CRDTs in Production

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Objective

- Understand tradeoffs developers must consider when interfacing with an AP database (Riak specifically this talk)

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- Learn the knobs and levers at our disposal to manage consistency

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Why leave in the first place?

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Desire: Cure the ACID hangover

Low conflict intensity

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- Majority of writes come from a single writer
- Writes occur sparingly

CRDT Preliminaries

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It depends!

- Convergent - state based RDTs
- Commutative - op based RDTs

CvRDTs

Definition

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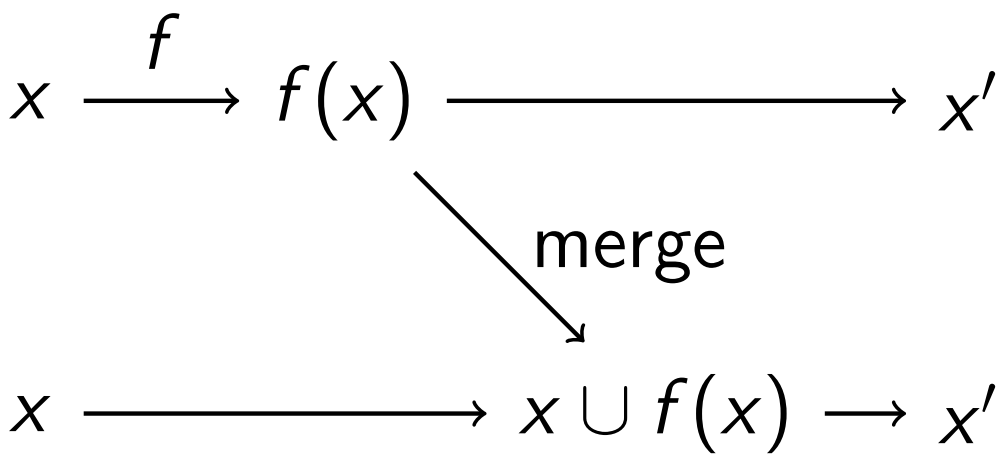

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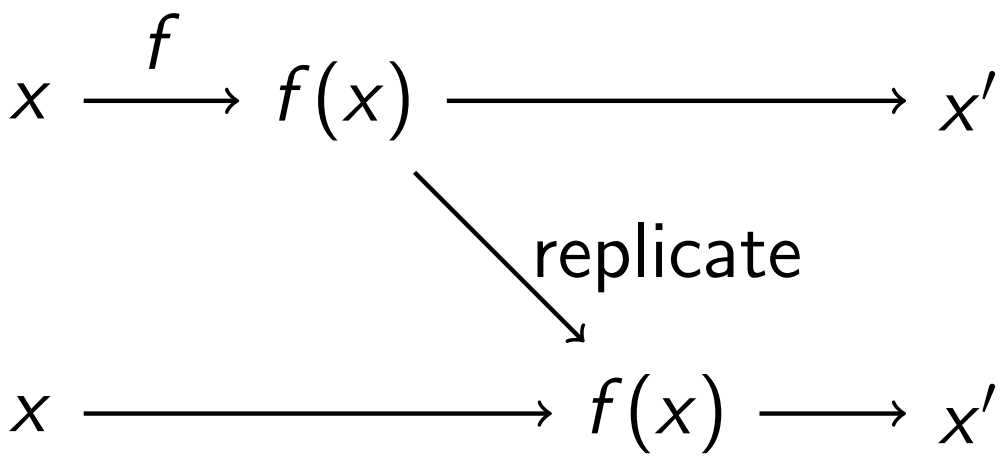

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3. Convergence:

$$C(x_i) = C(x_j) \Rightarrow x_i \equiv x_j$$

Application side CvRDT case study

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Data denormalization! Your database can't be expected to understand your schema.
Replica copies don't just exist in the database (think caching for example).

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Merges vs Commutative ops (why not a CmRDT)

- Maintainability - Avoid the merge function of doom (unless your data is canonical and merge-oriented)
- Tight coupling of operation with resolution behavior
- Resilience against schema changes

Shopping Cart Implementation

The schema is of the form (d, f), a tuple combining shopping cart data (d) and the optional last operation used (initially $\varnothing$).

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`apply(d, f)` - Given data and an operation, returns the tuple $(f(d), f)$. Then write to the database.

Shopping Cart Impl. 2

Definition

`resolve`$(\{s_1, s_2, \ldots, s_n\})$ - Given a list of siblings, returns the tuple $(f_2 \circ f_3 \circ \cdots \circ f_n(d_1), \varnothing)$. Then issues a write to the database.

Example: AddToCart

```
void AddToCart(Cart &cart,
               const Item &item,
               const unsigned int quantity) {
    if (cart.HasItem(item)) {
        cart.Get(item) += quantity;
    } else {
        cart.AddItem(item, quantity);
    }
}
```

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    } else {
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```
void RemoveFromCart(Cart &cart,
                    const Item &item) {
    if (cart.HasItem(item)) {
        ... item removal code
    } else {
        // What should I do here?

        // nothing
    }
}
```

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LWW would handle the case of duplicate removals of the same object, but doesn't handle conflicts of heterogeneous operations.

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We are essentially using *deferred transactions*. Consider the behavior of the shopping cart if we did not use this interface.

Relaxed CRDT constraints

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2. Eventual Effect (relaxed): For every operation on some x_i, an attempt to perform that operation is eventually performed on all later replica copies.
3. Convergence (relaxed): Replicas converge in the absence of write conflict but the worst case effects of a conflict are loss of operation.

Differences from a standard transaction

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- Passive vs active merge resolution

Improving our database interface

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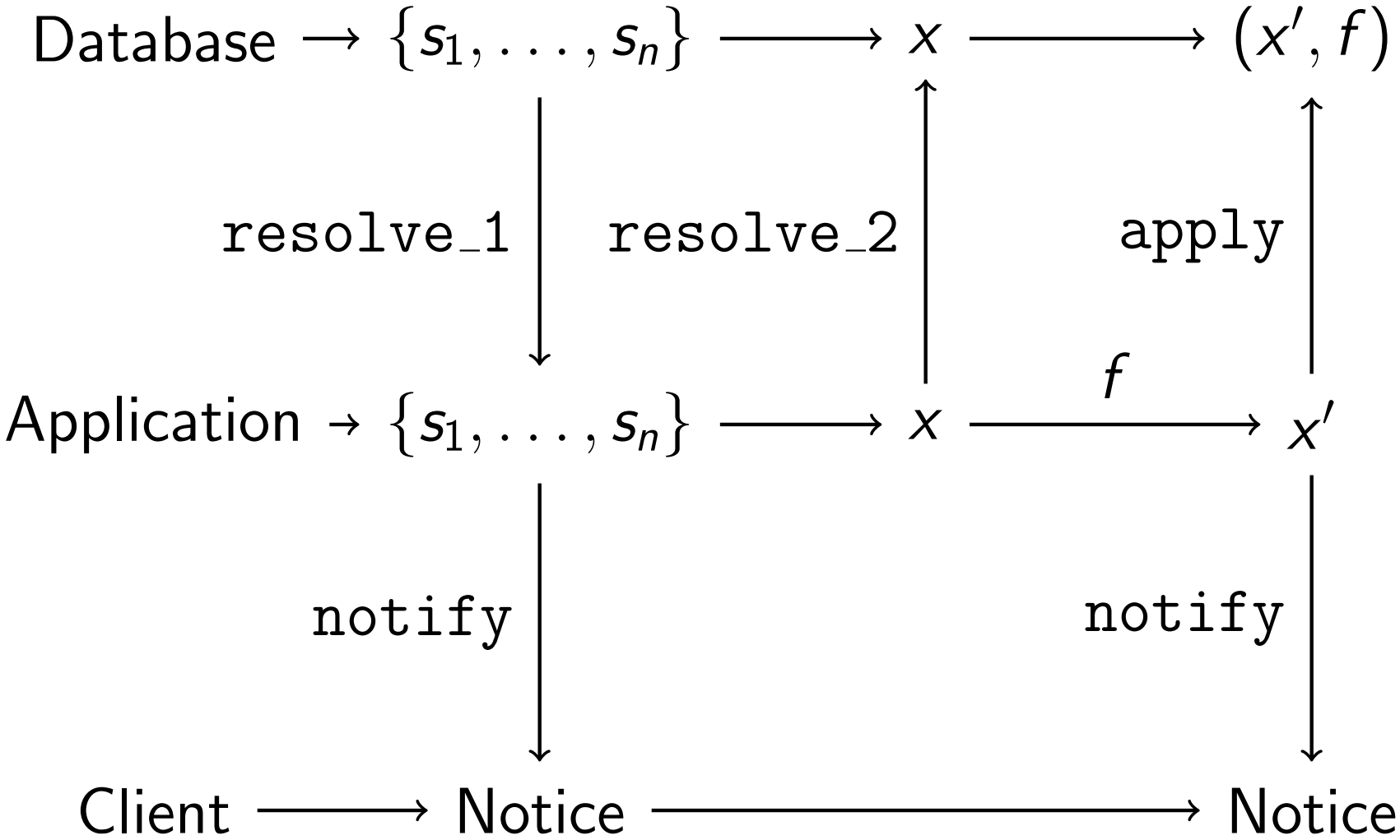
- Handling multiple key updates... ignore for now

Interface Flow



Read/Write Quorums

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1. `resolve_1`: initial read which may return multiple siblings
2. `resolve_2`: write for resolving conflicts
3. `apply`: write to record a new operation

`resolve_1` and `apply`

`resolve_1` is application dependent

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Use of a high R value will:

- (-) reduce availability

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`apply` is the opposite of `resolve_1` and has similar characteristics

`resolve_2`

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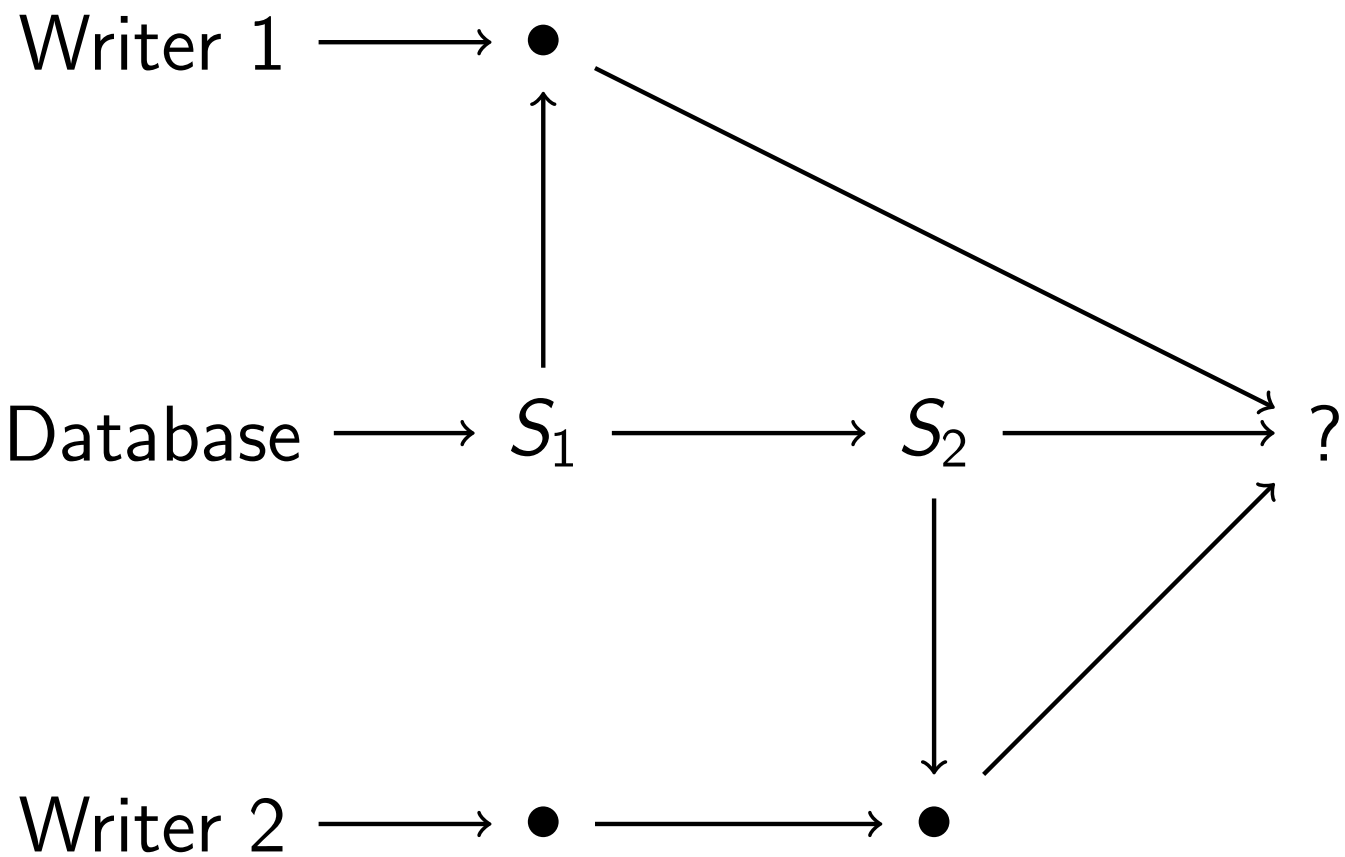
W should be at least $\lceil Q/2 \rceil$ to prevent conflicts during a netsplit

Handling a `resolve_2` conflict



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The tradeoff, as always, is availability over consistency.

What about when...

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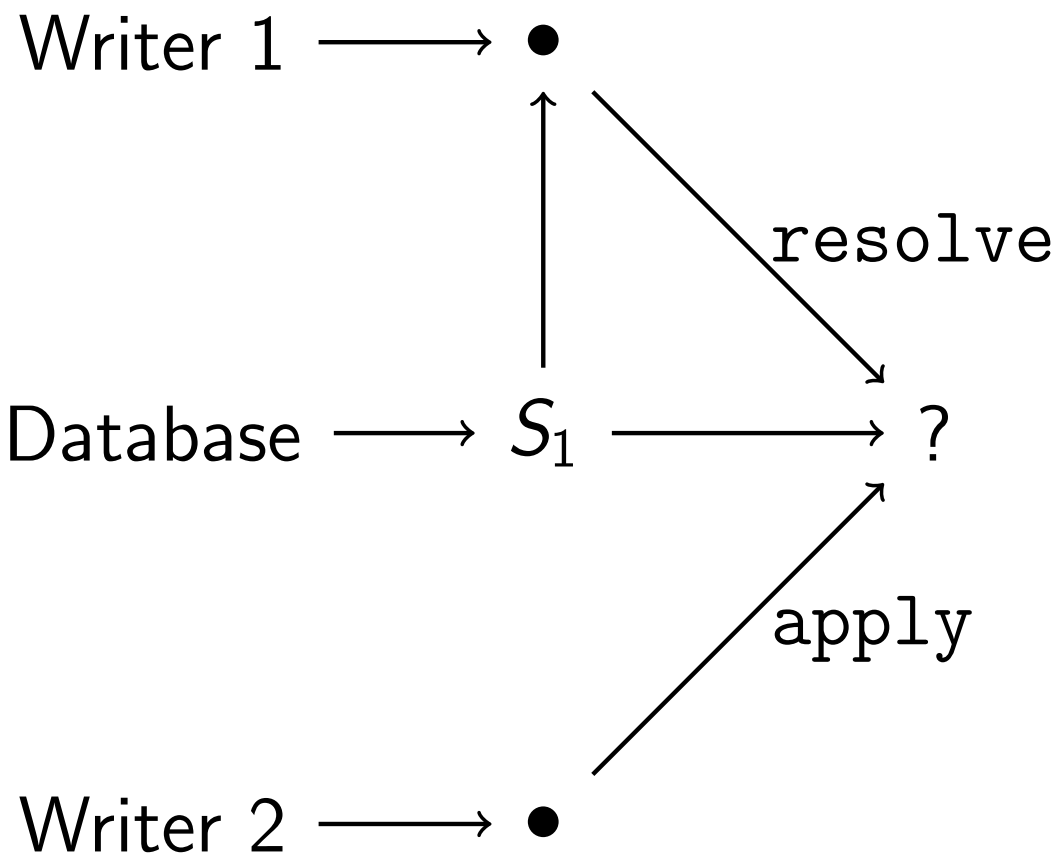
Assuming all writers are well-behaved and read first with the `resolve` interface, it's safe to ignore the result of the flatten operation.

Another kind of conflict



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Important takeaways:

- Make sure you can handle all cases, or some sets of siblings will be stuck (your `resolve` function should not have an exit path that doesn't result in a valid write).
- The best strategy isn't always the most complicated. With low conflict intensity, the majority of cases will be simple

Writer hierarchy

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e.g. In an implementation of an email browser client, we may want to prioritize one tab over another.

Note about multi-key transactions

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If you absolutely must impose a strict transactional relationship between two keys, there is a scheme to ensure that if an op on one key of the transaction fails, the op should fail on the other side (through the usage of inverse operators). Outside the scope.

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Conclusion

- If you can reduce conflict intensity in other areas of the system, do it.
- This approach will not provide guaranteed consistency like a canonical CRDT, but is better than LWW.
- Consistency is a spectrum and the developer can lean in either direction. You must choose!