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OVERVIEW OF RFID MIDDLEWARE

Abstract: In this article, the RFID middleware is introduced and compared. The overview is based on data extracted from the Forrest Research Inc. and some other sources. Main vendors of RFID middleware software was describing: IBM, Microsoft, SAP, Sun and others. In the article was also a comparison of software for applied technology, databases etc. Therefore, the basic concepts related to the RFID technology and the EPC standard are detailed.

Keywords: RFID, RFID middleware, RFID Vendors, EPC.

1. Introduction

Radio Frequency Identification (RFID) is rapidly changing the way businesses track inventory and assets. From Wal-Mart and Tesco to the U.S. Department of Defense, early efforts are already showing benefits, but software, integration, and data processing for RFID still present a challenge. The really powerful way is an integration RFID technology with EPC standard and use the Internet to take information's about the products from global databases located on entire world (more: [Rutkowski 2005]).

2. The basic of RFID technology

RFID is the system of controlling the flow of goods (or any other objects) on the base of remote – through radio rays – data reading and writing using special electronic systems fixed to monitored objects. This technology replaces bar codes by a micro system, from which information can be read, but it cannot be seen. Unlike using bar codes, RFID allows reading data from identifiers and writing data without optical contact between reading appliance and identifier. By using this technology it is also possible to record data many times. So the system is fully-automatic and does need to be cooperative with humans.

RFID is one of the more recent four-letter abbreviations to have greatness thrust upon it in a flurry of industry mandates, governmental legislation, and hyperbole.

RFID stands for Radio Frequency Identification, a term that describes any system of identification wherein an electronic device that uses radio frequency or magnetic field variations to communicate is attached to an item. The two most talked-about components of an RFID system are the tag, which is the identification device attached to the item we want to track, and the reader, which is a device that can recognize the presence of RFID tags and read the information stored on them. The reader can then inform another system about the presence of the tagged items. The system with which the reader communicates usually runs software that stands between readers and applications. This software is called RFID middleware [Majewski 2006; Leszczyńska 2007].

3. The basic of EPC standard

EPCglobal, Inc., is a joint venture between the UCC and EAN International. The aim of EPCglobal is to establish worldwide standards for designing, implementing, and adopting Electronic Product Code (EPC) and EPCglobal Network (described later). The EPCglobal specification [Hansen, Gillert 2008, p. 98] targeted for supply-chain operations is probably the most promising global specification for RFID that can also be applied to a very wide array of applications.

A short history of EPCglobal is in order. EPCglobal, Inc., took over the administrative responsibilities of its predecessor Auto-ID Center on November 1, 2003. The research functions of Auto-ID Center were transferred to several worldwide Auto-ID labs. EPCglobal, Inc., maintains a very close relationship with Auto-ID labs to enhance the technology and meet future needs. Auto-ID Center was founded at MIT in October 1999 as a partnership research program sponsored by 100 companies and 5 of the world's leading universities. It was responsible for conceptualizing, creating, and promoting the original specification called the Auto-ID Center specification that involved the EPC technology. Why was the transformation from Auto-ID Center to EPCglobal, Inc., needed? After the EPC technology was sufficiently developed in the research setting, the need of an experienced standards body was felt to commercialize and drive global adoption of the technology. Both EAN and UCC have several years of experience in handling standards, and the combination of these two bodies truly makes one of the most globally capable entities for advancing the EPC and EPCglobal Network [Lahiri 2005, p. 283].

The EPC standard is described at www.epcglobalinc.com.

4. The basics of RFID middleware

RFID middleware is software that was designed to process the streams of tag or sensor data (event data) coming from one or more reader devices. It performs the filtering, aggregation, and counting of tag data, reducing the volume of data prior to sending it to Enterprise Applications. Auto-ID Savant Specification 1.0 defines how

RFID middleware works, and how it defines the interface to Enterprise Applications. This specification has now been replaced by EPCglobal Architecture Framework Version 1.0 (www.epcglobalinc.com).

RFID middleware sits between the tag readers and the enterprise applications (Figure 1) which are intended to address the unique computational requirements presented by EPC applications. Many of the unique challenges come from the vastly larger quantity of fine-grained data that originates from radio frequency (RF) tag readers, as compared to the granularity of data that traditional enterprise applications are accustomed to. Hence, a lot of processing performed by RFID middleware concerns data reduction operations such as filtering, aggregation, and counting. Other challenges arise from specific features of the EPC architecture, including the ONS and PML Service components [Chrobak 2010, p. 406].

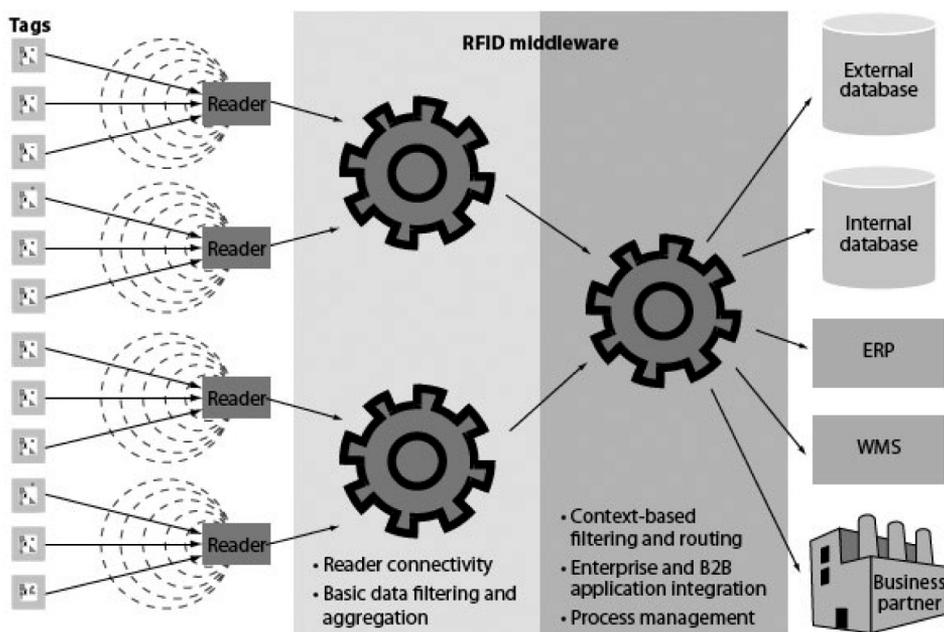


Figure 1. RFID SMiddleware architecture

Source: [Leaver 2004, p. 10].

Specific requirements for EPC processing vary greatly from application to application. Moreover, EPC is in its infancy; as it matures there will be a great deal of innovation and change of what applications do. Therefore, the emphasis in the RFID middleware specification is on extensibility rather than specific processing features. The RFID middleware is defined in terms of “Processing Modules,” or “Services,” each with a specific set of features which can be combined to meet

the needs of his or her application. The modular structure is designed to promote innovation by independent groups of people, avoiding the creation of a single monolithic specification that attempts to satisfy all needs for everybody [Williams 2006, p. 106].

EPC Information Service. The EPC Information Service makes EPC Network-related data available in Physical Mark-Up Language (PML) format to any requesting service. The data available through the EPC Information Service includes tag read data collected from RFID middleware (e.g., to assist with object tracking and tracing serial number granularity); instance-level data such as the date of manufacture, the expiry date, and so on; and object class-level data such as product catalogue information. When responding to requests, the EPC Information Service draws on a variety of data sources that exist within an enterprise, translating that data into PML format. When the EPC Information Service data is distributed across the supply chain, any industry can create an EPC Access Registry to act as a repository for EPC Information Service interface descriptions. Auto-ID EPC Information Service Specification 1.0 defines the protocol for accessing the EPC Information Service.

Object Name Service. The Object Name Service (ONS) provides a global lookup service for translating an EPC into one or more Internet Uniform Reference Locators (URLs). These URLs identify with EPC Information Service; however, ONS may also be used to associate EPCs with Web sites and other Internet resources relevant to an object. ONS provides both static and dynamic services. Static ONS typically provides URLs for information maintained by an object's manufacturer. Dynamic ONS records a sequence of custodians as an object moves through a supply chain.

ONS is built using the same technology as the Domain Name Service (DNS). Auto-ID Object Name Service Specification 1.0 defines how ONS works and interfaces with applications.

ONS local cache. The local ONS cache is used to reduce the need to ask the global ONS for each object, because frequently-asked values can be stored in the local cache which acts as the first port of call for ONS-type queries. The local cache can also look up private internal EPC's for asset tracking. Coupled with the local cache are registration functions for registering EPC's with the global and dynamic ONS systems for private tracking and collaboration.

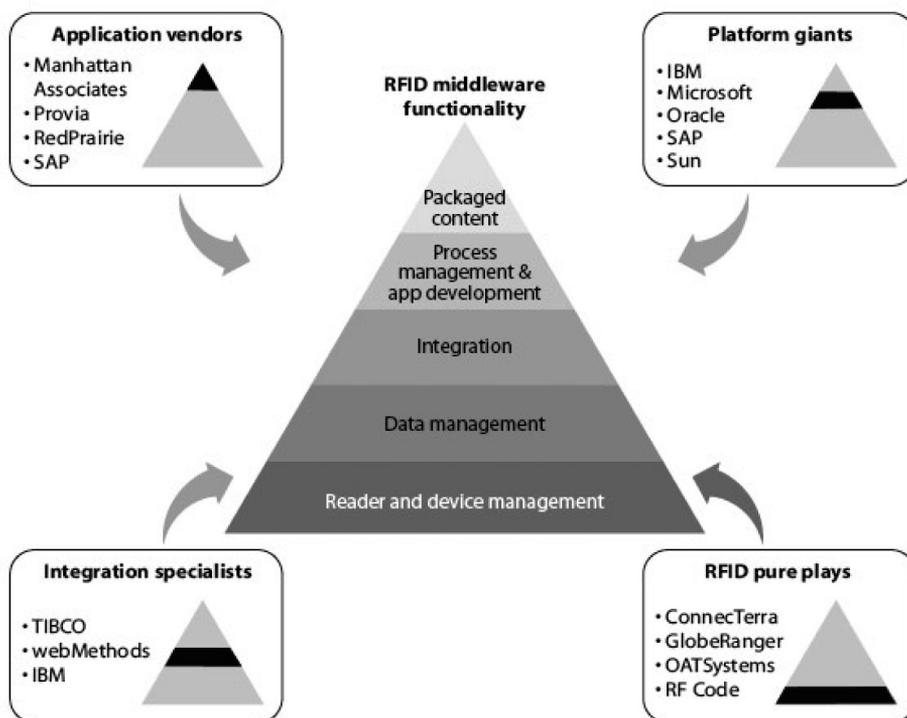
EPC Network data standards. The operation of EPC Network is subject to the data standards that specify the syntax and semantics of the data exchanged among the components.

EPC. The EPC is the fundamental identifier for a physical object. Auto-ID Electronic Product Code Data Specification 1.0 defines the abstract content of the EPC in the form of RFID tags, Internet URLs, and other representations [Williams 2006, pp. 104-105].

5. The giant RFID middleware vendors

There is many suppliers of RFID middleware systems. This article is talking about the biggest players on the word's common market. The comparison below is based on the information's from Forrest Research Inc. and some other sources.

The giant world vendors are flocking to the RFID middleware market. It is riddled with mandate-driven user companies with increasing RFID budgets. But as is typical of most emerging markets, the vendor landscape is far from simple. RFID middleware vendors are crawling out of the woodwork, with four key segments – each of which brings different expertise to the table – making a play (Figure 2).



Note: The small triangles represent the core strengths of the vendors, not their entire feature set.

Figure 2. Vendors apply core expertise to RFID middleware

Source: [Leaver 2004, p. 3].

RFID pure plays. Vendors like ConnectTerra, GlobeRanger, and OATSystems emerged out of the early pilots sponsored by the Auto-ID Center. These vendors, along with some RFID hardware veterans like RF Code, offer products that integrate

with RFID readers, filter and aggregate data, and even incorporate business rules. These vendors are still in their early stages, but their involvement in pilots and RFID standards development has turned them into valuable resources for practical RFID know-how.

Application vendors. Driven by RFID mandates, supply chain ISVs like Provia Software, Manhattan Associates, RedPrairie, and SAP now offer software ranging from RFID-enabled applications for warehouse and asset management to more robust RFID middleware solutions with reader coordination, data filtering, and business logic capabilities. Many application vendors like Provia Software and RedPrairie have tackled this market by striking up OEM relationships with middleware vendors, while others like Manhattan Associates and SAP have built their own solutions.

Platform giants. Vendors like Sun Microsystems, IBM, Oracle, and Microsoft are extending their application development and middleware technology stacks to handle RFID requirements. Each of these vendors is working to amass RFID experience and bring a strategic RFID middleware architecture – which leverages its standard application development, data management, and process integration products – to market. These vendors bring unparalleled experience with highly scalable application platforms to the table.

Integration specialists. Similar to the platform giants, integration specialists like webMethods, TIBCO Software, and Ascential Software are adding RFID-specific features like reader coordination and edge-tier filtering to their existing integration broker technology. These vendors offer extensive experience with high-volume data and process integration scenarios and have an opportunity to capitalize on RFID adopters that have already invested heavily in their integration broker technology.

Given today's lack of large-scale RFID implementations, it is much too early to definitively identify the leading vendor(s) for supporting broad RFID deployments. But the Forrester Inc. is trying to identify which vendors are best positioned to dominate this market. They applied a different set of reference criteria weightings that reflect our opinion on which features will matter most for these broad deployments. Their weightings prioritize features like architecture scalability, integration, and process management, which will be critical for successful broad RFID deployments. The results are shown in Figure 3.

SAP leads with a balance between applications and infrastructure. SAP's experience straddling the fuzzy line between applications and infrastructure puts it in a strong position to support large-scale RFID deployments – within its vast installed base. But to capitalize on this opportunity, SAP should further decouple its RFID middleware functionality – which is currently quite “baked into” its logistics and supply chain solutions. SAP NetWeaver components like Exchange Infrastructure (XI) and Master Data Management (MDM) should become the cornerstone of SAP's RFID middleware offering. Why? So firms can easily integrate RFID data across a more heterogeneous application environment and manage RFID data exchanges across trading partners.

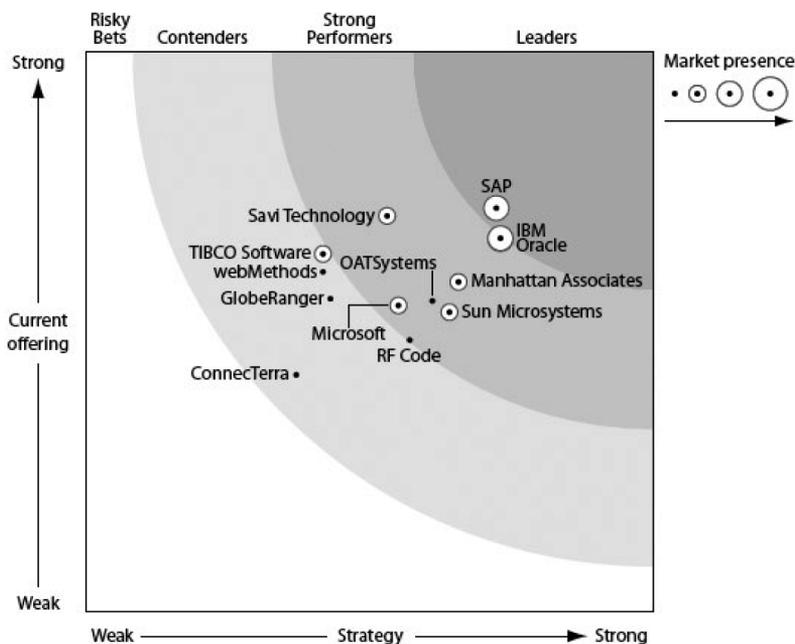


Figure 3. RFID for future scalable deployments

Source: [Leaver 2004, p. 11].

IBM and Oracle show promise for scalable RFID architectures. Both IBM and Oracle have flexible, multi-tiered architectures planned for their RFID middleware offerings. IBM’s solution will build on its existing WebSphere platform, which supports large-scale integration and application development projects, and Oracle’s solution will leverage its application development and data management technology. And because of Oracle’s eBusiness Suite and IBM’s Global Services offerings, both of these vendors also have the potential to offer packaged content like process logic and data schemas.

Early adopter leaders fade – but do not fade away. OATSystems and Manhattan Associates – which are leading the way in RFID middleware for early adopters – do not offer platforms that support centralized, enterprise-level integration, and data management needs – and face an uphill battle to break into this market. This means that these solutions should not stand as the sole RFID middleware tool within larger deployments. Early adopters that want to move to a more scalable architecture should couple these specialized products with larger integration and data management solutions from platform or integration vendors like IBM, Oracle, webMethods, or TIBCO Software.

Integration specialists get an opportunity to shine. Integration vendors like webMethods and TIBCO Software have n’ot made much progress in adding

RFID-specific features like reader coordination and edge-tier filtering to their existing integration broker technology. But coupled with a pure play like OATSystems, these vendors have an opportunity to become key players in the RFID middleware market – especially among their current installed bases.

6. The comparison a giant RFID middleware's suppliers

There is a few philosophy about buildings RFID Middleware's system. Some are based on the ALE specification proposed by EPCglobal, while some predate ALE but provide similar event management capabilities. This article provides an overview of some of the RFID event managers out there. It is important that the information included here is just a representative sample, not a comprehensive list, of available products.

The free first middleware products described below provide information about the core functions of encapsulating reader interactions, managing events, and providing a high-level service-oriented interface for applications. In addition to these core functions, the products describe below provide varying degrees of management and monitoring capabilities, service-oriented architecture integration capabilities, and built-in adapters to various ERP packages. The following describes a few companies mentioned earlier.

Sun Microsystems

Sun Microsystems was one of the early entrants into the RFID market. Sun provides a Java-based RFID middleware platform called the Sun Java System RFID Software. Sun's RFID software is designed specifically to provide high levels of reliability and scalability for your EPC network, while also simplifying the task of integrating with multiple existing backend enterprise systems. Sun's RFID middleware is part of the Java Enterprise System (JES) and supports standards-based integration with leading enterprise integration servers, including the Sun Java Enterprise Integration Server.

The four components of the project are the RFID Event Manager, the RFID Management Console, the RFID Information Server, and a software development kit (SDK) for creating adapters and stand-alone applications.

Version 3.0 of this product adds support for the latest readers and printers. The product is built on top of Jini 2.0.1, Rio 3.1, the Java Web Services Developer Pack 1.5, and the Sun Java System Application Server 8.1, but it is designed for maximum portability and supports a wide variety of platforms, including Solaris, Linux, Windows XP, and an ALE implementation for J2ME CDC (embedded devices) [Glover, Bhatt 2006, p. 200].

ConnecTerra/BEA

ConnecTerra's primary product, RFTagAware, is a software infrastructure platform for the development of device applications and RFID solutions. ConnecTerra was one of the first companies to implement a middleware solution

based on the Application Level Events (ALE) standard. ConnecTerra is very active in the EPCglobal standards groups, and its founder and CTO Dr. Ken Traub was the leading author for the Application Level Events specification.

With RFTagAware, devices such as RFID readers are abstracted, similar to how a database is abstracted by SQL. Users simply describe the events they are interested in, much like a database query, and subscribe to the results that are produced based on the RFID activity. The RFTagAware Edge Server, a piece of software deployed on or near a device, processes the raw tag information and, based on any number of outstanding queries (known as Event Cycle Specifications), delivers qualifying results to any number of subscribing applications. Queries can be added, changed, or removed independently in real time without affecting the queries or results used by other applications. The Edge Server takes care of optimizing the use of the hardware, ensuring that the device utilization is optimized for the collection of outstanding queries.

RFTagAware provides the following capabilities:

- data filtering and aggregation,
- monitoring and managing an RFID infrastructure,
- integrating data with enterprise applications,
- rapid application development.

The main components of this Edge Server offering include the Filtering and Collection Engine (also known as the ALE Engine) and the device management agent. The RFTagAware Edge Server interfaces to a wide variety of popular readers and printers, as well as various sensor inputs that are used as triggers to the reader control. The Edge Server implements the EPCglobal ALE API and includes extensions for tag writing and other capabilities not yet covered by the standard. It also includes APIs for managing and monitoring the Edge Server and devices, as well as an Administration Console that provides remote visibility into Edge Server Operations.

The ConnecTerra technical architecture mirrors the architecture framework that is being used by EPCglobal in its standards-creation efforts. The stack uses a number of layers with defined APIs. These APIs are then mapped into a number of implementation-specific protocols. In addition to the standards, ConnecTerra has added architectural interfaces in the areas of real-time reader monitoring, tag writing, tag provisioning, as well as key local workflow components) [Glover, Bhatt 2006, p. 201].

GlobeRanger

GlobeRanger is one of the early pure-play RFID middleware companies focused on providing an edgware platform for RFID, sensors, and other edge devices. GlobeRanger offers its iMotion software platform through partners OEMs and VARs who then build solution offerings for their clients across multiple industries. The iMotion software platform incorporates visual tools to simplify solution development, deployment, and management.

The iMotion platform is built on Microsoft's .NET framework and takes advantage of several emerging standards, including the ALE and EPCIS specifications. The iMotion platform consists of four major system components [Glover, Bhatt 2006, p. 203]:

- Edge Device Management,
- Edge Process Management,
- Enterprise Management Console,
- Visual Device Emulator.

IBM

IBM is leveraging its consulting experience in early RFID pilots to inform plans for a packaged RFID middleware solution which will build on existing WebSphere and DB2 technology. Forrester expects IBM to deliver RFID-specific features, including reader management and filtering and routing capabilities across a multi-tiered architecture by the end of 2004. IBM's strong integration and application development capabilities will make it a good option for firms with a best-of-breed application landscape – particularly those looking for a one-stop services and software offering. More detailed analysis of IBM's RFID middleware offering and strategy is provided in the vendor's individual vendor profile document [Leaver 2004, p. 12].

Manhattan Associates

Manhattan Associates is a warehouse management application veteran that has jumped headfirst into the RFID middleware market. The vendor's product, Integration Platform for RFID, has straightforward data filtering, routing, and aggregation tools, and is best suited for current Manhattan Associates customers that are facing immediate mandates. Firms looking for centralized, enterprise-level data management and a robust integration platform should couple the product with third-party tools [Leaver 2004, p. 13].

Microsoft

Microsoft plans to develop RFID-specific capabilities like data filtering and reader management to complement its BizTalk and SQL Server middleware tools and take advantage of the vendor's experience with mobile technology. But the go-to-market packaging and timing of this functionality has not been finalized. Microsoft shops should factor BizTalk and SQL Server into their overall RFID middleware strategies, but early adopters will have to turn to Microsoft partners like GlobeRanger for immediate RFID capabilities [Leaver 2004, p. 13].

Oracle

Oracle's sensor-based services product strategy will enhance Oracle's application server and database technology to provide RFID middleware functionality. Specifically, in 2010 Oracle planned to add "edge services", including reader device management and filtering capabilities to the 10.1.2 release of Oracle AS. Oracle's database and data hub technology will be at the heart of the vendor's RFID middleware architecture, making it a good option for Oracle shops and firms with a heterogeneous IT systems environment that are looking to create a single source of truth for all RFID data [Leaver 2004, p. 13].

SAP

SAP's RFID middleware strategy, which centres on its Auto ID Infrastructure product as well as other components like Event Manager and Exchange Infrastructure, walks a fuzzy line between application and infrastructure software. The solution includes balanced functionality across reader management, integration, and data routing, but it appears quite "baked into" – and limited to – SAP's logistics functionality within its supply chain management solution. The product is best suited for firms currently using SAP to support their supply chain management processes – particularly those that want to get started today with RFID projects that can grow into broader deployments [Leaver 2004, p. 14].

TIBCO Software

TIBCO Software is one of the first integration specialists to get serious about capitalizing on the current demand for RFID middleware. The vendor's EPC Agent software package – which will add RFID-specific features like standard aggregation algorithms to its BusinessWorks platform – is due out for general availability at the end of 2004. Current BusinessWorks customers looking to adopt RFID over time should consider TIBCO for RFID middleware. But early adopters will have to couple it with products from RFID pure plays like OATSystems or ConnecTerra to get a complete solution [Leaver 2004, p. 14].

webMethods

webMethods is one of the first integration specialists to get serious about capitalizing on the current demand for RFID middleware. The vendor's RFID Starter Pack adds a few RFID-specific features to its Enterprise Services Platform capabilities, such as packaged RFID process logic and packaged integration with the EPCglobal Network. It is a good start for current webMethods customers looking to adopt RFID over time. But early adopters will have to couple it with products from RFID pure plays like OATSystems to get a complete solution [Leaver 2004, p. 14].

7. The comparison a RFID middleware's software

Table 1 presents a comparison of the basic parameters of featured RFID middleware software. The table includes basic information about the product (name, manufacturer, technology, and compatibility with databases) and a summary of the basic functionality of the software. The common criteria used in describing the functionality of the following middleware software:

- EPC Global – compatible,
- Integrating Data with Enterprise Applications,
- Monitoring RFID Devices,
- Data filtering and aggregation,
- Extension API for developers.

As can be seen from Table 1, all products are fully functional to allow their full use in commercial software. The primaries databases are: Oracle and Microsoft SQL.

Table 1. Comparison RFID middleware software

Product	Company	Technology	Databases	Operating system	Functionality				
					EPC Global -compatible	Integrating Data with Enterprise Apps.	Monitoring RFID Devices	Data filtering and aggregation	Extension API for developers
BizTalk ¹	Microsoft	NET framework	MS SQL or Oracle (by adapters)	Windows Server	Yes	Yes	Yes	Yes	Yes
Modules for SAP R/3 software	SAP	Java	Oracle / DB2 / MSSQL	UNIX/ Windows Server	Yes	Yes (with SAP)	Yes	Yes	
WebSphere ²	IBM	Java	DB2	Linux	Yes	Yes	Yes	Yes	Yes
Sun Java System RFID Software ³	Sun Microsystems	Java	Oracle / PostgreSQL	Solaris/Red Hat/Windows Server	Yes	Yes	Yes	Yes	Yes
RFTagAware	ConnecTerra	-	-	Solaris/Linux/Windows Server	Yes	Yes	Yes	Yes	Yes
iMotion ⁴	GlobeRanger	.NET framework		Windows Server	Yes	Yes	Yes	Yes	Yes
	Tibco Software ⁵				Yes		Yes	Yes	

¹ <http://www.microsoft.com/biztalk/en/us/default.aspx>.

² <http://www-01.ibm.com/software/websphere/>.

³ https://sun-rfid.dev.java.net/sjs_rfid_software.html.

⁴ <http://www.globetanger.com/products/imotion.asp>.

⁵ <http://www.tibco.com/solutions/biztech/rfid/default.jsp>.

The specific software is a product of IBM using DB2 database that uses promoted by the manufacturer.

8. Summary

The article concentrates on the RFID technology and is trying to show how this technology is going to support the supply chain management. In the information society, in which knowledge possessing is the main source of wealth, companies in order to meet client needs have to adopt to constantly improving IT solutions. Logistic information systems allow the cooperation among producers, deliverers, distribution centres and clients. This cooperation needs all participants of the supply chain to communicate. Automatic identification of data improves this communication. One of the most promising solutions within logistic information systems of automatic identification is RFID technology. The RFID technology in assets with EPC standard make possible to full-cooperate for each company in supply chain.

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PRZEGLĄD PLATFORM RFID MIDDLEWARE

Streszczenie: Artykuł przedstawia przegląd najważniejszych producentów oprogramowania zarządzającego infrastrukturą czytników RFID (RFID middleware) oraz ich produktów. Omówienie dostawców opiera się głównie na danych pochodzących z raportów Forrester Research Inc., a także z innych źródeł. Scharakteryzowano głównych dostawców oprogramowania RFID middleware, m.in. takich jak: IBM, Microsoft, SAP, Sun. Przeprowadzono również porównanie oprogramowania m.in. w zakresie stosowanych technologii, baz danych. W artykule wyjaśniono koncepcję działania oprogramowania RFID middleware oraz standardu EPC.