

Merge

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Handling Write Operations

- ❑ All destructive write operations, e.g. INSERT and UPDATE, are stored within a differential buffer (delta) first
- ❑ Read-operations on differential buffer are more expensive than on main store
- ❑ Outdated tuples values in main store are invalidated
- ❑ To guarantee optimal performance the differential buffer needs to be merged periodically into the main store

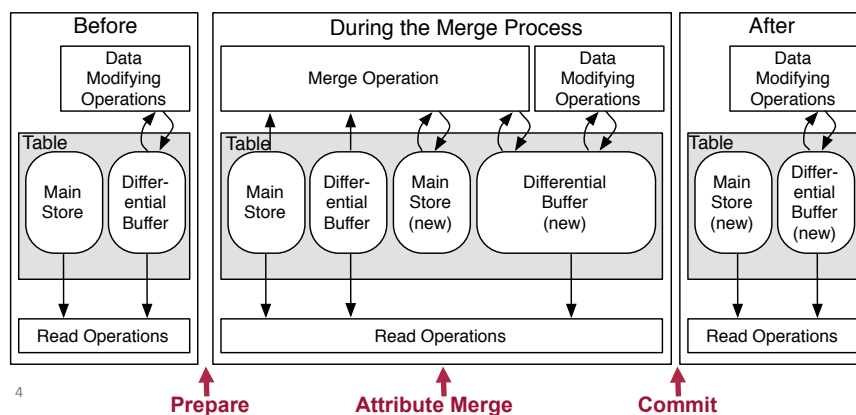
Merge Process Overview

- The merge process is working table wise
- Consists of:
 1. Prepare merge
 2. Attribute merge
 3. Commit merge
- Is triggered by:
 - Amount of tuples in buffer
 - Cost model, which e.g. takes query cost into account

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Online Merge

- Working on data copies allows asynchronous merge
- Very limited interruption due to short lock
- But: At least twice the memory needed!



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- ❑ Check validity vector of entries
- ❑ Merge main and differential buffer dictionaries
- ❑ Create mappings if valueIDs changed

- ❑ Create new main column (if needed)
- ❑ Rewrite main store column attribute vector if
 - ❑ Dictionary increases over #bit value range
 - ❑ Sort changed dictionary values

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Dictionaries			Attribute Vectors			Validity Vector	
valued	fname	city	recID	fname	city	recID	valid
0	Albert	Berlin	0	2	0	0	1
1	Michael	London	1	1	1	1	1
2	Nadja		2	0	0	2	1

The diagram illustrates the structure of three vectors used in the system:

- Dictionaries:** A vector with a single element, `valueID`, which points to a table with two columns: `fname` and `city`.
- Attribute Vectors:** A vector with a single element, `recID`, which points to a table with two columns: `fname` and `city`.
- Validity Vector:** A vector with a single element, `recID`, which points to a table with a single column: `valid`.

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Example

Michael moves from London to Berlin

Main Store

Dictionaries			Attribute Vectors			Validity Vector	
valueID	fname	city	recID	fname	city	recID	valid
0	Albert	Berlin	0	2	0	0	1
1	Michael	London	1	1	1	1	0
2	Nadja		2	0	0	2	1

Differential Buffer

Dictionaries			Attribute Vectors			Validity Vector	
valueID	fname	city	recID	fname	city	recID	valid
0	Michael	Berlin	0	0	0	0	1

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Example

Nadja moves from Berlin to Potsdam

Main Store

Dictionaries			Attribute Vectors			Validity Vector	
valueID	fname	city	recID	fname	city	recID	valid
0	Albert	Berlin	0	2	0	0	0
1	Michael	London	1	1	1	1	0
2	Nadja		2	0	0	2	1

Differential Buffer

Dictionaries			Attribute Vectors			Validity Vector	
valueID	fname	city	recID	fname	city	recID	valid
0	Michael	Berlin	0	0	0	0	1
1	Nadja	Potsdam	1	1	1	1	1

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Example

Michael moves from Berlin to Potsdam

Main Store

Dictionaries			Attribute Vectors			Validity Vector	
valueID	fname	city	recID	fname	city	recID	valid
0	Albert	Berlin	0	2	0	0	0
1	Michael	London	1	1	1	1	0
2	Nadja		2	0	0	2	1

Differential Buffer

Dictionaries			Attribute Vectors			Validity Vector	
valueID	fname	city	recID	fname	city	recID	valid
0	Michael	Berlin	0	0	0	0	0
1	Nadja	Potsdam	1	1	1	1	1
			2	0	1	2	1

Example

Hanna is added, she lives in Dresden

Main Store

Dictionaries			Attribute Vectors			Validity Vector	
valueID	fname	city	recID	fname	city	recID	valid
0	Albert	Berlin	0	2	0	0	0
1	Michael	London	1	1	1	1	0
2	Nadja		2	0	0	2	1

Differential Buffer

Dictionaries			Attribute Vectors			Validity Vector	
valueID	fname	city	recID	fname	city	recID	valid
0	Michael	Berlin	0	0	0	0	0
1	Nadja	Potsdam	1	1	1	1	1
2	Hanna	Dresden	2	0	1	2	1
			3	2	2	3	1

First Step: Validity Detection

Main Store

Dictionaries			Attribute Vectors			Validity Vector	
valueID	fname	city	recID	fname	city	recID	valid
0	Albert	Berlin	0	2	0	0	0
1	Michael	London	1	1	1	1	0
2	Nadja		2	0	0	2	1

Differential Buffer

Dictionaries			Attribute Vectors			Validity Vector	
valueID	fname	city	recID	fname	city	recID	valid
0	Michael	Berlin	0	0	0	0	0
1	Nadja	Potsdam	1	1	1	1	1
2	Hanna	Dresden	2	0	1	2	1
			3	2	2	3	1

Will be moved to history partition

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First Step: Dictionary Merge

- Create combined dictionaries:

Dictionaries

Differential Buffer		Main	
valueID	city	valueID	city
0	Berlin	0	Berlin
1	Potsdam	1	London
2	Dresden		

Combined Dictionaries

valueID	city
0	Berlin
1	Dresden
2	London
3	Potsdam

valueID	fname	valueID	fname
0	Michael	0	Albert
1	Nadja	1	Michael
2	Hanna	2	Nadja

valueID	fname
0	Albert
1	Hanna
2	Michael
3	Nadja

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First Step: Dictionary Merge

Main Store

Dictionaries

valueID	fname	city
0	Albert	Berlin
1	Michael	London
2	Nadja	

Differential Buffer

Dictionaries

valueID	fname	city
0	Michael	Berlin
1	Nadja	Potsdam
2	Hanna	Dresden

Combined Dictionaries

Dictionaries

valueID	fname	city
0	Albert	Berlin
1	Hanna	Dresden
2	Michael	London
3	Nadja	Potsdam

Mappings

fname: old to new Main

Old Main	0	1	2
New Main	0		

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First Step: Dictionary Merge

Main Store

Dictionaries

valueID	fname	city
0	Albert	Berlin
1	Michael	London
2	Nadja	

Differential Buffer

Dictionaries

valueID	fname	city
0	Michael	Berlin
1	Nadja	Potsdam
2	Hanna	Dresden

Combined Dictionaries

Dictionaries

valueID	fname	city
0	Albert	Berlin
1	Hanna	Dresden
2	Michael	London
3	Nadja	Potsdam

Mappings

fname: old to new Main

Old Main	0	1	2
New Main	0	2	

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First Step: Dictionary Merge

Main Store

Dictionaries

valueID	fname	city
0	Albert	Berlin
1	Michael	London
2	Nadja	

Differential Buffer

Dictionaries

valueID	fname	city
0	Michael	Berlin
1	Nadja	Potsdam
2	Hanna	Dresden

Combined Dictionaries

Dictionaries

valueID	fname	city
0	Albert	Berlin
1	Hanna	Dresden
2	Michael	London
3	Nadja	Potsdam

Mappings

fname: old to new Main

Old Main	0	1	2
New Main	0	2	3

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First Step: Dictionary Merge

Main Store

Dictionaries

valueID	fname	city
0	Albert	Berlin
1	Michael	London
2	Nadja	

Differential Buffer

Dictionaries

valueID	fname	city
0	Michael	Berlin
1	Nadja	Potsdam
2	Hanna	Dresden

Combined Dictionaries

Dictionaries

valueID	fname	city
0	Albert	Berlin
1	Hanna	Dresden
2	Michael	London
3	Nadja	Potsdam

Mappings

fname: old to new Main

Old Main	0	1	2
New Main	0	2	3

fname: Delta to new Main

Delta	0	1	2
New Main	2		

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First Step: Dictionary Merge

Main Store

Dictionaries

valueID	fname	city
0	Albert	Berlin
1	Michael	London
2	Nadja	

Differential Buffer

Dictionaries

valueID	fname	city
0	Michael	Berlin
1	Nadja	Potsdam
2	Hanna	Dresden

Combined Dictionaries

Dictionaries

valueID	fname	city
0	Albert	Berlin
1	Hanna	Dresden
2	Michael	London
3	Nadja	Potsdam

Mappings

fname: old to new Main

Old Main	0	1	2
New Main	0	2	3

fname: Delta to new Main

Delta	0	1	2
New Main	2	3	

First Step: Dictionary Merge

Main Store

Dictionaries

valueID	fname	city
0	Albert	Berlin
1	Michael	London
2	Nadja	

Differential Buffer

Dictionaries

valueID	fname	city
0	Michael	Berlin
1	Nadja	Potsdam
2	Hanna	Dresden

Combined Dictionaries

Dictionaries

valueID	fname	city
0	Albert	Berlin
1	Hanna	Dresden
2	Michael	London
3	Nadja	Potsdam

Mappings

fname: old to new Main

Old Main	0	1	2
New Main	0	2	3

fname: Delta to new Main

Delta	0	1	2
New Main	2	3	1

First Step: Dictionary Merge

Main Store

Dictionaries

valueID	fname	city
0	Albert	Berlin
1	Michael	London
2	Nadja	

Differential Buffer

Dictionaries

valueID	fname	city
0	Michael	Berlin
1	Nadja	Potsdam
2	Hanna	Dresden

Combined Dictionaries

Dictionaries

valueID	fname	city
0	Albert	Berlin
1	Hanna	Dresden
2	Michael	London
3	Nadja	Potsdam

Mappings

fname: old to new Main

Old Main	0	1	2
New Main	0	2	3

fname: Delta to new Main

Delta	0	1	2
New Main	2	3	1

city: old to new Main

Old Main	0	1
New Main	0	

First Step: Dictionary Merge

Main Store

Dictionaries

valueID	fname	city
0	Albert	Berlin
1	Michael	London
2	Nadja	

Differential Buffer

Dictionaries

valueID	fname	city
0	Michael	Berlin
1	Nadja	Potsdam
2	Hanna	Dresden

Combined Dictionaries

Dictionaries

valueID	fname	city
0	Albert	Berlin
1	Hanna	Dresden
2	Michael	London
3	Nadja	Potsdam

Mappings

fname: old to new Main

Old Main	0	1	2
New Main	0	2	3

fname: Delta to new Main

Delta	0	1	2
New Main	2	3	1

city: old to new Main

Old Main	0	1
New Main	0	2

First Step: Dictionary Merge

Main Store

Dictionaries

valueID	fname	city
0	Albert	Berlin
1	Michael	London
2	Nadja	

Differential Buffer

Dictionaries

valueID	fname	city
0	Michael	Berlin
1	Nadja	Potsdam
2	Hanna	Dresden

Combined Dictionaries

Dictionaries

valueID	fname	city
0	Albert	Berlin
1	Hanna	Dresden
2	Michael	London
3	Nadja	Potsdam

Mappings

fname: old to new Main

Old Main	0	1	2
New Main	0	2	3

fname: Delta to new Main

Delta	0	1	2
New Main	2	3	1

city: old to new Main

Old Main	0	1
New Main	0	2

city: Delta to new Main

Delta	0	1	2
New Main	0		

First Step: Dictionary Merge

Main Store

Dictionaries

valueID	fname	city
0	Albert	Berlin
1	Michael	London
2	Nadja	

Differential Buffer

Dictionaries

valueID	fname	city
0	Michael	Berlin
1	Nadja	Potsdam
2	Hanna	Dresden

Combined Dictionaries

Dictionaries

valueID	fname	city
0	Albert	Berlin
1	Hanna	Dresden
2	Michael	London
3	Nadja	Potsdam

Mappings

fname: old to new Main

Old Main	0	1	2
New Main	0	2	3

fname: Delta to new Main

Delta	0	1	2
New Main	2	3	1

city: old to new Main

Old Main	0	1
New Main	0	2

city: Delta to new Main

Delta	0	1	2
New Main	0	3	

First Step: Dictionary Merge

Main Store

Dictionaries

valueID	fname	city
0	Albert	Berlin
1	Michael	London
2	Nadja	

Differential Buffer

Dictionaries

valueID	fname	city
0	Michael	Berlin
1	Nadja	Potsdam
2	Hanna	Dresden

Combined Dictionaries

Dictionaries

valueID	fname	city
0	Albert	Berlin
1	Hanna	Dresden
2	Michael	London
3	Nadja	Potsdam

Mappings

fname: old to new Main

Old Main	0	1	2
New Main	0	2	3

fname: Delta to new Main

Delta	0	1	2
New Main	2	3	1

city: old to new Main

Old Main	0	1
New Main	0	2

city: Delta to new Main

Delta	0	1	2
New Main	0	3	1

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Second Step: Translation of Columns

Main Store

Original Attribute Vector

recID	fname	city
0	2	0
1	1	1
2	0	0

Mappings

fname: old to new Main

Old Main	0	1	2
New Main	0	2	3

city: old to new Main

Old Main	0	1
New Main	0	2

Attribute Vector translated

recID	fname	city
0		
1		
2		

Differential Buffer

Original Attribute Vector

recID	fname	city
0	0	0
1	1	1
2	0	1
3	2	2

fname: Delta to new Main

Delta	0	1	2
New Main	2	3	1

city: Delta to new Main

Delta	0	1	2
New Main	0	3	1

Attribute Vector translated

recID	fname	city
0		
1		
2		
3		

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Second Step: Translation of Columns

Main Store

Original Attribute Vector

recID	fname	city
0	2	0
1	1	1
2	0	0

Mappings

fname: old to new Main

Old Main	0	1	2
New Main	0	2	3

city: old to new Main

Old Main	0	1
New Main	0	2

Attribute Vector translated

recID	fname	city
0	3	
1		
2		

Differential Buffer

Original Attribute Vector

recID	fname	city
0	0	0
1	1	1
2	0	1
3	2	2

fname: Delta to new Main

Delta	0	1	2
New Main	2	3	1

city: Delta to new Main

Delta	0	1	2
New Main	0	3	1

Attribute Vector translated

recID	fname	city
0		
1		
2		
3		

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Second Step: Translation of Columns

Main Store

Original Attribute Vector

recID	fname	city
0	2	0
1	1	1
2	0	0

Mappings

fname: old to new Main

Old Main	0	1	2
New Main	0	2	3

city: old to new Main

Old Main	0	1
New Main	0	2

Attribute Vector translated

recID	fname	city
0	3	
1	2	
2		

Differential Buffer

Original Attribute Vector

recID	fname	city
0	0	0
1	1	1
2	0	1
3	2	2

fname: Delta to new Main

Delta	0	1	2
New Main	2	3	1

city: Delta to new Main

Delta	0	1	2
New Main	0	3	1

Attribute Vector translated

recID	fname	city
0		
1		
2		
3		

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Second Step: Translation of Columns

Main Store

Original Attribute Vector

recID	fname	city
0	2	0
1	1	1
2	0	0

Mappings

fname: old to new Main

Old Main	0	1	2
New Main	0	2	3

city: old to new Main

Old Main	0	1
New Main	0	2

Attribute Vector translated

recID	fname	city
0	3	
1	2	
2	0	

Differential Buffer

Original Attribute Vector

recID	fname	city
0	0	0
1	1	1
2	0	1
3	2	2

fname: Delta to new Main

Delta	0	1	2
New Main	2	3	1

city: Delta to new Main

Delta	0	1	2
New Main	0	3	1

Attribute Vector translated

recID	fname	city
0		
1		
2		
3		

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Second Step: Translation of Columns

Main Store

Original Attribute Vector

recID	fname	city
0	2	0
1	1	1
2	0	0

Mappings

fname: old to new Main

Old Main	0	1	2
New Main	0	2	3

city: old to new Main

Old Main	0	1
New Main	0	2

Attribute Vector translated

recID	fname	city
0	3	0
1	2	
2	0	

Differential Buffer

Original Attribute Vector

recID	fname	city
0	0	0
1	1	1
2	0	1
3	2	2

fname: Delta to new Main

Delta	0	1	2
New Main	2	3	1

city: Delta to new Main

Delta	0	1	2
New Main	0	3	1

Attribute Vector translated

recID	fname	city
0		
1		
2		
3		

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Second Step: Translation of Columns

Main Store

Original Attribute Vector

recID	fname	city
0	2	0
1	1	1
2	0	0

Mappings

fname: old to new Main

Old Main	0	1	2
New Main	0	2	3

city: old to new Main

Old Main	0	1
New Main	0	2

Attribute Vector translated

recID	fname	city
0	3	0
1	2	2
2	0	0

Differential Buffer

Original Attribute Vector

recID	fname	city
0	0	0
1	1	1
2	0	1
3	2	2

fname: Delta to new Main

Delta	0	1	2
New Main	2	3	1

city: Delta to new Main

Delta	0	1	2
New Main	0	3	1

Attribute Vector translated

recID	fname	city
0	2	0
1	3	3
2	2	3
3	1	1

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Second Step: New Main Columns

Main Store

Dictionaries

valueID	fname	city
0	Albert	Berlin
1	Hanna	Dresden
2	Michael	London
3	Nadja	Potsdam

Attribute Vectors

recID	fname	city
0	3	0
1	2	2
2	0	0
3	2	0
4	3	3
5	2	3
6	1	1

Validity Vector

recID	valid
0	0
1	0
2	1
3	0
4	1
5	1
6	1

Differential Buffer

Dictionaries

valueID	fname	city
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Attribute Vectors

recID	fname	city
-------	-------	------

Validity Vector

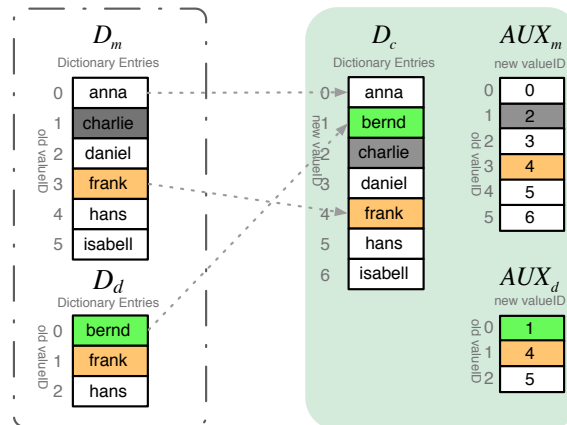
recID	valid
-------	-------

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First Step: Dictionary Merge

Inputs Step 1

Outputs Step 1

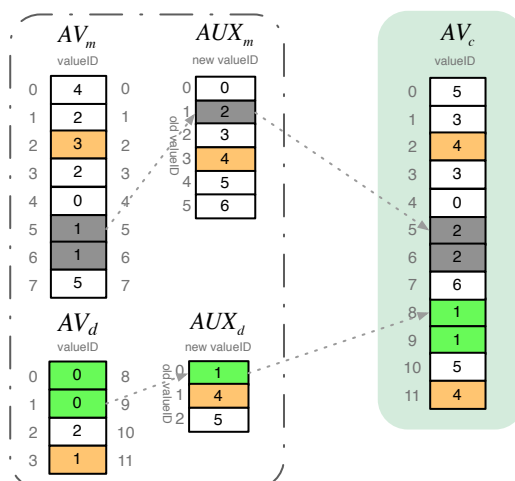


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Second Step: Attribute Vector Rewriting

Inputs Step 2

Output Step 2



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