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# Default-all is dangerous!

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http://db.cs.washington.edu/causality/

# Overview Provenance Definitions

| | Why? | Where? |
|---|---|---|
| *Naive* | Witness | "SQL interpretation" |
| *Provenance definition* | Why-provenance = witness basis ($\alpha_w$) Buneman et al. [ICDT'01] | Where-provenance = propagation ($\alpha_p$) Buneman et al. [PODS'02] |
| *QRI definition (Query-Rewrite-Insensitive)* | Minimal witness basis ($\alpha_w^m$) Buneman et al. [ICDT'01] | Default-all propagation ($\alpha_p^d$) Bhagwat et al. [VLDB'04] |

Has problems if one interprets annotations on attribute values

Minimal propagation ($\alpha_p^m$)
Proposed in this paper!

*We do not discuss here whether QRI is desirable (see also Glavic, Miller [Tapp'11]), but merely point out that, if aiming for QRI, care has to be taken about the ramifications of the proposed semantics.*

Independent work presented at this WS

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($\alpha_w^m$)

DT'01]

Default-all propagation ($\alpha_p^d$)

Bhagwat et al. [VLDB'04]

Glavic, Miller [Tapp'11]

| Semantics | | Sound | Complete | Responsible | Insensitive (set) | Insensitive (bag) | Stable |
|---|---|---|---|---|---|---|---|
| **Why** | Wit | - | X | - | X | X | X |
| | Why | - | X | - | - | X | X |
| | IWhy | - | X | X | X | X | X |
| **Where** | Where | - | - | - | - | ? | X |
| | IWhere | - | - | - | X | X | - |
| **How** | | - | X | - | - | X | X |
| **Lineage-based** | Lineage | X | X | - | - | - | X |
| | PI-CS | X | X | - | - | - | X |
| | C-CS | X | - | - | - | - | X |
| **Causality** | | - | X | X | X | X | X |

Has problems if one interprets annotations on attribute values

Minimal propagation ($\alpha_p^m$)

Proposed in this paper!

Note that Minimal propagation is "stable", in contrast to Default-all

# Example 1: Query-Rewrite-Insensitivity (QRI)

## Why

Why-provenance = witness basis ($\alpha_w$)

Minimal witness basis ($\alpha_w^m$)

Lineage ($\alpha_l$)

*Input*
*R*

| | A | B |
|---|---|---|
| $t_1$ | 1 | 2 |
| $t_2$ | 1 | 3 |
| $t_3$ | 2 | 2 |

*Query 1*
$Q_1(x,y)$:-$R(x,y)$

| A | B | |
|---|---|---|
| 1 | 2 | $\{\{t_1\}\}$ |
| 1 | 3 | $\{\{t_2\}\}$ |
| 2 | 2 | $\{\{t_3\}\}$ |

*Query 2 ≡ Query 1*
$Q_2(x,y)$:-$R(x,y),R(\_,y)$

| A | B | | | |
|---|---|---|---|---|
| 1 | 2 | $\{\{t_1\},\{t_1,t_3\}\}$ | $\{\{t_1\}\}$ | $\{t_1,t_3\}$ |
| 1 | 3 | $\{\{t_2\}\}$ | $\{\{t_2\}\}$ | $\{t_2\}$ |
| 2 | 2 | $\{\{t_3\},\{t_1,t_3\}\}$ | $\{\{t_3\}\}$ | $\{t_1,t_3\}$ |

## Where

Where-provenance = propagation ($\alpha_p$)

Minimal propagation ($\alpha_p^m$)

Default-all propagation ($\alpha_p^d$)

*Input*
$R^a$

| A | B |
|---|---|
| $1^a$ | $2^b$ |
| $1^c$ | $3^d$ |
| $2^e$ | $2^f$ |

*Query 1*
$Q_1(x,y)$:-$R^a(x,y)$

| A | B |
|---|---|
| $1^a$ | $2^b$ |
| $1^c$ | $3^d$ |
| $2^e$ | $2^f$ |

*Query 2 ≡ Query 1*
$Q_2(x,y)$:-$R^a(x,y),R^a(\_,y)$

| A | B | A | B | A | B |
|---|---|---|---|---|---|
| $1^a$ | $2^{b,f}$ | $1^{a,c}$ | $2^{b,f}$ | $1^a$ | $2^b$ |
| $1^c$ | $3^d$ | $1^{a,c}$ | $3^d$ | $1^c$ | $3^d$ |
| $2^e$ | $2^{b,f}$ | $2^e$ | $2^{b,f}$ | $2^e$ | $2^f$ |

Example adapted from Cheney et al. [Foundations and Trends in DBs'09]

# Real example: Why Default-all is dangerous

## Hanako queries a community DB for contents of LF-milk*:

*Community Database*
$R^a$

| *Food* | *Content* |
|---|---|
| LF Milk | Cesium-137[b] |
| LF Milk | Calcium[d] |
| SC Water | Cesium-137[f] |

b *Bob, March 18, 2011*
*Don't drink, lots of Cesium!*

f *Fuyumi, March 19, 2011*
*No Cesium, save to drink!*

*Hanako's query*
*Q (y):-$R^a$('LF Milk',y)*

| *Content* |
|---|
| Cesium-137[???] |
| Calcium[d] |

## Default-all propagation makes her drink the milk:

Default-all propagation ($\alpha_p{}^d$)

| *Content* |
|---|
| Cesium-137[bf] |
| Calcium[d] |

b *Bob, March 18, 2011*
*Don't drink, lots of Cesium!*

f *Fuyumi, March 19, 2011*
*No Cesium, save to drink!*

"semantically irrelevant information": annotations leak over from SC Water tuple to LF Milk

Minimal propagation ($\alpha_p{}^m$)

| *Content* |
|---|
| Cesium-137[b] |
| Calcium[d] |

b *Bob, March 18, 2011*
*Don't drink, lots of Cesium!*

"all relevant and only relevant"

* Note the one-to-one correspondence of this example with example 1

# Definition Minimal propagation ($\alpha_p^m$)

$$\alpha_p^m(t,A,Q) := \bigcup_{t' \in \Cup \alpha_w^m(t,Q)} \alpha_p(t',A')$$
$$A' \in \text{attributes of } t' \text{ propagating to cell}(t,A)$$

$\Cup$ transforms 'sets of sets' into 'sets', hence something like QRI lineage

**Intuition:**
Return the intersection between:
- query-specific where-provenanc ($\alpha_p$)
- and QRI minimal witness basis ($\alpha_w^m$)

"all relevant ... and only relevant"

## Example 1

Where provenance ($\alpha_p$)

Minimal propagation ($\alpha_p^m$)

*Input*

$R^a$

| | A | B |
|---|---|---|
| $t_1$ | $1^a$ | $2^b$ |
| $t_2$ | $1^c$ | $3^d$ |
| $t_3$ | $2^e$ | $2^f$ |

*Query 2*

$Q_2(x,y)$:-$R^a(x,y),R^a(\_,y)$

| A | B | | |
|---|---|---|---|
| $1^a$ | $2^{b,f}$ | $\{\{t_1\}\}$ | $\{t_1\}$ |
| $1^c$ | $3^d$ | $\{\{t_2\}\}$ | $\{t_2\}$ |
| $2^e$ | $2^{b,f}$ | $\{\{t_3\}\}$ | $\{t_3\}$ |

$\Cup \alpha_w^m$

Minimal witness basis ($\alpha_w^m$)

| | A | B |
|---|---|---|
| $t_4$ | $1^a$ | $2^b$ |
| $t_5$ | $1^c$ | $3^d$ |
| $t_6$ | $2^e$ | $2^f$ |

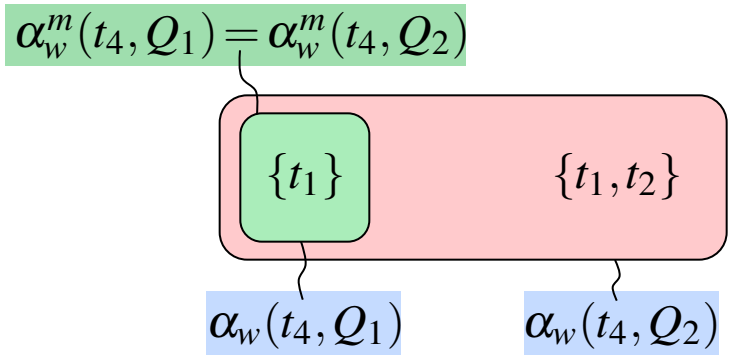
$$\alpha_p^m(t_4,B,Q_2) = \bigcup_{t' \in \{t_1\},A'} \alpha_p(t',A') = \alpha_p(t_1,B) = \{b\}$$

# Example 1: Illustration of "minimal" versus "all"

## Why-provenance

Why-provenance ($\alpha_w$)

Minimal witness basis ($\alpha_w{}^m$)

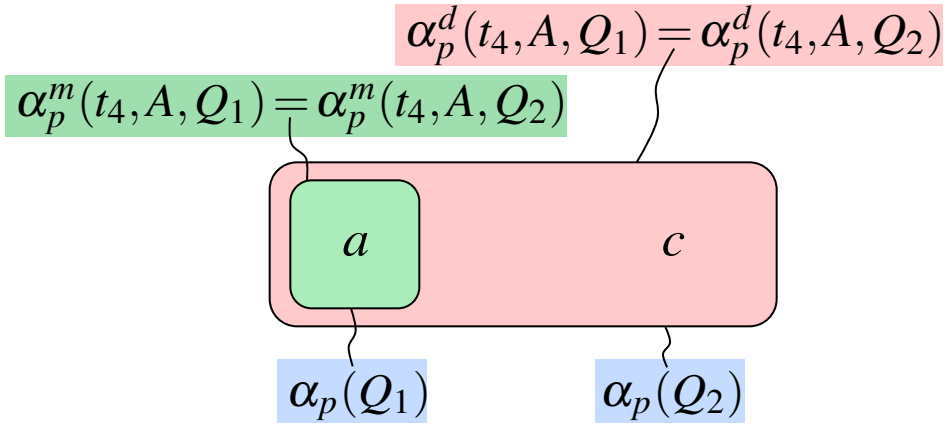



## Where-provenance

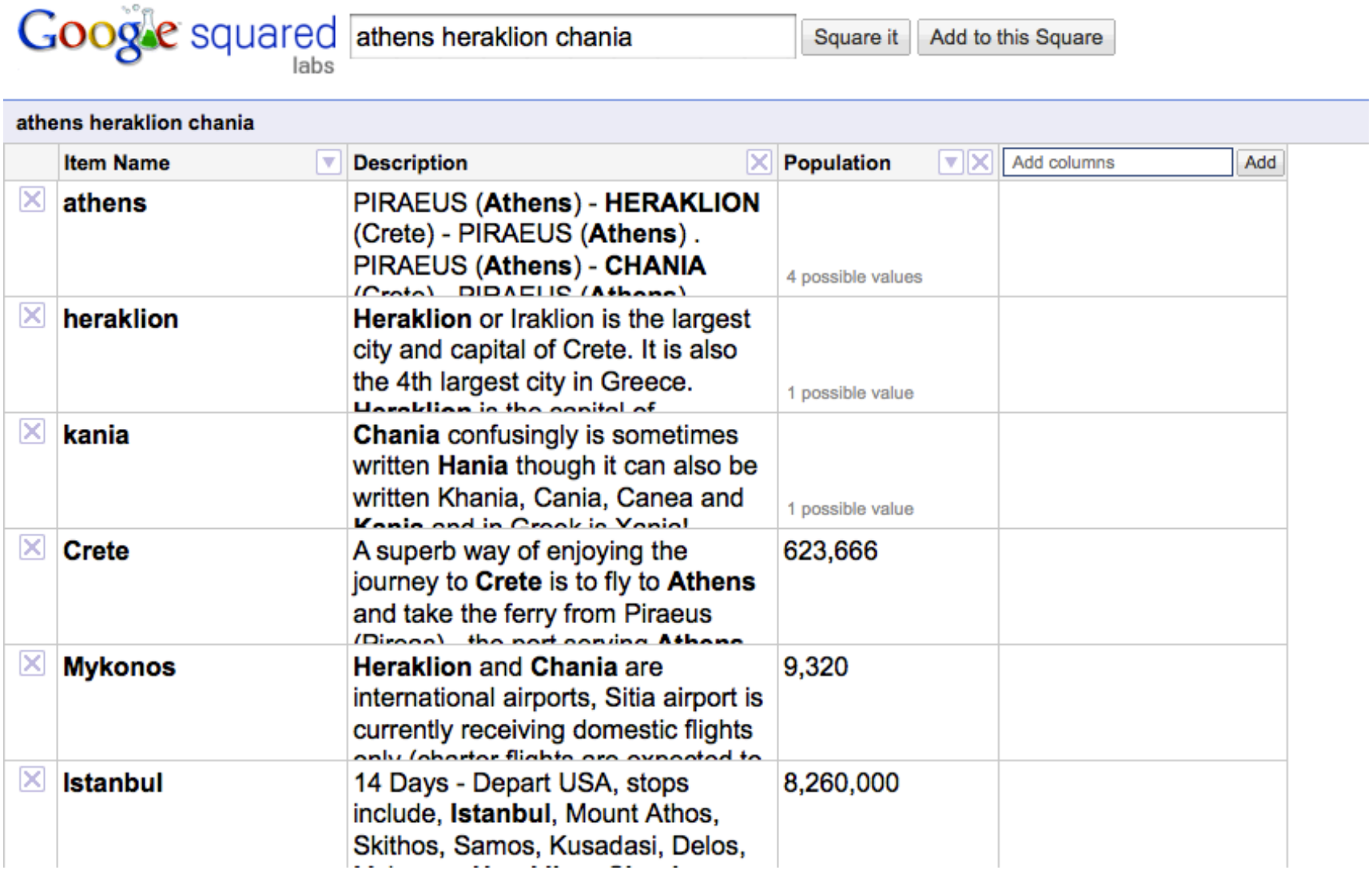
Where-provenance ($\alpha_p$)

Default-all propagation ($\alpha_p{}^d$)

Minimal propagation ($\alpha_p{}^m$)

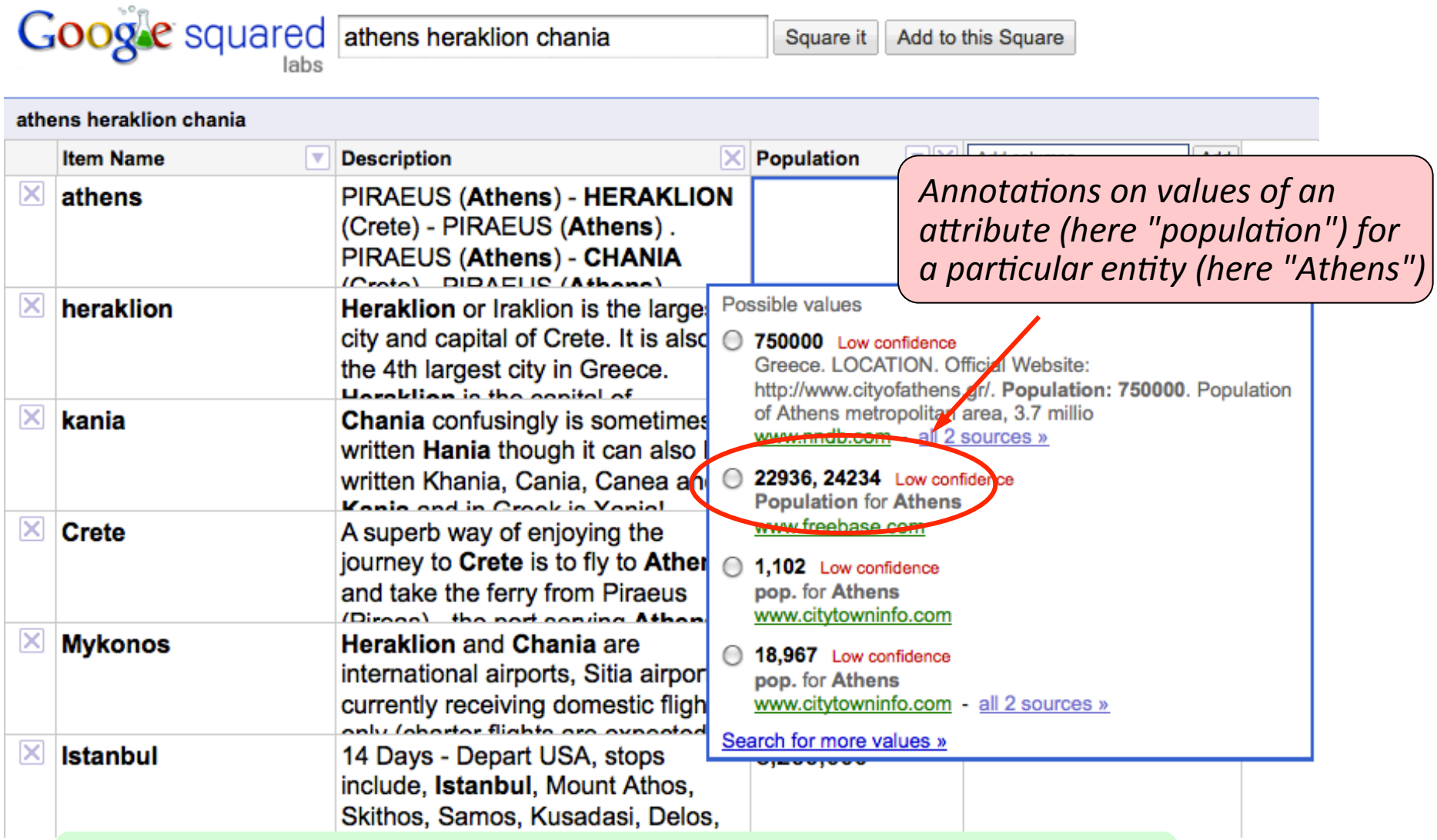


# Interpretation of Annotations 1: Attribute Value*




* Interpretation of annotations on entity attribute values favored by us and underlying our model

# Interpretation of Annotations 1: Attribute Value*




Argument: Interpreting cell annotations as relevant to the tuple (entity) adds something that is not trivially modeled with normalized tables.

* Interpretation of annotations on entity attribute values favored by us and underlying our model

# Interpretation of Annotations 2: Domain Value*

## Domain value annotations*

*Input $R^a$:*

| A | B |
|---|---|
| $1^a$ | $2^b$ |
| $1^c$ | $3^d$ |
| $2^e$ | $2^f$ |

b: *Bob, March 18, 2011*
*This number is a prime number.*

f: *Fuyumi, March 19, 2011*
*Two is not a prime number because it is even.*

*Input $S^a$:*

| ... | Date |
|---|---|
| ... | Dec 25 |
| ... | ... |
| ... | Dec 25 |

b: *This is a holiday.*

f: *This is a holiday too !!!*

Argument for default-all: If annotations are on domain values, then retrieving all annotations are relevant.

## Alternative representation

*Annotation table $S^a$:*

| B | annotation |
|---|---|
| 2 | b: *Bob, March 18, 2011*<br>*This number is a prime number.* |
| 2 | f: *Fuyumi, March 19, 2011*<br>*Two is not a prime number because it is even* |

*Annotation table $S^a$:*

| Date | annotation |
|---|---|
| Dec 25 | This is a holiday. |

Counter-Argument: But then these annotations can be modeled in a separate table as normalized tables.

* Alternative interpretation suggested by Wang-Chiew Tan (example created after conversation at Sigmod 2011)

# Backup: Detailed Example 2

$R^a$

| | A | B |
|---|---|---|
| $t_1$ | $1^a$ | $2^b$ |
| $t_2$ | $1^c$ | $3^d$ |
| $t_3$ | $2^e$ | $2^f$ |
| $t_4$ | $2^g$ | $4^h$ |

$Q_5(x,y)$:-$R^a(x,y),R^a(y,\_),R^a(x,\_)$

| | A | B |
|---|---|---|
| $t_5$ | $1^{a,c}$ | $2^{b,e,g}$ |
| $t_6$ | $2^{e,g}$ | $2^{e,f,g}$ |

$\{\{t_1,t_3\},\{t_1,t_2,t_3\},\{t_1,t_4\},\{t_1,t_2,t_4\}\}$
$\{\{t_3\},\{t_3,t_4\}\}$

Why-provenance ($\alpha_w$)

Where-provenance ($\alpha_p$)

$\{\{t_1,t_3\}, \{t_1,t_4\}\}$
$\{\{t_3\}\}$

Minimal witness basis ($\alpha_w^m$)

$\{t_1,t_3,t_4\}$
$\{t_3\}$

$\cup\alpha_w^m$ (~QRI lineage)

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## Default-all propagation ($\alpha_p^d$)

| A | B |
|---|---|
| $1^{a,c}$ | $2^{b,e,f,g}$ |
| $2^{e,g}$ | $2^{b,e,f}$ |

$\alpha_p^d(t_4,B,Q_5) = \alpha_p(t_4,B,Q_6)$ with

$Q_6(x,y)$:-$R^a(x,y),R^a(y,\_),R^a(x,\_),S^a(\_,y)$

## Minimal propagation ($\alpha_p^m$)

| | A | B |
|---|---|---|
| $t_4$ | $1^a$ | $2^{b,e,g}$ |
| $t_5$ | $2^e$ | $2^{e,f}$ |

$$\alpha_p^m(t_4,A,Q_5) = \bigcup_{t'\in\{t_1,t_3,t_4\},A'} \alpha_p(t',A') = \alpha_p(t_1,A) = \{a\}$$

$$\alpha_p^m(t_5,B,Q_5) = \bigcup_{t'\in\{t_3\},A'} \alpha_p(t',A') = \alpha_p(t_3,B)\cup\alpha_p(t_3,A) = \{e,f\}$$

Note minimal propagation is not equivalent to just evaluating the where-provenance for the query: $Q_7(x,y)$:-$R^a(x,y),R^a(y,\_)$. E.g. $\alpha_p(t_5,B,Q_7) = \{e,f,g\}$