Panel Discussion: Future Research on RFID Data Management

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Temporal and History Oriented

- Observations are timestamped
- Observations generate new events, and carry state changes
- Location and aggregation change along the time
- Powerful queries needed to support tracking and monitoring of objects upon collected histories

→ RFID data management system has to be temporal oriented, and support expressive and efficient temporal queries
Multi-Dimensional

- Temporal dimension
- Spatial dimension: symbolic locations and physical locations (e.g., physical locations from active RFID)
- Containment dimension: truck → pallet → case → item
- EPC hierarchy: domain manager (manufacturer) → object class (SKU) → serial number (unique ID with object class)

→ RFID data management system or data warehousing system needs to consider all the dimensions to optimize the data model, storage and queries
Implicit Semantics

- Readings imply location changes, aggregations, and business rules
  - What does it mean when an item is read? Packed into a case or pallet? Leave for a warehouse, loaded onto a truck, etc?
  - What does it mean if a patient is out of his room for 30 minutes and without any nurse with him?

- How to automatically interpret the semantics from readings or complex sequence of readings?
  → RFID data processing needs to be able to process complex RFID events, and AUTOMATE the semantics transformation
  → RFID data semantics analysis can add significant new value to RFID data
Streaming and in Large Volume

- Large scale streaming RFID data need to be processed on the fly, especially when item-level tagging is supported.
- For many RFID applications, history data need to be archived for tracking and monitoring of RFID objects.

→ Need efficient RFID data stream processing for real-time based RFID applications,
→ Need efficient temporal RFID data management and query support for tracking based RFID applications.
Heterogeneous

- Readers: fixed readers, movable readers, 802.11 wireless access point “readers”
- Tags: class 0,1 (read-only), 2 (read-write), 3 (sensor-write) and Wi-Fi tags
- Reader semantics: a reader can represent a location, a subject, or even an operation
- The diversity of RFID applications leads to complex semantics of RFID data

→ This poses another challenge for generic RFID data modeling and management
Integration

• RFID data need to be integrated into existing business applications, and such integration cost is a big hurdle for the adoption of RFID

• Middleware platforms need to adopt RFID as a source adapter to support plug-and-play, and provide high adaptability and interoperation for different applications

• Adaptable RFID middleware and data management system could provide customization based integration and deployment, thus minimize integration effort
Generic RFID Data Modeling and Data Management
[VLDB05, MDM06]
• Develop temporal-oriented RFID data management to provide comprehensive queries for tracking and monitoring
• Generalize RFID data semantics through a large variety of RFID applications and provide generic integrated RFID data modeling

**Our Contributions**
1: Cases packed onto pallets
2: Pallets loaded onto a truck
3: Pallets unloaded to a retail store
4. Cases checked out at register

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**RFID Data Manager**
- **RFID Data Server**
- **RFID Data Manager**

**Tag Type**
- Class 0,1: Read-only
- Class 2: Reader-write
- Class 3: Sensor-write (Semi-Passive)

**Reader/Location/Operation**
- Fixed Reader: Fixed Location
- Moveable Reader: No Location, Discrete Location, Continuous Location
- With Operation: E

**Tag Types**
- A: Fixed Location
- B: No Location
- C: Discrete Location
- D: Continuous Location
- E: With Operation

**Reader/Location/Transaction**
- Reader
- Location
- Transaction

**Data Types**
- Reader/Location/Operation
- Transaction Item
- Containment
- Observation
- Continuous Location
- Discrete Location

**Semantic Filtering**
- Data Transformation
- Event Aggregation
- Real-time Monitoring

**Temporal Relationships**
- State-based Temporal Relationship
- Event-based Temporal Relationship

**Data Model**
- RFID Tables
- Reader
- Location
- Transaction Item
- Containment
- Observation

**State-based Temporal Relationship**
- tstart
- tend

**Event-based Temporal Relationship**
- timestamp
- tstart
- tend

**Static Relationship**
- Location

**Supplier Warehouse**
- 1: Cases packed onto pallets
- 2: Pallets loaded onto a truck
- 3: Pallets unloaded to a retail store
- 4: Cases checked out at register
Complex RFID Event Processing [EDBT06]

• Develop a rules-based framework for automatic RFID data transformation and aggregation

• Generalize complex RFID events and develop an RFID event engine to process highly-temporal constrained and non-spontaneous events
  – Graph based event processing with both bottom-up propagation and top-down queries, and use pseudo events to process non-spontaneous events
Our Contributions

Complex RFID Event Processing with DSMS [ICDE07]

- Study the possibility of using data streaming management system for processing complex RFID events
  - DSMS provides nature continuous queries with a (frequently SQL-based) query language and is designed for near-real time response
- Study the query language of Stream Mill and provide extensions of the language to support complex RFID events (collaboration with Prof. Zaniolo)
Adaptable RFID Data Management System

• Develop an adaptable RFID data management system by integrating:
  – RFID Edge Server,
  – RFID event filtering,
  – generic RFID event processing and semantic translation and
  – generic RFID data modeling and query processing
Advanced Complex RFID Event Processing

• Effective and efficient processing of complex RFID events with temporal, spatial, and/or aggregation based constraints
  – E.g., wireless network based active RFID provides precise continuous location tracking, thus can generate spatial-temporal events

• Generic, efficient and robust RFID event processing engine to support enterprise RFID data processing
  – Specialized event/rule engine optimized for RFID applications
Advanced Complex RFID Event Processing (cont’d)

• Complex RFID event processing with Data Stream Management Systems
  – What are the advantages and disadvantages?
  – How to extend DSMS query language to provide sufficient support for RFID events?
  – What is the performance bottleneck and how can it be improved to support enterprise RFID event processing?

• Distributed RFID event processing and correlation
  – How can distributed RFID events can be correlated?
  – How can they be efficiently processed?
Advanced RFID Data Management

• Distribution of RFID Data – where:
  – what data need to stay local at a site level, and what need to propagate to the enterprise level?
  – How distributed queries and event processing can be supported in such distribution?

• Data warehousing of RFID data: how to take advantage of the multi-dimensionality of RFID data for RFID data warehousing?
Advanced RFID Data Management (cont’d)

• Generalization of RFID data model to support diverse RFID applications, and generic RFID data management middleware to support lightweight integration with enterprise applications

• Advanced data normalization for negative false readings

• Discovery and semantic mapping of uniquely identified object data
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