PRISM++

Update Rewriting and Integrity Constraint Maintenance

Carlo Curino

Hyun J. Moon, Alin Deutsch, Carlo Zaniolo

Motivation

- Information Systems Evolution… it's hard!

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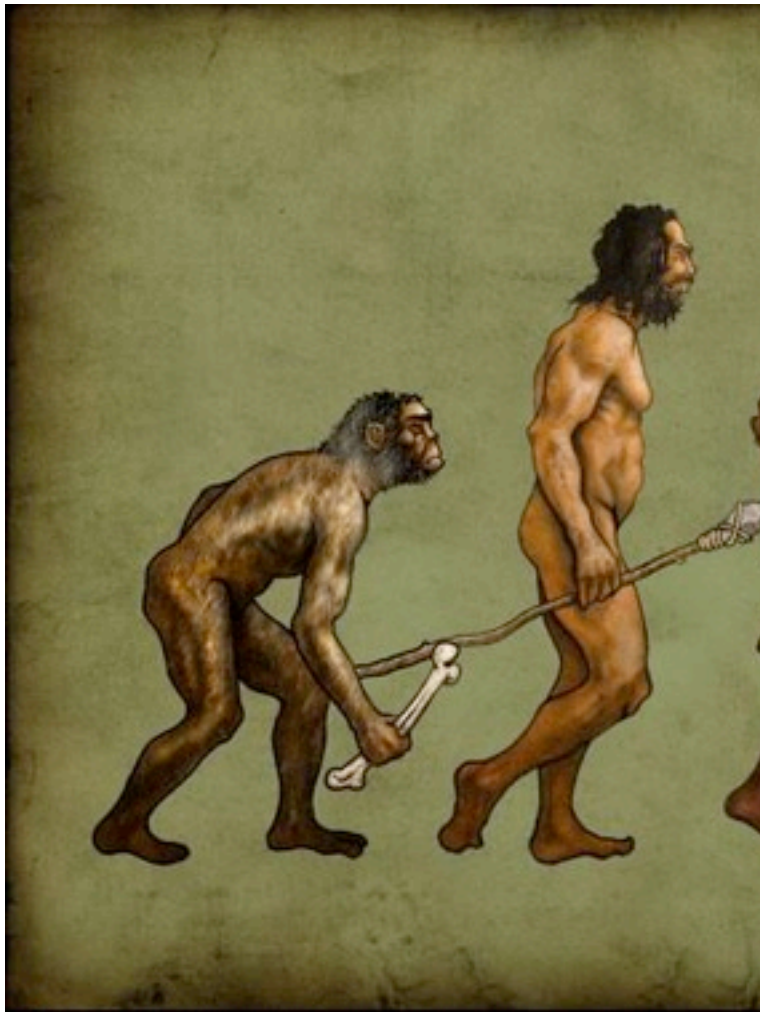

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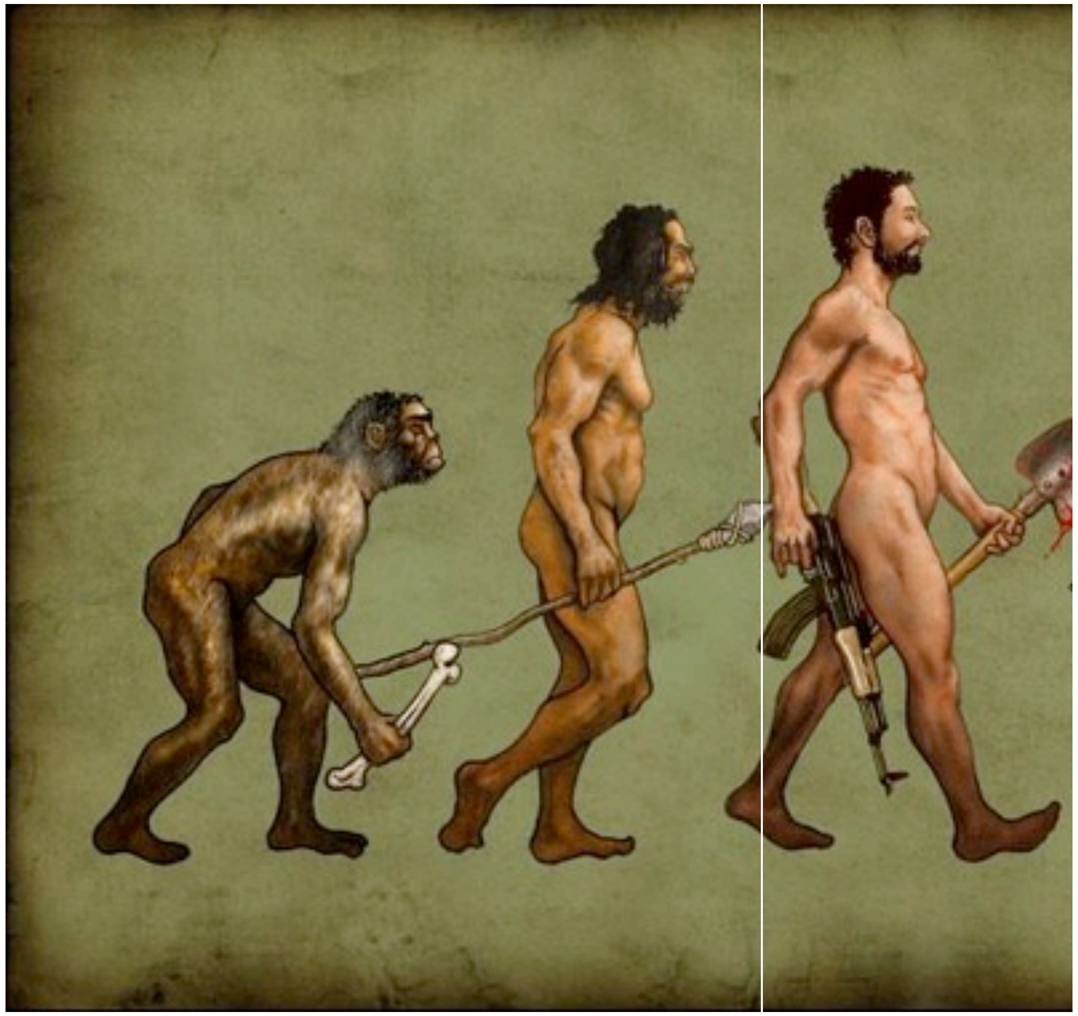

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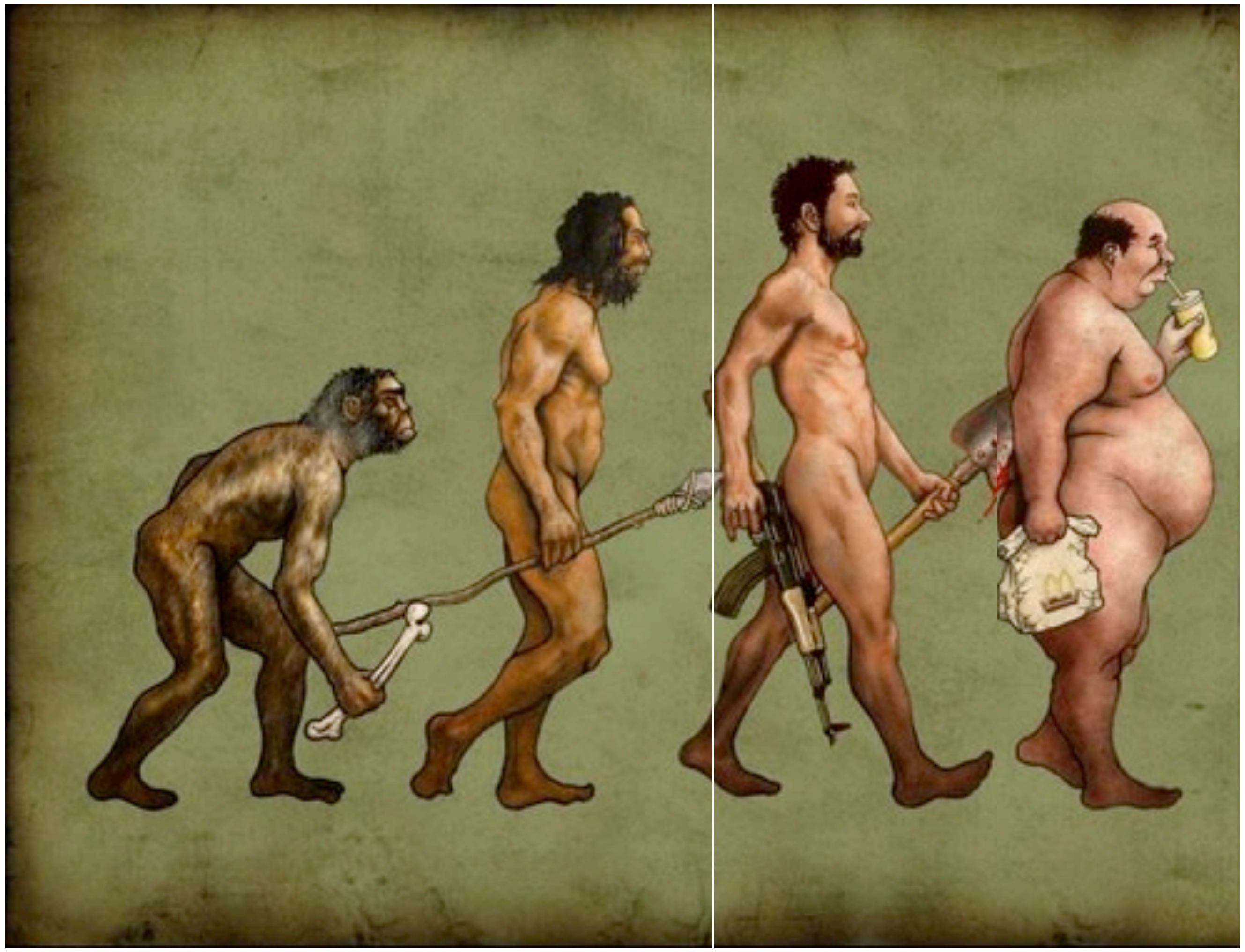

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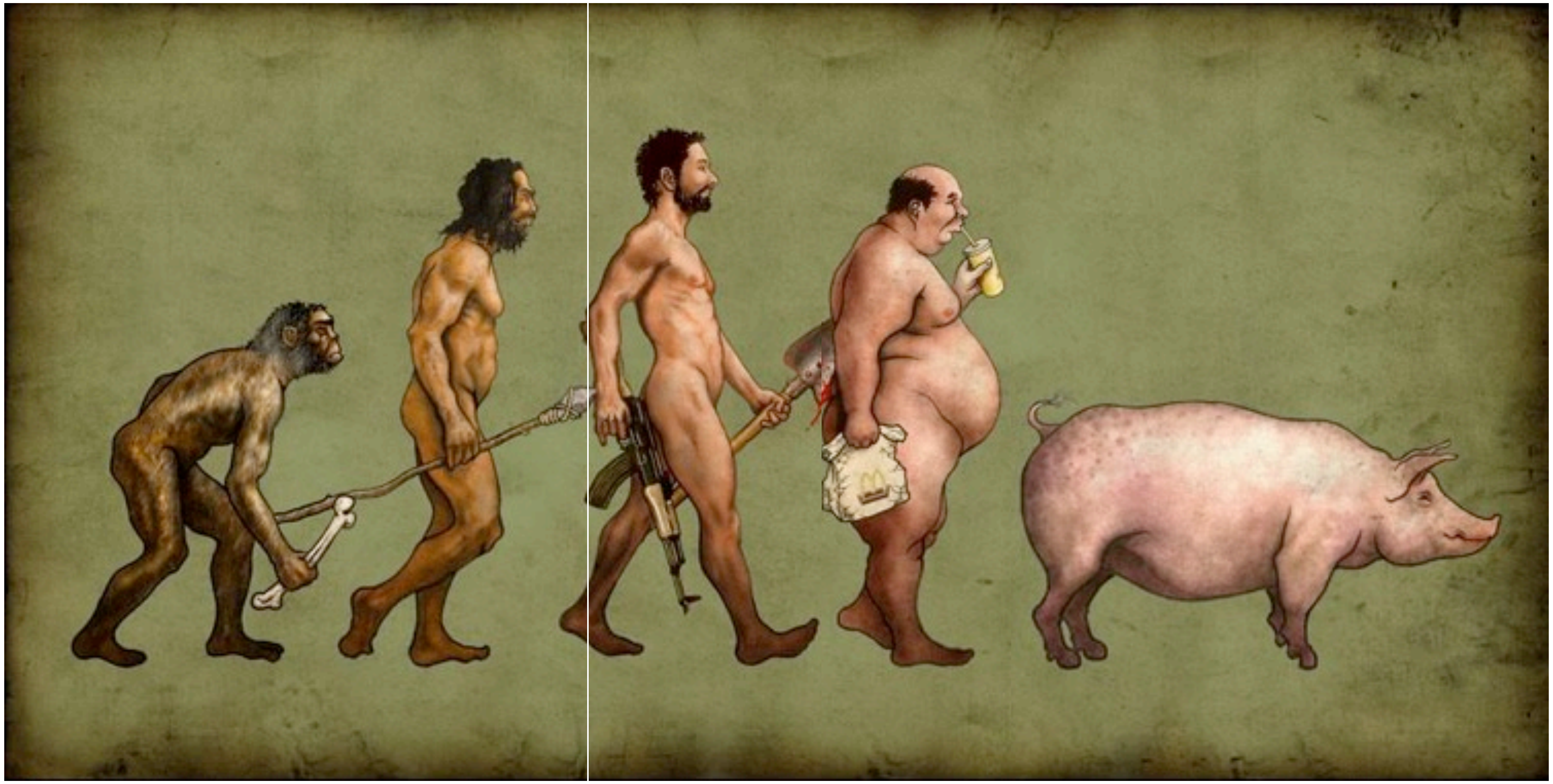

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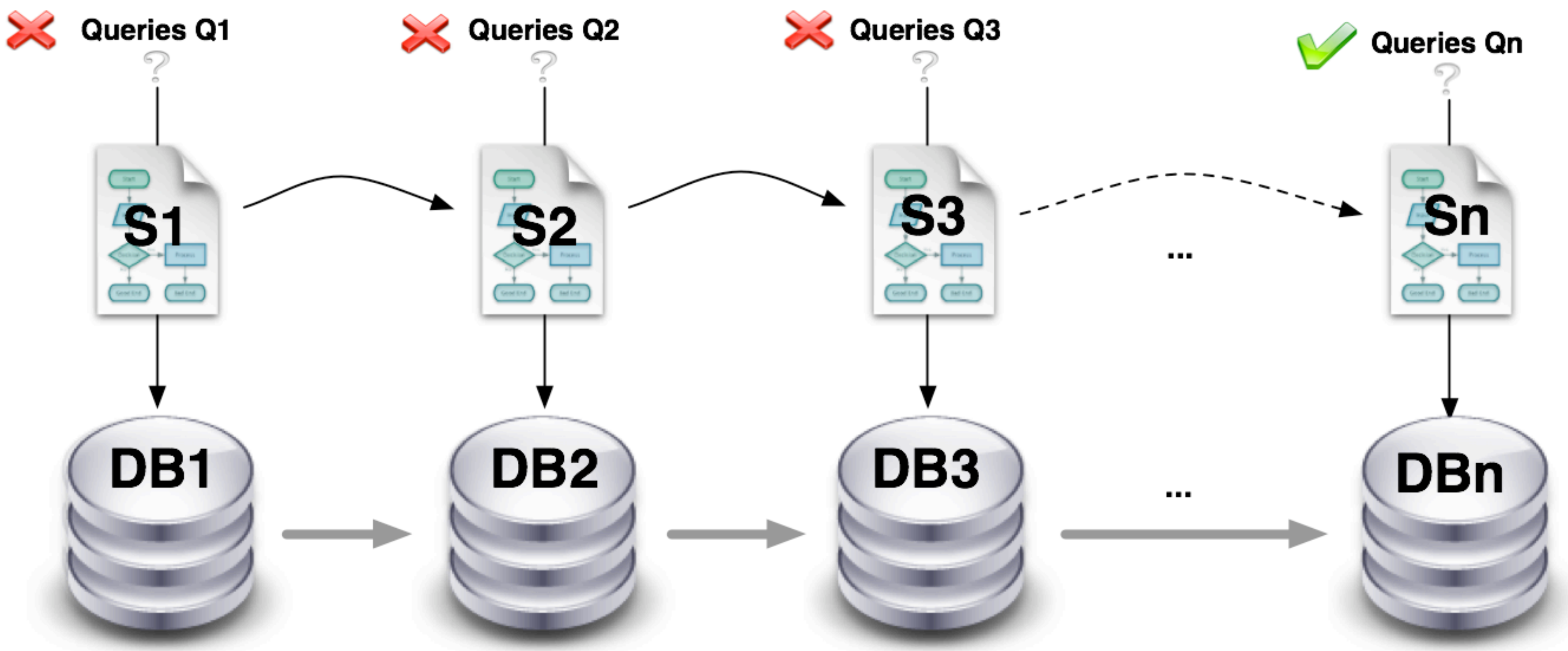
Motivation: Schema Evolution



- change schema
- migrate data
- fix queries/updates
- check/modify app code

Motivation: Schema Evolution

System Name	System type	# of schema versions	lifetime (years)
ATutor	Educational CMS	216	5.7
CERN DQ2	Scientific DB	51	1.3
Dekiwiki	CRM, ERP	11	1.11
E107	CMS	16	5.4
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- Average of 31 schema version per year

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Our Previous Work

	Structural Evolution	Integrity Constraints Evolution
Data	✓	✓ ✗
Queries	✓	✗
Updates	✗	✗

- Schema Modification Operators (SMOs)
- Query rewriting engine based on <u>*chase&backchase*</u>

What are we going to do?

- Integrity Constraints Evolution
  - Introduce integrity-constraint mod. operators (ICMOs)
  - Adapt schema modification operators (SMOs)

- Updates (and queries with negation)
  - Novel update representation *(query equivalence)*
  - Extended rewriting engine *(support for negation and ICMOs)*

Evolution Operators

- Key idea: *separate structural changes (SMOs) from non-information preserving* ones (ICMOs)*

**information-preserving = invertible mapping = constant information-capacity*

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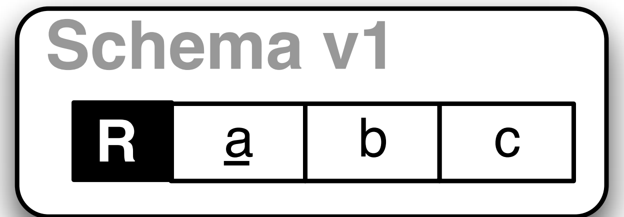

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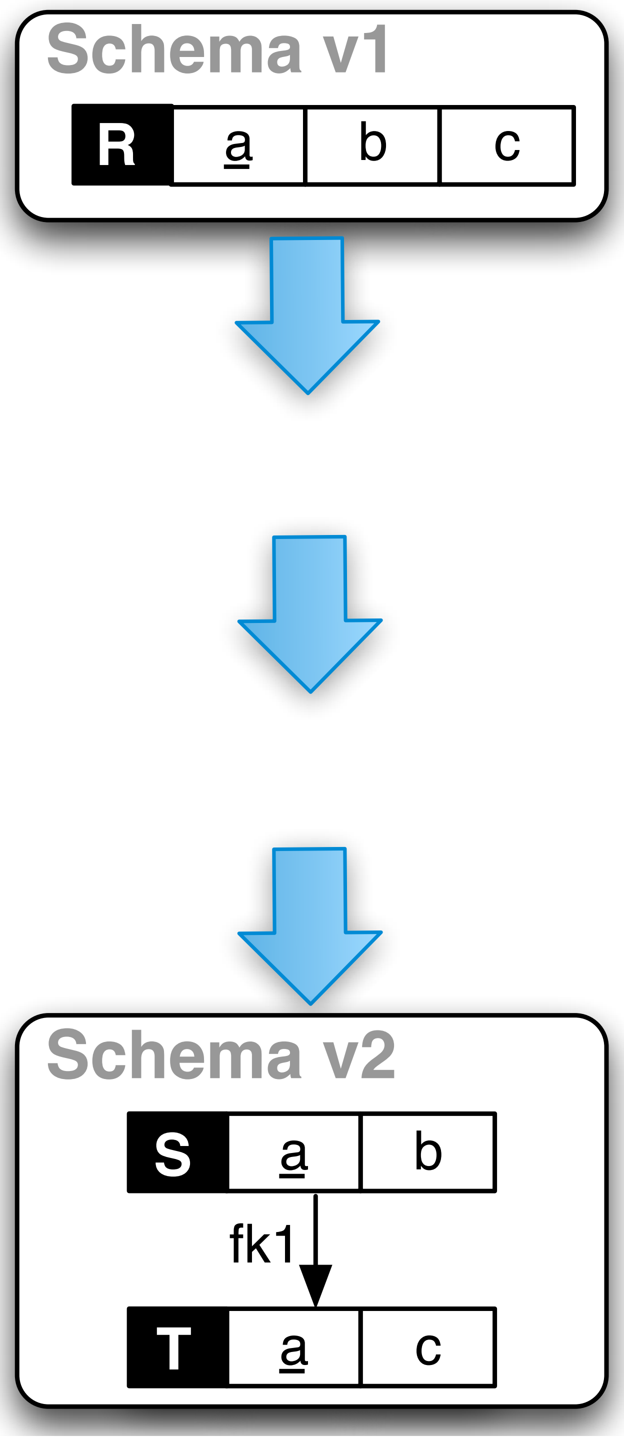

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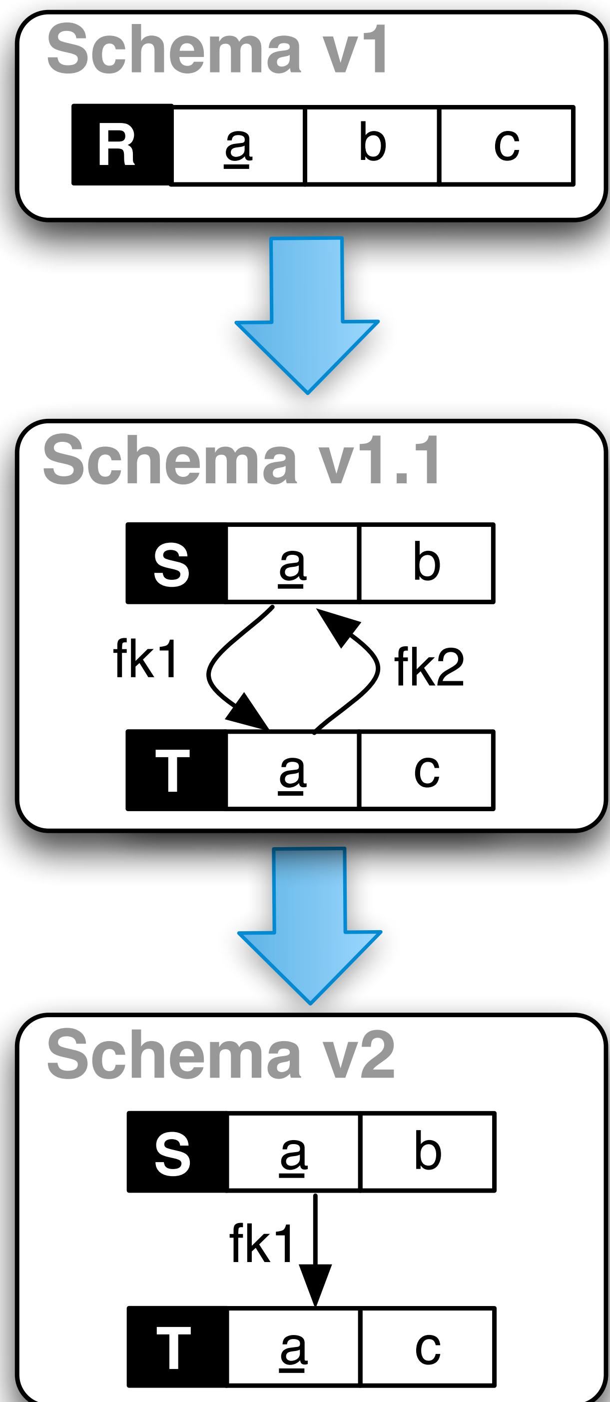


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DECOMPOSE R INTO S(a,b), T(a,c);
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```
ALTER TABLE T DROP FOREIGN KEY fk2;
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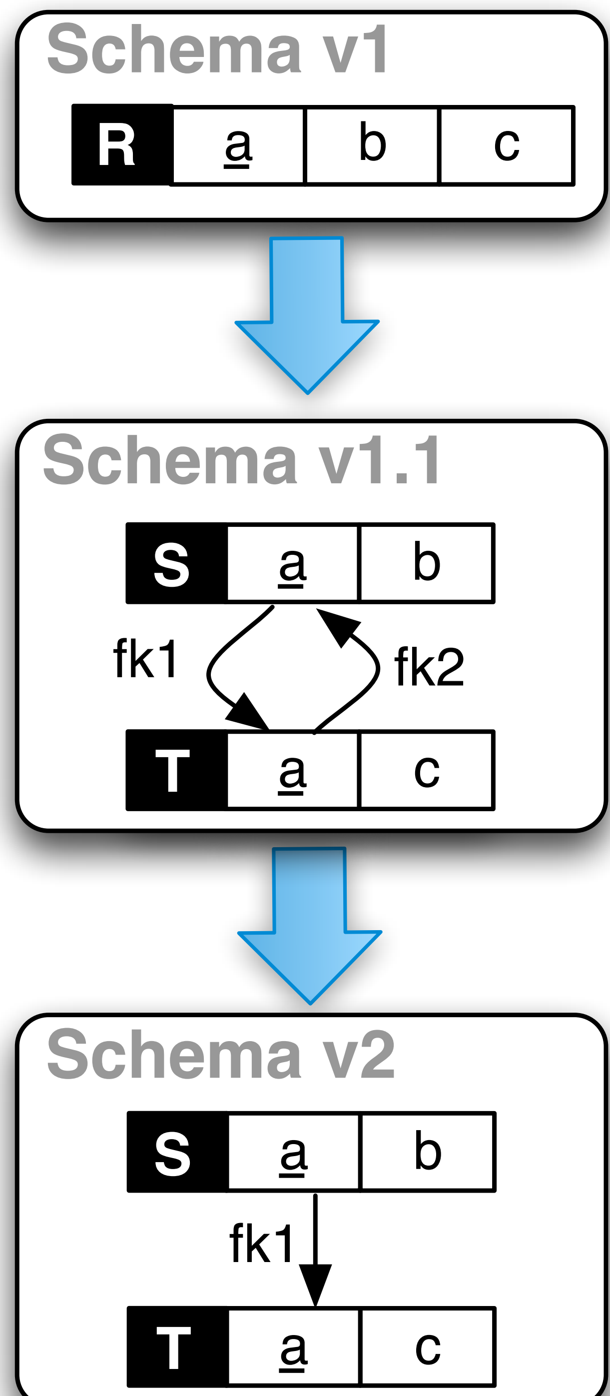

DECOMPOSE R INTO S(a,b), T(a,c);

- changes to schema structure
- information preserving

ALTER TABLE T DROP FOREIGN KEY fk2;

- no changes to schema structure
- not information preserving

Good/Bad News

- We force every *SMO* to be information-preserving (*data migration and query rewriting paradise!*)

- *ICMOs:*
  - risk of data loss
  - rewriting not obvious (*new alg.*)
  - inverse operator (*user input*)

Data Migration

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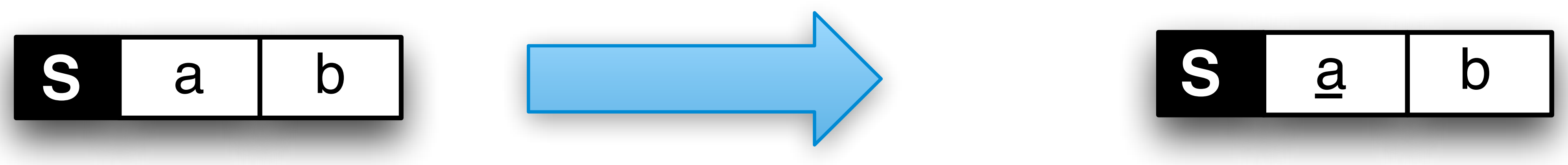

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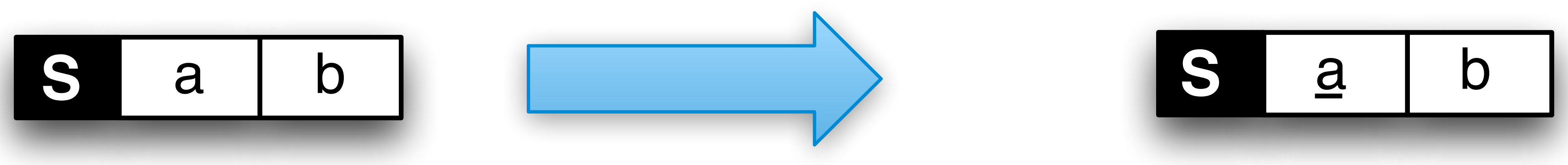

- <policy>:
  - CHECK: *migrates data only if constraint already holds*
  - ENFORCE: *"canonical repair" by moving all violating tuples to special table* S_{viol} a b

Query Rewriting

- Challenge: *evolution towards a "looser" schema (inverse is not inf-preserving)*

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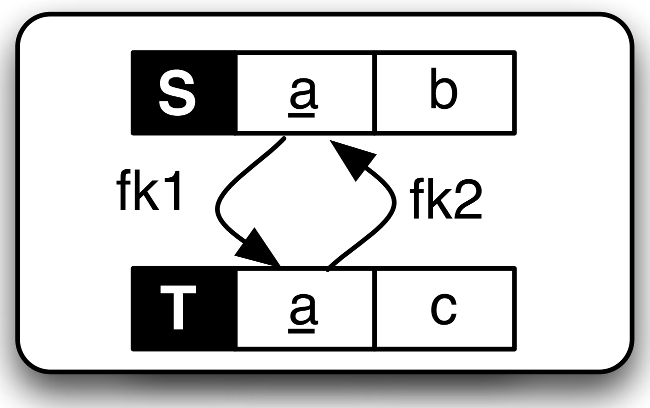


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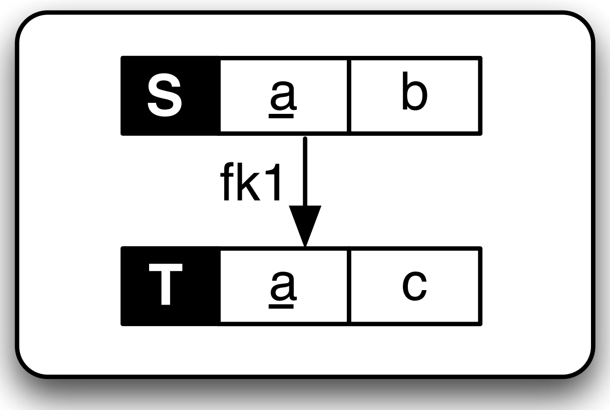

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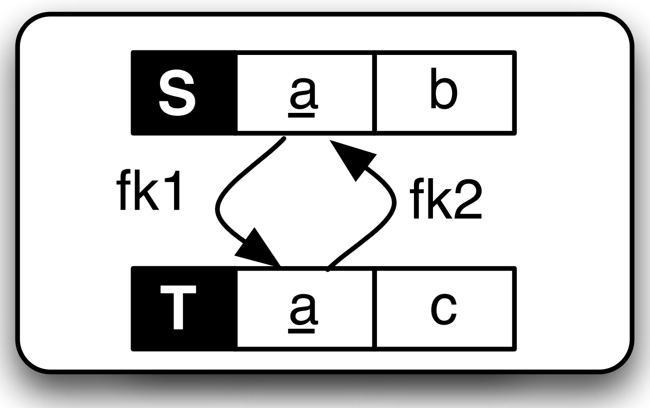


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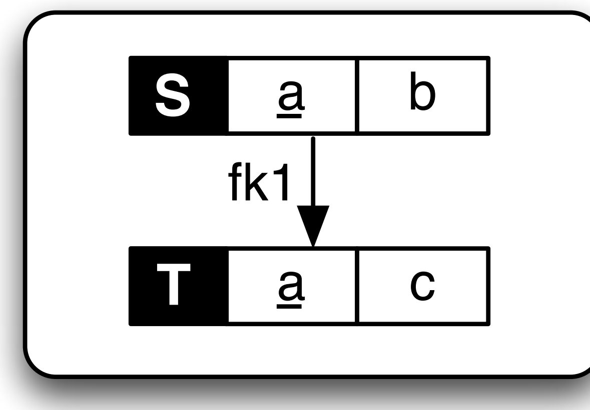


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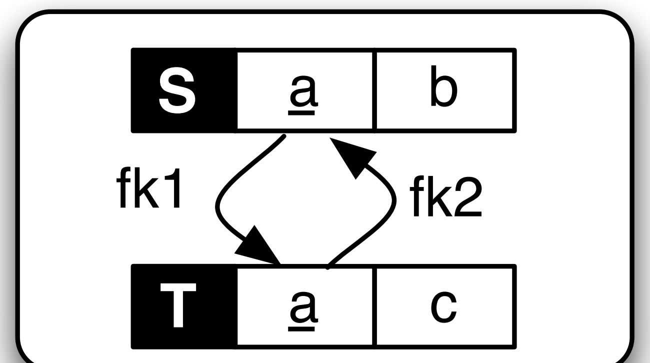


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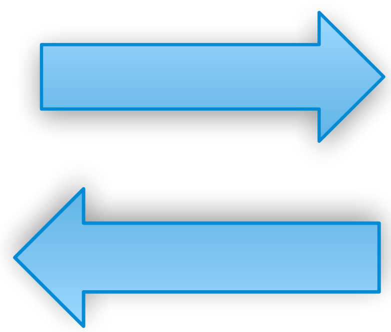

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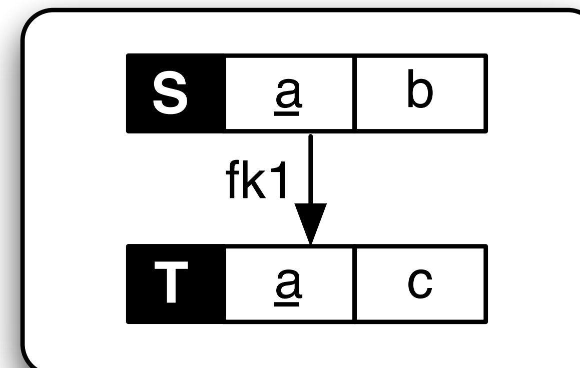

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  - CHECK: *checks constraint before running query*
  - ENFORCE: *limits query scope to non-violating tuples*
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Query Rewriting Example

- ENFORCE: *limits query scope to non-violating tuples*

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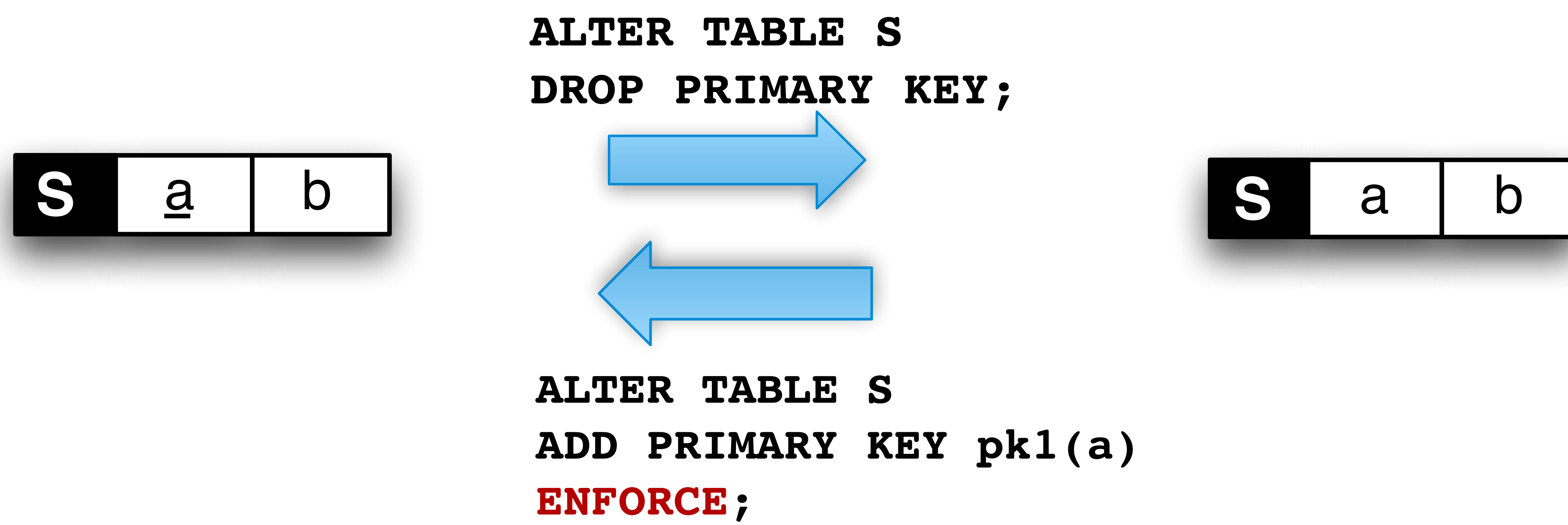

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Query Rewriting Example

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SELECT a,b FROM S
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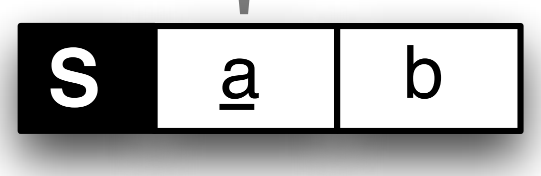


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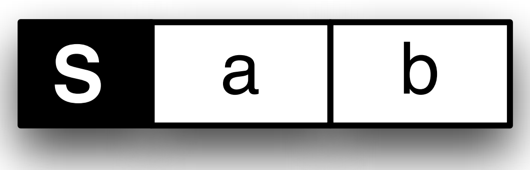


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S	<u>a</u>	b

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SELECT a,b FROM S
WHERE a=1 and NOT EXISTS
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  WHERE S.a=s2.a AND
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S	a	b

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This application of Chase & Back-Chase is sound but not complete

So far...

	Structural Evolution	Integrity Constraints Evolution
Data	✔	✔
Queries	✔	✔
Updates	✘	✘

- Introduce ICMOs, Adapted SMOs
- Extended Query Rewriting Engine (ICMOs + neg.)

Update Rewriting (through SMOs)

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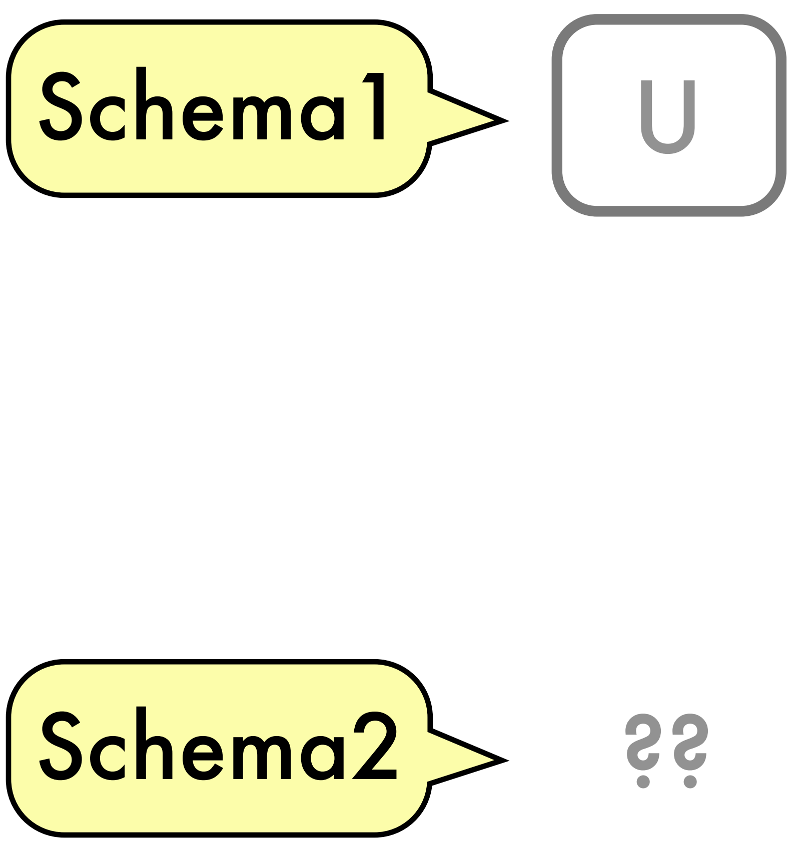

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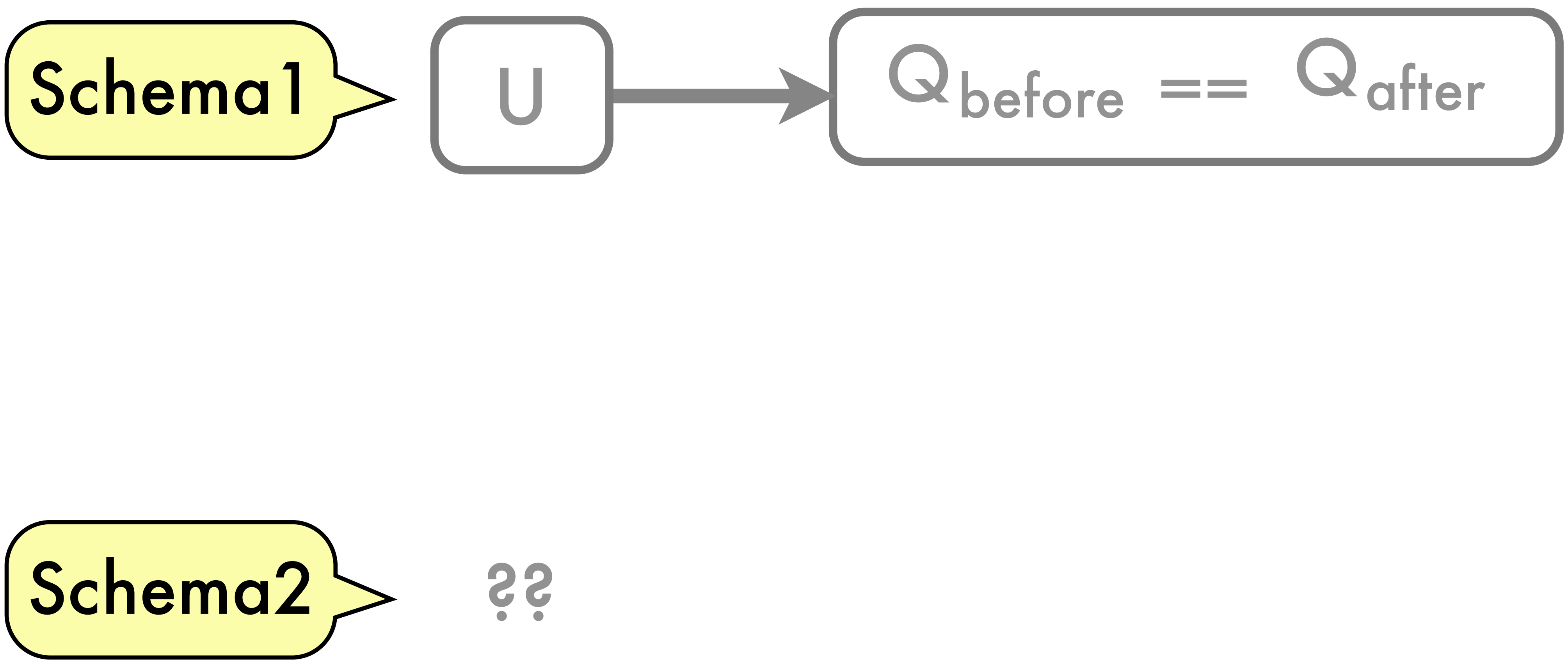

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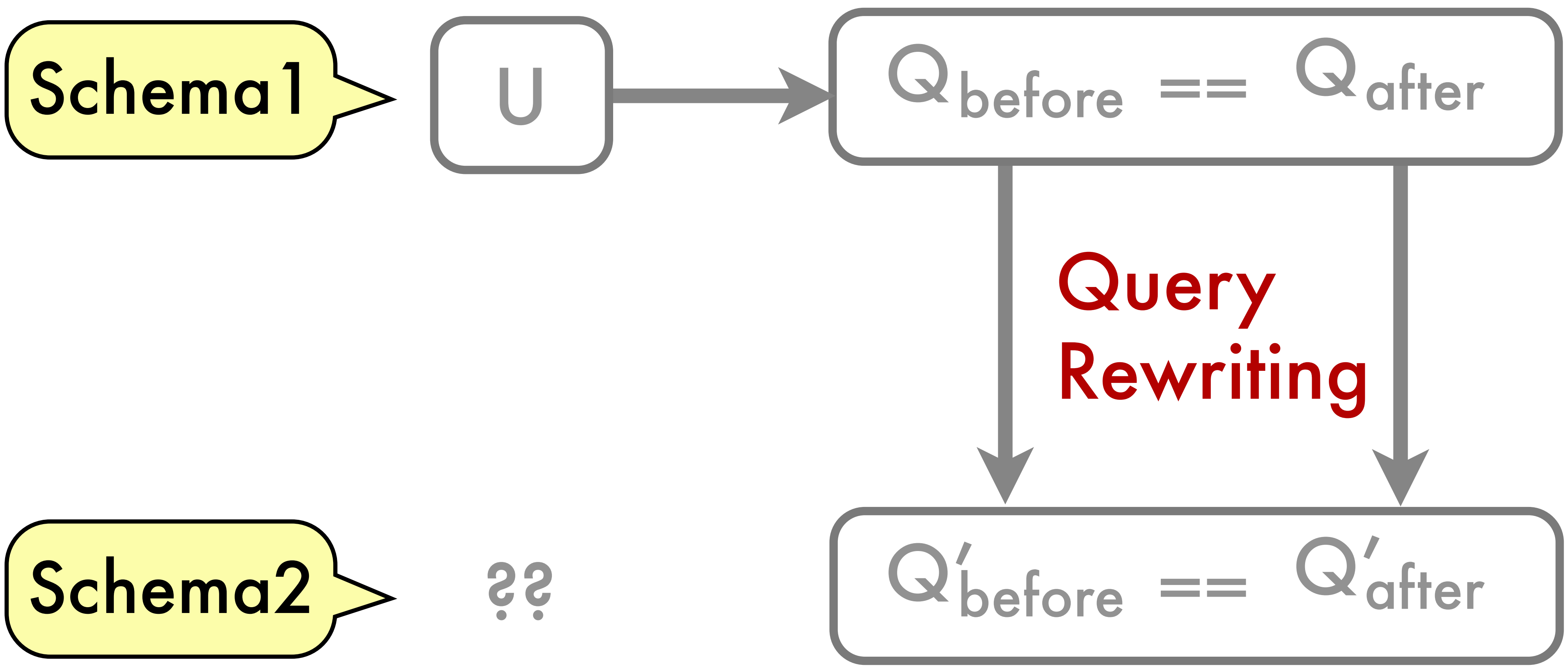

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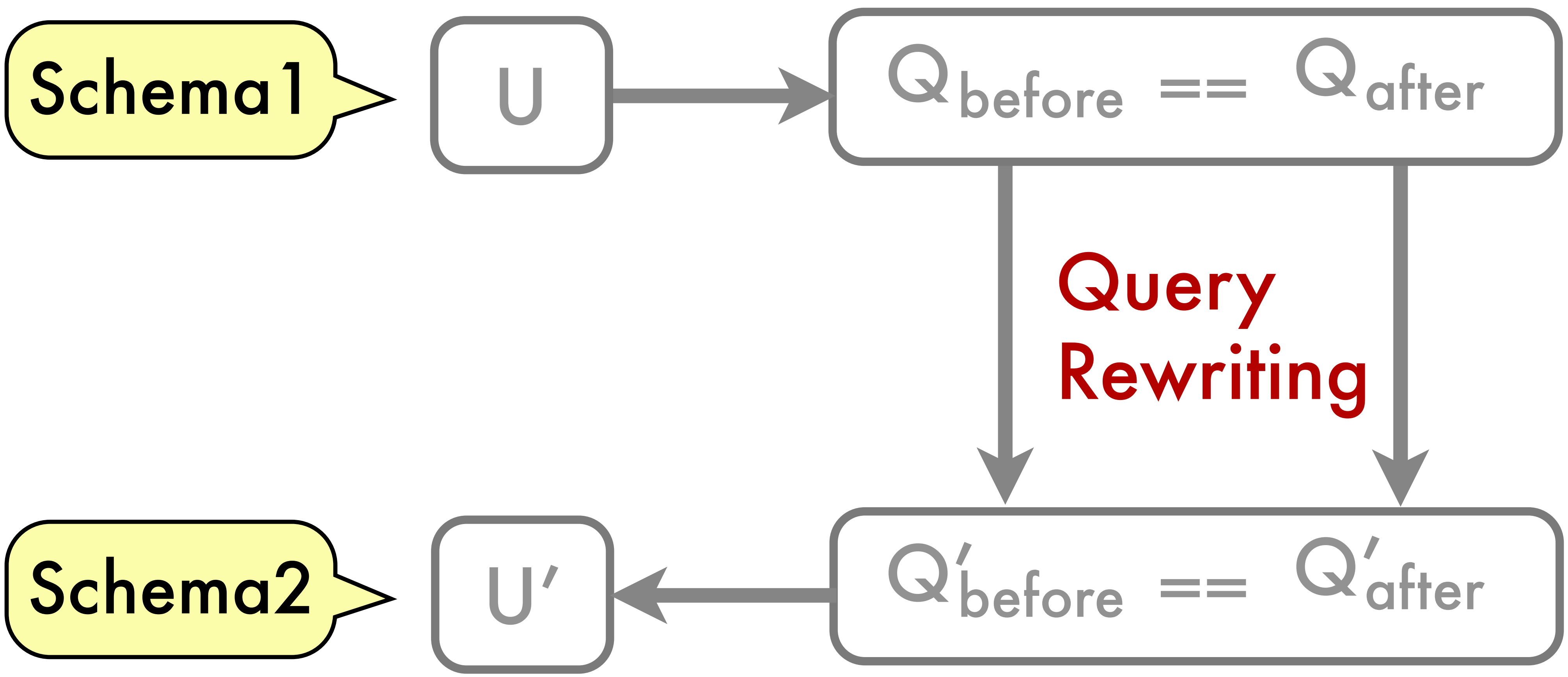

A New Update Representation

- Intuition: *represent updates as (equivalence between) queries, exploit query rewriting*

$$\boxed{U} \longrightarrow \boxed{Q_{before} == Q_{after}}$$

A New Update Representation

- Intuition: *represent updates as (equivalence between) queries, exploit query rewriting*

U → Q_{before} == Q_{after}

```
UPDATE S
SET b=7
WHERE a=1;
```

```
SELECT a,7
FROM S
WHERE a=1;
 UNION
SELECT a,b
FROM S
WHERE a!=1;
```

==

```
SELECT a,b
FROM S;
```

Update Rewriting (through ICMOs)

- Intuition: *the policies specify popular special-cases of view-update problem*

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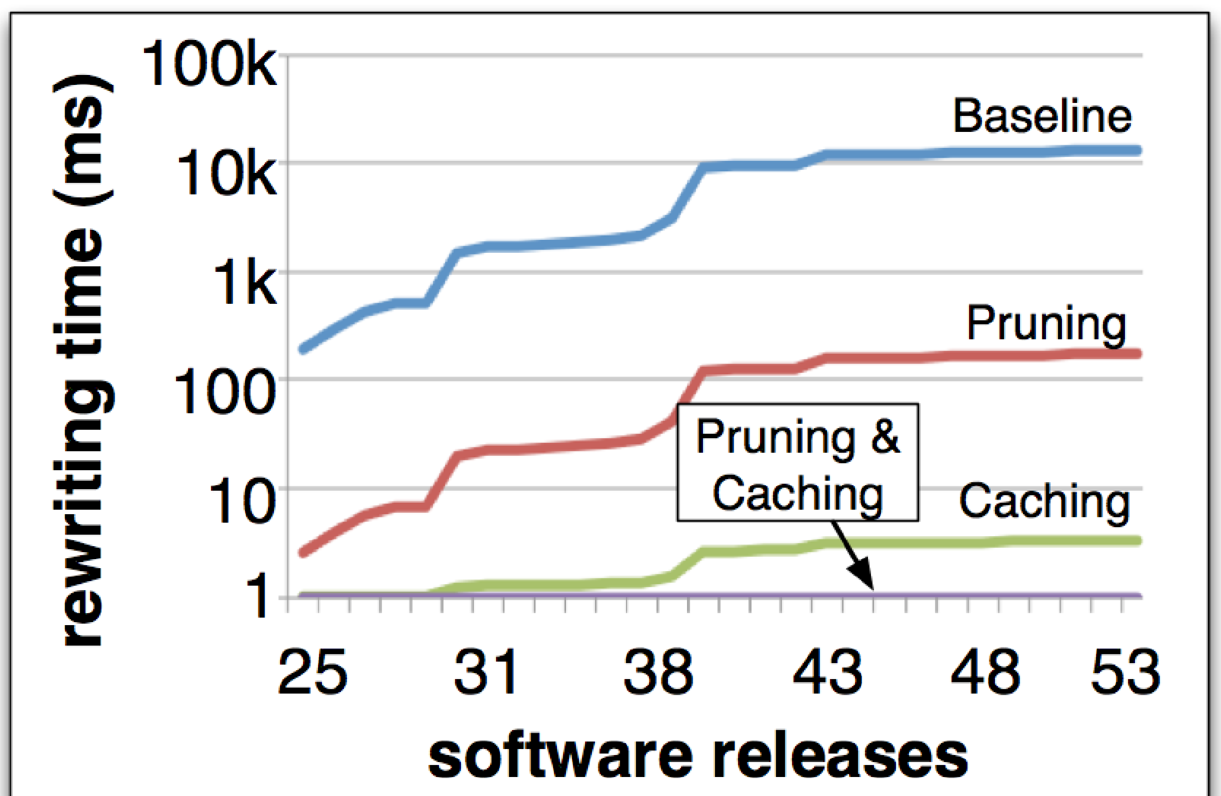
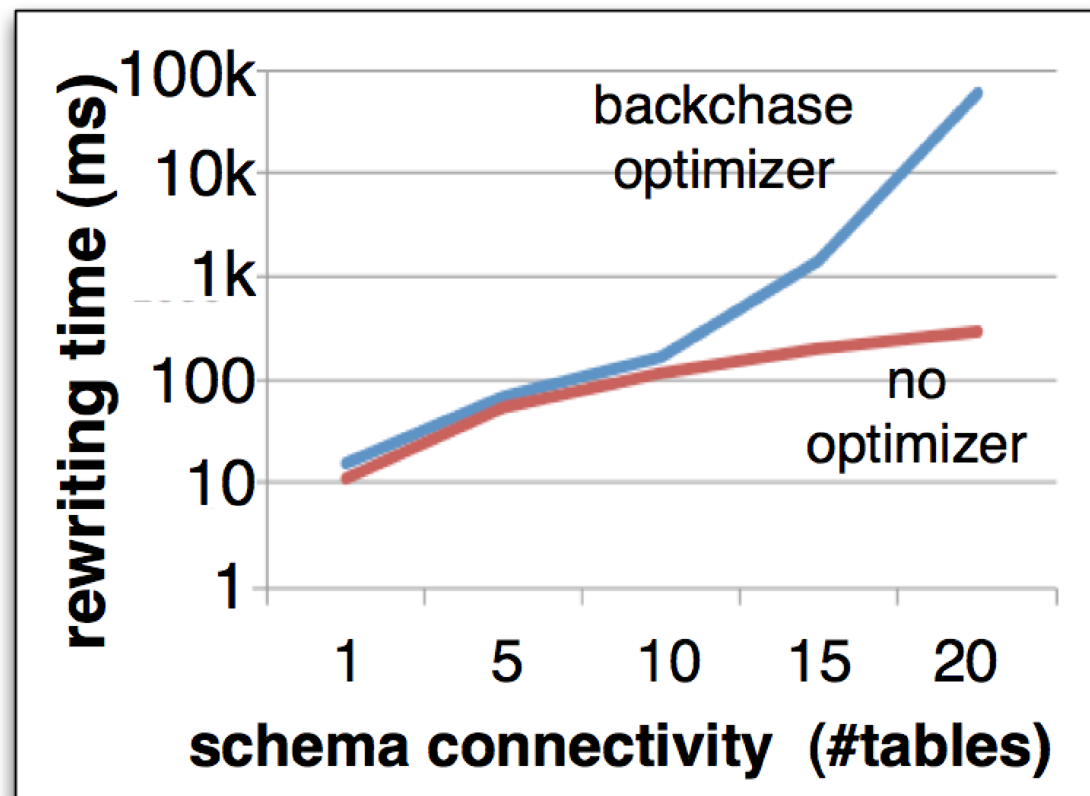
  - <policy>:
    - CHECK: *checks constraint before* ***and after*** *running update*
    - ENFORCE: *limits update scope to non-violating tuples,* ***checks violation-set is not changed***
    - IGNORE: *runs update as-is* ***(allows side effects)***

Optimization

- Challenge: *rewriting complexity depends on mapping size (foreign keys and ICMOs make things harder)*
- *Solution: extract templates, cache rewritings*



Ensembl genetic DB



Synthetic Dataset

Wikipedia hit/miss ratio: up to 88M

Conclusion

- Prism++ is a **high-performance** practical system supporting DB schema-evolution:

	Structural Evolution	Integrity Constraints Evolution
Data	✓	✓
Queries	✓	✓
Updates	✓	✓

For More info contact me:
krl@yahoo-inc.com

Wikipedia

- Solution: *effectiveness of template caching*

Statement type	number of templates	avg hit/miss ratio	max hit/miss ratio
update	142	5,661.21	80,870
select	1294	248,005.41	88,740,689
select*	610	526,096.72	88,740,689

*with improved template extraction factorizing DB names.

Statements	execution time	rewriting time	overhead
S1	77.37 ms	1 ms	1.29%
S2	21.674 ms	1 ms	4.6%
S3	48.2 ms	1 ms	2.07%

Chase & BackChase

- Intuition: *behind the scene Disjunctive Embedded Dependencies and chase-based rewritings*

```
JOIN TABLE gene,g_descr
INTO gene
WHERE gene.id=g_descr.id
```

inverse

```
DECOMPOSE TABLE gene
INTO g_descr(id,description),
     gene(id,type,region,start,end);
```

derive mapping

mapping (S2-S3)

$$gene_3(x,y,z,w,k,l) \implies gene_2(x,y,z,w,k), g\_descr(x,l)$$
$$gene_2(x,y,z,w,k,l), g\_descr(x,l) \implies gene_3(x,y,z,w,k,l)$$

```
SELECT description
FROM gene g, g_descr gd
WHERE g.id=gd.id AND
      g.region=1;
```

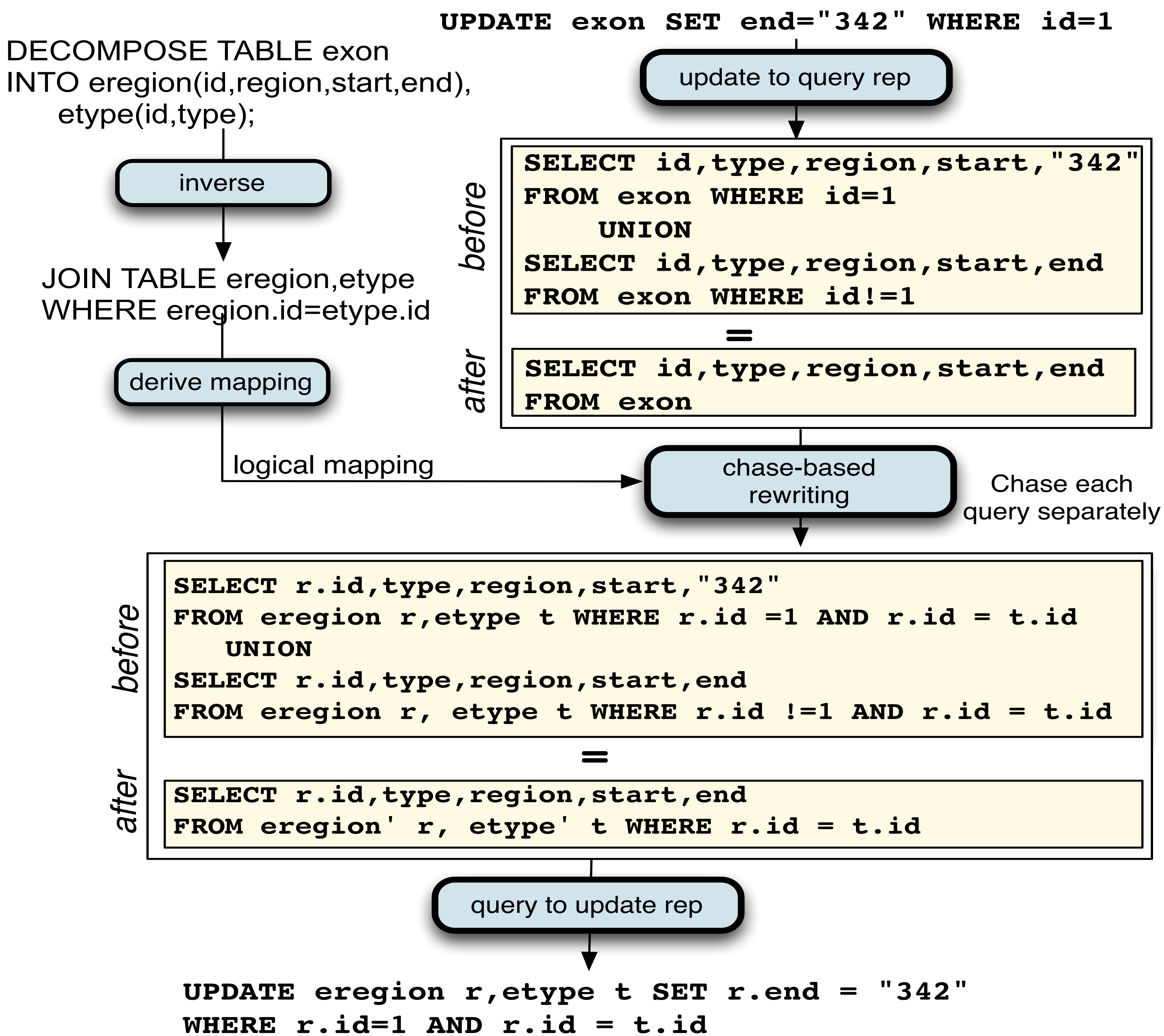
input query (on S2)

chase-based rewriting

rewritten query (on S3)

```
SELECT description
FROM gene g
WHERE g.region=1;
```

Update Rewriting through SMO: Example



Update Rewriting ICMOs: Example

ALTER TABLE exon
DROP PRIMARY KEY pk1

inverse

ALTER TABLE exon
ADD PRIMARY KEY pk1(id)
CHECK

```
INSERT INTO exon VALUES (1,2,3,4,5)
```

ICMO
rewriting

```
@pre = SELECT * FROM exon e,exon e2
       WHERE e.id=e2.id AND e.rank=e2.rank AND
            (e.type!=e2.type OR e.start!=e2.start OR e.end!=e2.end);
@post = SELECT * FROM exon e WHERE e.id=1;

IF(isempty(@pre)&& isempty(@post)) INSERT INTO exon VALUES(1,2,3,4,5)
ELSE RETURN ERROR;
```