Null Values

Used to represent missing information

At least two kinds

- dne — does not exists
- unk — value exists but unknown

PILOT	FLIGHT	DATE	TIME
Cushing	615	5Oct	**unk**
dne	704	6Oct	5:50a
Cook	**dne**	**dne**	**dne**

"Does Not Exist" Null

Like adding an additional value to domain of an attribute

So it enlarges the set of possible relation instances

Issue: dne = dne?

Maybe no: LD → P

PILOT	FLIGHT	DATE	TIME
Cook	**dne**	**dne**	**dne**
Cadiz	**dne**	**dne**	**dne**

Maybe yes: FIRST MI LAST → AGE

FIRST	MI	LAST	AGE
Alex	**dne**	Cook	37
Alex	**dne**	Cook	39

Unknown Null

More like variables

Can view an instance with **unk** nulls as a set of possible fully-defined instances

PILOT	FLIGHT	DATE	TIME
Cushing	615	5Oct	**unk**
Cook	704	6Oct	5:50a
Cushing	**unk**	6Oct	**unk**

Some Possible Instances

PILOT	FLIGHT	DATE	TIME
Cushing	615	5Oct	5:00p
Cook	704	6Oct	5:50a
Cushing	872	6Oct	11:00p

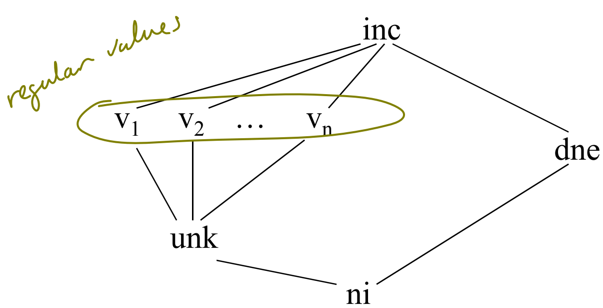
PILOT	FLIGHT	DATE	TIME
Cushing	615	5Oct	6:00p
Cook	704	6Oct	5:50a
Cushing	615	6Oct	6:00p

Also, "No-Information" and "Inconsistent"

$x \sqsubseteq y$: y more informative than x

ni $\sqsubseteq$ unk $\sqsubseteq$ v_i $\sqsubseteq$ inc

ni $\sqsubseteq$ dne $\sqsubseteq$ inc



Extend Order to Tuples

Use ⊑ on each component

```
<Fred, unk, 6> ⊑ <Fred, 10.25, 6>
<Fred, unk, 6> ⊑ <Fred, unk, 6>
<ni, dne, 6> ⊑ <unk, inc, 6>
<ni, dne, 6> ⊑ <inc, inc, inc>
```


Extending to Relations

Concentrate on unk null

ord1(Person Price Amt)

Person	Price	Amt
Fred	unk	6
Fred	10.25	unk
Fritz	unk	unk

ord2(Person Price Amt)

Person	Price	Amt
Fred	11.50	6
unk	10.25	7

ord3(Person Price Amt)

Person	Price	Amt
Fred	11.50	6
Fred	10.25	7
Fritz	12.25	7

What Does a Tuple Mean

For partial relations r, q, what should $r \sqsubseteq q$ require? $q \sqsupseteq r$

For tuple t in r
- exactly one (tuple) s in q with $t \sqsubseteq s$?
- at least one s in q with $t \sqsubseteq s$?

For tuples t1, t2 in r, can there be a single s in q with $t1 \sqsubseteq s$ and $t2 \sqsubseteq s$?

Can there be s in q where $t \not\sqsubseteq s$ for all t in r? (closed world assumption)

Book's Definition

"Fill in the blanks"

$r \sqsubseteq q$ means there is a total, onto map θ from r to q where for every t in r

$$t \sqsubseteq \theta(t)$$

Examples

ord1(Person Price Amt) ⊑ ord3(Person Price Amt)

Person	Price	Amt		Person	Price	Amt
Fred	unk	6	→	Fred	11.50	6
Fred	10.25	unk	→	Fred	10.25	7
Fritz	unk	unk	→	Fritz	12.25	7

θ

ord1(Person Price Amt) ⊑ ord4(Person Price Amt)

Person	Price	Amt		Person	Price	Amt
Fred	unk	6	→	Fred	10.25	6
Fred	10.25	unk	→ (Fred 10.25 6)	Fritz	12.25	unk
Fritz	unk	unk	→ (Fritz 12.25 unk)			

θ

But Consider

ord2(Person Price Amt) ⋢ ord3(Person Price Amt)

Person	Price	Amt		Person	Price	Amt
Fred	11.50	6	→	Fred	11.50	6
unk	10.25	7	→	Fred	10.25	7
		?	→	Fritz	12.25	7

θ

Possible Worlds

View a partial relation as specifying a set of possible worlds

no unknowns

POSS(r) = {q | r ⊑ q and q is fully defined}

Can include constraints C

POSS(r, C) = {q | q in POSS(r) and q in SAT(C)}

What Happens if We Have Constraints?

Recall

PILOT	FLIGHT	DATE	TIME
Cushing	615	5Oct	**unk**
Cook	704	6Oct	5:50a
Cushing	**unk**	6Oct	**unk**

Not All Satisfy the FDs

$F = \{L \to T, PDT \to L, LD \to P\}$

PILOT	FLIGHT	DATE	TIME
Cushing	615	5Oct	5:00p
Cook	704	6Oct	5:50a
Cushing	615	6Oct	5:00p

PILOT	FLIGHT	DATE	TIME
Cushing	615	5Oct	5:00p
Cook	704	6Oct	5:50a
Cushing	615	6Oct	6:00

FD violations

Use FD-Chase on Instances with Unknowns

$L \to T$

r

PILOT	FLIGHT	DATE	TIME
Cushing	704	5Oct	**unk**
Cook	704	6Oct	5:50a
Cushing	**unk**	6Oct	**unk**

r′

PILOT	FLIGHT	DATE	TIME
Cushing	704	5Oct	5:50a
Cook	704	6Oct	5:50a
Cushing	**unk**	6Oct	**unk**

$POSS(r, F) = POSS(r', F)$

Querying Relations with Unknowns

Let r be a relation with unknowns, and Q a query on full relations

Would like Q' on partial relations

- Q'(r) represents {Q(q) | q in POSS(r)}

When r is fully defined, would like Q'(r) and Q(r) to agree. (Faithful)

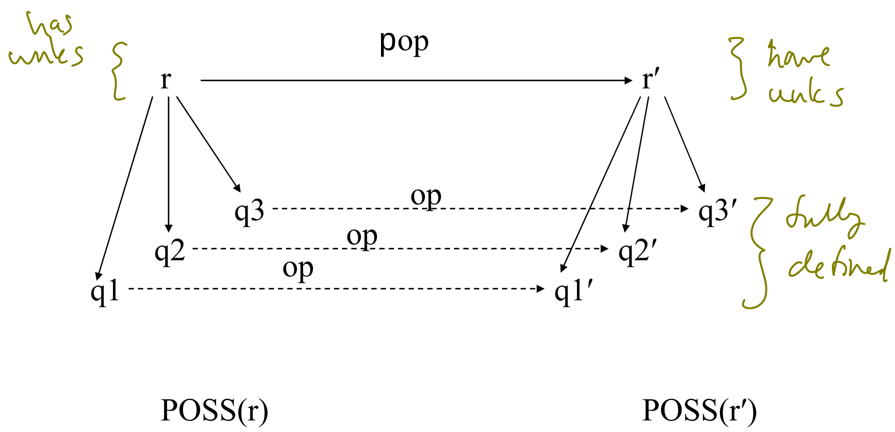
Principles of Databases

Relational Algebra

One approach: Multi-relation

- Let pop be partial version of operator op
- pπ and π
- POSS(pop(r)) = {op(q) | q in POSS(r)}

Diagram



Sometimes Exists

r

PILOT	FLIGHT	DATE	TIME
Cushing	615	5Oct	~~unk~~ 6:00p
Cook	704	6Oct	5:50a
Cushing	~~unk~~ 81	6Oct	~~unk~~ 7:00p

$p\pi_{DT}(r)$

DATE	TIME
5Oct	unk
6Oct	5:50a
6Oct	unk

Fill in → ⊑

π_{DT}

DATE	TIME
5 Oct	6:00p
6 Oct	5:50a
6 Oct	7:00p

Not Always

$\sigma_{L=872}(r)$

r1

PILOT	FLIGHT	DATE	TIME
Cushing	615	5Oct	5:00p
Cook	704	6Oct	5:50a
Cushing	872	6Oct	11:00p

ans(r1)

PILOT	FLIGHT	DATE	TIME
Cushing	872	6Oct	11:00p

Not Always

$\sigma_{L=872}(r)$

r2

PILOT	FLIGHT	DATE	TIME
Cushing	615	5Oct	5:00p
Cook	704	6Oct	5:50a
Cushing	615	6Oct	5:00p

ans(r2)

PILOT	FLIGHT	DATE	TIME
∅			

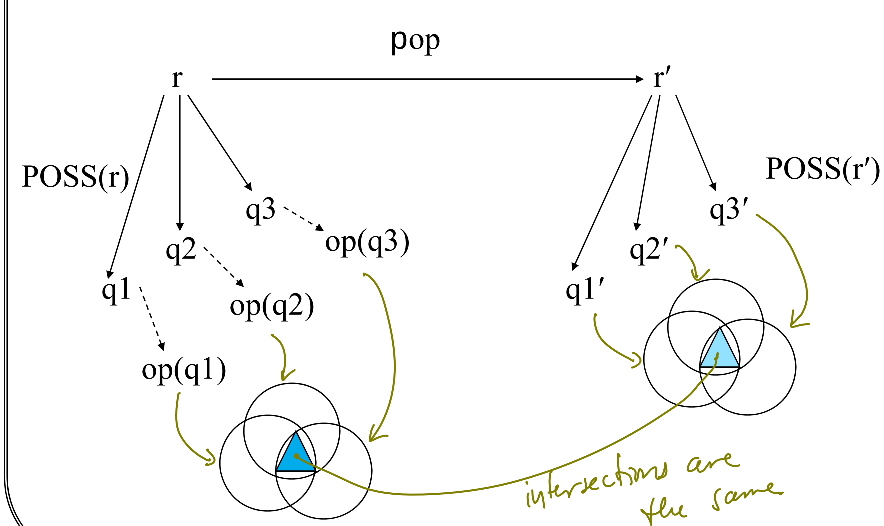
"For sure semantics"

Truth preserving: common part of all possible results

$\cap\{q \mid q \text{ in } POSS(pop(r))\} =$
$\quad \cap\{op(q') \mid q' \text{ in } POSS(r)\}$

tuples that are definitely in the answer for anything in POSS(r)

Diagram



CS 589 Principles of Databases, Unit 2, Part 4

Projection

$p\pi_Y(r) = \{t[Y] \mid t \text{ in } r\}$

ord1

Person	Price	Amt
Fred	unk	6
Fred	10.25	unk
Fritz	unk	unk

$p\pi_{Person\ Price}(r) =$

ans

Person	Price
Fred	unk
Fred	10.25
Fritz	unk

Projection 2

POSS(r) includes

Person	Price	Amt
Fred	11.50	6
Fred	10.25	7
Fritz	12.25	7

POSS($p\pi_{Person\ Price}(r)$) includes

Person	Price
Fred	11.50
Fred	10.25
Fritz	12.25

Common part will be <Fred 10.25>

Union

r1 p∪ r2 = {t | t in r1 or t in r2}

ord1 p∪ ord2

```
ans(Person Price Amt)
    Fred   unk   6
    Fred   10.25 unk
    Fritz  unk   unk
    ----------------
    Fred   11.50 6
    unk    10.25 7
```


What if We Let Intersection Be the Result?

Might only want tuples that are in every possible answer

pop(r) = {t|t in op(q) for every q in POSS(r)}

For example, r

PILOT	FLIGHT	DATE	TIME
Cushing	615	5Oct	**unk**
Cook	704	6Oct	5:50a
Cushing	**unk**	6Oct	**unk**

$p\pi_{PL}(r)$

PILOT	FLIGHT
Cushing	615
Cook	704

But Note

r

PILOT	FLIGHT	DATE	TIME
Cushing	615	5Oct	**unk**
Cook	704	6Oct	5:50a
Cushing	**unk**	6Oct	**unk**

$p\sigma_{P=Cushing}(r) = \emptyset$

$p\pi_{LD}(p\sigma_{P=Cushing}(r)) =$

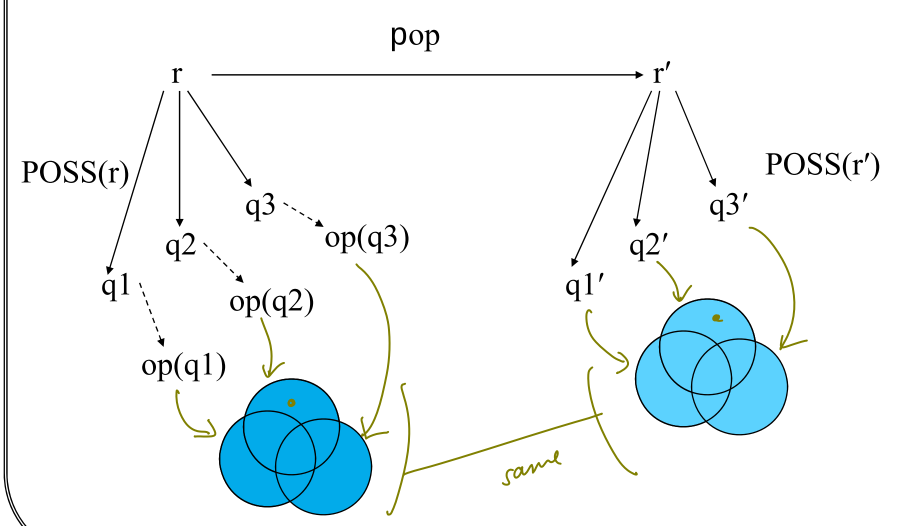
FLIGHT	DATE
615	5Oct

"Could Be" Semantcs

Possibility Preserving: combination of all possible results

$\cup\{q \mid q \text{ in } POSS(pop(r))\} =$
$\cup\{op(q') \mid q' \text{ in } POSS(r)\}$

Diagram



Selection Conditions

t.B = 6

	A	B	
<Fred	6>		true
<Fred	4>		false
<Fred	unk>		maybe

3-valued logic

or	T	F	M
T	T	T	T
F	T	F	M
M	T	M	M

Example

A B

t1 <Fred unk>

t2 <Fritz unk>

	t.A = Fritz	**or**	t.B = 6	
t1	F	**or**	M	= M
t2	T	**or**	M	= T

But

t1 <Fred unk>

	t.B < 6	**or**	t.B ≥ 6	
t1	M	**or**	M	= M

But it would be T for any value for unk