



hochschule mannheim

# Understanding Eventual Consistency

MSI Presentation SS2014

Horst Schneider, Patrick Beedgen

Hochschule Mannheim

June 17th, 2014

# Introduction

*„A prominent quote“*

# Anfang Hauptteil Horst

# Replicated Data Types

- A replicated database stores **objects**  $\text{Obj} = \{x, y, \dots\}$

## Replicated Data Types

- A replicated database stores **objects**  $\text{Obj} = \{x, y, \dots\}$
- Every object  $x \in \text{Obj}$  has
  - a **value**  $\in \text{Val}$

# Replicated Data Types

- A replicated database stores **objects**  $\text{Obj} = \{x, y, \dots\}$
- Every object  $x \in \text{Obj}$  has
  - a **value**  $\in \text{Val}$
  - a **type**  $\text{type}(x)$

# Replicated Data Types

- A replicated database stores **objects**  $\text{Obj} = \{x, y, \dots\}$
- Every object  $x \in \text{Obj}$  has
  - a **value**  $\in \text{Val}$
  - a **type**  $\text{type}(x)$
  - **operations**  $\text{Op}_{\text{type}(x)}$  that a client can perform on it

## Replicated Data Types

- A replicated database stores **objects**  $\text{Obj} = \{x, y, \dots\}$
- Every object  $x \in \text{Obj}$  has
  - a **value**  $\in \text{Val}$
  - a **type**  $\text{type}(x)$
  - **operations**  $\text{Op}_{\text{type}(x)}$  that a client can perform on it
- Two examples: Int Register **intreg**, Counter **ctr**

$$\text{Op}_{\text{ctr}} = \{\text{rd}, \text{inc}\}$$

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



# Replicated Data Types

## Sequential Data Type Specification

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

$$S_{\tau} : \text{Op}_{\tau}^{+} \rightarrow \text{Val}$$

# Replicated Data Types

## Sequential Data Type Specification

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

$$S_{\tau} : \text{Op}_{\tau}^{+} \rightarrow \text{Val}$$

Examples:

$$S_{\text{ctr}}(\sigma_{\text{rd}}) = (\text{number of inc operations in } \sigma);$$

# Replicated Data Types

## Sequential Data Type Specification

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

$$S_{\tau} : \text{Op}_{\tau}^{+} \rightarrow \text{Val}$$

Examples:

$$\begin{aligned} S_{\text{ctr}}(\sigma_{\text{rd}}) &= (\text{number of inc operations in } \sigma); \\ S_{\text{intreg}}(\sigma_{\text{rd}}) &= k; \text{ if } \text{wr}(0)\sigma = \sigma_1 \text{wr}(k)\sigma_2 \text{ and} \\ &\quad \sigma_2 \text{ does not contain wr operations} \end{aligned}$$

# Replicated Data Types

## Sequential Data Type Specification

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

$$S_{\tau} : \text{Op}_{\tau}^{+} \rightarrow \text{Val}$$

Examples:

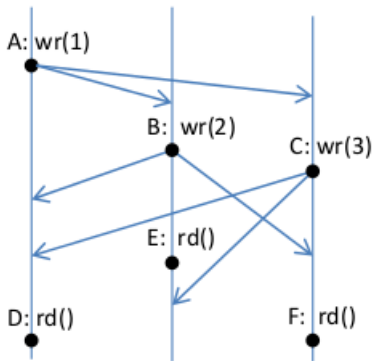
$$S_{\text{ctr}}(\sigma \text{rd}) = (\text{number of inc operations in } \sigma);$$

$$S_{\text{intreg}}(\sigma \text{rd}) = k; \text{ if } \text{wr}(0)\sigma = \sigma_1 \text{wr}(k)\sigma_2 \text{ and} \\ \sigma_2 \text{ does not contain wr operations}$$

$$S_{\text{intreg}}(\sigma \text{wr}(k)) = S_{\text{ctr}}(\sigma \text{inc}) = \perp;$$

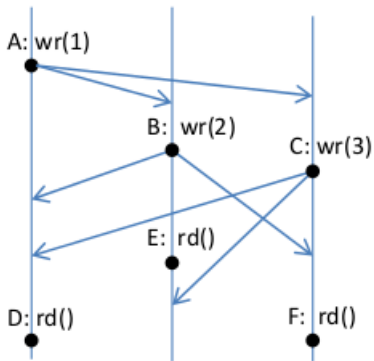
# Replicated Data Types

## Conflict Resolution Strategies



# Replicated Data Types

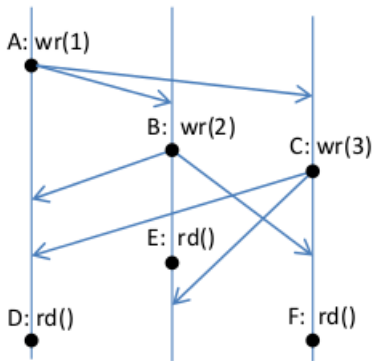
## Conflict Resolution Strategies



- ① Make concurrent operations commutative

# Replicated Data Types

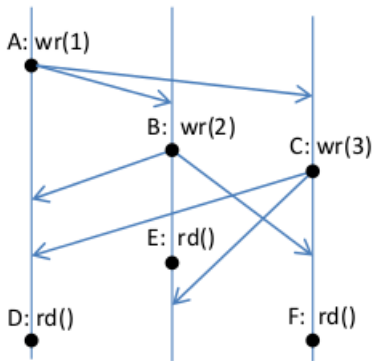
## Conflict Resolution Strategies



- ① Make concurrent operations commutative
- ② Order concurrent operations

# Replicated Data Types

## Conflict Resolution Strategies

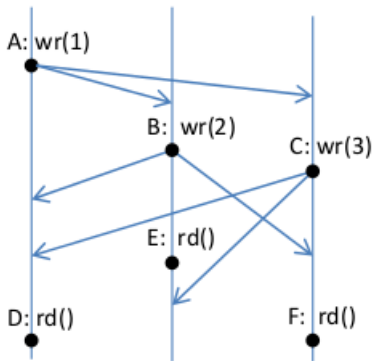


- ① Make concurrent operations commutative
- ② Order concurrent operations
- ③ Flag conflicts (let the user decide)



# Replicated Data Types

## Conflict Resolution Strategies



- ① Make concurrent operations commutative
- ② Order concurrent operations
- ③ Flag conflicts (let the user decide)
- ④ Resolve conflicts semantically

# Replicated Data Types

## Replicated Data Type Specification

- $S_\tau$  is not strong enough to formalize these strategies

# Replicated Data Types

## Replicated Data Type Specification

- $S_\tau$  is not strong enough to formalize these strategies
- visibility and order of preceding operations have to be included

# Replicated Data Types

## Replicated Data Type Specification

- $S_\tau$  is not strong enough to formalize these strategies
- visibility and order of preceding operations have to be included
- $F_\tau$ : takes an **operation context** and returns a **value**

$$F_\tau(C) \in \text{Val}$$

# Replicated Data Types

## Replicated Data Type Specification

- $S_\tau$  is not strong enough to formalize these strategies
- visibility and order of preceding operations have to be included
- $F_\tau$ : takes an **operation context** and returns a **value**

$$F_\tau(C) \in \text{Val}$$

- operation context  $C$  adds **visibility** and **arbitration relations** to preceding operations:

$$C = (f, V, \text{ar}, \text{vis})$$

# Replicated Data Types

## Replicated Data Type Specification

- $S_\tau$  is not strong enough to formalize these strategies
- visibility and order of preceding operations have to be included
- $F_\tau$ : takes an **operation context** and returns a **value**

$$F_\tau(C) \in \text{Val}$$

- operation context  $C$  adds **visibility** and **arbitration relations** to preceding operations:

$$C = (f, V, \text{ar}, \text{vis})$$
$$u \xrightarrow{\text{vis}} v, \text{vis} \subseteq V \times V$$

# Replicated Data Types

## Replicated Data Type Specification

- $S_\tau$  is not strong enough to formalize these strategies
- visibility and order of preceding operations have to be included
- $F_\tau$ : takes an **operation context** and returns a **value**

$$F_\tau(C) \in \text{Val}$$

- operation context  $C$  adds **visibility** and **arbitration relations** to preceding operations:

$$\begin{aligned} C &= (f, V, \text{ar}, \text{vis}) \\ u &\xrightarrow{\text{vis}} v, \text{vis} \subseteq V \times V \\ u &\xrightarrow{\text{ar}} v, \text{ar} \subseteq V \times V \end{aligned}$$





# Ende Hauptteil Horst

# Anfang Hauptteil Patrick

# Ende Hauptteil Patrick

# Conclusion

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