

Towards a Context-Aware Relational Model



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Outline

- **Motivation**
- Context Definition
- CR Model
- Operations
- Conclusions/Future Work



What is Context?

- Many definitions for context...
 - “location, identities of nearby people and objects, and changes to those objects”
 - “environment or situation”
 - etc...
- Two more general definitions [Dey01]:
 - *Context* is any information that can be used to characterize the situation of an entity.
 - A system is *context-aware* if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user’s task.



Motivation

- Numerous modeling approaches for context representation:
 - Logic based Models, Ontology based Models, Markup Scheme Models, Graphical Models, Object oriented Models.
- Models for representing information entities:
 - Relational Model, Logic based Models, Semi-structured data Models, etc.
- Our focus is in Relational Model:
 - Although relational model can be in principle used to represent context dependent information, context as such cannot be handled in database level but through the use of application logic.



Motivation

- Disadvantages of manipulating information entities that exist under different contexts at application level:
 - Redundancy: The logic and the different basic operations must be reimplemented in each context-aware application.
 - Implementations that are strictly connected to specific design decisions and the nature of each application.
 - Inflexible and hard to maintain architecture.



Motivation

- Our goal:
 - Management of information entities and context in a uniform way.
 - Incorporation of context as a «first class citizen» into DBMS.
- Advantages:
 - Comprehensive data design: context and its relation to data are taken into account at the stage of schema design.
 - High level query language incorporating context.
 - Efficient access/optimization.
 - Consistency checking mechanism for context.



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Context Definition

- World
 - environment under which data obtain a substance.
- Dimension
 - the set of parameters used to specify the worlds.
 - example set of dimensions $D = \{\text{device, country}\}$
- Context specifier
 - [device=PC]
 - [device=PDA, country in {Greece, France}]
- Universal context: []
- Empty context: [-]



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Context-Relational Model

- Multi-facet entity e : information entity which assumes different facets as defined under different words.
- Facet f_{ij} : variant of an entity e_i defined under a specific word w_j .
- Context-relation R : a set of multi-facet entities representing the same real-word information entity.
- For context-relation R , a set of attributes are defined in each word.



Context-Relational Model

- The sets of attributes defined for R under two different words can be:
 - The same.
 - Have a common subset.
 - Have no common attributes at all.

R has ***different schema*** under different words

- An attribute A_i of a single entity can have ***different values*** under different words.

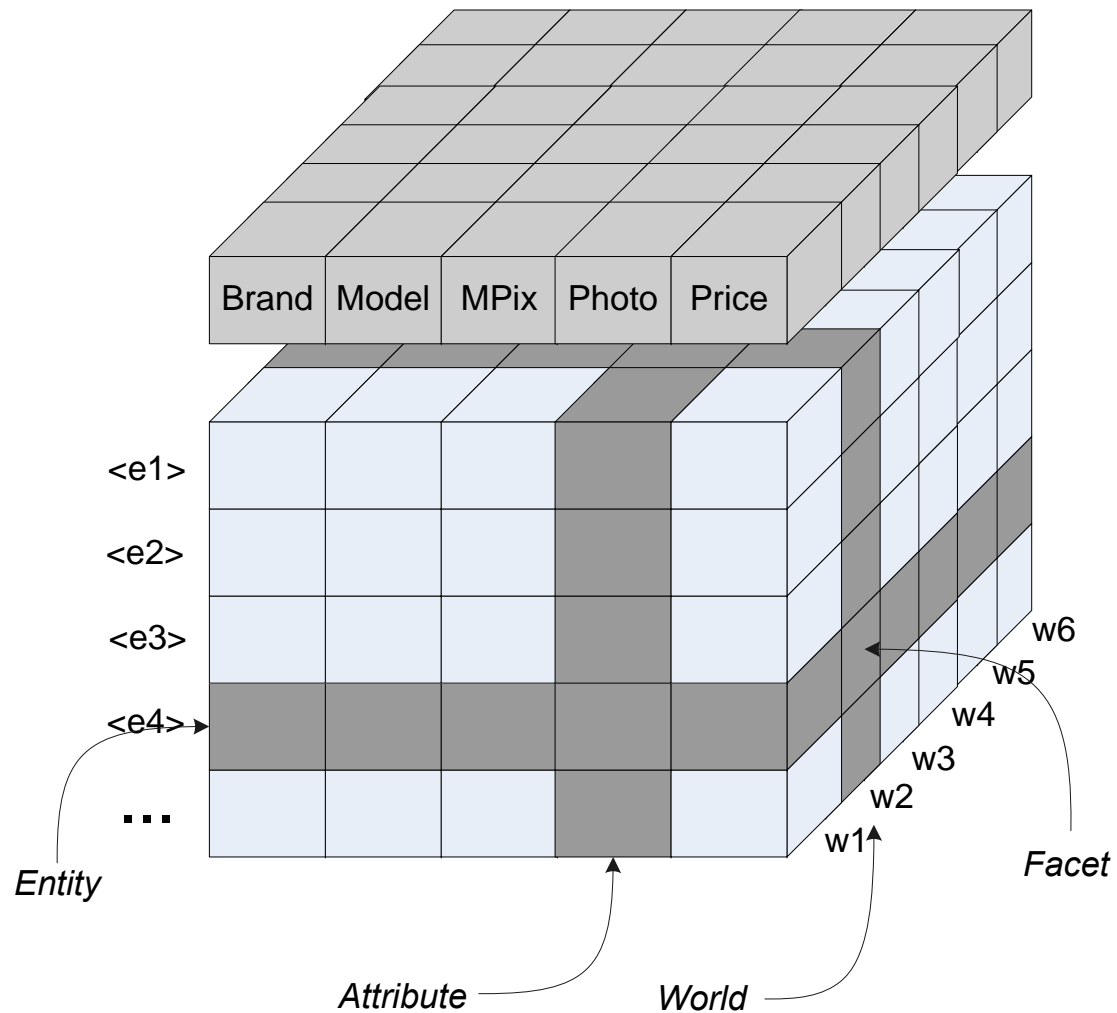


Running Example

- Web site about digital cameras.
- Context Relation *dcamera* with attributes:
 - Brand, Model, MPix, Photo, Price
- Dimensions:
 - *device* ranging over {PC, PDA, CELL}
 - *payment* ranging over {Credit Card, Cash}
- Photo: defined only for worlds with browsing device in {PC,PDA}
- Price: defined in every world but its values may change

World	Device	Payment
w1	PC	Credit Card
w2	PDA	Credit Card
w3	CELL	Credit Card
w4	PC	Cash
w5	PDA	Cash
w6	CELL	Cash

Context Relation dcamera



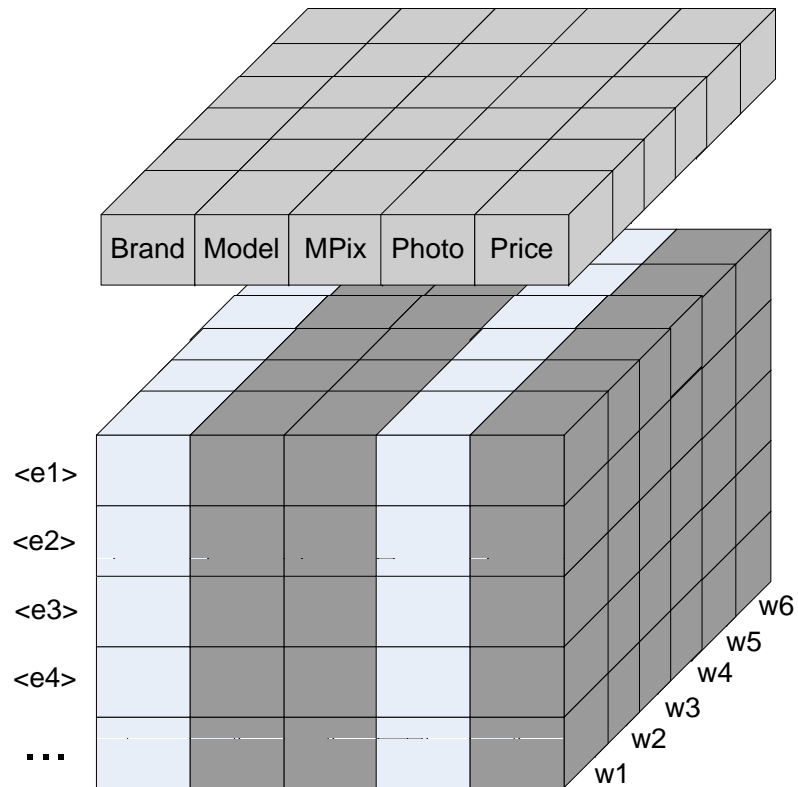


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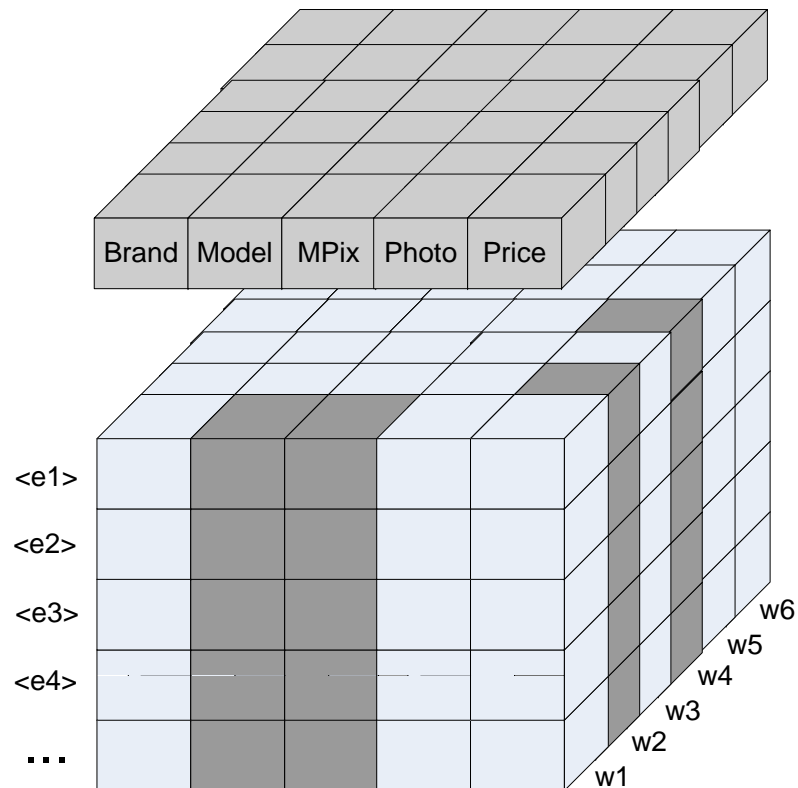
Context-Project

- $\Pi_{Model[], MPix[], Price[]} dcamera$



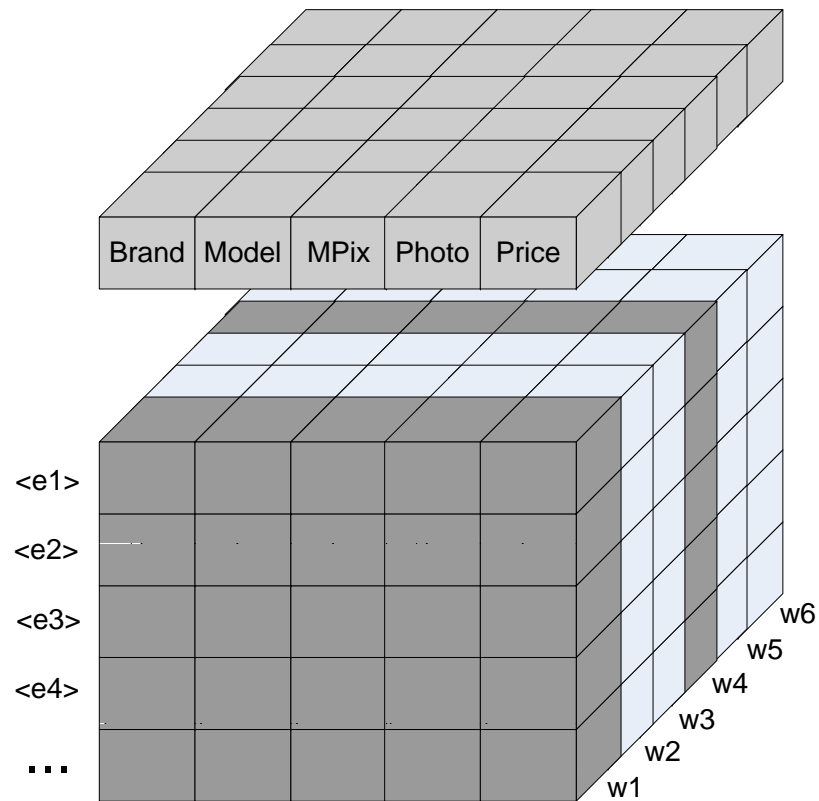
Context-Project

- $\Pi_{\text{Model}[\text{Device}=\text{PC}, \text{Payment}=\text{CreditCard}], \text{MPix}[\text{Device}=\text{PC}, \text{Payment}=\text{CreditCard}], \text{Price}[\text{Device}=\text{PDA}, \text{Payment} \in \{\text{CreditCard}, \text{Cash}\}]}$ *dcamera*



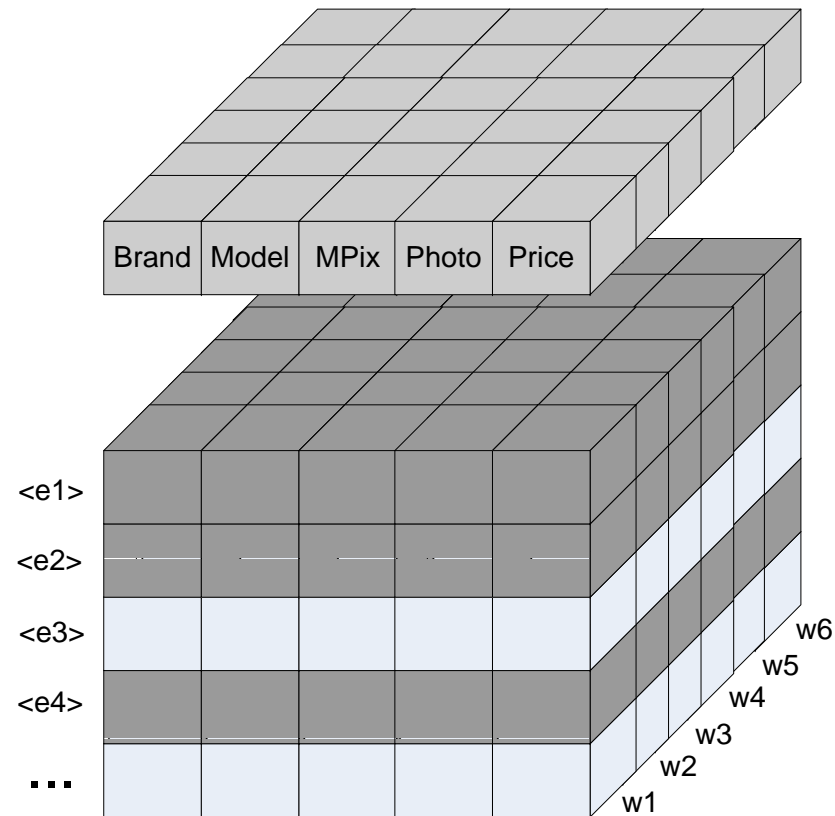
World Project

- $K_{[\text{Device}=\text{PC}]}$ *dcamera*



Entity Context-Select

■ σ^{entity} (*BRAND[]='Kodak' AND Price[]>300*) *dcamera*



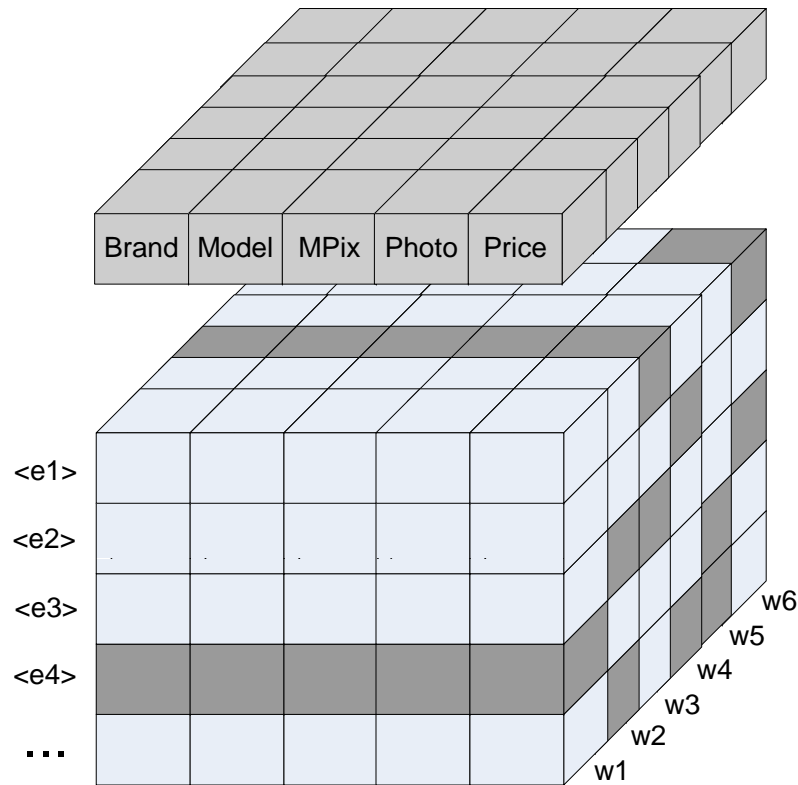
Entity Context-Select

- σ^{entity} ($BRAND[] = 'Kodak' \text{ AND } Price[Payment=Cash] > 300$) *dcamera*
- σ^{entity} ($Price[Device=PC, Payment=Cash] < Price[Device=PC, Payment=CreditCard]$) *dcamera*
- σ^{entity} ($BRAND[] = Kodak \text{ AND } Price < 300$) *dcamera*

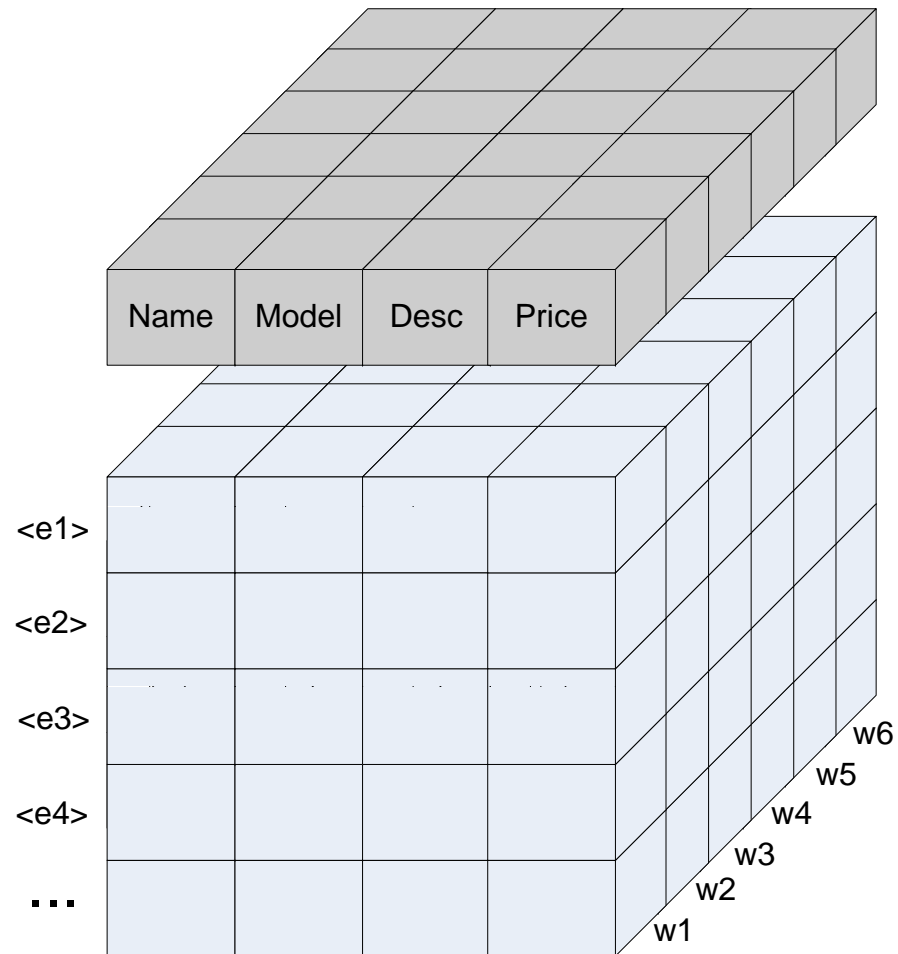
NO context specifier →
evaluate the condition to
true if there exists at least
one world where the
condition holds.

Facet Context-Select

- σ^{facet} (Price < 500) *dcamera*

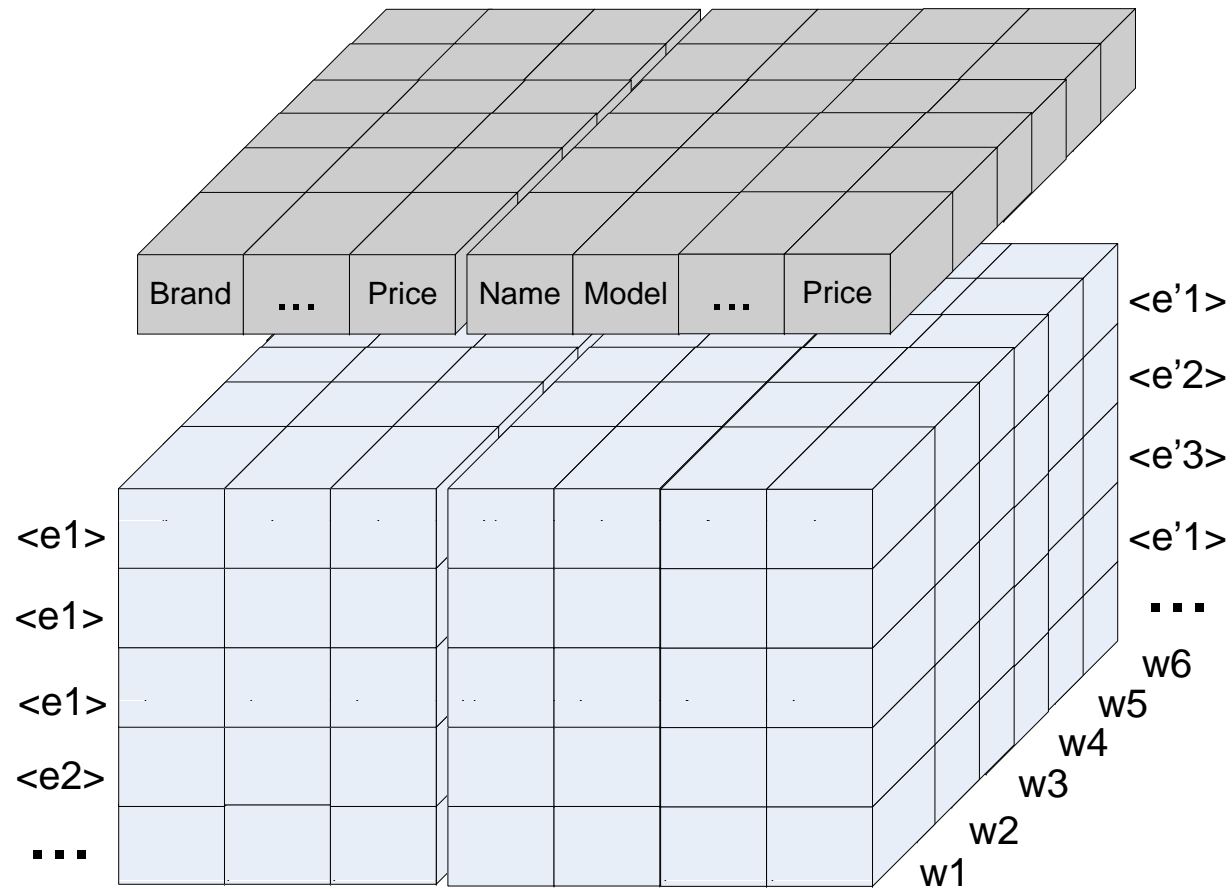


Context Relation accessories



Context

Cartesian Product/Join





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CR model vs Relational model

- Relational implementation:
 - A single denormalized relation.
 - {Number of different worlds} relations.
- Context as such cannot be handled in database level but through the use of application logic.
 - The link between the facets of the same entity is lost.
 - The link between the same attribute under different worlds is lost.



Future Work

- Extend the relational calculus and algebra to incorporate context.
- Context-aware query language for the CR model.
- Design efficient access methods to take context into account.
- Query optimization.
- Possible uses of CR Model
 - Temporal information/histories of data.
 - Personalization/profiles.
 - Data integration.



Thank You!

Questions?

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Illustrating Example

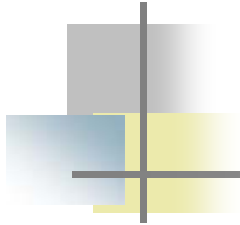
Customer who uses a PC and wants to buy Kodak camera with price < 400 Euros and accessories for it. He also wants to pay using cash for camera and using credit card for accessories.

- *Ctx-Rel1* ← context cartesian product(*dcamera*, *accessories*)
- *Ctx-Rel2* ← σ^{entity} (*dc.Model*[] = *ac.Model*[] AND *BRAND*[] = 'Kodak' AND *dc.Price*[*Device=PC, Payment=Cash*] < 400) *Ctx-Rel1*
- *Result* ← $\Pi_{dc.Model[Device=PC, Payment=Cash], dc.Price[Device=PC, Payment=Cash], ac.Name[Device=PC, Payment=CreditCard], Ac.Price[Device=PC, Payment=CreditCard]}$ *Ctx-Rel2*



Operations

- Context Project.
- World Project.
- Entity Context Select.
- Facet Context Select.
- Context Cartesian Product.
- Context Join.
- Set operations.



Relational Implementation A

dcamera

Model_w1	Model_w2	Model_w3	...	Brand_w1	Brand_w2	...



Relational Implementation B

dcamera_w1

Model	Brand	MPIX	Photo	Price

dcamera_w2

Model	Brand	MPIX	Photo	Price

dcamera_w3

Model	Brand	MPIX	Price