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Understanding Eventual Consistency

MSI Presentation SS2014

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Introduction

„...the storage system guarantees that if no new updates are made to the object, eventually all accesses will return the last updated valuee“
–W. Vogels (2009)

Introduction

Interpretations of Eventual Consistency

Interpretation 1:

> *"When you read data[...], the response might not reflect the results of a recently completed write operation. The response might include some stale data. Consistency across all copies of the data is usually reached within a second; so if you repeat your read request after a short time, the response returns the latest data."*

Interpretation 2:

> *"This sort of system we term "single writer eventual consistency". So what are its properties?*
> *(1) A client could read stale data. (2) The client could see out-of-order write operations. [...] So this is our weakest form of consistency - eventually consistent with out of order reads in the short term."*

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Interpretations of Eventual Consistency

DynamoDB Documentation

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MongoDB Documentation

> *"This sort of system we term "single writer eventual consistency". So what are its properties?*
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> *(2)The client could see out-of-order write operations.[...]*
> *So this is our weakest form of consistency - eventually consistent with* **out of order reads** *in the short term."*

The Problem

- Disparate and low-level formalisms
  consistency model is tied to system implementation
- Weak guarantees
  in realistic scenarios updates **never** *stop*
- Conflict resolution policies
  resolution of conflicts in multiple replicas
- Combinations of different consistency levels
  strong consistency may be needed at certain times

⇒ Some sort of formalism is needed to define semantics of Eventual Consistency

Agenda

1. Replicated Data Types

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- Two examples: Int Register **intreg**, Counter **ctr**

$$\mathrm{Op}_{\mathrm{ctr}} = \{\mathrm{rd}, \mathrm{inc}\}$$
$$\mathrm{Op}_{\mathrm{intreg}} = \{\mathrm{rd}, \mathrm{wr}(k) | k \in \mathbb{Z}\}$$

Replicated Data Types

Sequential Data Type Specification

In a *strongly consistent system*, the semantics of a data type can be described by a function

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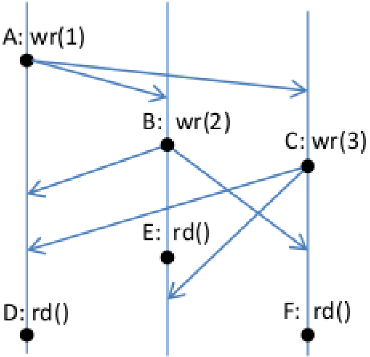
Replicated Data Types

Conflict Resolution Strategies



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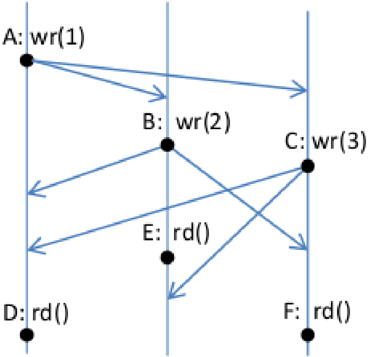

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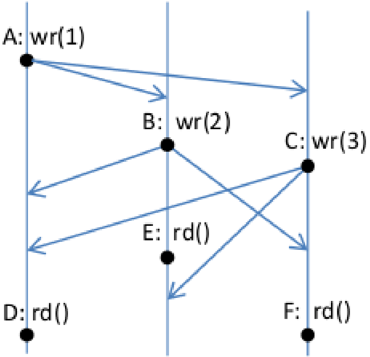

1. Make concurrent operations commutative
2. Order concurrent operations

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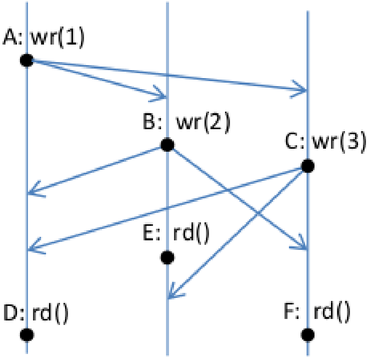

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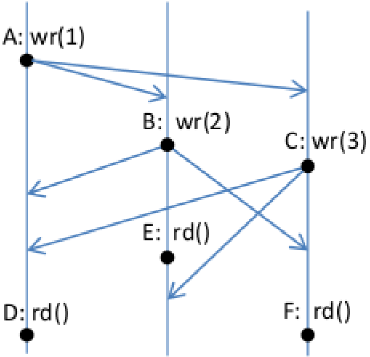

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3. Flag conflicts (let the user decide)
4. Resolve conflicts semantically

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Anfang Hauptteil Patrick

Axiomatic Specification Framework

Levels of Eventual Consistency

- With replicated data types we can define multiple forms of eventual consistency
  - Basic eventual consistency
  - Ordering guarantees
  - on-demand consistency strengthening
- Every form contains multiple axioms

Axiomatic Specification Framework

Client Interaction Model

- Clients often wish to perform multiple operations within some context
- bla

Axiomatic Specification Framework

Basic Eventual Consistency Axioms

- Axioms a database has to fulfill to be eventual consistent
- SOWF, ARWF, VISWF, RVAL, EVENTUAL, THINAIR

Axiomatic Specification Framework

Session guarantees

- Axioms that ensure that databases stay consistent within a single session with a client
- RYW, MR, WYRV, WFRA, MWV, MWA

Axiomatic Specification Framework

Causal Consistency Axioms

- POCV, POCA, COCV, COCA

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Conclusion

- Which problems does the techreport solve?
- What is not solved by it?
- What do **we** think about it?