Deep Set Operators for XQuery

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Motivation: XML Access Control

- XML Access Control
- Rules and queries are described by XPath
- Positive rules: some nodes are allowed to access.
- Negative rules: access to some nodes is restricted.

Positive Rules

Query: //item **Rule: (Role, //item/name, +, LC)**

```
<item id="item0">
  <location>United States</location>
  <quantity>1</quantity>
  <name>duteous nine eighteen</name>          <name>duteous nine eighteen</name>
  <payment>Creditcard</payment>
  <description/>
  <shipping/>
  <incategory category="category0" />
</item>

<item id="item1">
  <location>United States</location>
  <quantity>1</quantity>
  <name>great</name>                          <name>great</name>
  <payment>Money order, Cash</payment>
  <shipping>Will ship
     internationally</shipping>
  <incategory category="category0" />
</item>
```


Positive Rules

- There is an “intersect” semantics between positive rules and query.
- Operands may not be at the same level.
  - E.g. //item *intersect* //item/name
- Existing intersect operator in XQuery could not handle this semantics.

Negative Rules

Negative rules:
- Query: /site/people
- Rule: (*Role*, /site/people/person/credicard, -, LC)

```
<people>
    <person id="person6">
          <name>Moheb Mersereau</name>
          <emailaddress>mailto:Mersereau@umass.edu</emailaddress>
          <creditcard>4462 9674 4373 8450</creditcard>
    </person>
    <person id="person7">
          <name>Yuanyuan Sydow</name>
          <emailaddress>mailto:Sydow@newpaltz.edu</emailaddress>
          <phone>+213 (600) 7188249</phone>
    </person>
</people>
```

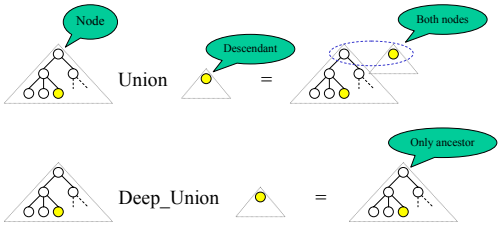

Negative Rules

- There is an “except” semantics between negative rules and query.
- They may not be at the same level.
  - E.g. //people *except* //people/person/creditcard
- Existing intersect operator in XQuery could not handle this semantics.

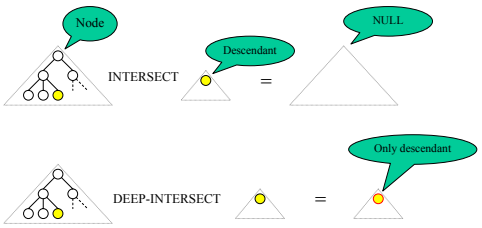
Deep set operators

- Existing set operators in XQuery
  - UNION, INTERSECT, EXCEPT
  - Operations are based on nodes (node_ids)
  - Take node sequences as operands
  - Compare, process and return nodes in these sequences
- The deep set operator
  - Deep_Union, Deep_Intersect, Deep_Except
  - Operations are based on subtrees (nodes and descendants)
  - Take node sequences as operands
  - Compare and process nodes and their descendants (deep)

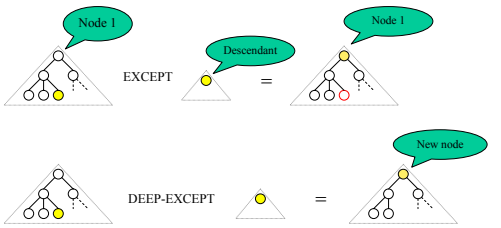
Union vs. Deep-Union



Intersect vs. Deep-Intersect



Except vs. Deep-Except



Examples

- XML fragment:

```
<a>
    <b> <c/> </b>
    <d/>
</a>
```

- /a UNION //b — **a** and **b** nodes

```
<a>
    <b> <c/> </b>
    <d/>
</a>,
<b> <c/> </b>
```

/a INTERSECT //b — **NULL**

/a EXCEPT //b — **a** nodes

```
<a>
    <b> <c/> </b>
    <d/>
</a>
```

- /a DEEP-UNION //b — **a** nodes

```
<a>
    <b> <c/> </b>
    <d/>
</a>
```

/a DEEP-INTERSECT //b — **b** nodes

```
<b> <c/> </b>
```

/a DEEP-EXCEPT //b — new **a** nodes

```
<a>
    <d/>
</a>
```


Definitions

- First, we denote node sequences as

  $P = \{p_1, \ldots p_n\}$

  $Q = \{q_1, \ldots q_n\}$.
- And the enumeration of the nodes and all their descendant nodes as:

  $P_d = P/\text{descendant} - \text{or} - \text{self} :: *$

  $Q_d = Q/\text{descendant} - \text{or} - \text{self} :: *$

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Definitions: DEEP-UNION

Deep-union operator takes two node sequences *P* and *Q* as operands, and returns a sequence of nodes:

- (1) who exist as a **node** or as a **descendant** of the nodes in "***either***" operand sequences
- (2) whose parent does not satisfy (1).

Mathematically:

P **Deep-Union** $Q = \{r \mid (r \in P_d \vee r \in Q_d) \wedge (r::parent() \notin P_d \wedge r :: parent() \notin Q_d)\}$

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Definitions: DEEP-INTERSECT

Deep-intersect operator takes two node sequences *P* and *Q* as operands, and returns a sequence of nodes:

- (1) who exist as a **node** or as a **descendant** of the nodes in "***both***" operand sequences
- (2) whose parent does not satisfy (1).

Mathematically:

P **Deep-Intersect** $Q = \{r \mid (r \in P_d \wedge r \in Q_d) \wedge (r::parent() \notin P_d \vee r :: parent() \notin Q_d)\}$

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Definitions: DEEP-EXCEPT

- Deep-except (ad-hoc):

  P Deep-Except *Q*

  Return the subtrees of *P*, with subtrees rooting at *Q* been removed from the answer.
- Deep-except constructs new nodes.

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Conclusions and Discussions

- Each XML node is "a set of set(s)'"
- Regular set operators only rely on node-IDs to identify and compare nodes.
  - They ignore the comparability issue of operands
  - They neglect the tree-structured hierarchy of XML data.
- Deep set operators recognize the ancestor-descendant relationships in the tree-structured hierarchy of XML.
  - Nodes in input node sequences are not regarded as atomic entities
  - They are treated as hierarchically nested elements.
  - Traverse into descendants of nodes to conduct comparison and processing, in a ``deep'' manner.