Analyzing Product Flows with the Supply Chain Visualizer

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Abstract. Globalization and technical advances have created a new level of competition and complexity for supply chains. The risk is high that due to this complexity and limited visibility causes of inefficiencies remain undiscovered. Radio Frequency IDentification (RFID) technology has recognized potential to increase the visibility along a supply chain due to cost-efficient gathering of process event data. With the Supply Chain Visualizer, we provide a tool for analyzing this event data and show how simple rules can reveal inefficiencies. By using a map-based user interface, a supply chain manager is finally able to pinpoint the sources of inefficiencies.

Keywords: RFID, trace data analysis, rule engine, visualization

1 Introduction

Due to globalization and technical advances, it is not the single firm anymore that decides the competition, but the interplay between several organizations along the supply chain. With increased complexity, supply chains face the high risk that due to limited visibility inefficiencies remain undiscovered. While managers know about the impact of delays, inaccurate data or shrinkage, they rarely know why and where the problems in the supply chain really originate. Technologies such as Radio Frequency IDentification (RFID) provide the potential to increase a supply chain managers' visibility in a high-resolution manner [1]. RFID technology can be used to generate trace data events of business processes and thus link the physical world to information systems. As the whole supply chain is now represented digitally, the data can be used to detect and locate inefficiencies in the actual supply chain.

The goal of the Supply Chain Visualizer project is to provide an easy to use visibility tool to support supply chain managers. The tool analyzes the integrity of RFID data events to locate "hot spots" in a supply chain. This information could be relevant for supply chain managers as the hot spots are a good indicator for further investigations and hereby help to direct quality improvement efforts accordingly. We provide a bottom-up supply chain integrity analysis that is based on generic consistency rules. With the recently standardized EPCIS interface [2], generic rules for detecting inefficiencies can be built and applied to a broad context. To our best knowledge, no paper exists studying the concept of generic rules for trace data analysis to detect inefficiencies in supply chains. In the following, we describe the system design and outline the high-level architecture of the Supply Chain Visualizer. Afterwards, we propose our concept of generic trace data rules to locate problems in supply chains and show some details about our prototype. Finally, we conclude our paper and suggest future work.

2 System

We consider a supply chain where every product is equipped with an RFID tag. Every time a RFID tag is read, an event record is generated. As the Supply Chain Visualizer is focused on the inter-organizational supply chain aspects, we consider three different types of events. We use a so-called shipping/receiving supply chain model [3], and differentiate between 1) shipping, 2) receiving and 3) internal events. An example for this model can be seen on Fig 1.

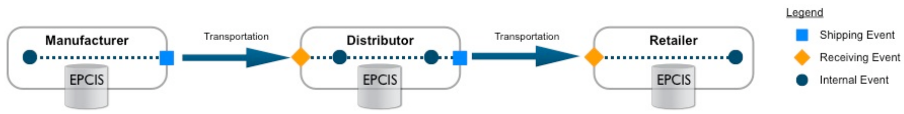

Fig 1. Illustration of the shipping/receiving data model for a generic retail supply chain

As specified in the EPCglobal architectural framework [4], the component for sharing the event data with other supply chain members are the so-called EPC Information Services (EPCIS). The Supply Chain Visualizer uses the EPCIS interfaces to collect data from various stages of a supply chain and stores them in a local data warehouse. The advantage is that several levels of analysis can be run without interfering with operational processes.

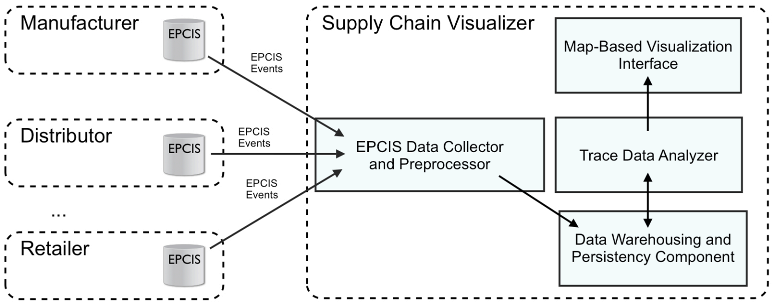

Fig 2. High-level architecture of the Supply Chain Visualizer and data flows between the components

The high-level architecture of the Supply Chain Visualizer is depicted on Fig 2 and comprises four main components. The boxes represent the components of the Supply Chain Visualizer and the arrows indicate data flows. The EPCIS data collector component uses the open source Accada Framework [5] to connect to a set of preconfigured EPCIS systems. The component retrieves the event data and preprocesses them for storage in the data-warehousing component. The data-warehousing component manages persistency and access to the backend MySQL database, which contains both, the imported data sets and the results from the trace data analyzer component. On the presentation layer, a map-based visualization interface displays the results and interacts with the user.

3 Rule-based trace data analysis

From the EPCIS specification [2], we make use of the following event data fields for our analysis: *epcList*, *eventTime*, *action*, *bizStep* and *bizLocation*. In the current version of the Supply Chain Visualizer we implemented four generic rules that provide a good indication for problems in the supply chain. The *speed consistency* rule utilizes utilizes *eventTime* and *bizLocation* to calculate the transition speed from one shipping event to another receiving event. If the speed exceeds a certain threshold, an inconsistency alert is raised. This alert could for example be triggered if products are subject to counterfeiting and thus two traces of a product with the same serial number occur. The *dwell time* rule calculates the time between receiving and shipping event. If the difference exceeds a certain threshold, time-critical products (such as perishables) might not be handled accordingly by a supply chain entity. The *shipping/receiving pairconsistency* rule utilizes the *bizStep* data field and might be very useful in various industries. Every item that is shipped from one location must have an appropriate read event. Otherwise, it could be an indication that a product was actually not shipped or was stolen during transport. The fourth rule that is implemented concerns the lifecycle of a product. As the field *action* indicates the initialization (e.g. manufacturing) or inactivation (e.g. product sold) of a product's tag, the *lifecycle* rule checks that there are no events registered before an initialization event ("ADD") or after an inactivation event ("DELETE").

4 Our demo

The Supply Chain Visualizer is a web-based application. A standard computer with a web-browser and Internet connection is sufficient. No specific client software is needed. We will use data from a fictive retail supply chain (about 10000 traces) and put the visitor into the role of a supply chain manager. A screenshot of our demo can be seen on Fig 3. The visitors will be able to see that product flows are highly aggregated to single lines and thus provide a clear view on the whole supply chain. With an easy to understand three-color scheme, the visitors can now see where the problems are and track them down. Green pins hereby indicate that the integrity analysis did not find any problems at a location. Yellow means that there are some problems detected which deserve attention and red indicates that the number of problems exceed a critical threshold. By clicking on the pins, the visitor will get more details about the type of integrity violation and find out which products are involved.

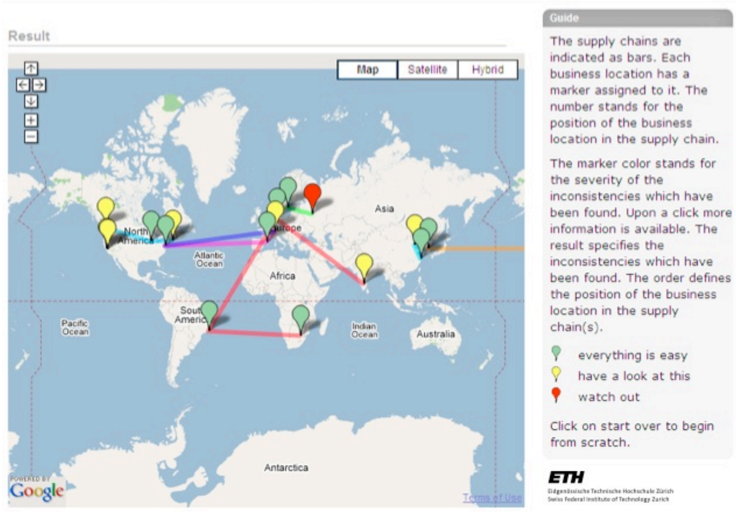

Fig 3. Screenshot of the Supply Chain Visualizer demo

5 Conclusions

We showed how simple generic rules can increase a supply chain managers visibility of problems by analyzing RFID trace data. Our map-based interface provides an easy to use representation suitable also for larger data sets. Future research directions include the use of probabilistic rules and also the role of supply chain managers for configuring the rules to a specific problem.

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