Service-oriented Continuous Queries for Pervasive Systems
EDBT 2008 Ph.D. Workshop

Yann Gripay

Ph.D. Supervisors: Frédérique Laforest, Jean-Marc Petit

Laboratoire d’InfoRmatique en Image et Systèmes d’information
Université de Lyon, Insa-Lyon, LIRIS – UMR 5205 CNRS
7 avenue Jean Capelle
F-69621 Villeurbanne, France
http://liris.cnrs.fr
Pervasive Environments

Citation

“The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.”, Mark Weiser [Scientific American, 1991]

- Various devices
  - Desktop computers
  - Servers
  - Mobile devices
  - Sensors
  - Actuators

- Complex environment
  - Distributed and dynamic
  - Heterogeneous data sources and services

- Currently: ad hoc development of pervasive applications
Unified View of a Pervasive Environment

- Abstraction of system layers
- Data-centric approach
  - Unified view of resources as non-conventional data sources
    - Relational data
    - Data streams
    - Services
  - Declarative definition of pervasive applications
    - SQL-like query language
    - Continuous queries

Question

How continuous query techniques over non-conventional data sources can make the development of pervasive applications easier?
Unified View of a Pervasive Environment

- Abstraction of system layers
- Data-centric approach
  - Unified view of resources as non-conventional data sources
    - Relational data
    - Data streams
    - Services
  - Declarative definition of pervasive applications
    - SQL-like query language
    - Continuous queries

Question
How continuous query techniques over non-conventional data sources can make the development of pervasive applications easier?
Challenges

- Homogeneous representation of a pervasive environment
  - Heterogeneous non-conventional data sources
  - A pervasive environment as an extended database
- Service-oriented Continuous Queries
  - Declarative definition of pervasive applications
- Pervasive Environment Management System
  - Services
  - Data
  - Queries
Plan

1. Introduction
2. Non-Conventional Data Sources
3. Service-oriented Continuous Queries
4. Pervasive Environment Management System
5. Conclusion
Plan

1. Introduction

2. Non-Conventional Data Sources

3. Service-oriented Continuous Queries

4. Pervasive Environment Management System

5. Conclusion
Homogeneous Representation
Relations, Services and Methods

- Standard relational model
  - Constants, attributes, schemas, relations
  - Example: \( Contact = \{\text{last\_name}, \text{first\_name}, \text{address}\} \)

<table>
<thead>
<tr>
<th>last_name</th>
<th>first_name</th>
<th>address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petit</td>
<td>Jean-Marc</td>
<td><a href="mailto:jmpetit@liris.cnrs.fr">jmpetit@liris.cnrs.fr</a></td>
</tr>
<tr>
<td>Laforest</td>
<td>Frédérique</td>
<td><a href="mailto:flaforest@liris.cnrs.fr">flaforest@liris.cnrs.fr</a></td>
</tr>
<tr>
<td>Gripay</td>
<td>Yann</td>
<td><a href="mailto:ygripay@liris.cnrs.fr">ygripay@liris.cnrs.fr</a></td>
</tr>
</tbody>
</table>

- Adding services
  - Method prototypes
  - Services, that implement some method prototypes
  - Example:
    - Method \( sendMessage(\text{address, text}) \mapsto (\text{sendResult}) \)
    - Services \( \text{mail\_server and jabber implement sendMessage} \)
Homogeneous Representation

Extended Relations

- Extending relations with 2 notions
  - Virtual attributes
    - No value
  - Binding patterns [Florescu, SIGMOD’99] [Goldman, SIGMOD’00]
    - Method providing some attributes
    - Attribute identifying the service (at the tuple level)
  - Notion of extended relations

Example:
- ExtendedContact = \{last\_name, first\_name, address, messenger, text\_v, sendResult\_v\}
- \(BP(ExtendedContact) = \{\langle sendMessage, messenger\rangle\}\)

<table>
<thead>
<tr>
<th>last_name</th>
<th>first_name</th>
<th>address</th>
<th>messenger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petit</td>
<td>Jean-Marc</td>
<td><a href="mailto:jmpetit@liris.cnrs.fr">jmpetit@liris.cnrs.fr</a></td>
<td>mail_server</td>
</tr>
<tr>
<td>Laforest</td>
<td>Frédérique</td>
<td><a href="mailto:flaforest@liris.cnrs.fr">flaforest@liris.cnrs.fr</a></td>
<td>mail_server</td>
</tr>
<tr>
<td>Gripay</td>
<td>Yann</td>
<td><a href="mailto:ygripay@jabber.liris.cnrs.fr">ygripay@jabber.liris.cnrs.fr</a></td>
<td>jabber</td>
</tr>
</tbody>
</table>
Homogeneous Representation

Dynamic Relations

- Introducing time in the relational model
  - Discrete time domain \([CQL, \text{STREAM Project}]\)
  - Homogeneous model for streams and relations
    - Timestamped tuples
    - Instantaneous relation at each instant
    - Finite or infinite relation

- Example: \(\text{Temperatures} = \{\text{temperature, area}\}\)

<table>
<thead>
<tr>
<th>timestamp</th>
<th>temperature</th>
<th>area</th>
</tr>
</thead>
<tbody>
<tr>
<td>@16</td>
<td>17.5</td>
<td>A</td>
</tr>
<tr>
<td>@25</td>
<td>18.5</td>
<td>B</td>
</tr>
<tr>
<td>@25</td>
<td>16.0</td>
<td>C</td>
</tr>
<tr>
<td>@27</td>
<td>19.5</td>
<td>A</td>
</tr>
<tr>
<td>@27</td>
<td>15.0</td>
<td>D</td>
</tr>
<tr>
<td>@29</td>
<td>17.0</td>
<td>B</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>
Homogeneous Representation
Extended Dynamic Relations

- XD-relations
  - Virtual attributes
  - Binding patterns
  - Timestamped tuples

- Example:
  - Method `takePhoto(area) \rightarrow (photo)`
  - Services `camera_1, camera_2` implement `takePhoto`
  - `Temperatures = \{temperature, area, camera, photo_v\}`
  - `BP(Temperatures) = \{(takePhoto, camera)\}`

<table>
<thead>
<tr>
<th>timestamp</th>
<th>temperature</th>
<th>area</th>
<th>camera</th>
</tr>
</thead>
<tbody>
<tr>
<td>@16</td>
<td>17.5</td>
<td>A</td>
<td>camera_1</td>
</tr>
<tr>
<td>@25</td>
<td>18.5</td>
<td>B</td>
<td>camera_2</td>
</tr>
<tr>
<td>@25</td>
<td>16.0</td>
<td>C</td>
<td>camera_1</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

infinite XD-relation `temperatures`
Homogeneous Representation
Extended Dynamic Relations

- XD-relations
  - Virtual attributes
  - Binding patterns
  - Timestamped tuples

Example:
- Method \( \text{takePhoto}(\text{area}) \mapsto (\text{photo}) \)
- Services \( \text{camera}_1, \text{camera}_2 \) implement \( \text{takePhoto} \)
- \( \text{Temperatures} = \{\text{temperature, area, camera, photo}_v\} \)
- \( \text{BP}(\text{Temperatures}) = \{\langle\text{takePhoto, camera}\rangle\} \)

<table>
<thead>
<tr>
<th>timestamp</th>
<th>temperature</th>
<th>area</th>
<th>camera</th>
</tr>
</thead>
<tbody>
<tr>
<td>@16</td>
<td>17.5</td>
<td>A</td>
<td>\text{camera}_1</td>
</tr>
<tr>
<td>@25</td>
<td>18.5</td>
<td>B</td>
<td>\text{camera}_2</td>
</tr>
<tr>
<td>@25</td>
<td>16.0</td>
<td>C</td>
<td>\text{camera}_1</td>
</tr>
</tbody>
</table>

finite XD-relation \( \text{temperatures} \)
Homogeneous Representation
Relational Pervasive Environment

- Relational Database
  - A relational database is a set of relations
- Pervasive Environment
  - A pervasive environment is ...
Homogeneous Representation
Relational Pervasive Environment

- Relational Database
  - A relational database is a set of relations

- Pervasive Environment
  - A pervasive environment is a set of XD-relations
Homogeneous Representation
Relational Pervasive Environment

- Relational Database
  - A relational database is a set of relations

- Pervasive Environment
  - A pervasive environment is a set of XD-relations
  - A “relational pervasive environment” ?
  - A “Data Space” ?
    - [Franklin, Halevy, Maier, *SIGMOD Record, 2005*]
    - [Imielinski, Nath, *VLDB’02*]
Plan

1. Introduction
2. Non-Conventional Data Sources
3. Service-oriented Continuous Queries
4. Pervasive Environment Management System
5. Conclusion
Extending relational algebra on XD-relations

- Algebra with formal definitions
- Standard operators
  - Key idea: virtual attributes don’t have a value, so… don’t use their value!
  - Selection $\sigma$, Projection $\pi$, Join $\Join$, Rename $\rho$, Cartesian product $\times$
- New operators for virtual attributes
  - Unification with an attribute $\alpha A_v \equiv B$ or a constant $\alpha A_v \equiv a$
  - Invocation of a binding pattern $\beta_{bp}$
Service-oriented Continuous Queries
Operators for Dynamic Relations

- **Infinite XD-relation to finite XD-relation** *(Stream-to-Relation [CQL])*
  - Window operators
  - Time-based
  - Tuple-based

- **Finite XD-relation to infinite XD-relation** *(Relation-to-Stream [CQL])*
  - Streaming operators
  - Upon insertion or deletion of tuples
  - Time-based
Service-oriented Continuous Queries

Queries

- Operators can be composed: the result of an operator on XD-relations is an XD-relation
- A query is an expression over a pervasive environment (i.e. a set of XD-relations) with a finite number of operators
- Continuous queries or snapshot queries
- Examples:
  - Send a message to <name>
  - Get a photo of an area when the temperature exceeds a threshold
  - Send a message to the manager of an area when the mean temperature over the last minute exceeds a threshold
  - Send a message to every new contact
  - ...
Plan

1. Introduction
2. Non-Conventional Data Sources
3. Service-oriented Continuous Queries
4. Pervasive Environment Management System
5. Conclusion
Management of dynamic data sources
Service discovery and remote invocation
Continuous query processor
Query adaptation strategies
Pervasive Environment Management System
Prototype Architecture

- Query Processor
- Extended Table Manager
- Environment Resource Manager
- Network
- Local Environment Resource Manager
- Device Management
- Local Environment Resource Manager
- Device Management

Yann Gripay – http://liris.cnrs.fr/yann.gripay
SoCQs for Pervasive Systems – EDBT’08 Ph.D. Ws
1 Introduction
2 Non-Conventional Data Sources
3 Service-oriented Continuous Queries
4 Pervasive Environment Management System
5 Conclusion
Main Objectives

- Homogeneous representation
  - Pervasive environment as a set of XD-relations
  - Model for the “Data Space”?

- Queries
  - Query operators on XD-relations
  - Declarative definition of pervasive applications as SoCQs

- Management System
  - Middleware for pervasive environments

Work in Progress

- Formalization of XD-relations and query operators
- Definition of a SQL-like query language for SoCQs
- Development of the PEMS prototype
Conclusion

Middle Term Objectives

- Query optimization techniques
- Data description language
- Virtual attributes with events
- “Demo-ready” PEMS prototype

Long Term Objectives

- Dynamic query adaptation
- Peer-to-peer PEMS

Yann Gripay – http://liris.cnrs.fr/yann.gripay

SoCQs for Pervasive Systems – EDBT’08 Ph.D. Ws
THANK YOU FOR YOUR ATTENTION!

SoCQ Project Web Site
http://socq.liris.cnrs.fr