YATA: COLLABORATIVE DOCS AND HOW TO MAKE THEM FAST

INTRODUCTION

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AGENDA

- When do we need CRDTs
- YATA: conflict resolution for arrays and maps
- Update merge & split
- Optimizations

YJS.DEV

PROBLEM STATEMENT

COLLABORATIVE TEXT EDITOR

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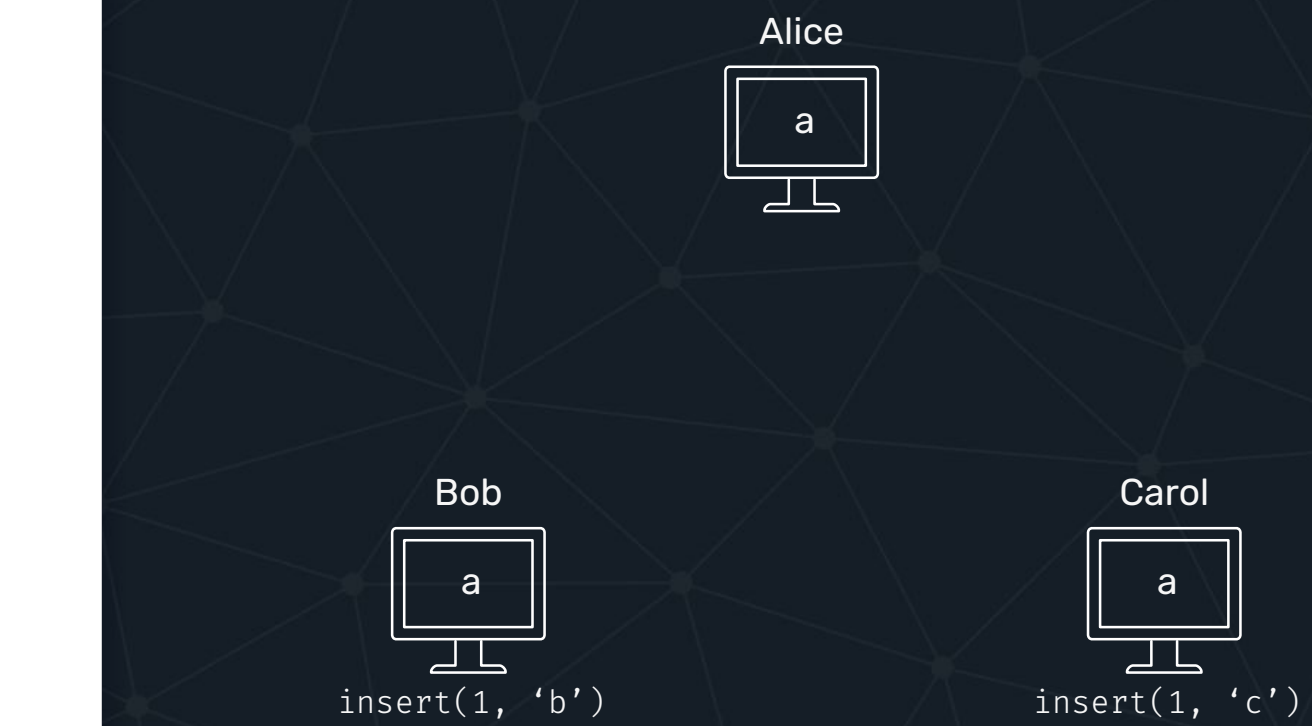

COLLABORATIVE TEXT EDITOR

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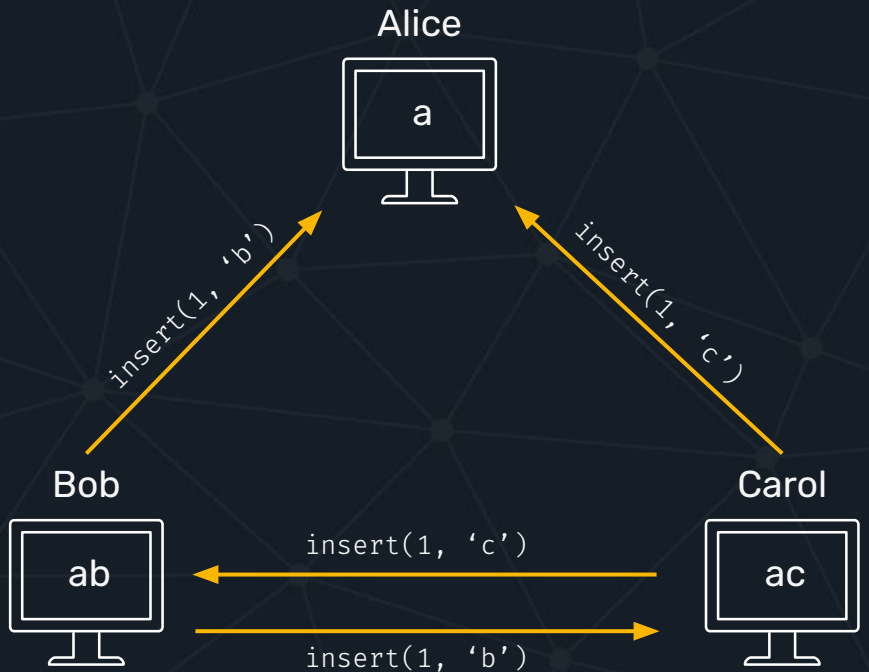

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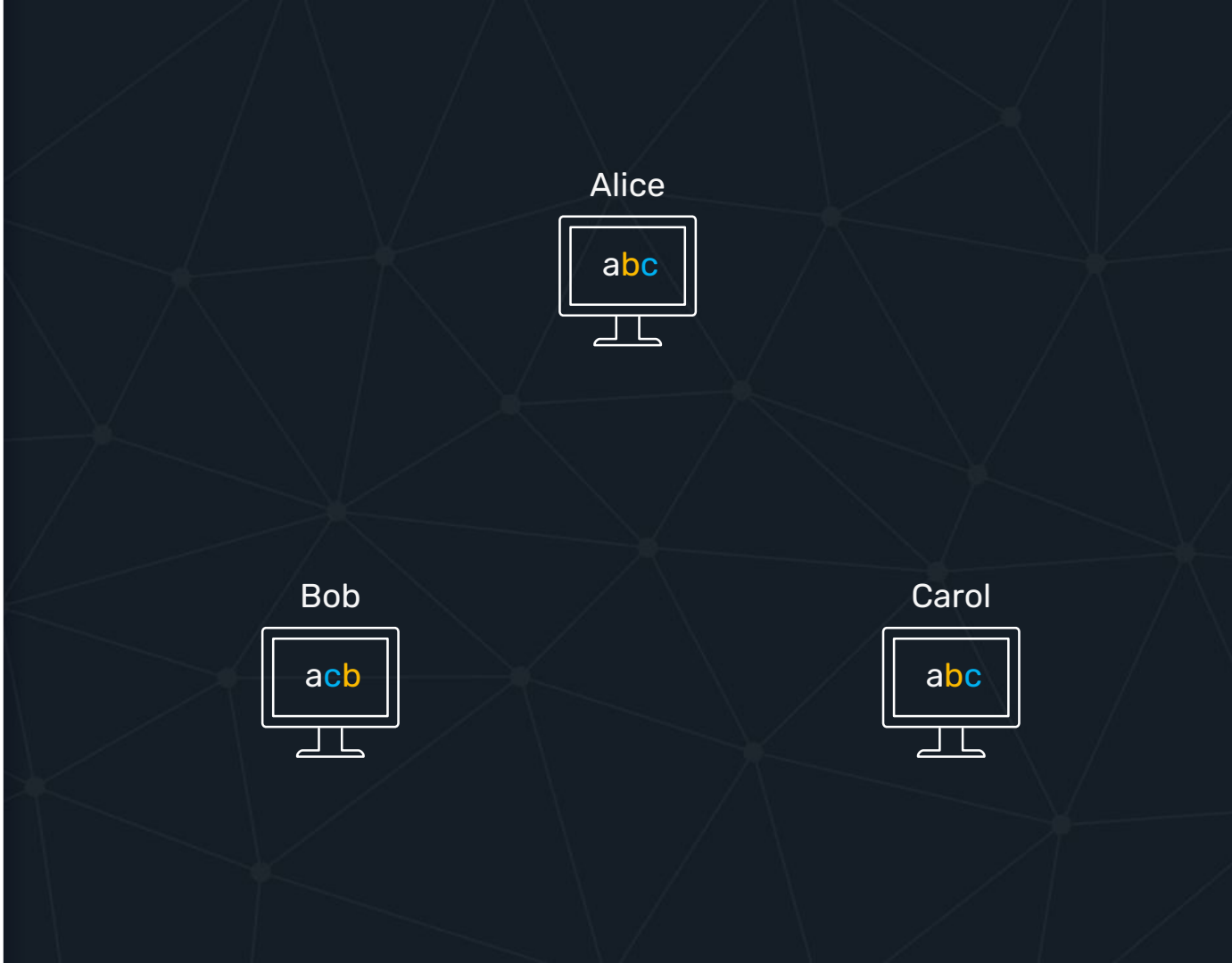
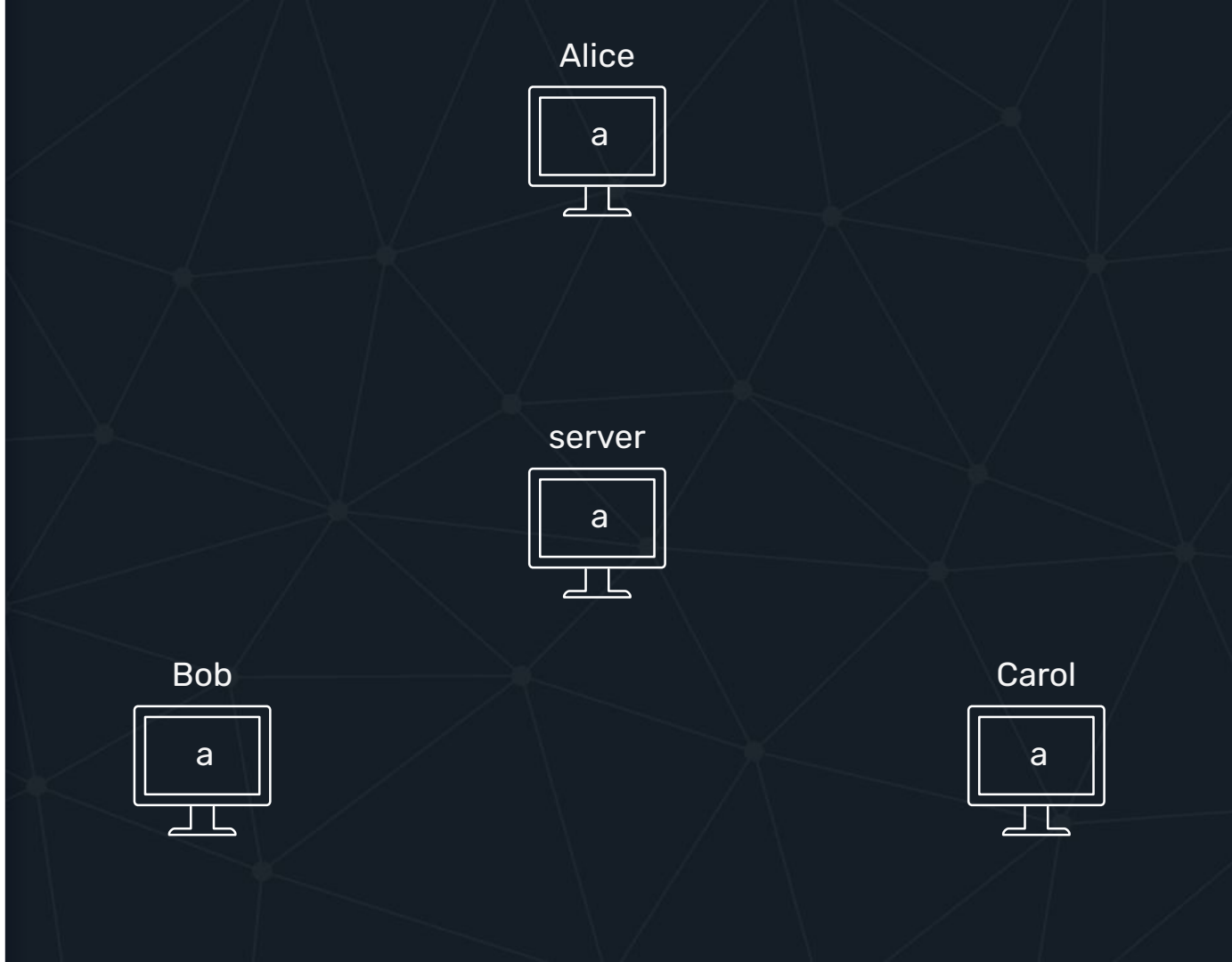


MAYBE JUST SYNCHRONIZE VIA CENTRAL SERVER?

SERVER-DRIVEN TEXT EDITOR



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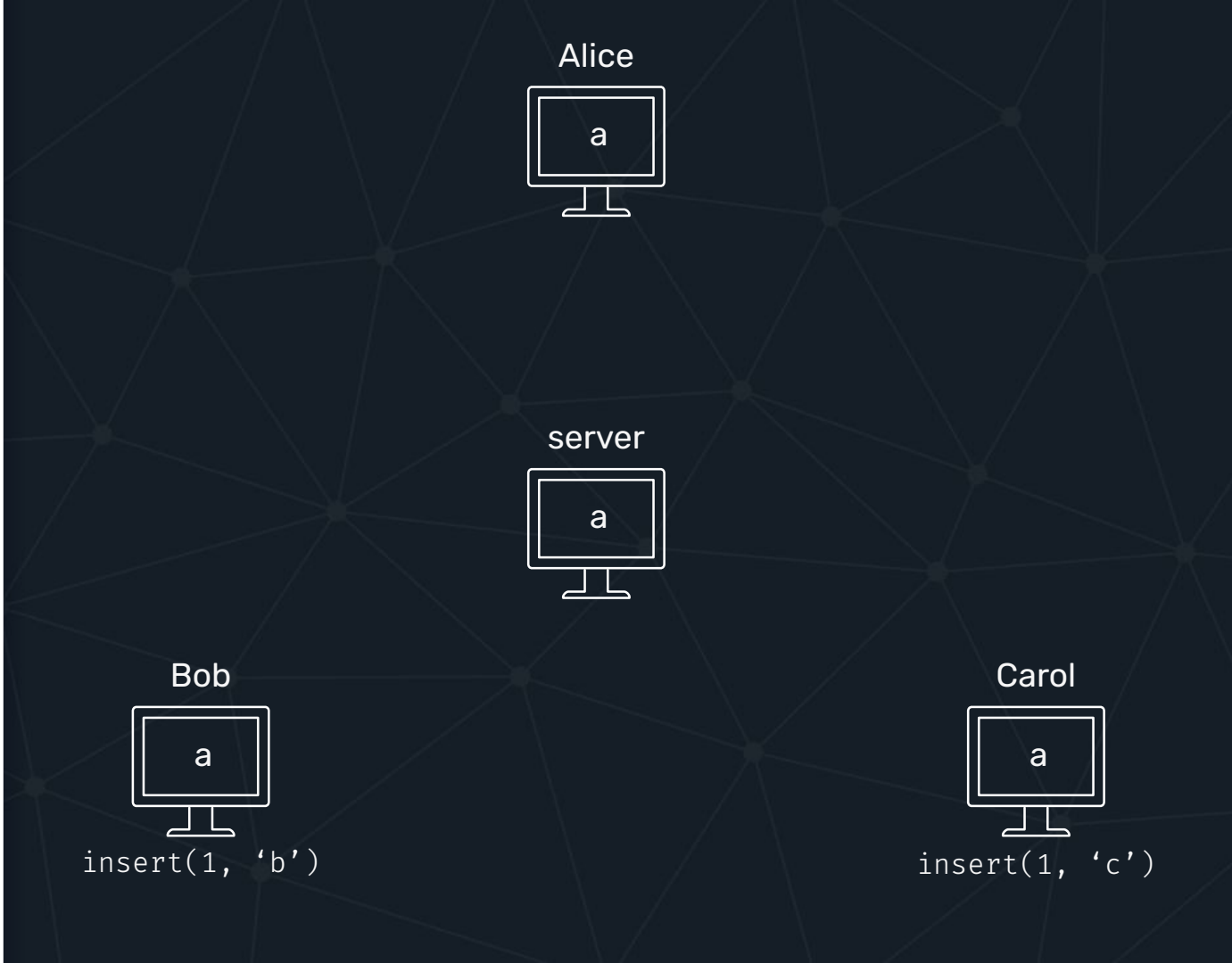

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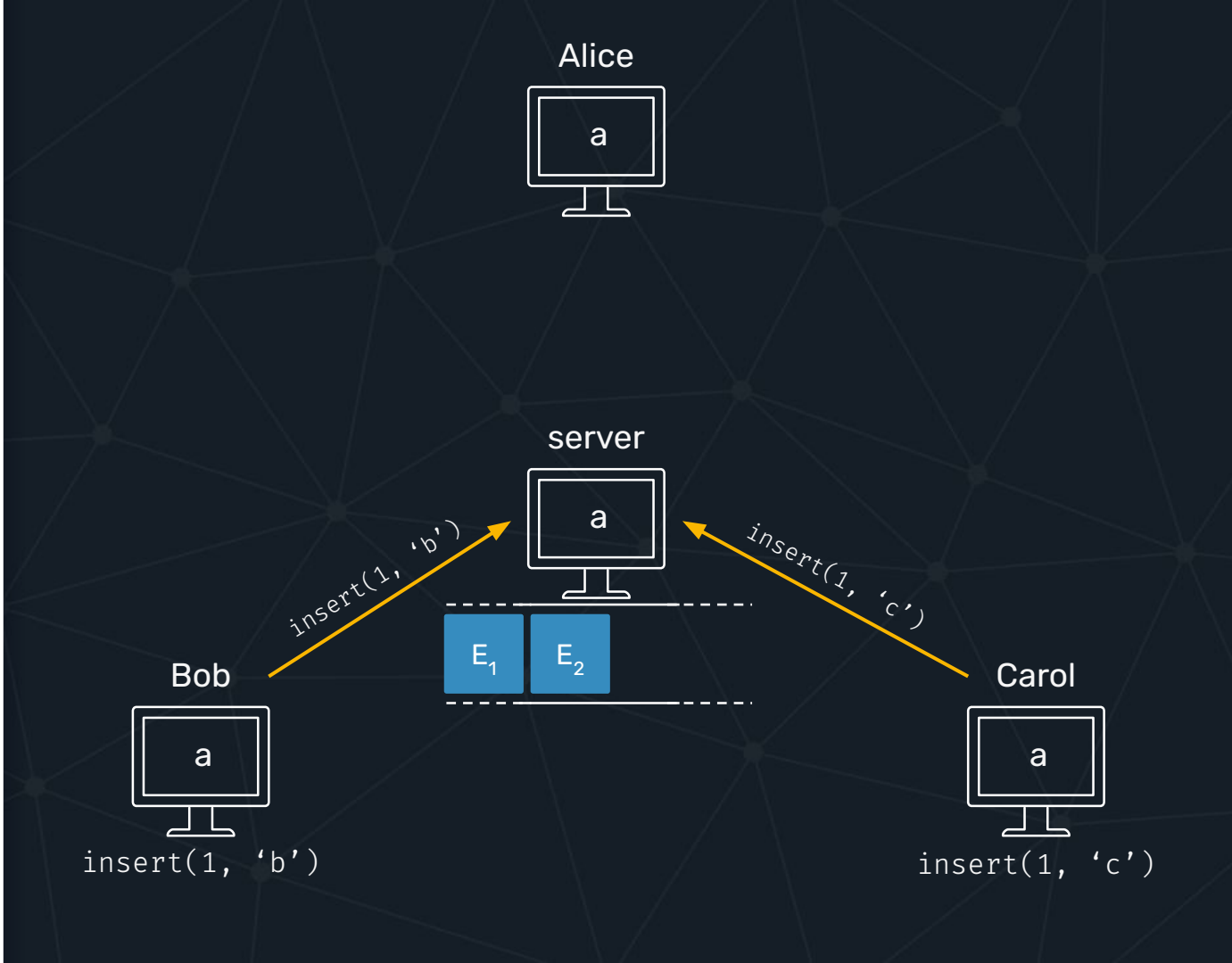

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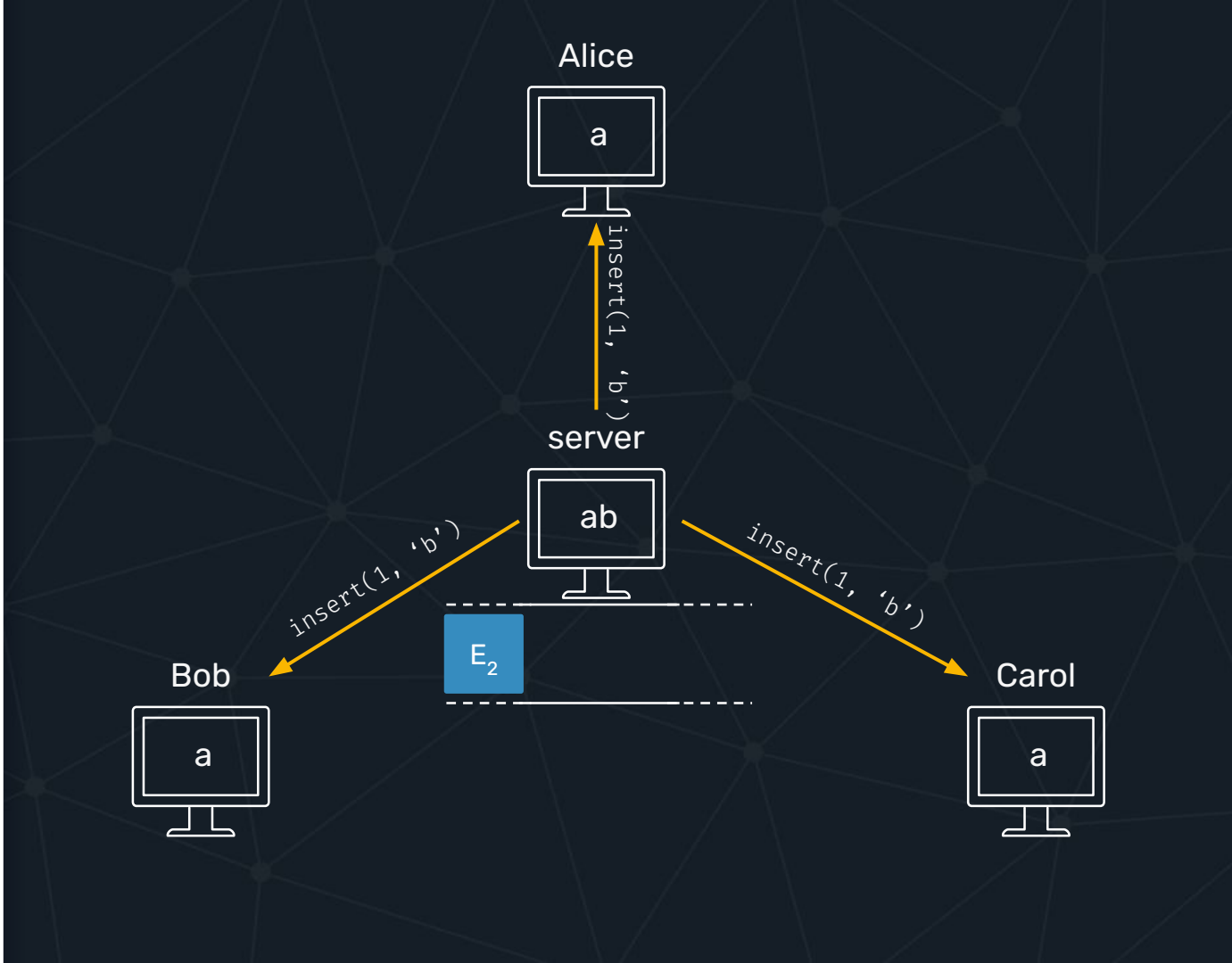

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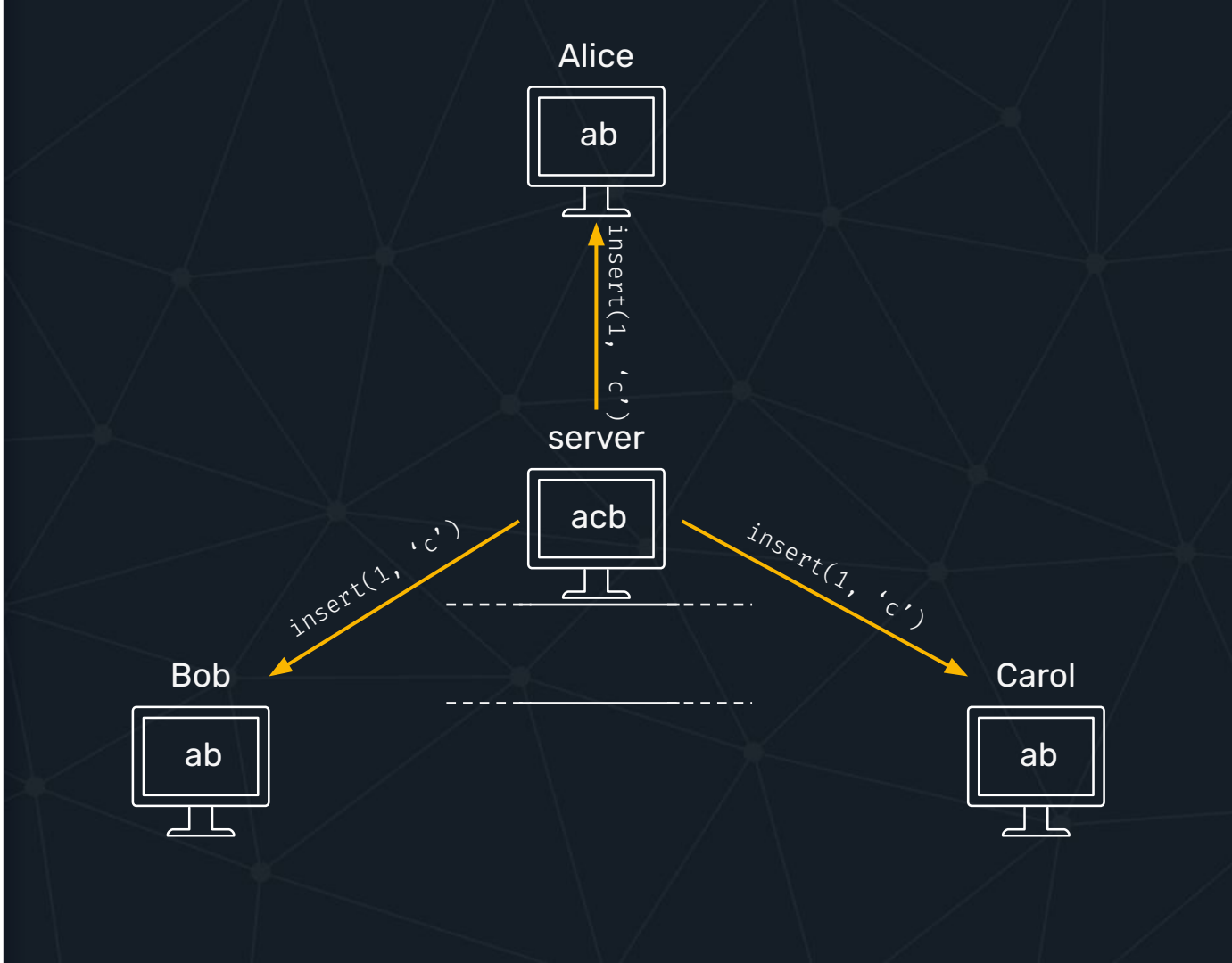

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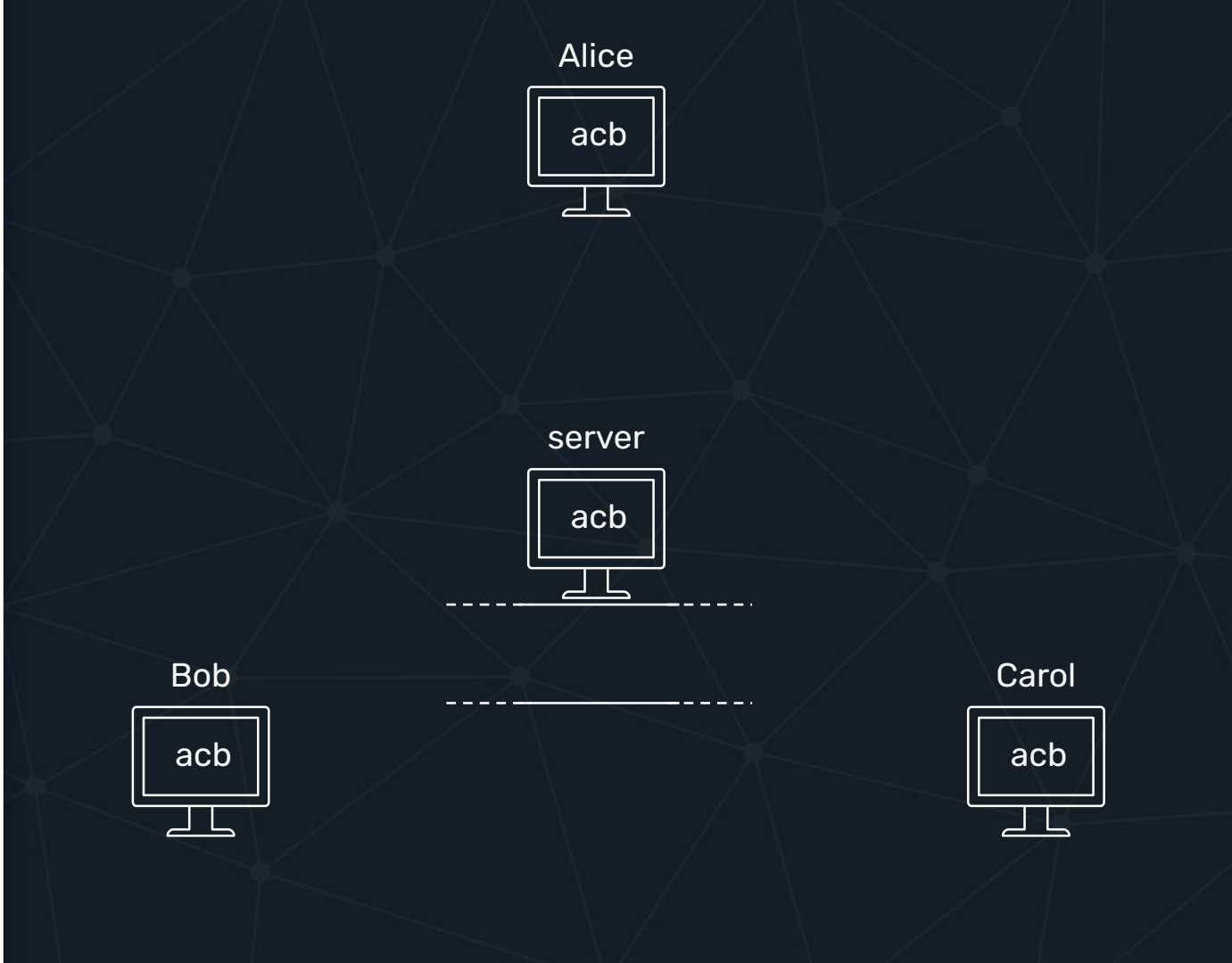

ISSUES

1. Latency
2. Online-only / Network issues
3. Characters interleaving
4. Server: bottleneck & point of failure

FIELDS SHARING SIMILAR PROBLEMS

1. *Collaborative text editors*
2. *Cross-continental data replication*
3. *Vehicle apps*
4. *Remote areas*
5. *One-account/multi-device sync*

CONFLICT AVOIDANCE

Decisions are made by quorum

“Let the majority decide on the correct order.”

CONFLICT AVOIDANCE

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“Let the majority decide on the correct order.”

CONFLICT RESOLUTION

Decisions are made individually

“Given enough context everyone should come to the same conclusion.”

CONFLICT RESOLUTION

IT’S ALL ABOUT PRESERVING THE ORIGINAL INTENT

SEMANTICS MATTER

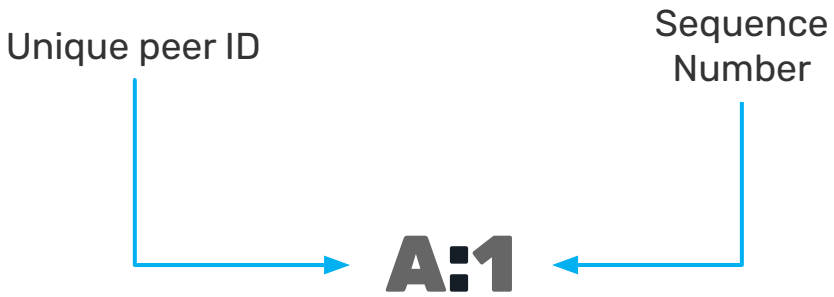
1. Insert characters one after another
2. Fixing a typo
3. Move an element
4. Move a range of elements

1. Insert characters at positions X, X+1, X+2, etc.
2. Insert/remove character at position X
3. Remove an element then re-insert it
4. Delete then re-insert range of elements

DON’T USE INDEXES FOR POSITIONING

THEIR MEANING CHANGES OVER TIME

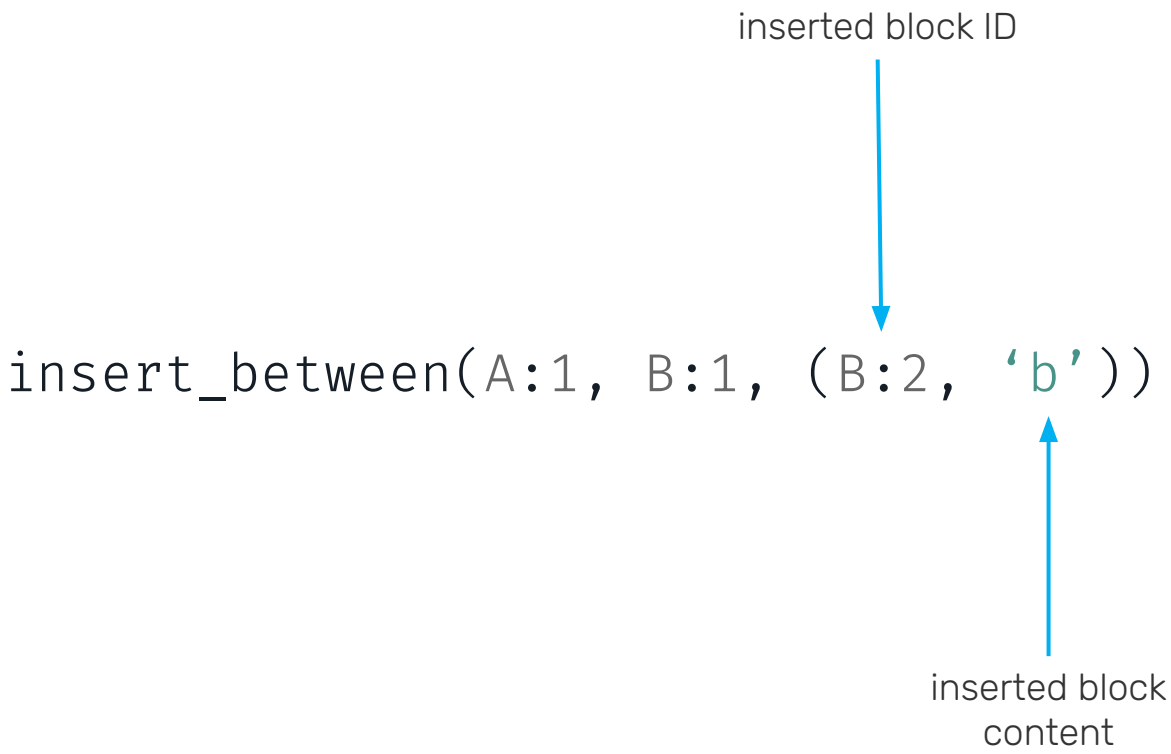
LAMPORT CLOCK



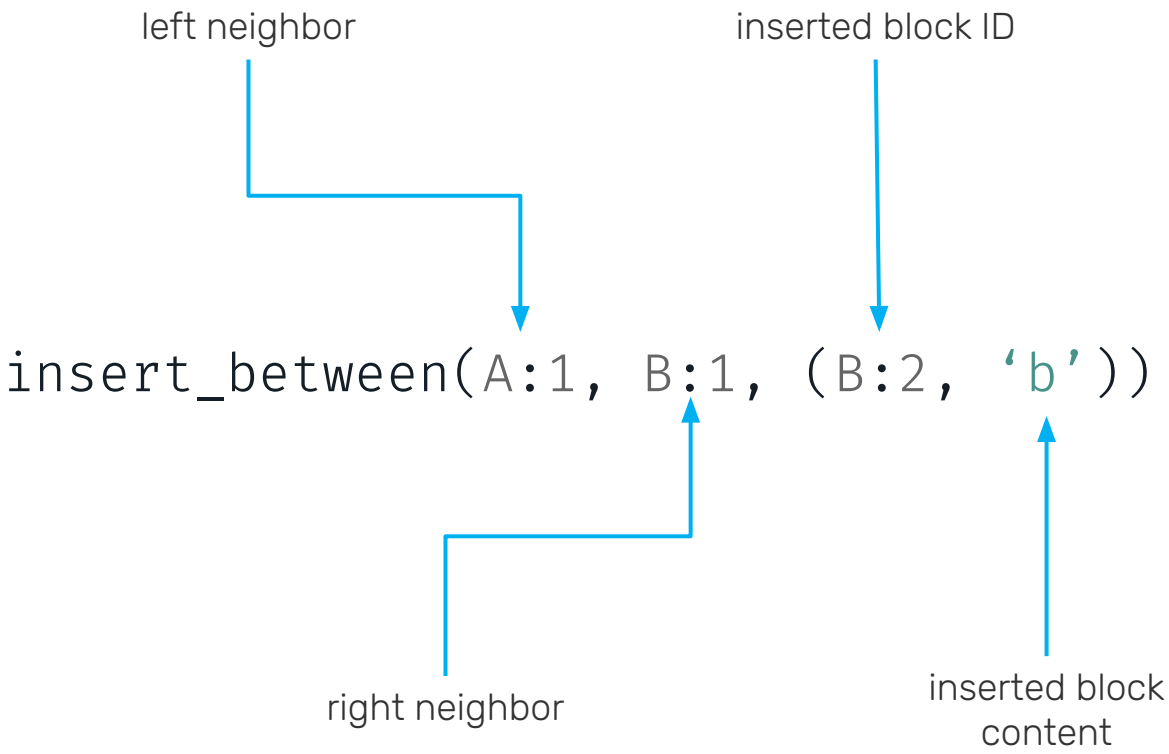
CONTEXT-AWARE INSERTION

```
insert_between(A:1, B:1, (B:2, ‘b’))
```

CONTEXT-AWARE INSERTION



CONTEXT-AWARE INSERTION



CONFLICT RESOLUTION

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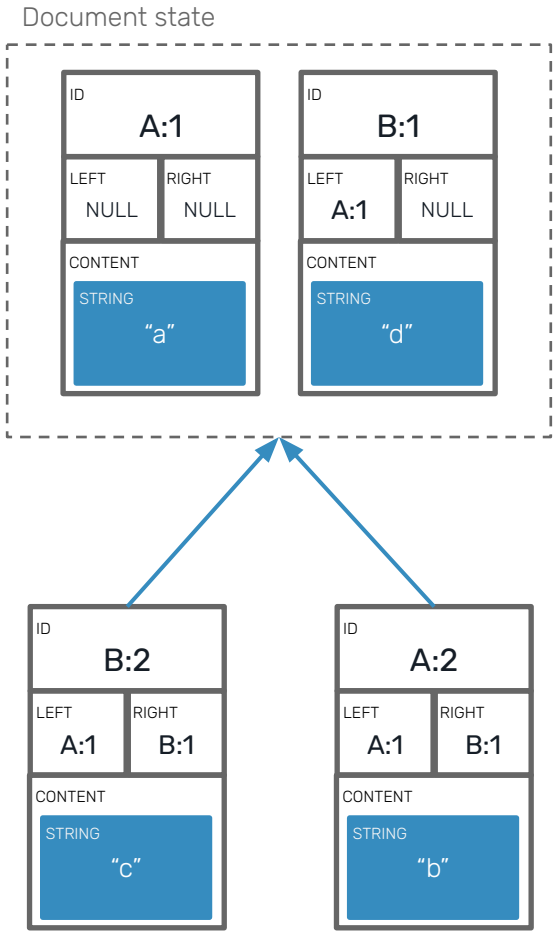

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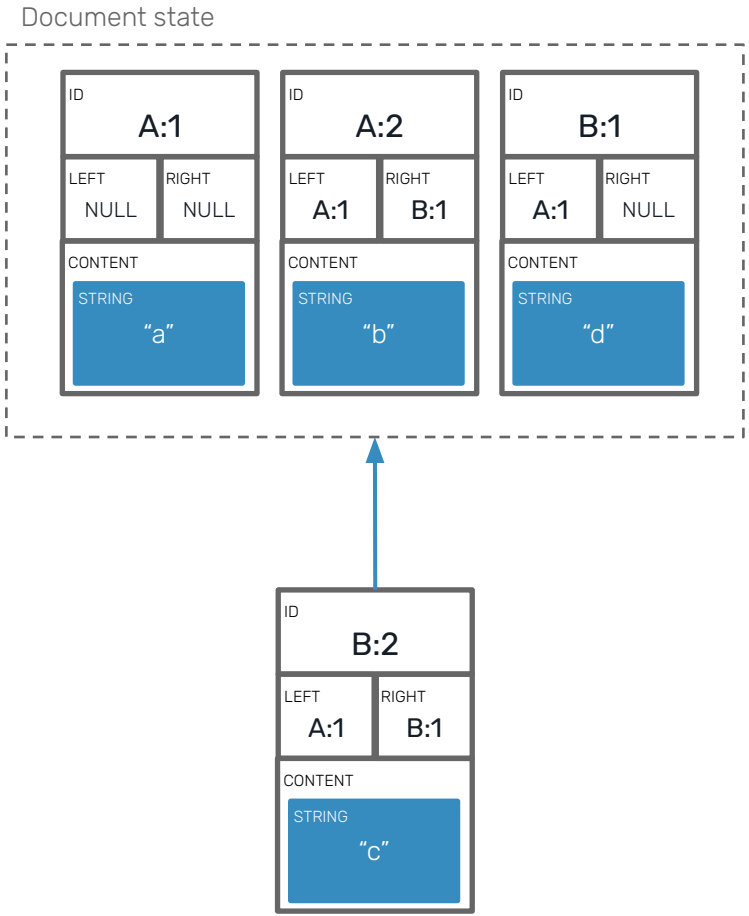

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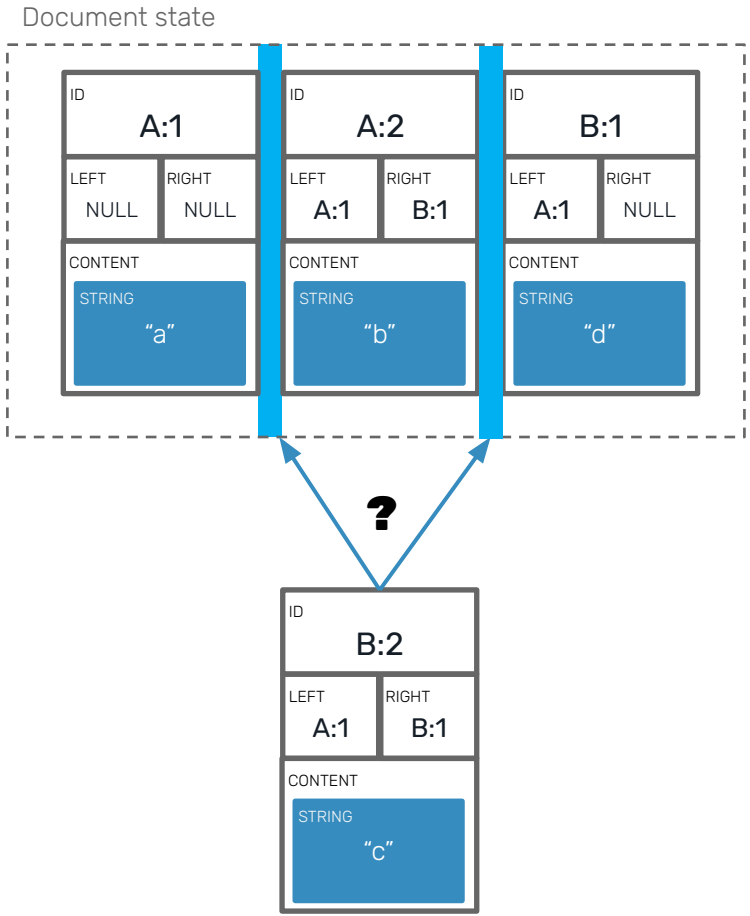

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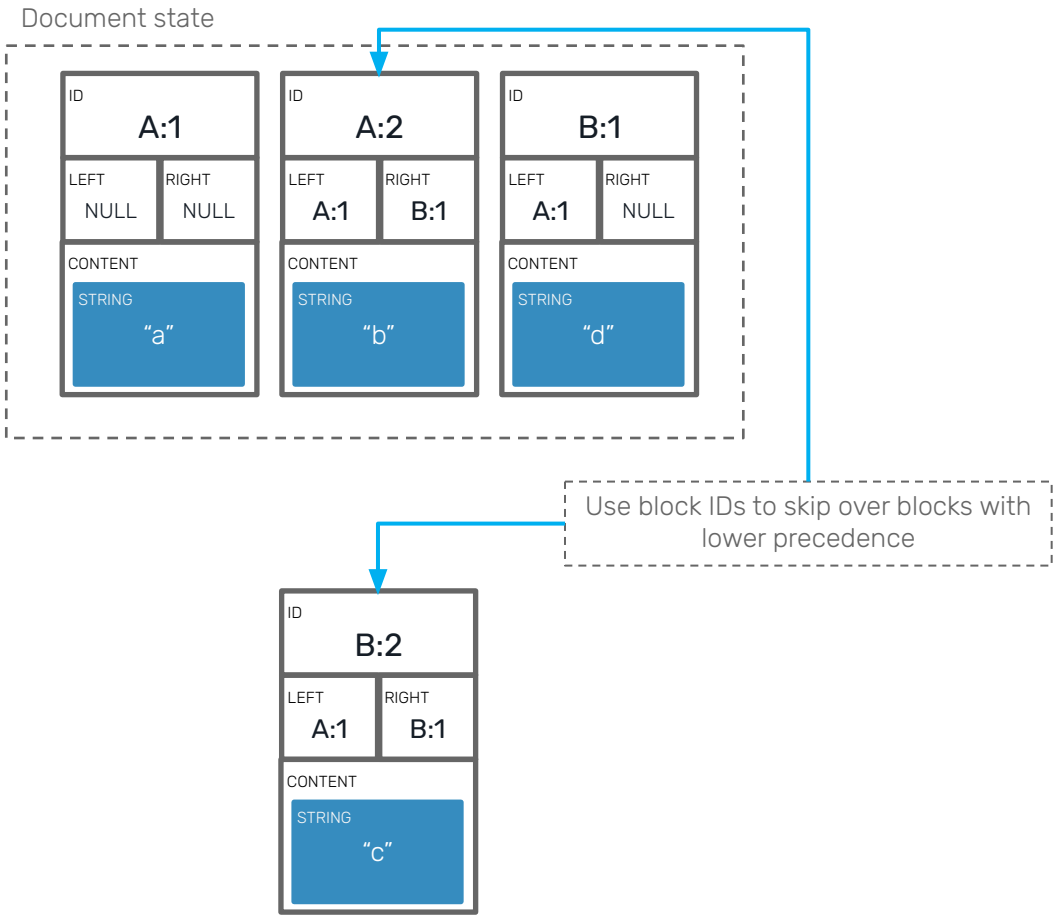

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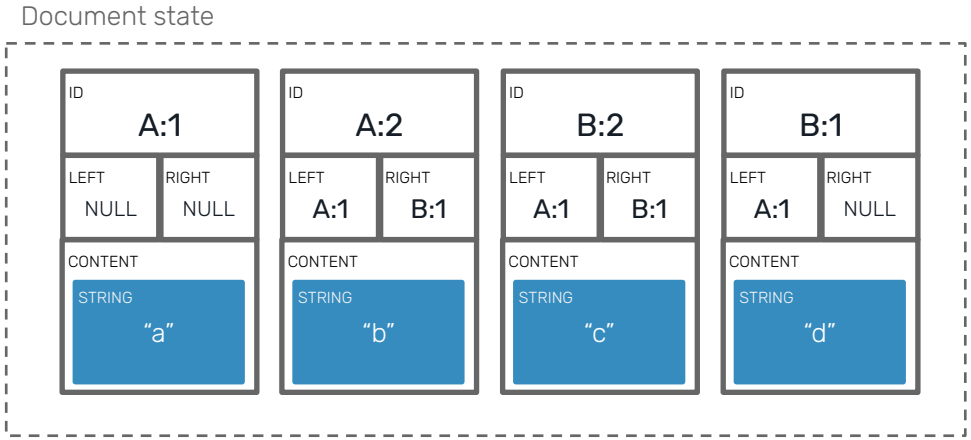
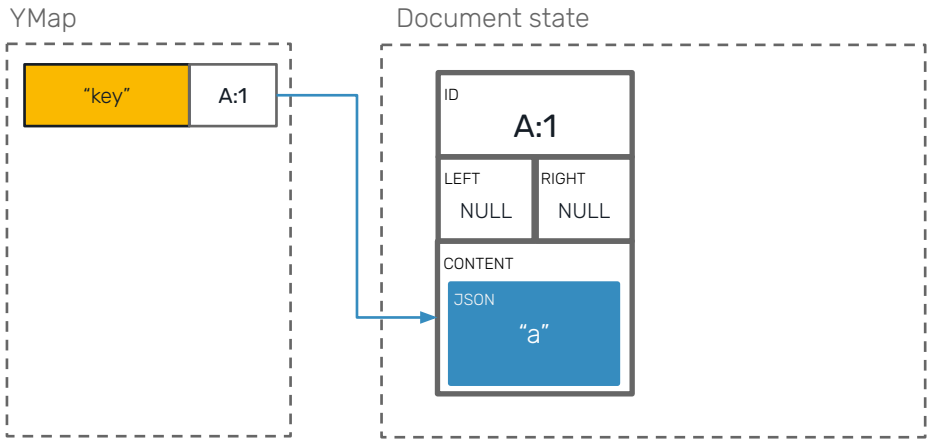


YATA FOR MAPS

YMAP

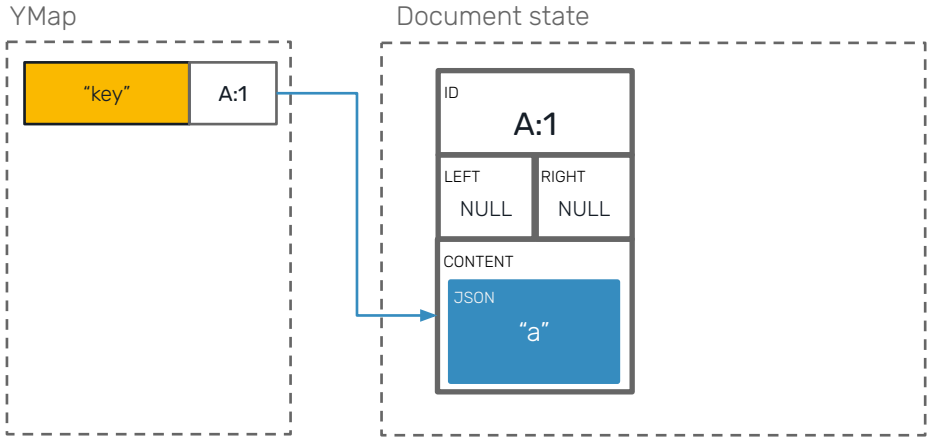
ENTRY INSERTION



YMAP

ENTRY INSERTION

```
ymap.set('key', 'b')
```



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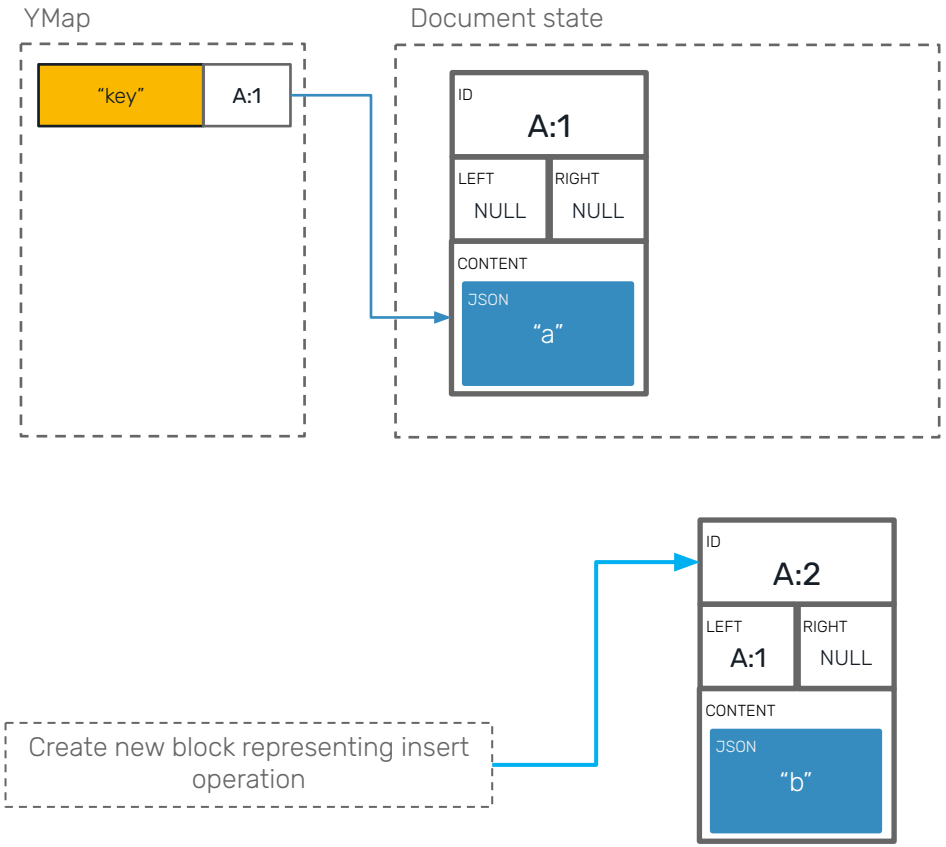

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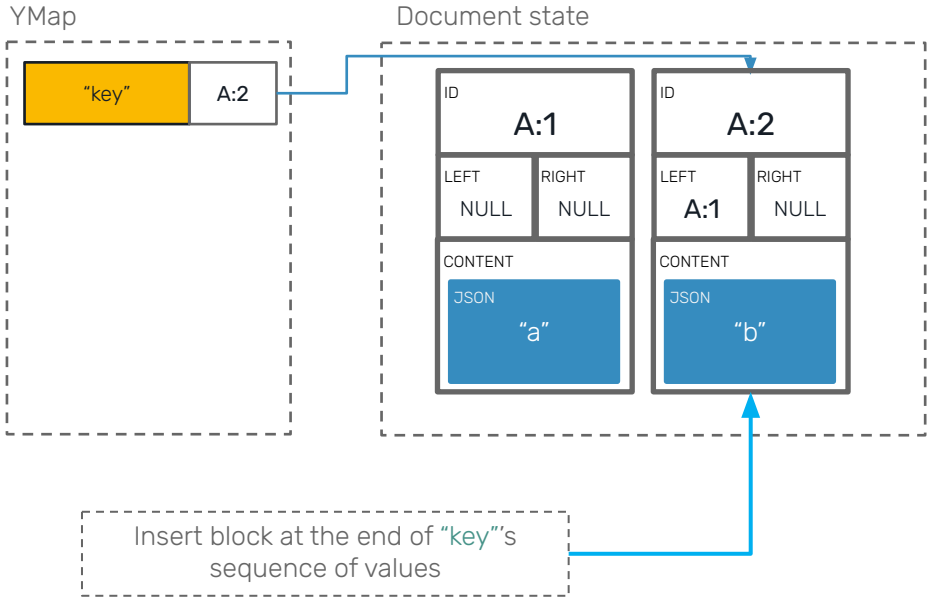

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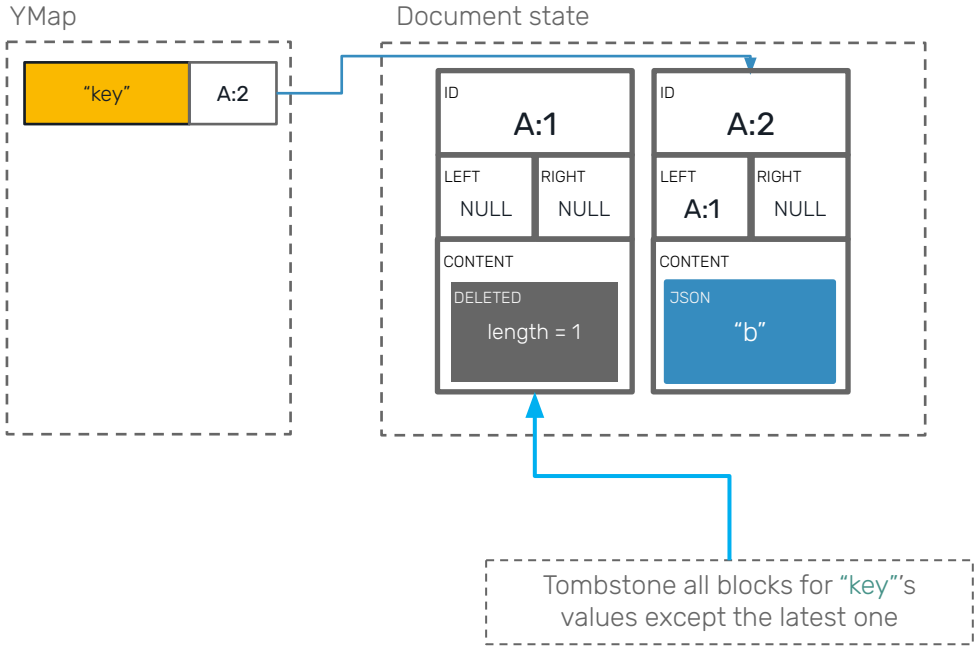
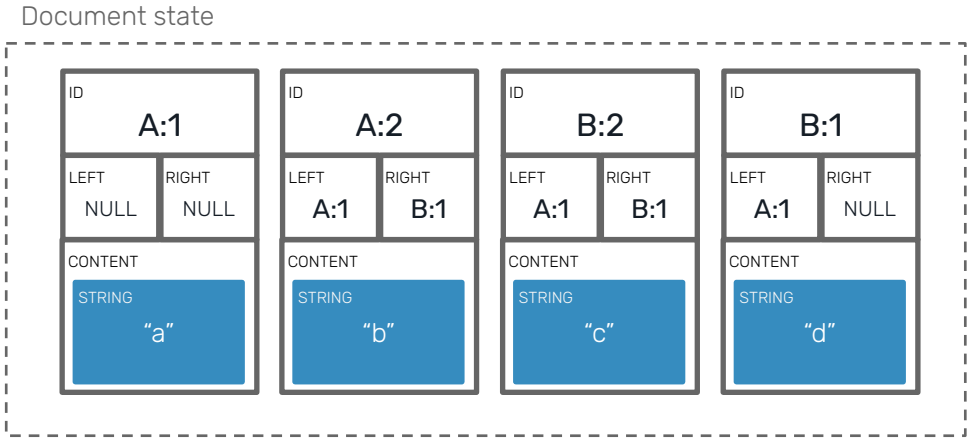


MOVING ELEMENTS

WHY DON’T JUST USE REMOVE + INSERT?

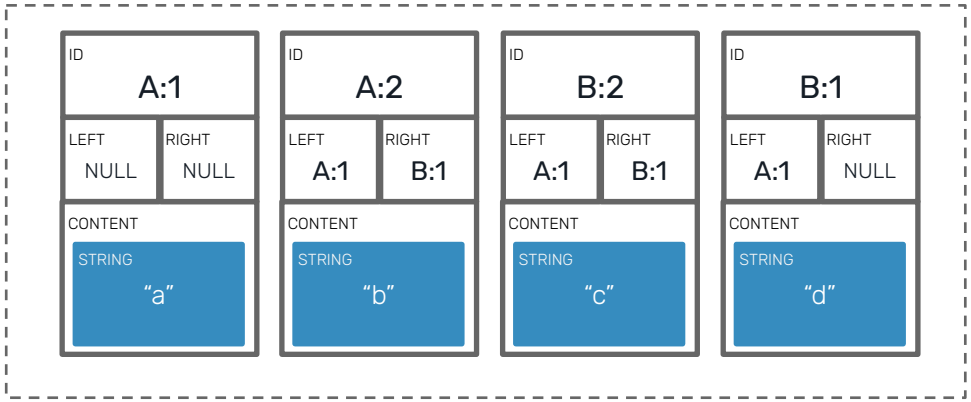
MOVING ELEMENTS



MOVING ELEMENTS

```
doc.move(1..2, 0)
```

Document state



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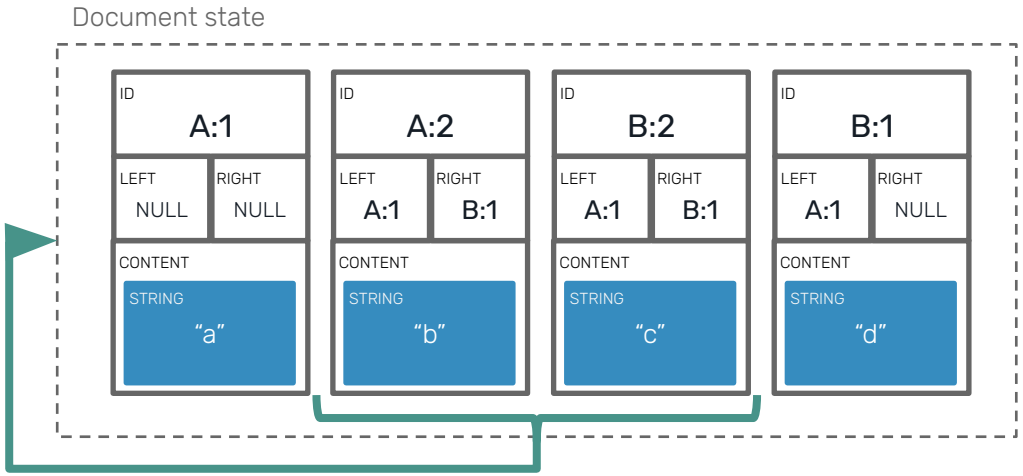

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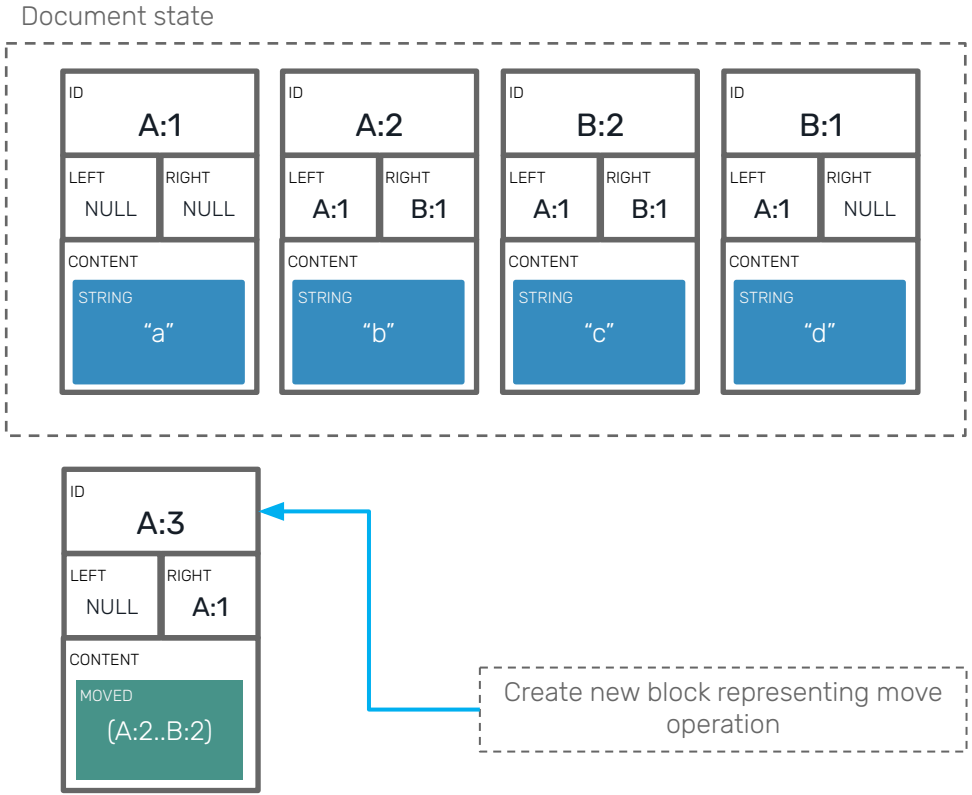

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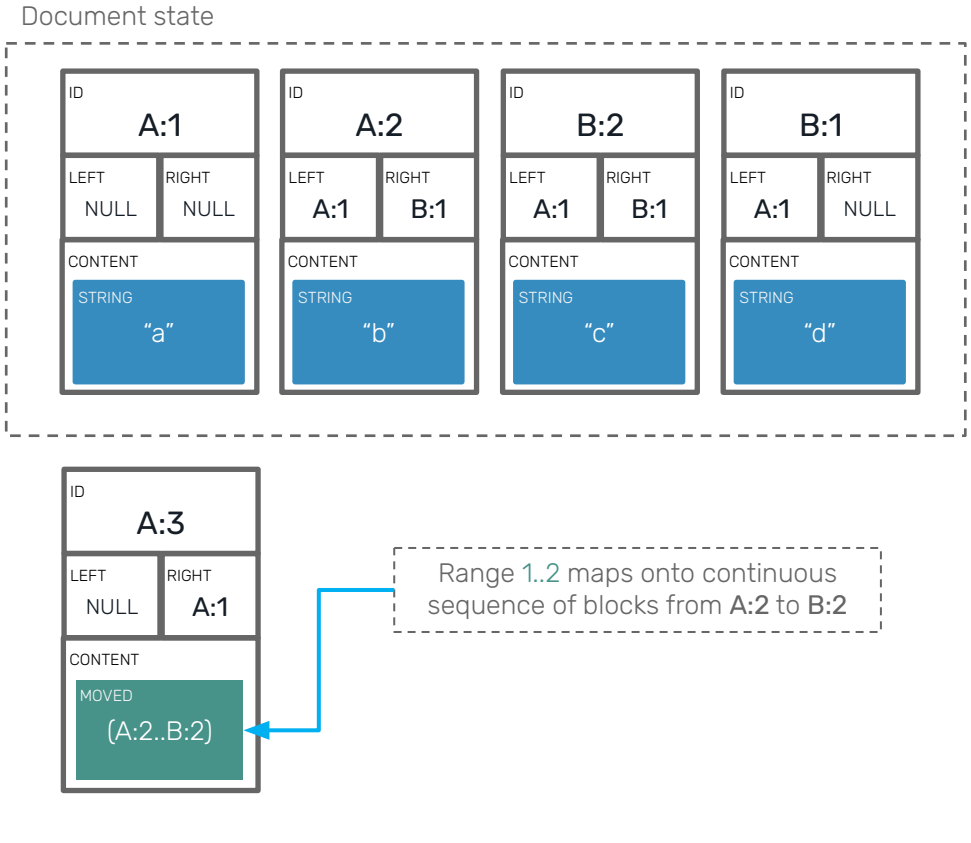

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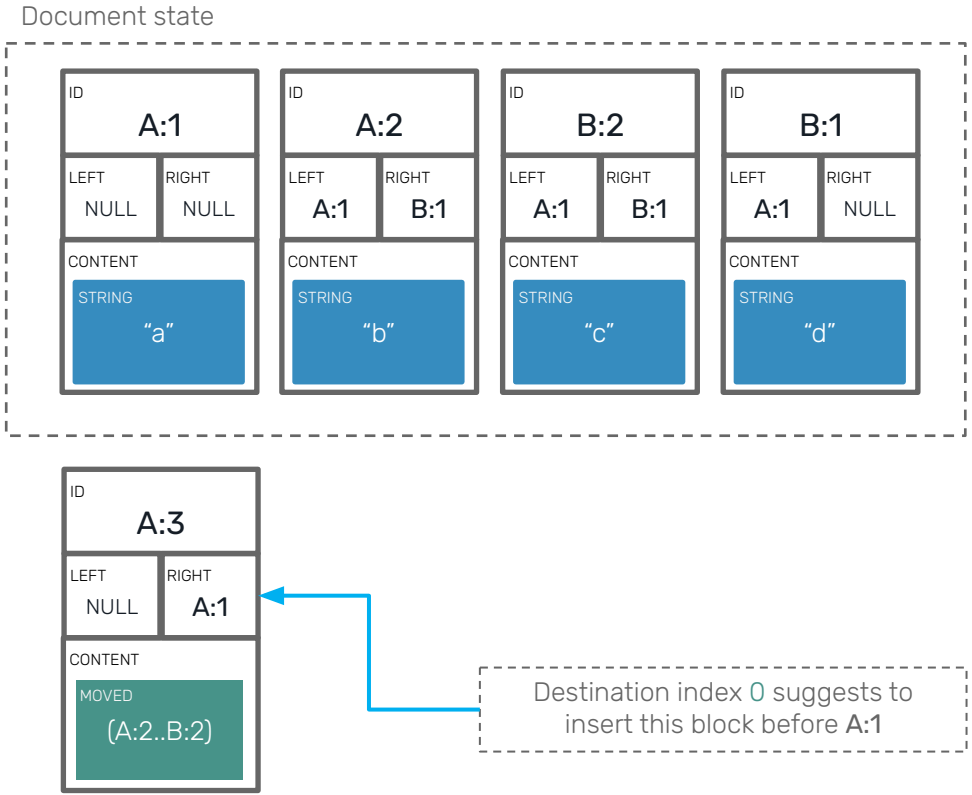

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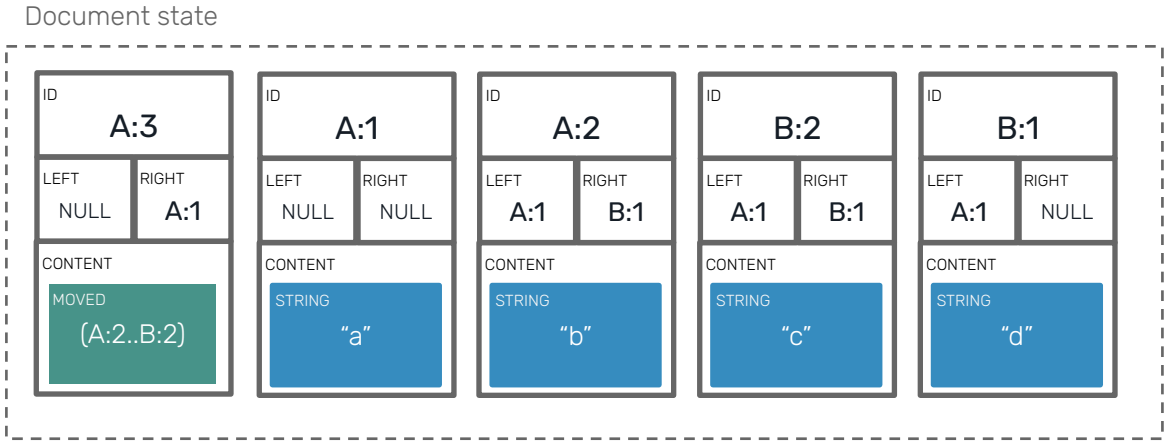

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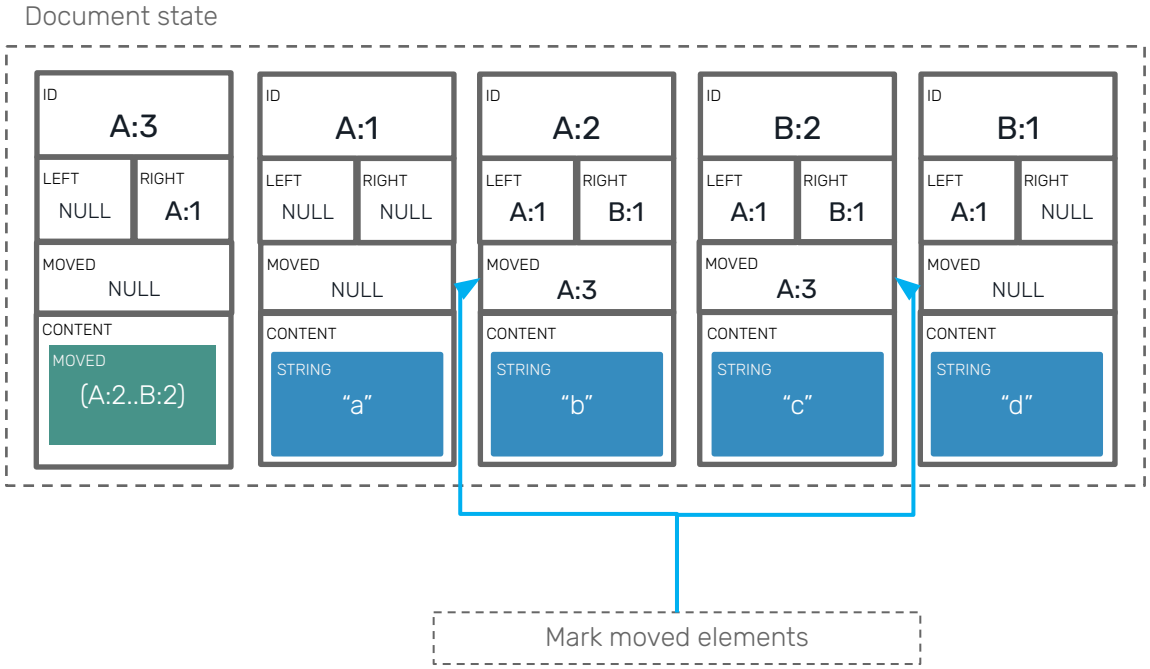
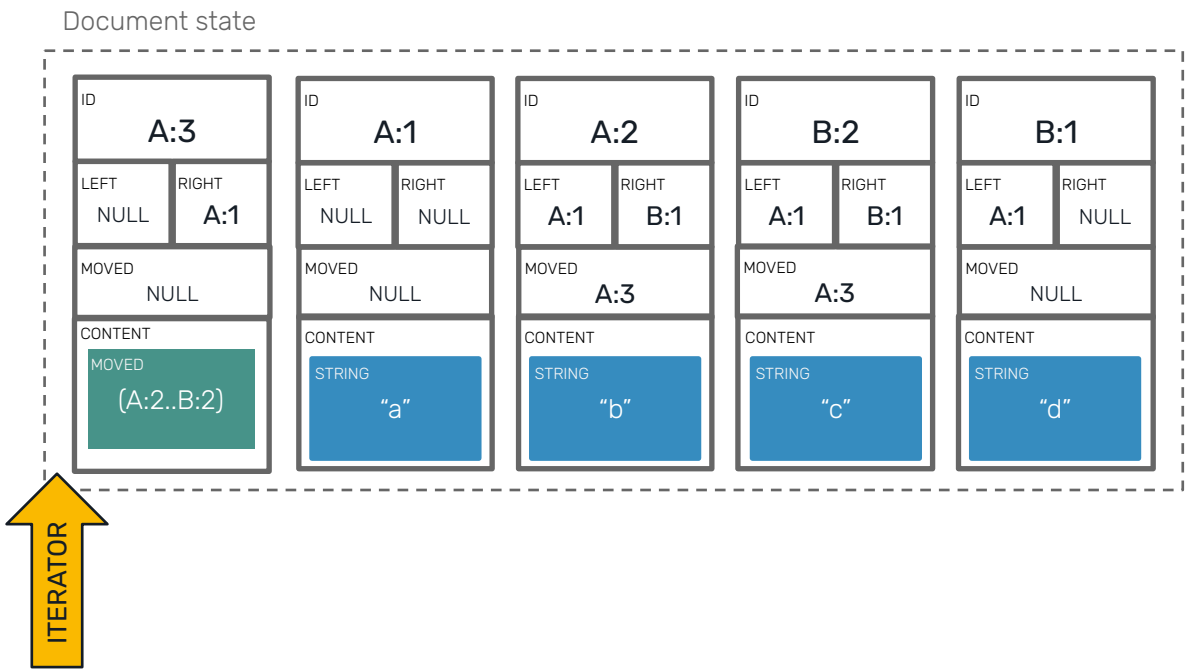


HOW ARE WE GOING TO READ THAT?

READING MOVED ELEMENTS



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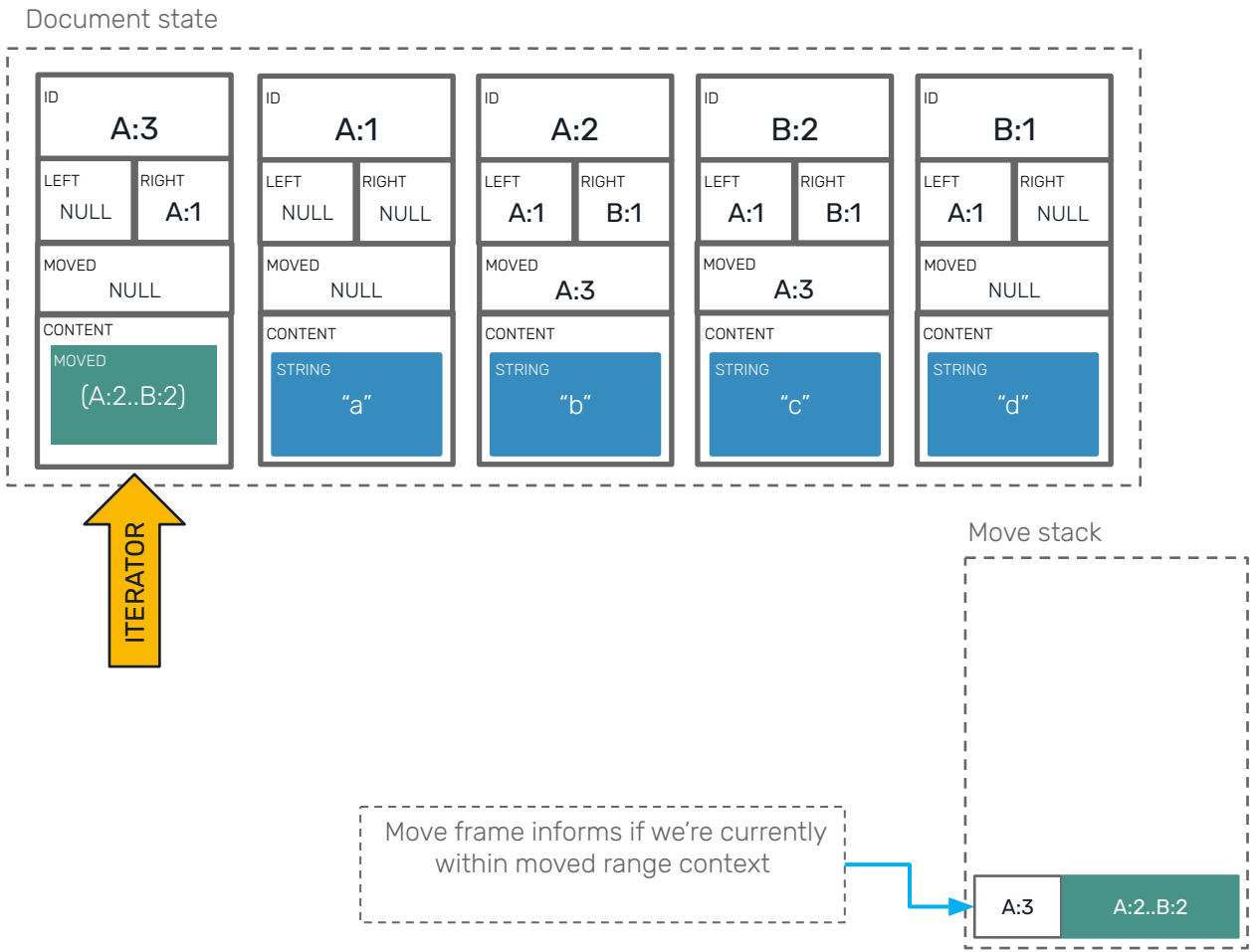

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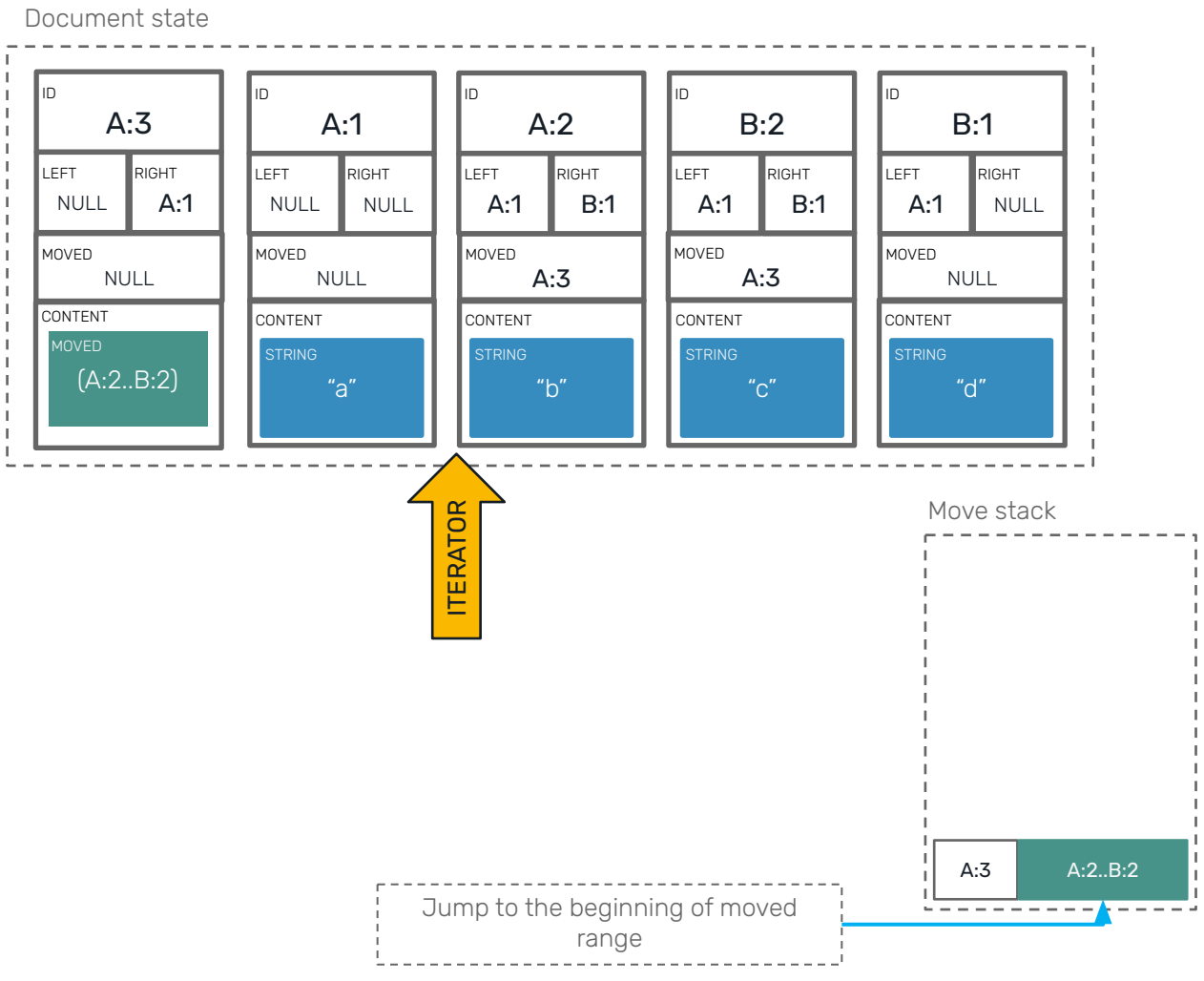

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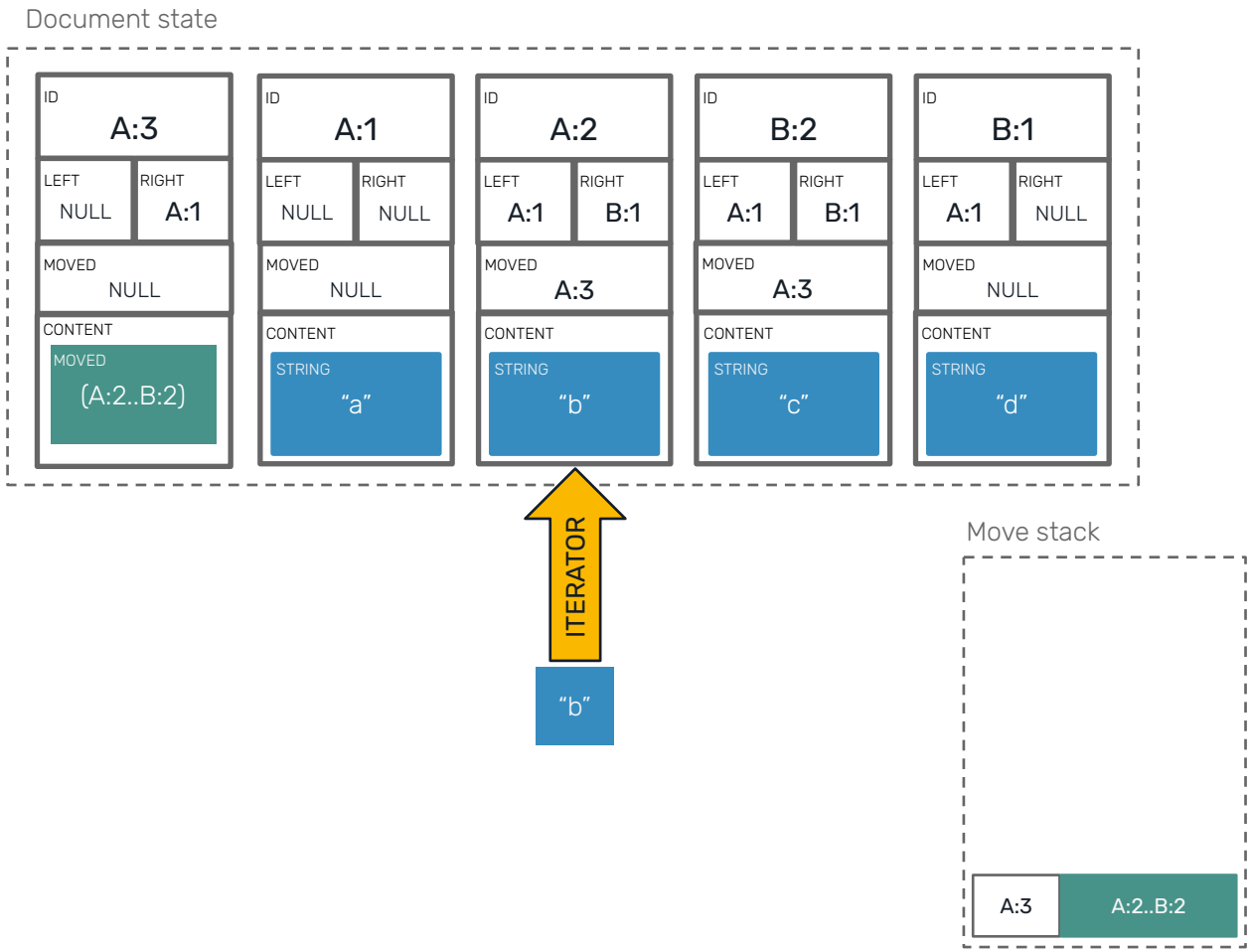

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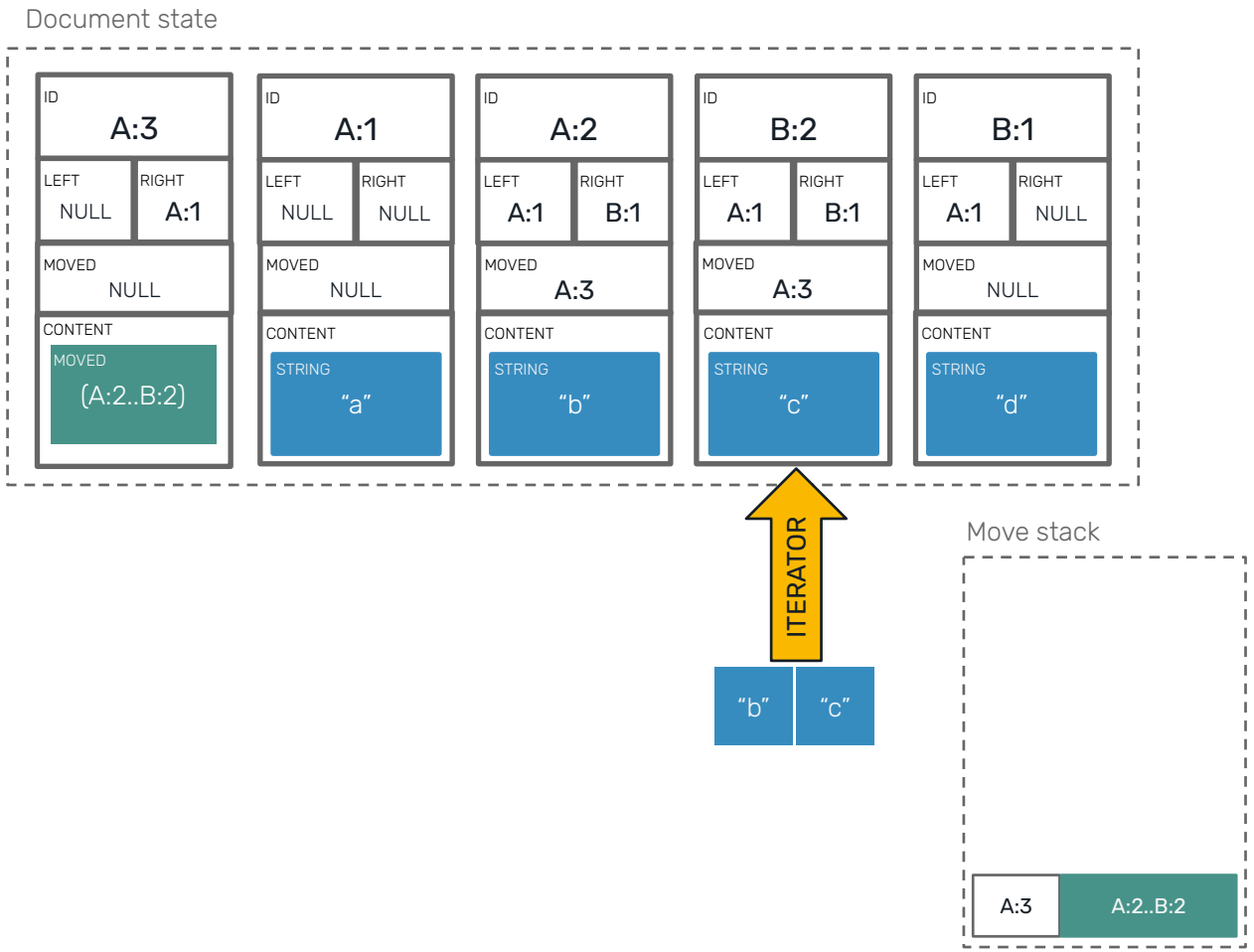

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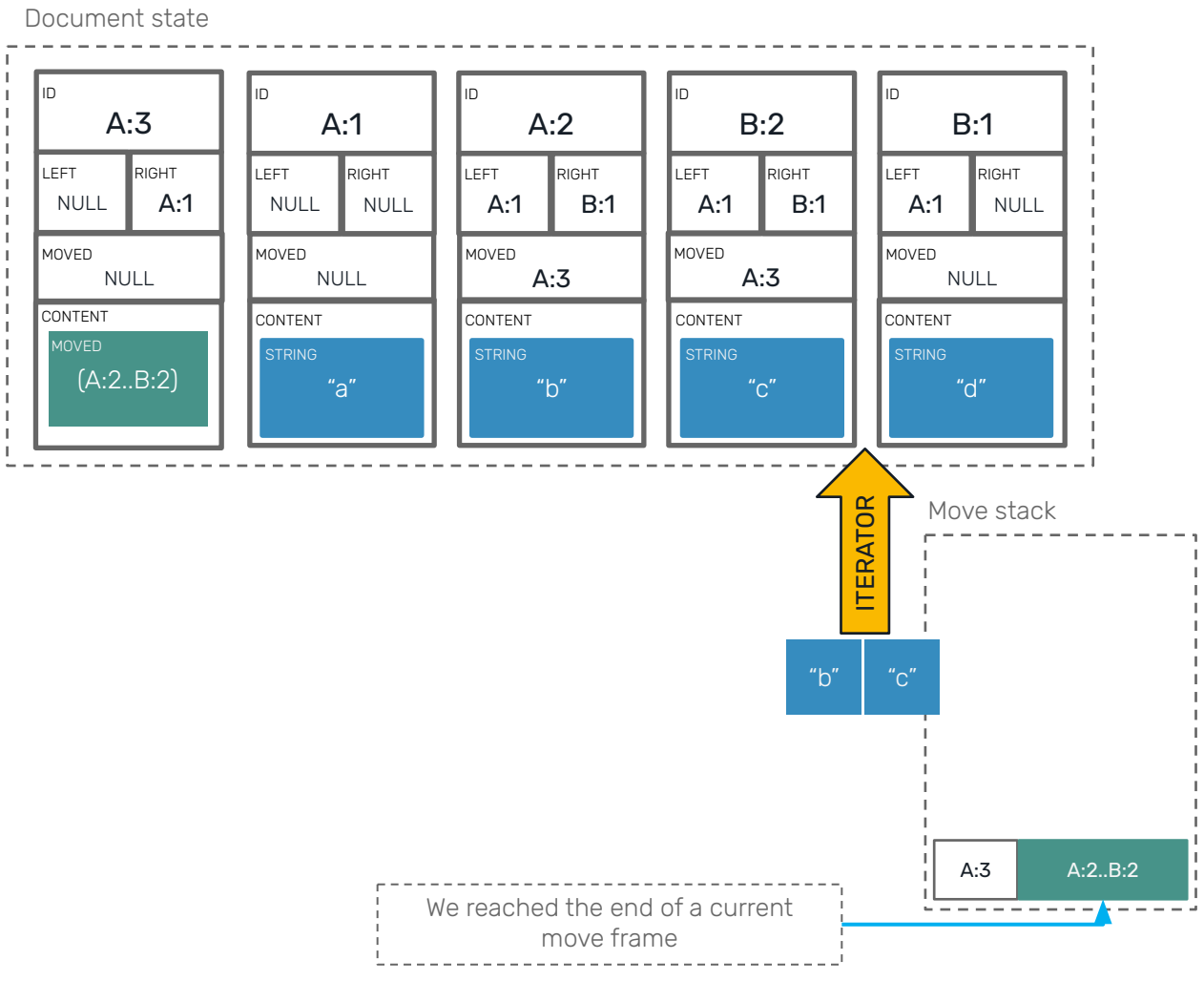

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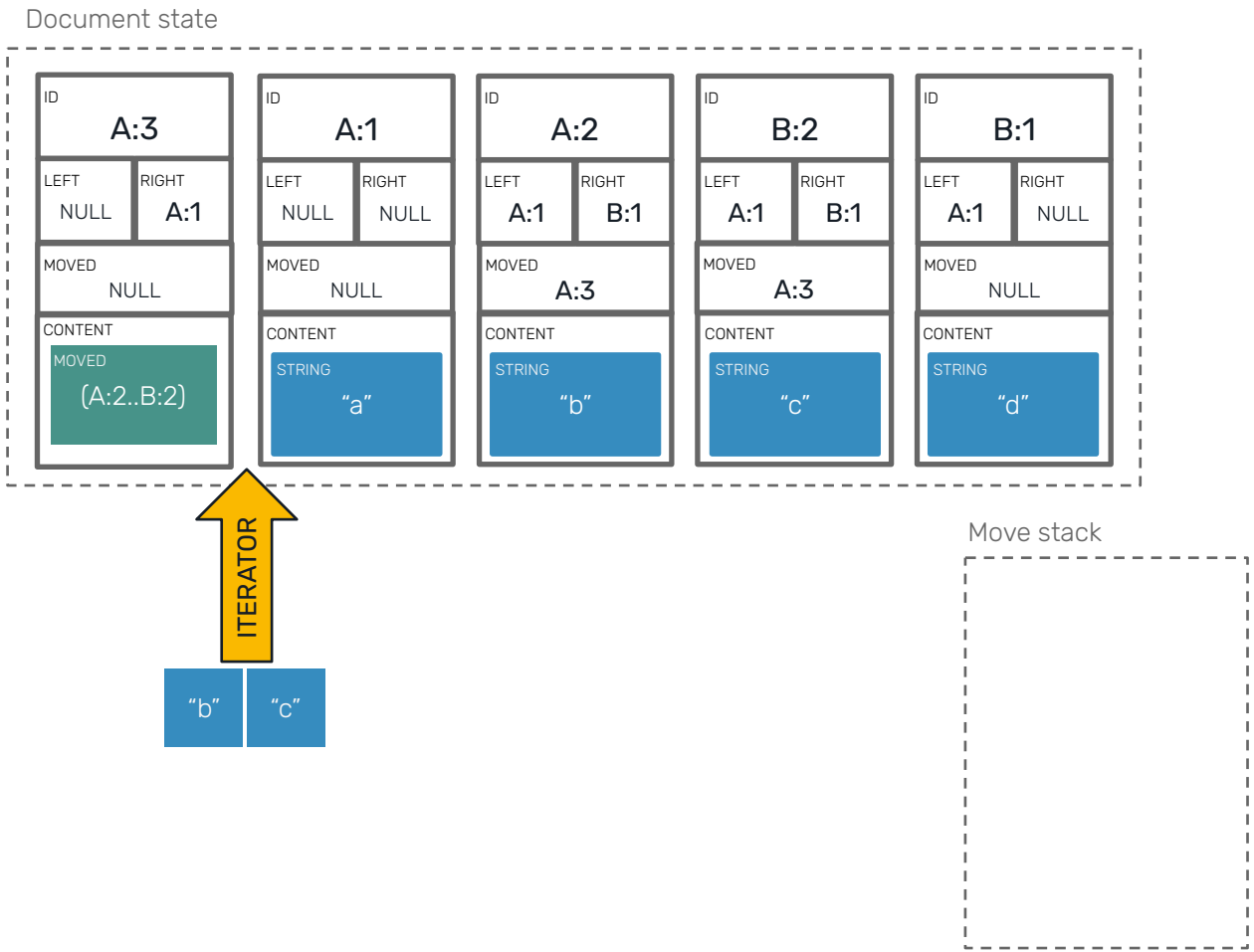

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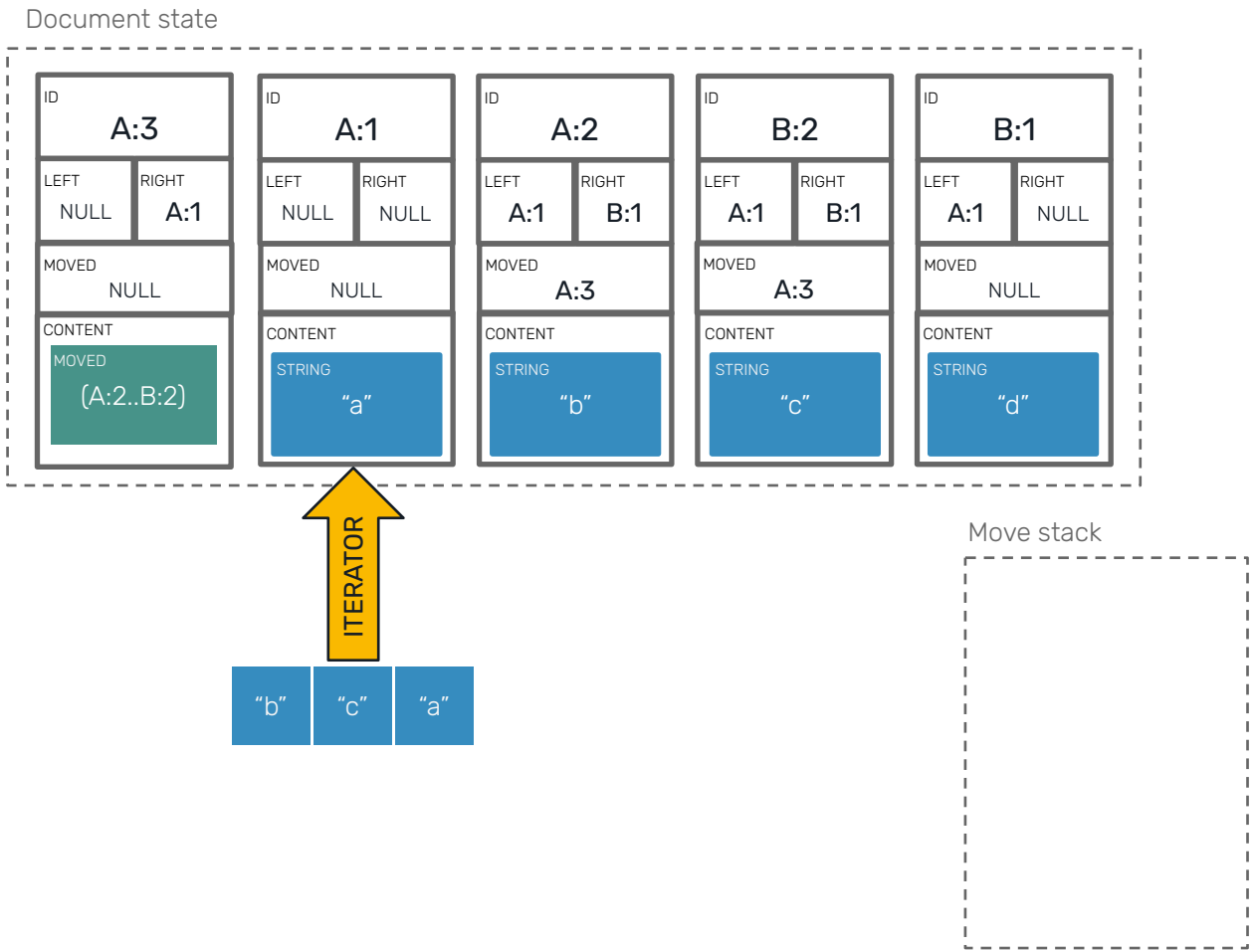

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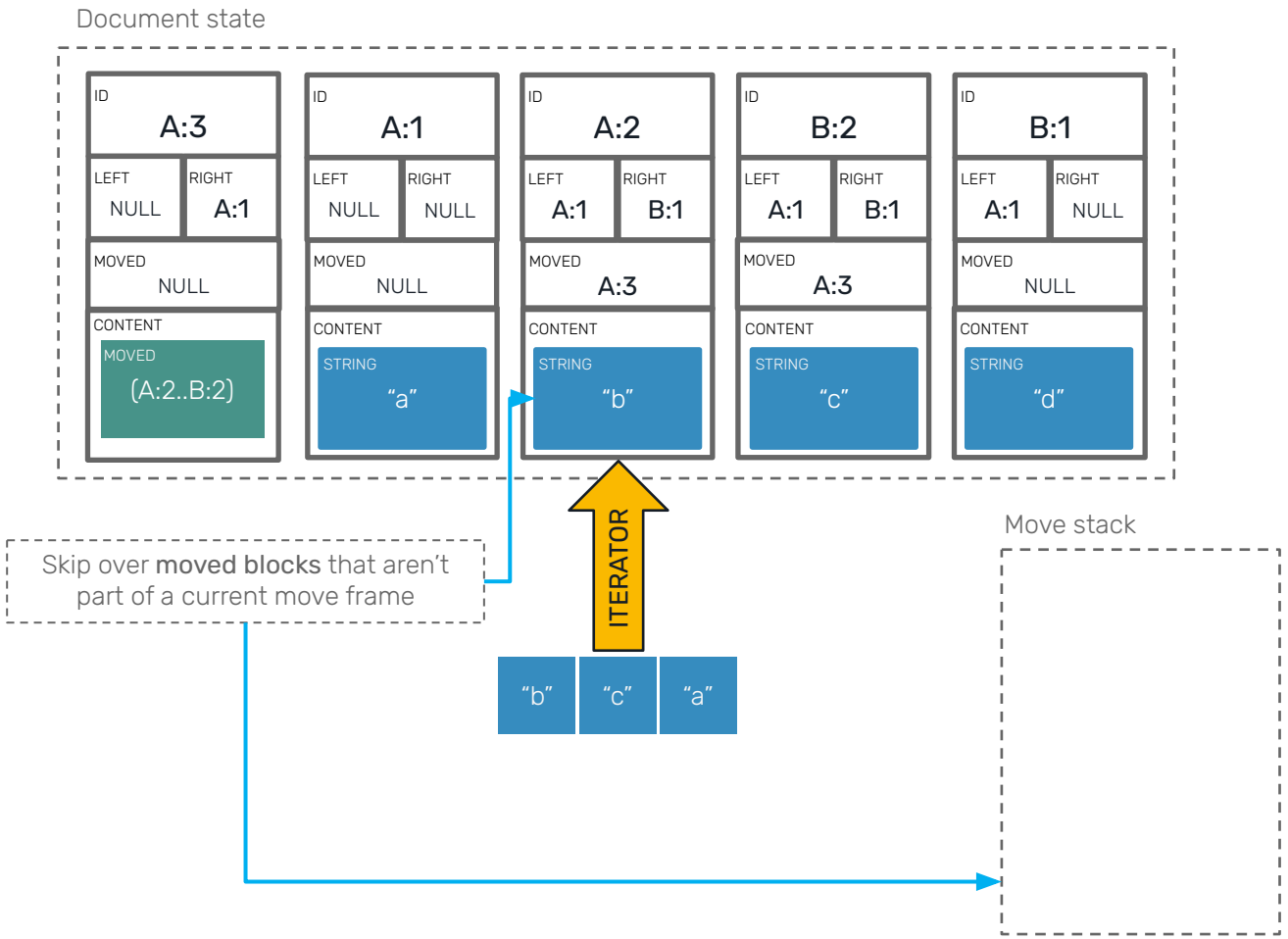

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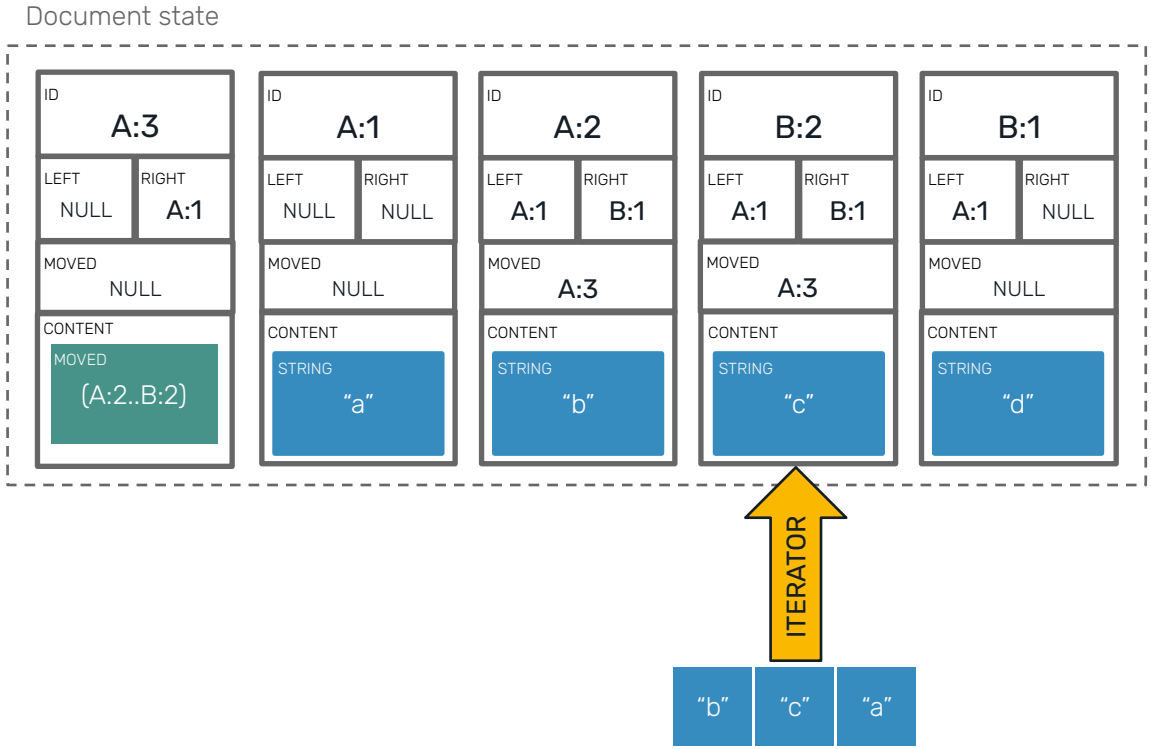

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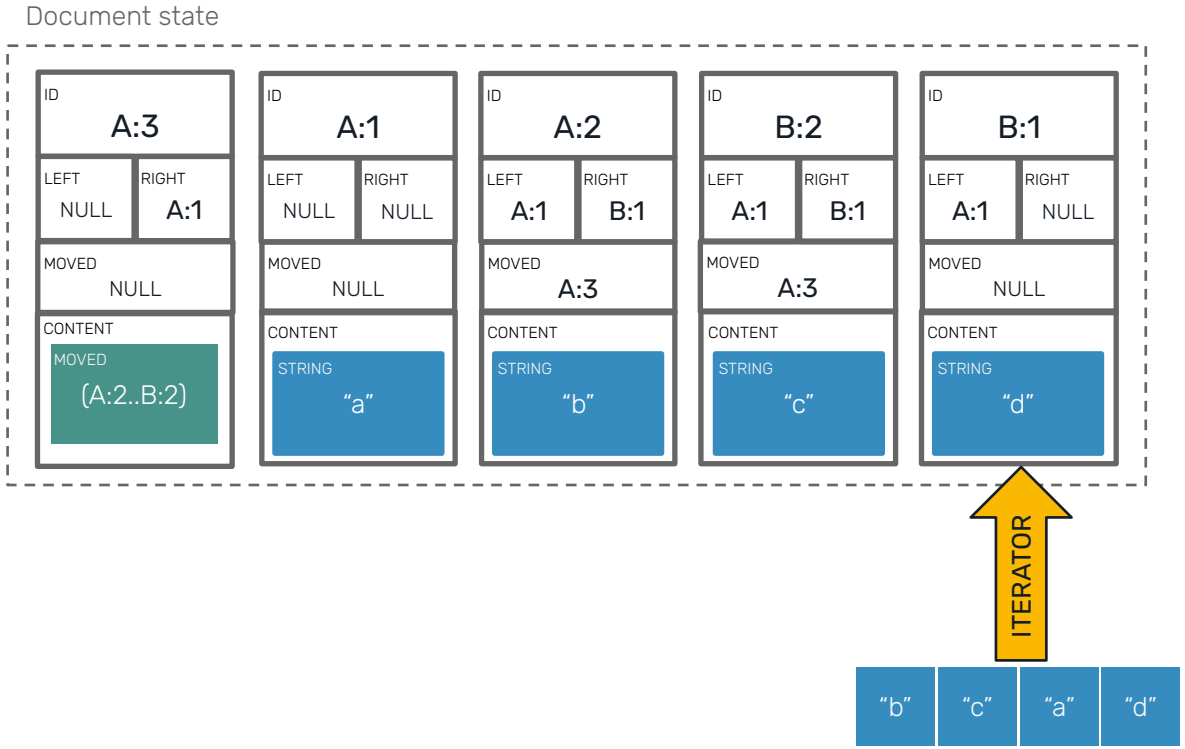


OPTIMIZATIONS

1. KNOW YOUR ENVIRONMENT

KNOW THE DIFFERENCE

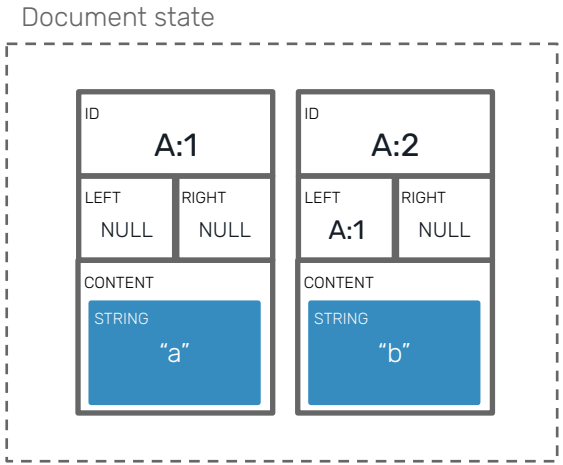
	Peer to Peer	Client / Server
Examples	Yjs/Yrs, Automerge	RiakDB, AntidoteDB, DynamoDB
Ops / sec.	few* (related to single user activity)	> 1000 ops / sec
Collaborators	unknown, limited control	known, under full control
Network / connections	heterogenous, unreliable	Homogenous, fairly stable
Data volume	fits in memory (hopefully)	greater than disk

OPTIMIZATIONS

2. REDUCE NUMBER OF OPERATIONS

OPTIMIZATIONS

BLOCK MERGING



OPTIMIZATIONS

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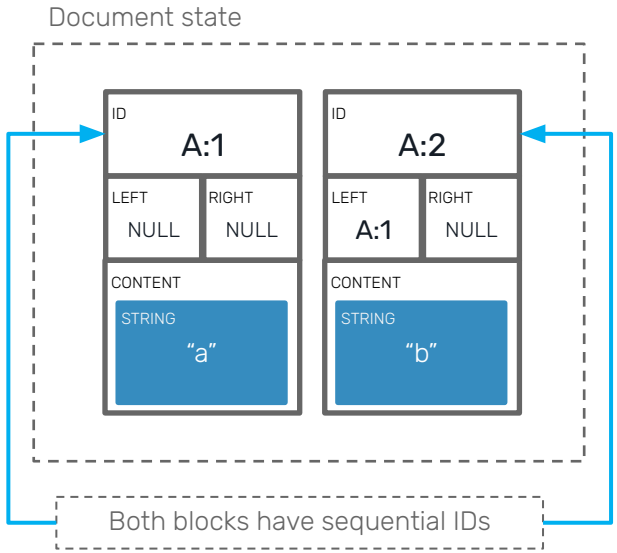

OPTIMIZATIONS

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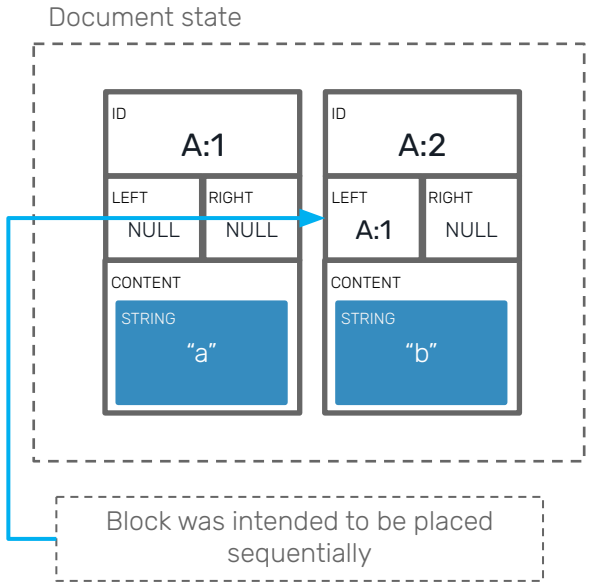

OPTIMIZATIONS

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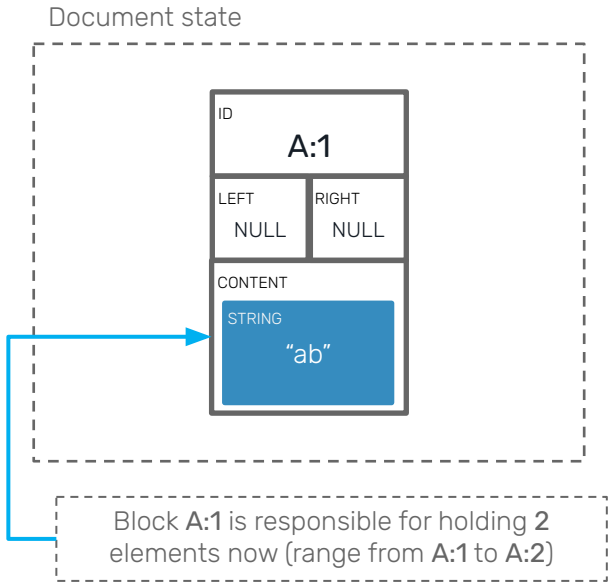
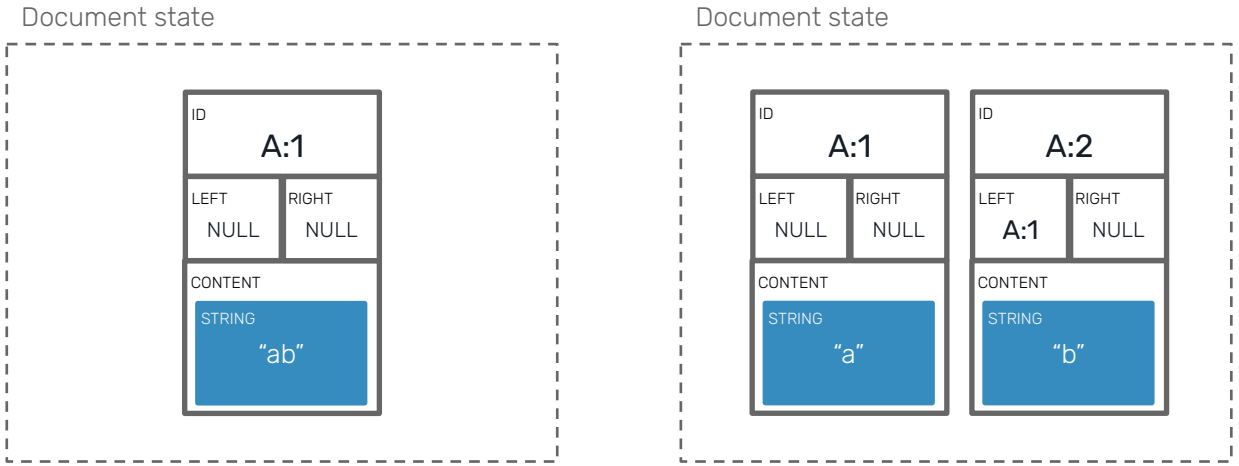


OPTIMIZATIONS

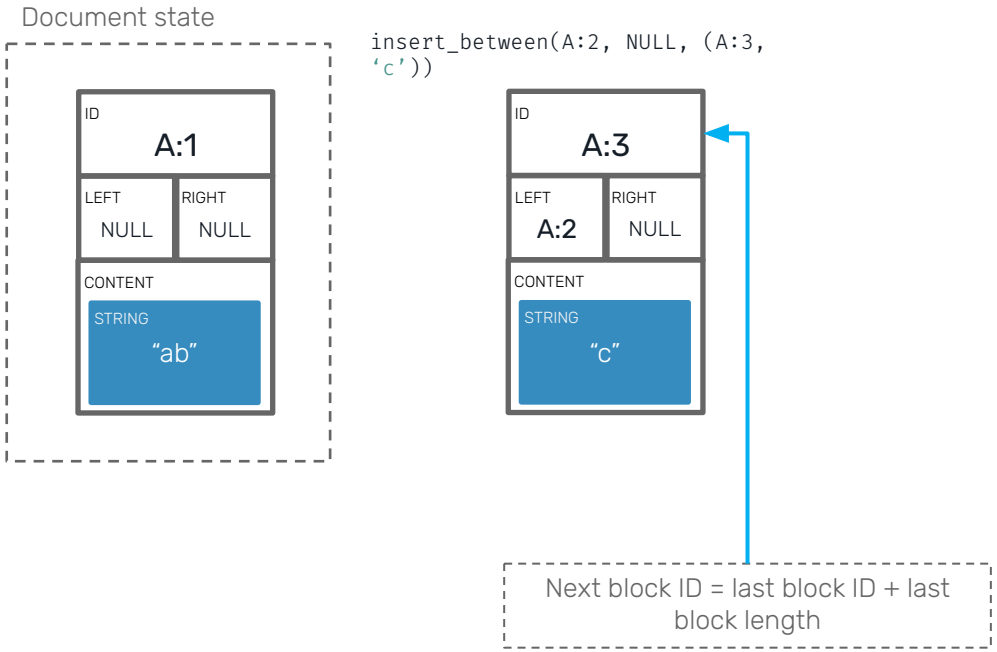
BLOCK MERGING

These two representations are logically equivalent



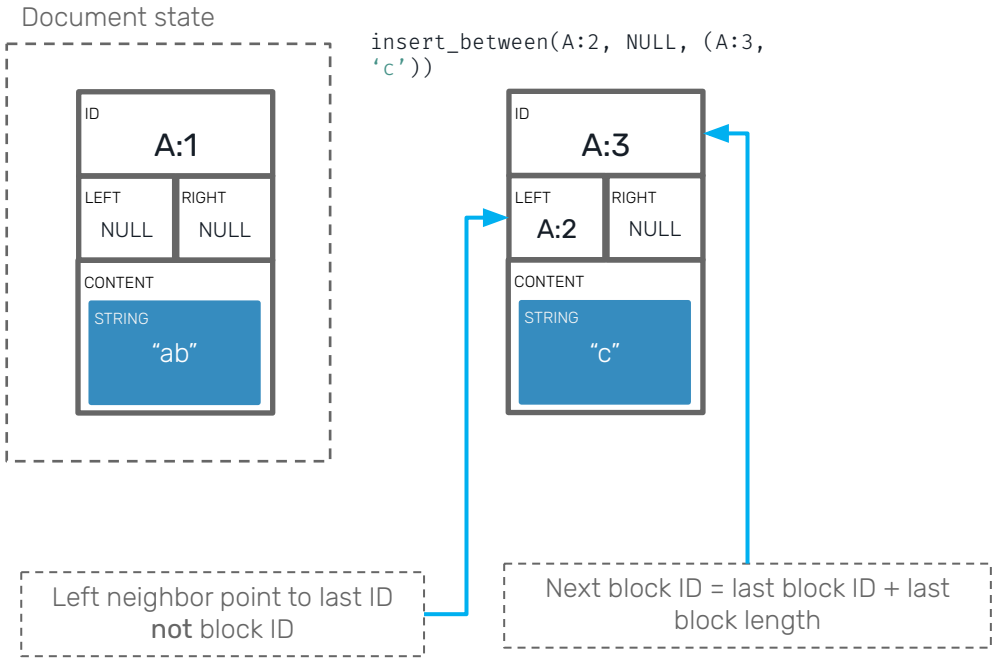
OPTIMIZATIONS

BLOCK MERGING



OPTIMIZATIONS

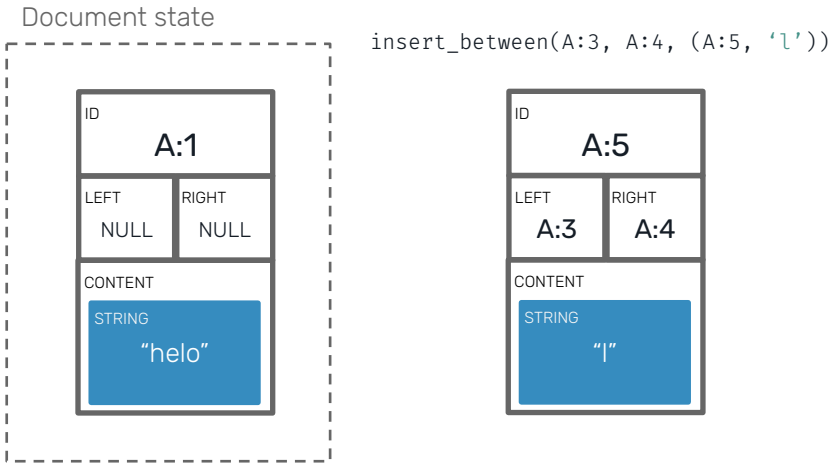
BLOCK MERGING



WHAT IF WE WANT TO INSERT ELEMENT WITHIN BLOCK?

OPTIMIZATIONS

BLOCK SPLITTING



OPTIMIZATIONS

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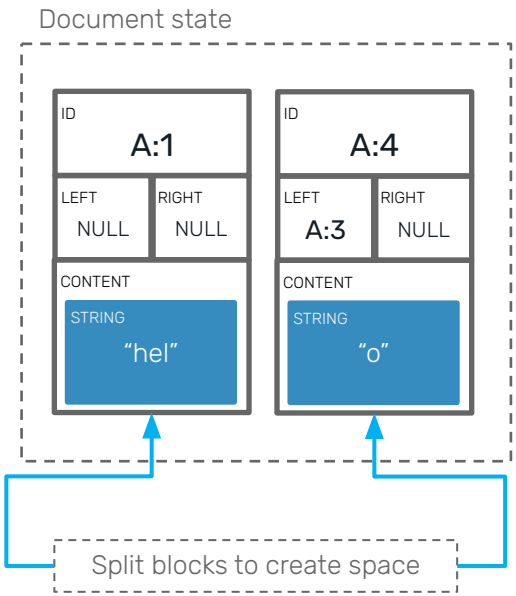
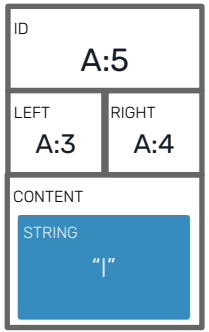
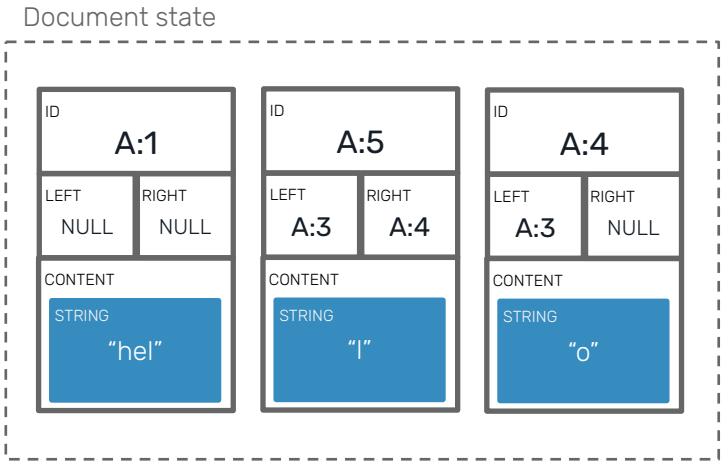



```
insert_between(A:3, A:4, (A:5, 'l'))
```



OPTIMIZATIONS

BLOCK SPLITTING

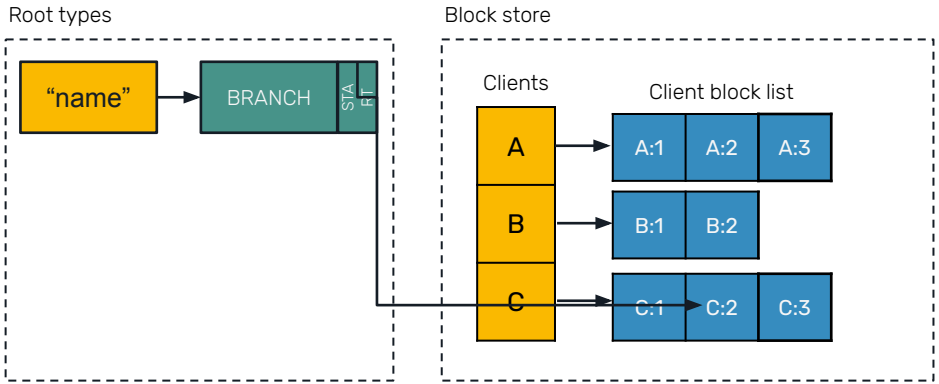


OPTIMIZATIONS

3. IMPROVE BLOCK INSERTION TIME

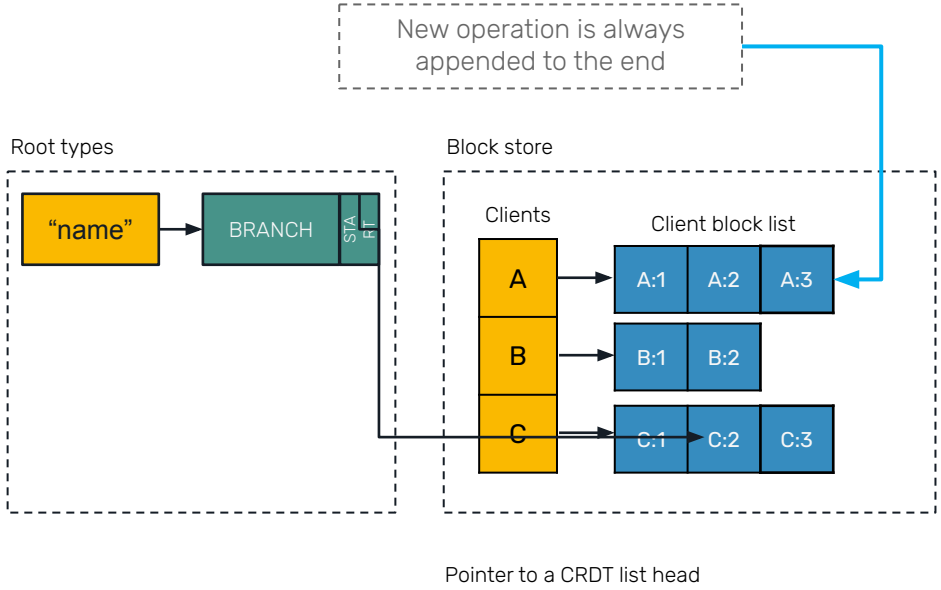
PREFER SEQUENTIAL ACCESS WHENEVER POSSIBLE

DOCUMENT BLOCK STRUCTURE UNDER THE HOOD

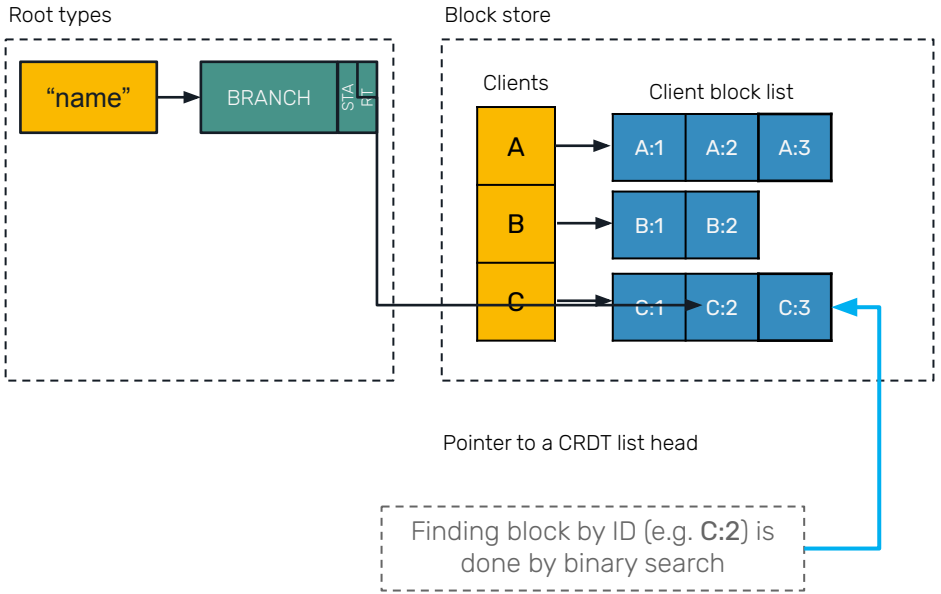


Pointer to a CRDT list head

DOCUMENT BLOCK STRUCTURE UNDER THE HOOD

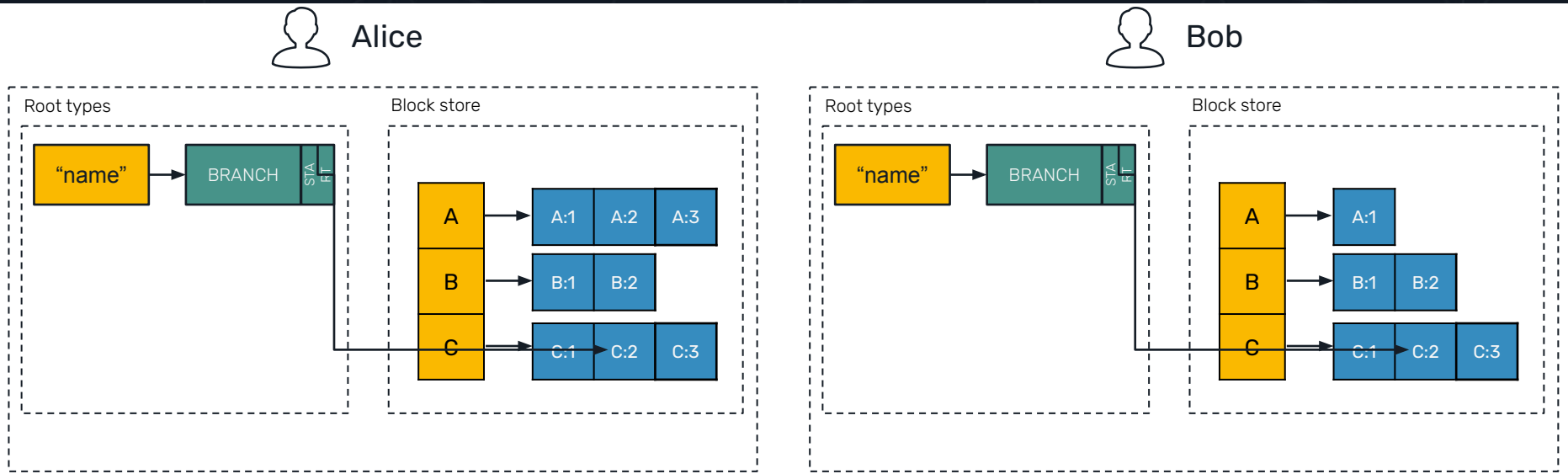


DOCUMENT BLOCK STRUCTURE UNDER THE HOOD

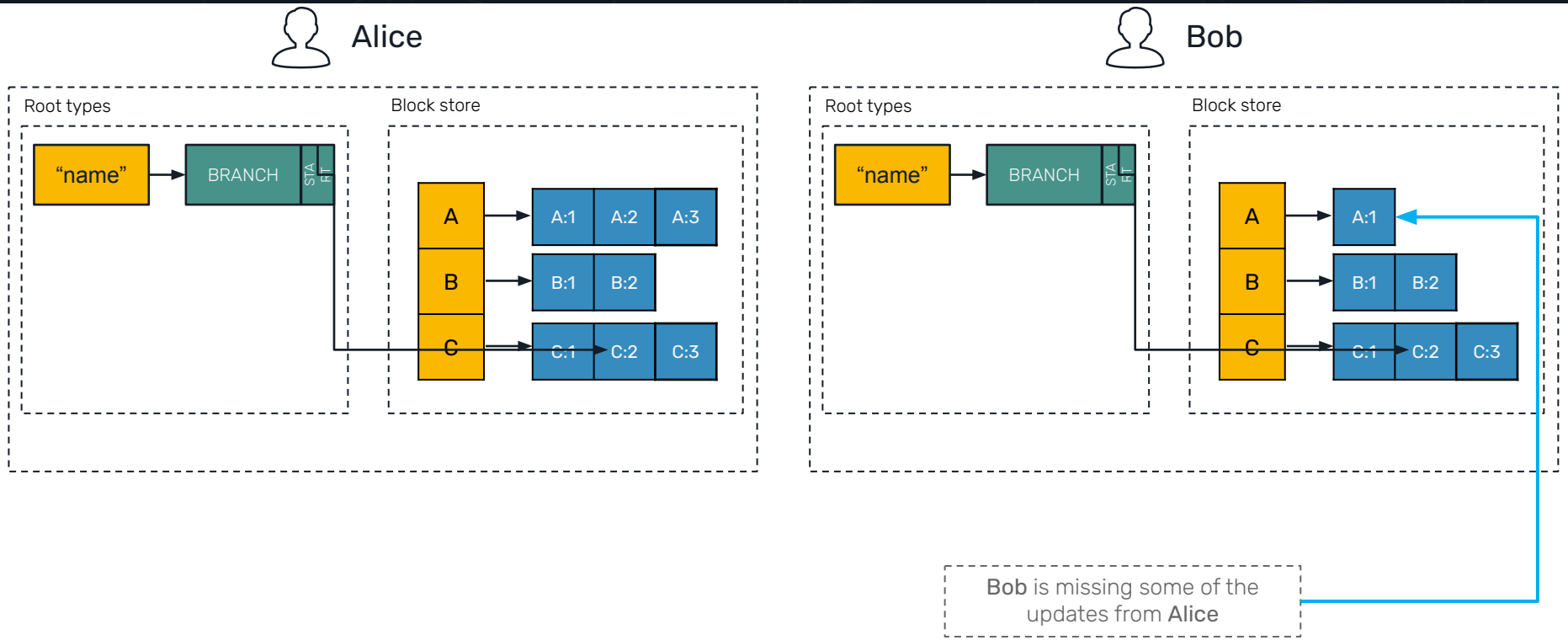


IT’S ALSO BETTER FOR SYNCHRONIZING DATA

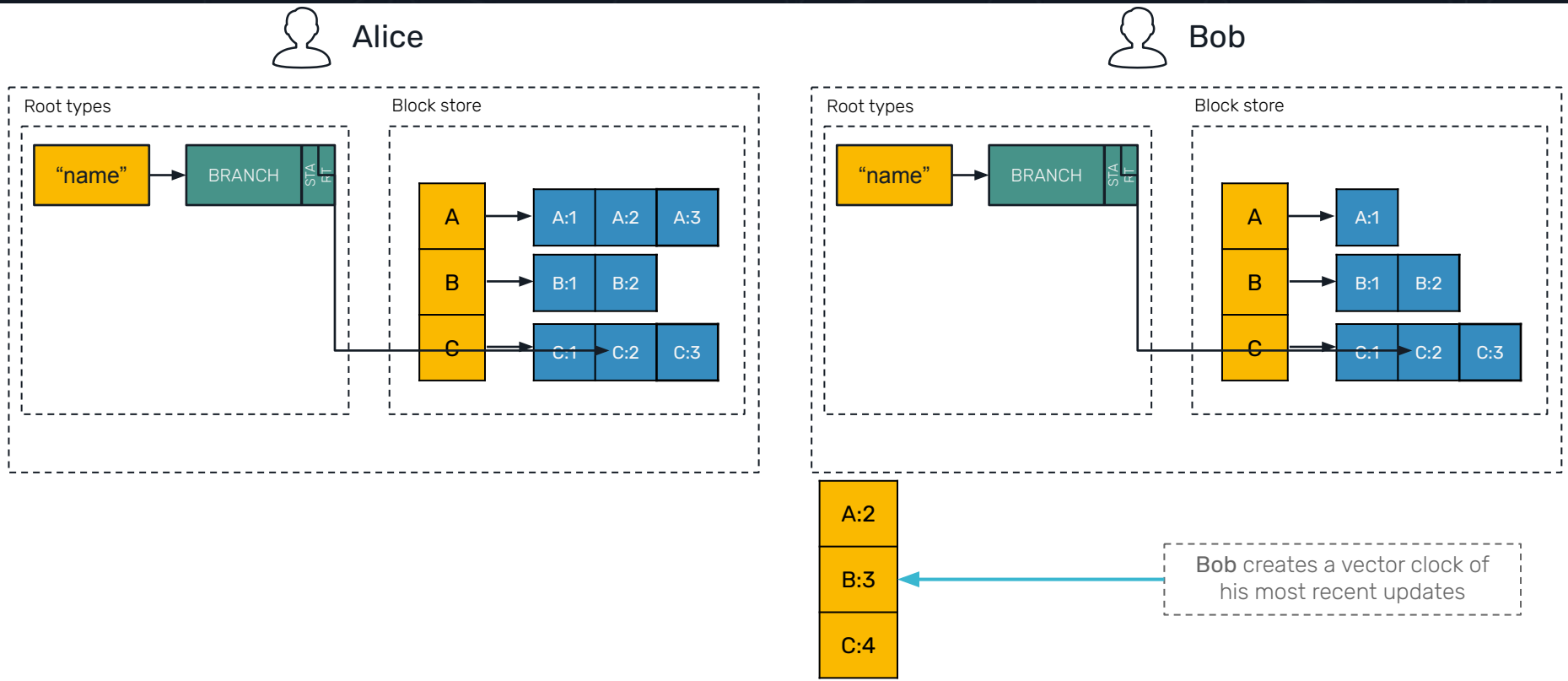
DELTA REPLICATION



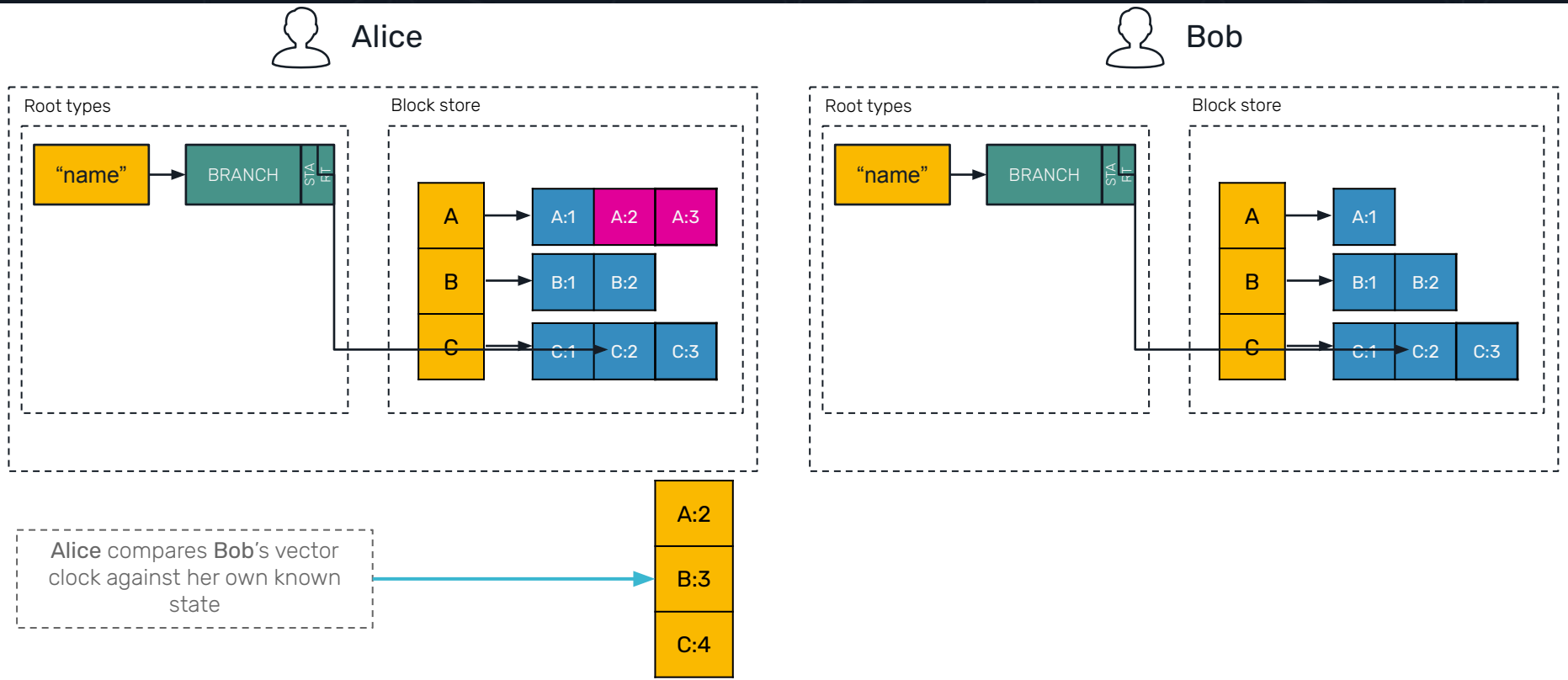
DELTA REPLICATION



DELTA REPLICATION



DELTA REPLICATION



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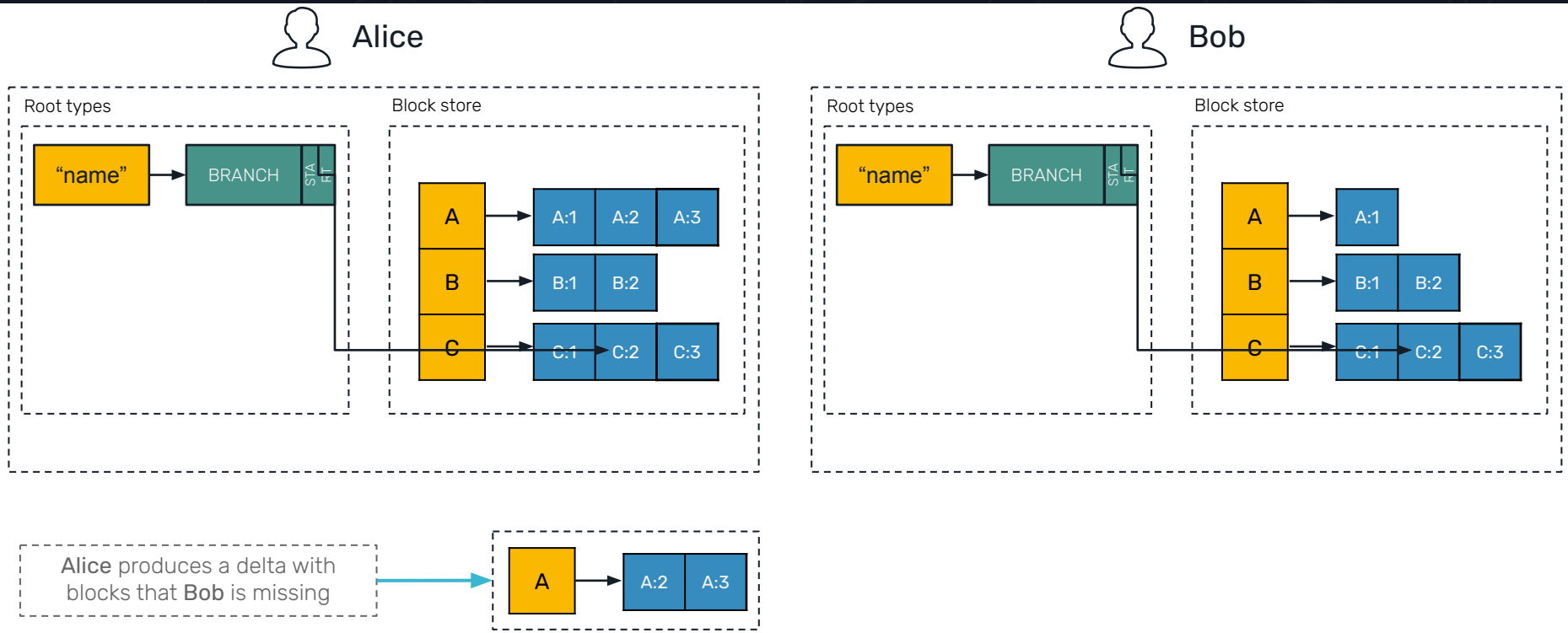
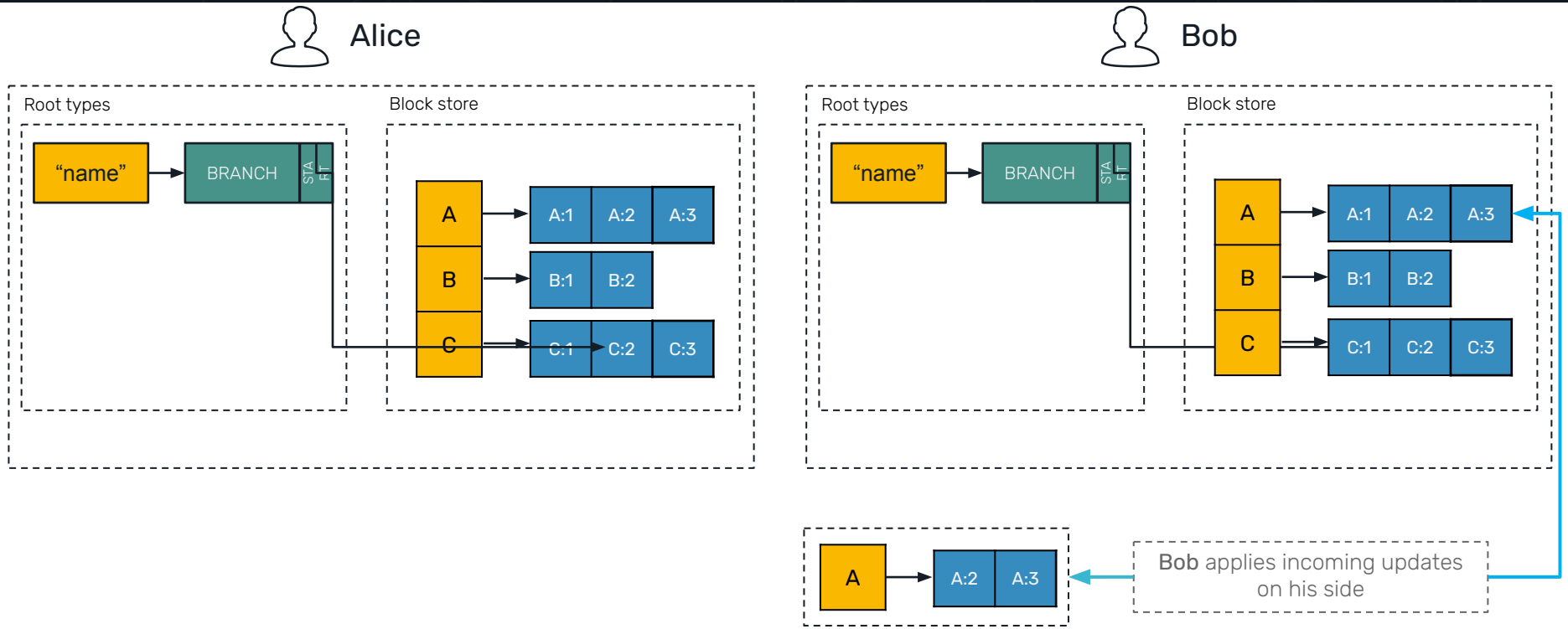


DELTA REPLICATION



OPTIMIZATIONS

4. INSERTING ELEMENTS CONSECUTIVELY

```
let doc = Doc::new();
let txt = doc.transact().get_text("text");
txt.insert(&mut doc.transact(), 0, "hello");
txt.insert(&mut doc.transact(), 5, "world");
```

OPTIMIZATIONS

CACHING LATEST POSITION

MAPPING BETWEEN USER INDEX AND BLOCK ID INTRODUCES COST

OPTIMIZATIONS

CURSORS

```
let doc = Doc::new();
let txt = doc.transact().get_text("text");
let mut cursor = txt.seek(0);
cursor.insert(&mut doc.transact(), "hello");
cursor.insert(&mut doc.transact(), "world");
```

SUMMARY

CRDT PROJECTS

- Yjs/Yrs: https://crates.io/crates/yrs
- Automerge: https://automerge.org/
- Ditto.live: https://www.ditto.live/
- RiakDB: https://riak.com/
- Amazon DynamoDB: https://aws.amazon.com/dynamodb/
- AntidoteDB: https://www.antidotedb.eu/

REFERENCES

- CRDTs deep dive: https://bartoszsypytkowski.com/tag/crdt/
- List of aggregated CRDT articles: https://crdt.tech
- Making CRDTs faster: https://josephg.com/blog/crdts-go-brrr/

THANK YOU