Presentation of Update Semantics of Relational Views

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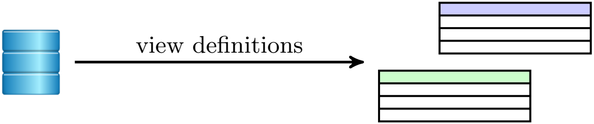
FCCOD 2014

Outline

1. Problem
   - Overview of the problem being addresseds
   - Formal definition of the problem
2. Solution
   - Translation under constant complement
   - Update policy
   - Advantages and disadvantages of solutions

Overview



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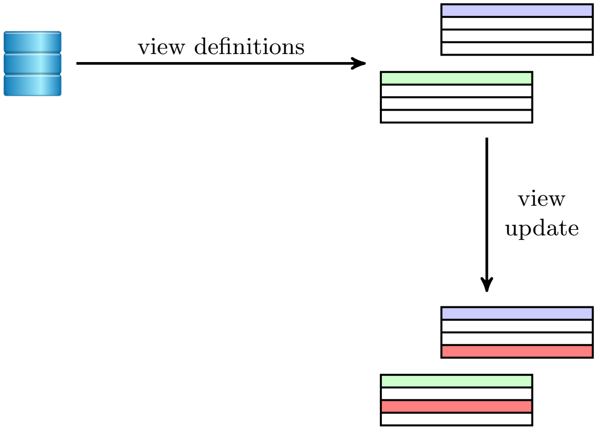

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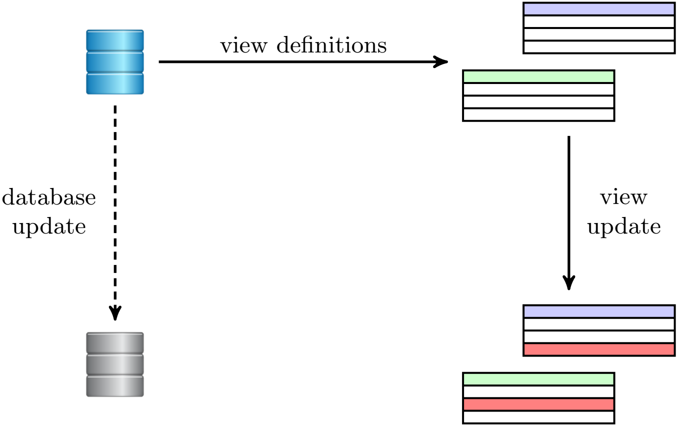

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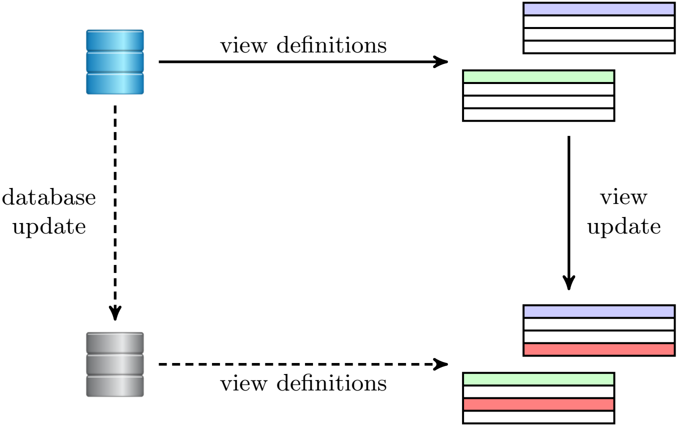
view definitions
database
update
view
update
view definitions

Example 1

Unexpected changes on the view

$$V = E \bowtie D$$

EMP	DEP	MGR
Mike	EEE	Susan

EMP	DEP
Mike	EEE
Mary	CS

DEP	MGR
EEE	Susan

Example 1

Unexpected changes on the view

$$V = E \bowtie D$$

EMP	DEP	MGR
Mike	EEE	Susan
Jane	CS	Alex

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DEP	MGR
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The changes on the db must reflect *exactly* the changes on the view

Example 2

Unjustified changes on the database

$V = \pi_{EMP,\ DEP}(R)$

EMP	DEP
Mike	EEE
Jane	CS

R

EMP	DEP	MGR
Mike	EEE	Susan
Jane	CS	Alex
Jane	CS	Max

Example 2

Unjustified changes on the database

$V = \pi_{EMP,\ DEP}(R)$

EMP	DEP
Mike	EEE
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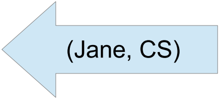

R

EMP	DEP	MGR
Mike	EEE	Susan
Jane	CS	Alex
Jane	CS	Max

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Unjustified changes on the database

$$V = \pi_{\text{EMP, DEP}}(R)$$

EMP	DEP
Mike	EEE
Jane	CS

(Jane, CS)

R

EMP	DEP	MGR
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Jane	CS	Max

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Unjustified changes on the database

$V = \pi_{EMP,\ DEP}(R)$

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Jane	CS

← (Jane, CS)

R

EMP	DEP	MGR
Mike	EEE	Susan
~~Jane~~	~~CS~~	~~Alex~~
Jane	CS	Max

Modify the database *only if required* to reflect the changes on the view

Basic Notation

S database schema - set of all database instances (*database states*)

T set of all view instances (*view states*)

- view $f\colon S \to T$
- view update $u\colon T \to T$
- database update $d\colon S \to S$

U_1 set of all database updates

U_f set of all view updates

Concepts to be formalized

- Q1: Given a view update u, what are the constraints on the database update that translates u ?

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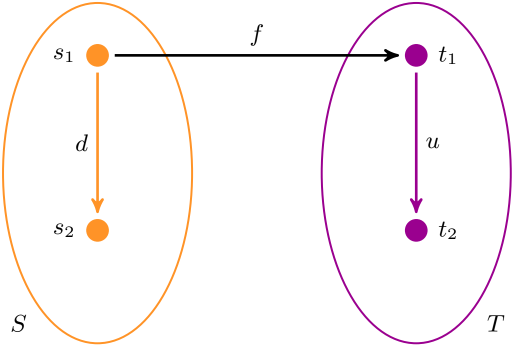
- Q2: What sets of view updates do we want to translate, that is, what sets of updates users are to be allowed on the view ?

Concepts to be formalized

- Q1: Given a view update u, what are the constraints on the database update that translates u ?
- Q2: What sets of view updates do we want to translate, that is, what sets of updates users are to be allowed on the view ?
- Q3: How do we associate with each view update a database update that translates it ?

Definitions

Q1: A translation of a view update



A database update d is a *translation* of a view update u iff
for each database state $s \in S$

(1) $uf(s) = fd(s)$ (*consistent*)

(2) $uf(s) = f(s) \rightarrow d(s) = s$ (*acceptable*)

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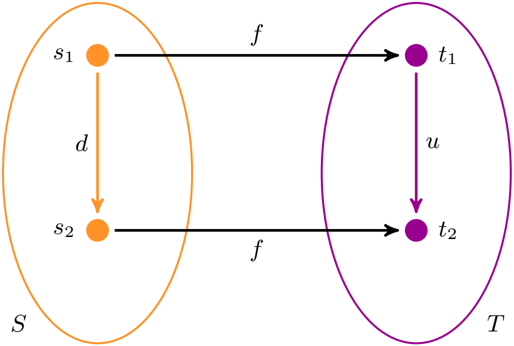

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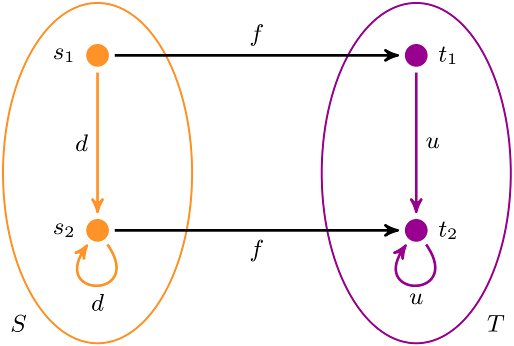

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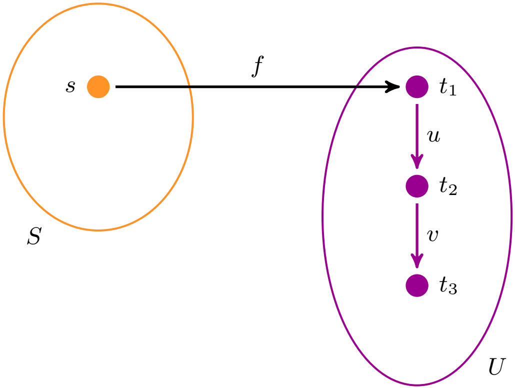
Definitions

Q2: A complete set of view updates



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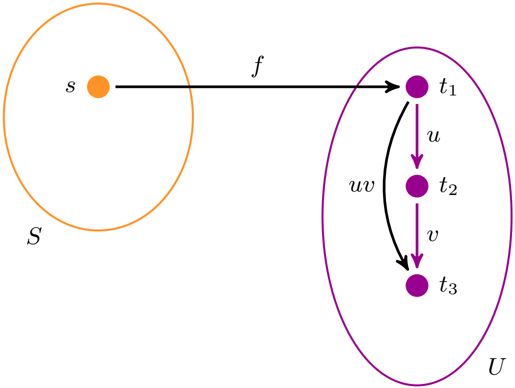

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(1) $\forall u, v \in U,\ uv \in U$

Definitions

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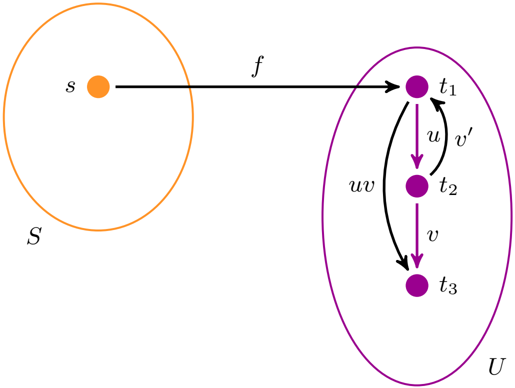


A set U of view updates is called *complete* iff

(1) $\forall u, v \in U,\ uv \in U$

(2) $\forall s \in S,\ \forall u \in U,\ \exists u' \in U\ \ u'uf(s) = f(s)$

Definitions

Q3: A translator

A mapping $T : U \to U_1$ is called a *translator* iff

(1) $\forall u \in U$, T_u is a translation of u

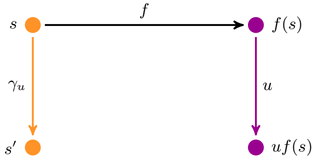
(2) $\forall u, v \in U$, $T_{uv} = T_u T_v$

The view update problem

Given a complete set U of view updates, find a translator of U

Intuitive idea

- If the view f is injective



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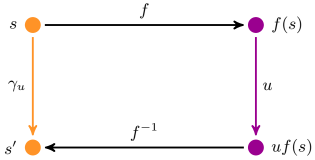
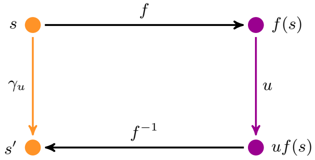


Intuitive idea

- If the view f is injective



- If the view f is not injective
  Need a view complement g of f so that $f \times g$ is injective

The view complement

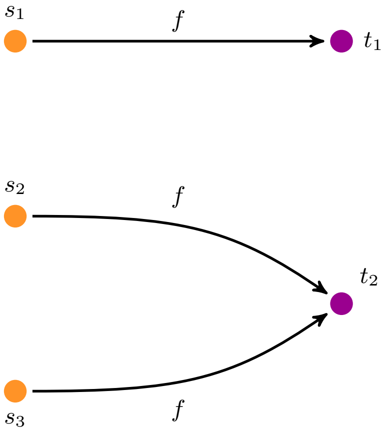
g is a *complement* of f iff $f \times g = 1$

g is a *complement* of f iff $\forall s, s' \in S_\Sigma,\ s \neq s' \wedge f(s) = f(s') \rightarrow g(s) \neq g(s')$

- A complement of f contains "the information not visible within f "
- A complement of f is able to distinguish database states that f maps to the same view state
- A view complement always exists (a renamed copy of the whole db schema in the worst case)
- In general, there is no unique minimal complement

The view complement

An example



The view complement

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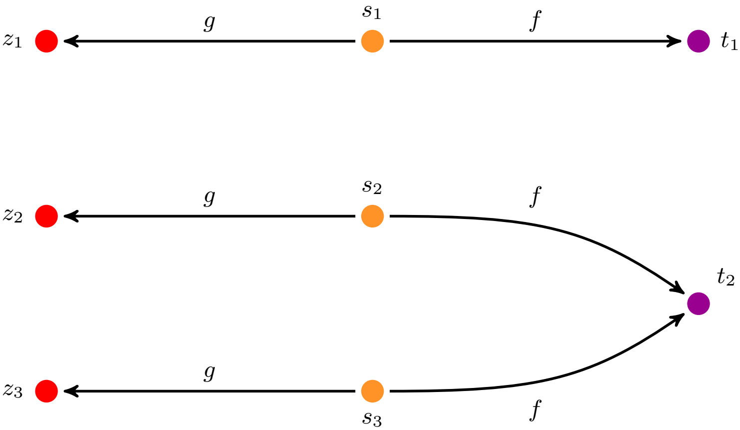

The view complement

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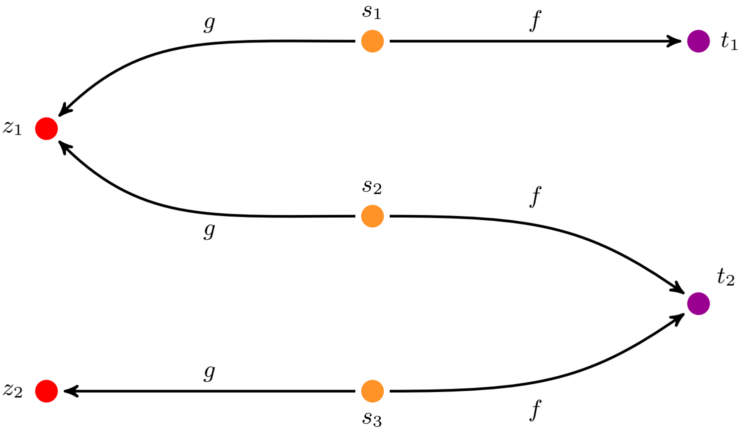


Constant Complement & Translation under constant complement

Rectangle Rule from Chamberlin et al (1975): *"An insertion, deletion, or update via a view must affect only information visible within the rectangle of the view."*

- A complement g of a view update u should not be changed (i.e. invariant) by a database update.
- A translation γ_u of u should be verified that it makes g invariant.

A given database, a view and a complement view

E(EMP, DEP)
M(DEP, MGR)
C1: EMP $\rightarrow$ DEP
C2: DEP $\leftrightarrow$ MGR
C3: E[DEP] = M[DEP]

$s =$

E	
EMP	DEP
Mary	CS
Jane	CS
Mike	EEE

M	
DEP	MGR
CS	Alex
EEE	Susan

$f(s) = \pi_{DEP,MGR} E \bowtie M$

$f =$

EM	
DEP	MGR
Mary	Alex
Jane	Alex
Mike	Susan

$g(s) = M$

$g =$

M	
DEP	MGR
CS	Alex
EEE	Susan

Example of a translation that leaves a complement invariant

u: Replace employee Mary by employee John.

g: Table M.

γ_u : E $=$ (M*u(EM))[EMP,DEP];M $=$ M.

$s =$

E	
EMP	DEP
Mary	CS
Jane	CS
Mike	EEE

M	
DEP	MGR
CS	Alex
EEE	Susan

$\xrightarrow{\gamma_u}$ $s' =$

E	
EMP	DEP
John	CS
Jane	CS
Mike	EEE

M	
DEP	MGR
CS	Alex
EEE	Susan

$\downarrow$

$f =$

EM	
DEP	MGR
Mary	Alex
Jane	Alex
Mike	Susan

$\xrightarrow{u}$ $uf =$

EM	
DEP	MGR
John	Alex
Jane	Alex
Mike	Susan

u is $g - translatable$

u is $g - translatable$ iff for all s in S, there exists a s' that:

1. $f(s') = uf(s)$
2. $g(s') = g(s)$

The composition of $g - translatable$ updates is also $g - translatable$

- u, v are $g - translatable \Rightarrow uv$ is $g - translatable$
  1. $f(s'') = u(f(s')) = uvf(s)$
  2. $g(s'') = g(s') = g(s)$

Example of a composition of $g - translatable$ updates

u: Replace employee Mary by employee John.
v: Replace employee Jane by employee Lewis.
g: Table M.
γ_{uv} : E = (M*uv(EM))[EMP,DEP];M = M.

$s =$

E	
EMP	DEP
Mary	CS
Jane	CS
Mike	EEE

M	
DEP	MGR
CS	Alex
EEE	Susan

$\overset{\gamma_{uv}}{\longmapsto}$ $s'' =$

E	
EMP	DEP
John	CS
Lewis	CS
Mike	EEE

M	
DEP	MGR
CS	Alex
EEE	Susan

$\downarrow$

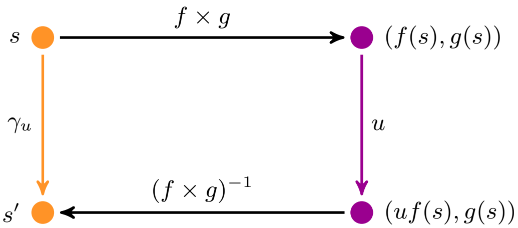
$f =$

EM	
DEP	MGR
Mary	Alex
Jane	Alex
Mike	Susan

$\overset{uv}{\longmapsto}$ $uvf =$

EM	
DEP	MGR
John	Alex
Lewis	Alex
Mike	Susan

$g - translation : \gamma_u$



For a given f, g, u if u is $g - translatable$ then $\gamma_u = (f \times g)^{-1}(uf \times g)$.

γ_u is a translation of u (γ_u is called a $g - translation$ of u):

- $uf = f\gamma_u \rightsquigarrow Consistent$
- $\gamma_u(s) = s \rightsquigarrow Acceptable$

γ_u leaves g invariant

- $g\gamma_u = g$

If u is $g - translatable$, γ_u always exists and is unique.

How to choose a complement of a view?(1)

The choice of g impacts that whether u is $g - translatable$ or not.

u: Replace employee Mary by employee John.
g': Table E.
γ_u : E = (M*u(EM))[EMP,DEP];M = M.

$s =$

E	
EMP	DEP
Mary	CS
Jane	CS
Mike	EEE

M	
DEP	MGR
CS	Alex
EEE	Susan

$\overset{\gamma_u}{\longmapsto}$ $s' =$

E	
EMP	DEP
John	CS
Jane	CS
Mike	EEE

M	
DEP	MGR
CS	Alex
EEE	Susan

$\downarrow$

$f =$

EM	
DEP	MGR
Mary	Alex
Jane	Alex
Mike	Susan

$\overset{u}{\longmapsto}$ $uf =$

EM	
DEP	MGR
John	Alex
Jane	Alex
Mike	Susan

How to choose a complement of a view?(2)

The choice of g impacts that whether u is $g - translatable$ or not.

w: Permute the managers.
g': Table E.
γ_w : E = E;M = (E*w(EM))[EMP,DEP].

$s =$

E	
EMP	DEP
Mary	CS
Jane	CS
Mike	EEE

M	
DEP	MGR
CS	Alex
EEE	Susan

$\xrightarrow{\gamma_w}$ $s' =$

E	
EMP	DEP
Mary	CS
Jane	CS
Mike	EEE

M	
DEP	MGR
CS	Susan
EEE	Alex

$\downarrow$

$f =$

EM	
DEP	MGR
Mary	Alex
Jane	Alex
Mike	Susan

$\xrightarrow{w}$ $wf =$

EM	
DEP	MGR
Mary	Susan
Jane	Susan
Mike	Alex

How to choose a complement of a view?(3)

For a given view u, g, h are both complements of f and h contains less information than g. If u is $g - translatable$ then:

1. u is also $h - translatable$
2. $h - translation = g - translation$

The set of $g - translatable$ updates is maximal when the complement g is minimal.

- We could like to find the minimal complements, so that get maximal update sets (a minimal complement is not unique).

A complement view: an update policy

Universal property of translation under constant complement

Given a complete set $U \subset U_f$, a view f and a complement view g of f:

This paper provided translators T for U if $\forall u \in U$: u is $g - translatable$:

1. Select a complement g of the given view f.
2. Verify that view updates of the given complete set U make g invariant.
3. For each view update $u \in U$, the translation $T_u = (f \times g)^{-1}(uf \times g)$.

For every T of U, there exists a complement g that:

1. $\forall u \in U$, u is $g - translatable$.
2. $\forall u \in U$, $g - translation\ \gamma_u = (f \times g)^{-1}(uf \times g)$

Advantages & Disadvantages

Advantages:

1. This paper provides a formal framework for solving the view update problem.
2. The method is beneficial for solving view update issues in Data Integration.

Disadvantages:

1. Too theoretical, no algorithms for implementation from practical point of view.
2. This paper does not show how to find a minimal complement.

Related works

- Lechtenboerger (2003) gives a characterisation of the constant complement principle in terms of "undo" operations in SQL server.
- Cosmadakis and Papadimitriou (1984) consider a restricted setting that consists of a single database relation and two views defined by projections.
- Gottlob et al (1988) extend to the class of so-called consistent views, which properly contains the views translating under constant complement. The complement is not required to remain invariant in their framework.
- Enrico Franconi and Paolo Guagliardo [2011] provide a general framework for view updating (under constraints) based on the notion of determinacy .