Enabling Traceability in Large-Scale RFID Networks

A dissertation submitted in fulfillment
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Doctor of Philosophy
in
Computer Science

Yanbo Wu
Supervisor: Prof. Hong Shen, Dr. Quanzheng Sheng

School of Computer Science
The University of Adelaide

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Abstract of the Dissertation

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The emergence of radio frequency identification (RFID) technology brings significant social and economic benefits. As a non line of sight technology, RFID provides an effective way to record movements of objects within a networked system formed by a set of distributed and collaborating parties. A trail of such recorded movements is the foundation for enabling traceability applications. While traceability is a critical aspect of the majority of RFID applications, realizing traceability for these applications brings many fundamental research and development issues, including storage efficiency, query processing complexity, privacy etc.

In this dissertation, we present a novel approach to realize RFIID-based traceability in large, autonomous and heterogeneous distributed networks. We first propose a Peer-to-Peer (P2P) architecture, namely PeerTrack. PeerTrack does not require any kind of centralized database for the RFID data or their index, neither it requires RFID data to be fully shared to partners. In PeerTrack, only a specific portion of data is requested by partners, when the access is necessary.

We introduce a distributed model, namely MOODS (a **M**odel for m**O**ving **O**bjects in **D**iscrete **S**pace), for the essential data structures of traceability.

MOODS is maintained by a distributed index on the top of a structured Peer-to-Peer overlay. We then propose efficient algorithms for the maintenance of MOODS. The algorithms are optimized to consume statistically minimal cost of bandwidth. Based on this model, we propose algorithms for efficient item-level and statistical traceability query processing.

We also propose a traceability mining model for distributed RFID streams, namely TISH (**T**ilted T**I**me **F**rame of **H**istogram). TISH takes advantages of two important data mining tools, namely *Tilted Time Series* and *Histogram*, and combines them to describe the patterns of RFID streams in the dimensions of both time and space, and capture the dynamicity of the patterns. We propose efficient algorithms to maintain TISH and algorithms that use it for traceability query processing and RFID stream mining.

We present a platform, namely PeerTrack Cloud, to bring the aforementioned RFID data modeling and traceability query processing techniques to the Cloud Environments. The platform features specific traceability-oriented modules for real-time query processing and efficient data storage.

The techniques proposed in this dissertation are implemented in "Asset Management System", which is a collaborative project with a local company. Finally, we conduct extensive performance studies of the proposed techniques. The experimental results reveal that our system i) is more scalable and outperforms the centralized approach when the data volume or the network becomes larger; ii) provides powerful programming interfaces for query processing; iii) is economy in both storage and bandwidth; and iv) can be easily adopted in cloud computing platforms.

ORIGINALITY STATEMENT

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To my mother and father,

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