Modeling the Propagation of User Preferences

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ER 2011, Brussels


ER 2011
October 31
-
November 3
Brussels

Eating out in Brussels

- Moules-frites
- (Belgian!) Beer

Eating out in Florence

- Florentine steak
- Tuscan Wine

Eating out in Vancouver

- Salmon
- Canadian beer

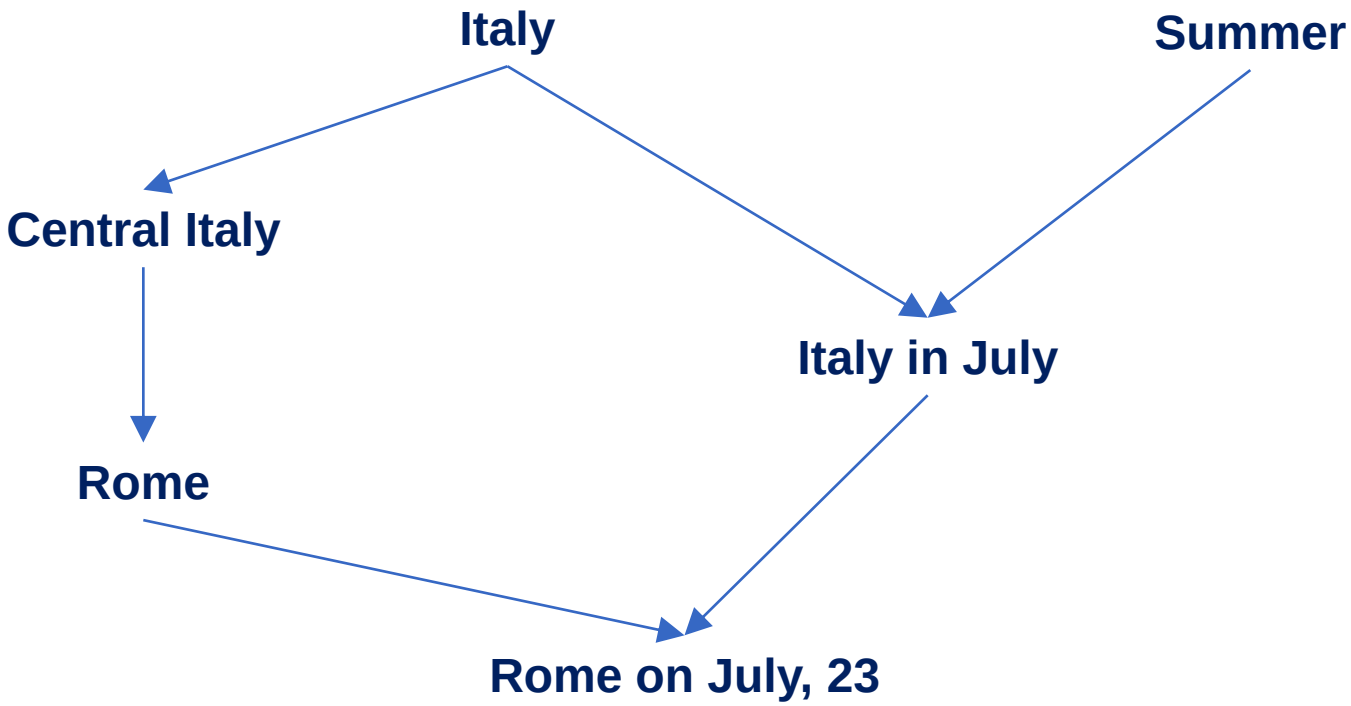
Preferences depend on the context

Goal

- Modeling contextual preferences
- The problem has been investigated following pragmatic, operational approaches:
  - Agrawal et al. SIGMOD 2006,
  - Miele et al. EDBT 2009,
  - Stefanidis et al. ICDE 2007.
- Our objectives:
  - Tackle the problem in a principled way
  - Provide a solid basis to the issue of context-aware preferences in database applications

Context model

- Any context model in which the set of contexts form a poset
- Poset = generalization relationship



Preference model

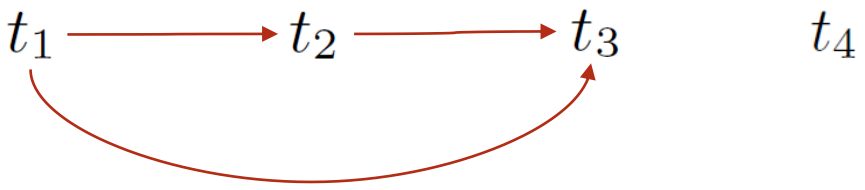
- A strict partial order over tuples of a relation

	Food	Calories	Fat
t_1	pasta	221	1.3
t_2	beef	63	2.5
t_3	salad	15	0.1
t_4	pizza	160	3.2

$$t_1 \succ t_2$$

$$t_2 \succ t_3$$

$$t_1 \succ t_3$$



Choosing the best

- Best operator:

$$\beta_{\succ}(r) = \{t \in r \mid \nexists t' \in r, t' \succ t\}$$

- Preference query: any expression of the relational algebra augmented with the Best operator
- Example:

	Food	Calories	Fat
t_1	pasta	221	1.3
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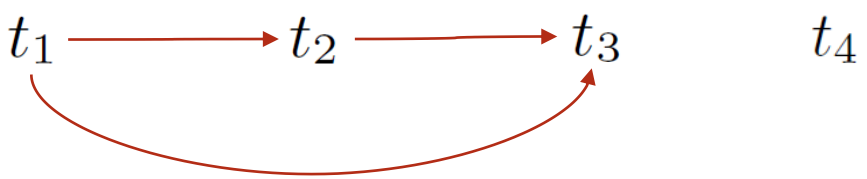


$$\pi_{\text{Food}}(\beta_{\succ}(r)) = \{\text{pasta}, \text{pizza}\}$$

Contextual preferences

- A set of preferences $\succ_c$ defined in a context c

Preferences Propagate

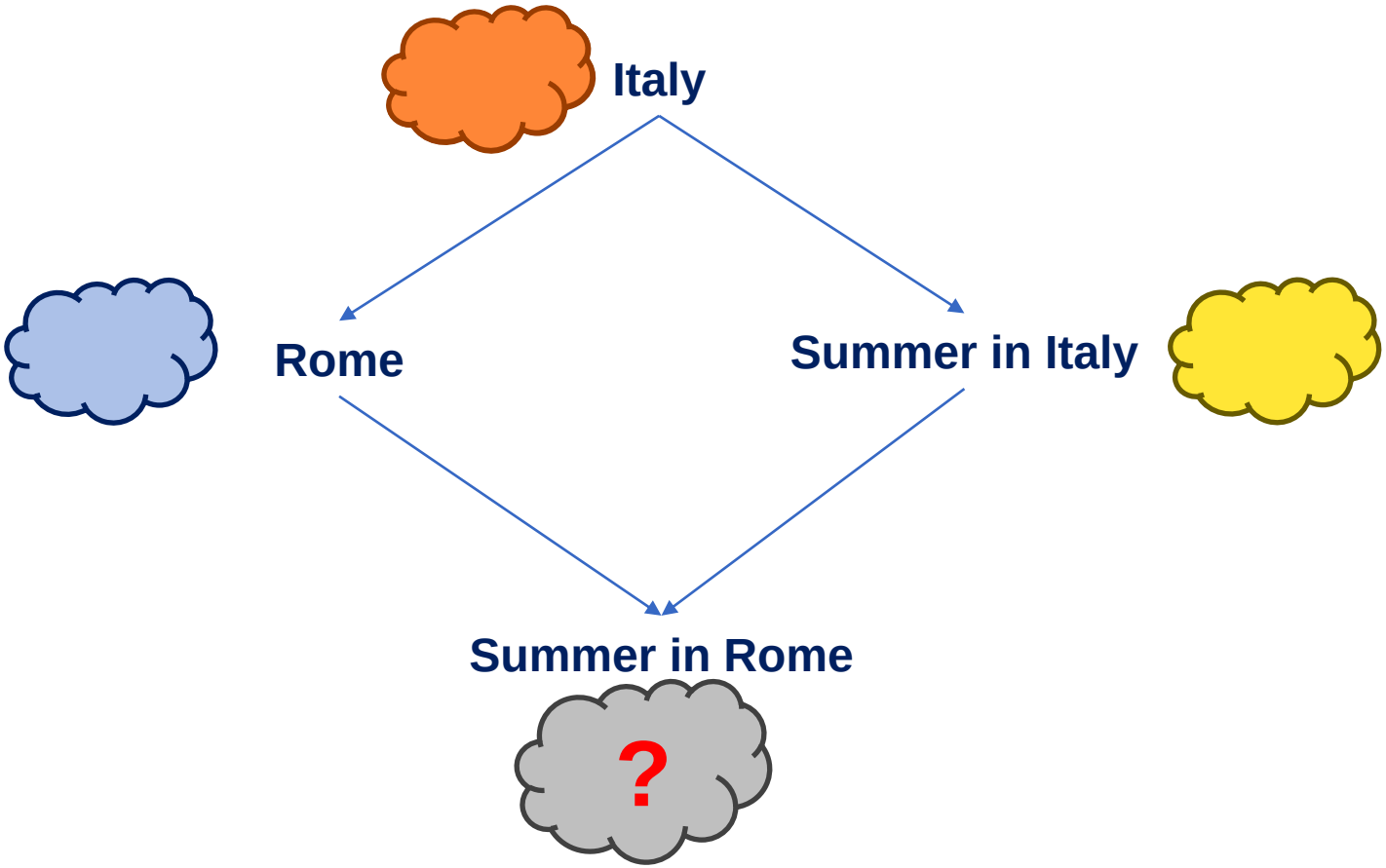
Italy

Central Italy

Rome

The preference propagation problem

- Given a poset of contextual preferences, which are the preferences valid in a context of the poset?



The specificity property

Italy

Florence

ER 2012

Prioritized composition

- This behavior is precisely captured by the prioritized composition of preference relations
- **Definition**: The Prioritized composition of two preference relations $\succ_1$ and $\succ_2$, written $\succ_1 \circledast \succ_2$, is defined as:

$$t_1 \succ_1 \circledast \succ_2 t_2 \Leftrightarrow (t_1 \succ_1 t_2) \vee (t_1 \succ_2 t_2 \wedge t_1 \approx_1 t_2)$$

- Example:

$$\succ_1 = \{t_1 \succ_1 t_2, t_1 \succ_1 t_3\} \quad \succ_2 = \{t_2 \succ_2 t_1, t_2 \succ_2 t_3\}$$

$$\succ_1 \circledast \succ_2 = \{t_1 \succ t_2, t_1 \succ t_3, t_2 \succ t_3\}$$

The fairness property

Rome

Summer

Summer in Rome

Pareto composition

- This behavior is precisely captured by the pareto composition of preference relations
- **Definition**: The Pareto composition of two preference relations $\succ_1$ and $\succ_2$, written $\succ_1 \oplus \succ_2$, is defined as:

$$t_1 \succ_1 \oplus \succ_2 t_2 \Leftrightarrow (t_1 \succ_1 t_2 \wedge t_1 \succ_2 t_2) \vee$$
$$(t_1 \succ_1 t_2 \wedge t_1 \approx_2 t_2) \vee (t_1 \approx_1 t_2 \wedge t_1 \succ_2 t_2)$$

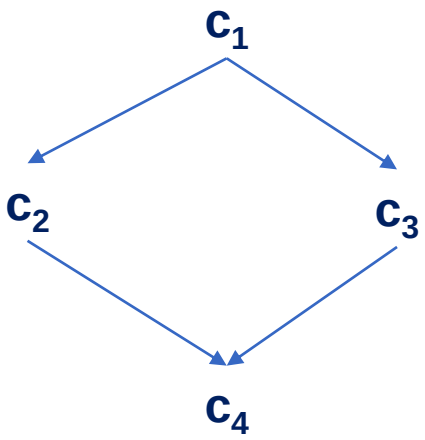
- Example:

$$\succ_1 = \{t_1 \succ_1 t_2, t_1 \succ_1 t_3\} \quad \succ_2 = \{t_2 \succ_2 t_1, t_2 \succ_2 t_3\}$$

$$\succ_1 \oplus \succ_2 = \{t_1 \succ t_3, t_2 \succ t_3\}$$

An algebraic approach to preference propagation

- Given a context c in a context poset C:
  - $\succ_c$: the base preferences in c
  - $\succ_c^+$: the complete preferences in c
- $\succ_c^+$ is expressed by means of a PC-expression of the form: $E ::= \succ_c | \; E \oplus E \mid E \circledast E \mid (E)$
- Example:



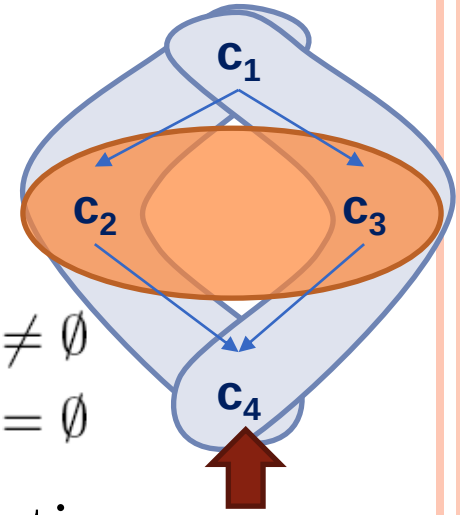
$$\succ_{c_4}^+ = \succ_{c_4} \circledast ((\succ_{c_2} \circledast \succ_{c_1}) \oplus (\succ_{c_3} \circledast \succ_{c_1})).$$

Problem

- How can we derive the PC-expression computing the complete preferences in a context c?
- Condition: specificity and fairness should be preserved
- Three approaches:
  - Complete-cover propagation
  - Active-cover propagation
  - Tuple-specific propagation

THE COMPLETE COVER (CC) PROPAGATION

- Computed recursively by considering the covering $\mathrm{COV}_C(c)$ of a context c



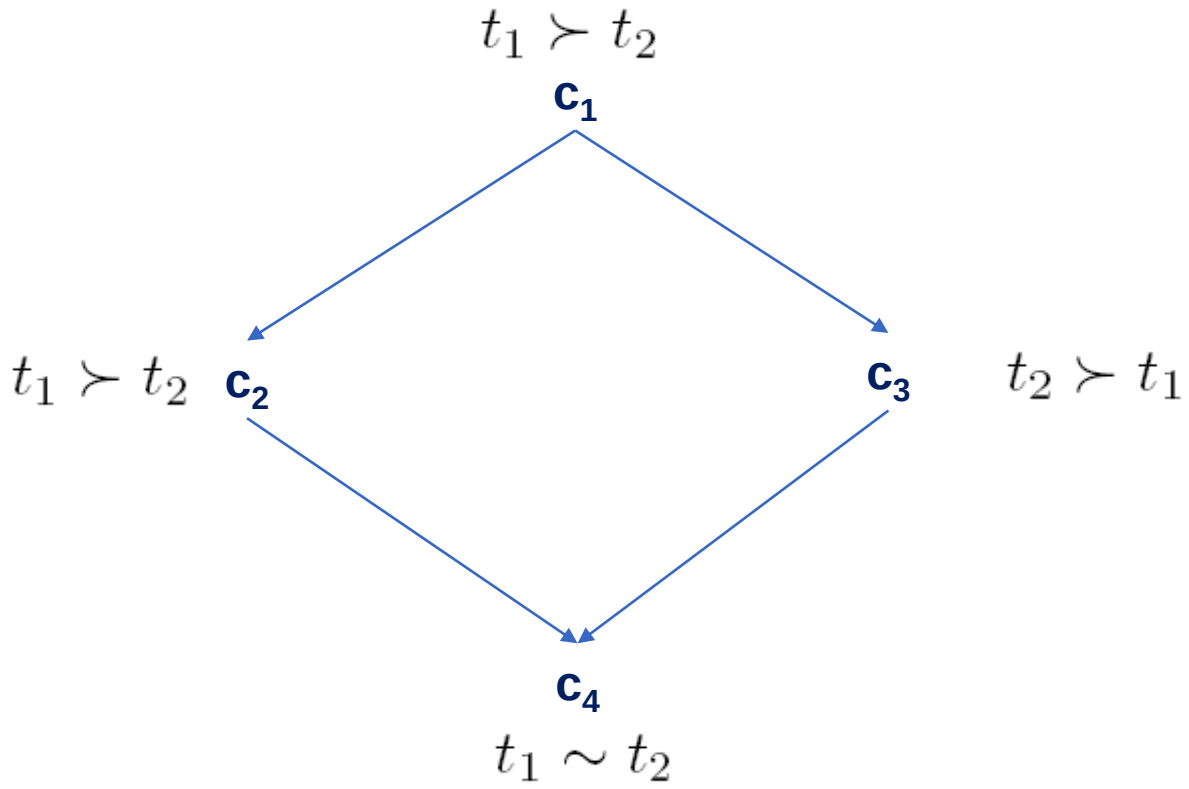
$$\succ_c^{+cc} = \begin{cases} \succ_c \circledast (\succ_{c_1}^{+cc} \oplus \succ_{c_2}^{+cc} \oplus \ldots \oplus \succ_{c_k}^{+cc}) & \text{if } \mathrm{COV}_C(c) \neq \emptyset \\ \succ_c & \text{if } \mathrm{COV}_C(c) = \emptyset \end{cases}$$

- There exists a canonical expression computing the CC propagation

$$(\succ_{c_4} \circledast \succ_{c_2} \circledast \succ_{c_1}) \quad \oplus \quad (\succ_{c_4} \circledast \succ_{c_3} \circledast \succ_{c_1})$$

Problem with the CC propagation

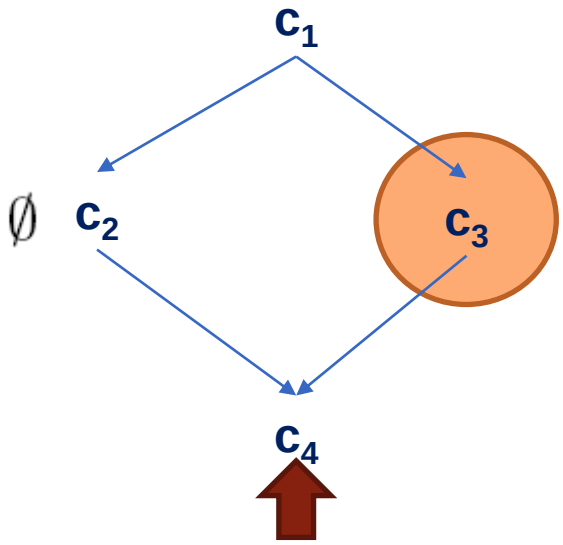
- The CC propagation is fair but not specific
- Cause: contexts with no base preferences



The active cover (AC) propagation

- Computed recursively by considering the active covering of a context c

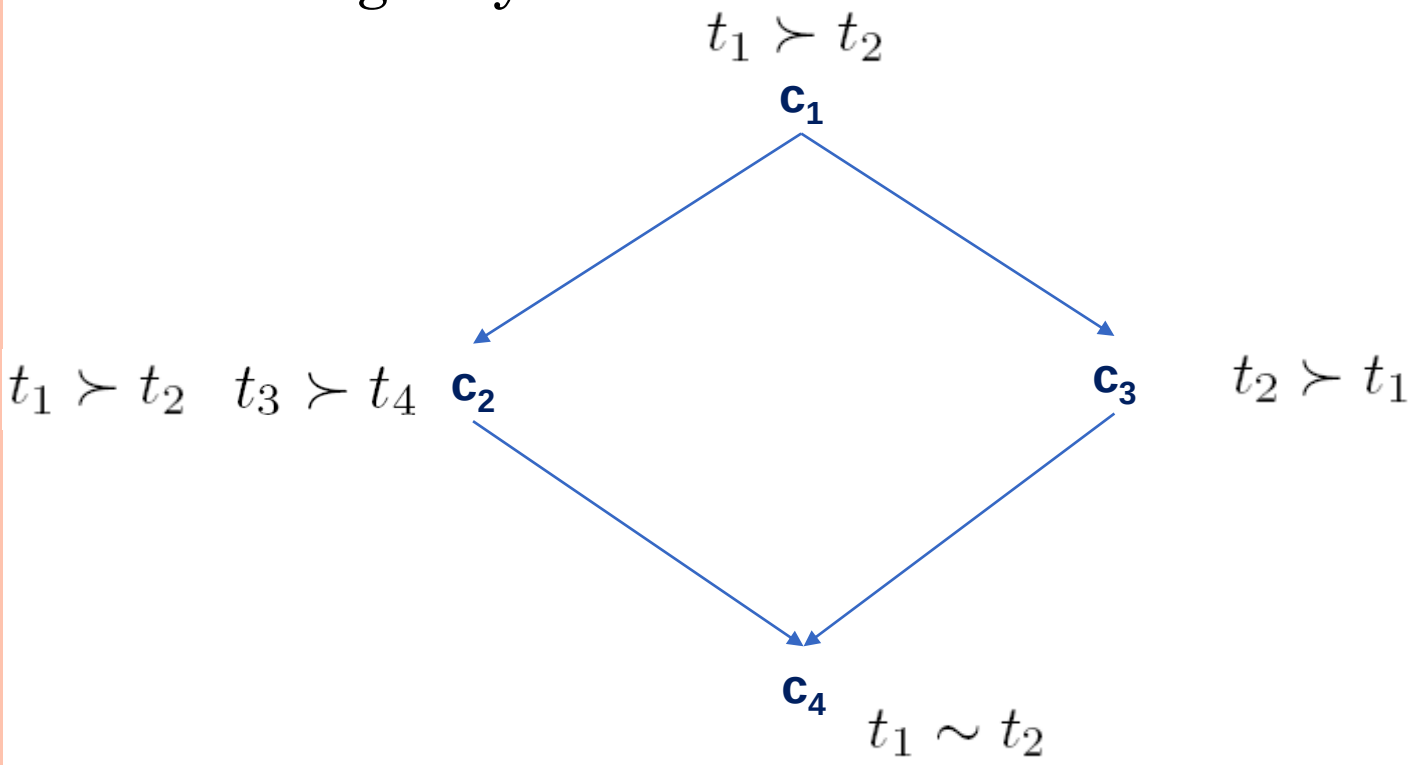
$$\succ_c^{+\mathcal{AC}} = \succ_c \circledast (\succ_{c_1}^{+\mathcal{AC}} \oplus \succ_{c_2}^{+\mathcal{AC}} \oplus \ldots \oplus \succ_{c_l}^{+\mathcal{AC}})$$



$$\succ_{c_4} \circledast \succ_{c_3} \circledast \succ_{c_1}$$

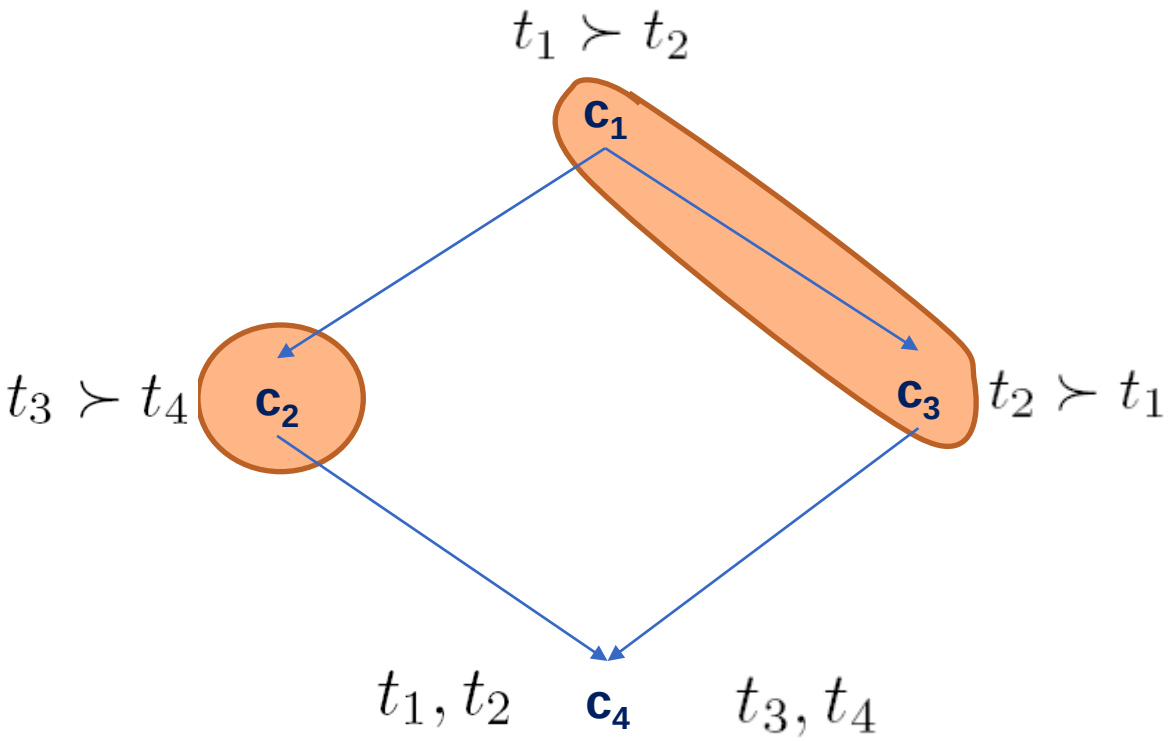
Problem with the AC propagation

- The AC propagation is fair but not specific
- Cause: specific preferences may still propagate in a wrong way



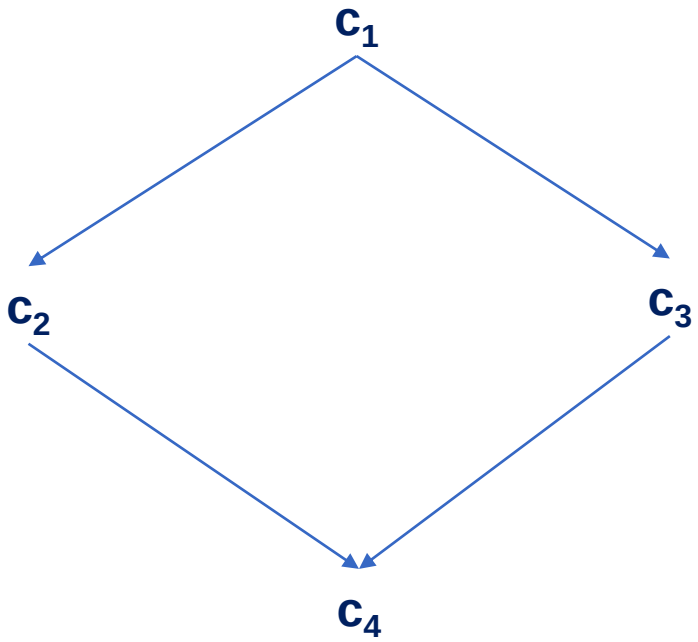
The tuple-specific (TC) propagation

- The propagation is computed for each pair of tuples t_1 and t_2 by considering only the contexts in which they are ordered



THAT IS GOOD!

- The TC propagation is both fair and specific
- There exists a PC-expression computing the TC propagation
- Example:



$$(\succ_{c_4} \circledast \succ_{c_2} \circledast \succ_{c_1}) \oplus (\succ_{c_4} \circledast \succ_{c_3} \circledast \succ_{c_1})$$

$$((\succ_{c_4} \circledast \succ_{c_2}) \oplus (\succ_{c_4} \circledast \succ_{c_3})) \circledast \succ_{c_1}$$

Conclusions

- A principled approach to contextual preferences
  - General context and preference models
  - Basic properties of preference propagation
  - Algebraic model based on pareto and prioritized operators
  - Three alternative propagation methods
- Future work
  - specialized optimization techniques for contextual preference queries
  - application to numerical preference models

Questions?