# Zanzibar: Google's Consistent, Global Authorization System

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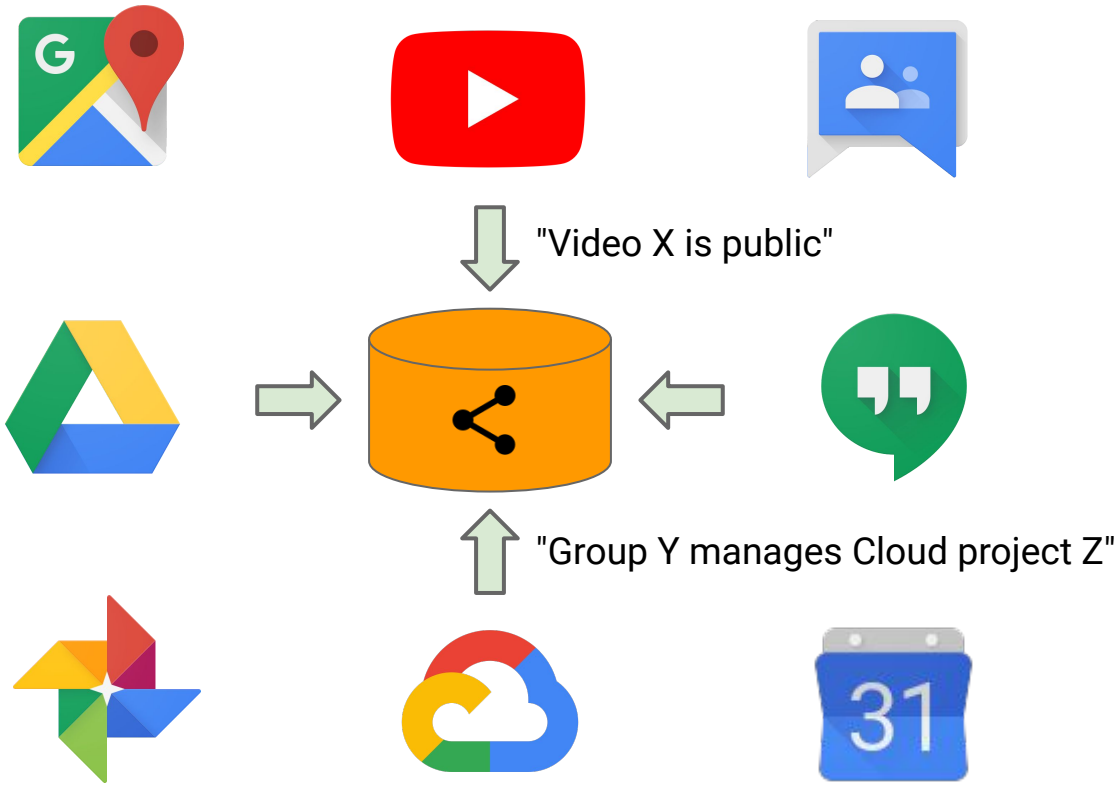
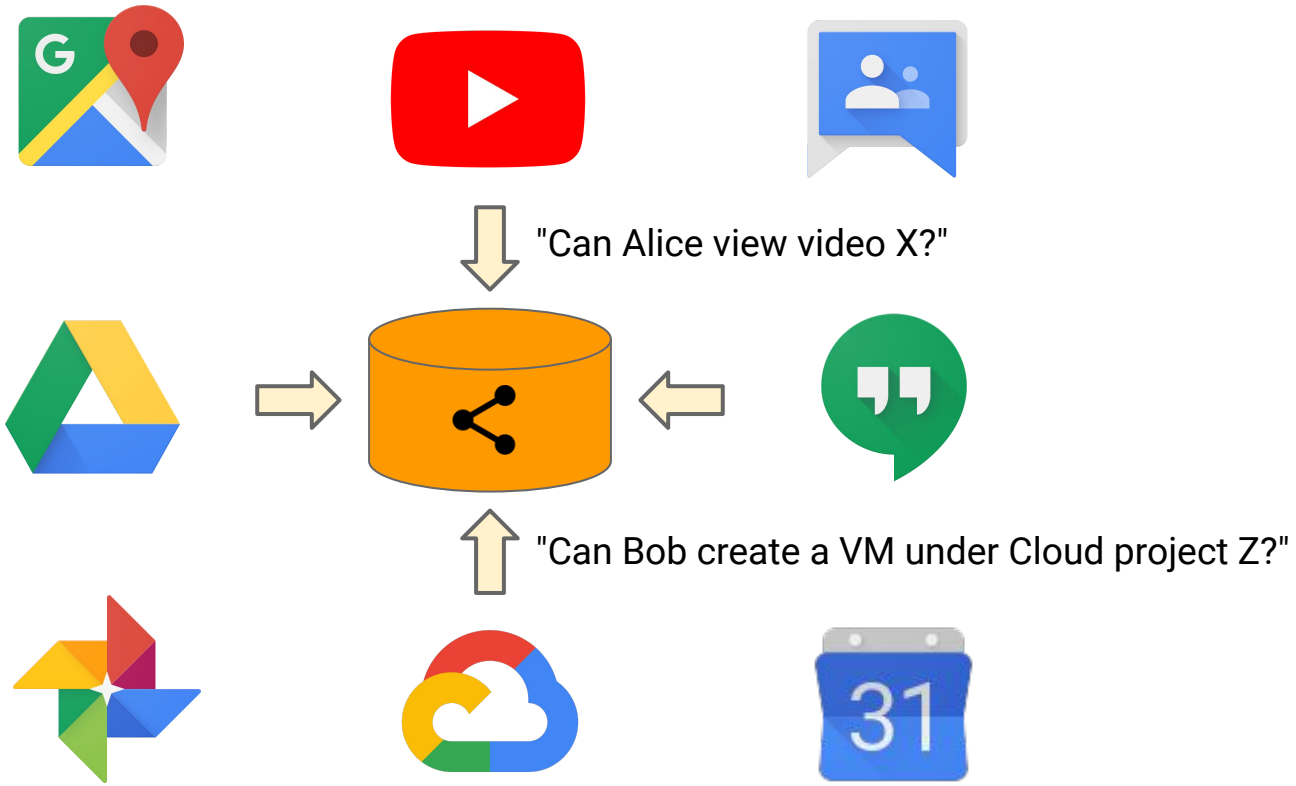
# Authorization checks are central to preserving privacy

# Zanzibar stores access control lists (ACLs)



# ...and performs authorization checks based on stored ACLs



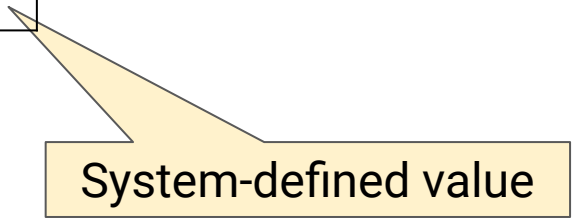
# Zanzibar is...

- **Consistent**: Respects causal ordering of updates to ACLs and objects
- **Flexible**: Supports a rich variety of access control policies
- **Scalable**: Trillions of ACL entries, millions of checks/second
- **Fast**: Less than 10ms @ 95%, less than 100ms @ 99.9%
- **Available**: 99.999% over the past 3 years

# Namespaces, relations, usersets, and tuples

**Namespace:** videos

| **Object** | **Relation** | **Userset** |
|---|---|---|
| video X | viewer | user A |
| video Y | viewer | All Users |



# Namespaces, relations, usersets, and tuples

**Namespace:** videos

| Object | Relation | Userset |
|---|---|---|
| video X | viewer | user A |
| video Y | viewer | All Users |

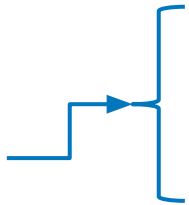
**Check results:**

- video X, viewer, user A? **Yes**
- video X, viewer, user B? **No**
- video Y, viewer, user A? **Yes**
- video Y, viewer, user B? **Yes**

# Userset indirection can create deep/wide hierarchies

**Namespace:** videos

| Object | Relation | Userset |
|---|---|---|
| video X | viewer | user A |
| video X | viewer | (group 1, member) |



**Namespace:** groups

| Object | Relation | Userset |
|---|---|---|
| group 1 | member | user B |
| group 1 | member | user C |

# Userset indirection can create deep/wide hierarchies

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|---|---|---|
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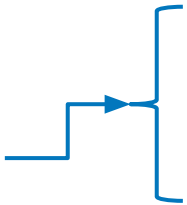


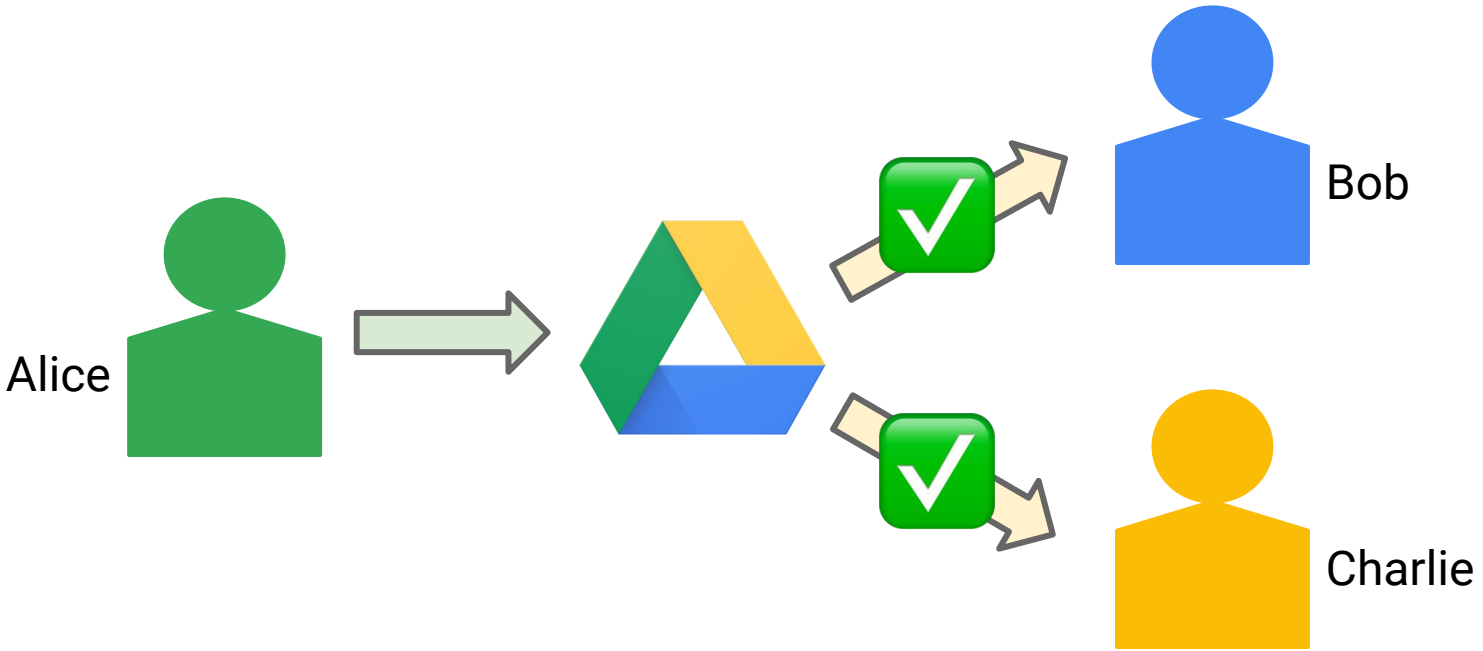
**Namespace:** groups

| Object | Relation | Userset |
|---|---|---|
| group 1 | member | user B |
| group 1 | member | user C |

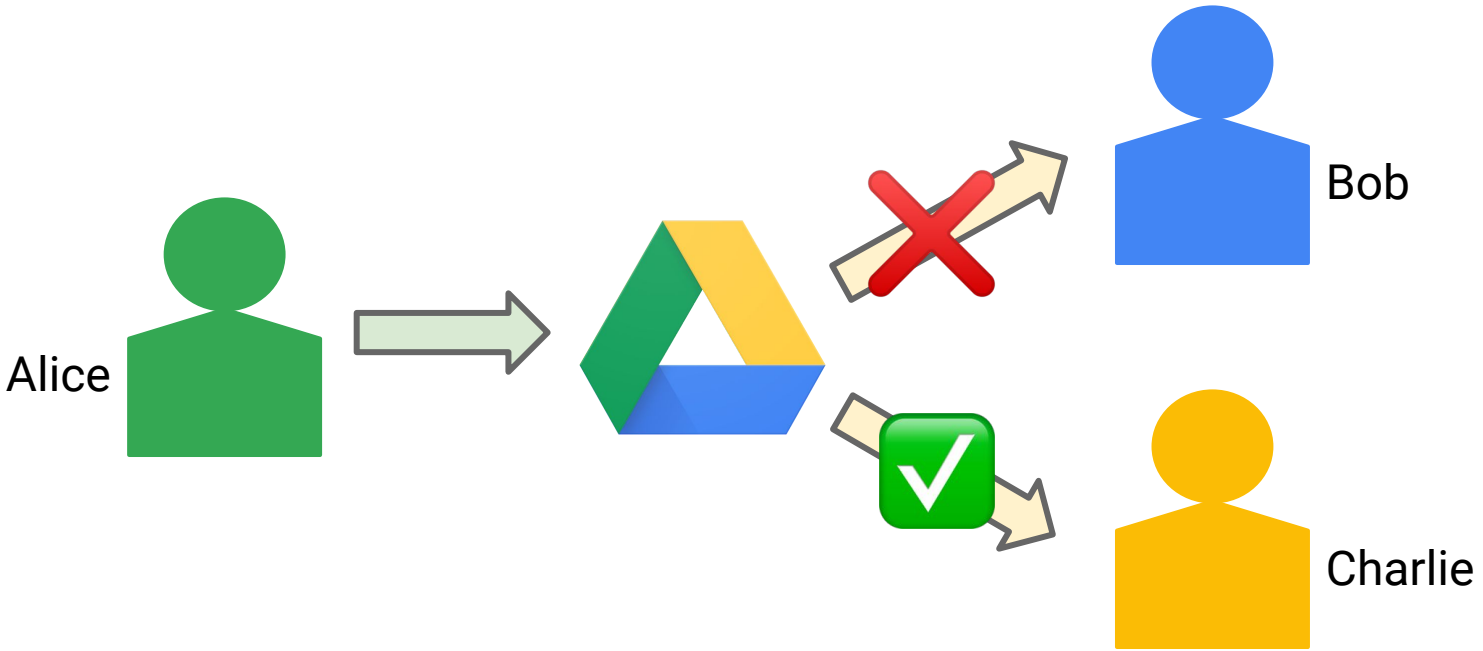
**Check results:**

- video X, viewer, user B? **Yes**
- video X, viewer, user D? **No**

# “New enemy” protection

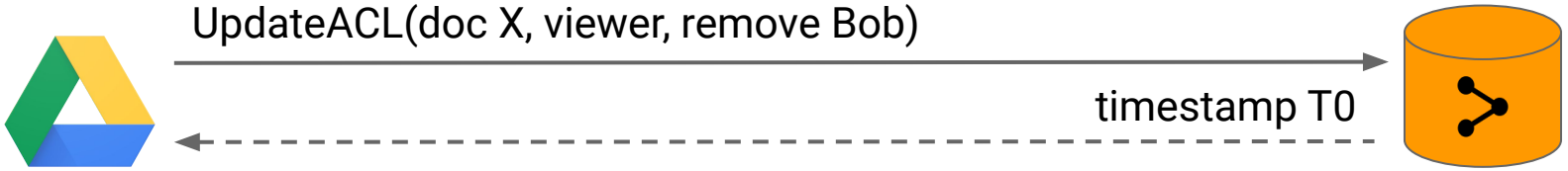


# “New enemy” protection



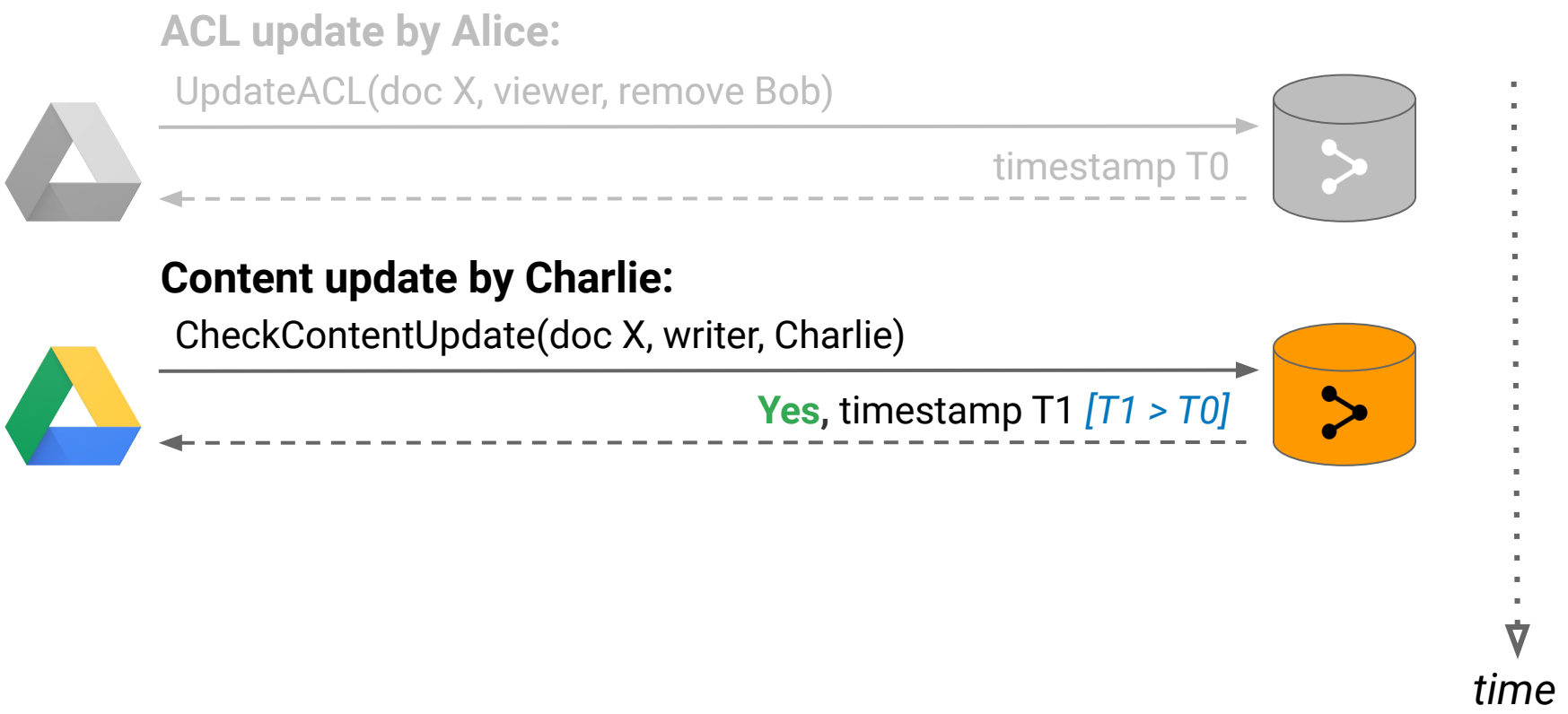
# Consistency protocol

**ACL update by Alice:**

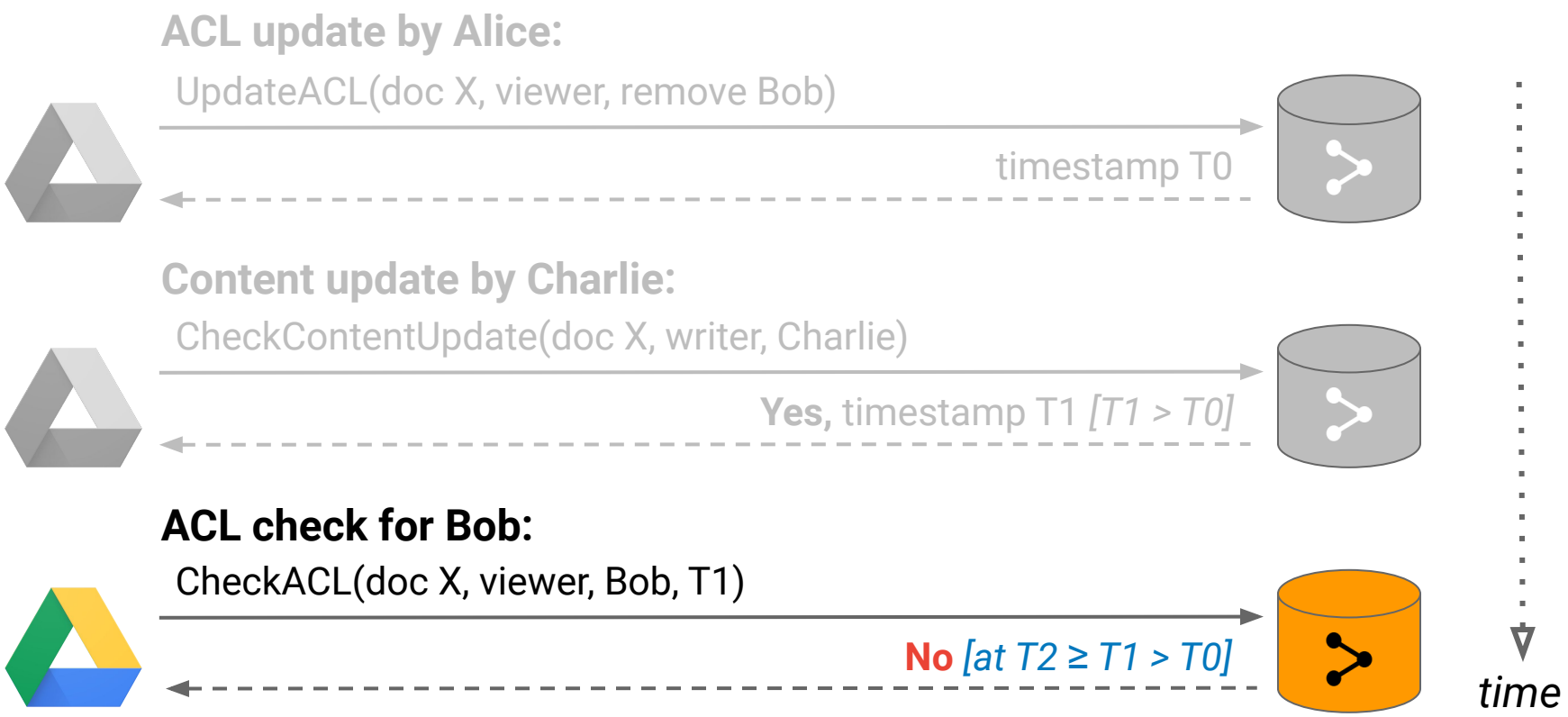



*Leverages Spanner's TrueTime mechanism [Corbett et al. 2012]*

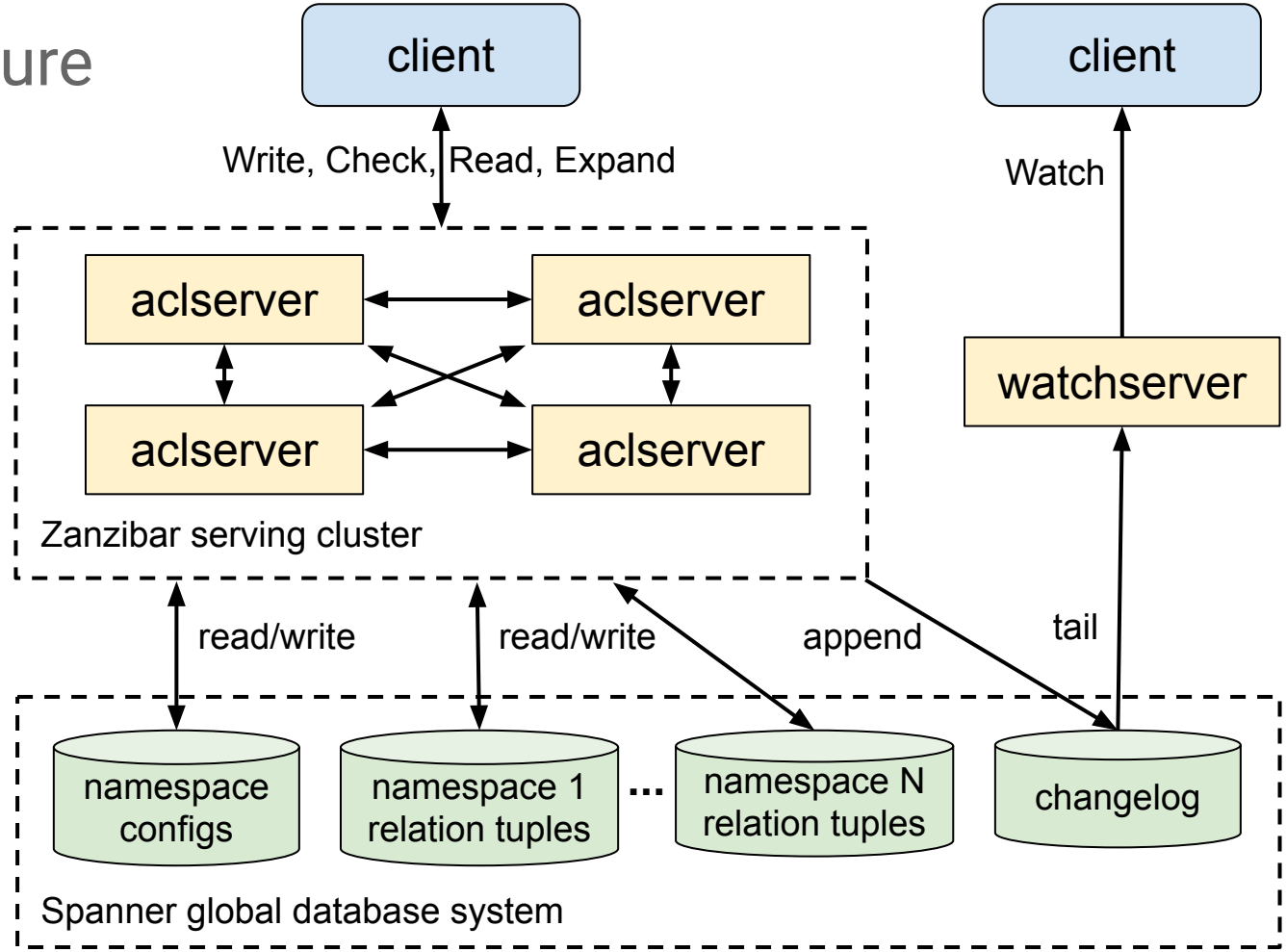
# Consistency protocol



# Consistency protocol



# Architecture



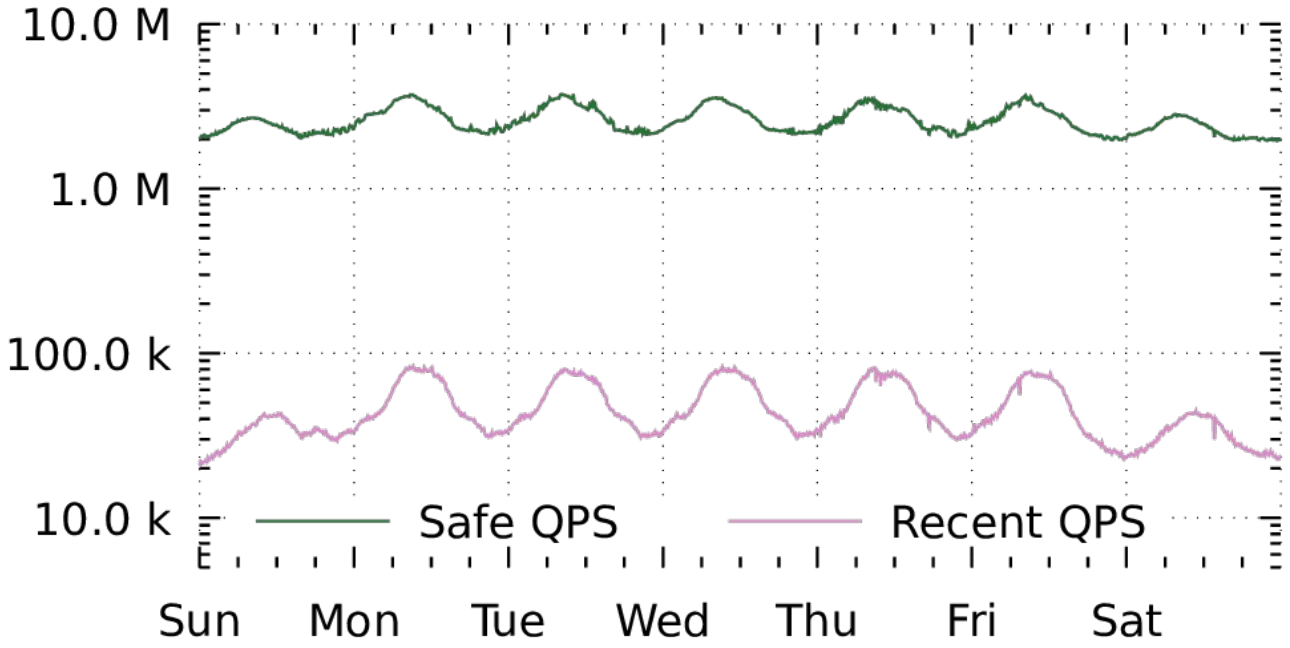
# Implementation techniques

- Timestamps chosen to reduce latency
- Hot-spot mitigation to increase availability
- Request hedging to reduce tail latency
- Isolation to protect against misbehaving clients
- Optimized processing of large and deeply nested sets

# Deployment

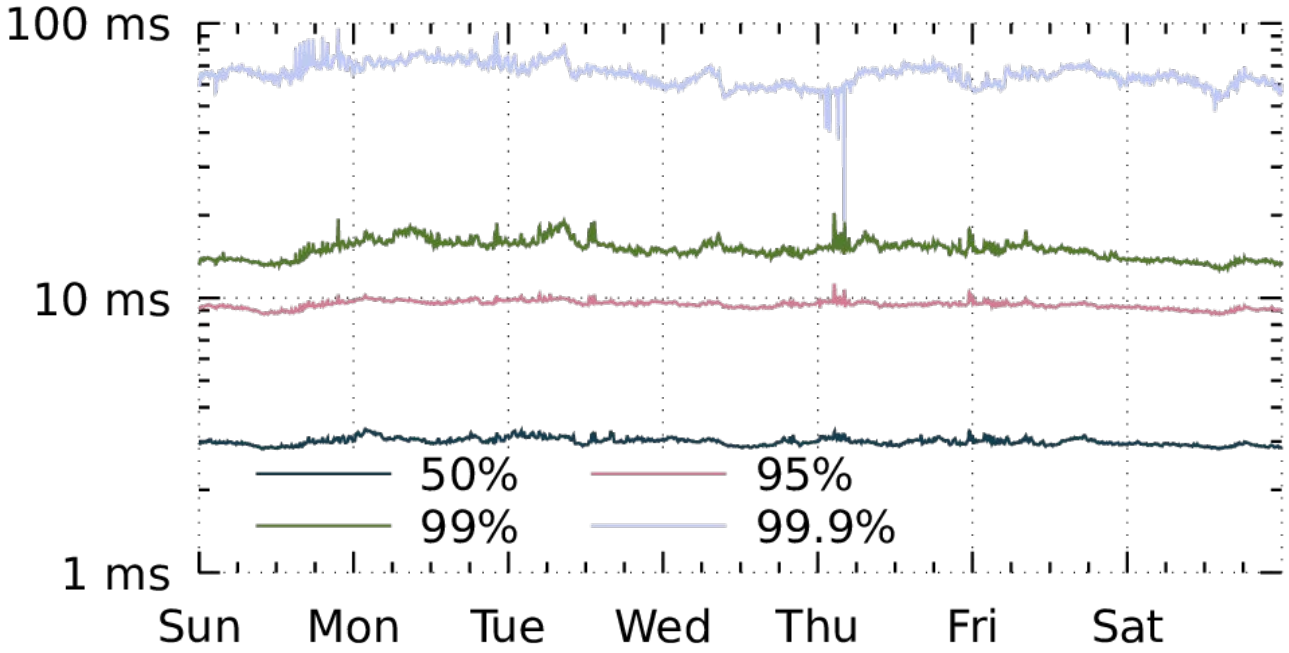
- Zanzibar has been in production use for > 5 years
- > 1,500 namespaces defined by hundreds of clients
- > 2 trillion relation tuples replicated in several dozen locations worldwide
- > 10 million client queries per second, mostly read-only
- > 10,000 servers in several dozen clusters worldwide

# Check queries per second



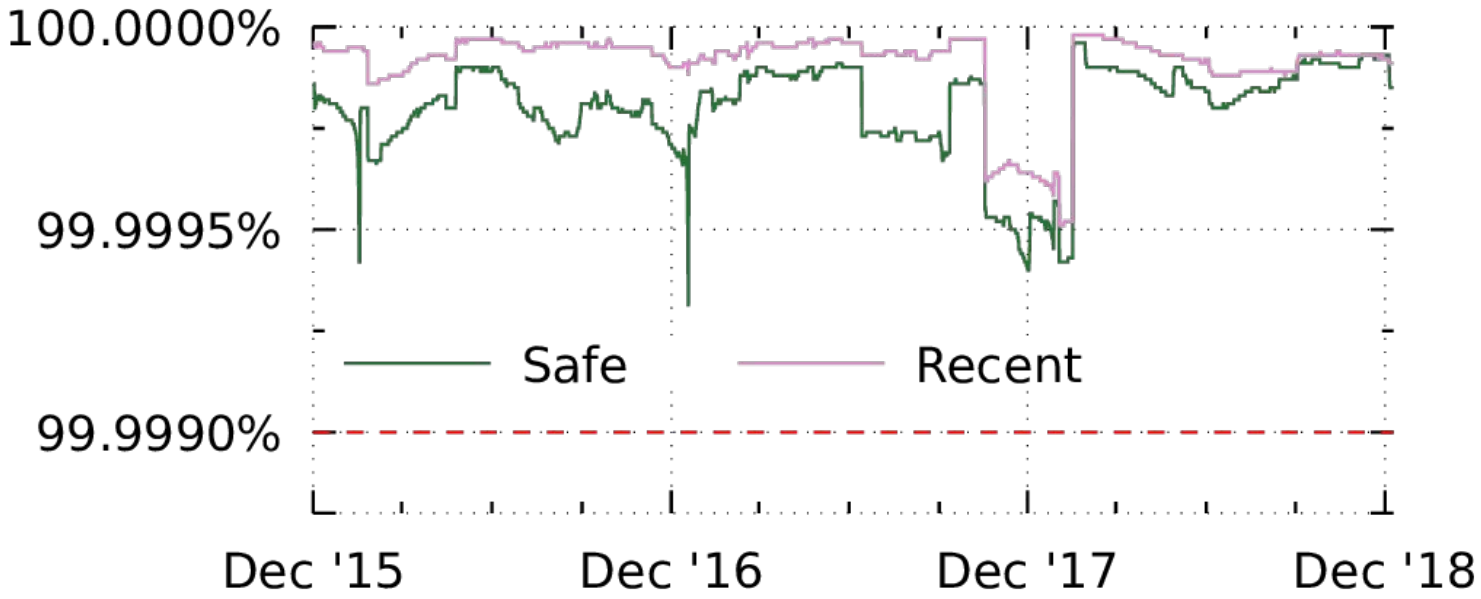

Checks peak at 4.2M QPS, Reads at 8.2M, Expands at 760K, Writes at 25K

# Check Safe latency




95th-percentile latency is below 10 ms, 99.9th-percentile below 100 ms

# Availability




Availability over the last 3 years has remained above 99.999%

# Summary

- Robust authorization checks are central to preserving privacy
- Zanzibar is a unified authorization system for Google services
  - Respects causal ordering of user actions
  - Supports a rich variety of access control policies
  - Offers low latency and high availability
  - Scales to trillions of ACL entries and millions of checks per second
  - Supports hundreds of services used by billions of people

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