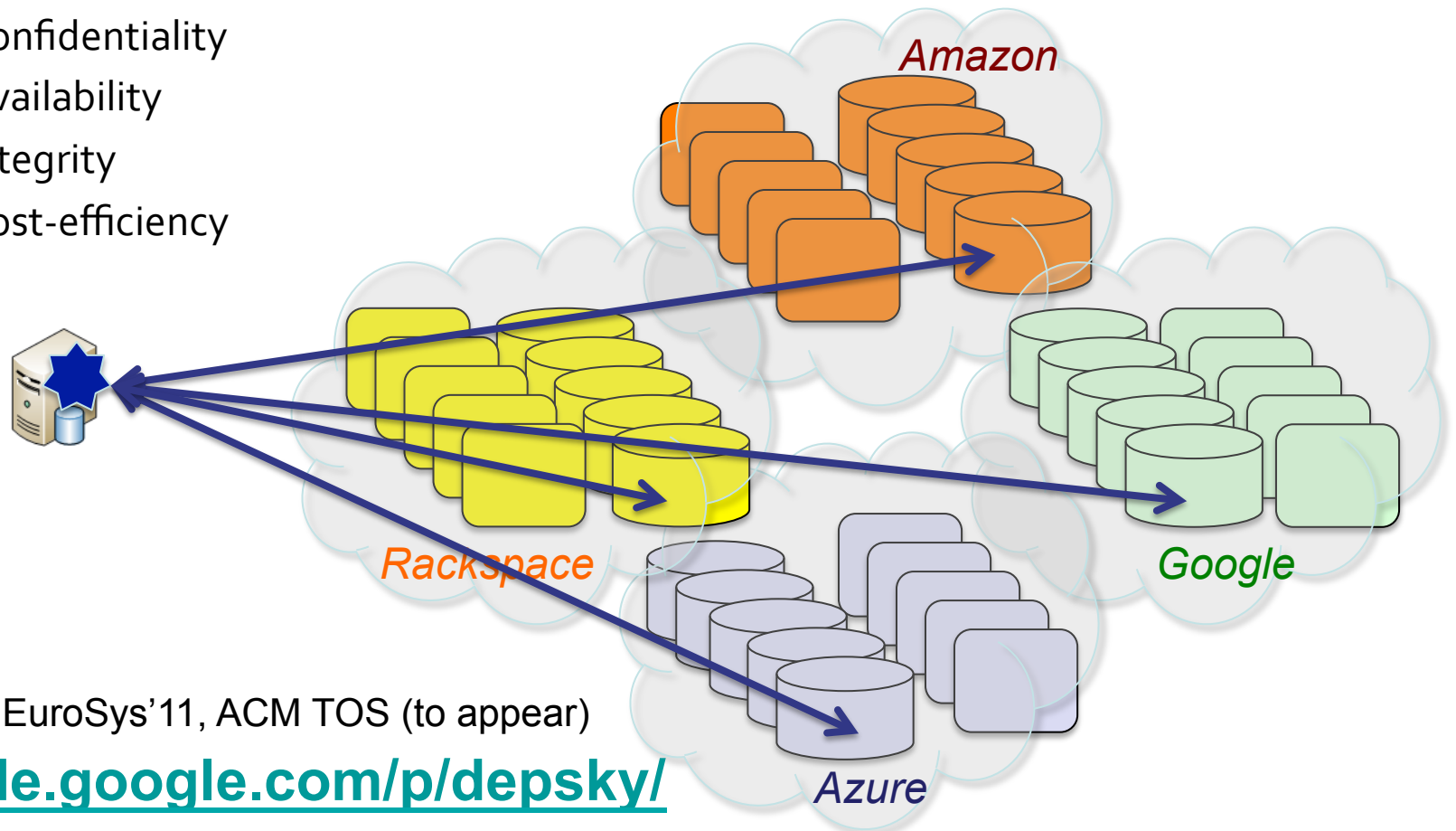
# Abstractions for Cloud-of-Clouds

- Cloud-of-clouds services avoid internet-scale single point of failures, one of the main treats to cloud customers
  - Do not assume modifications or cooperation of cloud providers
- From cloud to cloud-of-clouds abstractions
  - Clouds abstractions
    - Storage resources (object storage)
    - Processing resources (VMs)
  - Cloud-of-clouds abstractions
    - Resilient object storage
    - State machine replication

**Challenge: How to implement them efficiently?**

# Cloud-of-Clouds Resilient Object Storage

- DepSky – object read/write interface
  - Confidentiality
  - Availability
  - Integrity
  - Cost-efficiency



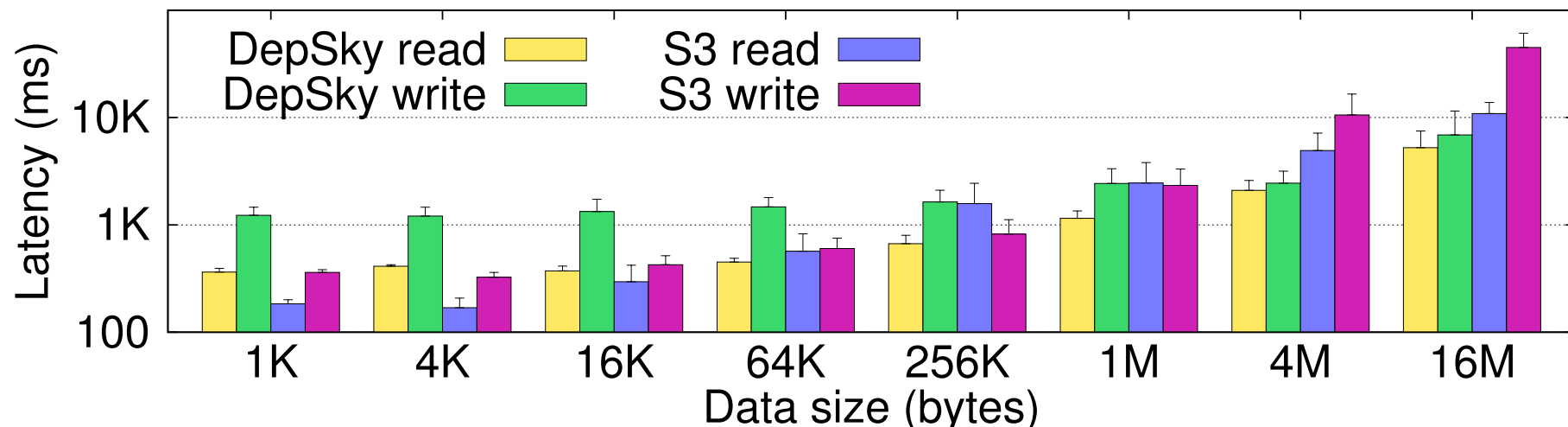
Bessani et al. EuroSys'11, ACM TOS (to appear)

<http://code.google.com/p/depsky/>

# CoC Storage Performance

## ➤ DepSky

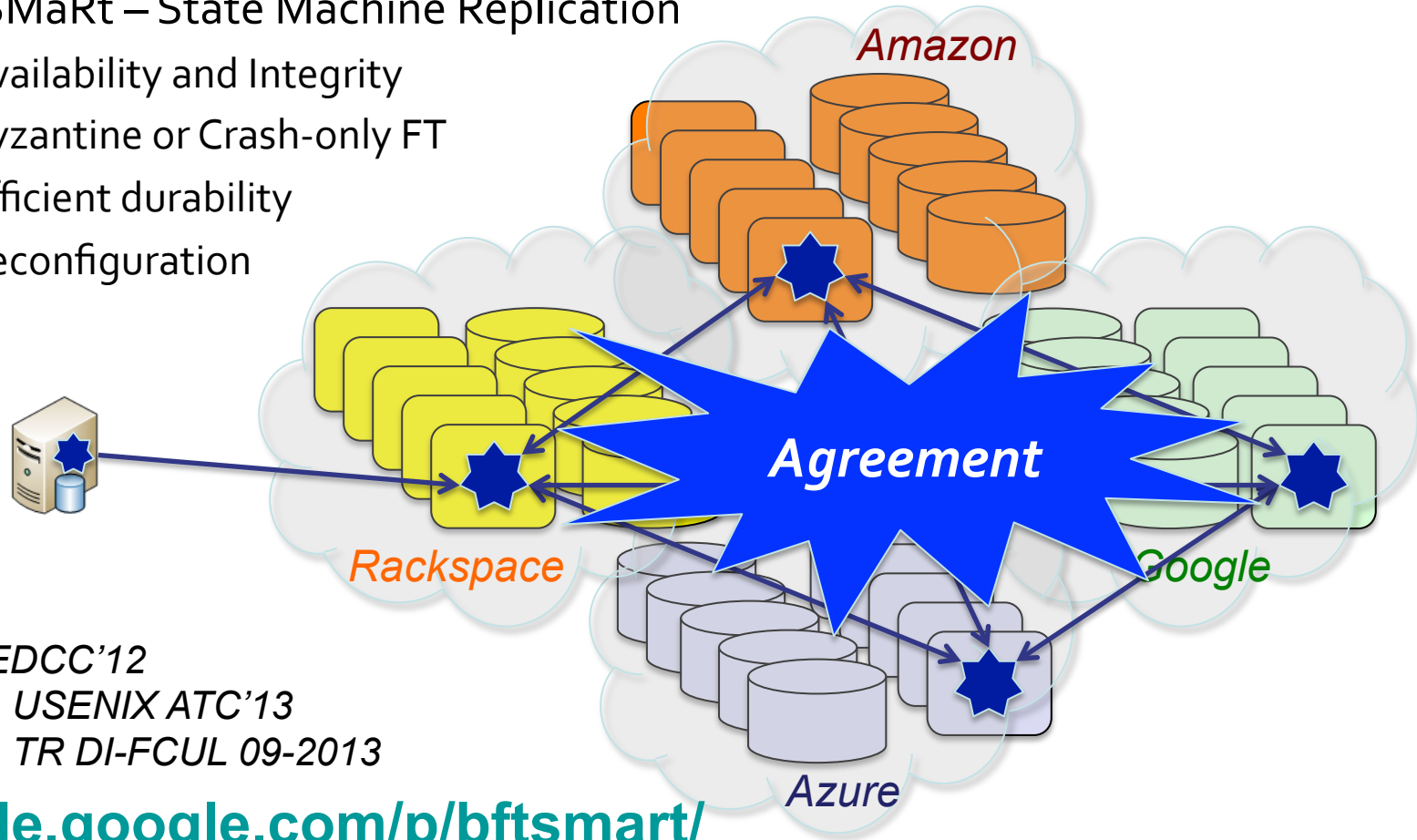
- Client in Lisbon
- Storage services: S3, Azure B, Google Storage, Rackspace Files



# Cloud-of-Clouds State Machine Replication

## ➤ BFT-SMaRt – State Machine Replication

- Availability and Integrity
- Byzantine or Crash-only FT
- Efficient durability
- Reconfiguration



*Sousa et al. EDCC'12*

*Bessani et al. USENIX ATC'13*

*Bessani et al. TR DI-FCUL 09-2013*

<http://code.google.com/p/bftsmart/>

# CoC SMR Performance

## ➤ BFT-SMaRt

- Client in Lisbon
- Replicas: EC2, Rackspace, Azure, Elastichosts (all in Europe)

	MS Operation	Local	EC2	CoC
In-memory reads	getMetadata	$2.21 \pm 0.85$	$79.85 \pm 0.85$	$72.81 \pm 1.48$
	getDir	$3.26 \pm 0.45$	$84.56 \pm 1.51$	$94.03 \pm 0.81$
In-memory writes	update	$5.13 \pm 1.42$	$86.32 \pm 0.83$	$96.44 \pm 1.11$
	put	$5.82 \pm 0.88$	$87.15 \pm 2.21$	$96.96 \pm 1.36$
	delete	$3.31 \pm 0.67$	$84.52 \pm 0.91$	$93.95 \pm 0.68$

*(everything in milliseconds)*



# Cloud-of-Clouds: Does it make Sense?

- From the **trust** perspective
  - Incident reports appear all the time
  - Fault independence appears to be very high
- From the **economical** perspective
  - Providers keep improving their “resource per money” offers
  - Secure offers are/will be very expensive and complex
- From the **performance** perspective
  - Better networks and ISP offers
  - New replication protocols, weak consistency
  - For hybrid clouds it can be great (customer security)
- From the **complexity** perspective
  - ???

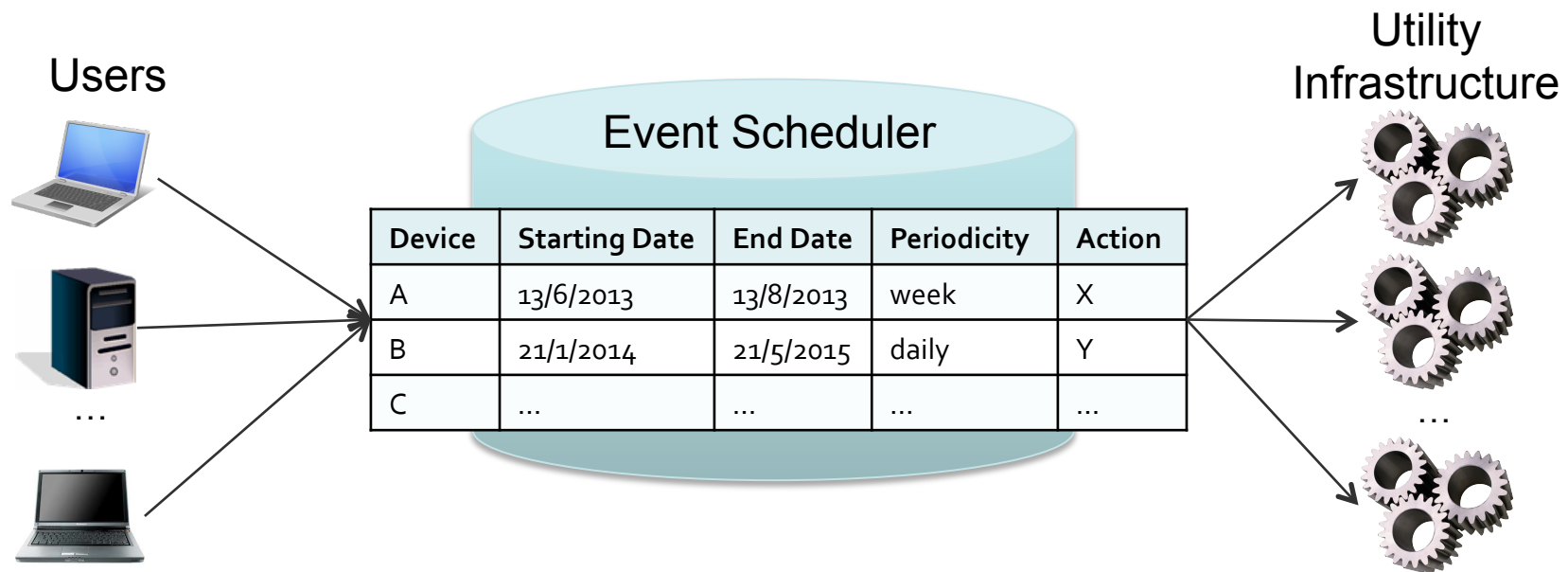


Smart Lighting System

# A PUBLIC UTILITY USE CASE

# Utility Infrastructure Schedulers (UIS)

- User schedule actions to be executed by devices managed by a utility infrastructure (usually a SCADA system)
- In a smart grid, every citizen can be a user and every home can have one or more devices



# Non-functional Requirements

➤ Integrity

➤ Availability

➤ Openness

(vs. Integrity)

➤ Confidentiality

(vs. Integrity and Availability)

Conflicting requirements!!!

# Are UIS Cloudy?

- In principle, no...
  - ... but as an applied research project, we can try it
- However, we can use public clouds for
  - Added dependability (e.g., disaster tolerance)
  - Added scalability & elasticity



Scenario	#Users	#Devices	Transactions/day*
2012 (PT)	10S	300	1.2K
2015 (PT)	100S	12000	48K
UIS as a Service	1000S	120000	480K
Smart Grids	millions	millions	millions to billions

\* Only utility infrastructure-initiated

# Smart Lighting System

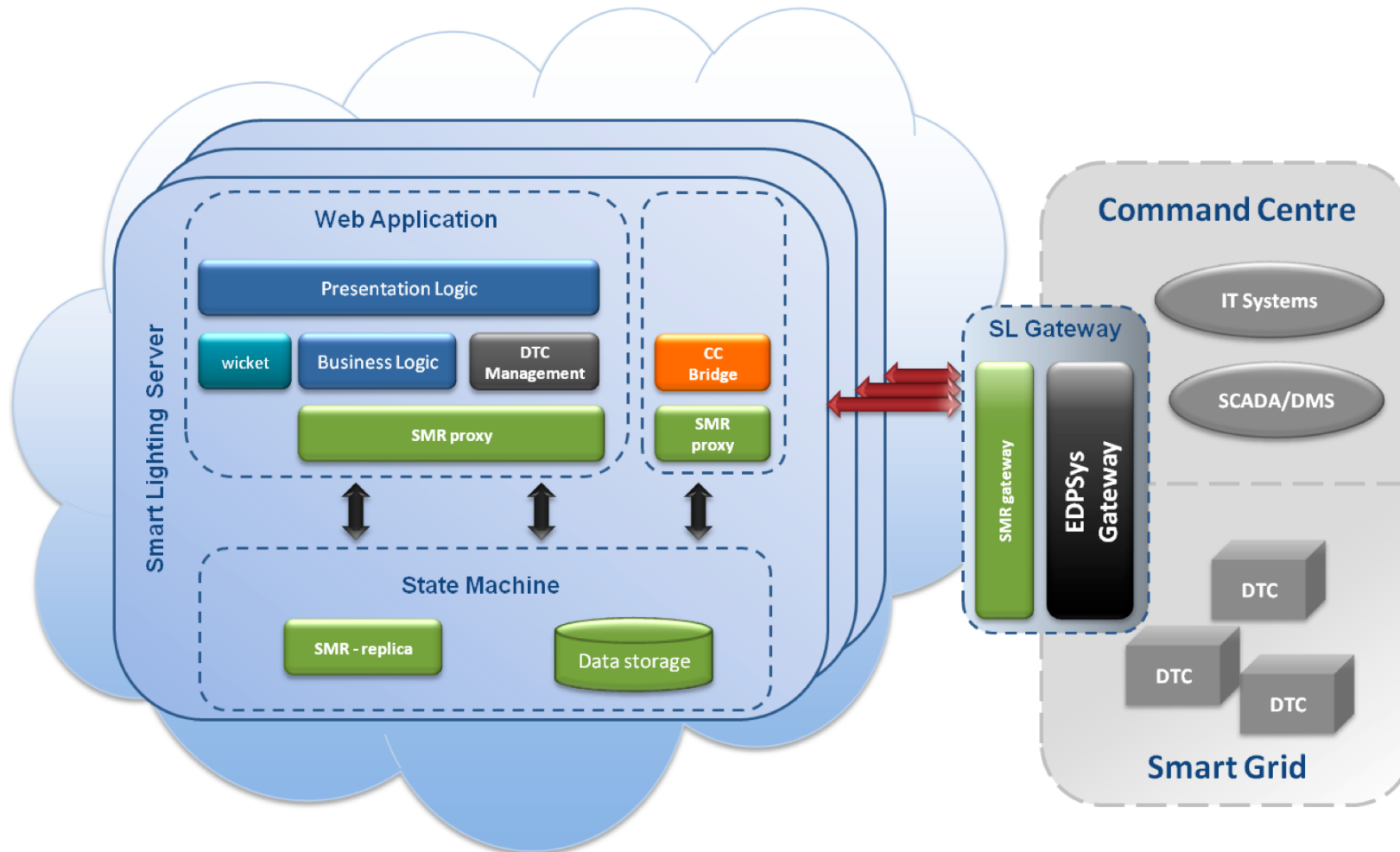
- A TClouds application scenario implementing the UIS concept for managing municipalities public lighting
- Main partners involved: **EFACEC**, **EDP**, FCUL, SIRRIX, TUBS

A screenshot of the 'smart lighting authentication' web interface. The page features a red owl logo and the text 'smart lighting' in the top left. The main heading is 'authentication'. Below this, there is a form with two input fields: 'User' and 'Password'. A red 'Enter' button is located below the password field. A link for 'Forgot my password' is positioned to the right of the 'Enter' button. At the bottom of the page, there are logos for 'edp distribuição' and 'efacec', the 'TClouds' logo, and the text 'Smart Lighting v0.1.0 © 2012 All rights reserved. Powered by TClouds'. A 'Contact support' link is also present in the bottom right corner.

# Smart Lighting System

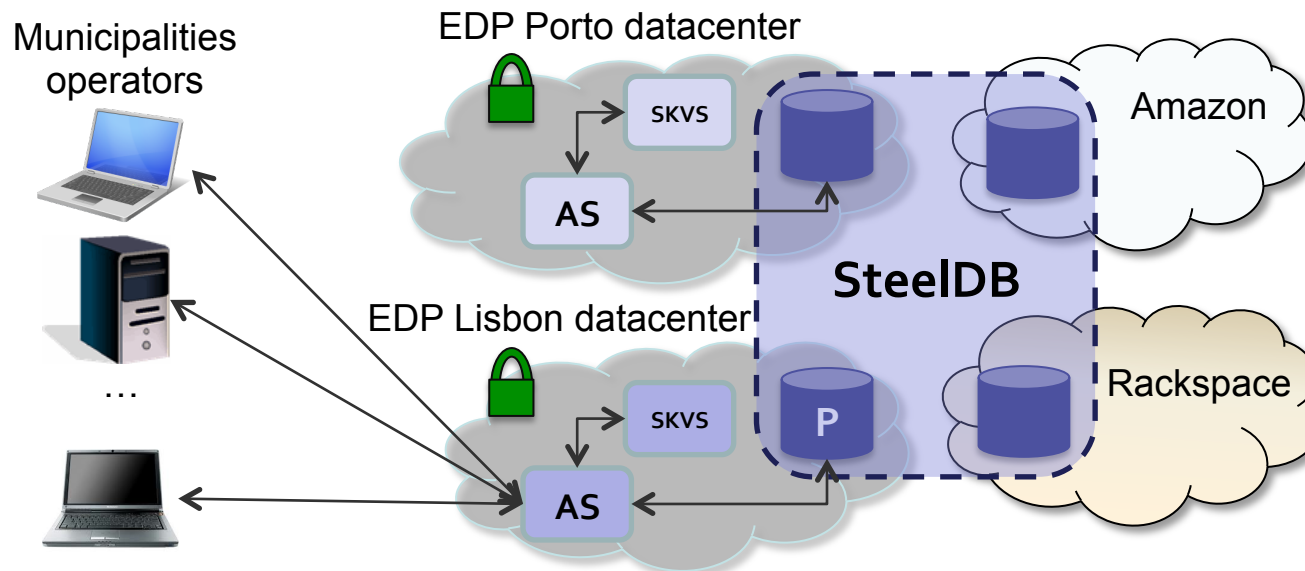
The screenshot shows the 'smart lighting' web interface. At the top left is the logo with a red owl icon. Navigation links include 'home', 'configuration', and 'reports'. The user is logged in as 'Évora Operator'. The current profile is 'Summer in Évora / 1º. DE MAIO (TP 3) TP1 / DTC Timetables'. There are tabs for 'GARDENS' and 'STREETS'. A 'Schedule Type' dropdown menu is open, showing options: Consolidated, Base (A LOT of entries), Specific, and Special Day. The main area displays a calendar for the year 2012, with months from January to December. Each month's calendar shows days of the week (Su, Mo, Tu, We, Th, Fr, Sa) and dates. Days are color-coded: brown for Solar, blue for Manual, and green for Photocell. A legend at the bottom explains the color coding for 'Off' and 'On' states. A 'back' button is located at the bottom right of the calendar area.

# Smart Lighting System





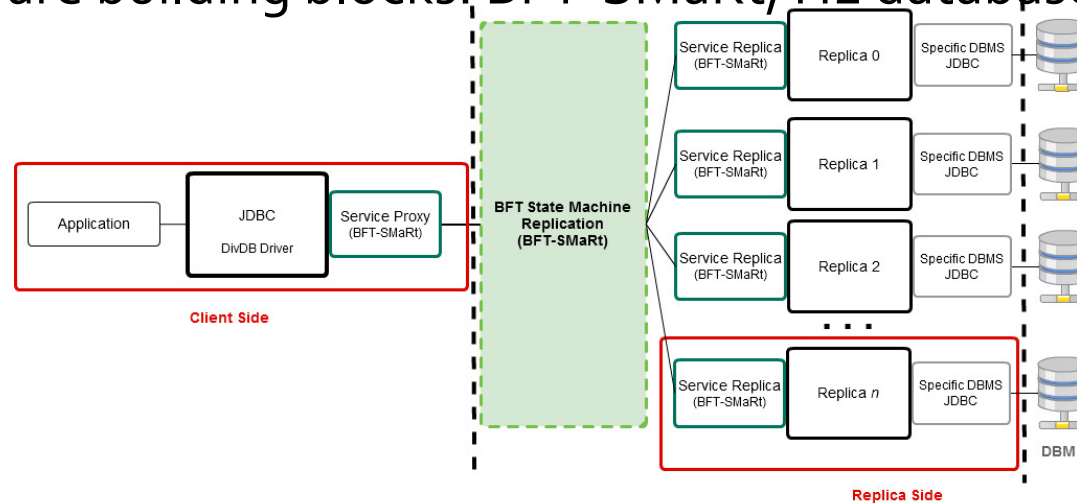
# (A Possible Real) Architecture



- Trusted infrastructure (by SIRRIX)
- SQL Database over BFT-SMaRt (by FCUL)
- Simple Key Value Store (by TUBS)

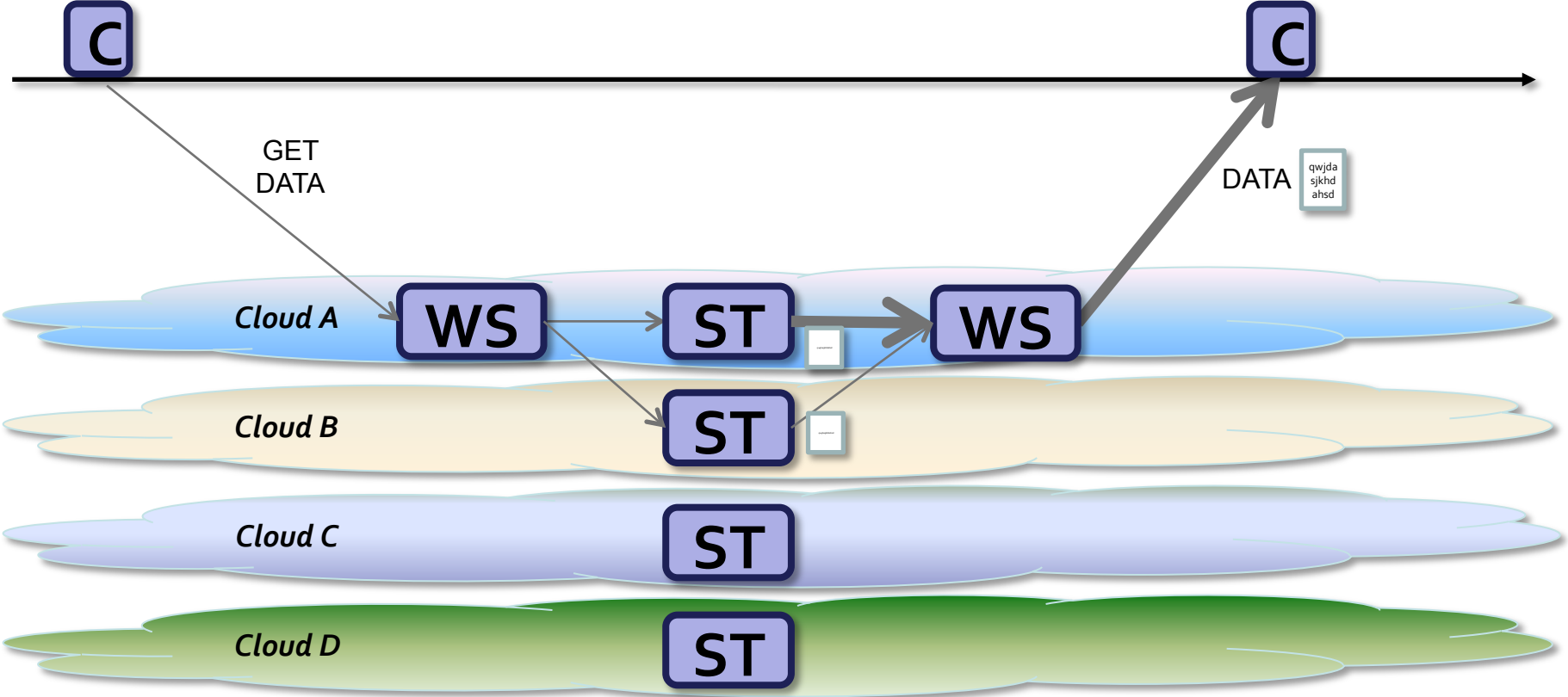
# SteelDB: SQL Database over BFT-SMaRt

- Middleware-based Database replication engine
  - Employs the Byzantium algorithm (Garcia et al, EuroSys'11), with some pragmatic modifications
  - Satisfy Snapshot Isolation
  - Tolerate crashes on clients and Byzantine faults on replicas
  - Software building blocks: BFT-SMaRt, H2 database



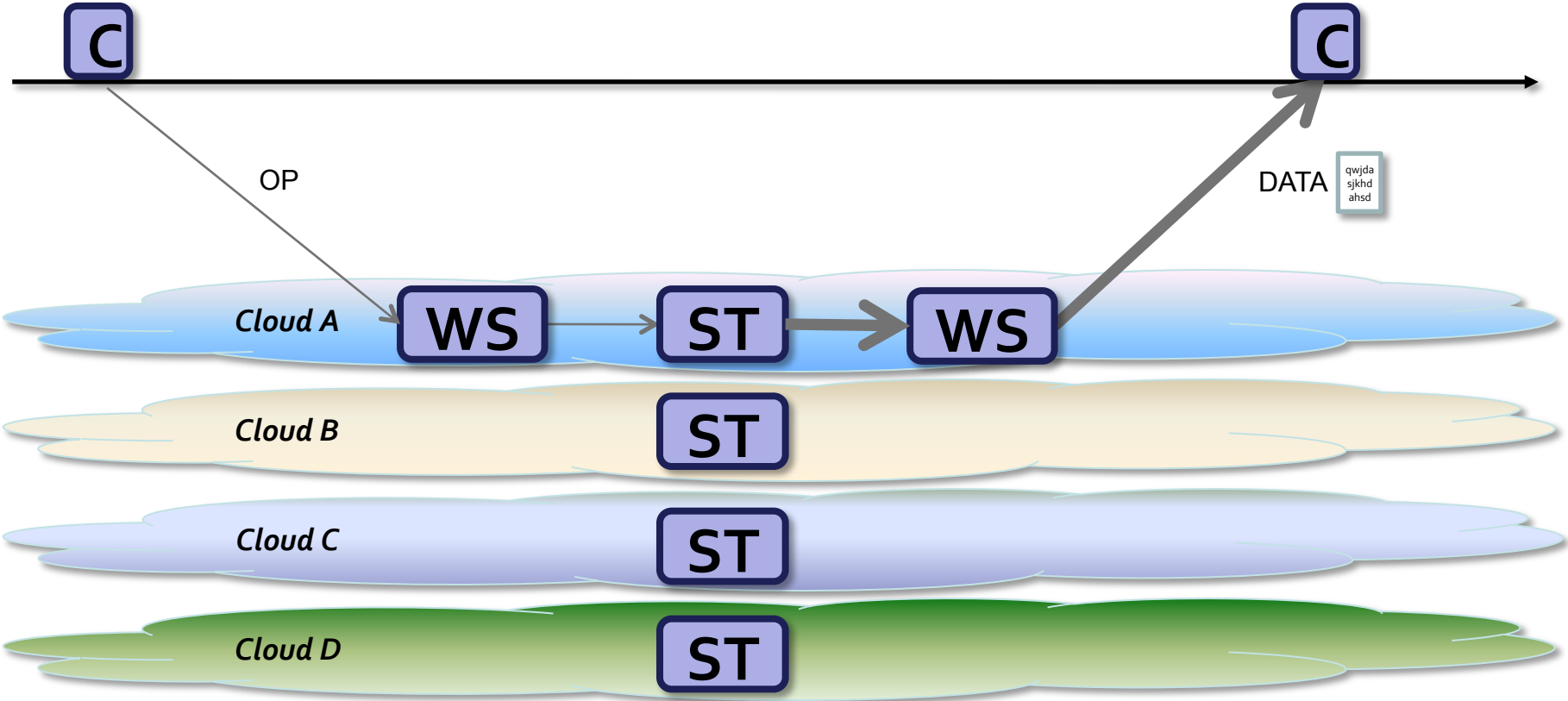
# SteelDB Operation

Read-only operations (reads)



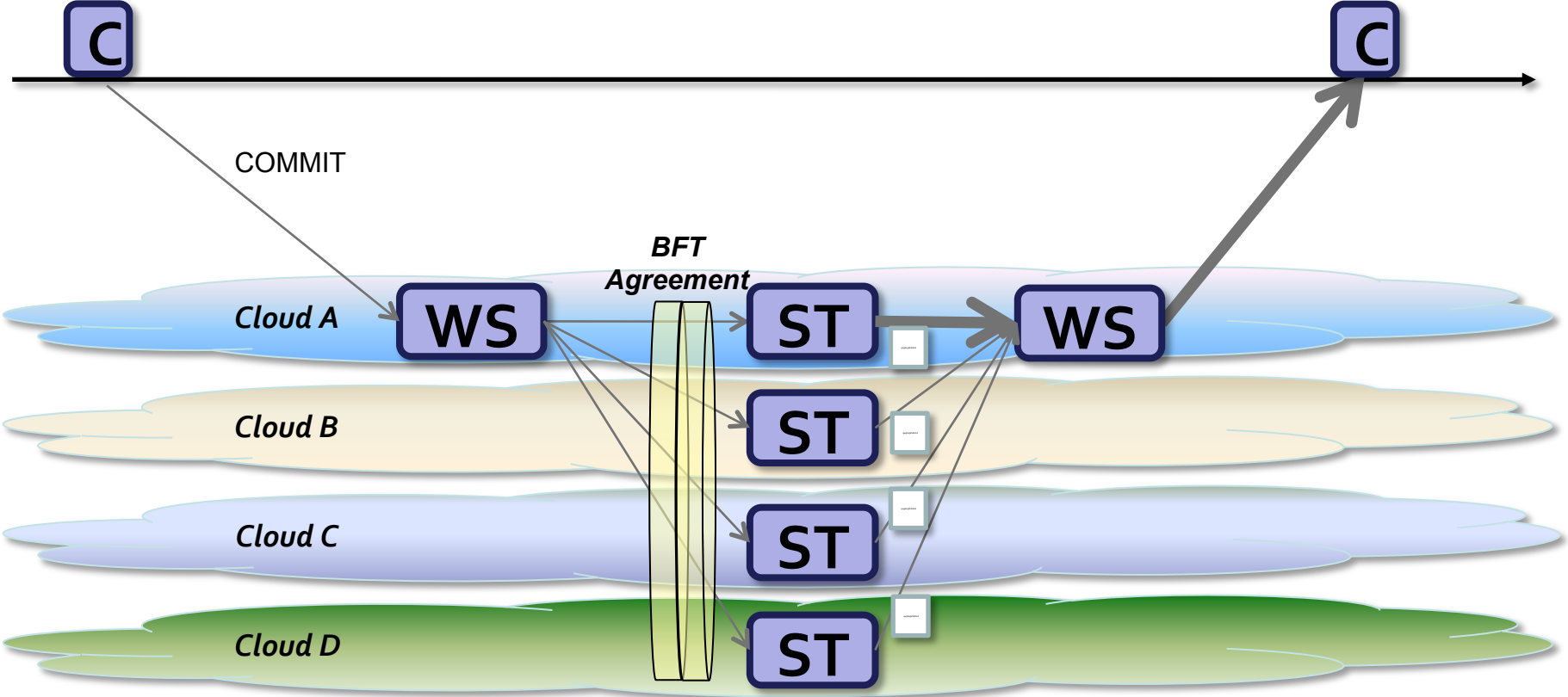
# SteelDB Operation

Non-certified operations (non-committed reads and writes)



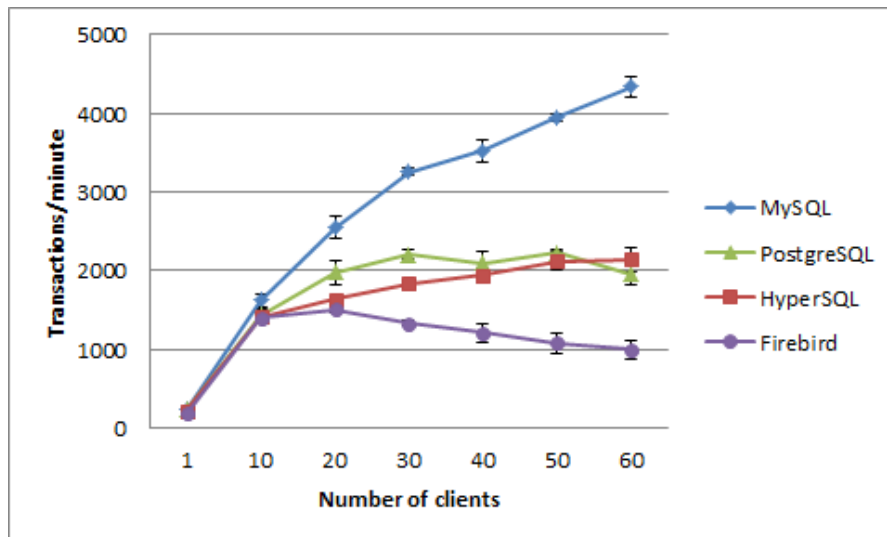
# SteelDB Operation

Certified operations (writes and transaction commits)

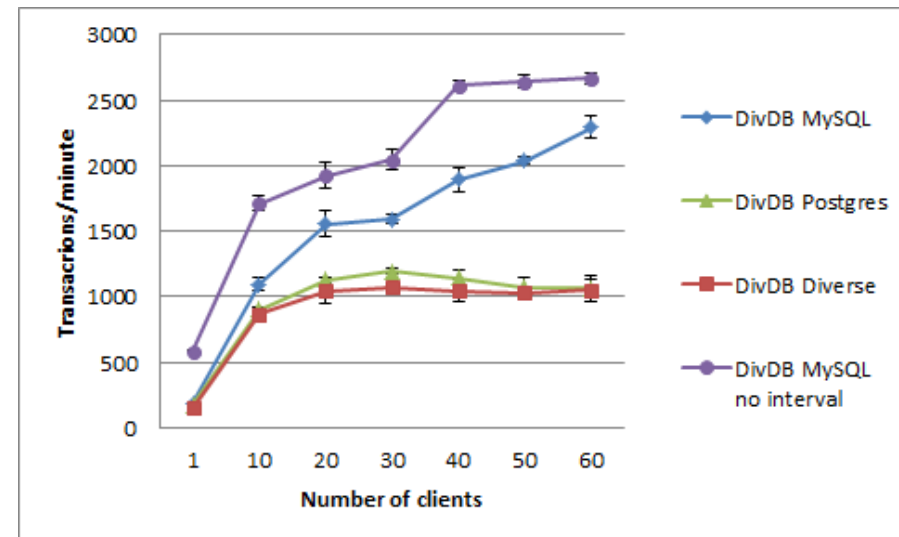


# What about Performance?

- Performance is not our first concern
- We don't have measurements for this scenario
- But we do have some encouraging numbers...



(a) Standalone DBMS.



(b) SteelDB variants.

# Lessons Learned

- Cloud-of-clouds replication is doable
  - DepSky is a proof-of-concept, but more work is required
- BFT SMR is now a software artifact
  - Thanks to TClouds (and EC)
- Utility computing can (and want) to use the cloud
  - They don't want to be "datacenter operators"
  - SCADA vendors do use state-of-the-art software
- Middleware-based Database replication is too hard to impl.
  - That's why it is seldom used in practice
  - It should be better to open the database and modify it

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If you need further information, please contact the coordinator:

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