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Real-time Business Intelligence Opportunities Derived from Radio Frequency Identification Data

ZELJKO PANIAN
The Graduate School for Economics and Business
University of Zagreb
J.F. Kennedy Sq. 6
CROATIA
http://www.informatika.efzg.hr/zpanian

Abstract: - The real-time business intelligence (BI) is not just some industry hype. It is a need of contemporary business. With real-time changes reflected into business intelligence solutions, a whole new platform is open to the users where they can access up-to-the-minute or even second operational information. The source of real-time business intelligence may be data captured by Radio Frequency Identification (RFID) devices. The paper discusses solutions that enable real-time business intelligence to be derived from RFID data, as well business benefits that can be achieved by using real-time business intelligence in business decision-making processes.

Key-Words: - Real-time business intelligence, operational business intelligence, business activities monitoring, RFID

1 Introduction

Real-time intelligence solutions are no longer a novelty or luxury. These solutions are no longer in their infancy stage. They are becoming instrumental in delivering information crucial for organizations to remain competitive in their core businesses.

Given the amazing number of tools, touting anything from ready-to-go solutions on day one to analytical ability on the fly and on demand, real-time business intelligence solutions appear to be a piece of cake. However, the reality often reveals a different picture than one might imagine.

There are some obvious challenges people are facing when considering real-time business intelligence for an organization [1]:

- Ability to provide analytical information with superior performance while refreshing the data marts and data warehouse real time.
- Justification of cost versus benefits for real-time business intelligence.
- Impact on performance of one or more source applications.
- Ability to perform all of the transformations in the extract, transform, load (ETL) process in real time.

These responses are not incorrect; however, they are only a small part of the total answer. During the implementation of real-time business intelligence solutions, the biggest challenges include more than just issues around tools and technologies.

In the following sections these challenges are described and, correspondingly, the rules that should be followed.

2 What Is Actually Real-time Business Intelligence?

In absolute terms, there is no such thing as a truly real-time business intelligence solution [2].

Paradoxically, the term real-time business intelligence is not just some industry hype. The definition of ‘real-time’ is relative to an organization’s critical information needs. For some organizations, real-time response may be defined as ‘within a minute’, while for other organizations working in situations where instantaneous response is required it may be as small as a few milliseconds.

For any given scenario, the time it takes to capture changes in the source system should be taken into account, as well as time needed to perform ETL processes and cache frequently accessed reports. Every step in this entire cycle introduces overhead in overall response time [3].

Considering the time taken in each step of data integration and presentation the solution will almost always be accurately called ‘near real time’. However, many business intelligence solutions usually deal with information needs that are up-to-the-minute or delayed by at most a few minutes. For practical purposes, there is nothing wrong in labeling them real time.

The greater challenge lies in managing the expectations of user communities from the beginning of the implementation. It is essential to ensure that everyone thinks about the same thing when defining real time.

It is difficult to avoid the misconception that every single piece in data mart or data warehouse has to be refreshed in real time. While most of the information in a

real-time business intelligence solution may be categorized as absolute real time, not all pieces of puzzle need to be paid out in real time. For this reason, subject areas and/or information elements which are required to be available in an absolute real-time manner should be differentiated from those that can be fulfilled with a daily, weekly or even a monthly refresh frequency.

As an example, let us consider a sales analytics solution where it is important to report monthly and year-to-date sales by employee on a real-time basis. The data integration engine that populates the sales facts into a real-time data warehouse needs to perform this task as soon as the source application reflects such changes. However, what about the refresh frequency of the employee dimension?

Let us assume that some attributes of the employee dimension are derived from a human resources (HR) application that reflects the changes occasionally and that those data elements are not critical for sales analysis.

In this scenario, it may make sense to break down the employee dimension in two components. Absolutely necessary information (e.g., user IDs and passwords) should be derived in real time from the security system while other attributes such as office location may be 'back filled' overnight from the HR application. This kind of arrangement will reduce the load on the real-time ETL process.

Similarly, if some snapshot facts are required only for monthly reporting purposes, those snapshots may be built only once a month.

A leaner set of data is to be designed to integrate in real time. Drawing a line between each refresh frequency and deciding which information should be real time and which can wait for some time is a key to successful real-time business intelligence solution.

These requirements need to be tackled early during the analysis and high-level solution design phase.

3 Capturing Data in a Real-time Fashion

The simplest way to capture data from any source application in a real-time fashion is to actually read the source system real time [4].

Most of the real-time integration tools have a real-time data replication engine separate from the batch integration engine. Such engines often come with a separate price tag. This real-time data replication engine leverages database logs in order to do its work. While such tools make life easy for the development team, database native replicators offered by database vendors can prove to be simpler and cost-effective solution.

Alternatives to such real-time data capture can be designed through database triggers as well. If this option does not tax the source system in terms of performance and maintenance, it is a better candidate than separate toolsets since both cost and maintenance will be lower [6]. Such triggers can post changes captured in source system into a separate staging area and the real-time integration engine can read continuously from the staging area without affecting the performance of the source system.

Most likely, the volume and refresh cycles of the data that need to be integrated from various systems can be easily handled by standard ETL refresh triggers including database triggers, replication or some other mechanism [7].

Even if there is a latency of few minutes in the alternate mechanism, they should be considered over implementing separate replication tools. The cost and complexity involved in implementing specialized tools solely for purpose of replicating data may not justify the benefits received by providing the information a few seconds early.

4 Delivering Real-time Business Intelligence

Most real-time business intelligence initiatives start with an objective of delivering the right information at the right time. That correctly describes the importance of the timeliness and correctness of information. However, where should that timely and correct intelligence be delivered?

Delivering the right information to the right place or person at the right time has never been easier with the latest communication gadgets and technologies. Besides the traditional desktop reporting interface, the real-time solution can deliver dashboard reports or exception alerts to PDAs, mobile phones or similar Web-enabled devices.

While technology is readily available, the art remains in defining the critical exceptions and provide concise alerts or selective information based on the users' differing information needs [8]. Attention needs to be given to such analysis during the requirements gathering sessions with users at various levels in the organization. Such consideration will reveal personalization as well as security requirements based on each user's roles and responsibilities within the organization.

Data mining and satisfying ad hoc analysis are key features of the traditional business intelligence and data warehouse applications [9]. At the same time both these types of analyses impact database performance. For a real-time solution this is a primary challenge because the solution has to perform both data refresh as well as deliver reports in real time.

If the objectives of data mining and ad hoc analyses are contemplated, it becomes obvious that neither of the two require up-to-the-minute information. When users

are interested in researching trends over a few years or finding correlation between two discrete attributes or even investigating a particular instance, they can utilize a snapshot as of yesterday or even last month.

A pragmatic approach would be to maintain a separate environment that delivers information for such uses from a backup of data warehouse databases and not the real-time data warehouse solely. Without this arrangement, it would be a challenge to please all of the users at a time.

One of the popular myths about business intelligence is that it can fulfill analytical reporting needs while the core transactional applications deliver operational information. In reality, a typical business intelligence solution must satisfy both kinds of needs with equal ease.

Real-time business intelligence is no exception. Dashboards and alerts are not meant only for senior management. In a typical organization, the majority of the analytical research and reporting initiatives is performed by tech-savvy middle managers.

At the same time they are also responsible for monitoring the performance of their sub-units on a real-time basis. The slightest deviation from the plan can result in a large impact on the bottom line. These middle managers are in fact the most frequent and heaviest users for both the operational and analytical research and reporting capabilities of the business intelligence systems.

With real-time changes reflected into business intelligence solutions, a whole new platform is open to the users where they can access up-to-the-minute or even second operational information. This is superior to traditional business intelligence solutions where users have to wait for a day or more in order to get the same information.

Careful consideration to operational reporting requirements during the requirements gathering phase is essential to deliver the highest return on real-time business intelligence solution investment.

5 Radio Frequency Identification Technology as a Support to Real-time Business Intelligence Solutions

5.1 Overview of Radio Frequency Identification Technology

Radio Frequency Identification (RFID) is a flexible technology that is convenient, easy to use, and well-suited for automatic operation. It combines advantages not available with other identification technologies [10]. RFID can be supplied as read-only or read/write, does not require a physical contact or line-of-sight to operate, can function under a variety of environmental conditions, and provides a high level of data integrity. In addition, since the technology is difficult to counterfeit, RFID provides a high level of security.

In concept, RFID is similar to barcoding. Barcode systems use a reader and coded labels that are attached to an item, whereas RFID uses a reader and special RFID devices that are attached to an item. Barcode uses optical signals to transfer information from the label to the reader. On other side, RFID uses radio signals to transfer information from the RFID device to the reader.

Radio waves transfer data between an item to which an RFID device is attached and an RFID reader. The device can contain data about the item, such as what the item is, what time the device (and the item, of course) traveled through a certain zone, perhaps even a parameter such as temperature. RFID devices, such as tag or label, can be attached on virtually anything – from a vehicle to a package of merchandise.

RFID technology uses frequencies within the range of 50 kHz to 2.5 GHz. An RFID system typically includes the following components [11]:

- an RFID device (transponder or tag) that contains data about an item
- an antenna used to transmit the radio signals between the reader and the RFID device
- an RF transceiver that generates the radio signals
- a reader that receives RF transmissions from an RFID device and passes the data to a host system for processing.

The interplay of these components in their typical implementation is shown in Fig. 1.

In addition to the basic equipment, an RFID system includes application-specific software.

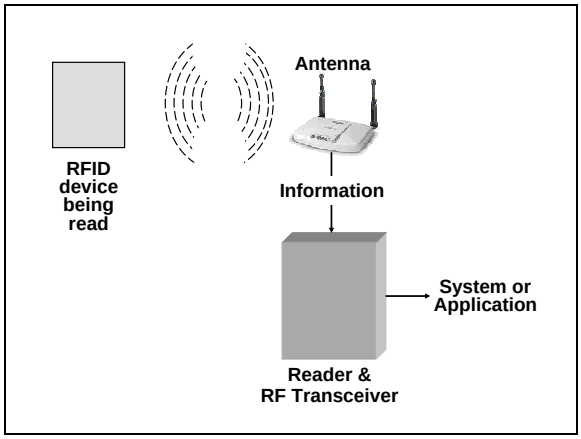

Fig. 1 – Typical RFID System Components

5.2 Active RFID vs. Passive RFID

RFID tag technology falls into two broad categories – passive and active. Simply stated, active has an on-board power supply (e.g. battery) while passive relies on capturing and 're-using' a small portion of the wake-up signal signal's energy to transmit its RFID tag identification back to the receiver.

This is a 'good news, bad news' situation.

The 'good news' is that passive tags can be manufactured and sold at much lower price point today than active tags. This is a critical element in many RFID supply chain applications requiring the tagging of millions of units.

The 'bad news' is that passive tags often struggle to provide reliable reads given the performance limitations of a technology using only a small amount of power to push its signal off metal surfaces, through layers of palletized products, through different space barriers, etc. Also, passive RFID tags sometimes struggle to provide a highly reliable signal when tags (goods) are in motion.

Active tags therefore have an initiate performance advantage over passive tags when it comes to providing a consistently robust, penetrating signal. So higher value 'things' at the pallet level and above often require active tags. Considering the total cost of ownership, an active tag's higher cost is offset by a lower cost reader and processor infrastructure making the cost justification easier. Containers, trucks, and trailers are the best examples of high value items that require active tags.

In summary, passive and active RFID capabilities are related, but they are distinctly different technologies which should be matched to the application's technical and economic requirements. Automatically identifying personnel, assets, and vehicles are 'active' applications and the cornerstones of automated visibility, security, and quality improvements in the enterprise. In the supply chain, for example, visibility, security, and quality can only be attained by utilizing both.

5.3 Active RFID Key Capabilities

In an August 2004 market study and end user survey [12], active RFID systems were found to have a series of valuable characteristics including:

- enhanced dependability because of high performance
- enhanced security/access control including theft reduction
- the ability to link tag together in software for custodianship
- the ability to automate identification and location by removing human intervention
- improved data integrity because of accuracy and reliability
- improved read accuracy and longer read ranges
- increased data transfer rate

The study found the reasons end users implement active RFID systems centers around increased productivity including:

- streamlined processes
- labor reductions
- increased visibility and automation
- provision of real-time information

Additional capabilities unique to active tags were also cited by end users as being important including: sensor monitoring, automatically beaconing signals and tamper resistance.

The applications most important for customers when considering adoption include:

- asset tracking including work-in-progress
- supply chain management and intelligence
- security and access control
- sensing/monitoring

The target markets for active RFID were cited to grow at the annual rate of 38%. Key industries included: automotive, electronics, aerospace, pharmaceuticals, government/military, transportation, and retail.

5.4 RFID's Strategic Role in the Enterprise

Radio communications is now a pervasive technology in the world, from cordless and mobile phones to wireless LANs connecting offices and Wi-Fi hot spots at the local bus station. RFID applications encompass a very wide scope: forklift tracking, vehicle toll collection, tracking library books, preventing diversions and brands, tracking wild animals, buying gasoline (and perhaps cigarettes), race timing, tracking healthcare emergency personnel, car ignitions/immobilizers, automobile manufacturing, finding personnel in nature parks, ski lifts access, etc.

Security applications are now broad as well: electronic asset surveillance, human access control, vehicle access control, and asset protection [13]. So, it is with little surprise that RFID is a key platform for solving the unique access control challenges of the 21st century.

But it does not stop here. The security industry's use of active RFID is once again an example of applying today's technology to today's new challenges. And, once again we see the security network evolving toward a strategic role in the enterprise, in this case through the potential to support supply chain automation activities.

Many RFID systems can operate in a parallel, standalone mode with graphical tracking software to locate assets and personnel and show recent movements. This represents a powerful capability, a step up in intelligence of the system and improving its productivity.

These systems can also use middleware to automatically read and convert virtually any sensor, alarm, or transaction as input to the intelligent filtering process. The degree of automatic control and tracking elements in the system becomes endless. With this middleware the automatic control and tracking elements of active RFID for access control meets any of the needs the supply chain specialists cannot solve any other way.

For now however, today's solutions define a clear path for active RFID's role in many industries. Active RFID improves on the productivity and convenience of proximity systems and adds necessary elements of automatic control and tracking to increase the scope of the application systems.

The ability to use industry standard methods to augment existing systems for personnel access control, vehicle movements tracking, and asset protection adds active RFID as a vital weapon in company's arsenal of potentially intelligent applications for addressing the new challenges of the 21st century.

6 Real-time Business Intelligence Derived from RFID Data

As more businesses strive for the ideal of real-time enterprise, there is growing interest in reducing the latency of traditional business intelligence delivery. Making faster decisions based on more real-time information can benefit enterprises seeking faster and more efficient operational business processes.

Real-time business intelligence in form of business activity monitoring (BAM) is a new style of application that harnesses real-time events in the context of business operations and is some times also referred to as the 'operational business intelligence' [14]. In this case, the real-time events are triggered by the inflow of RFID data.

Using the real-time RFID information with business activity monitoring tools built on Enterprise Resource Planning (ERP) and Business Process Management (BPM) software, data is presented in real time through a portal or dashboard. The dashboards in this case have drill-down or actionable control functions, so users can not only monitor but also respond to and control the processes under watch.

To get an idea of how real-time business intelligence or business activity monitoring tools work, let as look at a basic model. A basic real-time business intelligence tool installed on an enterprise's information technology (IT) level is schematically shown in Fig. 2.

This enterprise has a bunch of applications that play critical roles in its business transactions, purchase order (PO) entry system, writing Electronic Product Code (EPC) information into the case tags, pallet building, shrink wrap processing and Electronic Data Interchange (EDI) gateway.

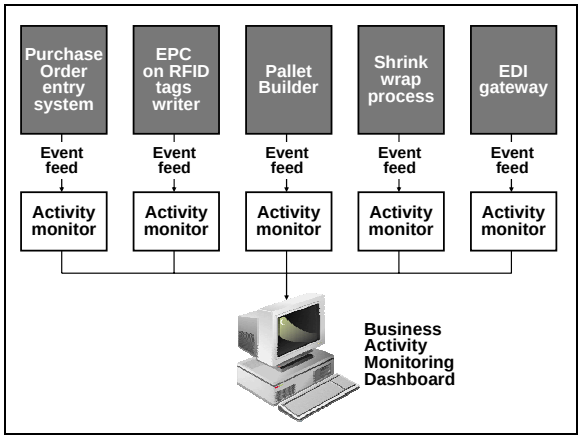

Fig. 2 – A basic real-time business intelligence tool

The enterprise applications communicate by sending messages or events across the middleware layer.

For example, a workflow engine starts on receipt of purchase order in the enterprise's system. This triggers the application which writes the EPC information into the RFID tag. This will in turn send a message to initiate the pallet building application. Each message triggers an application to perform a step in processing the order. This sequence continues till the information of the shipment is sent to the customer through the EDI gateway.

Consider that the enterprise installs business activity monitoring tool to help track its transactions. The arrows in Fig. 2 indicate flows of events added to the real-time business intelligence tool's components.

This tool reads events from the applications but does not interfere with the communication between applications. It feeds the events to activity monitors installed to watch each application. The monitors use the events to measure certain metrics or statuses which are all displayed on the dashboard in nice colors.

When metrics or statuses reach the critical state, the colors change and alert events are created. This enables real-time information available from the RFID infrastructure that can be utilized to make sound business decisions.

By being able to pull together data from across the organization, executives at all levels of the organization expect the information they need to support their decision-making on their desktops [15]. Real-time business intelligence in the form of business activity monitoring is the key to meeting this challenge, and hence these will become vital IT component supporting organizational decision-making processes.

With RFID infrastructure in place in the downstream, along with efficient real-time business intelligence tools in the upstream, companies can harness information from terabytes of dynamic and detailed RFID data. Using this information in real time to recover lost revenues, improve risk management, reduce fraud, and compress decision cycles, companies can further strengthen customer relationships and even enable new, previously impossible business processes.

7 Conclusion

Business intelligence (BI) is evolving from strategic, through tactical, to operational level. On the operational level, i.e. level of business process execution business intelligence should be delivered in real time. In this sense, it is referred to as 'real-time BI', 'operational BI' or 'business activity monitoring'.

As it is well known, business intelligence needs source data from which it will be derived. Those data should be numerous, representative to the event and/or processes they originate from, accurate, and reliable. Radio Frequency Identification (RFID) technology provides data on operational business processes with such attributes.

Knowing this, it is quite logical that research initiatives are put in action to find and develop solutions which will enable the real-time business intelligence to be created from RFID data. With real-time changes detected by RFID system and reflected into business intelligence solutions, a whole new platform is open to the users where they can access up-to-the-minute or even second operational information. This is superior to traditional business intelligence solutions where users have to wait for a day or more in order to get the same information.

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